UNIT 1 INTRODUCTION TO ENVIRONMENT

Structure

1.0 OBJECTIVES

After reading this unit, you should be able to:

- comprehend the concept of environment;
- list the components of ecosystem and establish the linkages between various environmental factors; and
- list the sources of energy and discuss their role in the sustenance of life.

1.1 INTRODUCTION

We are concerned with understanding the close link between health and environment. But first we will need to understand what is environment. This unit will introduce you to the meaning and the components of the environment as we cover a wide range of concepts and issues which will help you become familiar with this pressing topic of our time. Terms like ecosystem, energy flows, cycles which you have so often heard now become clear to you. This unit forms a base on which the further units have been built on.

Read the material systematically and keep track of your study by doing the self check section called Check Your Progress. Be sure to take note of the diagrams whenever reference is made as this will help you understand the material even more. Do not ignore the boxes with facts and figures as these will strengthen what you learn. These will give you a good idea of the magnitude of the problem we face as we confront the ecological crisis with a view to improve health conditions.

1.2 WHAT IS ENVIRONMENT?

Let us start by understanding the term environment. Very simply everything around you is your environment. The environment in plain terms means "surroundings". The air you breathe, the trees and flowers you admire, the water you drink, the sky you look up to, and the people you live with are all part of your environment. The physical factors include air, water, soil, climate, heat, light, noise, housing, radiations, debris, etc. The biological factors are all types of plants and animals including man. For plants and other animals environment is limited, but for man it also extends to the social conditions under which we live. Social conditions include customs, culture, religion, habit, occupation, income, technology, economics, politics.

So the term 'environment' implies the constant interactions between living beings and, the surrounding physical, biological and social factors.

The environment is constantly changing and i.e. to be expected. Populations increase. Machines replace manual work. More and more space as well as resources is required to sustain all of this growth. Life is not the same as it was a hundred years ago. Apart from positive change, there is also the negative side. Modern life has introduced some risk factors into our natural environment. The air you breathe is polluted by smoke from vehicles and factories, the water you drink contains impurities that have flowed into rivers and lakes, and even the calmness that was once part of rural life has been disturbed with increased noise from gadgets that back up today's life-style.

1.2.1 You and Your Environment

You are now ready to try and understand your environment in a more intimate way. Let us look around to consider our own surroundings. We all live in varied environments and here is a study you can conduct to help yourself in understanding the environment.

If you live in a rural area, as most people in South-East Asia do, your environment is one of villages and small towns where people work mainly in the surrounding fields, forests, or mines. Take some time to observe the kinds of fields (flat, sloping, large, and small), field boundaries (ditches, fences), crops and animals that occur in your area. What kind of farming do you see? Are the products used locally, or are they sold in the nearest market town or even sold to markets in other countries? How do the monsoons affect your area? Is your area affected by floods, soil losses, forest removal? Where do you dispose domestic and other wastes? What changes have you and your family seen over the last 20 years? Have you seen changes in land quality, water availability, weather, and local plants and animals? Have you seen change in your own life-style? Have you seen health improve or deteriorate?

If you live in an urban area, as increasing numbers do, your surroundings and daily concerns will be different. Buildings such as homes and work places dominate the area. Trees and gardens are decreasing. People work in shops, offices, and factories and as domestic help in houses. They travel to work by walking, by cycles, motorcycles, or cars, and by buses and trains. What sort of locality do you live in? What do people do in offices and factories known to you? What changes have you or your family experienced over the last 20 years? Has your family moved from a rural to urban area in this time? How does the summer heat, monsoon rains and some recent climatic changes effect life in your area? How do you get your water and electricity? How does the local government dispose off wastes? Have you noticed significant increase in pollution in your own locality? Has health improved or deteriorated? What new diseases have you noticed in your city in the past few decades?

Check Your Progress 1

Find answers to the questions in the preceding para and summarize them below.

Your answers to the questions raised above will give you a good idea about your local environment.

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1.2.2 Is there an Environmental Crisis?

Life has not always been like this. It was only towards the end of the twentieth century, with the first stages of industrial revolution, there began a noticeable deterioration of the natural environment. There was pollution in land, water and air, as well as other alarming facts started to cause concern. In cities, where populations increased, there was accumulation of waste which caused pollution, while outside the cities there was degradation of soil, extinction of some forms of wild life and an overall change in natural surroundings. Technology which was supposed to make our life easier began to affect our surroundings and human life itself began to be effected in various ways. Rural life began to change with pressures being put on them to supply the demands of the urban rich. Newer problems entered into the often more serene and healthy community life of the past. You already begin to see the direct connection between our health and the state of the environment around us. With pollution mounting at such a frightening magnitude health problems also are compounded. Many of the diseases today are directly linked to the deteriorating environment.

Centuries of uncontrolled exploitation of nature has played havoc on Planet Earth. Agricultural revolutions, phenomenal advance of science and technology, the frightening increase in population and the increasing demands of our materialistic world today have placed enormous pressures on the Earth's energy and resources. Depletion, desertification and deforestation, climatic changes, droughts and floods and several other natural problems are threatening the future of life on Earth. And with pollution increasing at an alarming scale these problems are being compounded to even more frightening proportions.

As the crisis deepens there are severe consequences for everyone. Those living in the Third World, or the developing countries, are not only fighting for their own survival, but battling with the growing disparity between the North and their own poorer South. The wealthier northern countries face new pressures as they depend on the resources of the poorer South, while the South wants to have a say in the management of its own resources. The divide increases, and with it the crisis intensifies. Resources are needed in greater quantities but these are limited. Wars for resources have broken out.

With such grave concerns, you should be challenged by the urgent task and the need to come to grips with its root issues. Dealing with superficial symptoms will not be sufficient. Neither can we look merely at local situations, as ecological concerns are interlinked and have global dimensions, penetrating total human life. And therefore, whether philosophically, economically, socially, politically or in any other way possible, we will need to handle the mounting problems collectively and with determination.

The former United Nations General Secretary Boutros Ghali summing up the impact of the Rio Summit in 1992 said "It is no longer enough for man to love his neighbour, he must now love the world. Beyond man's covenant with God and his social contract with his fellowmen, we now need an ethical contract with nature and the earth... The earth has a soul. To restore it, is the essence of Rio." You need a new love for the natural surroundings around them in order to deal with the crisis with dedication. You will need to dedicate yourself to handle this crisis wherever you are!

"The present decade has been marked by a retreat from social concerns. Scientists bring to our attention urgent but complex problems bearing on our very survival: a warming globe, threats to the earth's ozone layer, deserts consuming agricultural land. We respond by demanding more details, and by assigning the problems to institutions ill equipped to cope with them. Environmental degradation, first seen as mainly a problem of the rich nations and a side effect of industrial wealth, has become a survival issue for developing nations. It is part of the downward spiral of linked ecological and economic decline in which many of the poorest nations are trapped. Despite official hope expressed on all sides, no trends identifiable today, no programmes or policies, offer any real hope of narrowing the growing gap between rich and poor nations. And as part of our 'development', we have amassed weapons, arsenals capable of diverting the paths that evolution has followed for millions of years and of creating a planet our ancestors would not recognize."

Gro Harlem Bruntland
"Our Common Future" 1987, United Nations

1.3 FEATURES OF OUR ENVIRONMENT

You will note that the environment comprises of static features such as hills and buildings and dynamic events such as floods, weather changes and the economic, cultural and political features imposed by human beings. Naturally, the idea of environment is different to different people. The concept of the environment is not just one of passive scenery but includes highly dynamic events and processes that affect our daily lives. When we plan for the future, as when we plant crops or build a new factory or house, we need to consider the potential impact on environmental factors of each place where we intend to carry out such actions. This is true for individuals and for groups of people.

There is much debate over the building of dams, the setting up of power plants or even the construction of residential complexes in some areas. These are not only displacing whole villages and settlements but also disrupting the ecological balance of nature. It has become important to take into account various environmental factors. Some people, therefore, will carefully consider where they should live, construct their house or factory, or even rent a house because they are beginning to realise the good and bad effects of the environment on their health.

During the last ice age, parts of what is now the Amazon jungle were verging on desert. From year to year the Earth's climate varies, gradually bringing about many dramatic changes. The variations are governed by how much energy reaches the planet from the Sun, how much is absorbed by the atmosphere and the Earth's surface, and how much is radiated or reflected back into space. The climatic changes that follow these variations occur naturally, but human factors are playing an increasing and unpredictable role in influencing the world's weather patterns.

Parts of Siberia can vary in temperature from –78°C (–108°F) in winter to over 36°C (97°F) in summer. This is the world's most extreme temperature variation, and the farther away from the equator and the closer to the poles, the more life is influenced by seasonal change. Plants reproduce on a seasonal cycle. Some animals change fur colour in winter, others migrate to escape winter's ravages. Many Arctic and temperate animals, however, reduce all bodily functions to the absolute minimum to sustain life, then, to the casual observer, a hibernating animal appears dead.

If there were no moisture or carbon dioxide in the atmosphere, the Earth's average temperature would only be –18°C (0°F). But the presence in the atmosphere of small quantities of the above, and several other gases, helps to trap the Sun's heat. This natural insulation is vital for our survival. But the gases involved seem to have increased during the last century, trapping more heat and warming up the atmosphere. The increase may be due to human activities and the gases may well double in concentration in the coming decades, with dire consequences.

The Mitchell Beazley Family Encyclopedia of Nature

1.3.1 Our Unique Earth

Let us see how our planet Earth functions within the environment we have described above. Earth is a unique planet in the solar system. Planets nearer the Sun are warmer and planets farther from the Sun are colder. Mars has a rocky surface and has a thin atmosphere. The outer planets, such as Saturn, Jupiter, Neptune, Uranus and Pluto, are mostly composed of extremely cold gases. It is unlikely that living organisms exist on any other planet in the solar system (Fig. 1.1).

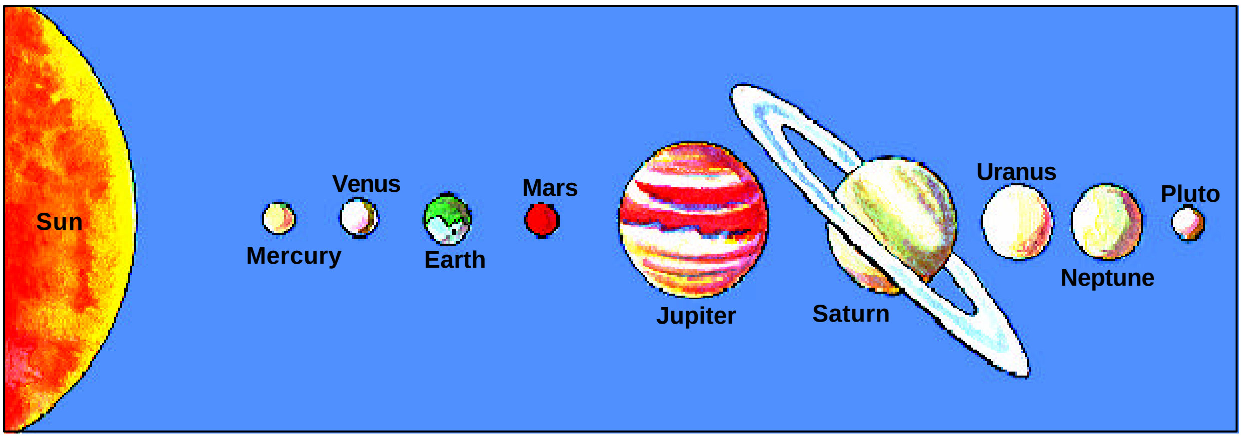

Fig. 1.1: Solar system

Earth's environment is friendly to plants and animals largely because of the climates. The main reason for Earth's friendliness is that it is at approximately 150 million km from the Sun, and is tilted so that the Sun's energy is spread over much of the world at different seasons of the year. Most parts of Earth can support a variety of living organisms. Temperatures throughout Earth are in the range that allows water to exist in all its forms—as a gas, as a liquid and as a solid. As we will see, this is most important for the functions of all sorts of environmental systems on Earth.

1.3.2 The Biosphere

The part of the earth where we reside is called the biosphere. This is the part of the earth and atmosphere in which life is possible. The biosphere has three main subdivisions which are called lithosphere (solid matter), hydrosphere (liquid matter), and atmosphere or the gaseous envelope of the earth which extends up to a height of 20 km. All known life is confined to the biosphere. Living organisms mainly exist where solar radiation is received during the day i.e. the atmosphere, the land surface, and the upper layers of water of oceans, lakes and rivers. However, there is life in parts of the ocean where light cannot penetrate, and this is because, gravity enables energy flow to continue downward, and make life possible.

Atmosphere

All life is supported by an extremely thin layer of atmospheric oxygen about 20 kms above Earth's surface. This is our atmosphere. The Earth is unique among the planets as it possesses this capacity to support life. You will notice that as you go higher, it becomes more difficult to breathe and also you tend to feel cooler. Outside of this atmospheric limit it is impossible for us to survive for even a few minutes.

The atmosphere consists of the right proportion of oxygen and the other gases like carbon dioxide and nitrogen. Oxygen is required for human survival and, therefore, a good number of forest trees and green plants are required to supply the atmosphere with plenty of oxygen. The trees and plants utilize carbon dioxide for the production of food. This food is also consumed by other organisms in order to survive. You will now realise why with chopping down trees and growth of population the atmosphere has been affected making living conditions difficult. Health and wholeness depends on the right atmosphere with adequate amounts of oxygen. It is no exception that health problems have increased and you will notice that most diseases are found in slums and settlements which are congested and lack of proper supplies of healthy environments.

Hydrosphere

Water is and has always been considered an essential part of human life. It is the most important component of the Earth. Early settlements always took into account a good source of water supply. The hydrosphere is that part of the Earth where water is available. It comprises 71-72 per cent of the Earth's surface but, of that total amount, as much as 97 per cent is sea water and is unfit for human consumption. Out of the remaining 2 per cent is frozen in the polar caps and mountain glaciers, leaving hence only 1 per cent easily available water. Water is a most precious commodity.

Surface water today is badly contaminated by numerous pollutants peculiar to modern life. Water that flows from agricultural fields into rivers and lakes contain chemicals from fertilizers and pesticides. Sometimes sewage from the city runs into fresh water supplies, dangerous effluents from industries have polluted large water bodies. Increasing pollution of the hydrosphere has increased health hazards. Even rain water that returns to the Earth comes with various pollutants that cause damage to crops as well as human beings.

Lithosphere

The lithophere is literally the rock covering on the Earth's crust, but refers to the whole of the soil surface. Continuous physical, chemical and biological processes convert and conserve the soil over the Earth's surface. Fertile soil is essential for growing food for human beings. The bulk of the rich soil with organic matter that enables growth is just a few inches on the top. This is called the topsoil. Again, pollutants have penetrated the lithosphere making the food i.e. grown harmful to humans.

Check Your Progress 2

1) Write a brief definition of the terms Biosphere, Atmosphere, Lithosphere and Hydrosphere.

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2) Why is life possible only on the planet Earth?

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1.4 ECOSYSTEM

By this time, you have begun to get an overall picture of the Earth and its surroundings. You have been introduced to some terms such as environment, biosphere etc. The terms environment and ecology are sometimes used synonymously. You will be interested to know that the term ecology started with the study of these integrated interrelationships within the biological world. The prefix *eco* is taken from the Greek word "*oikos*'' which means the home. Ecology started as the study of the relationships within the home of the vegetable and animal world, but soon became the study of the widest concerns that involve human beings and everything around them. Ecology is the study of all the intricate relationships within our vast and varied environment. As in an ideal home, harmony is expected in these relationships. Decades of abusive overexploitation of the resources of the environment have disrupted the fragile ecological balance. It needs to be restored.

You have become fairly familiar with the concept and the components of the environment which we have been talking about as one big whole. This whole can be broken up into smaller integral units called ecosystems. An ecosystem is an apparently independent unit within which plants, animals and the surrounding environment interact together.

We can define an ecosystem as a self-sustaining system formed by the interaction of individual organisms with each other as well as with the physical components of the environment. Ecosystems are self-contained and self-regulating because of the cycling of matter within the system. An ecosystem can be a tropical forest, a lake, a desert, a grassland, a field, a fallen log. As shown in Fig. 1.2, life on this speedily moving Earth depends on two things: i) recycling of matter, and ii) energy flow from the Sun through the materials and living things. We will discuss about these aspects later in this unit.

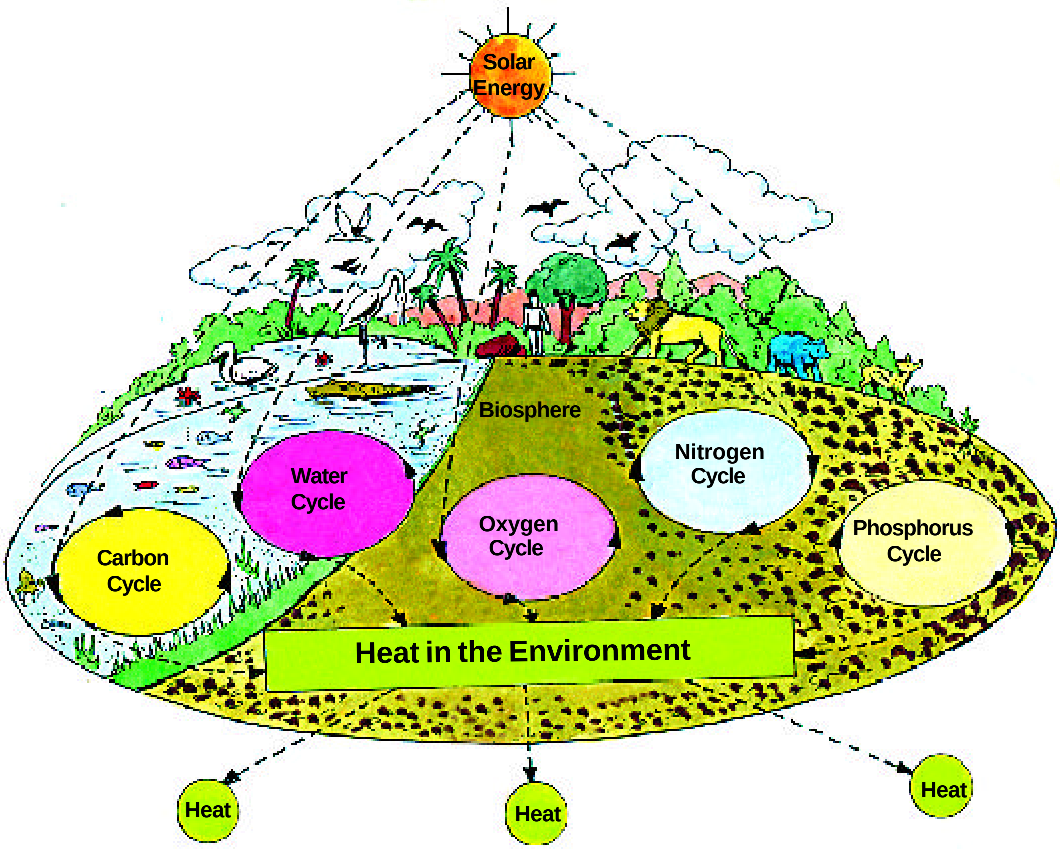

Fig. 1.2: Cycling of materials and one way flow of energy from the Sun makes life possible on the Earth

While the whole of our living world could be looked at as one ecosystem we prefer to break this up into smaller units. A community of humans, animals, trees, plants and micro-organisms exists within this unit and is interlinked with that particular surrounding. Most ecosystems have their own distinctive features and adapt within their environment. The differences among ecosystems are due to variations in temperature, precipitation and nutrients. Ecosystems are classified into general types that have similar plants and animals. Terrestrial ecosystems (Fig. 1.3) or biomes are the land ecosystems such as forests, grasslands, desert etc. Other major ecosystems are aquatic ecosystems (Fig. 1.4). The examples are ponds, lakes, rivers, oceans etc.

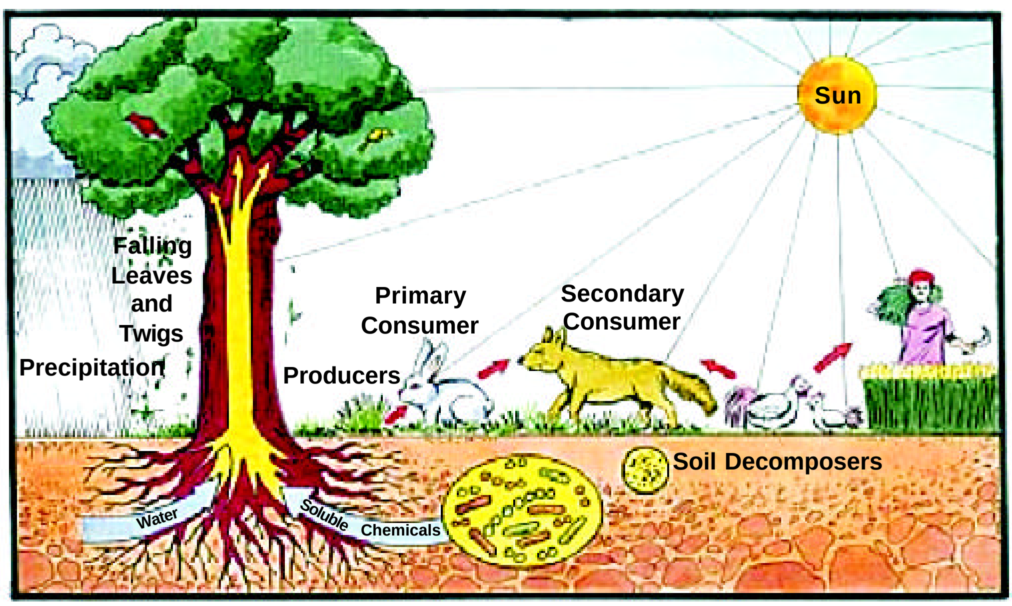

Fig. 1.3: Terrestrial Ecosystem—a field (major components of the ecosystem are indicated here)

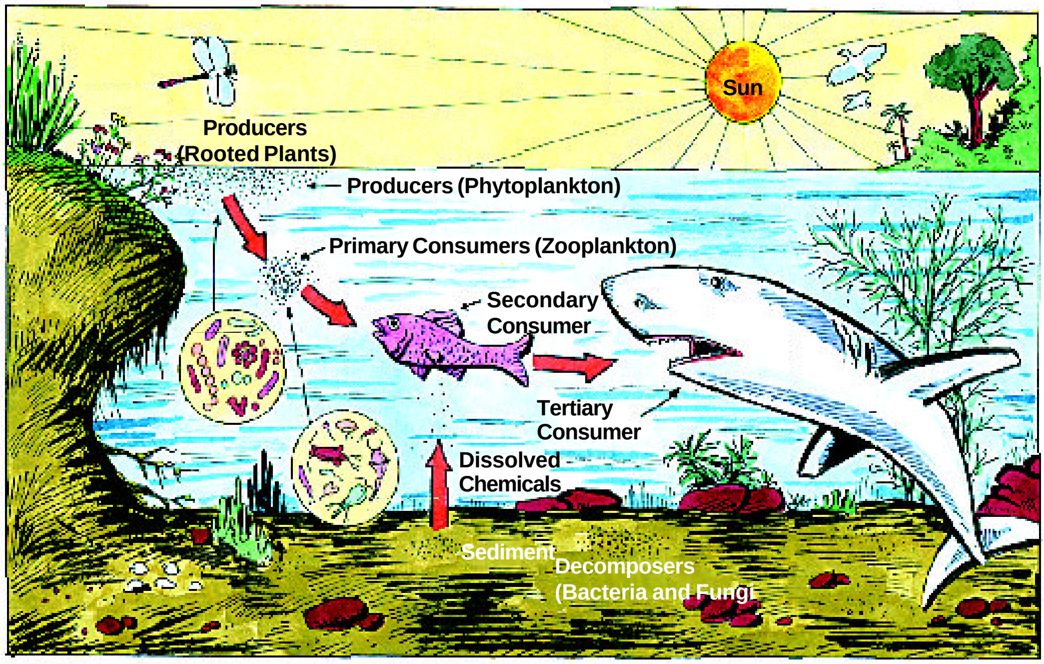

Fig. 1.4: Aquatic Ecosystem–a freshwater pond showing the major components

1.4.1 Components of the Ecosystem

The environment includes living and non-living components. Living things are referred to as biotic and non-living things as abiotic components. Biotic components are living microbes, plants, animals and human beings, while abiotic components are energy and resources such as nutrients, water, soil, air, temperature, etc., that sustain the life. The biotic component lives within and depends on the abiotic component.

Each ecosystem has its own set of resources. It is an area of a variable size, comprising flora, fauna, microbes, air, water, soil, etc. The interrelationship between these components is well ordered and that is why uncontrolled human interference can result the disruption of the ecological balance with potential disastrous consequences to the ecosystem. However, since each ecosystem also exists in interdependence with others, disruptive effects can be felt even in other, sometimes distant ecosystems.

Energy and resources in each system are not in endless supply and care must be taken not to exhaust them. Each ecosystem is an energy-processing unit with solar energy driving it to fulfil its potential. The over utilisation of energy and resources has caused ecosystems to become effected by a variety of pollutants. Increased utilisation through growing demands leads to acceleration of disturbance in the ecological balances and accumulation of pollutants. Ecologists strongly feel that our future concern should be with arresting energy dissipation by the industrial society which eventually causes irreversible damage to the ecosystem. Conservation efforts should help to check the depletion of resources and thereby work towards the sustaining of natural ecosystems.

1.4.2 Production and Consumption

There are producers and consumers in each ecosystem. Plants make their own food, so these are producers i.e. autotrophs. Animals cannot produce their own food and hence need to consume other organisms for their survival. Therefore, these animals are consumers. Consumers are also referred to as heterotrophs because they require other sources of food.

Consumers or heterotrophs are of two types—herbivorous i.e. animals that eat plants, and carnivorous i.e. animals that consume the flesh of other animals. There are also scavengers and decomposers in an ecosystem. Scavengers feed on dead animals and plants that are also called detritus. A vulture scavenges on dead carcasses while termites feed on live as well as dead and decayed wood. Decomposers also feed on dead animals and plants. However, during their feeding activity the complex molecules of the dead material are broken into simpler molecules/chemicals that return to the soil and water for reuse by consumer. This process of decay of dead material is called decomposition. Scavenging and decomposition are necessary for cleaning process and recycling in the ecosystem (see Fig. 1.5).

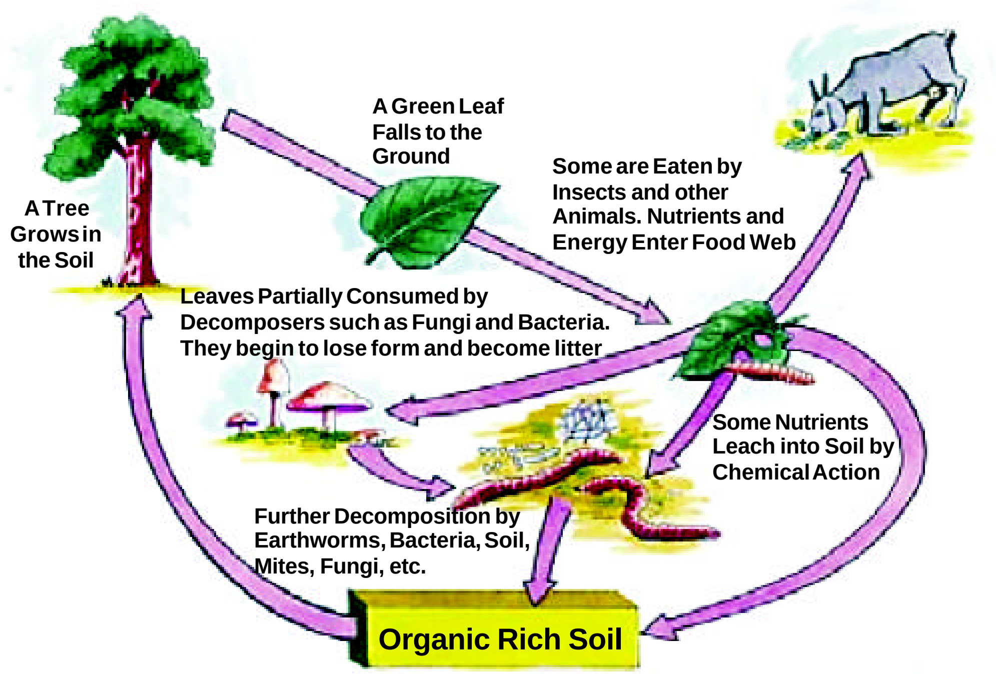

Fig. 1.5: Cycling of nutrients by the decomposers in the ecosystem

It should become clear that a well balanced ecosystem is one in which there is the right proportion of producers, consumers and decomposers. Populations need to be able to keep in balance with resources available (carrying capacity) to ensure that the levels of consumption do not jeopardize healthy living. When there are decreasing level of producers and production, animals and humans are forced to consume lower levels than required, or even consume unhealthy food which leads to disease and death.

Check Your Progress 3

1) Briefly describe an ecosystem.

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2) Show how the interrelated components of an ecosystem interact together using specific examples from your own environment.

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1.5 FOOD AND ENERGY FLOW

The functioning of an ecosystem involves various cycles. There is a constant giving and receiving of nutrients to and from various components of the environment. Thus, each ecosystem is an energy processing unit which is limited to the amount of nutrients and resources actually available. The food and energy flow in an ecosystem is an integral part of its whole functioning. Life is sustained through this food energy flow which functions in a very systematic and efficient manner. Food chains function in various feeding levels, technically known as trophic levels e.g. autotrophic or heterotrophic as we will see below.

1.5.1 Trophic Level

The trophic level (*trophe* Greek word for nourishment) is the broad class that organisms belong to in terms of their source of food supply. The first level is green plants, manufacturing their nourishment from carbon dioxide and water utilising solar energy and are called autotrophs.

The second are herbivores feeding on the autotrophs, and the third are carnivores which consume herbivores and so on. The organisms that feed on other organisms are called heterotrophs.

Basically the trophic level in which an organism is placed, shows how distant the organism is from the plant material in its feeding. In Fig. 1.6 you can see the food energy flow through the trophic levels. The trophic level is the broad class that the organisms belonging to in terms of their source of food supply. The first level is green plants, manufacturing their nourishment from the solar energy, and is called an autotroph. The second are herbivores, feeding on the autotrophs, and the third are carnivores which consume herbivores. Animals are really omnivores belonging to various trophic levels. Omnivores are the animals that can belong to many trophic levels. For example bear is an omnivore as it feeds on organisms from various trophic levels in the food chain.

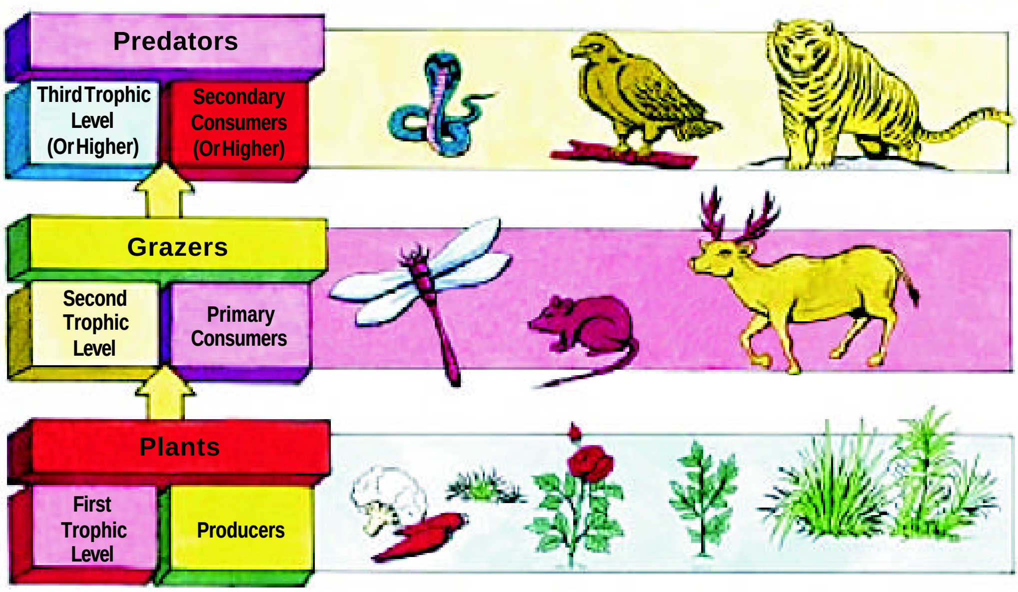

Fig. 1.6: A diagrammatic representation showing an example of trophic level

1.5.2 Energy Flow

The green plants through the intricate process of photosynthesis, convert radiant energy of the sun into chemical energy. The portion of the radiant energy absorbed by the green plants and stored in the form of chemical energy is food energy. When the primary consumers feed on plants, the energy is transferred from the autotrophs to these herbivores. The herbivore in turn may be eaten by a carnivore, thus, transferring the energy further in the food chain. However, not all the solar energy received in the ecosystem reaches at the end of the food chain. Less than 1 per cent of total available energy is captured by plants and ecosystems.

About 10 per cent of energy available in one trophic level is transferred to the next trophic level. If the secondary level receives 10 per cent of the energy of the procedures, the tertiary level captures 10 per cent of this energy. Because of this 10 per cent law, as it is called sometimes, you find less number of carnivores as compared to herbivores. Of course it is much easier to find plants in the ecosystem. The energy loss at each trophic level is due to various factors such as:

i) Organisms use energy in respiration and other metabolic activities.

ii) Some organisms are not consumed by the next trophic level and therefore, get decayed and decomposed.

iii) Some of the food energy eaten by organisms is not assimilated and passed out of the body.

You can see in Fig. 1.7 the biological pyramid of an ecosystem depicting the number of organisms and energy available at each trophic level.

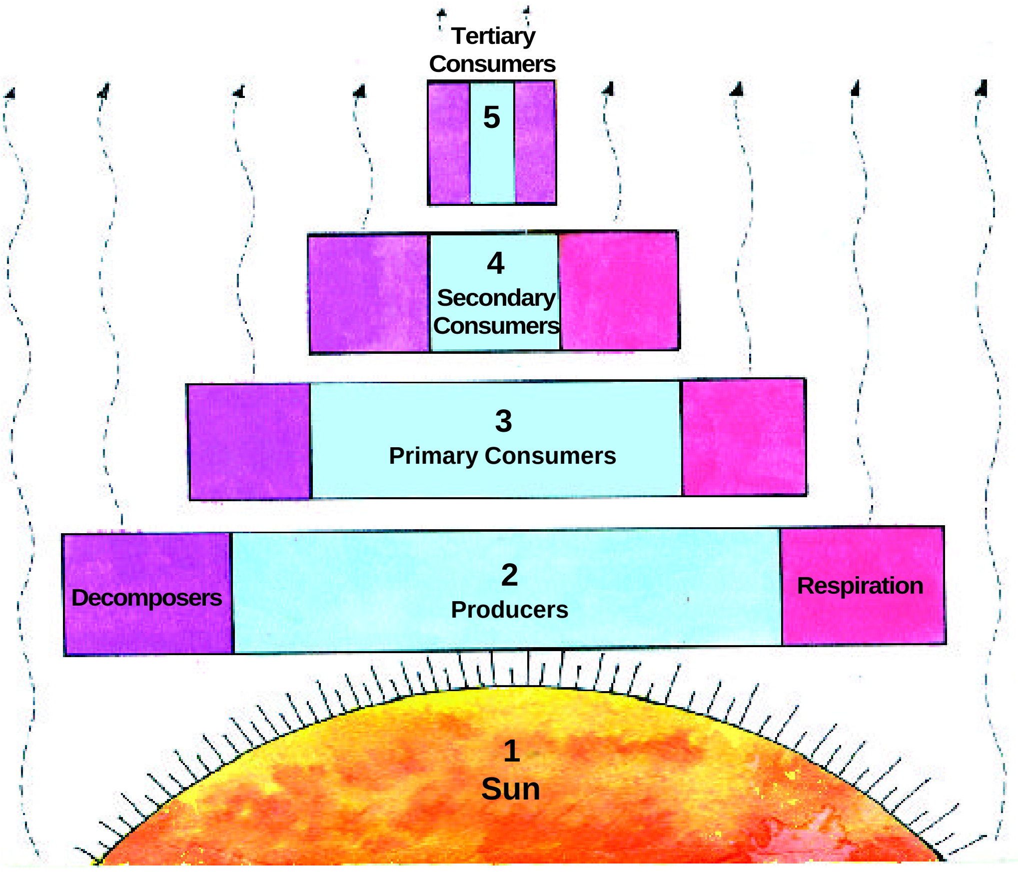

Fig. 1.7: Biological pyramid in an ecosystem

Note the following points in this diagram:

i) Some part of solar energy dissipates as it passes through the ecosystem.

ii) A small portion of solar energy is captured by the plants (producers).

iii) At each trophic level a part of energy is captured from previous trophic level. This is because at each level some energy is used for metabolic purposes and also some goes to decomposers. Because of this type of inefficient energy transfer not much energy is left after 4 or 5 levels.

iv) The number of organisms is also reduced as we go up the trophic levels.

1.5.3 Food Chain

The transfer of "food energy" through a chain of organisms from one trophic level to another is called the "food chain" (Fig. 1.8).

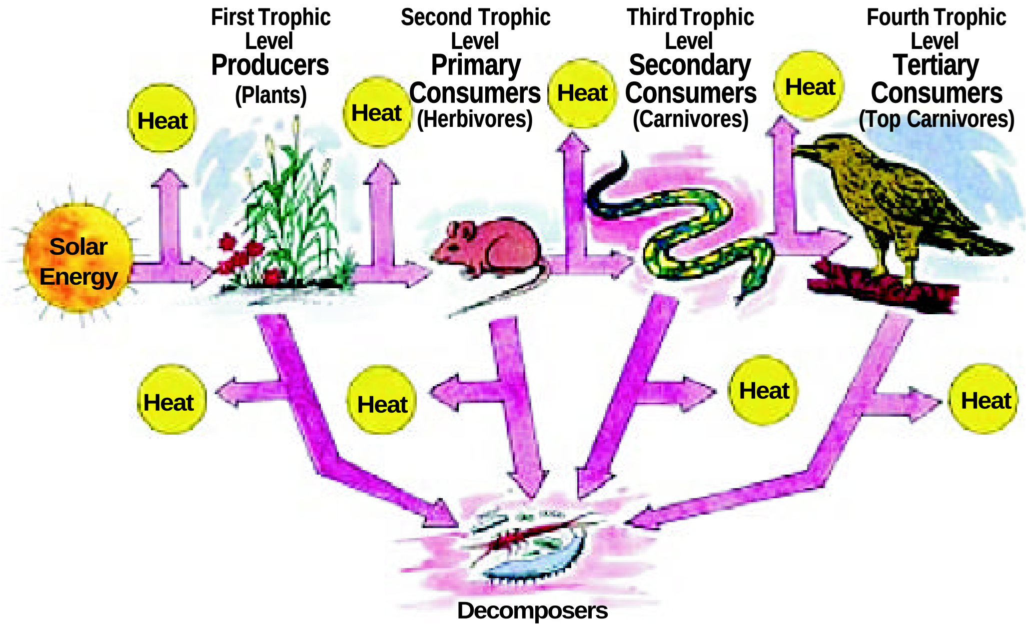

Fig. 1.8: Example of a food chain

Note : Arrows indicate the paths of energy utilised through the trophic levels and dissipated as heat.

Nature has an inbuilt system to handle what we may consider as intruders. We see this as we look at some of the food chains for instance, Predator-Prey Food Chain. Let us take the example of a butterfly sucking the nectar from flowers. The chemical energy stored in these plants is transferred to the butterfly. The butterfly may one day be eaten by a larger fly or insect. Naturally the food energy is again transferred. This fly or insect is swallowed by a frog, which may be swallowed by a snake or another frog eating animal. Here food energy flows from the dragonfly to the frog and from the frog to the snake. This will continue till an eagle or a hawk devours the snake and energy had flowed in a very natural upward progression. We note that even insects have a role to play in controlling nature.

In some cases the food chain ends with a predator like a tiger or a lion, or human beings who have varying food habits ranging from vegetarian i.e. herbivorous, or non-vegetarian or carnivorous.

Also, in the Detritus Food Chain, the food chain that starts from dead or decomposed organic matter is called detritus. Here organic matters are decomposed by micro-organisms like bacteria and fungi. There are certain animals (consumers) which feed on this detritus and, therefore, form part of what is called the "detritus food chain". Here we see how nature has an inbuilt system to clean up the environment from dead and decayed matter. Another example is the vulture who feeds on dead animals to clean up our environment. The Parasitic Food Chain is another kind of food chain in which parasites live on or inside the body of a host like a plant or tree and feed from this host. The parasite gets nourished but the host is harmed. The parasitic food chain is common in human beings where people are infested with worms. Here, worms are draining the nourishment of the human body, ultimately leading to deficiencies and diseases.

1.5.4 Food Web

We have just seen that a food chain is the chain or link between organisms, animals or human beings within which they depend on one other for their food energy. This is not a rigid link, as some species depend on more than one species for survival. That is why ecologists will talk of food webs as being a more appropriate term to use. We will however find the terms food chain and food web being used synonymously.

A food web (Fig. 1.9) describes a larger network something like a spider's web. Many animals, in nature, utilise more than one species for their food. Herbivores feed on different kinds of plants. Carnivores feed on different kinds of insects and animals. Thus, the food chains in nature are interconnected in different ways, invariably with a number of intermediate links, and sometimes with side chains also.

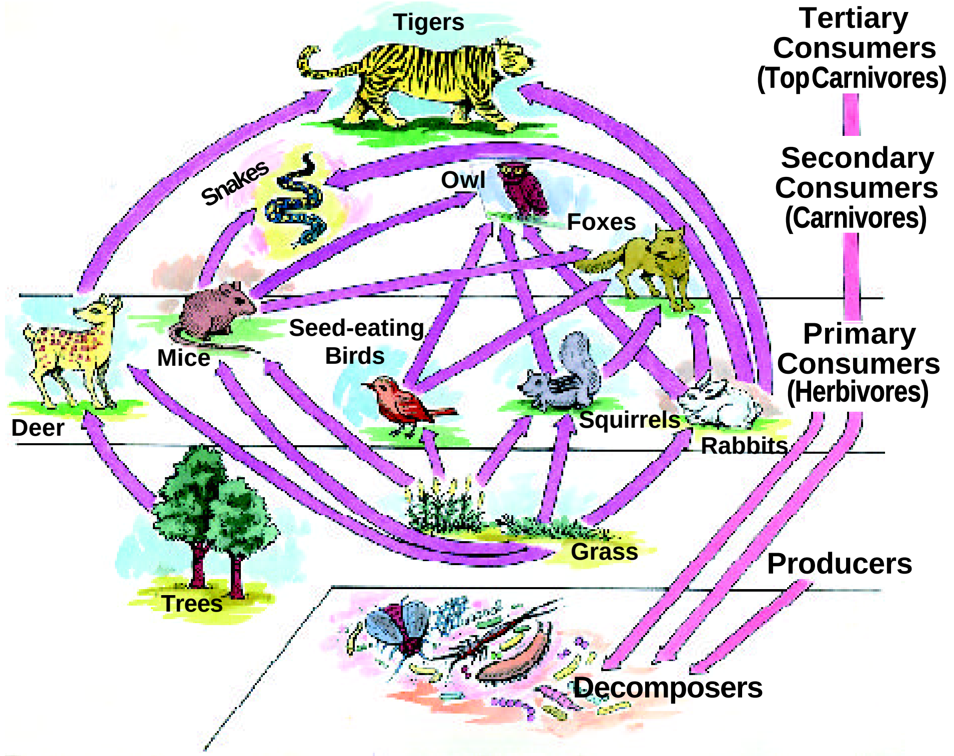

Fig. 1.9: Example of a food web in a terrestrial ecosystem

Take an example where at least four food chains are interconnected. The rodents feed on the product of green plants. These rodents are eaten by snakes which in-turn are eaten by the hawk. The ungulates, or hoofed mammals, feed on the green plants. These ungulates are hunted and eaten by lions and tigers. The green plants are also eaten by rabbits which in turn are eaten either by hawks or by lions and tigers. Many insects feed on the green plants and their products. These insects are eaten by lizards which in turn are eaten by the hawks. The insects are also swallowed by the frogs which in turn can be captured and eaten by the hawks. Here the hawks, lions and tigers occupy the top of the food web.

These interconnected feeding networks make up the food web which allows for the transfer of energy from one form to the other. Humans find themselves at the top of the web too. They eat sheep or fish which have been linked in a food chain starting from the lowest form of organisms. Undoubtedly, a web is a more appropriate way to describe the networking rather than a rigid chain as we see something more than a one way process. Life is far more intricate and we are discovering this all the time.

1.5.5 Bio-magnification

Biomagnification is the gradual build up of the concentration of chemicals as they transfer through higher levels of the food chain. It is also called bio-accumulation. For instance, a lake may have a very small concentration of a harmful chemical — such as mercury — dissolved in its water. The zooplankton keeps on absorbing this chemical from the water, and so increases its concentration. Larvae may eat many zooplankton and fishes may eat many of these larvae, which could then be eaten by larger fish. As each step is climbed at the trophic level of the food chain it gradually receives higher concentration of the chemical as compared to the previous level. The concentration will be highest in the organisms occupying the highest level of the food chain. The effects of DDT as it bioaccumulates have seen to be devastating.

This phenomenon of biological amplification may affect the survival of individual organism as well as the populations. In Fig. 1.10 you can see how the concentration of DDT, a chemical pesticide has amplified in a five step food chain of an aquatic ecosystem. The accumulation of a potentially harmful chemical is more pronounced in the aquatic ecosystem as they generally have four to six trophic levels. Most terrestrial food chains and webs generally have two to three levels. The high concentration of DDT in the species at higher trophic level (such as bird shown in Fig. 1.10) can reduce their population either by directly killing by reducing the reproductive ability or by weakening the organisms so that they are more susceptible to diseases. DDT is one of the now well known persistent organic pollutants that have biomagnifying characteristics.

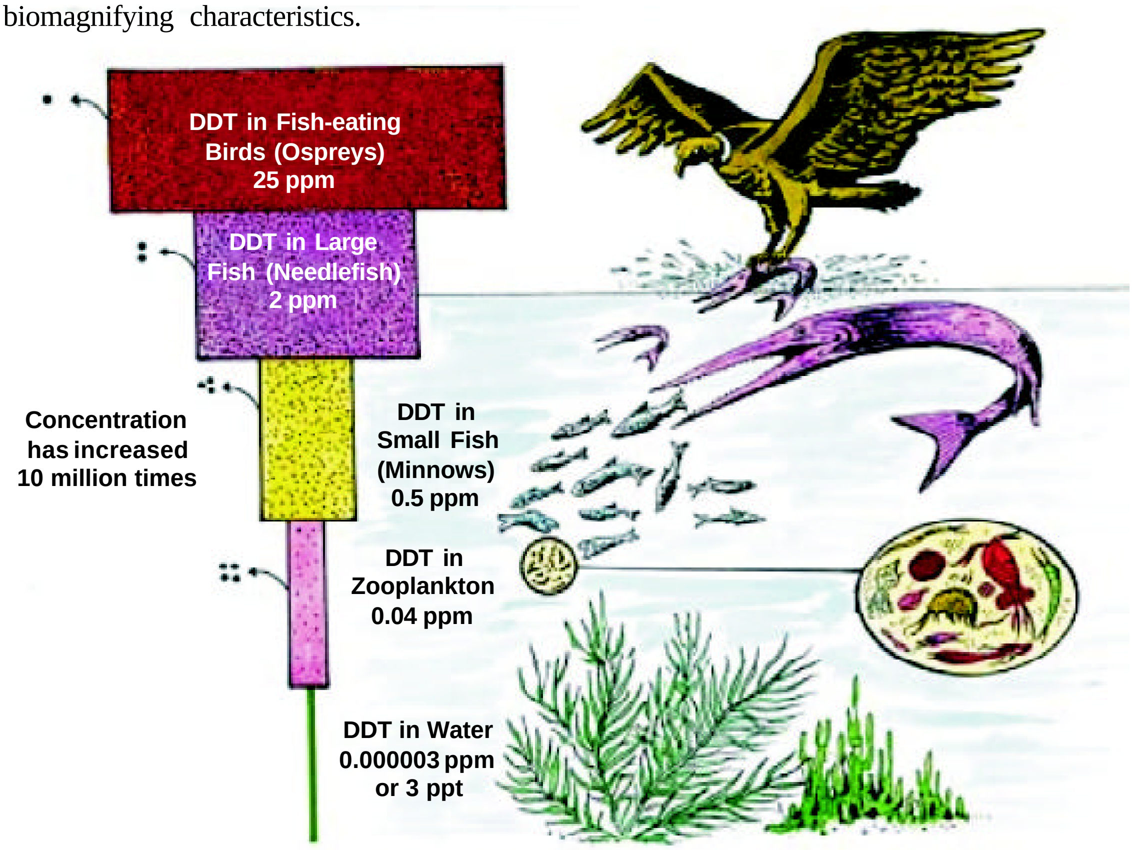

Fig. 1.10: Biological amplification of DDT in the food chain of a water body

Note: Concentration is increased at higher trophic levels because of the increased number of organisms consumed.

Chemicals that are fat-soluble and tend to deposit in the cells of the body are the ones that are bio-magnified. On the other hand, water soluble chemicals are removed out of the system by natural excretion processes.

Check Your Progress 4

1) Outline the food chains that you are familiar with in your locality.

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2) Explain the concept of bio-magnification.

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1.6 MATTER CYCLES

Of all the naturally occurring elements on the earth only 20-30 are part of the living systems. Some of these elements are required in large amounts to sustain life and are called macronutrient (e.g. Carbon, Oxygen, Hydrogen, Nitrogen and Phosphorous). The others are needed in trace amounts and are called micronutrients. The utility of these chemicals for living forms varies with the physical and chemical form and location of the chemicals. For example plants take most carbon as carbon dioxide gas from the atmosphere or water and most of the nitrogen or phosphorous as nitrate and phosphate ions from soil and water. The chemicals essential for life are continuously cycled through air, water, soil and plants and animals by being converted to various forms. These cycles are known as biogeochemical cycles (bio-living forms; geo-water, rocks, soil; chemical-change in the form of chemicals). The biogeochemical cycles are dynamic in nature as atoms are recombined and re-assigned and the starting materials are regenerated. These cycles are progressed by using directly or indirectly the solar energy. The important fact about these cycles is that their steps or stages can be slowed, blocked or accelerated, mainly because of human interference with the natural processes. Given below are the diagrammatic representations of some of these cycles—hydrologic cycle (Fig. 1.11), carbon cycle (Fig. 1.12), nitrogen cycle (Fig. 1.13) and phosphorous cycle (Fig. 1.14).

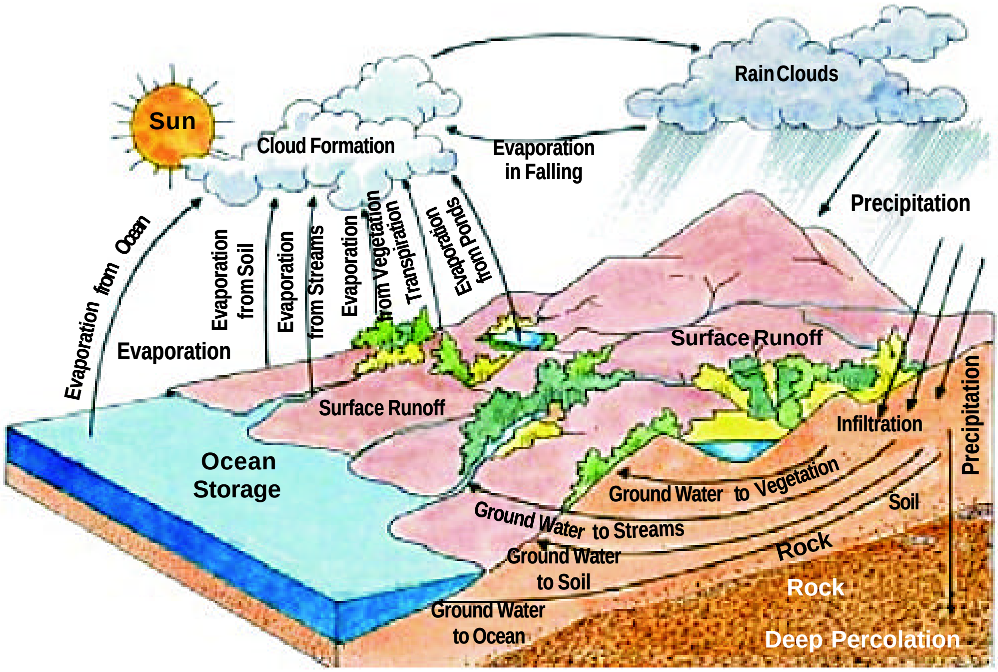

Fig. 1.11: Water cycle

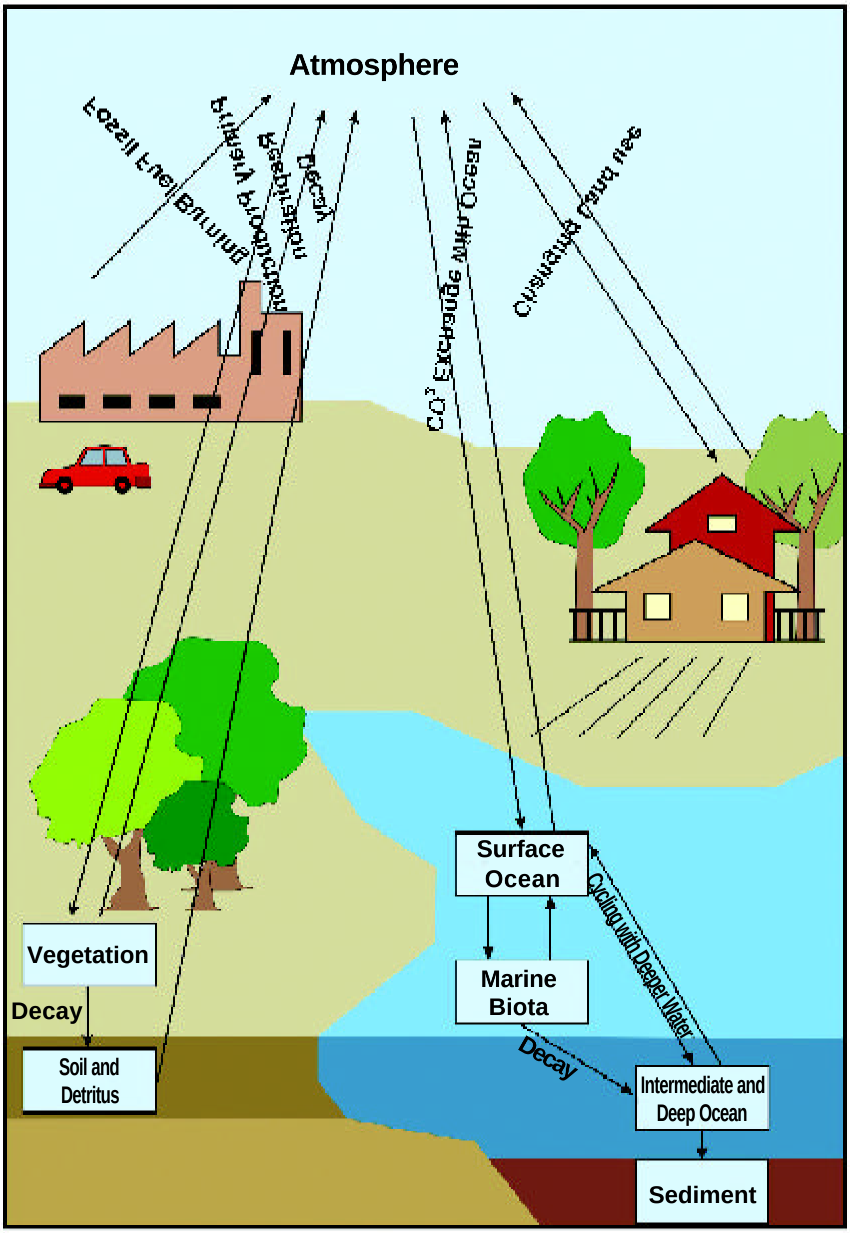

Fig. 1.12: Carbon cycle

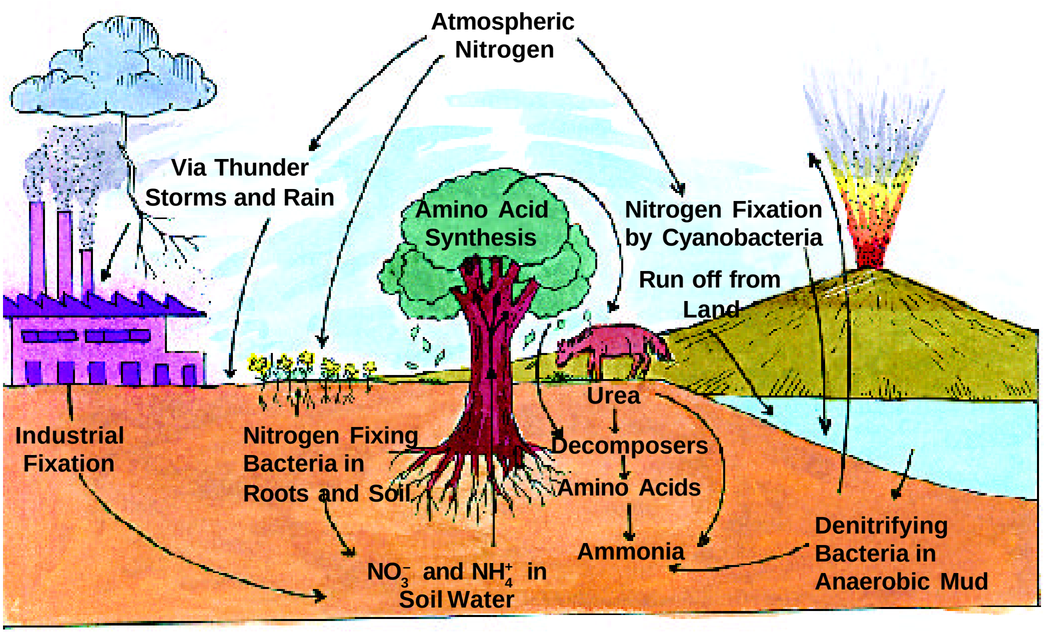

Fig. 1.13 : Nitrogen cycle

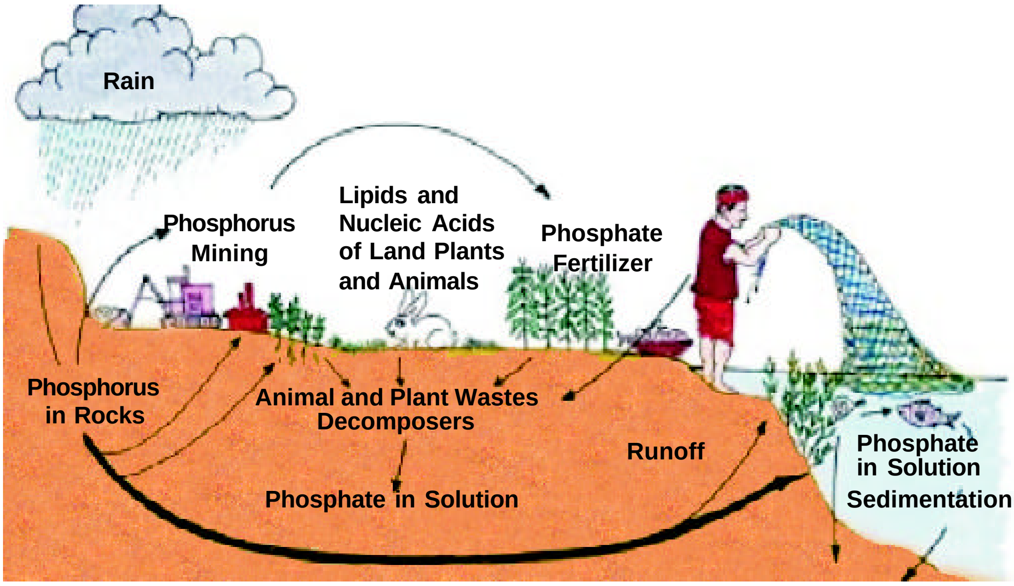

Fig. 1.14: Phosphorous cycle

1.7 POPULATION AND COMMUNITY

We have become used to speaking of population and community specifically in relation to human beings. With the environmental debate thrown open to the whole world and its environment, we begin to see their use for other species as well. Hence a community is the assemblage of plants and animals found in a river, in the garden, or in any other place. In the biological sense communities consist of a variety of species, many of them never seen by the average person because of their habits and small size. But what is a species. For most purposes a species of plant or animal can be said to consist of similar individuals which potentially are able to breed among themselves. The combination of a community of species and its environment is the ecosystem.

A population is a group of the individual organisms of the same species found in a given space. There are some basic features of population, just as with humans, for instance density. The density of a population is influenced by births, deaths and migrations. The main objective of population studies in ecology is to see how all these factors influence the size of the population.

We can define community as the population of all the species such as plants, animals, humans etc. living and interacting in a given place at a given time. One main feature of communities is the interactions between individuals of the same and of different species and hence concerns the question of what eats what and who breeds with whom. Almost every species of plant is eaten by several other species of animals, and some trees support hundreds of different species, most of them insects. That is why there is so much of concern over tropical forests being chopped down as they may contain species that could be of immense use to humankind in the future. Green plants are of central importance in all communities for they are the producers of food upon which all other organisms depend. Plants are also the most obvious organisms in a community, followed by the animals feeding directly on them, and then there is a huge variety of predators and parasites feeding on the plants and on each other.

Interrelationships between Species in Communities

Each species plays its part in maintaining the essential structure of the community and each individual needs a space and resources in which to live and reproduce. An individual animal requires food, shelter, and a place to hide from enemies; a plant requires light, water and nutrients. The particular way in which an individual interacts with its environment in order to satisfy its needs and to fulfil its role in the community, is often called its niche. The term niche implies not only a place to live but the manner in which an individual operates and survives successfully in familiar surroundings.

You may speak of your niche as your role in life. When we do this we are not thinking especially of an ecological role but rather how we fit into a job, a profession and neighbourhood. We say someone is “at home” in a particular environment. In a similar way ecology will refer to insects and other species having their niche in a particular community.

Check Your Progress 5

1) What species are native to your area?

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2) List some changes in your environment in relation to these species that have occurred over the years.

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1.8 ENERGY

Energy, a word derived from the Greek *energon* meaning work is available and utilised by everyone in the world. With added pressures on our energy resources it is predicted that by the middle of the next century we may require as much as four times more energy than what we use now. Urgent attention must be given to the use and conservation of energy, as well as commitment towards a search for alternate energy sources.

Each ecosystem is driven by energy. We use energy in every part of our daily life—in our homes, at work, in the fields, in major industries. Science and technology have helped to convert energy from the naturally available forms into forms that can perform various tasks. Heat energy is converted into electrical energy and used to operate many modern appliances and machines. Electrical energy is converted into heat for domestic purposes such as cooking and heating. Energy is a very vital part of the whole ecosystem. Energy is interconnected and is transferred from one form to the other. We consume food to enable us to use our muscle energy for physical work. Physical work is employed to produce other forms of energy for human use. There is energy all around us with the Sun being the primary source of all energy. Solar energy converts carbon dioxide and water into organic compounds which store the trapped solar energy in the form of chemical energy. This kind of chemical energy is transformed into coal, oil and natural gas which is again converted into heat energy to be used for a variety of purposes. The vast expansion of industry and agriculture sectors depends largely on available energy sources. About 88 per cent of world’s present energy production comes from coal, oil and natural gas. Apart from depletion of these resources, there is the added problem of pollution which is inevitable. Other sources of energy are hydro-energy and nuclear energy which contribute to the balance of commercial energy. Poorer countries even depend on wood and cattle dung for cooking and other domestic needs.

In this section let’s get to know something about solar energy. We will study about natural resources in the next unit.

1.8.1 The Sun and its Energy

The sun is our primary source and a glowing symbol of energy. You have felt heat from the sun. You have seen its light. People in countries where there is little sun will "sunbathe" for many hours. In a country like India, where there is plenty of sun, some worship the sun, others believe in the healing properties of the sun's radiation. The sun which provides virtually all the energy that makes the atmosphere and ocean function, is like a huge nuclear furnace with internal temperatures of several million degrees and a surface temperature of around 6000°C.

Sun Facts

- One square metre (10.8 sq ft) of sun surface shines as brightly as 600,000 (100-watt) light bulbs.
- The biggest observed solar prominence reached a height of 700,000 km (435,000 miles) in one hour in 1946.
- In one second, sun gives out 35 million times the average annual electricity supply for the entire United States.
- Solar flares can interrupt radio communications on Earth, cause magnetic storms, and confuse birds flying long distances.
- The rotation of the sun's surface varies from 25 days at equator to 35 days at poles. Its radiative zone rotates regularly every 27 days.
- If the sun's cooler outer layers were peeled off, dangerous radiation from its core would destroy life on Earth.

The Dorling Kindersley Illustrated Factopedia

Energy flow from the sun has a sequence of interactions with Earth's atmosphere and oceans that can be understood best by following the route of solar radiation as it arrives at our planet. Starting from its source it passes through the atmosphere, encounters land or ocean and passes back through the atmosphere and out to space. This is called INSOLATION—a term coined from the first parts of three other terms — Incoming Solar Radiation.

1.8.2 Insolation Reaches Earth

The energy transferred from the sun across 150 million km (94 million miles) of space reaches our Earth without any alteration. However, the insolation undergoes major modifications during its short passage through the Earth's atmosphere. The gases, dust, and clouds in the atmosphere absorb, scatter and reflect so much that just under half reaches Earth's surface. You will realise that this is a blessing as some of the sun's rays, for instance x-rays, although useful in certain cases, could be very harmful to human beings.

Many of the shorter wavelengths in the sun's radiation which contain x-rays and gamma rays are absorbed by the outermost layer of the atmosphere, heating them to temperatures of 1200°C (2200°F). Lowerdown, the ozone in the upper stratosphere absorbs ultraviolet rays, with the molecules heating to 20°C (70°F), x-rays, gamma rays, and ultraviolet rays are harmful to living tissue and these two layers in the upper atmosphere thus, provide a shield for living organisms at Earth's surface. There are also infrared rays, at the other end of the spectrum, which are absorbed in the lower atmosphere by such gases as carbon dioxide and water vapour.

The Earth absorbs or reflects the insolation that reaches it in varying proportions depending on the surface materials. That is why you feel hot or cold depending on where you are. Insolation i.e. absorbed is transformed into heat energy, raising the temperature of the surface. About 80 per cent of insolation reaching the surface of the earth hits the oceans. Although they cover just 71 per cent of Earth's surface, oceans dominate the tropics and so receive a higher proportion of the insolation. Oceans take longer to heat up and are slower to cool than land. The absorption of such a large proportion of insolation makes the oceans a huge heat store and makes the tropics as hot as they are.

1.8.3 Radiation from the Ground

The Earth's average surface temperature is 12°C (54°F) as the result of absorbing insolation (less than 1 per cent of the heating is due to heat from Earth's interior). That surface temperature causes Earth to radiate energy at a much lower intensity than the sun. Terrestrial radiation is composed of long-wave, low frequency infrared (heat) waves. A small proportion of terrestrial radiation goes directly out to space through small "windows" in the atmosphere. Around 95 per cent is absorbed by gases and dust particles in the lower atmosphere.

Nature has its own remedial measures. Gases such as carbon dioxide and water vapour are particularly effective at absorbing infrared rays. The absorbing gases and dust are heated and emit their own longwave rays in all directions—some upwards to space and some downwards back to Earth (counter-radiation). The counter-radiation reinforces the heating of the ground and lowest layers of the atmosphere.

In addition to radiation, the atmosphere is also heated by conduction from surface rocks, soil and water into the lowest inch or so of the atmosphere, and by convection that causes warm surface air to rise. The lower atmosphere is heated more by this combination of terrestrial radiation, conduction and convection than by direct insolation. Heating of the lower atmosphere begins from the ground and progresses upwards. The processes combine with the denser atmosphere at sea level—which has more absorbing gases—to make temperatures higher at sea level than at altitudes of several thousand feet.

The presence or absence of clouds affects the transfers of energy in the lower atmosphere. Clouds absorb, reflect and scatter energy from above and below. The cloud-tops reflect and radiate energy out into space above. Cloud bases absorb terrestrial radiation from below. The overall effect is to slow the return of heat energy to space from the ground and to keep more heat in the lower atmosphere. That is why cloudy nights are warmer than clear nights.

Climate: Facts and Figures

- In India, during the summer monsoon up to 75 per cent of annual rainfall may fall in just three months.
- In the tropics, the difference between the highest annual noon temperature and the lowest, may be only 2°C (3.6°F).
- At the Equator, the temperature is about 25-30°C (77-86°F) everyday.
- The average temperature close to the South Pole is –50°C (–122°F). This is much colder than a deep freeze, which is about 18°C (0°F).
- Tundra regions are sometimes described as cold deserts, because their climate is so dry.
- Driest place is the Atacama Desert, Chile, with an average of only 0.51 mm (0.02 inch) of rain per year.
- Sunniest place is Eastern Sahara, which has sunshine for more than 90 per cent of daylight hours.
- Hottest place is Daliol, Ethiopia, where the average temperature over a six-year period was 34.4°C (94°F).
- Coldest place is Polus Nedostupnost, Antarctica, which has an annual average temperature of – 57.5°C (– 72°F).

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1.8.4 Greenhouse Effect and Global Warming

The heat transfer processes maintain a complex heat balance in the lower atmosphere and this helps to maintain temperatures without wild fluctuations. The heat balance in the atmosphere has been likened to that in a greenhouse. In a greenhouse the glass lets in light rays but prevents most of the heat rays from escaping. Once inside the greenhouse, the visible light is either reflected out or absorbed by plants, soil and air. The heat i.e. radiated from internal surfaces is mainly absorbed by the glass and other greenhouse components. It is trapped inside, raising the temperatures. The balance is maintained by opening windows to enable heat to escape in summer, or by heating in winter. The glass of the greenhouse acts as a barrier to both the upward converted transfer of warm air and the influences of winds that bring colder or warmer air from other areas. Carbon dioxide and some other gases act like the glass in the greenhouse. They allow some of the sun's rays to enter the atmosphere and trap some of the heat so it does not escape. With the increase of carbon dioxide emissions into the atmosphere you will not be surprised that there will be a resulting increase in temperatures.

> The richest 20 per cent of the world's population consumes 70 per cent of the world's energy. It is said that an entire forest is required each week, more than half a million trees, in order to supply America's Sunday newspapers. Population growth, mainly in the developing world, is putting great pressure on the world's resources.

However, there may be other reasons. The balance of heating in the atmosphere is not precisely maintained at all times, but that there are varying phases of warming and cooling. Experts have noted that there is a 1°C rise in temperature since around A.D. 1850. The International Panel on Climate Change has declared that reason is to believe that global warming is occurring also as a result of additional carbon dioxide, dust and other polluting materials being added to the atmosphere by human activities (so called "dangerous anthropogenic influence", ***more at:*** http://www.ipcc.ch/) . At the same time, long-term natural fluctuations in the globe's heating balance may also be playing a role. An increased greenhouse effect, however, may lead to overheating, as when the windows and doors of a greenhouse are left closed in summer. You will read more about this later in the course.

Check Your Progress 6

1) What is insolation?

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2) Briefly describe global warming.

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1.9 POLLUTION AND POLLUTANTS

We cannot conclude this unit without a brief reference to pollution. More attention will be given to it later in your study. In recent decades human activities have led to significant increases of wastes and emissions of pollutants and humans have suffered from these consequences in the atmosphere. There is an increasing amount of pollutants mainly through expanding use of resources—fossil fuels, fertilizers, agro-chemicals, and through the disposal of industrial, urban, and agricultural and domestic wastes. Pollutants may produce both beneficial and detrimental types of effects which may cause immediate or delayed long-term damage.

The various kinds of environmental pollution include land, water pollution, air pollution, noise and other related forms. Some waste is extremely hazardous. Environmentalists have started to handle and dispose waste in more scientific ways helping to conserve energy and resources. Almost all of man's activities produce wastes. Many wastes can be recycled or reduced at source but some wastes and their residues are inevitable and have to be disposed in landfill sites. Unattended waste causes severe health problems.

One significant problem yet to be handled efficiently is that of hazardous wastes from industries and health care facilities. Modern development and economic prosperity has unfortunately depended on activities that have produced a wide range of wastes. Waste has become a symbol of our materialistic society. The proper disposal, waste management, needs careful consideration.

A new report shows that some 60 per cent of the benefits that the global ecosystem provides to support life on Earth (such as fresh water, clean air and a relatively stable climate) are being degraded or used unsustainably. In the report, scientists working on the Millennium Ecosystem Assessment (MA) warn that harmful consequences of this degradation to human health are already being felt and could grow significantly worse over the next 50 years. ***More at:*** http://www.millenniumassessment.org

You will find that pollutants in the environment are the major cause of most of our health problems. You will see this graphically depicted in slums. But the same thing is happening a bit more subtly in the outwardly cleaner sections of our urban settings. The damaging effects of industrial pollution on the Taj Mahal and the landmark judgement taken by the high court received worldwide attention. But have you thought carefully of what this means to us? If this has happened to solid marble which is so strong and sturdy, can you realise what is happening to the more delicate organs of our human body in today's polluted world? Health and environment is, therefore, an important link as you will learn throughout this programme. ***More at:*** www.who.int/globalchange/climate/en

1.10 LET US SUM UP

We are now ready to sum up our cursory study of the environment, its various components, its many implications and some complications that may arise if we do not handle our resources wisely. You will be studying some of these facts in more detail later in this block. What you have learnt so far is sufficient to give you a bird's eye view of your environment.

You have understood what is environment and understood the intricate interlinking of its various components. You have seen that the environment is not merely something static; it is definitely a most dynamic interaction. You have also learned about the biosphere as that part of the universe within which life exists. The biosphere is broken up into smaller ecosystems within which plants, animals and the immediate environment interact together.

Energy and resources are a vital part of the universe. Wise management is needed in order to conserve these both for our own use as well as to sustain them for our future generations. You have briefly seen how misuse and overuse of the resources has resulted in an imbalance in the ecosystem, the damaging effects of pollutants all over and hence health and well-being of life is itself threatened.

Natural cycles have their own inbuilt system to handle intricate processes which we humans have tempered with. There is an intricate food energy chain and web that keeps the various components of the environment fulfil their functions. The concept of biomagnification is crucial to understand the build up of pollutants in and around us has also been dealt with.

1.11 KEY WORDS

Biodegradable : Substances that can be readily decomposed by living organisms.

Biosphere : The part of the earth and its atmosphere that supports life.

Climate : The study of interrelationships among living beings and their interactions with their physical environment.

Environment : All the external factors and conditions with which an organism interacts during its lifetime and which affect the organism throughout its life.

Photosynthesis : The process by which green plants use solar energy to convert carbon dioxide and water into sugars in the presence of chlorophyll.

Plankton : Small (microscopic or nearly microscopic) free floating organisms living in the water body like rivers, lakes, oceans.

Species : A group of organisms that interbreed within the group but do not breed with individual outside the group.

1.12 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

The answer to this question will require your own observations to items listed in the text. Be vigilant about the environment around you. Make a separate list of the questions asked in the text. Find the answer of each question on the basis of your observations.

Check Your Progress 2

1) Biosphere is the part of the Earth where we live. This has three main divisions— Atmosphere which has the gases necessary for survival and sustenance of life, Hydrosphere the part of the Earth where there is water, and Lithosphere the rock and soil cover of our planet.

2) The Earth is unique and situated in relation to the sun which gives it a climate, water and other resources that makes life possible.

Check Your Progress 3

1) An ecosystem is a self-contained unit where life system function in continuous interaction with other living and non-living components. Each ecosystem derives its energy from the sun.

2) This answer will require your own observation regarding your dependence on all i.e. around you. Make a broad list of the components of your environment such as number and types of species, their populations, water supply, living conditions, food items etc. After that link such factors with each other.

Check Your Progress 4

1) Make a diagrammatic representation of two or three food chains familiar to your locality. For instance, grain—bird—snake—eagle.

2) This is the gradual build-up of chemicals in the organisms as they go up higher trophic levels.

Check Your Progress 5

I) Make a list of all the animal and plant species that you see in your area. These may include types of trees, plants, herbs, birds, mammals etc.

2) You must have made observations about the birds in your area, like sparrows. Are they still as many as they used to be? What about their eating habits? If you are in a rural, open setting you may have noticed that migratory birds may not be as common as they used to be.

Check Your Progress 6

1) Insolation is the term that describes incoming solar radiation. All life depends on this radiation for energy and the fulfilling of the cycles that make living possible.

2) Global warming is the phenomenon that occurs due to the increase of carbon emissions in the earth caused by human activities as well as natural fluctuations. This leads to overheating which will have its toll on all life eventually.

1.13 FURTHER READINGS

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UNIT 2 ENVIRONMENTAL POLLUTANTS

Structure

2.0 OBJECTIVES

After going through this unit, you will be able to:

- identify and define various types of pollutants encountered in day to day activities;
- comprehend and trace the transport routes of pollutants in all components of ecosphere i.e. air, water and land;
- enumerate the adverse effects of pollutants;
- identify activities contributing towards environmental pollution; and
- explain global environmental issues and their likely implications.

2.1 INTRODUCTION

Human well being, health and development all are closely linked with the state of the surrounding environment. Any degradation in any of the environmental components (air, water, soil, biosphere) will have adverse effects on the health of the individuals. It is interesting to note that while the health and development are closely linked with the state of the surrounding environment, it is the developmental activities that are responsible for the release of a variety of pollutants and degradation of the surrounding environment.

Natural resources like water, air, land and biosphere play important role to meet the demands imposed by man with an aim to achieve development. We mostly take it for granted that there is abundant supply of natural resources. The excessive use of these resources has now made us realize that these resources are not abundant but finite. Today, we face major crisis of fresh water and fast depletion of fossil fuel reserves. Over exploitation of any one of the natural resource disturbs the delicate eco-balance. In nature, there is often a bidirectional movement of energy and materials (Fig. 2.1). Overuse or abuse of any of the natural resources creates an imbalance between the flow of energy and material exchange between the components of environment. The imbalance thus results in global environmental changes leading to natural hazards and adverse climatic phenomena like floods, famine, acid rain, forest fires etc. These hazards coupled with adverse effects on human health lead to huge economic costs, which may even outweigh the benefits of development. Besides, some effects may result in irreversible damage and we may even destroy the life sustaining ability of the mother earth. Thus, it is important that we are aware of the activities leading to the degradation of environment and contribute towards protecting and maintaining the delicate eco-balance.

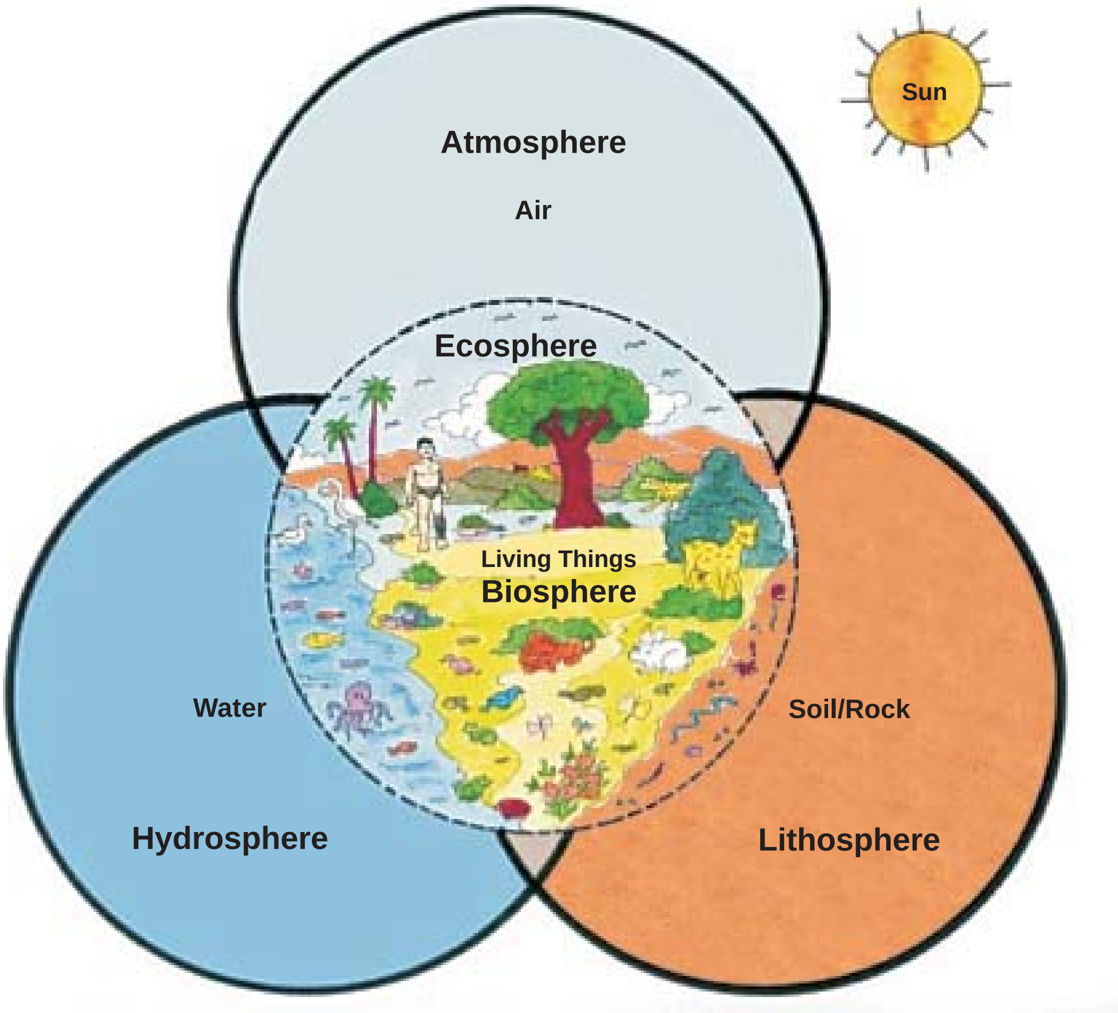

Fig. 2.1: Biosphere consists of all living beings as well as their habitat

According to the "Indian Environment Protection Act, 1986'' a pollutant has been defined as any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to the environment.

In this unit 'pollutants' occupy the centre stage. As you know, this word, in our daily usage implies to the adverse state of the environment we live in. Our efforts will be to make you learn the precise meaning of the word 'pollutant', to identify its sources and to be aware of the activities responsible for their release into the environment. After going through this unit you will be able to identify the conditions which are responsible for the build up of pollutants from local to global scale.

2.2 HISTORICAL DEVELOPMENT

People have given different reasons to explain origin of pollution. While some have blamed religion, others have held man's activities responsible for the build up of pollutants. Some authors (Southwick, 1976) have even associated the human population explosion with the pollution problem. They postulated that with population explosion there has been more sewage, more solid wastes, more fuel burning and greater use of fertilizers and insecticides to produce more food. But, there have been other writers who blame the technologically developed countries rather than the underdeveloped countries. They feel that the wasteful production of more convenient products (disposable items) has resulted in the build up of pollutants.

Some authors have blamed the profit motives and capitalism of the modern economic system of the capitalist countries for pollution. Finally, there have been modern ecologists like Odum (1971), Southwick (1976), Smith (1977) etc. who regarded many factors such as human population explosion, unplanned urbanization, deforestation and technological development for origin of pollution crisis on earth. The countries with greatest technological advancement are the ones facing worst pollution episodes.

Katyal and Satake (1989) have defined environmental pollution as the unfavourable alteration of our surroundings, wholly or largely as a by-product of man's actions, through direct or indirect effects of changes in energy patterns, radiation levels, chemical and physical constitution and abundances of organisms. These changes may affect man directly or through his supplies of water and of agricultural and other biological products, his physical objects or possessions or his opportunities of recreation and appreciation of nature.

Before the onset of industrialization, the human needs, besides food, were few. The per capita energy consumption was low, this implies that use of natural resource utilization was also low. The waste emitted into the environment was small and it did not affect the natural dynamics operating between the abiotic and biotic components of the environment.

The onset of industrialization and the fast pace of increasing human population initiated the process of change where, an increase in the consumption of natural resources and energy utilization led to a steady rise in the emission of gases, chemicals and the other materials into air/water/soil/biosphere. The operating concept of development assumed that the reserves of energy and natural resources are infinite and there are no limits to the economic development. The environment around us was never considered a part of this development process and its normal functions were taken for granted. This phase of unbridled economic growth and natural resource exploitation led to the build up of pollutants. To appreciate the growth and build up of the pollutants during this period you should look carefully at the information given on the key indicators of natural resources usage in Table 2.1. Their build up, started during industrialization, is responsible for number of diverse environmental crisis we face today.

Table 2.1: The Trends in the Increase of the Key Resources and their Buildup Since the Onset of Industrialization Affecting the Environment

Pollutant	Concentration 1950	Concentration 1995	Links with environment
Fertilizer use	14 million tons	125 million tons	Water pollution
Coal use	884 million tons oil equivalent	2083 million tons oil equivalent	Air pollution and climate change
Oil Production	518 million tons	2953 million tons	Air pollution and climate change
Natural Gas Production	180 million tons oil equivalent	2128 million tons oil equivalent	Climate change
CFC Production	42 thousand tons	300 thousand tons	Ozone layer depletion
Human Population	2.55 billion	More than 5.6 billion	Changed land use pattern
Nuclear Arsenal	304	45100	Global security

Source: Vital signs, 1995, World Watch Institute (www.worldwatch.org/)

The concept of development is human centric. The natural resources are needed to fulfil the needs of mankind; food, housing, transportation, entertainment etc. All these needs require the availability of natural resources; plants, wood, minerals, water, air, soil, coal, oil, gas, etc. It is apparent that with the increase in human population demand for more natural resources and energy increases. To meet the rising demand for natural resources more energy is required to process the natural resources to meet man's need. The process of reshaping of natural resources and energy utilization leads to the accumulation of waste products; gases, chemicals, particulates and other materials in air, water, soil and biosphere. Concentration of these waste materials beyond a certain extent start altering the natural cycles (hydrological, carbon etc.), radiation balance and introduces large number of pollutants in soil, air, water and biota.

You should also know that the environment also possesses resilience capacity to decrease the pollutant concentration. For example, a constant flow of upstream water into the river will ensure decrease in the concentration of pollutants, in time, below the threshold level. Going a step forward in our understanding of pollutants they can be further divided into two distinct classes: Local, and Global.

Local Pollutants are those substances whose concentrations cross the threshold concentration levels within a small area or volume of air, soil or water. The local concentration (e.g. within home, place of work, parts of the city and around, areas of industrial activities) can vary temporarily above the threshold concentrations. For example, the presence of NO_x (oxides of nitrogen), VOCs (Volatile Organic Compounds) and aerosols in air will fall under this class of pollutants.

Global Pollutants are those substances whose concentration levels have cumulative built up in air, water or soil over years. For example, the threat of global warming, stratospheric ozone depletion is due to increase in CO_2 (carbon dioxide) and CFCs (Chlorofluorocarbons) respectively.

2.3 AIR POLLUTION

According to WHO, air pollution may be defined as: "Substances put into air by the activity of mankind at concentrations sufficient to cause harmful effect to his health, vegetables, property or to interfere with the enjoyment of his property. The first severe air pollution episode occurred in 1930 in the Meuse Valley of Belgium, next occurred in 1948 at Donora, Pennsylvania where hundreds of people died because of the killing smog, it was followed by London episode in 1952 where more than 4000 people died on account of air pollution. In India, the Bhopal gas tragedy (1984) was the first industrial accident resulting in around 500,000 casualties (death toll 16,000) due to leak of methyl-isocyanate (MIC) gas from the Union Carbide Pesticide Plant.

> More people are killed due to choking caused by smoke and fumes generated by fire as compared to that killed by being burnt. The fumes and smoke caused by technology advancement and fires have affected and continue to affect adversely the people, crops and all other living forms.

2.3.1 Types of Air Pollutants

By now you know that air pollution is an unwanted change in the quality of earth's atmosphere caused by the pollutants. Broadly, we can classify the air pollutants into the following two types.

i) **Natural Pollutants:** These are the pollutants that are released into the atmosphere from a natural source or as a result of natural activity. Examples of the sources can be pollens and volatile organic compounds from the flowers and leaves, forest fires, soil erosion, volcanic eruptions, decomposition of organic matter, sulfate particles from sea spray, natural radioactivity, etc. Naturally occurring air pollution is a continuous phenomenon and nature has its own mechanism of dealing with such type of pollution. Natural emissions are generally in low concentrations than required to cause serious damage except in some cases viz., volcanic eruptions where gaseous (SO_2, CO_2 etc.) and particulate emissions may be in enormous amounts.

ii) **Anthropogenic Pollutants:** These pollutants are released into the environment as a result of human activities such as use of vehicles, application of fertilizers or pesticides, but also smoke from cooking (using bio-fuels).

Indoor Air Pollution is Major Killer

More than half of the world's population relies on dung, wood, crop waste or coal to meet their most basic energy needs. Cooking and heating with such solid fuels on open fires or stoves without chimneys leads to indoor air pollution. This indoor smoke contains a range of health-damaging pollutants including small soot or dust particles that are able to penetrate deep into the lungs. In poorly ventilated dwellings, indoor smoke can exceed acceptable levels for small particles in outdoor air 100-fold. Exposure is particularly high among women and children, who spend the most time near the domestic hearth. Every year, indoor air pollution is responsible for the death of 1.6 million people — that's one death every 20 seconds.

The World Health Organization (WHO) has assessed the contribution of a range of risk factors to the burden of disease and revealed indoor air pollution as the 8th most important risk factor and responsible for 2.7 per cent of the global burden of disease. Globally, indoor air pollution from solid fuel use is responsible for 1.6 million deaths due to pneumonia, chronic respiratory disease and lung cancer. ***More at:*** http://www.who.int/indoorair/en/

Pollutants can further be categorized into primary and secondary pollutants:

i) **Primary Pollutants:** The pollutants that directly enter the air as a result of natural or human activity are called primary pollutants (Fig. 2.2). Examples are carbon dioxide (CO_2) and carbon monoxide (CO) that are produced as a result of burning of fuels and are present in automobile exhausts, sulfur dioxide (SO_2) is added to the atmosphere by burning of coal.

ii) **Secondary Pollutants :** These types of pollutants are formed in air as a result of chemical reactions between the primary pollutants and/or naturally occurring gases under the influence of electromagnetic radiations from the sun. For example sulphur dioxide, the primary pollutant reacts with oxygen in the atmosphere to form sulfur trioxide (SO_3), a secondary pollutant: $2SO_2+O_2$® $2SO_3$. This sulfur trioxide can react with water vapours to form sulphuric acid (H_2SO_4): SO_3+H_2O®H_2SO_4.

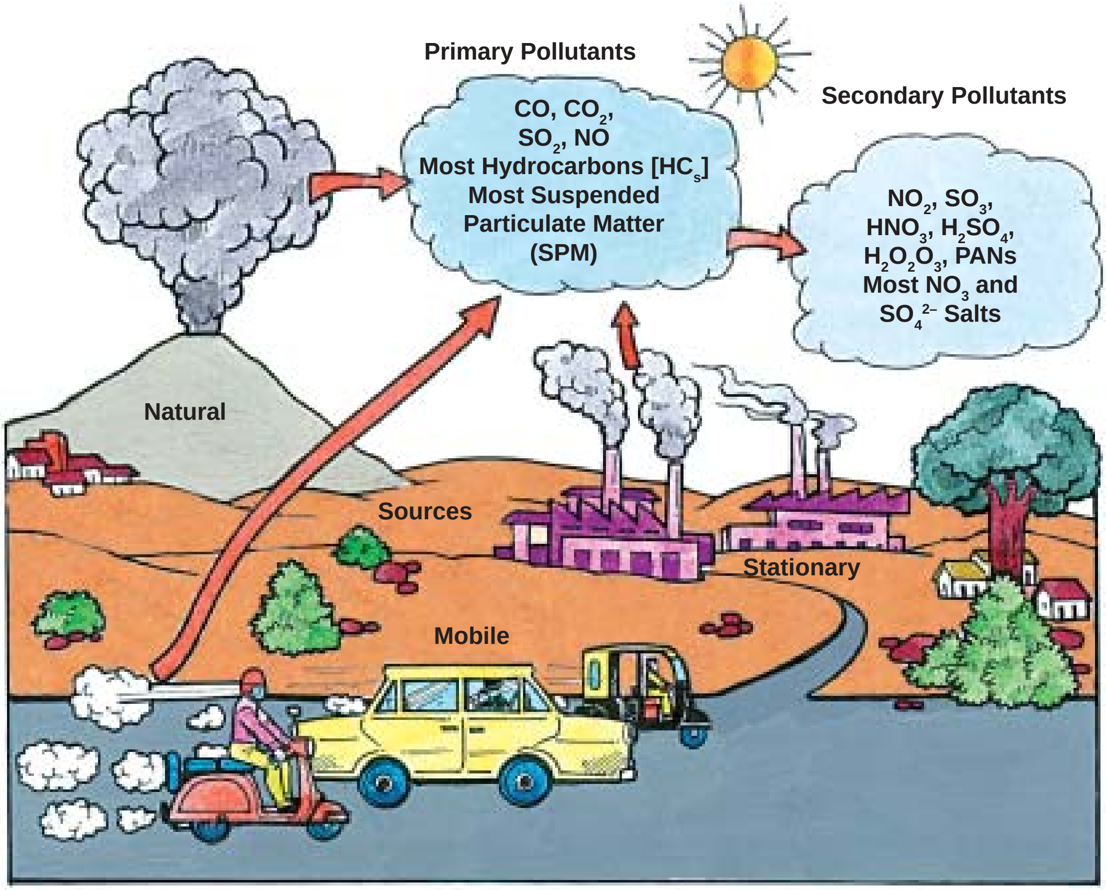

Fig. 2.2: Primary and secondary air pollutants formed as a result of natural and human activities

2.3.2 Major Air Pollutants

The air pollutants that are produced in significant amounts and have hazardous effect on health and environment are the major pollutants. Let us now look into Table 2.2 for an overview of the major air pollutants.

We will now discuss about some commonly occurring air pollutants. There is some commonality in the sources, ill effects and control strategies of these pollutants. However, you will see that each of these pollutants is chemically unique.

Oxides of Carbon (CO_x)

Major chunk of carbon monoxide in the atmosphere comes from anthropogenic source, i.e. incomplete combustion of fuels, mainly in automobiles. Small amounts are produced naturally along with marsh gases from decaying material, from volcanoes and forest

Table 2.2: Major Types of Air Pollutants and their Sources

Pollutants class	Major members of the class	Sources of origin
Oxides of carbon (CO_x)	Carbon dioxide (CO_2) Carbon monoxide (CO)	Combustion of coal, oil and other fuels for energy production, manufacturing and transport; biomass burning, forest fires
Oxides of sulphur (SO_x)	Sulphur dioxide (SO_2) Sulphur trioxide (SO_3)	Combustion of sulphur containing fuels like coal, oil, ore smelting for metal extraction, petroleum extraction, petroleum refining, paper manufacturing, municipal incineration
Oxides of nitrogen (NO_x)	Nitric oxide (NO) Nitrogen dioxide (NO_2) Nitrous oxide (N_2O)	Use of petrol, diesel for transport vehicles; burning of coal etc., by-product in the manufacturing of fertilizers, biomass burning
Hydrocarbons (HCs) also called volatile organic compounds (VOCs)	Methane (CH_4), Butane (C_4H_{10}), Ethylene (C_2H_4), Benzene (C_6H_6), Benzopyrene ($C_{20}H_{12}$)	Evaporation of gasoline from vehicles, carburetros, burning of fossil fuel, biomass, municipal landfill, microbial activity of sewage, industrial process involving solvents.
Suspended particulate matter (SPM)	Dust, soil, sulphate salts, sulphuric acid droplets, metals (like oxides of lead, iron, chromium, etc.), finely divided particles of carbon (soot) or silica, asbestos	Combustion of fuel, transport vehicles, building construction, mining, stone crushing, thermal power stations, industrial processes, forest fire, refuse incineration.
Other inorganic compounds	Hydrogen sulfide (H_2S), lead, mercury etc.	Chemical industries, oil, wells, refineries, municipal landfills, manufacturing of fertilizers, paper, paints, chemicals, ceramics etc.
Liquid droplets	Sulphuric acid (H_2SO_4), Nitric acid (HNO_3), oil, pesticides such as DDT and malathion	Reactions of pollutants in the atmosphere, pesticides and insecticides fumigation, oil refineries
Photochemical oxidants	Ozone (O_3), Peroxy acyl nitrates (PAN), formaldehyde (CH_2O), acetaldehyde (C_2H_4O), Hydrogen peroxide (H_2O_2), hydroxy radical (OH)	Photochemical reactions in the atmosphere involving hydrocarbons, oxides of nitrogen and sunlight

Notes: 1) Subscript x is used for all oxides of pollutants.

2) The contents given in the table are for you to realize the link between pollutants and their sources. The table is for broadening your concepts on air pollutants and not for memorizing.

fires. In cities, the level of CO is very high, about 95-98 per cent of CO is generated from human made sources. Carbon monoxide has no effect on materials but adversely affects human health. Improved technology which allows complete combustion of the fuel would avoid the formation of CO.

Carbon dioxide is produced as an end product of burning of carbon containing materials such as wood, leaves, paper and fossil fuels. It is slightly soluble in water and produces weak carbonic acid, thereby, adding to acid rain. CO_2 has major role to play in greenhouse effect.

Oxides of Sulphur (SO_x)

The electric power plants that use coal as a fuel are mainly responsible for producing oxides of sulphur. The sulphur content in the fuel varies from 5 per cent in coals obtained from some mines to only trace amounts in natural gas. Among the oxides of sulphur, SO_2 (sulphur dioxide) has maximum deleterious effect. SO_2 is itself poisonous to animals and plants, but it can react with ozone, hydrogen peroxide, water vapour and other substances in the atmosphere to form sulphuric acid (one of the strongest acid) — a secondary pollutant and a major component of the acid rain. Its effects on materials include corrosion of lime stone, metals, clothes and building material. Sulfuric acid has a harmful effect on the respiratory tissues.

Oxides of Nitrogen (NO_x)

When fuel is burned at high temperature, nitrogen (ordinarily inert) combines with oxygen to form NO_x . They are produced in the atmosphere mainly from combustion of coal, oil, natural gas, vehicular fuels form power plants and other industrial units. In nature, soil bacteria as well as lightening during thunderstorms produce NO_2. Human sources generate much more NO_2 in and around the cities, where it reaches harmful concentrations, which is sometimes 0-100 times greater than produced naturally in villages.

O_2 and N_2 combine to form nitric oxide (N_2+O_2®2NO) during combustion at a very high temperature such as 2000°F. NO as such is not very harmful because it does not readily dissolve in water. However, by the action of sunlight (ultra violet radiations) nitric oxide can combine with O_2 to form nitrogen dioxide (2NO+O_2®2NO_2). NO_2 is a toxic gas and adversely affects the environment. NO_2 in the atmosphere reacts with various substances and forms the secondary pollutants: peroxy acetyl nitrate (PAN) and nitric acid (HNO_3). These secondary pollutants aid in the formation of 'smog' (smoke + fog) and do more harm to materials and health.

Gaseous Hydrocarbons and Other Volatile Organic Compounds

Hydrocarbons as the name indicates are compounds that are made of hydrogen and carbon. Some hydrocarbons such as polycyclic hydrocarbons (hydrocarbons with multiple ring structure) can be carcinogenic and affect the humans directly. Another carcinogenic hydrocarbon benzopyrene is produced by burning coal. These hydrocarbons aid in the formation of ozone.

Photochemical Oxidants

Hydrocarbons and oxides of nitrogen from automobile exhausts, in the presence of sunshine, react to form photochemical oxidants like ozone, peroxyacetyl nitrate, acrolein, etc. These are the secondary pollutants and ozone may account for almost 90 per cent of the total oxidants. It is chosen as an indicator for the measurement of the photochemical oxidants. Let us see in Fig. 2.3 the basic reactions involved in the formation of ozone.

Ozone is formed in two ways in the atmosphere. At higher up in the atmosphere, oxygen molecule absorbs ultraviolet light and splits into 2O_2® O_2 + 2O that ultimately forms O_3 (O+O_2¬ O_3). At lower level, pollutants like NO_2 react with the O_2 atom to produce O_3 (NO_2 + O_2 ¬ NO + O_3).

Do you know that ozone is both a problem and a protector for us? Let us see how. Ozone is a powerful oxidizing agent, therefore, it can damage crops and other vegetation and can cause harm to human being, damage to fabric, rubber etc. Some people are affected even at lower concentration of 0.001 ppm.

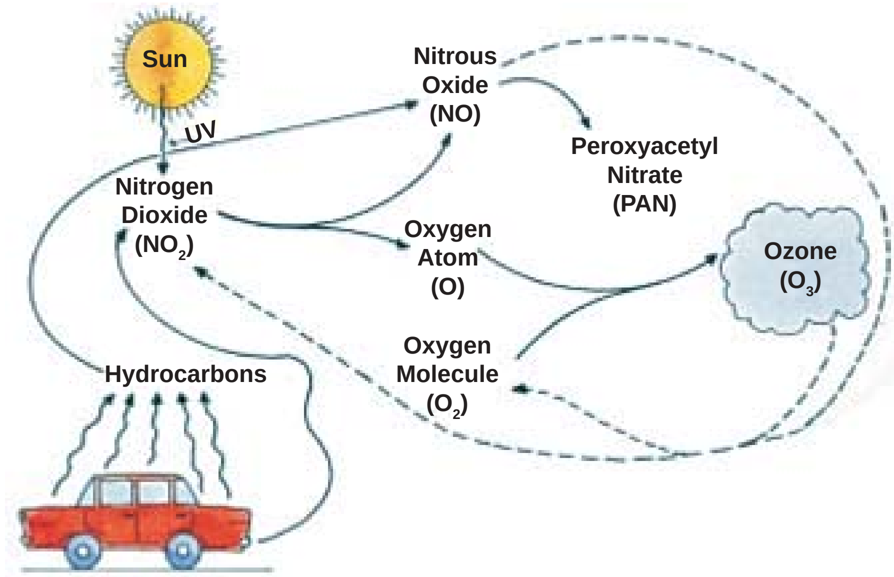

Fig. 2.3: Basic chemical reactions that lead to the formation of ozone in troposphere

However, ozone is also an important constituent of the atmosphere. The ozone layer surrounding the earth in the stratosphere protects the life on earth from ultraviolet radiations having wavelengths shorter than 340 nanometers. Such radiations can cause cancer and mutations. The useful O_3 layer gets damaged by pollutants produced as a result of human activities. Ozone hole, in the stratosphere, is an outcome of the scavenging effects of pollutants.

Chloroflurocarbons (CFCs): These are the compounds of chlorine, fluorine and carbon. The two types of CFCs that are environmentally important are CCl_2F_2 (di-chlorodifluromethane) and CCl_2F_2 (tri-chlorofluromethane). Both of these CFCs absorb infrared radiations thus, contributing to greenhouse effect. These gases are non-flammable, water insoluble and chemically inert. So these gases remain as such and drift around. Ultimately they reach the stratosphere where these gaseous molecules are decomposed by high energy ultraviolet radiations, which break C-Cl bonds releasing free chlorine atoms (Cl). It is estimated that one Cl atom on an average can destroy 100,000 molecules of O_3. Now you can well imagine how the protective layer of ozone is destroyed.

Fluorine atoms are not released because C-F bond is too strong to be broken by the UV rays. CCl_2F_2 is used as coolant in refrigerators and air-conditioners. CCl_3F is used as propellant in aerosol cans and as a foaming agent in the making of the polyurethane.

Suspended Particulate Matter (SPM): The important characteristic of the SPM is its size which ranges from 0.05 µm to about 100 µm. Particles having size less than 10 µm diameter are called **fine particulate matter or RSPM** (80 per cent of these particles are less than 2 µm), while the particles of size above 10 µm are the **coarse particulates.** The heavy particles settle down quickly due to gravitational force. The small sized particles are removed from the atmosphere by rain but are mostly kept afloat in the air by wind currents. The small sized particulates, though are one per cent of the total particulate load, have an important impact on the health. Particles in sprays, mist and dust come from spraying, grinding, land clearing activities and storms. Electric power plants and factories, forest fires and biomass burning contribute particulates in the form of soot and fly ash. Other kinds of particulates present in the atmosphere are metal salts, sulphate salts, silica, asbestos, smoke, fog, fume, flames, smog and other aerosol.

Metals: Metals enter the air as a result of various industrial processes that include metal extraction and other concerned processes. In this text we will discuss two metals —

lead and mercury. You can extend your study of these metals to other metals by taking into account individual metals, their characteristics and uses. Lead (Pb) as a pollutant comes from paints, automobile exhaust (leaded petrol), lead smelters, etc. Leaded petrol has maximum contribution in lead pollution. The present use of unleaded petrol has reduced the level of lead in the air. The increased level of lead in the blood causes various biochemical and physiological problems.

Mercury: Mercury pollution in the atmosphere occurs due to natural as well as anthropogenic sources. Degassing of earth's crust produces between 25,000 to 125,000 tons of mercury per year. Mercury also comes from geothermal plants and coal-fired power plants, paper, chemical and paint industries and agricultural sources such as pesticides and fungicides. In the environment, mercury is found in vapour form, as a solute in water, or as a solid particulate in different chemical forms having differential toxicity. For example, pure metallic mercury is harmless as compared to mercuric chloride ($HgCl_2$) and methyl mercury which is a deadly poison. You will read about specific health problems further in this course [Unit 1, Block 3 of this course (BHM-001)]. In Fig. 2.4 you can see various ways by which mercury enters human body. In fact mercury found in the soil enters the food chain and is biomagnified by the time it reaches the human.

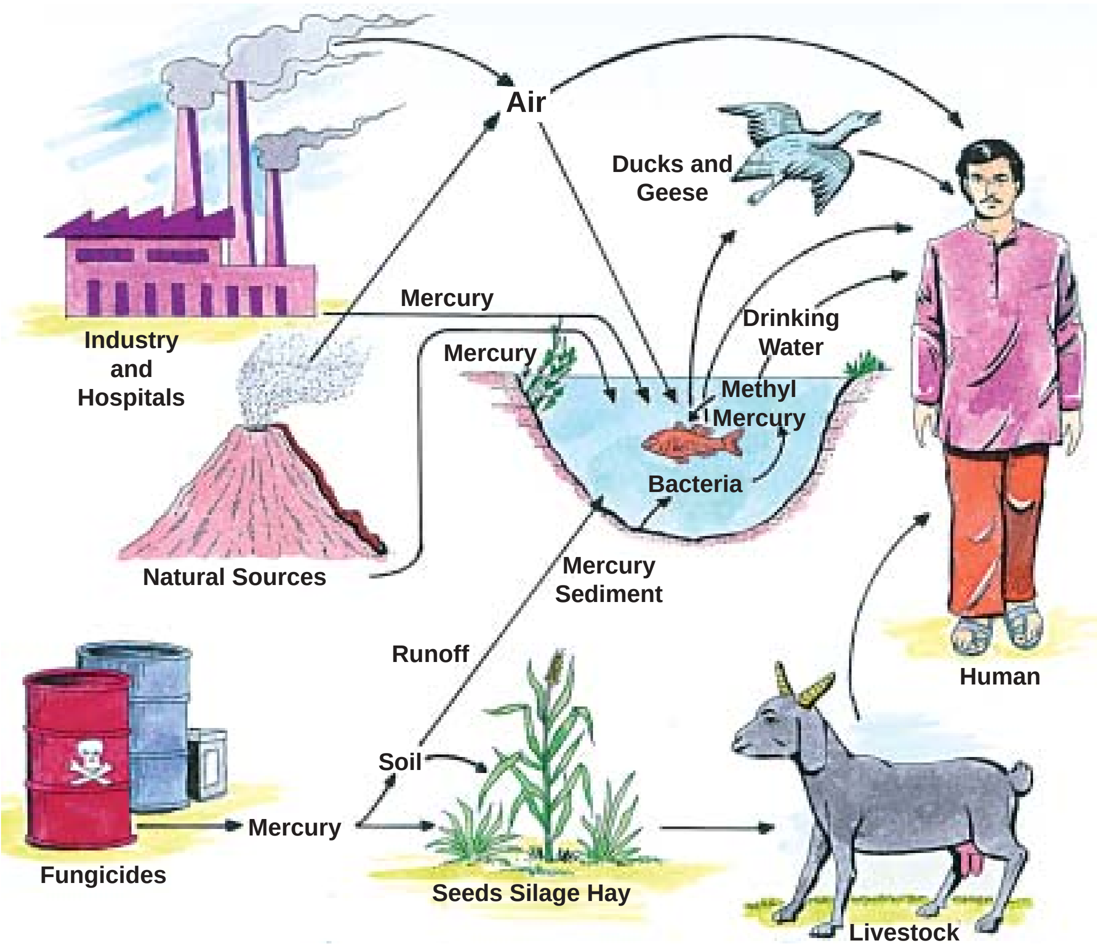

Fig. 2.4: Entry of mercury into human body through air, water, soil and food chain

For this course we limit our discussions on air pollutants here. However, when you go through the reference books, you can study in detail about various pollutants and much more on the topics that interest you most. Before we go on with our discussions on noise pollution check you progress by doing the following questions.

Check Your Progress 1

1) Define 'Pollutant'.

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2) What are CFCs and what harm do they cause?

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3) What health problems are associated with small particles?

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2.4 NOISE POLLUTION

The term noise may be defined as undesirable, disturbing or harmful sound interfering to the peace of mind and capable of causing stress. At higher levels, noise may also impair the normal hearing process. Noise mostly has a direct effect on the mind and often results in irritable nature thereby hampering the efficiency of an individual.

To understand if we are encountering noise pollution is not very difficult. If there is excessive sound and we have to raise our voice level more than normal so that others may hear the same, it is enough indication that we are facing noise pollution. It can cause various adverse effects associated with it. Annoyance is the first response to excessive noise. As a result of excess noise, adrenalin is released in the body. Result is that the heart beat becomes faster, blood pressure becomes high and muscles get tensed. If the exposure to excessive noise continues for longer durations, it may lead to permanent hearing loss, hypertension, migraine, gastric problems, irritability, insomnia and psychological disorders including increased aggressive behaviour.

Sound is measured by several complex systems but the best known unit of measurement is the decibel (dB). The decibel measures sound intensity or the loudness. Another unit, frequency, is defined as the number of vibrations/second. Unit of frequency is hertz (hz) and one hz is equal to 1 vibration/second. People can hear sound from 16 to 20,000 hz. Vibrations below 16 hz are infra-audible and above 20,000 hz are ultrasonic. Animals (i.e. dogs) can hear sounds inaudible to human ear.

Human ear is known to be sensitive to extremely wide range intensity from 0 to 180 dB. Here, zero decible is the threshold of hearing while 140 dB is the threshold of pain. By threshold, it implies the lowest intensity at which stimulus gets perceptible. Some people feel discomfort even with sound of 85 dB whereas most do not feel discomfort with sound of 115 dB. Pain is usually felt at 140 dB.

Ordinary talk or discussion is having the frequency range from 30-60 dB while noise produced by a jet plane at take-off may exceed 160 dB. The effect on man depends upon the frequency or pitch of the sound.

Table 2.3: Sound Levels and their Effect on Humans			
Source	**Sound Level (dB)**	**Perception of Sound**	**Effect**
Rocket Engine	180	Painful	Eardrum rupture
Jet takeoff (25 meters away)	150	Painful	Eardrum rupture
Jet takeoff (100 meters away)	130	Painful	—
Jet takeoff (161 meters away), textile loom, live rock music	120	Uncomfortably loud	Pain threshold
Steel mill, automobile horn	110	Uncomfortably loud	—
Jet takeoff (305 meters away), power lawn mower, farm tractor, printing plant, motorcycle	100	Uncomfortably loud	Hearing damage (in 8 hours)
Busy urban street, diesel truck, blender/mixer	90	Very loud	Impaired hearing (In 8 hours), speech interference
Average factory, freight train at 15 meters, dishwasher	80	Very loud	Possible hearing damage
Freeway traffic at 15 meters, vacuum cleaner, noisy party	70	Moderately loud	Annoying
Average office, supermarket, restaurant	60	Moderately loud	Intrusive
Quiet suburb (daytime), conversation in living room	50	—	Quiet
Library, soft background music	40	—	—
Quiet rural area (night time)	30	—	—
Whisper, rustling leaves	20	—	Very quiet
Breathing	10	—	—

Major sources of noise pollution are discussed below:

1) **Traffic:** Both individual vehicles (autos, trucks, buses, etc.) and the flow of traffic on roads create noise pollution. The noise is produced from engines, use of horn, sudden application of breaks, exhaust system and slamming of car doors. You must have experienced irritating noise mostly produced by engines of three-wheelers, 'tampoos' etc. People residing or working near to busy roads are often exposed to continuous noise from the flow of vehicles. This noise is a mixture of all of the above.

2) **Aircrafts:** With an increase in the air traffic, noise levels have also increased. Noise is produced from the engines of the aircraft and is particularly high during take-off and landing. People residing near airports have to bear this noise. Noise is also created by flying helicopters and planes. Since the aircraft noise is quiet high it often results in impaired hearing in persons who are regularly exposed to it.

3) **Construction work:** Noise from construction sites, be it construction of buildings, roads, bridges, etc., results from the use of heavy machinery like tractors, road-rollers, drillers, etc. The noise is particularly harmful for the workers involved in the construction work.

4) **Industry:** Noise from industry also arises from the use of heavy machinery and during process operations such as impact, vibration, cutting, drilling, etc.,

depending on the type of industry. Usually factories are seen to have louder than permissible noise levels.

5) **Domestic:** This includes noise from household activities such as water motors, blenders, vacuum cleaners, improper door hinges, etc.

Effects of Noise

It is well known that noise is an undesirable sound and when it is not in our control to switch it off it often leads to irritability. People living near airports often experience interrupted sleep, which has a harmful physiological effect on human beings. Continuous exposure to noise levels above 100 dB has an adverse effect on hearing ability. Hearing defects are commonly seen in workers exposed to aircraft noise or noisy work places. Besides, communication is also affected by noise. It affects conversation and interferes in concentration ability. It affects the efficiency and the ability to perform mental activity. It also leads to changes in the psychosocial behaviour. Prolonged exposure to high levels of noise causes nervous disorder, headaches, high blood pressure and short memory. It can even lead to cardiovascular problems. Workers exposed to high noise levels show circulatory problems, cardiac disturbances, neurosensory and motor impairment and even social conflicts. Fig. 2.5 gives a diagrammatic sketch of the effects of noise on human beings.

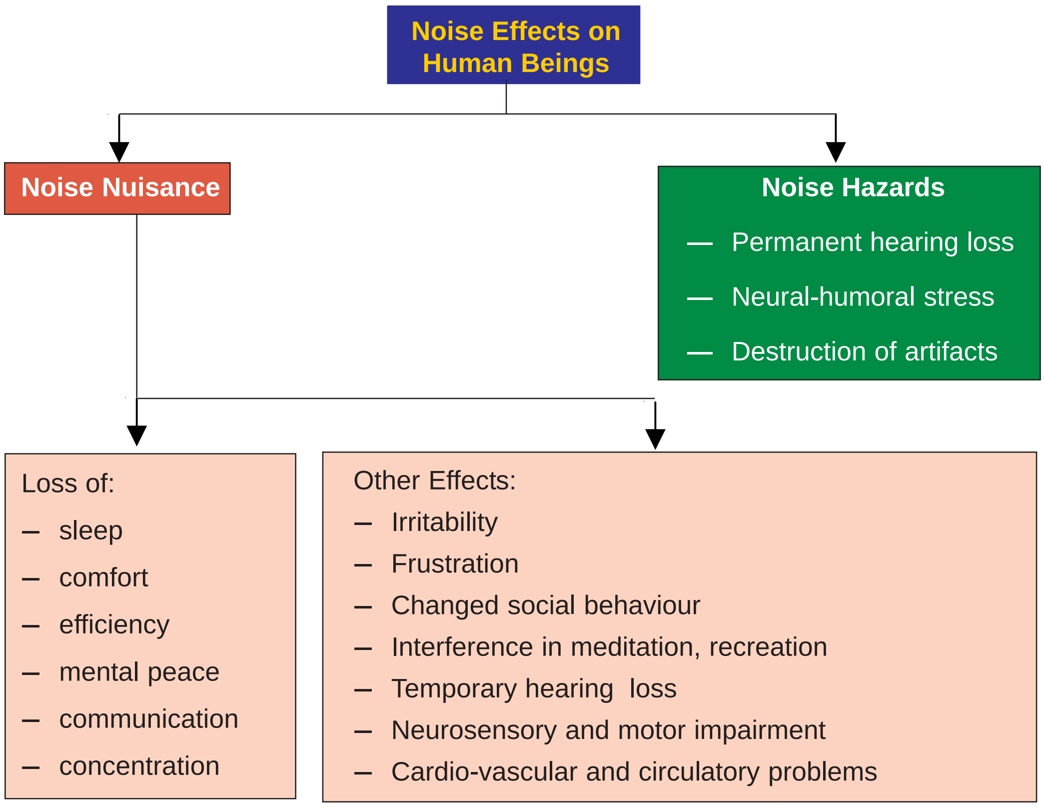

Fig. 2.5: Noise effects on human beings

Control of Noise Pollution

Noise pollution can be controlled in any of the following ways:

1) By reducing the noise at source.
2) By making sound proof compartments and by using sound absorbing materials in the buildings, homes etc.
3) By setting standards/limits for noise levels in public places and enforcing to adhere by these standards.

4) By limiting the use of horns in vehicles and by banning noisy vehicular engines.
5) By planting noise breaking plants along the roadside and within factory premises i.e. neem, tamarind etc.
6) By keeping the noise levels from household activities under control.
7) By educating people through media about the ill effects of noise pollution.

Some nations i.e., U.K. has Control of Pollution Act, 1974, Part III and USA has Noise Control Act, 1972 (amended by Quiet Communities Act, 1978). In India there are certain laws under which noise can be dealt. For example, noise can be considered a public nuisance and it can be dealt under Sections 68, 290 and 291 of IPC as well as under Section 133 of CrPC. Recently, the Government of India has issued draft rules entitled 'Noise Pollution (Control and Regulation) Rules, 1999'. The draft rules recognize the importance of increasing noise pollution from various sources and their deleterious effects on human health. Hence, using its powers under Environment (Protection) Act, 1986, the Government decided to regulate noise pollution. Ambient noise standards have been specified for different areas. Additionally, it has been proposed that noise emanating from any source shall not exceed the background noise level by 10 dB or more when measured at a point outside the premises of the location of the source. If the noise level exceeds the limit of 10 dB, the source of noise may be ordered to be removed or commensurate corrective measures may be ordered. The rule proposes to control the use of loudspeakers by restricting its use only when permission is granted by the District Magistrate/Police Commissioner or the officer designated as per the Local Laws. Considering fire crackers as an important source of community noise, it has been proposed that manufacture, sale and use of firecrackers which may cause noise exceeding 125 dB(AI) or 145 dB(C) peak measured at a distance of 4 meters from the source of noise will be prohibited. It is expected that this comprehensive legislation will take care of different sources of noise when it is finally notified and becomes applicable. (***More on noise and health at:*** www.euro.who.int/Noise)

Check Your Progress 2

1) What effects are produced in human beings by high noise levels?

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2) What are the most common sources of noise pollution in Indian cities?

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3) Give some examples of the domestic noise pollution sources.

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2.5 WATER POLLUTION

Water is a universal solvent as a variety of substances dissolve in it. Because of this remarkable property, contamination of water becomes inevitable. Rainwater on its way to earth picks up soluble gases, particulates, etc. So how do we define water pollution? Essentially water pollution is any physical or chemical change in water mainly due to human activities that impairs its use as a resource for human beings as well as other life forms. You can see in Fig. 2.6 how water gets polluted due to human activities. The term 'Water Pollution' is relative, as water that is too polluted to drink can be used for washing, electricity generation, cooling the steam or hot water produced in various

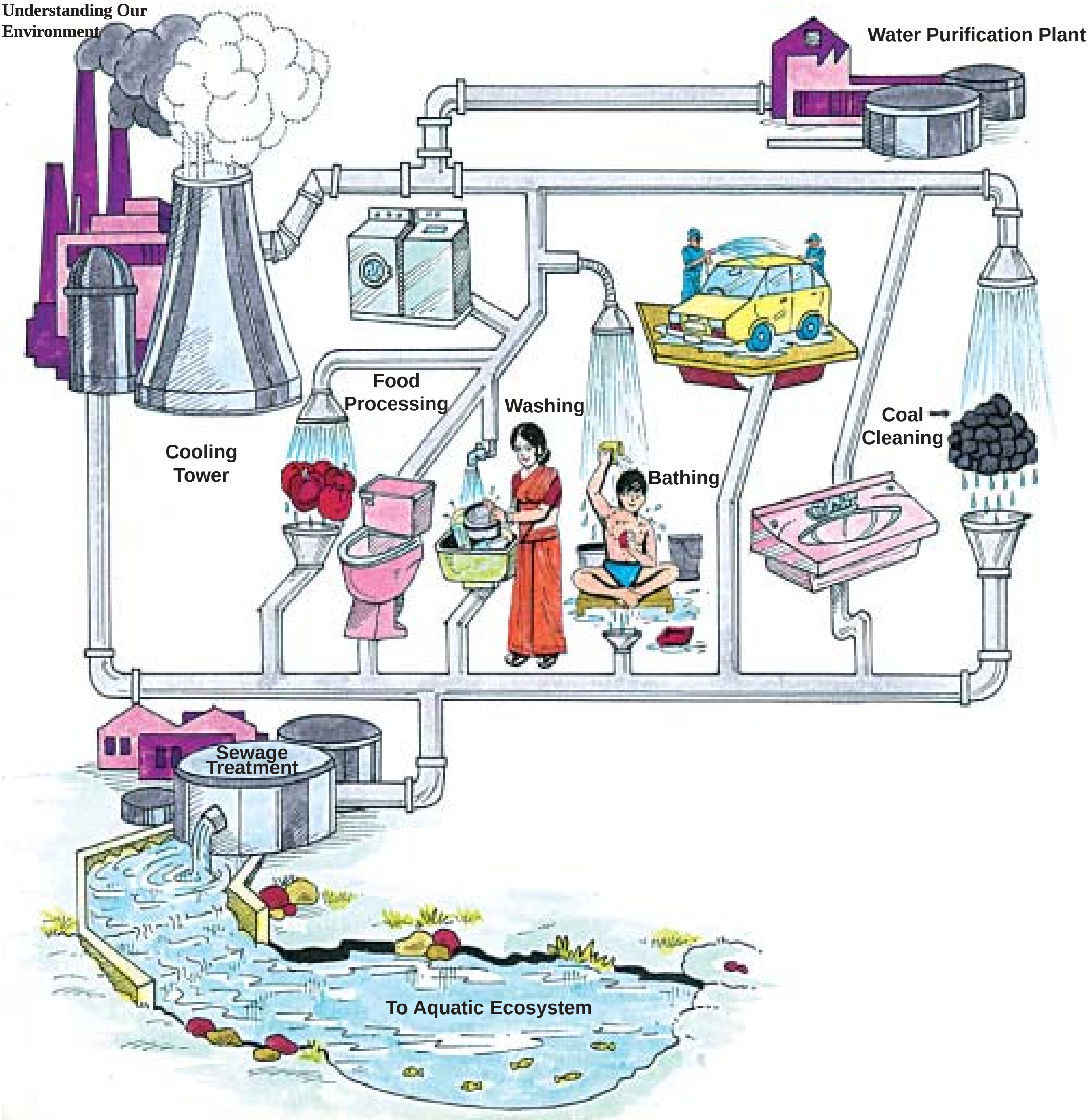

Fig. 2.6: Pollution of water caused by day to day activities

industrial processes. You can also think of other such examples, which you encounter, in your daily life. Let us now discuss the types of water pollutants and their sources.

2.5.1 Types of Water Pollutants

Basically the agents that cause water pollution fall into three main categories:

1) **Biological Agents**

   Disease causing organisms such as virus, bacteria, protozoans and worms.

2) **Chemical Agents**

   a) ***Inorganic:*** Nitrates, phosphates, acids, salts, toxic heavy metals, gasoline, pesticides, dyes, paints, plastics, cleaning solvents and detergents.

   b) ***Organic:*** Oil and organic wastes such as sewage, animal manure, etc.

   c) ***Radioactive Substances***

3) **Physical Agents**

a) ***Suspended Solids:*** Insoluble particles of soil, silt, organic materials, etc.

b) ***Heat***

Now we will discuss about these pollutant categories in brief.

Biological Agents

All of us know very well the relationship between human disease and water sanitation. The problem of water borne diseases is in fact due to the contamination of drinking water with disease causing micro-organisms. The contamination of drinking water occurs due to the mixing of wastes (i.e., domestic and sewage wastes), polluted water discharges from industries such as canneries and slaughter houses and food processing units. The micro-organisms and parasites from these waste discharges enter the fresh water supplies and infect human and animals. For example, presence of a large slum near a river would cause influx of human organic waste, which when mixed with the water bodies results in the outbreak of various epidemics. In addition the mixing of organic waste acts as an excellent medium for the growth of a variety of bacteria and protozoans. Similarly the influx from the slaughter houses will carry with it different types of worms in addition to the microbes. (***More at:*** www.who.int/water_sanitation_health/en)

Chemical Agents

The chemical pollutants in water listed above can be water-soluble, water insoluble, oxygen demanding wastes or toxins. In Table 2.4 you can study some examples of chemical pollutants, their sources and their effects.

Addition of inorganic nutrients like phosphates, nitrates, organic chemicals, serve as food for decomposers, thereby enriching the ecosystem of the water body and increasing its productivity. A lake with very high productivity ultimately becomes eutrophic, as the huge amounts of nutrients favour unlimited growth of phytoplankton and zooplankton which consume all the dissolved oxygen (DO) in the water body leading to the stagnation of lake. The process is called eutrophication.

What happens when eutrophication occurs? Organic wastes such as domestic and sewage wastes, wastes from various industrial processes like milk plants, canneries, slaughter house, starch factories, paper mills, fish processing plants, etc., run off from agricultural lands and inorganic wastes like nitrate and phosphates reach the water body such as ponds or lakes and cause the increase in the nutrient contents of that water body. The release of nutrients from organic wastes occur due to the activity of aerobic bacteria i.e. the decomposers, in presence of oxygen. These nutrients then act as a fertilizer and cause the population explosion of water microscopic plants like algae; such an abundant growth of algae is also called algal bloom, duck weed, water hyacinth (longer plants), etc. More the plants grow, more plants die adding to the waste in the water body. More waste means more population of decomposers leading to breakdown activity to release the nutrients. The concept of eutrophication is further explained in the box.

The productivity of an ecosystem reflects the rate at which its producers photosynthesize. In land ecosystem such as farms and forests high productivity is beneficial for human beings as these systems supply useful products such as grains, wood and other plant products. In lakes and streams, however, opposite type of ecosystem is preferred. A lake which has clear water is called oligotrophic lake and is characterized by low productivity. The water is clear because it has less number of planktons and rooted plants. This is because growth of producers is limited by shortage of nutrients. Such an aquatic system is beneficial to humans. However, addition of nutrients will increase the producers and thus eutrophication, i.e. high productivity in lake. In nature it takes many thousand years for an oligotrophic lake to become eutrophic. However, due to human activities this process is speeded up.

Table 2.4: Major Sources of Chemical Water Pollutants and their Effects		
Pollutant	**Sources**	**Effects**
Oxygen demanding/ Organic wastes	Natural runoff from land, human sewage, animal wastes, decaying plants, industrial wastes (from oil refineries, paper mills, food processing etc.), urban runoff	Decomposition by oxygen consuming bacteria depletes dissolved oxygen in water, fish die or migrate away, plant life destroyed, foul odors.
Inorganic Chemical wastes:		
Acids	Mine drainage, industrial wastes, laboratories, domestic and industrial cleaning	Kills some organisms, increases solubility of harmful compounds
Salts	Natural runoff from land, irrigation, mining, industrial wastes, oil fields, urban storm runoff	Kills freshwater organisms, causes salinity buildup, makes water unfit for domestic, irrigation and many industrial uses
Lead	Leaded gasoline, some pesticides, smelting of lead	Toxic to many organisms including humans
Mercury	Natural, industrial wastes, laboratories and fungicides	Highly toxic to humans (especially methyl mercury)
Plant nutrients (phosphates and nitrates)	Natural runoff from land, agricultural runoff, mining, domestic sewage, industrial wastes, inadequate wastewater treatment, food-processing industries, phosphates in detergents	Algal blooms and excessive aquatic growth, kills fish and upsets aquatic ecosystems, eutrophication, possibly toxic to infants and livestock, foul odours
Sediments	Natural erosion, poor soil conservation, runoff from agricultural, mining, forestry and construction activities	Major source of pollution (7000 times solid sewage discharge), blocks water channels, harbors and reservoirs, reduces fish population, reduces ability of water to assimilate O_2 demanding wastes
Pesticides and herbicides	Agriculture, forestry, mosquito control	Toxic or harmful to some fishes, shellfish, predatory birds and mammals, concentrates in human fat (bio-accumulation), toxic to humans, possible birth and genetic defects, cancers
Detergents (phosphates)	Homes, industries and commercial establishments	Encourages growth of algae and aquatic weeds, kills fish and causes foul odors as dissolved oxygen gets depleted
Chlorine compounds	Water disinfection with excess chlorine, paper industry and bleaching process.	Sometimes fatal to plankton and fish, foul tastes and odors, possible cancer in humans
Oil and grease	Machine and automobile wastes, pipeline breaks, offshore oil and blowouts, natural ocean seepages, oil spills and cleaning operation	Potential disruption of ecosystems, economic recreational and aesthetic damage to coasts, damage to fishes and coastal birds, taste and odour problems
Plastics	Homes and industries	Kills fish, releases carcinogenic chemicals

Dissolved oxygen (DO) in the water body is consumed by the phytoplanktons, larger plants, bacteria, zooplanktons and other aquatic life. This leads to a decrease in the available oxygen required by fish, ultimately causing death of the fish. The lake chemical cycle, ecosystem changes and eutrophication ultimately diminishes the life sustaining capacity of the water body. However, such a phenomenon does not occur in flowing water bodies (i.e., rivers) as due to turbulence there is constant mixing of oxygen adding to the DO.

Inorganic Salts

Inorganic salts dissolve in water as ions. These enrich the water and add to the hardness (i.e. calcium salts). Hardness of water makes it difficult to produce a soapy lather. It causes the problem of deposition of salts in the pipes, interferes in the textile and brewing processes. These salts are present naturally in water in low quantities but at a much higher concentration in industrial wastes.

Acids: Acids are produced as by-products of various types of industrial processes including mining. Some chemicals in the air contribute to acid rain.

Alkalis: Such as sodium hydroxide are produced as by-product of soap manufacturing, textile manufacturing and tanning of leather. Some chemical discharges impart colour to the water such as iron oxide (gives red colour) and iron sulfate (gives yellow colour). Certain pollutants and detergents used in leather and other industries cause foaming in water supplies. Ingredients like whiteners, fabric softeners and bleaching agents contain phosphates that are also added to the municipal waste water. Now-a-days people are making more of biodegradable detergents to reduce this problem.

Floating and Foaming Materials: Materials such as oil, grease, detergents and a number of other materials that cause water pollution form a layer on the water surface thereby causing fire hazard if inflammable and cutting the diffusion of gases from the atmosphere into the water body.

Heavy Metals: Many human activities release chemicals that are toxic to the biota and ecosystem such as heavy metals, pesticides, hydrocarbons, poly-chlorinated biphenyls etc.

Arsenic, cadmium, cyanide, lead, selenium, mercury, copper, chromium and zinc are some inorganic toxic metals that are released from various types of industries. The problem of metal toxicity is often compounded by the process of bio-magnification in the aquatic food chain.

Radioactive Substances

Radioactive substances are released into water bodies from processing of uranium ore, wastes from research laboratories, hospitals using isotopes, effluents from nuclear power plant and fallout generated by nuclear weapon testing. Radio-nuclides in the water enter the food chain via aquatic organisms and bio-magnify in the food chain.

Physical Agents

Suspended or sedimentary solids and temperature are the physical factors that adversely affect the quality of water. Suspended solids can be of two types—one which dissolves over a period of time and the other, which never dissolves. Some of the adverse effects of these suspended solids in water are silting, clogging of water ways, adding to the turbidity of water. These solids can cause problem to the gill breathers (i.e., fish). Suspended organic and mineral solids can absorb metals and other toxins and pass them into food chain. Agriculture, steel and clay industry, construction process and likes contribute to the sediments which get washed out into the water stream by surface runoff.

Water is an ideal cooling medium because it has high heat capacity (ability to absorb large amounts of heat with relatively small increase in its own temperature). Therefore, water is used for cooling purpose in many industrial operations. This heat laden water when reaches back into the water body, raises the temperature of the aquatic environment. This **thermal pollution** of water causes adversities that affect the life forms. The examples of adversities are: lowering of dissolved oxygen, acceleration in metabolic reactions of organism that do not have constant body temperature; death of heat sensitive organisms and growth in the number of certain undesirable micro-organisms.

The source of water pollution should be distinguished as point source or non-point source. As you can see in Fig. 2.7, a **point source** is a source that discharges pollutants/ effluents through a channel such as conduiting pipes, sewers, tunnels etc. Examples are factories, sewage treatment plants, power plants, coal mines, oil tankers, oil wells etc. The point sources are easy to identify, therefore, most of the pollution control efforts are focused on reducing and treating the effluents.

A **non-point source** is the source that is widely scattered and discharges pollutants over a large area. The examples are run offs from urban areas such as construction areas, roadways, from agricultural areas, forest areas, livestock feeding areas, seepage into ground water etc. Less progress has been made in the control of non-point sources mainly because of difficulty in identifying and controlling the discharge.

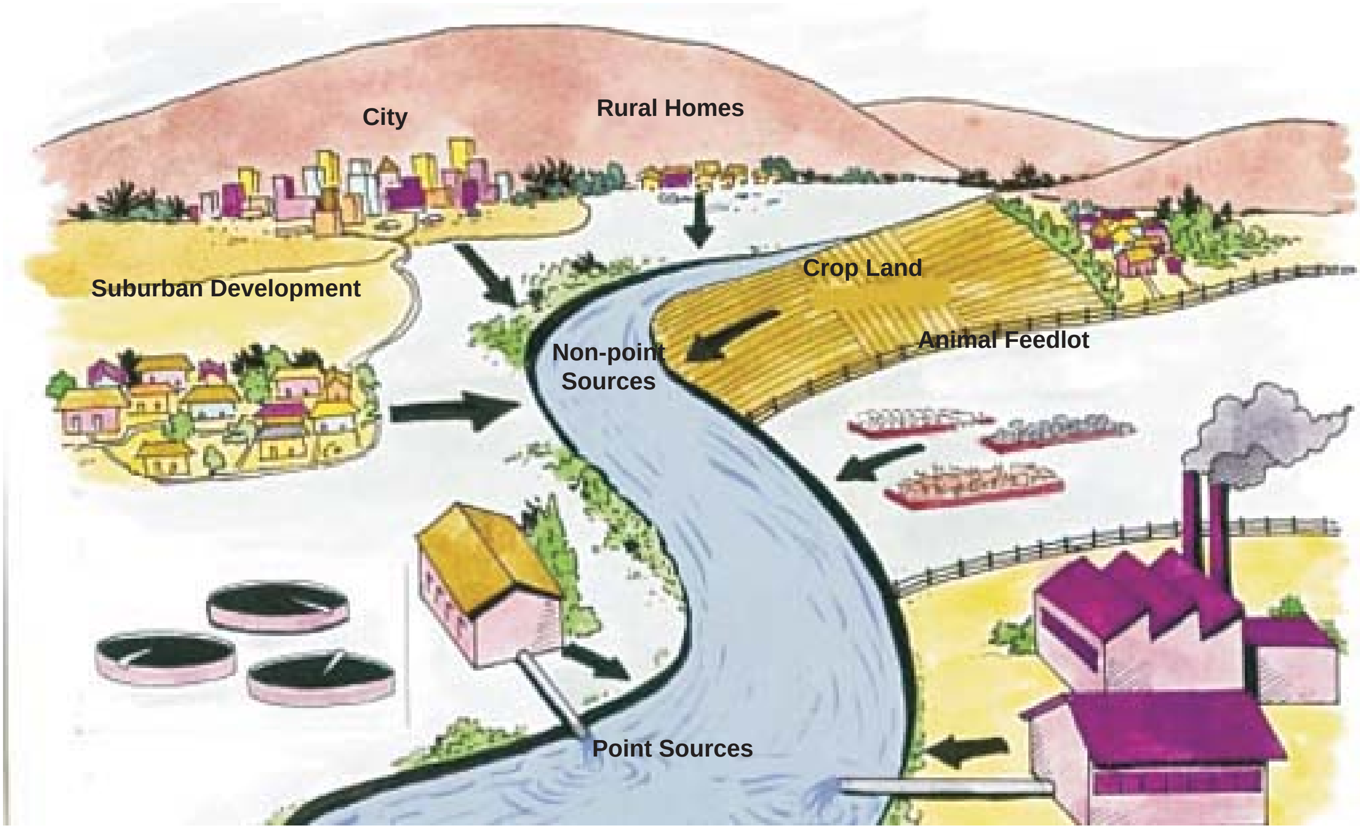

Fig. 2.7: Water pollution-point and non-point sources

Check Your Progress 3

1) List the water polluting agents?

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2) Explain eutrophication in brief.

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2.6 RADIATION POLLUTION

Before we talk about the radiation as a pollutant it is necessary to understand what radiation is? Radiation is a character which is inherent in all types of matter and atoms. It is the phenomenon of propagation of energy in the form of particles or waves through matter or space. Such fast moving particles are called particulate radiations and the waves are called electromagnetic waves or radiations. All types of radiations are the form of energy. The simplest example of radiation is the light coming out of an electric bulb, candle, lightening in sky, fire crackers, etc. In all the above examples, you are able to see the radiations coming from the respective source because they fall in the visible region and our eyes are sensitized to the visible range of radiation only. Other types of radiation that are present around us but do not fall in visible range are given different names. For example, you are aware of x-rays, gamma rays, radio waves, micro waves, infrared (IR), etc. Their classification and the naming is done on the basis of the wavelength span of the region and their interaction with matter. All these names signify different wave lengths and they interact in different manner with matter and consequently are used for different applications. You will be surprised to know that all types of living and non-living forms emit radiation including our own body. The energy of the radiation from any source is related to its wave length. Shorter the wave length higher the energy and longer the wave length lesser is the energy.

To broaden the understanding you should go through the schematic representation of Fig. 2.8 which gives the entire spectrum. From this figure we can see that the energy

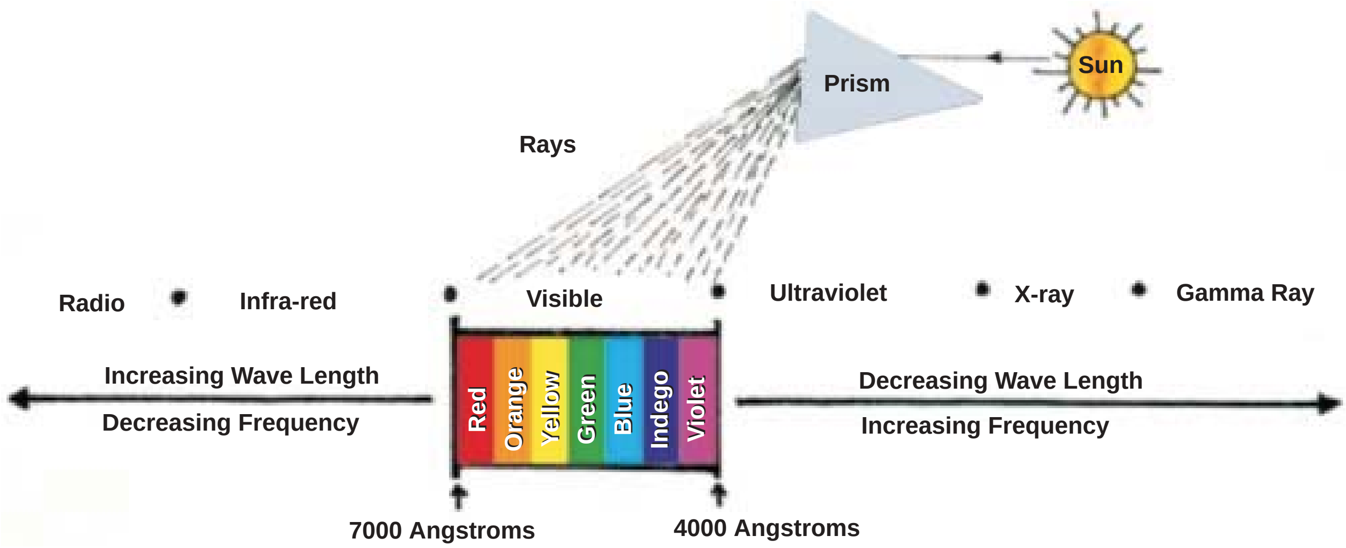

Fig. 2.8: Electromagnetic Spectrum

of radiation in UV or x-ray region will be much more than the energy of radiation in the visible and radio-wave region. Similarly, if we only look at visible light, the energy of violet light will be much more than that of the red light. In Fig. 2.9 you can see the wave length values of different types of electromagnetic radiations.

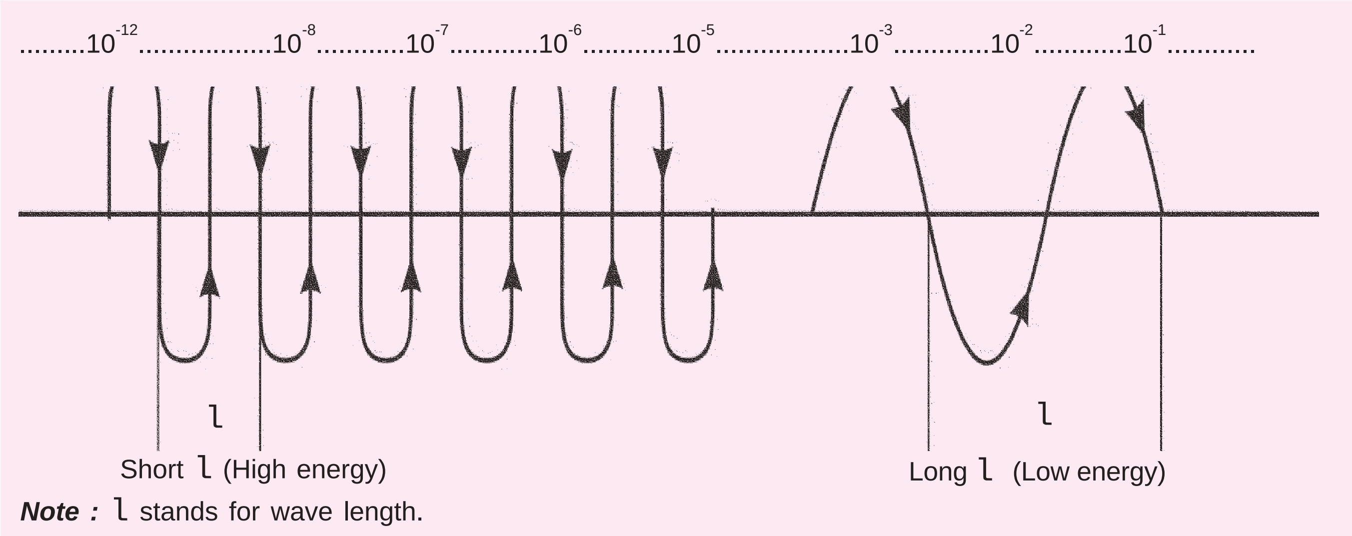

Fig. 2.9: The electromagnetic radiations and their wave lengths

Nuclear Radiation

From preceding section it is clear that radiations have a very wide range of energy. The energy depends upon the source of radiations. Also a high wave length radiation has low frequency and a low wave length radiation has high frequency. Higher the energy of the radiation more damage it can cause to the biotic and abiotic materials due to the higher penetration power. In next section we will focus on high energy radiation.

Radioactivity

In nature, various types of matter are made up of different atoms. There are some atoms which due to their structural properties (arrangement and the proportion of neutrons, electrons and protons) exhibit inherent unstable configuration. This state has a tendency to become stable by emitting radiations (i.e., electron, proton and neutron). In this process the atoms are transformed into new atoms with different character. An isotope of an atom whose unstable nucleus spontaneously emits either radiation or particles or both is called radioactive element or radioisotope. The property of emission of high energy electromagnetic radiation and particulate radiation during this transformation is known as radioactivity. The rate at which radioactive atoms transform is a distinct property of respective atoms and is called as the half life of the atoms. Some radioactive elements decay faster than others. This property does not change under the influence of other chemicals and changes in temperature etc. This property of half life helps in distinguishing one radioactive element from the other.

Half life is defined as the time taken by the radioactive element to decay exactly half the number of atoms that were present originally. For example, if N_0 were the number of radioactive atoms present at time t=0 and after time T the number of radioactive atoms are $N_0/2$, then 'T' will be the half life of this atom.

The radiations emitted by radioactive elements or radioisotopes hit other atoms as they pass the surrounding living and non-living medium and alter these into positively charged ions by dislodging one or more electrons from the same. It is for this reason that these radiations are called **ionizing radiations.** The positively charged ions created by ionizing particles which are emitted by the radioisotopes are alpha (a) and beta (ß) particles. The alpha particles are positively charged and these are fast moving chunks of matter with two protons and two neutrons. The beta particles are electrons moving with high speed and carry net negative charge. You can see some examples of radioactive isotopes, their half life and the radiations emitted by these in Table 2.5. In addition to the emission of charged particles, radioactive atoms emit high energy ionizing electromagnetic radiations called gamma (g) rays. These are not charged but possess only energy and are more penetrating than x-rays. The absence of charge on g-radiations enables them to travel very far when they pass through the medium. You can see in Fig. 2.10 the penetrating capacity of ionizing particles and radiations. X-rays are a form of high energy ionizing radiations but they are not emitted by a radio isotope. Radio waves and infra-red waves are non-ionizing electromagnetic radiations that do not have much energy to cause ionization and damage to living tissues.

Table 2.5: Half Life of Radiations Emitted by Radioisotopes

Isotope	Half life	Radiations emitted
Potassium-42	12.4 hours	Alpha, beta
Iodine-131	8 days	Beta, gamma
Cobalt-60	27 years	Beta, gamma
Hydrogen-3 (tritium)	12.5 years	Beta
Strontium-90	28 years	Beta
Carbon-14	5,370 years	Beta
Plutonium-239	24,000 years	Alpha, gamma
Uranium-235	710 million years	Alpha, gamma
Uranium-238	4.5 billion years	Alpha, gamma

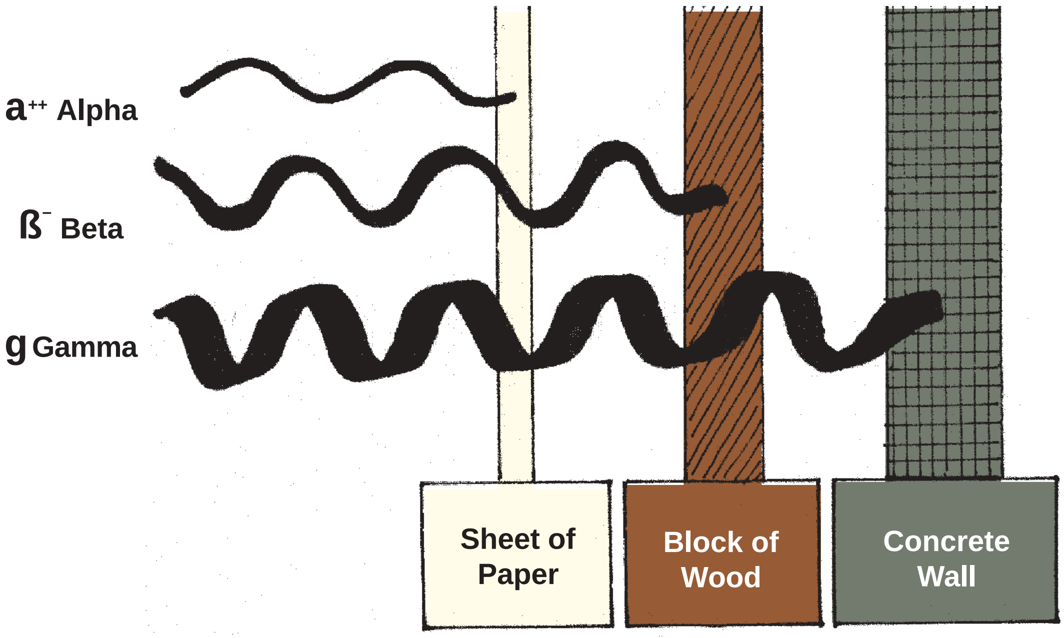

Fig. 2.10: The penetration ability of alpha, beta particles and gamma rays emitted by radioactive isotopes

Neutrons are also released by some radioactive atoms. Though they do not have charge but are capable of travelling through the material. They are capable of transforming the atoms by making them unstable and radioactive. They are also used to initiate the fission process used in atomic bomb and nuclear reactors.

Check Your Progress 4

1) What are radio isotopes?

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2) What is the difference between alpha and beta particles?

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2.6.1 Anthropogenic Sources of Radiation

There are two major usage of radioactivity: a) research and diagnostic, and b) power generation. In both these processes the use of radioactive material is required. Radioactive material, before its use requires mining, milling and processing. The utilization of radioactive material in nuclear reactor requires number of prior steps. Environmental concerns associated at each stage are summarized below:

Mining: Uranium used in reactors is present as an ore which is extracted from the mines. Further purification of the ore involves the use of chemicals. The first harmful effects from the mining will be to the people involved in this activity. They will be exposed constantly to the much higher background radiation. The radiation cannot be seen or felt but its effects can be seen in individuals in the form of severe biological defects. In addition to the threat of radiation exposures the threat of exposure to the toxic metals further adds to the health hazard.

Tailing: Various waste materials from mining are known as tailings. The radioactive and toxic chemical tailings need to be safely stored and disposed. Normal practice is to store this waste underground. The site is carefully selected to avoid the movement of this waste within the ground or across other environmental components (air and water). Normal practice is to bury this under a thickness of 1-3 meter thick gravel, sand or soil. These sites cannot be used for any other activity for thousands of years. With increase in human population there is immense pressure on the availability of land and this is imposing additional constraint on the disposal of such radioactive waste. The problem of radioactive waste disposal has acquired a global concern. There are instances where a developed nation has shipped this radioactive waste to developing countries for storage. The lack of awareness in these countries towards the harmful effects of such waste has made the citizens of these developing nations prone to the health hazards.

Refining and Fuel Fabrication Waste: Next stage involves the purification of uranium concentrates from mines. In this process small amount of radioactive waste is generated and most of it is cycled back. The chemical processing also generates ammonium nitrate in this operation. Sometimes this is mixed with commercial fertilizers for its use in agriculture. In fuel fabrication process, a small amount of waste is produced during pressing, grinding and sintering operation. This waste is recycled back into the fabrication process by the chemicals.

Spent Fuel: The decaying fission products from nuclear power plants need to be stored under water, subsequently, they are kept under dry storage. The spent fuel from reactors consists of U-235, plutonium and other fission materials. These radioactive elements have an extremely long half life (thousands of years) and need to be stored in absolute safe locations. There exists a threat of spillage of radioactivity and of theft of radioactive materials from the ill managed storage sites.

Accidental Radioactivity Release: The technology related to safety measures to operate nuclear reactors, on paper, is relatively safe. However, from time to time accidental toxic radioactive release has taken place from such facilities. Chernobyl accident in this regard stands out, accidental release of radioactivity in atmosphere and soil surrounding the reactor has caused major damage to all life forms. Keeping in view the large half life of radioactive elements released from the reactors, vast area of the surrounding land cannot be used for thousands of years. The population exposed in this accident has come down with various radiation related problems.

Example 1: During 1945 and 1980 large number of nuclear tests were performed which introduced huge quantities of nuclear fallouts into the atmosphere. After the Partial Test Ban Treaty such tests were reduced but did not cease on account of several countries continuing their tests even after the Treaty. Such tests released large quantities of radionuclide such as strontium-90 and ceasium-137 into the atmosphere. This radioactive material came down with precipitation and found its way into the hydrosphere. During the processing of nuclear material, some quantity of waste is always generated. Care is taken to dispose off these wastes in protected manner but the system can never be foolproof and there is always a possibility of leakage into the environment. In fact there is mounting evidence that the populations living around the areas where intensive nuclear testing was done suffer from serious genetic disorders and high incidence of cancer.

Example 2: In 1920s, many watches had radium dials. Such dials had the capacity to glow in dark. Those dials were painted manually using paint and brush. The painters had the habit of wetting their brush by touching on the tip of their tongues. This practice resulted in entry of radioactive radium into the body of the painters, who were mostly women. Many of these women were later diagnosed of bone cancer, which obviously was caused by the radioactive material entering the body. Similarly, large number of people have been found to be exposed to radiations on account of their occupation or due to accidents. For example, many people involved with uranium mining have been found to have lung cancer. The only possible explanation could be the radiation in the air. Wilhelm H. Roentgen who discovered x-rays had himself developed bone cancer and died with it in 1923. Marie Curie who discovered radium and her daughter, Irene had developed aplastic anaemia and it became the cause of their death. Now, it is well known that bone cancer and aplastic anaemia can be caused by radiations. Hence, it may be concluded that the regular encounters that these scientists had with radiation during their research works caused their death as awareness towards the hazards of radiation exposure was low.

How Much Radiation is Safe?

By now we are well aware that exposure to radiation from radioactive material is capable of causing harm to living systems. But the question arises as to how much radiation is harmful? To seek this answer, various research groups have looked for the threshold dose, i.e. below which the radiation could be considered safe. It was found that some of the effects of radiation are deterministic. It means that almost every one exposed to a particular dose of radiation will exhibit the same effect and the intensity of effect increases with increase in the dose. Another set of effects of radiation have been found to be **stochastic**. These effects are random i.e. some vulnerable individuals may show harmful effects with much smaller doses than others. A common example of the deterministic effect is acute radiation sickness which is caused by radiation of about 1 gray (a unit for measurement of radiation). The recipient suffers from nausea, vomiting, diarrhoea and occasionally intestinal bleeding leading to death in few hours, days or weeks. Examples of stochastic effects are cancer and genetic disorders. These, may be manifested many years after the dose is received. These effects become more common below a certain dose of radiation and these effects show up themselves with decreasing probability as the dose is reduced. But there is no zero level of threshold i.e. there is no such dose of radiation which may be considered safe. The chromosomes and DNA have no foolproof methods for their repair and hence if they are damaged once, the damage continues.

2.6.2 UV-Radiation

In 1974, two chemists, Sherwood Rowland and Mario Molina broke the news that certain chemicals were lowering the average concentration of ozone in the stratosphere. Stratosphere is a particular layer of the atmosphere which exists from 17 to 48 kilometers above the earth's surface. The ozone molecules were being destroyed by various chemicals used on the earth. One group of these chemicals are chlorofluorocarbons (CFCs). Another group is of halons, hydrobromoflurocarbons (HBFCs) and methyl bromide, all containing bromine atoms, and still another group is of carbon tetrachloride, methylchloroform etc. Although, there are other compounds present in stratosphere which also contribute to the destruction of ozone layer but the damage caused by CFCs is manifold. For example the research shows that one molecule of CFC on release of Cl atoms, destroys about 100,000 molecules of stratospheric ozone.

Most damaging consequence of ozone layer thinning is that the flux of incoming UV radiation increases. More UV radiations penetrate the troposphere and reach the earth's surface. For convenience the solar UV radiation is partitioned into three parts: 1) UV-A the least harmful and has low energy, 2) UV-B the most harmful and has intermediate energy, this part is partially filtered by ozone layer in stratosphere, and 3) UV-C this part of the solar radiation is most energetic but it is completely stopped by the upper atmosphere and never reaches the ground. Thus, the UV-B part of the solar radiation is of utmost concern as it adversely affects the human health.

Effects of UV-B at Ecosystem Level

By now it is clear that an increase in UV-B, on ground, will increase the genetic mutation rate over and above the natural rate of mutation in plants and crops. The changes will be a function of the type of plant, its physiology, rate of growth and other properties. As you know that in an ecosystem we have lot of plant species in equilibrium. If one plant in such a system gets affected by the increase in UV-B leading to its extinction from the ecosystem, the equilibrium will also be disturbed. These changes will endanger the existing ecosystems. These changes will establish some new speciation and ecosystem regimes. It has also come to light that some crops will be affected in a manner that their yield will decrease. From these changes, it is expected that even the nutrient cycling and soil micro-flora will undergo a change. These changes will have global dimensions.

Effects on Human Health

Adverse health effects due to UV-B radiation are expected to be widespread — sunburn, cataract, skin cancer, etc. The stratospheric ozone layer absorbs most of the UV-B radiation coming from the sun and so the life on earth remains safe. Researchers estimate that if the stratospheric ozone layer is reduced by ten per cent, there will be about 3,00,000 more cases of basal-cell and squamous-cell cancers, about 14,000 more cases of malignant melanomas, and about 16,00,000 more cases of cataracts. In addition to these our immune system will be adversely affected leading to reduction in our defense mechanism against a variety of infections. The only possible solution is to protect the stratospheric ozone layer by banning the use of substances that release ozone depleting compounds.

2.7 GLOBAL ISSUES

2.7.1 Greenhouse Effect

Greenhouse actually refers to a glass chamber where plants are kept under controlled conditions. It is usually seen in cold countries as the glass house is able to maintain warmer temperature ideal for the growth of plants. This greenhouse effect is seen in environment also. Some gases present in the atmosphere perform function similar to that of glass. The main greenhouse gases are carbon dioxide, methane, nitrous oxide, ozone and water vapours. These gases form a blanket over the earth's surface and allow the short wave solar radiations to pass through and fall on the earth thereby heating the earth's surface. However, these gases do not allow the long wave radiations reflected back from the earth to escape into the space. These reflected long wave radiations are re-emitted back to the earth's surface by the greenhouse gases, thereby resulting in the build up of temperature. Fig. 2.11 shows the greenhouse effect.

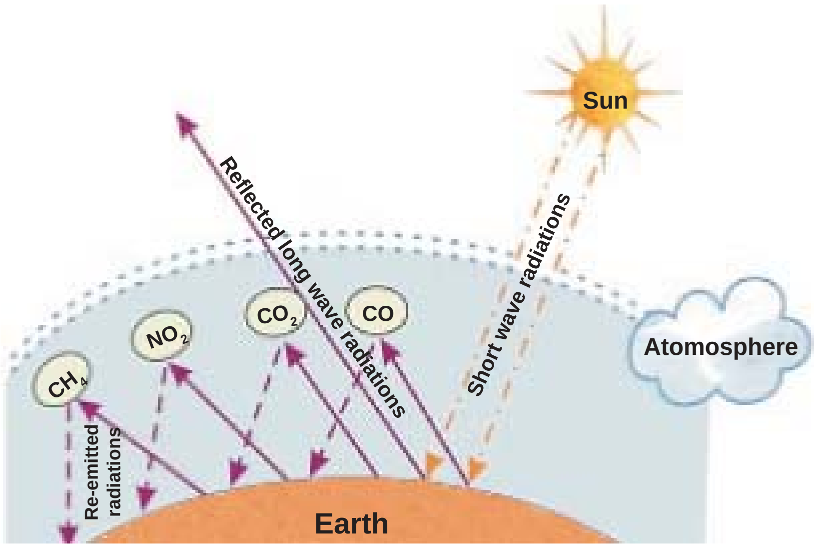

Fig. 2.11: Greenhouse effect

The most important of the greenhouse gases—carbon dioxide, has increased by about 25 per cent, in the last 100 years. The concentration of CO_2 in pre-industrial times was about 280 ppm and has increased to about 360 ppm today. Fossil fuel combustion and deforestation are the main reasons for the increase in the atmospheric CO_2. The residence time of CO_2 is about 230 years. On the basis of present day modeling studies it can be predicted that the eventual global warming of about 1.5 to 4.5°C will take place with the doubling of the CO_2 concentration. If this happens it will have far reaching consequences for the life on earth.

2.7.2 Global Warming

On the basis of the available data from the weather stations across the world, the average global temperature between 1951-1980 has been reported to have increased by about 0.5°C.

Now, the question arises as to whether the change in temperature is due to natural factors or has it been caused by the increasing concentrations of greenhouse gases in our atmosphere? The natural factors, which can influence the Earth's surface temperature are: sun's luminosity, presence of water vapours and volcanic dust in atmosphere. The solar intensity is one of the principal factors which govern earth's surface temperature. Any change in this can cause the earth's surface temperature to change. Similarly, the volcanic activity, dust and water vapour in the atmosphere can reflect the incoming solar radiation and thus cause a change in the amount of radiation reaching the ground as well as the earth's surface temperature. The problem we see, with this argument is that these changes together, do not account for the observed variation in the temperature. Therefore, the accumulation of greenhouse gases may be the most important factor responsible for the temperature rise. However, it should be clarified at this stage that certain other factors, i.e., increase in aerosols, cloudiness, etc., can counter balance the effect of greenhouse gases. Considering all these factors, i.e., increase in greenhouse gas concentrations and counter balancing due to other factors, one can state with certainty that increase in the global mean temperature since 1951 is due to greenhouse gases.

Some serious environmental consequences of global warming are: melting of glaciers, rise of sea level, and intrusion of salt water into land. Global warming also affects climate and the health of the population. Global warming would favour the spread of vector borne diseases and the growth of newer and more resistant strains of viruses and bacteria.

> "Human activity almost certainly drove most of the past century's warming, a landmark report from the United Nations Intergovernmental Panel on Climate Change (IPCC) declared in 2001. Global temperatures are shooting up faster than at any other time in the past thousand years. And climate models show that natural forces, such as volcanic eruptions and the slow flickers of the sun, can't explain all that warming." National Geographic Society, 2004 see: http://magma.nationalgeographic.com/ngm/0409/feature1

2.7.3 Ozone Hole

Another important global issue is the stratospheric ozone depletion. The stratospheric ozone is commonly known as 'Ozone Layer'. It forms a protective covering over the earth's atmosphere and prevents the entry of harmful solar UV radiation.

Worldwide monitoring of stratospheric ozone has shown that it has been decreasing for the past two decades or more. Globally averaged losses have been estimated to be about 5 per cent since the middle of 1960's with aggregate losses of 10 percent in spring and winter and 5 per cent in summer and autumn, over locations in Europe, North America and Australia. Since late 1970's ozone hole has appeared over Antarctica in southern hemisphere in the months of September/October, registering depletion of ozone. What is the cause of this ozone depletion? The large increase in atmospheric concentrations of chlorine and bromine rich CFC's released into atmosphere are responsible for this depletion. Laboratory studies show that free Cl reacts with and destroys ozone in a catalytic manner.

During 1992-93 ozone concentrations dropped by as much as 20 per cent in some populated northern mid-latitude regions and the levels in Antarctic ozone hole decreased to a record low level. This rather unusually large depletion in ozone concentration was attributed to volcanic eruptions of Mount Pinatubo in Philippines during 1991. These eruptions fed large quantities of sulfate aerosols into the stratosphere, which increased the ozone depletion caused by anthropogenic chlorine and bromine compounds. Recent observations have shown that these aerosols have now been swept out of the stratosphere and the ozone has returned back to the earlier levels observed prior to Mount Pinatubo Eruption. During the period 1992-93 increase in UV-B radiation was also observed at mid and high latitudes in the Northern Hemisphere. The enhancement clearly correlated with the depleted ozone concentration observed during this period.

The depletion of the protective ozone layer in the upper part of the atmosphere leads to greater exposure to UV radiations, which results in increased cases of skin cancer, especially among people of temperate latitudes and the weakening of the immune system of humans and animals. UV radiation can also cause damage to eye and certain types of cataract.

2.7.4 Acid Rain

Natural rainfall usually has pH value between 5 to 5.6. Acid rain refers to rainfall with pH < 5.0. Oxides of sulfur are emitted into the atmosphere as a result of combustion of fossil fuels, petroleum refining, copper smelting and cement manufacture. About 80 percent of oxides of sulfur come from burning of fossil fuels. Sulfur dioxide (SO_2), through series of chemical reactions gets converted into SO_3. This trioxide form of sulfur on reaction with water produces sulfuric acid (H_2SO_4) and this is the principal component (60-70 percent) of the acid rain. The conversion of sulfur dioxide into sulfuric acid is increased by the presence of metal ions like copper, lead and manganese and radicals like hydrocarbons and nitrogen oxides in the atmosphere and photo-chemical oxidation. Nitric acid (HNO_3) is the second most abundant component (30-40 per cent), hydrochloric acid (HCl) the third and carbonic acid the fourth in acid rain. Acid rain can damage vegetation, corrode metals and building materials, weaken organic fiber and destroy aquatic organisms. Acid rain decreases the pH of water bodies. Certain toxic substances like aluminum, lead and mercury which are insoluble otherwise, become soluble and can be life threatening to fish and other organisms. Prolonged exposure to acid rain can cause serious damage to building material including marble, limestone and mortar as the carbonates in these materials are replaced by sulfates. The reaction between lime stone ($CaCO_3$) and H_2SO_4 takes place in the following manner:

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O.$$

$CaSO_4$ produced in this reaction is water soluble and is easily washed away, leaving behind an eroded and pitted surface. Many of the world's historic monuments (e.g. Taj Mahal) and statues have been gradually degraded as a result of exposure to acid rain.

2.7.5 Deforestation

Deforestation is another important issue of global environmental concern. The world is losing closed forests at the rate of 7.5 million ha/year. Tropical forests are estimated to disappear at the rate of 21.5 ha/minute. In South-East Asia more than 150,000 km^2 of forests are cleared each year at the rate of 0.61 per cent per year. In India, during last three decades more than 4.3 million ha of forest land was either converted into agriculture fields or it was lost due to other construction activities and urbanization. It is believed that the country is losing 0.16 million ha/year of forest cover and at present only about 14 per cent of the land is left with forest cover.

Forests rank 2nd in terms of CO_2 sinks while oceans and seas are the primary sinks of CO_2. The changes in land use affect the amount of carbon locked up in vegetation and soils and, therefore, the carbon flux between land and atmosphere. Forests, for instance, contain about 20 to 100 times more carbon per unit area than the croplands. The transformation of croplands to forests withdraws carbon from the atmosphere and stores it again on land. Although in some parts of the world the forest cover has increased, on the whole there has been a considerable reduction in the area of forests and an increase of agriculture land area. This has resulted in the net release of carbon into atmosphere. The build up of CO_2 in atmosphere is in part due to deforestation. Deforestation and other changes in land use are estimated to have released about 120×10^{12} kg of carbon into atmosphere since 1850 which is 60 per cent of the total carbon released from combustion of fuels. Until about 1935, deforestation of temperate zone forest was thought to be responsible for most of this carbon (biotic) release but in last few decades most of the biotic carbon release has been due to deforestation in the tropics.

Apart from affecting the carbon flux of the atmosphere, deforestation might cause changes in climate with unforeseen consequences. As trees intercept solar radiation and also help in reducing wind speeds, the reduction in forest area would result in the increase in albedo of the Earth's surface and, therefore, the radiation budget of the Earth-atmospheric system. A change in the radiation budget will have an impact on climate and consequently rainfall, fresh and ground water supply as well as soil moisture. Further, removal of vegetation cover increases the rate of soil erosion. This may lead to further desertification. Thus, efforts should be made to conserve and maintain the eco-balance in addition to reforestation programmes to make up for the loss that has already been done.

2.7.6 Food Security

The regional food security is likely to come under stress as a consequence of increased global warming. Extreme reduction in agriculture output may result in a given year due to a single abnormal event such as storm, heat wave, and drought. A sequence of milder events occurring together may result in poor growing season. A single poor year of less agriculture output is not going to be a problem for food security as there may be enough reserves. But two or more such lean years of agriculture production occurring in succession will severely affect regional food supplies resulting in famine. This will threaten the survival of a large number of marginal farmers who are completely dependent on agriculture. Shortage of food supplies force the local population to migrate to other more prosperous areas. Constant emigration would have a bearing on other resources besides food, i.e., water, land, civic amenities, etc. Most of the metropolitan cities are facing multiple problems associated with ever increasing migratory population.

Check Your Progress 5

1) List the main greenhouse gases and explain greenhouse effect.

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2) What is the consequence of loss of stratospheric ozone?

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3) What is acid rain?

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2.8 LET US SUM UP

In this unit we have studied about our encounter with pollutants in our daily lives as well as about the various types of pollution (air, water, noise and radiation). We have studied about the historical development of pollution i.e. how man's activities led to the built-up of pollutants. We have seen how over-exploitation of natural resources leads to increase of pollutants. This unit presents a detailed account of different kinds and types of pollutants, their sources and a brief account of their adverse effects on environment and health. The unit also brings forth an account of the noise pollution — its sources, effects and measures to control. A detailed account of the types of water pollutants is also given along with their adverse effects such as eutrophication etc. It mentions about the various point and non-point sources of water pollution.

The unit also brings forth an account of the radiation pollution, radioactivity and its effects. It gives a brief mention about the natural and man-made sources of radiations along with their effects on ecosystem as well as on human health. The unit also explains some important global issues like greenhouse effect, global warming, ozone hole, acid rain, deforestation and food security.

2.9 KEY WORDS

Acid rain : The decrease in pH of rain water due to presence of dissolved SO_2, CO_2 and NO_x in the atmosphere

Aerosol : Particulates (solid, liquid or gaseous) suspended in the atmosphere

Decible (dD) : Unit used to measure the intensity of sound

Greenhouse effect : Rise in the atmospheric temperature due to the presence of greenhouse gases (CO_2, CH_4 etc.)

ha : Hectare

Ozone Depletion : The removal of stratospheric ozone by chlorine and bromine compounds

Pesticides : Chemicals used to eliminate insects, mainly applied in agriculture

Pollutant : Any undesirable substance when present above a threshold concentration in environment and adversely affects the natural environment as well as the health and well being of living organisms

Primary Pollutants : Pollutants produced directly due to natural or anthropogenic activity without undergoing any chemical change.

Radioactivity : Spontaneous disintegration of atoms resulting in the emission of harmful radiations and particulates.

Secondary Pollutants : Formation of pollutants by chemical reactions between primary pollutants or with other constituents (physical or chemical) present in the environment

Soil Erosion : Loss of top soil resulting in decreased soil fertility due to natural or man made activities.

2.10 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) According to the Indian Environmental Protection Act (1986) a pollutant is defined as any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to the environment.

2) CFCs are compounds of carbon, chlorine and fluorine. Free Cl released by CFCs are capable of destroying the protective stratospheric ozone and are largely responsible for O_3 hole.

3) As small particles cannot settle down by the gravitational force they remain suspended in the air and cause respiratory problems upon inhalation.

Check Your Progress 2

1) Irritable behaviour, lack of concentration, headaches, lack of sleep, rise in blood pressure, cardio-vascular problems, impaired hearing, neuro-sensory and motor impairment.

2) Vehicular traffic, loud speakers, construction and demolition of buildings, other heavy electronic machinery.

3) Water motors, vacuum pumps, mixers, blenders and loud audios.

Check Your Progress 3

1) i) Biological

   ii) Chemical

   iii) Physical

   Students should give two examples of each from their knowledge of water pollution and explain their adverse effects along with their sources.

2) Eutrophication is the process of enrichment of water bodies by nutrients. The enrichment leads to population explosion of plants as well as decomposers in the water bodies finally causing the death of the water body due to consumption of the dissolved O_2.

Check Your Progress 4

1) Radio isotopes are the isotopes of the element whose unstable nucleus spontaneously emits radiations.

2) The alpha particles are positively charged fast moving particles whereas beta particles are electrons moving with high energy.

Check Your Progress 5

1) The main greenhouse gases are carbon dioxide, methane, nitrous oxide, ozone and water vapours. These gases form a blanket over the earth's surface and allow the short wave solar radiations to pass through and fall on the earth thereby heating the earth's surface. However, these gases do not allow the long wave radiations reflected back from the earth to escape into the space. These reflected long wave radiations are re-emitted back to the earth's surface by the greenhouse gases, thereby resulting in the build up of temperature.

2) Ozone hole resulting in penetration of harmful UV radiation and increased incidence of skin cancers and eye problems.

3) Acid rain refer to rain with $pH < 5.0$. Sulfuric acid and Nitric acid are the main components of acid rain.

2.11 FURTHER READINGS

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UNIT 3 INTERRELATIONSHIP OF ENVIRONMENT AND HEALTH

Structure

3.0 OBJECTIVES

After going through this unit, you should be able to:

- define health and discuss its concept;
- describe the process of development of a disease; and
- discuss the environmental effects on health.

3.1 INTRODUCTION

You have already learnt about the basic concepts of environment in the first unit. In this unit we shall concentrate on the interrelationship between environment and health.

Health as you will learn is a relative concept. Development of disease in an individual is determined by a number of factors. Of these environmental factors play major role and go a long way in preventing and controlling many ailments.

3.2 CONCEPT AND DEFINITION OF HEALTH

You are all familiar with the word 'health'. However, if you are asked to explain what it means, you will all come up with different concepts and views. The most commonly encountered one is 'absence of disease'. However, the mere absence of disease does not in all circumstances imply that a person is healthy. Let us take a few examples:

1) A person who has no outward symptoms of a disease may on routine examinations be found to have a high blood pressure. Will we call this person healthy?

2) A person without any obvious manifestations of the disease on routine investigation is found to have a high level of blood sugar. Will we call this person healthy?

3) A person who is outwardly normal and all his physical attributes are normal may not be able to interact well with his family or social circle. Will we call this person healthy?

In all the three situations we cannot consider the person healthy.

Another point for consideration is that health is not a state that can be constant at all times and places. It varies from place to place, person to person and in each person from time to time. It can also be argued that what it means to be healthy depends upon an individual's own perception of good health.

After having understood the concept of health, let us now try to define health.

Health has been defined as ''a state of well being for the condition of being sound in body, mind and spirit, especially freedom from physical disease or pain" or even ''health is the soundness of body and mind", by different dictionaries.

Disease has also been defined by different dictionaries differently, two of the well used ones are:

1) A condition in which bodies health is impaired, a departure from the state of health, an alteration of the human body interrupting the performance of vital functions (Webster).

2) A condition of the body or some part disrupted or deranged (Oxford English).

World Health Organization has only defined health. It defines health as:

> Health is a state of complete physical, mental and social well being and not merely an absence of disease or infirmity in order that a person is able to lead a socially and economically productive life.

This definition has been considered as an idealistic goal. In other words, it is difficult to find a person who is physically, mentally as well as socially healthy.

You can also see from the above that there is no clear boundary line between health and disease. In fact, these two states are part of a continuum. The highest state that can be reached is state of positive health and lowest when person can fall to death.

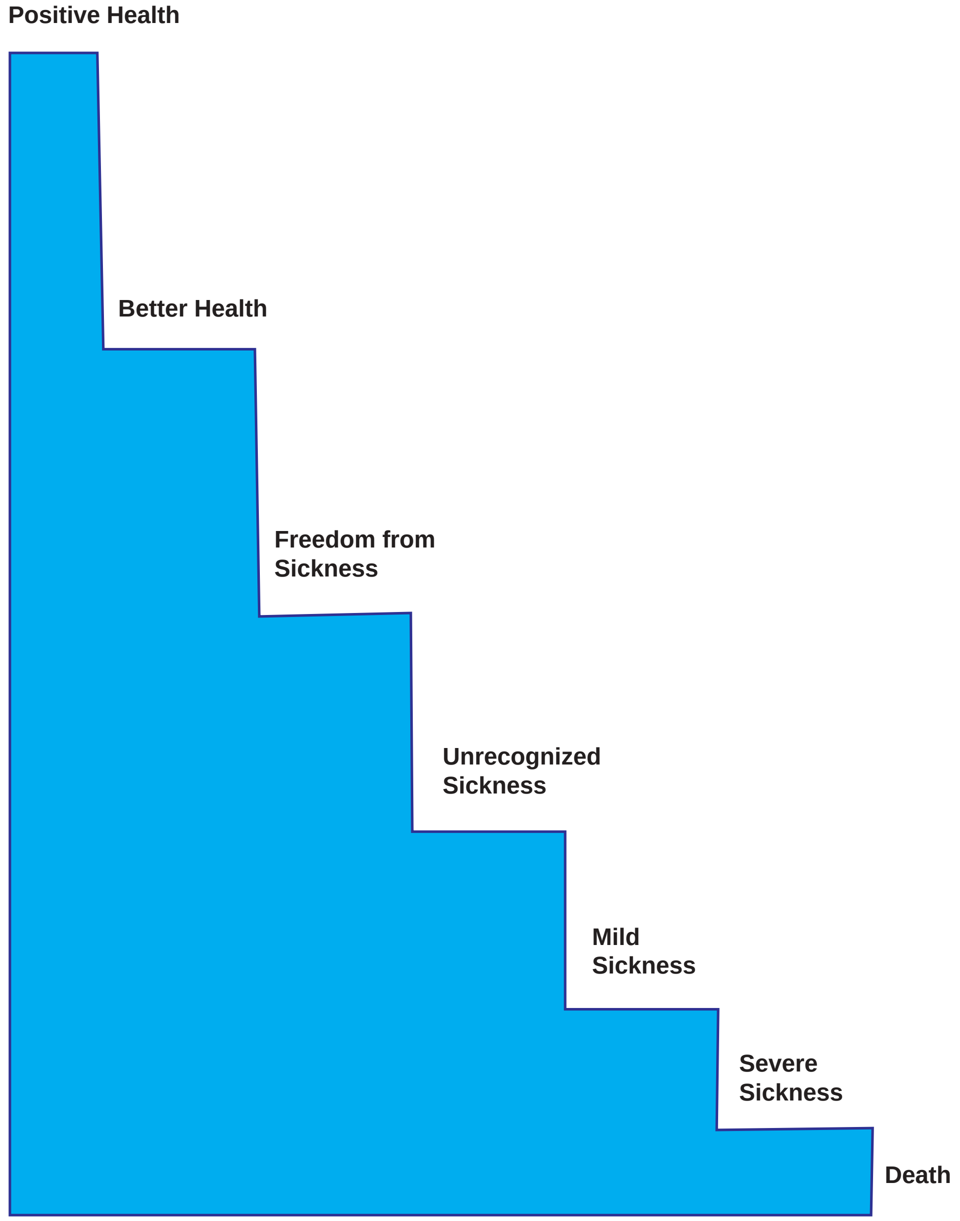

Fig. 3.1: The spectrum of health and disease

3.3 DYNAMICS OF DEVELOPMENT OF DISEASE

In this section we will try to understand why some individuals under certain circumstances start deviating from the state of being healthy. Before we go into these dynamics, it is important for us to understand the factors or determinants of health.

3.3.1 Determinants of Health

Determinants are factors that contribute to the maintenance of health. In reality it is usually a combination of factors whose interaction with each other promotes or has a negative effect on health.

The types of determinants can be grouped into the following types:

1) Biological e.g. our genetic make up. Diseases like diabetes, high blood pressure have biological factors as a predisposing one.

2) Behavioural e.g. smoking, alcohol, high fat diet, etc.

3) Again incidence of disease like high blood pressure, obesity, lung disease, etc., is affected by behavioural factors.

4) Environmental factors e.g. air, water, housing, waste disposal. The importance of the environmental factors in predisposing as well as affecting the course of both infectious and non-infectious diseases is being increasingly related.

5) Socio-economic and socio-cultural factors e.g. poverty, cultural practices and taboos especially concerned with diet, childhood and pregnancy have a strong bearing on health and disease. The duration till breast-feeding is allowed, the foods to be avoided in pregnancy, cold and hot foods are also some examples.

6) Health systems of provision of safe water, sanitary disposal of human waste.

7) Other determinants, which also have an indirect bearing on health are — aging of populations, science and technology, information and communication, human rights, etc.

"Environmental health comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations", WHO, 2005.

Check Your Progress 1

1) What is the World Health Organization's definition of health?

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2) List the groups in which determinants can be grouped?

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3.3.2 Causation of Disease

What causes a disease? Is it just a single factor like an organism or bacteria entering the body, or is it interplay of several factors. Let us take a few examples before we reach a conclusion. Let us first take the example of diarrhoea. Ingestion of the causation of diarrhoea can be said to be due to the bacteria. However, we know that every person who ingests the bacteria does not develop the disease. This implies that there must be other factors deciding whether the disease will occur or not. In-depth studies reveal that factors like a person's immunity, hygiene, the load of the organism ingested, etc., also contribute to the occurrence of the disease.

Let us now take another example — heart disease. There is no single factor which can be attributed as the causative agent. A number of factors like family history, smoking, alcohol, stress, increase the risk for heart disease. These factors are called high risk factors. Hence we see that instead of a one to one relationship with a single cause, a disease process is based on a web of several factors and is widely referred to as multifunctional causation. The factors can be grouped under these three domains, viz., the agent, host and environment. The dynamic interactions between these three can be represented in model called epidemiological triad (Fig. 3.2).

3.3.3 Natural History of Disease

Natural history of a disease is the sequence of events that cover the entire process of the evolution and termination of a disease in the absence of any treatment or presentation. In fact natural history of a disease is actually the natural course of a disease.

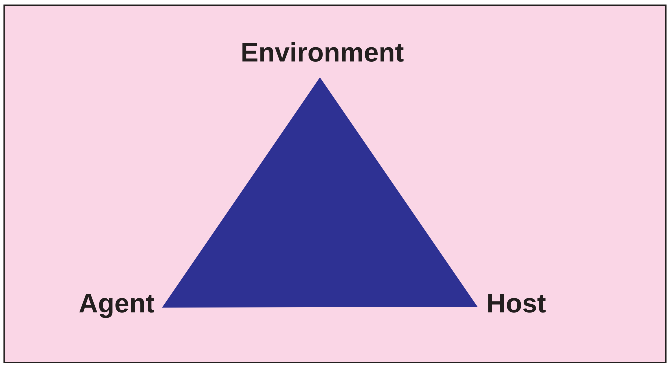

Fig. 3.2: Epidemiological Triad

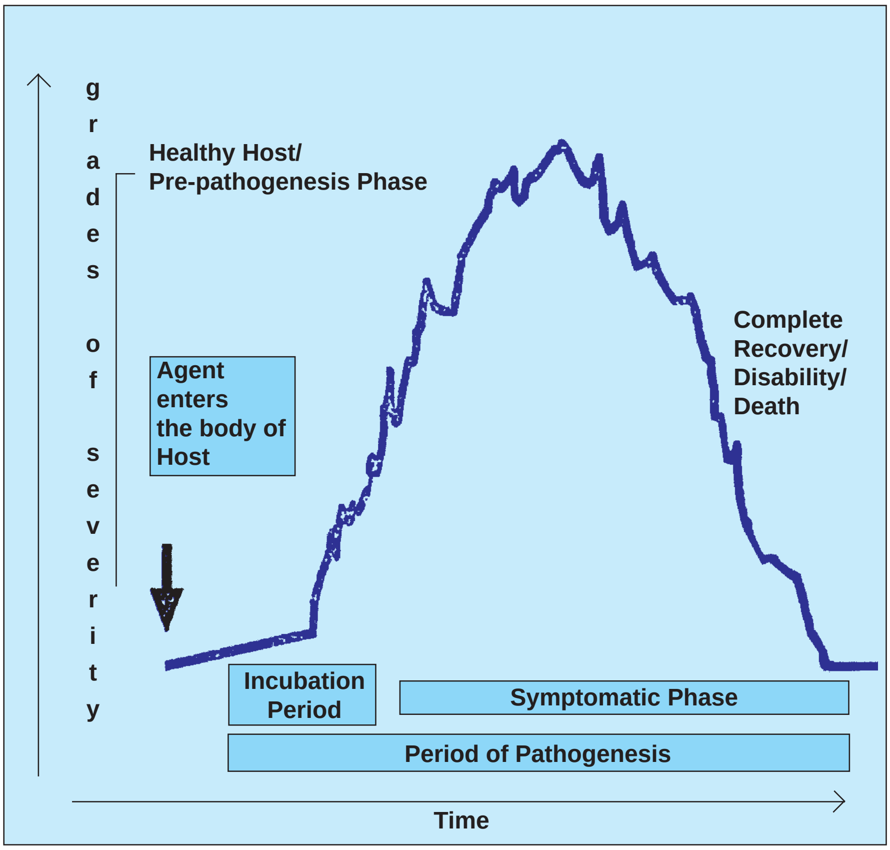

Fig 3.3: The natural history of an infectious disease

The natural history can be divided into a pre-pathogenesis period i.e. the period before the onset of the disease and the pathogenic phase or the course of diseases once the agent enters the body of an individual. As far as the environmental health is concerned, pre-pathogenesis phase is the most important part in the natural history of a disease. The disease causing agent is yet to gain access inside the human host but the interactions between agent, host and the environment as shown in epidemiological triad are most vital during this period. This is a phase when both the man and the disease agent are living side by side in the same environment and are trying to get an edge over the other. The result of this interaction shall determine the vulnerability of individuals towards a disease and the nature and load of sickness on the population. It may range from a single case to a rapidly spreading epidemic.

Pathogenesis Phase

The course of disease in man starts once the agent enters the body of a vulnerable human host. It establishes itself a suitable site and starts multiplying. This, added with the reaction of human body towards the agent, induces a chain of psychological and anatomical changes in the host. The disease passes through an incubation period before advancing to the phases of early pathogenesis and late pathogenesis. The termination of late pathogenesis phase can be in total recovery, disability or death. In many diseases, especially in the chronic ones, the early pathogenesis and late pathogenesis phases are also represented as pre-symptomatic and symptomatic phases.

Check Your Progress 2

1) Why is multifactorial causation of disease more accepted than the single cause theory?

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2) What is pre-pathogenesis and the pathogenesis phase?

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3.4 ENVIRONMENT AND ITS EFFECT ON HEALTH

There are number of pressures on the environment, which are indirectly related to either health or circumstances. These pressures are e.g. population growth, inequitable resource distribution, technological development, etc. These pressures in turn lead to a number of health hazards.

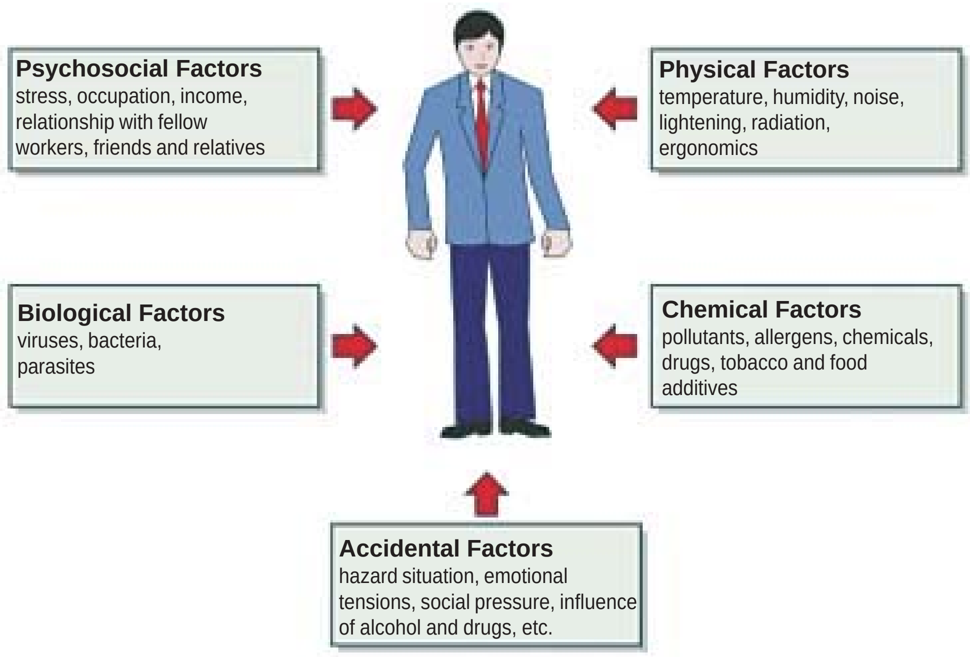

Fig 3.4: Environmental factors affecting health

Thus you can realize that environment quality is an important direct and indirect determinant of human health. In the developing countries the populations are most at risk from "traditional" environmental health hazards. These hazards include unsafe water supply and poor sanitation, poor housing, poor indoor air quality, unsafe food and high prevalence of vectors or agents that spread disease. On the other hand in developed countries the populations tend to suffer from both the "traditional" health hazards as well as from "modern" hazards like water pollution, air pollution, hazardous waste, unsafe use of chemicals, occupational hazards and traffic accidents.

There are a number of diseases that are directly the result of poor environment quality. Acute diarrhoeal disease and acute respiratory infections are the two most common ones. Other conditions include occupational hazards and vector borne disease.

3.4.1 Environmental Health Hazards

Environmental health hazards mean that any of the environmental factors, in combination or singly, interferes with normal physiological functioning of our human body and leads to disability, disease or even death. We can divide the health hazards for better understanding of their consequences into short-term and long-term health hazards.

Types of Health Hazards

1) ***Short-term Health Hazards***

These last for only days or weeks and are a result of temporary exposure to harmful materials. It is especially common among casual and contract labourers who are hired to handle hazardous material without proper safety training. Apart from a few dangerous chemicals, these short-term effects on the body usually disappear on withdrawal from exposure to the hazardous material. Only parts of the body or single organs are affected and these ill effects can also be usually treated.

Examples of these short-term hazards could be many skin allergies due to chemicals, radiation sickness due to exposure to radiation and anthrax bacterial infections of the skin among sheep and cattle skin handlers, etc.

2) ***Long-term Health Hazards***

These last for months and years and are due to long-term and continuous exposure to hazardous materials. Permanent workers and residents in the affected area are usually subject to the hazardous effect owing to the long period of stay in the same place as the hazardous material. Not only are multiple organs of the body affected but there is also continuing damage or residual damage to the human body. In some cases such as long exposure to various types of dusts, the ill effects (pneumoconiosis) persist even after removal from exposure after a number of years.

Usually these ill effects are not reversible even with treatment and the deterioration in health is progressive. If the person has chronic or long-term diseases such as hypertension, diabetes and heart diseases, these diseases could become worse in the presence of long-term exposure to certain hazardous material. In the case of long-term exposure to harmful radiation, there could be genetic mutations in the next generation of babies. The treatment is costly and not as effective. Finally, long-term exposure to hazardous materials also shortens the life span.

Examples of long-term hazards could be:

- The gradual accumulation of arsenic in the body from bore-well drinking water, leading to loss of hair, skin changes, bone damage, etc. This occurs in certain parts of West Bengal, India.
- Gradual accumulation of lead from traffic exhausts, which leads to damage to nearly all organs of the body over a period of time.
- Asthmatic attacks and allergies due to pollen grains in the air.

3) ***Transient Hazards***

The exposure of these types of hazards is usually sudden, accidental and occurs rarely. The effect on the body depends on the type and nature of the factor involved. If there is a dangerous chemical involved, the ill effect may be immediate and severe. However, the ill effect could also be only of a short duration with recovery thereafter if the factor is not so poisonous.

Examples of transient hazards could be spillage of chemicals in factories or in accidents of vehicles transporting the chemicals. The affected people in such spillages could have various skin, lung, eyes problems depending on the nature of the chemical.

Check Your Progress 3

1) Define environmental health hazards.

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2) Give one example each of short-term, long-term and transient hazards.

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3.4.2 Sources of Environmental Hazards

The sources of environmental hazards can be classified depending upon where they are present e.g. water, air, soil, etc.

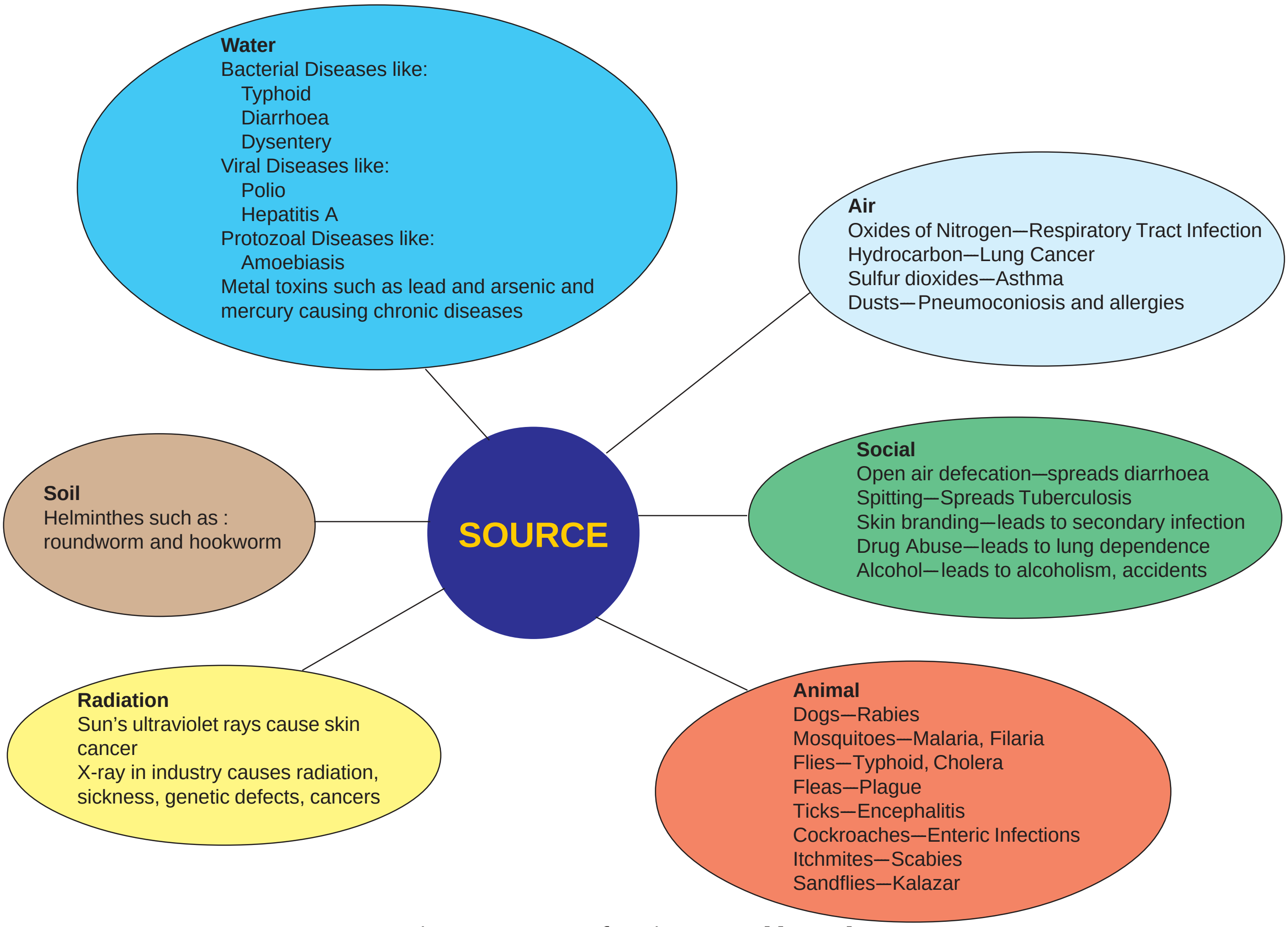

Fig. 3.5: Sources of environmental hazards

3.4.3 Effects of Hazards on Health

The effects that hazards have on the health are both direct and indirect. The direct effects are generally specific and can be easily observable or measurable. On the other hand indirect effects are long-term and cannot be easily quantified.

The amount of impact that a hazard will have on the health depends upon the dose of the insult, the frequency of administration or contract, nature and duration of application, nutritional status and the pre-existing illness.

3.4.4 Prevention and Control of Hazards

Prevention usually implies to strategies which are applied before the exposure to the hazard and the actions are usually applied on health individuals to eliminate their risk of exposure.

Control measures are usually employed after the exposure to the hazard. Action is usually taken at the individual level and aims at isolating and treating the affected people.

Check Your Progress 4

1) List the sources of environmental hazards.

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2) Fill in the blanks:

a) Effects that hazards have on the health are ………..........................……… and ……………

b) Strategies applied before the exposure to the hazard is called ....

3.5 LET US SUM UP

In this unit you have learnt about the concept of health. Since health is a relative concept, different people have defined health differently. The standard definition that is followed is the WHO definition. WHO defines health as a state of complete physical, mental and social well being and not merely an absence of disease or infirmity in order that a person is able to lead a socially and economically productive life.

There are number of factors which determine the state of health. These include biological, behavioural, environmental, socio-economic, socio-cultural and health system. Some other determinants like aging of population, gender, human rights, etc., also determine health. The development of disease in an individual is best understood by studying the natural history.

Environmental factors have a major role to play in the maintenance of health and development of disease. The environmental factors include the physical, chemical, biological, psychological and accidental factors. All these factors may act alone or in combination and act as hazards. The environmental hazards can be transient, short-term and long-term. These hazards can act directly or have an indirect effect on health. Occurrence of disease can be presented by either avoiding exposure to these hazards or by controlling them.

3.6 KEY WORDS

Determinant of Health **:** A factor that contributes to health

Environmental Health **:** Comprises those aspects of human health, including quality of life, that are determined by physical, chemical, biological, social, and psychosocial factors in the environment. It also refers to the theory and practice of assessing, correcting, controlling, and preventing those factors in the environment that can potentially affect adversely the health of present and future generations

Health **:** A state of physical, mental and social well being and not merely the absence of disease or infirmity in order that a person is able to lead a socially and economically productive life.

Health Hazard **:** Interference of normal physiological functioning of human body leading to sickness or death.

3.7 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) WHO defines health as a state of complete physical, mental and social well being and not merely an absence of disease or infirmity in order that a person is able to lead a socially and economically productive life.

2) The groups in which we can classify determinants are:

   — Biological

   — Behavioural

   — Environmental

   — Socio-economic and socio-cultural factors

   — Health system

   — Others

Check Your Progress 2

1) Disease causation is a complex process resulting from interactions between agent factors, host factors and environmental factors. One factor alone cannot sufficiently explain the genesis of disease process. This is why a group of several factors working together appear to be more rational explanation behind a disease.

2) Pre-pathogenesis phase is the period before the onset of the disease while pathogenesis phase is the period when the agent enters the body of a vulnerable host.

Check Your Progress 3

1) Environmental health hazards means any one or more environmental factors affecting the normal physiological functioning of a human body. This can lead to disability, disease or death.

2) Short-term hazard – Radiation sickness because of exposure to radiation.

Long-term hazard – Pneumoconiosis due to long exposure of disease.

Transient hazard – Spillage of chemical in factory.

Check Your Progress 4

1) The sources of environmental hazards are:

- Air
- Water
- Soil
- Animal
- Radiation
- Social

2) a) Direct and Indirect

b) Prevention

3.8 FURTHER READINGS

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UNIT 4 WASTE MANAGEMENT

Structure

4.0 OBJECTIVES

After reading this unit, you should be able to:

- identify various types of waste along with their source of origin;
- assign the correct disposal treatment method for different categories of waste; and
- discuss the life cycle of waste from its origin to its final disposal.

4.1 INTRODUCTION

All activities whether domestic, commercial and industrial generate wastes of different kinds and in different proportions. Piles of garbage scattered all around the city is a common site in developing countries. In this unit we will focus mainly on solid waste generated by domestic and commercial sectors. It is realized that mostly it is not the waste that causes the problem but the unscientific management of waste that leads to serious environmental problems. Open dumping of garbage serves as breeding ground for disease vector such as flies, mosquitoes, cockroaches, rats, etc., thereby leading to the spread of diseases like typhoid, cholera, dysentery, jaundice, plague, etc. The outbreak of plague in 'Surat' some years back is a classic example of an outbreak of disease due to insanitary conditions of the city.

The modern lifestyle has greatly affected the quality and quantity of the waste generation. Use of packaging material and plastic bags, has become an essential part of everyday life. The indiscriminate use of polyethylene bags not only creates unsightly surroundings but often leads to choking of sewers and other water bodies. Cases have been reported where polyethylene bags were found inside the cow's stomach of stray cattle.

Thus, the present scenario shows how important it is to adopt proper waste management practices.

There are three major steps involved in the management of municipal solid waste, viz., collection, transportation and disposal. However, segregation of waste at source level is a useful step prior to collection. All these steps are discussed in detail in this unit. Besides ensuring proper disposal and maintaining sanitary/hygienic conditions, waste management also involves the use of latest technology for making the best use of the waste products. Thus, the energy recovery technologies that can be made use of are:

— **Biomethanation:** Biological decomposition of organic waste to yield energy rich bio-gas which can be used for cooking purpose.

— **Sanitary landfill gas:** Bio-gas generation through sanitary landfilling process.

— **Pelletisation:** Compacting organic waste into small cubes/pellets to be used as a substitute for coal/wood.

— **Composting:** Converting organic wastes into humus by microbial action for use as a nutrient rich source in farming.

— **Vermiculture:** Utilizing earthworms for converting organic waste into bio-fertilizer to improve the soil fertility.

4.2 WASTE AROUND US

A little reflection will reveal that all human activities generate waste. In this unit we will examine waste in detail with reference to its source, characteristics so that we can evolve the most suitable method for its disposal. You will soon realize how complex is the problem of waste disposal.

In the next block you will learn about different types of health care waste and its management.

4.2.1 Definition and Identification

When we talk of wastes we generally refer to solid wastes. However, liquid waste/ wastewater and waste gases are also important categories. Let us first identify solid wastes around us. Whether one lives in a city, town or village, one can easily identify different types of waste scattered around in one’s locality. These wastes arising from residential and commercial sectors can be placed into following categories of material: papers, dirt and dust (from sweepings), metals (ferrous, aluminum, etc.), glass, plastics, rubber, textile, leather, wood, food material, garden waste, animal excreta and some other inorganic wastes.

Though the categories of wastes remain the same in urban and rural settings but their quality and quantity is different. In urban dwelling one encounters more of paper, plastic, glass and metal wastes whereas in rural setting we find more of biodegradable waste. Agriculture and food processing industry is considered to be the largest single contributor to the total annual production of solid wastes. Unfortunately, huge volumes of these wastes are set afire in order to dispose them off quickly and easily. Instead these wastes can become a good resource and generate employment when properly utilized. “What is waste to one industry may be raw material for another.” Agriculture and food processing industry wastes have tremendous potential for setting up small scale industries, viz., paper and cardboard manufacture, packing material, boxes manufacture etc. Even if these wastes are not utilized they do not pose pollution problem as they are biodegradable. Biodegradable materials are those, which break up into simpler elements naturally by the action of bacteria present in soil thereby enriching the soil with nutrients.

Thus, we see that it is not the biodegradable waste, which is of much concern, but rather the wastes such as glass, metals, plastics and polyethylene bags. Though we can manage these wastes through recycling and reusing but cost can be a constraint. Best would be minimizing the use of such products, which generate these wastes, and to strictly ban the use of polyethylene bags, which are the greatest menace. Burning of plastic particularly

PVC (poly vinyl chloride) forms highly corrosive hydrochloric acid, which is an extreme nuisance in the operation of refuse incinerators. A highly poisonous gas phosgene ($POCl_3$) may also be produced where PVC is burned at inadequately high temperatures.

Fig. 4.1: Wastes around us

4.2.2 Classification of Wastes

Wastes can be put under the following categories:

1) **Garbage:** It is the decomposable fraction of waste e.g. waste food, vegetable peelings and other organic matter. Its quality varies throughout the year. It needs careful handling because it breeds flies and insects, attracts birds and rodents for food. Garbage decomposes rapidly resulting in unpleasant odour. Valuable products like biogas, manure and animal food can be recovered.

2) **Rubbish:** Rubbish includes all non-putrescible waste except ashes. The combustibles and non-combustibles can be subjected to recycling. It includes paper, plastic, metals, glass, etc.

3) **Ashes:** Ash is the residue from solid fuel combustion incinerators as well as from refuse and biomass burning. One of the largest contributors of fly ash is the thermal power plants. Ash can create nuisance during collection and disposal.

4) **Large Wastes:** This includes demolition and construction rubble (pipes, lumber, bricks, masonry), automobiles, furniture, refrigerators and other home appliances. These wastes find their way to junk markets from where they are recycled into other useful goods. However, the demolition rubble needs to be disposed off via landfilling and thus requires some investment in terms of transportation and landfill site.

5) **Dead Animals:** Such as household pets, birds, rodents, zoo animals, cattle, etc., need to be disposed off properly so as to maintain a healthy environment.

6) **Sewage:** Sewage is the wastewater disposed from the kitchens and bathrooms. It can form the breeding ground for mosquitoes.

7) **Human Excreta:** These are a source of infection. It is an important cause of environmental pollution. The health hazards of improper excreta disposal are: soil and water pollution, contamination of foods and propagation of flies and other insects.

The sources of the above-mentioned solid wastes have been identified as:

i) **Municipal:** Street sweepings, sewage treatment plant wastes, wastes from schools and other institutions.

ii) **Domestic:** Garbage, rubbish, occasional large wastes and dead animals and ashes from some houses.

iii) **Commercial:** From stores and offices and market place.

iv) **Industrial:** Chemicals, paints, sand, explosives, sludge cakes from treatment plants, rags from textile industries and a large number of other types of wastes from various industries.

v) **Mining:** “Tailings”, slagheaps etc. from coal mining and mining of other minerals.

vi) **Agricultural:** Crop residues, farm animal excreta.

vii) **Hospital:** Anatomical and pathological wastes from hospitals.

4.2.3 Characterization of Wastes and its Importance

Characteristics of wastes are very important for the development of proper waste management systems, viz., to explore the potential for the recovery of specific waste components, reuse of certain wastes, to select appropriate method for waste disposal, by product development, suitability of a waste as a resource for manufacturing new products and to extract maximum energy and fertilizer value from them. For example, “Garbage” which comprises of biodegradable waste can be a useful source of manure as it can be subjected to composting and can also serve as a raw material for biogas generation.

Characterization of solid wastes is done on the basis of:

- Proximate analysis;
- Ultimate analysis; and
- Calorific value.

Proximate analysis involves determination of parameters like moisture content (free and inherent), volatile matter, ash content, fixed carbon and total carbon. Ultimate analysis involves elemental analysis for carbon, hydrogen, nitrogen, sulphur and oxygen. Calorific value can be determined through bomb calorimeter. Characterization of waste is an important step, which helps in determining the nature of its utilization.

The waste characteristics like bulk density, viscosity, compaction behaviour, acidity, calorific value, moisture, volatile matter, ash and fixed carbon, are explained briefly in Table 4.1.

Table 4.1: Characteristics of Waste

Bulk Density	:	Bulk density is the weight of a unit volume of a material. It is expressed in grams per cubic centimeter. The bulk density of most solid wastes is considerably lower than the ultimate density of their components. The low initial density and poor compaction characteristics of solid wastes contribute to the high cost of collection and transportation.
Compaction Characteristics	:	Compaction is required to reduce transportation costs and the disposal space. Densification of biomass is important for combustion and gasification process. Moisture affects compaction characteristics.
Viscosity	:	Viscosity is a measure of the fluid resistance to shear when the fluid is in motion. The viscosity decreases with temperature.
Acidity	:	It is important to know the pH of the liquid or semi-solid wastes as strongly acidic or basic waste require special attention in handling, storage and incineration. Strongly acidic wastes with pH less than 3.0 may be reactive and corrosive.
Calorific Value	:	Calorific value of a material is defined as the amount of heat released from combustion of a unit weight of a substance.
Moisture	:	Moisture content of solid wastes can be estimated by drying them at 104-110°C for 24 hours and then measuring the difference in weight. It is important to know the moisture content of the wastes before subjecting it to any treatment and disposal facility. Moisture affects the burning quality, composting and fermentation property of the wastes.
Volatile Matter	:	Volatile matter is estimated by heating the material in a furnace at 600°C for about 10 minutes. The material is heated in the absence of air to prevent oxidation and the volatile material such as oils and other chemical compounds volatize to gas or vapour form.
Ash	:	Complete combustion of the material results in the production of ash. It is important to know the elemental composition of the ash for its suitable applications and disposal.
Fixed Carbon	:	Fixed carbon is that portion of the solid waste that is left after driving off the moisture and volatile matter excluding ash. The fixed carbon content is calculated as follows: Fixed carbon (%) = 100 – (moisture % + volatile matter %) Total carbon = Volatile matter + Fixed carbon

Check Your Progress 1

1) List the various sources of solid waste generation along with examples.

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2) What is the importance of characterizing wastes?

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4.3 PRINCIPLES OF WASTE MANAGEMENT

Waste management involves effective and efficient management of the different types of wastes, from its generation, collection, transportation, storage and treatment to its final disposal; in such a way that it causes no threat to the environment in terms of health and safety and also ensures appropriate recovery, reuse and recycle of the materials wherever possible. Waste management is, therefore, an integrated process. The process differs for different categories of wastes. Waste management is often confused with waste disposal but, it is much more intricate, involving careful planning and handling at each of the above-mentioned stages. It involves the use of latest technology for extracting the best, whatever possible, from the waste.

Let us now discuss in detail the various steps involved in waste management.

4.3.1 Collection and Segregation

Collection

Door-to-door collection of waste is a common practice in countries of South East Asia and is done through privately hired scavenging staff. This system is quiet efficient since the housekeeper ensures that the waste is prepared for collection everyday. This collected waste is then dumped at a municipal dust bin, made to cater to the need of individual localities. These dust bins are often flooded with stray animals (viz., dogs, pigs, cows, etc.) and are often mis-managed leading to overflowing of waste into streets and adjoining areas. The air in this area often stinks making it difficult for the nearby residents as well as passers-by. It often creates unsightly and unhygienic conditions. The waste from these dust bins is collected by municipal trucks and disposed off to a landfill site.

Segregation

Apart from domestic waste, commercial waste from shops and market complexes is also managed in a similar fashion. Besides, there is also an informal sector which consists of individuals and groups of waste pickers, dealers and wholesalers selling solid wastes as raw materials to material recovery units.

Unlike solid waste, liquid wastes also have their origin from domestic, commercial and industrial sectors. While liquid wastes from domestic and commercial sectors are disposed off through closed or open channels into municipal drains, industrial liquid waste needs to be properly treated in specially built treatment plants before they are discharged into any river or natural streams. The objective of treating the industrial waste before discharge is to make it chemically inert, pathogen free and safe for nature to recycle and recharge it.

Mixing of industrial wastewater with municipal sewage drains, although strictly prohibited, has sadly become common practice. Segregation is the process of separating the various components in the waste. It has been explained that the characteristics of waste to a very large extent depend upon the source from where waste is produced and to a considerable extent is influenced by the process. In simple terms, industrial waste consists of chemicals and metallic parts, largely non-biodegradable. The domestic waste contains a mixture of biodegradable and non-biodegradable wastes. Biodegradable wastes are those waste which originate from life forms. Examples of biodegradable wastes include food wastes, wastes produced in the vegetable market yard, paper, clothes, rags, dead animals, etc. The non-biodegradable wastes include metal cans, plastic wares, glass wares, ceramics, etc.

It stands to reason that the time taken for degradation will depend on the characteristics of the waste, some very short and some very long. Generally speaking, more complex wastes (that is admixture of several types of wastes), compact, dense or solid wastes, large volume of wastes all take longer time to undergo degradation. The objective of segregation is to separate the various kinds of wastes so that appropriate treatment can be given to each type separately and thus hasten the degradation process. The other objectives are to separate the reusable and non-usable, recyclable from non-recyclable. Segregation is best carried out at the time of collection, but can be carried out at subsequent stages also. A chart showing segregation of waste helps in recycling waste into material is provided in Fig. 4.2.

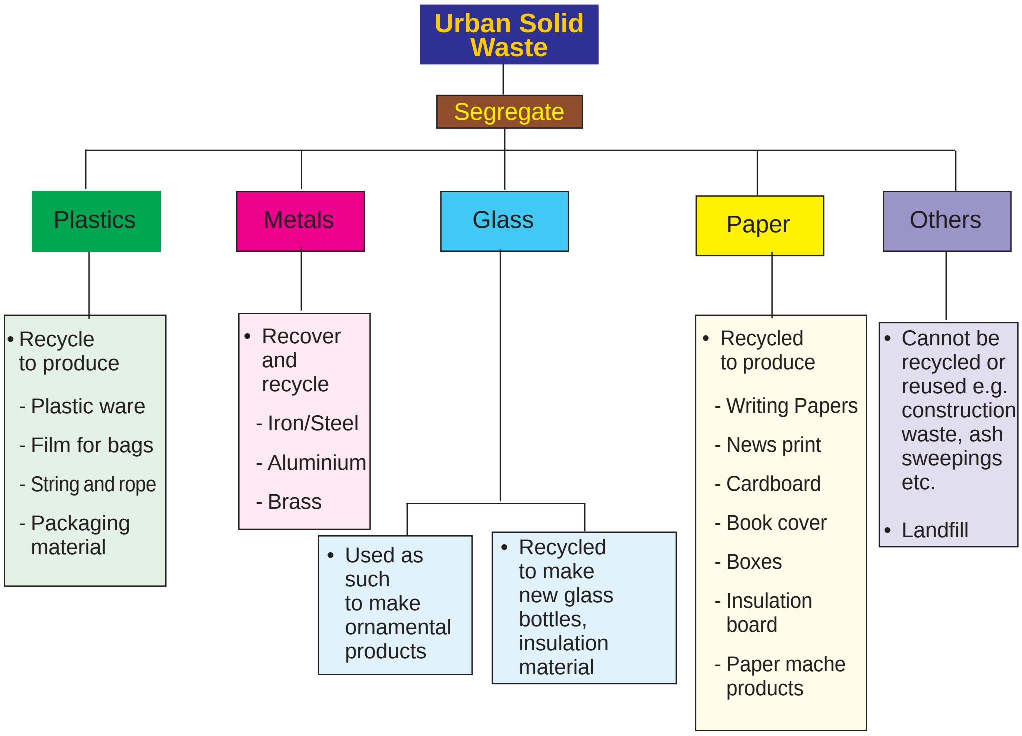

Fig. 4.2: Chart showing how segregation of wastes helps in recycling wastes into useful material

4.3.2 Recycle, Recovery and Reuse

Recycle: Recycling is another important waste disposal method. Here some of the waste products are used as raw materials to produce either similar materials or other materials of daily use. Broken glass pieces are used by the glass factory to produce new glass products. Similarly waste paper is recycled to produce paper, plastic wastes are recycled to produce plastic wares and so on. Sometimes in the recycling process many waste materials are combined, e.g., rags are also used in the manufacture of paper. Recycling should be encouraged as it is an efficient economical method of waste disposal for the finished product is marketable while the raw material used is almost free. You can see some examples of recycling in Fig. 4.3.

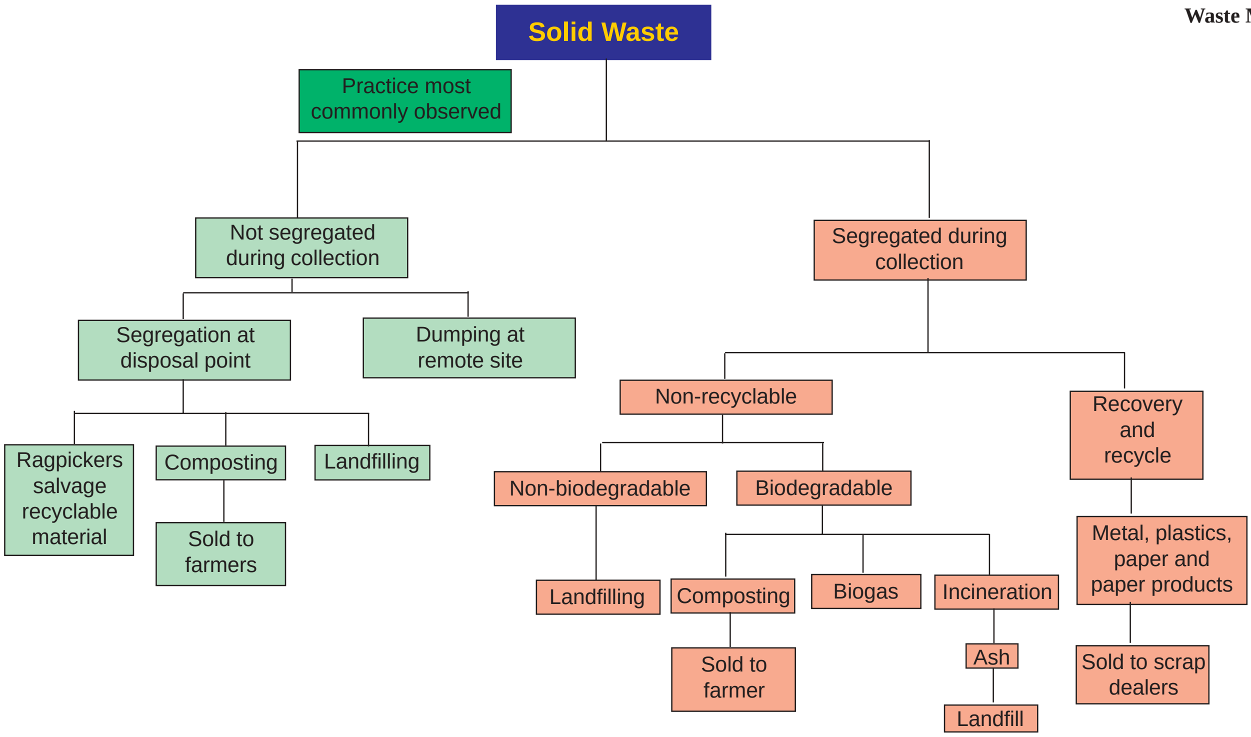

Fig. 4.3: Management of solid wastes

Composting

In 1985, Maharashtra Agricultural Bioteks was formed and established a small plant to manufacture vermicompost from agricultural waste. The organization currently produces 5,000 tons of vermicompost annually. Its real achievement, however, has been in raising awareness among farmers, researchers and policy makers in India about regenerative food production methods. The group is directly responsible for 2,000 farmers and horticulturists adopting vermicomposting. These converts have begun secondary dissemination of the principles they were taught. Nearly 1,000 farmers have reduced their use of chemical fertilizers by 90 per cent by using vermicompost as a soil amendment for growing grapes, pomegranates and bananas. Similar work is underway on mangoes, cashews, coconuts, oranges, limes, strawberries and various vegetable crops.

The organization has devised methods to convert biodegradable industrial waste like pulp waste from paper mills and filter cake and liquid effluent from sugar factories into vermicompost. These wastes are commonly regarded as pollutants, but three facilities are already producing 30 tons of vermicompost each month from this waste.

Through the simple act of eating, earthworms promote bacterial growth, enhance soil structure and hasten the decomposition of organic matter. However, due to different feeding habits, not all earthworms are suitable for vermiculture. Earthworms are divided into two groups — humus formers and humus feeders. The first group dwell on the surface and feed on nearly 90 per cent fresh organic materials and 10 per cent soil. They are generally red in colour, have a flat tail and are also called epegic or detritivorous worms. It is these worms that are harnessed for vermicomposting. The second group, the humus feeders, is deep burrowing worms that are useful in making the soil porous and mixing and distributing humus through the soil.

There is confusion between the terms reuse and recycle, they are used with the same meaning. Reuse as explained is using the material for the same purpose for which it was originally manufactured, a syringe used for drawing blood or for giving injection, bottles and tins used as containers are used again for the same purpose. On the other hand, recycling involves using the material to remanufacture either similar product or some other product. For example broken glass syringes can be used for manufacturing new syringes or glass containers. Plastic wastes can be used for the manufacture of cheap plastic household items and so on. Thus recycling is different from reuse.

Recovery: Recovery is similar to recycling but usually restricted for recovering metals and expensive materials which goes in the waste. One good example of recovery is the recovery of silver from the wash fluids from the photo studio. Goldsmiths always recover gold from the shop sweepings. Magnetic recovery systems are used to recover ferrous materials in the domestic and city wastes. The recovered materials generally are used as raw materials.

Reuse: Wastes can be classified in yet another way, namely, reusable and not reusable. Glass bottles and metal containers are good examples of reusable waste product. We are familiar with hair oil bottles, medicine bottles and such other products which are marketed in glass bottles, when empty, are washed and used to store some other materials. Similarly milk powder tins, edible oil tins are also used. Appropriate reuse of reusable waste is desirable as it can effectively reduce the volume of waste for disposal. Those articles which are labeled disposable and are intended for single use (e.g. disposable syringes, infusion sets, etc.) should never be reused.

4.3.3 Transportation and Disposal

Solid waste is transported in corporation trucks which goes around in different parts of the town and collect refuse or garbage from community bins. This activity usually takes place in the day time and creates nuisance for the commuters and pedestrians as these trucks emit offensive stench all along the route from which they pass. While in big cities these trucks cover the waste to prevent unsightly view, in many towns the trucks or carts do not cover the waste thus creating a double nuisance of obnoxious odours as well as unsightly view. Many ill managed trucks often go dropping the waste all along the route from which they pass.

This waste transportation problem can be prevented by some simple steps:

i) The collection and transportation of waste by corporation trucks should be done at night time preferably after mid-night.

ii) Trucks should be designed in such a manner that they are air tight so that neither offensive smell is emitted nor is there any dropping of waste while transportation. Collection and transportation of waste in the night time will prevent unhygienic and unsightly experiences by the commuters and local people. It would also ensure speedy transportation of waste to disposal site due to absence of traffic jams. Prior to disposal, waste material needs to be treated according to its characteristics in order to hasten the degradation process.

It was stated early in this unit that an important step in the waste management is the waste treatment. The aim of treatment is to "transform" the waste so that it loses its waste characteristics, and either becomes a useful product for some other purpose or it loses its infectious or toxic character and becomes safe for life forms and environment. That is, at the end of treatment, the waste is no longer capable of creating any problem. Obviously this generalized statement is a simple explanation of complex combination of physical and chemical action.

Nearly 75-80 per cent of all collected residential and commercial solid wastes are sent to open dumps. Less than 10 per cent is buried in sanitary landfills. A small but locally significant quantity is even dumped in nearby waste bodies. The reminder is incinerated to get rid of waste easily and immediately. Some of the common disposal methods include:

i) **Open Dumping:** This is the most common method of solid waste disposal. The collected refuse is dumped in open areas be it roadside, residential areas, parks, etc. Open dumps produce health and air pollution problems and are not an acceptable method of disposal. They cause public health problems by encouraging the growth of flies, rats, cockroaches, mosquitoes and attract birds and other animals. This in turn leads to typhoid, cholera, plague, dengue and other diseases.

ii) **Sanitary Landfills:** A method of disposing of refuse on land without creating nuisance or hazard to public health and safety, by utilizing principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume and to cover it with a layer of earth at the end of each day. When properly run, a sanitary landfill is odourless, smokeless and ratless. The sanitary landfill may be spread over the land area or a trench. In a well run sanitary landfill operation the soil covering has been deep enough to keep out rodents and flies and it prevents the escape of noxious odours. A carefully sited landfill should not be near a community groundwater reservoir as rain water may leach pollutants into the water supply.

iii) **Incineration:** Incineration involves the burning of solid wastes. Air pollution can be a major problem, because of emissions of highly toxic pollutants into the atmosphere during the burning process. The important factors to be observed during incineration are: (i) Never burn plastics, nor wastes contaminated with heavy metals (like mercury or lead), (ii) Maintenance of a temperature greater than 850°C to burn up not only the waste but also the smoke produced, and (iii) Ensure the presence of grit extractors to filter the finely divided dust particles, impeding them from discharging into the atmosphere.

iv) **Pyrolysis:** Pyrolysis unlike incineration involves heating the wastes at very high temperatures but in the absence of oxygen in order to produce useful chemicals and combustible gases. Thus it is an energy recovery technique as the obtained products are petroleum like mixture of gases and liquid which can be burned as fuel.

Check Your Progress 2

1) What is the importance of segregation?

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2) What precautions one must observe while reusing articles salvaged from waste?

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3) What is recycling of waste? How it is different from reuse?

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4) Which is the most unhygienic method of waste disposal?

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5) Which waste disposal method gives useful energy rich products?

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4.4 WASTE DISPOSAL VERSUS WASTE MANAGEMENT

These two terms are used commonly with the same meaning. However, they are different. Waste disposal simply means to "get rid off" the waste. It does not matter what happens to the waste, or what problem it creates at the new place. On the other hand, waste management is a comprehensive procedure where every step from waste generation to the final disposal is planned action. One crude way of describing waste management is that the waste is so handled that it does not complicate the existing problem. Waste management also ensures that the operating cost is minimized and every effort is made to generate new resources from waste.

In developing countries the most common practice of waste processing is uncontrolled open dumping/burning. This method involves little capital investment and has low operational costs.

However, these uncontrolled dumps have a negative effect on the landscape and surrounding environment. If combustion occurs regularly toxic gases are emitted. Also waste and soil pollution occur.

Let us consider a very common example; the uncooked waste food that comes from the kitchen is thrown along with other household wastes. These are then dumped by the city sanitation department or by the household itself at some distance away from

Fig. 4.4: Life cycle of waste

the city or the house and allowed to degrade by itself. The process gives an unsightly mound of rotting garbage, emitting offensive stench. It also becomes the abode for vermin who are in search of food, and a breeding place for flies.

Consider an alternate way of treating the same waste. Since these are food waste, they can be fed to the animals. Alternatively it may be buried in the ground in shallow trenches where after a short period of a few months, it would become biomass, which is something like manure. Yet another alternative is to put it in the biogas generator along with other materials for the generation of bio-gas. Only some common examples are stated here, there are several other methods that are beyond the scope of present discussion. The point that is being made is that in all the three methods, the waste is effectively used as a resource, viz., as an animal feed, soil nutrient and bio-gas generation. In each one, the final outcome is clean, efficient sanitary final disposal of the waste. What is the end result of the waste management? Firstly, the waste is disposed off in a sanitary manner so that neither the process nor the end products are offensive and unsightly. It is also important that the process or the procedure is cost effective. Secondly, one should be able to recover the resources to the maximum be it recyclable material, biogas for energy or manure for use as organic fertilizer. In fact a good waste management system, in addition to paying for itself is also capable of giving profits. Lastly, at the end of the process, nothing offensive is left or no new environmental or health problems are created. That is, the waste disposal technique should not cause pollution of air, water, or soil and should not become a health hazard for the life forms.

Check Your Progress 3

1) What is waste management?

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2) How does it differ from waste disposal?

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3) Why is incineration a hazardous practice?

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4.5 LET US SUM UP

Wastes are generated because of the normal life process and also because of development related human activities. The waste is generated because of the human activities is complex and large in volume. It is the natural decomposition process, which finally disposes the waste and allows it to enter the nature's recycling process. We can augment the process of the waste disposal by segregating the waste into biodegradable and non-biodegradable and thus reduce the quantity of waste, which will be subjected to natural decomposition process, at the same time putting the non-biodegradable waste to profit oriented uses such as recycling. Useful products such as biogas and organic fertilizer can be obtained by appropriate management of biodegradable waste. The integrated process of sanitary disposal of waste along with generation of resources from the waste is the objective of waste management.

4.6 KEY WORDS

Biodegradation	:	Decomposition due to the action by micro-organisms
Environmental Sanitation	:	The control of all those factors in the man's environment which exercise or may exercise a deleterious effect on his physical development, health and survival
Enzymes	:	An organic catalyst produced by the living cells but capable of acting independently of the cells producing them. All enzymes are proteins by nature
Night Soil	:	Human excreta
Pathogens	:	Microbes which cause disease

Sanitary : Promoting or pertaining to conditions improving health

Sewage : Human excreta, liquid waste together with street washing, industrial waste and storm water

Soil Bacteria : Bacteria which are normally found in soil

Street Washing : Waste materials from street surface, sidewalks, etc.

4.7 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Sources of solid waste generation are:

   i) **Municipal:** Street sweepings, sewage treatment plant waste

   ii) **Domestic:** Garbage, rubbish

   iii) **Commercial:** Paper, plastic, cardboard boxes, packaging material

   iv) **Industrial:** Chemicals, rags, oil

   v) **Mining:** Tailings, ashes

   vi) **Agriculture:** Crop residues, farm animal excreta

   vii) **Hospital:** Cotton swabs, anatomical and pathological waste, sharps

2) Characterization of wastes is important for not only knowing the type of waste but also for developing proper waste management system. It is important to know about the wastes potential for recovery, whether it is suitable for reuse or whether it can be recycled. After knowing the characteristics of wastes we can subject them to the most appropriate disposal method, which would help in not only hygienic and safe disposal but also in recovering energy and fertilizer value.

Check Your Progress 2

1) Segregation helps to sort out different components of waste so that appropriate treatment can be given to each type and thus hasten the degradation process. It also reduces the volume of the waste by separating out the reusable and recyclable parts.

2) Reuse of articles of waste should not be done for the same purpose for which the article was initially made. Articles, which are labeled disposable and are intended for single use should never be used.

3) Recycling of waste is the use of waste as raw material for the production of similar or some new product e.g. glass.

   In reuse, the material is used as such e.g. a container is used as container.

4) Open dumping

5) Pyrolysis

Check Your Progress 3

1) Waste management is the comprehensive procedure of planned action for all steps involved from waste generation to its final disposal. The aim of waste management is that apart from being the "most economically viable" solution, it will ensure that no new problems are created while solving the existing problem.

2) Waste disposal is one step in waste management, usually the end step. When the term is used alone (not as a part of waste management), it does not cover the other possible environmental pollution that may result.

3) Burning plastics, and notably PVC containing plastics will allow highly toxic molecules to form dioxins and furans. These chemicals are amongst the most dangerous. Incinerators can also discourage segregation and turn, with time, into dump sites where all is finally burnt. Burning mercury containing wastes (from broken thermometers, for example) is a health risk, as mercury will evaporate and fall back, polluting water, the soil/plants.

4.8 FURTHER READINGS

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UNIT 1 MANAGERIAL AND ADMINISTRATIVE ASPECTS

Structure

1.0 OBJECTIVES

After going through this unit, you should be able to:

- discuss the importance of systems approach to health care waste management;
- enumerate personnel involved in health care waste management and explain importance of training them;
- explain the complete evaluation process for health care waste management including setting up of waste audit; and
- identify and learn the functions of each functionary of waste management committee in the hospital.

1.1 INTRODUCTION

Bio-medical waste or health care waste (HCW) has assumed great importance the world over because of the serious hazards it poses to the environment in general and the public in particular. An inappropriate treatment and disposal of health care waste can lead to spread of infectious diseases like tuberculosis, hepatitis, enteric fever, HIV infections, etc. At the same time it poses an occupational health hazard not only to doctors, nurses, paramedics but also to personnel in house keeping, maintenance and waste handling. Thus the hospitals end up spreading the very diseases which it is meant to contain. Therefore, today there is a greater need to manage the health care waste in the most scientific manner.

In the South-East Asian Region, hospital waste management has now become a serious concern, largely due to reports in the print and audio-visual media which brought into limelight the plight of rag pickers who rummage through the waste and segregate materials which are sent for recycling. The proper management of health care waste depends largely on good administration and organization but also requires adequate legislation and financing, as well as active participation by trained and informed staff.

In this unit, you will learn about various managerial tools for proper health care waste management. Systems approach explains the interdependence of various components of health care waste like segregation, treatment at source, collection, transfer, intermediate storage, on site treatment, off site transport and final disposal. Systems approach also brings to the forefront the need for evaluation at every step and overall impact assessment for the medical staff, patients, health care facility in specific and community at large.

This unit emphasis the importance of having a proper organizational structure for health care waste management. Role and functions of each human element has been defined with emphasis on periodic training in improving quality of human resource in health care waste management. Importance of periodic assessment and audit has been explained in detail for your understanding of complete health care waste management system. In the next unit you will learn about infection control and waste management in greater detail.

1.2 MANAGEMENT TOOLS

We will now discuss the different management tools for setting up a sound health care waste management system.

1.2.1 Systems Approach

During recent years, many management scholars and writers have emphasized the need of systems approach to the study and analysis of any problem.

A system is essentially a set or assemblage of interconnected, interdependent, things that form a complex unity. These things may be physical such as the parts of an automobile engine or they may be biological like components of human body. All systems, except perhaps that of the universe, interact with, and are influenced by, their environments, although we define boundaries for them so that we can see them more clearly and analyze them. Thus when managers plan health care waste management they have no choice but to take into account such external variables as markets, technology, social forces, laws and regulations of the state and country. When they design an internal organizational system in a health care establishment for waste disposal, they cannot help but be influenced by the behaviour patterns people bring to their jobs from the environment external to an enterprise.

System also plays an important part within the area of managing itself. There are different areas like planning, organization system for health care waste, control or monitoring system and within these we can perceive many sub-systems such as system of human resource, system of costing and budgeting, system of collection of waste, system of segregation of waste, system of transport of waste and system of final disposal of waste.

WHO has recommended a systems approach involving the handling, storage, transport, treatment and disposal of waste by methods that at all stages minimize the risk to health and the environment. The World Health Organization (WHO) states that the human element is more important than the technology and almost any system of treatment and disposal i.e. operated by well-trained and well-motivated staff can provide more protection for staff, patients and the community, than an expensive or sophisticated system i.e. managed by staff who do not understand the risks and the importance of their contribution. The management of health care waste is basically a systems problem, usually beginning in clinical departments and wards. It involves the removal and disposal of the waste as hygienically and economically as possible by methods that at all stages minimize the risk to health and the environment.

Operations within organizations are composed of system and sub-systems working to produce outcomes that fulfil the aim of each system. To achieve desired outcomes the elements of system must be working together and not against each other. Although this sounds very straight forward, it is surprising how many systems are not aligned and actually are counter-productive within the organization. The late quality guru W. Edwards Deming indicated that we must optimise the operations of the interdependent components within an organization to accomplish the aim of the system. To ensure that medical waste is handled, containerized and stored properly, the environmental services staff within a health care facility must work with the doctors, nurses, laboratory staff and others that generate medical waste in their provision of services to patients. They must also work with purchasing staff to ensure that adequate bags, storage containers and treatment equipment are purchased in a timely manner. Input must also be provided to those that negotiate contracts for the facility to obtain services to haul away untreated medical waste for off site treatment. Although this is not an exhaustive list of all that is involved with medical waste, it does indicate that the medical waste handling system interfaces and interacts with a number of systems within the facility.

All of these systems must work together for the good of the organization, which in this case, is the proper handling, storage, transportation and treatment of medical waste. When this is accomplished, it will not only ensure compliance with the laws governing medical waste, but it will also lead to community and worker protection. When these systems are put together, proper medical waste handling should result.

Waste managers need to create sustainable systems that are economically affordable, socially acceptable and environmentally effective.

There are certain basic principles, which must be followed while laying down the system of health care waste management in any health care set up. These are:

a) Conducting a waste audit

b) Minimization and recycling of waste wherever possible

c) Identification of points of generation of waste

d) Segregation of waste at source

e) Compiling inventory of waste

f) Disinfection at the point of generation

g) Waste transportation: on-site and off-site

h) Waste treatment on-site or off-site

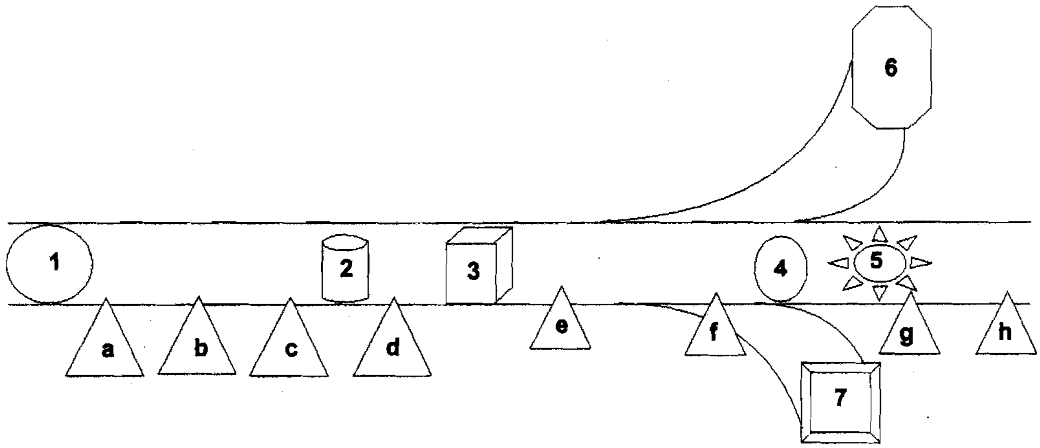
i) Final disposal

j) Occupational safety

k) Continuous monitoring of the system

l) Training of staff

While laying down the system it will be necessary to plan the health care establishment taking into consideration the generation and movement of the waste within the health care establishment as well as outside. The movement of waste must also include the interventions, which are required to be done at different points. The whole plan of movement of treatment and intervention is depicted in Fig. 1.1.



Intervention

(a) Disinfection
(b) Mutilation by Needle destroyer, Syringe cutter, Scissors, etc.
(c) Segregated collection in coloured containers/ buckets etc. with same coloured plastic bag inside
(d) Movement to Kerb collection point
(e) Movement by covered hand carts
(f) Recycling of certain waste
(g) Regular monitoring
(h) Waste Audit

Movement of Waste

1. Point of generation
2. Collection at point of generation
3. Kerb collection area
4. Final treatment option
5. Secured landfill area
6. Vermicomposting area
7. Recyclables to vendors

Note: In case common use facility is planned to be used, movement of waste by road in appropriate container is to be planned.

Fig. 1.1: Movement of waste and interventions

Facilities that generate health care waste should set up a comprehensive waste management system based on the most appropriate means of achieving the safe, environment friendly management of waste. The system should start with basic measures and then gradually be improved.

Important activities include:

- Assignment of responsibilities for waste management
- Allocation of sufficient human and financial resources
- Waste minimization, including purchasing policies and stock management practices
- Segregation of waste at the point of generation into infectious and non-infectious categories
- Implementation of safe handling, storage, transportation, treatment and disposal options
- Monitoring the system

In order to monitor system it would be necessary to have periodic audit of the whole system and apply remedial measures wherever required. Continuous monitoring and training is also an important aspect in hospital waste management system. Training capsule must be developed for doctors, nursing officers, paramedical staff and other waste handlers separately in the languages they understand and periodically the training programme should be implemented to refresh and update their knowledge and skills to ensure a sound waste management system.

Check Your Progress 1

1) **Define system.**

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2) Enumerate basic principles which must be followed while laying down the system of health care waste management in any health care set up.

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3) Make a checklist for systems approach for health care waste management.

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1.2.2 Sources of Health Care Waste

It is essential to review the list of health care waste producers in a community before identifying specific health care workers involved in health care waste management. Different departments within health care establishment produce different types of health care waste, which needs special treatment and disposal depending on risks involved.

The sources of health care waste can be classified as major or minor according to the quantities produced. The major sources of health care waste are listed below:

a) Hospitals

   i) University;

   ii) General; and

   iii) District hospital

b) Other Health Care Establishments

   i) Emergency medical care services

   ii) Health care centers and dispensaries

   iii) Obstetric and maternity clinics

   iv) Outpatient clinics

   v) Dialysis centers

   vi) First aid posts and sick bays

   vii) Long term health care establishment and hospitals

   viii) Transfusion centers

   ix) Military medical services

   x) Primary health centres, sub-centres

c) Related Laboratories

   i) Medical and bio-medical labs

   ii) Biotechnology labs

   iii) Medical research center

d) Mortuary and Autopsy Centers

e) Blood Banks and Blood Collection Services

f) Nursing Homes for the Elderly

While minor and scattered sources may produce some health care waste in categories similar to hospital waste their composition will be different. For example:

a) They rarely produce radioactive or cytotoxic waste

b) Human body parts are generally not included

c) Sharps consist mainly of hypodermic needles.

Minor sources of health care waste are given below:

a) Small health care establishments like physicians offices, dental clinics, acupuncturists, chiropractors, clinics of indigenous system of practitioners.

b) Specialized health care establishments like convalescent nursing homes, psychiatric hospitals, disabled person institutions, dermatological centres.

c) Non-health activities like cosmetic ear piercing, tattoo parlors, illicit drug users

d) Funeral services

e) Home treatment

f) Ambulance services

The composition of wastes is often characteristic of the type of source e.g., the different units within a hospital would generate waste with the following characteristics:

a) Medical Wards: Mainly infectious waste such as dressings, bandages, plaster, gloves, hypodermic needles, IV sets, body fluids and excreta, contaminated packaging and metal scraps.

b) Operating Theaters and Surgical Wards: Mainly anatomical waste such as tissues, organs, foetuses and body parts, other infectious waste and sharps.

c) Other health care units like OPD: Mostly general waste with a small percentage of infectious waste like bandages, syringes and hypodermic needles.

d) Laboratories: Mainly pathological, highly infectious waste cultures, stocks, blood and body fluids.

e) Pharmaceuticals and Medical Stores: General and pharmaceutical waste.

f) Support Units: General waste.

Average distribution of health care waste in terms of its composition is as follows:

a) 80 per cent general health care waste, which may be dealt with by the normal domestic and urban waste management system.

b) 15 per cent pathological and infectious waste which requires special handling and treatment.

c) 1 per cent sharps waste will require special handling, packaging, storage treatment, transport and final disposal

d) 3 per cent hazardous, chemical or pharmaceutical waste requires special handling and disposal

e) Less than 1 per cent special waste such as radioactive or cytostatic waste, pressurized containers, broken thermometers and used batteries.

After understanding the sources and variety of health care waste emanating from health care establishments it is important now to focus on health care provider groups, who deal with health care waste management.

Four main categories of personnel in hospital are involved in health care waste management:

a) Hospital managers and administrative staff

b) Doctors

c) Nurses and assistant nurses

d) Cleaners, porters, auxiliary staff and waste handlers.

External to the health care establishment, following personnel are involved in management of health care waste:

a) Health care waste management operators–private or public

b) Transportation staff who are drivers and waste handlers

c) Treatment plant operators

d) Landfill operators

1.2.3 Importance of Training

All individuals exposed to health care waste are potentially at risk, including those within health care establishments that generate hazardous waste and those outside these sources who either handle such waste or are exposed to it as a consequence of careless management. An urgent need of training public health care workers and waste handlers in proper health care waste management provides knowledge about proper health care waste management and reduces the incidence of hazards caused by medical waste.

The objectives of public education or community education on health care waste management are as follows:

a) To prevent exposure to health care waste and related health hazards; this exposure may be voluntary in case of scavengers, or accidental, as a consequence of unsafe disposal methods.

b) To create awareness and foster responsibility among hospital patients and their attendants regarding hospital hygiene and health care waste management.

c) To inform the public about the risks linked to health care waste, focusing on people living or working in close proximity to, or visiting health care establishment, families of patients treated at home, and scavengers on waste dumps.

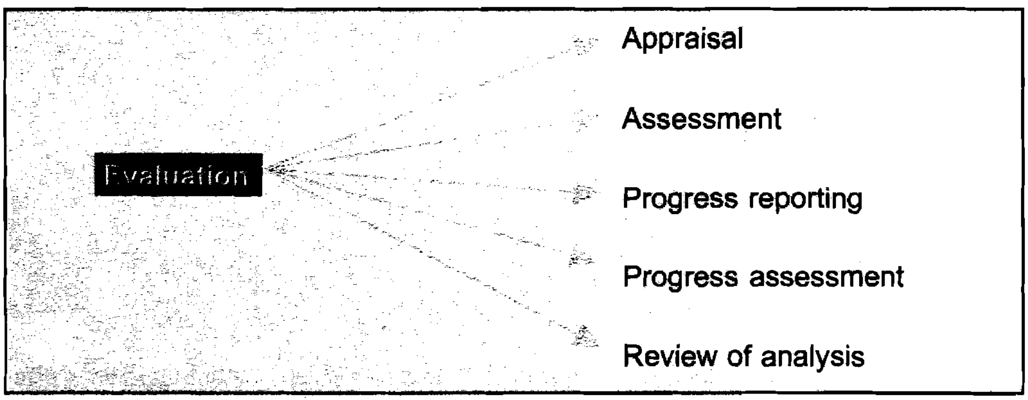
A policy for the management of health care waste cannot be effective unless it is applied carefully, consistently and universally. Training of health care personnel in implementing the waste management programme is thus critical. The overall aim of training is to develop awareness of health, safety and environmental issues relating to health care waste and how these can affect employees in their daily work. Training is also essential for them to understand their roles and responsibilities in the overall health care waste management plan.

People visit dispensaries and hospitals for healing and treatment of disease. Doctors and staff of hospitals have role of health educators of the society and are expected to inculcate among public the importance of clean air, water, healthy surroundings and good living practices. Very often we read newspaper reports and articles about the reuse of plastic syringe, IV canulas, needles, etc. This danger is very real. There are many cases of septicemic shock due to inadvertent use of contaminated syringes and needles. Thus it is the responsibility of all hospital managers to ensure that waste generated in their hospitals is handled and subsequently disposed in such manner, so as not to cause harm to environment and personnel and that's why training of managers is required on this aspect.

It is also common finding at every health care establishment in developing countries that doctors, nurses and paramedical workers have a high degree of knowledge and awareness about health care waste management. However, they lack an attitude for practicing the same. Hence there is a need to give practical training and attitude development training to these health care workers.

1.2.4 Evaluating the System

Evaluation is the process of determining the degree of success in achieving predetermined objectives. Measurement of action against accepted criteria and interpretation of relationship amongst them is also called evaluation.



Periodic assessment of services will facilitate timely corrective action to ensure quality assurance.

Why do we need evaluation?

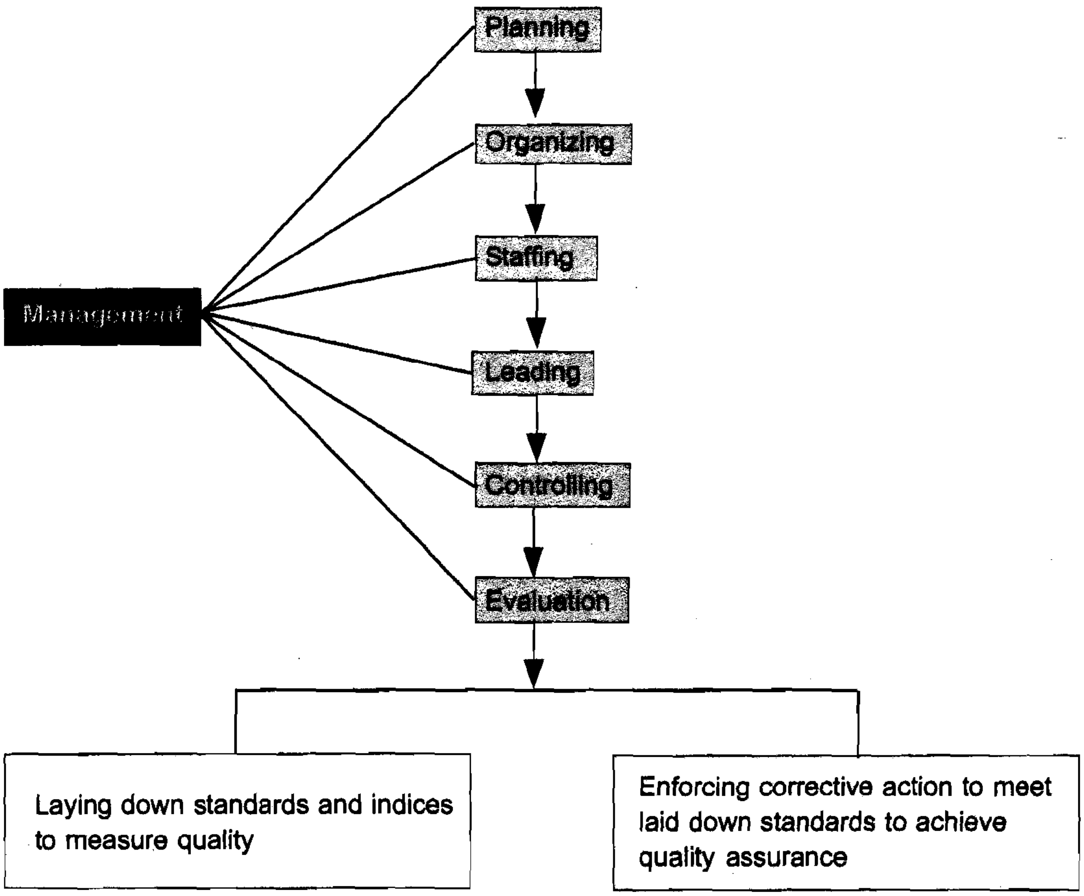
a) To safeguard interest of recipients of hospital care which is the moral and legal obligation of administrative and professional authorities.

b) To ensure that hospitals render safe and efficient medical services to patients.

c) To locate inadequacies and shortcomings of hospital staff, its plant and machinery, its working system.

d) To provide authorities a sound appraisal system comprising of evaluating knowledge, attitude and practice towards effective evaluation of staff at various levels, hospital administrator, individual physicians, nurses and paramedical workers.

Evaluation is one of the vital tasks in the process of management.



a) **Formative Evaluation**

   i) Carried out while the activity is still going on

   ii) It is part of continuous monitoring

   iii) It helps to identify features where improvements are possible

b) **Summative Evaluation**

   i) Carried out on completion of the project or activity

   ii) It is terminal

   iii) It enables judgement on what has been done

What to evaluate?

Five Indicators for Evaluation

a) Structural factors like physical facilities, personnel, finances, and materials.

b) Process factors like policies, procedures and actual utilization of resources.

c) Content like actual plan

d) Outcome factors for the hospital

e) Impact assessment for the community

Evaluation is carried through many standing committees like Infection Control Committee, Waste Management Committee, etc.

Evaluation of End Results

Judging the effectiveness or ultimate outcome of the benefits derived by individual health care worker and community from the health care institution. Any change in health status which could relate to reduced incidence of sharp injuries, any change in pattern of health and diseases due to lowered incidence of hospital acquired infection, any health effects due to environment changes, because of operating of incinerator, autoclave and microwave.

Evaluation Stages

a) ***Setting Out Questions***

   i) Baseline information like situation before starting health care waste management programme, statements about policies, priorities and programme

   ii) Input information like resources used in the programme

   iii) Process information — describing situation after the activity or during the activity

b) ***Sources of Information***

   i) Hospital records and statistics: All relevant data must be judiciously utilized.

   ii) Surveys: Includes attitudes of communities and health care workers, may be quantifiable or qualitative

   iii) Feedback: From staff, from management, from community

c) ***Obtaining Information:*** Information can be obtained from different sources as mentioned above.

d) ***Assessment of Information:*** How and by whom it can be carried out:

   i) External agency (experts involved in similar activities)

   ii) Service providers (people who administer the services)

   iii) Users (beneficiaries of the services).

Management of health care waste by a health care establishment should be viewed as a continuous process with periodic monitoring and assessment by the institution as well as by the responsible national and state government agency. Recommendations on treatment methods should be regularly updated to keep pace with new developments.

The national agency will base its assessment primarily on reports from the health care establishment on their success in implementation of waste management plan. It should review annual reports submitted by the heads of the establishments and make random visits to carry out audits of the waste management systems. Any deficiencies in the waste management system should be pointed out to the head of the establishment in writing, together with recommendations for remedial measures. The time limit for implementation of remedial measures should be specified and head of the establishment should be informed of the follow up date.

Off site waste treatment facilities, incinerator operators, road haulage contractors and landfill operators should also be audited.

Periodic review of waste management practices by both the national government agency and the health care establishments should result both in improved protection of occupational and public health and in enhanced cost effectiveness of waste disposal.

Sample questionnaire for collection of data for evaluation of any health care waste management system is attached as Annexure to this unit. This data collection system can be modified to suit individual health care establishment requirement. As mentioned earlier, evaluation may be carried out by an external agency like Pollution Control Board, Non-Government Organizations (NGO's) or individual experts or, in house by continuous evaluation by health care waste management committee.

Air quality monitoring in the vicinity of hospital incinerator to check the impact of hospital incinerators/common bio-medical waste treatment facility. Ground water quality monitoring near landfill sites will also help in identifying impact of health care waste management system on the community.

Indirect indicators for impact assessment on hospital patients could be lowering of hospital acquired infection rate.

Check Your Progress 2

1) Enumerate main categories of personnel in hospital involved in health care waste management.

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2) Define evaluation.

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3) Why do we need evaluation of system?

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1.3 ADMINISTRATIVE ASPECTS

To ensure a sound health care waste management system we will learn more about the role of infection control and health care waste management committee in establishing and running the waste management system.

1.3.1 Infection Control Committee

You will learn that the key to the administrative control of hospital infection is the constitution of a hospital infection control committee (HICC) consisting of senior doctors, microbiologist, hospital administrator and matron with co-opted members from blood bank, housekeeping, laundry, Central Sterile Supply Department (CSSD) and engineering services. The microbiologist/senior doctors should be the in-charge of HICC. The HICC functions at the policy-making level on hospital infection surveillance and control programme.

HICC should be tasked to do the following:

a) Formulate simple, effective and practical policies for infection control and surveillance with the help of suggestions and cooperation of every specialist.

b) It is responsible for producing infection control manual giving clear policies of antibiotic use, waste disposal protocols for aseptic precautions, high-risk areas, isolation practices, universal precautions, etc.

c) Meet every month to review and evaluate the surveillance and infection control policies and measures.

d) Circulate a monthly infection control bulletin informing all the staff of the occurrence and remedial instructions based on site specific, ward specific and type specific incidence rates of Hospital Acquired Infection (HAI) reported by Infection Control Team (ICT).

e) Advice head of the establishment on deploying resources, manpower and purchase of equipment and materials, etc.

As HICC has specific responsibilities to control HAI. Considering the importance of safe management of health care waste, there is a need to highlight health care waste management activities in terms of specific responsibilities, like waste audits, awareness programmes and monitoring in the HICC systems. However, a conjoint action along with health care waste management committee is still required as far as overall control of HAI is concerned.

1.3.2 Health Care Waste Management Committee

It is a sound organizational policy to have a waste management committee, especially in large hospitals. The Committee should be chaired by the Head of the health care institution and the Officer In-charge of hospital waste management committee should be the member secretary. The function of the waste management committee is to:

- ensure top quality hospital waste management in the health care institution.
- evolve and formulate the hospital waste management policy and ratify it.
- lay down the duties of the various officers for hospital waste management.
- evaluate and monitor effective waste management in hospitals.
- ensure proper and timely training programmes for all categories of workers.

The head of the hospital should form a waste management team to develop a waste management plan. The team should have the following members:

1) Head of the Hospital (Chairman)
2) Heads of Hospital Departments
3) Infection Control Officer
4) Chief Pharmacist/Medical Stores In-charge
5) Radiation Officer/Physicist
6) Nursing In-charge (Senior Nursing Officer)
7) Officer In-charge of operation theatres
8) Hospital Manager
9) Hospital Engineer
10) Financial Controller
11) Waste Management Officer (if already designated).

In certain establishments, the structure may include a Hospital Hygienist, in addition to or instead of the Infection Control Officer, to address specific problems relating to hospital hygiene. In such cases, some or all of the duties of the Infection Control Officer specified below will be carried out by the Hospital Hygienist.

The Head of the Hospital should formally appoint the members of the waste management team in writing, informing each of them of their duties and responsibilities. In an institution i.e. not directly involved in patient care, such as a medical research institution, the head of the establishment should use his discretion to appoint members of the waste management team from among the relevant staff. He/she should appoint a waste management officer with overall responsibilities for the development of the hospital waste management plan and for the subsequent day to day operation and monitoring of the waste disposal system. Depending on availability of relevant staff, this post may be assigned to the Hospital Engineer, Hospital Manager, or any other appropriate staff member at the discretion of the Head of Hospital.

1.3.3 Conjoint Action

As brought out earlier there are clearly demarcated functions of Infection Control Committee and Waste Management Committee, however, there is a need to coordinate their activities. Infection Control Officer acts as a liaison officer between two committees. His duties specific to health care waste management are as follows:

The Infection Control Officer should liaise with the waste management officer on a continuous basis and provide advice concerning the control of infection and the standards of the waste disposal system other than this his/her duties are to:

- identify training requirements according to staff grade and occupation;
- organize and supervise staff training courses on safe waste management;
- liaise with the department heads, the matron, and the hospital manager to coordinate the training;
- responsibility for ensuring good waste management practices and waste minimization.

1.3.4 Key Persons in Health Care Waste Management

Management Structure, Liaison Paths and Duties

A typical hospital waste management structure is shown in Fig. 1.2, with line management responsibilities and liaison paths between key personnel involved in the handling of health care waste. This structure may be adjusted to the particular needs of each hospital. The sharing of duties of key personnel in large hospitals is described in the following paragraphs; in smaller hospitals, one individual may fulfil two or more sets of responsibilities, but the same principles will apply.

Role of Head of Hospital

The Head of Hospital is responsible for the following tasks:

- Forming a waste management and infection control team to develop a written infection control and waste management plan for the hospital. The plan should clearly define the duties and responsibilities of all members of staff, both clinical and non-clinical, in respect of the handling of health care waste, and establish lines of accountability.
- Designating a waste management officer (WMO) to supervise and coordinate the waste management plan. The Head of Hospital retains overall responsibility for ensuring that health care and other wastes are disposed off in accordance with national guidelines

- Allocating sufficient financial and personnel resources to ensure efficient operation of the plan.
- Ensuring that monitoring procedures are incorporated in the plan. The efficiency and effectiveness of the disposal system should be monitored so that the system can be updated and improved when necessary.
- Immediately appointing a successor in the event of personnel leaving key positions in the waste management team (or temporarily assigning responsibility to another staff member until a successor can be appointed).
- Ensuring adequate training for key staff members and designating the staff responsible for coordinating and implementing training courses.

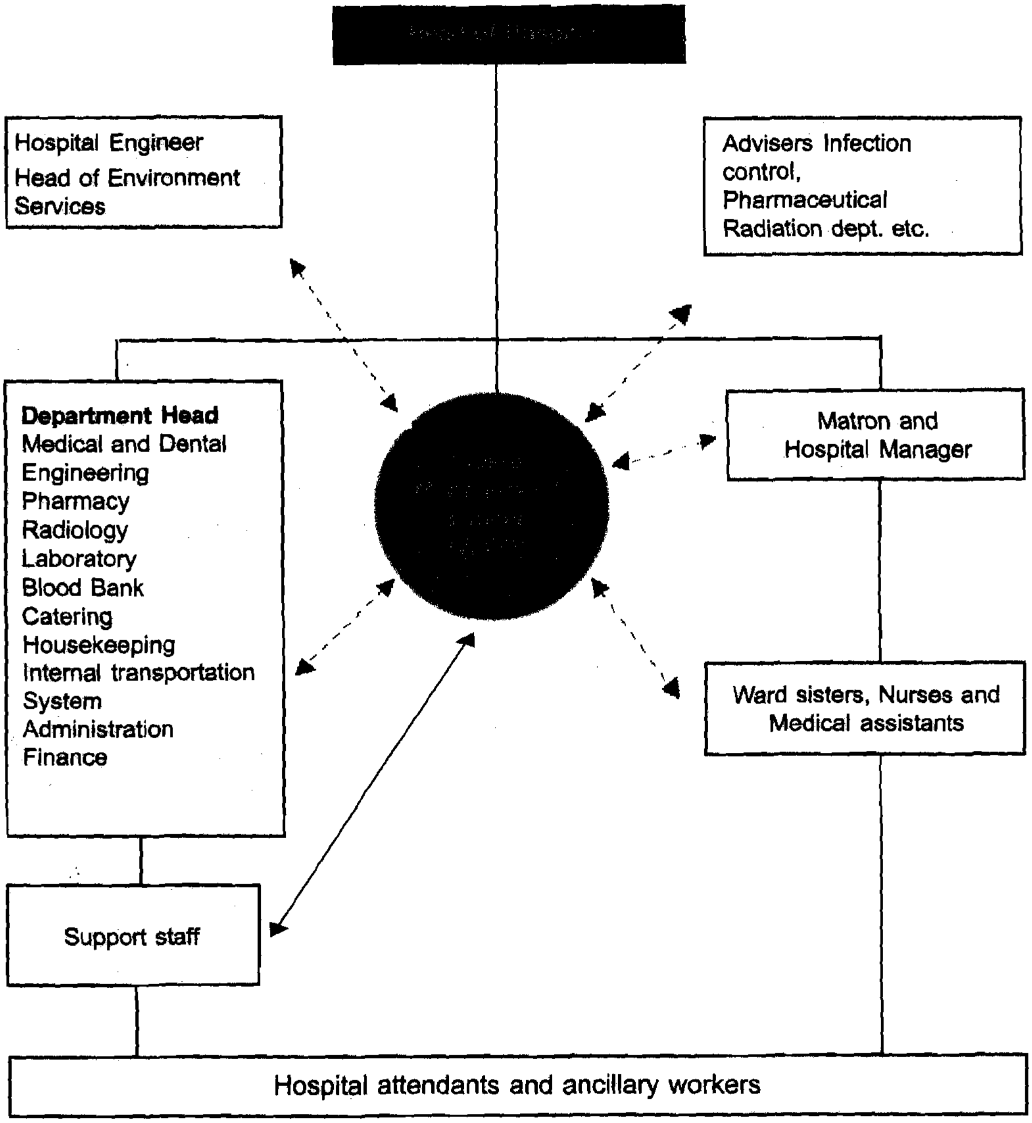

Fig 1.2: Health Care Waste Management Committee Structure

- - - - - - Liaison paths

______ Line management paths

Role of Waste Management Officer

The Waste Management Officer (WMO) is responsible for the day-to-day operation and monitoring of the waste management system. It is therefore essential that he/she have direct access to all members of the hospital staff (see Fig. 1.2). The WMO is directly responsible to the Head of Hospital.

In the area of waste collection, the WMO should:

- control internal collection of waste containers and their transport to the central waste storage facility of the hospital on a daily basis;
- liaise with the supplies department to ensure that an appropriate range of bags and containers for health care waste, protective clothing, and collection trolleys are available at all times;
- ensure that hospital attendants and ancillary staff immediately replace used bags and containers with the correct new bags or containers;
- directly supervise hospital attendants and ancillary workers assigned to collect and transport health care waste.

Concerning waste storage, the WMO should:

- ensure the correct use of the central storage facility for health care waste, should be kept locked but should always be accessible to authorized hospital staff;
- prevent all unsupervised dumping of waste containers on the hospital grounds.

To supervise collection and disposal of the waste, the WMO should:

- coordinate and monitor all waste disposal operations;
- monitor methods of transportation of wastes both on and off-site and ensure that wastes collected from the hospital are transported by an appropriate vehicle in a well defined route to the designated treatment and disposal site;
- ensure that waste is not stored for longer than specified in the guidelines and that the transport organization (which may be the local authority or private contractor) collects the waste with the required frequency.

For staff training and information, the WMO should:

- liaise with the matron (or senior nursing officer) and the hospital manager to ensure that training is given to the nursing staff, nursing students and medical assistants about their responsibilities for segregation and storage of waste. Similarly with housekeeping supervisor to ensure, training of hospital attendants and ancillary staff;
- liaise with department heads to ensure that all doctors and other qualified clinical staff are aware of their responsibilities regarding segregation and storage of waste and that the responsibilities of hospital attendants and ancillary staff are limited to the handling and transport of sealed bags and containers;
- awareness material on health care waste management are displayed throughout the health care institutions.

For incident management and control the WMO should:

- ensure that written emergency procedures are available, that they are in place at all times, and that personnel are aware of the action to be taken in the event of an emergency;
- investigate and review any reported incidents, accidents concerning the handling of health care waste.

In addition, the WMO should continuously monitor certain parameters, which are listed in Box 1.1.

Box 1.1: Parameters to be Monitored by the Waste Management Officer

Waste generated each month, by waste category:

- In each department;
- Segregation, treatment and disposal methods.

Financial aspects of health care waste management:

- Direct costs of supplies and materials used for collection, transport, storage, treatment, disposal, decontamination, and cleaning;
- Training costs (labour and material);
- Costs of operation and maintenance of on-site treatment facilities;
- Costs for contractor services like cost for centralized facilities.

Public health aspects

- Incidents resulting in injury, "near misses", or failures in the handling, separation, storage, transport or disposal system, which should also be reported to the Infection Control Officer; this will be the basis for preventive measures to prevent recurrences.
- **Regulatory mechanism:** Ensure compliance of the waste management system with the national legislation.
- **Training Awareness:** To coordinate training programmes for all the staff members.

Role of Department Heads

Department Heads are responsible for the segregation, storage and disposal of waste generated in their departments. They should:

- ensure that the staff in their departments are aware of the segregation and storage procedures and that all personnel comply with the highest standards;
- continuously liaise with the WMO to monitor working practices for failures or mistakes;
- ensure that key staff members in their departments are given training in waste segregation and disposal procedures;
- encourage medical and nursing staff to be vigilant so as to ensure that hospital attendants and ancillary staff follow correct procedures at all times.

Role of Physician to Prevent Infection

Physicians have unique responsibilities for the prevention and control of hospital infections:

- by providing direct patient care using practices which minimize infection;
- by following appropriate practice of hygiene (e.g., hand washing, isolation);
- serving on the infection control committee;
- supporting the infection control team.

Specifically, physicians are responsible for:

- protecting their own patients from other infected patients and from hospital staff who may be infected;
- complying with all the practices approved by the infection control committee;

- obtaining appropriate microbiological specimens when an infection is present or suspected;
- notifying cases of hospital-acquired infection to the team, as well as the admission of infected patients;
- complying with the recommendations of the antimicrobial use committee regarding the use of antibiotics;
- advising patients, visitors and staff on techniques to prevent the transmission of infection;
- instituting appropriate treatment for any infections they themselves have and taking steps to prevent such infections being transmitted to other individuals, especially patients;
- ensure good waste segregation practices.

Role of the Microbiologist

The microbiologist is responsible for:

- handling patient and staff specimens to maximize the likelihood of a micro-biological diagnosis;
- developing guidelines for appropriate collection, transport and handling of specimen;
- ensuring laboratory practices meet appropriate standard;
- ensuring safe laboratory practice to prevent infections in staff;
- ensuring the appropriate handling of infectious wastes in collaboration with housekeeping services;
- performing antimicrobial susceptibility testing following internationally recognized methods and providing summary reports of prevalence of resistance;
- monitoring sterilization, disinfection and the environment where necessary;
- timely communication of results to the Infection Control Committee or the hygiene officer;
- epidemiological typing of hospital micro-organisms where necessary.

Role of the Nurse In-charge

The nurse in-charge of infection control is a member of the infection control team and health care waste management team and responsible for:

- identifying nosocomial infections;
- investigation of the type of infection and infecting organism;
- participating in training of personnel;
- participating in outbreak investigation;
- development of infection control health care waste management policy;
- ensuring compliance with the waste management system, and other local and national regulations to prevent infections;
- liaison with public health and other facilities where appropriate;
- providing expert consultative advice to health staff and other appropriate hospital programmes in matters relating to transmission of infections.

Role of the Nurse In-charge of a Ward

The nurse in-charge of a ward is responsible for:

- maintaining hygiene, consistent with hospital policies and good nursing practice in the ward;
- monitoring aseptic techniques, including hand washing and use of isolation;
- reporting promptly to the attending physician any evidence of infection in patients under the nurse's care;
- initiating patient isolation and ordering culture specimens from any patient showing signs of a communicable disease, when the physician is not immediately available;
- limiting patient exposure to infections from visitors, hospital staff, other patients, or equipment used for diagnosis or treatment;
- maintaining a safe and adequate supply of ward equipment, drugs and patient care supplies.

Role of the Director of Central Sterilization Service

The responsibilities of the central sterilization service are to clean, decontaminate, test, prepare for use, sterilize and store aseptically all sterile hospital equipment.

It works in collaboration with the Infection Control Committee and other hospital programmes to develop and monitor policies on cleaning and decontamination of:

- reusable equipment;
- contaminated equipment, including:
  - wrapping procedures, according to the type of sterilization,
  - sterilization methods, according to the type of equipment,
  - sterilization conditions (e.g. temperature, duration, pressure, humidity);
- the director should oversee the use of different methods — physical, chemical and bacteriological — to monitor the sterilization process;
- maintain complete records of each autoclave run and ensure long-term availability of records;
- maintain close collaboration with housekeeping services and the waste management officer.

Role of the Director of Food Service

The director of food services must be knowledgeable in food safety, staff training, storage and preparation of foodstuffs, job analysis and use of equipment.

The head of catering services is responsible for:

- defining the criteria for the purchase of foodstuffs, equipment use, and cleaning procedures to maintain a high level of food safety;
- ensuring that the equipment used and all working and storage areas are kept clean;
- issuing written policies and instructions for hand washing, clothing, staff responsibilities and daily disinfection duties;
- ensuring that the methods used for storing, preparing and distributing food will avoid contamination by micro-organisms;
- ensuring appropriate handling and disposal of wastes, in collaboration with the waste management officer;
- establishing programmes for training staff in food preparation, cleanliness and food safety.

Role of Director of the Laundry Service

The laundry is responsible for:

- developing policies for the collection and transport of dirty linen;
- defining, where necessary, the method for disinfecting infected linen, either before it is taken to the laundry or in the laundry itself (in collaboration with the waste management officer);
- developing policies for the protection of clean linen from contamination during transport from the laundry to the area of use;
- developing criteria for selection of site of laundry services:
  - ensuring appropriate flow of linen, separation of "clean" and "dirty" areas,
  - recommending washing conditions (e.g., temperature, duration),
  - ensuring safety of laundry staff through prevention of exposure to sharps or laundry contaminated with potential pathogens.

Role of the Housekeeping Service

The housekeeping service is responsible for the regular and routine cleaning of all surfaces and maintaining a high level of hygiene in the facility. In collaboration with the Infection Control Committee it is responsible for:

- developing policies for the sound management of the different types of medical wastes throughout the various stages—production, segregation, storage, collection, transport and disposal of waste (e.g., practices, use of specific containers, frequency, etc.);
- assisting the waste management officer, responsible for the day-to-day operation and monitoring of the waste management system. It is, therefore, essential that he/she has direct access to all members of the hospital staff;
- classifying the different hospital areas by varying need for cleaning.

The housekeeping service should have a continuing programme for staff training. This programme should stress personal hygiene, the importance of frequent and careful washing of hands and cleaning methods (e.g., sequence of rooms, correct use of equipment, dilution of cleaning agents, sound management of wastes, etc.). Staff must also understand causes of contamination of premises and how to limit this, including the method of action of disinfectants.

Cleaning staff must know to contact staff health officer in case of any accident while working in hospital.

The housekeeping staff should be responsible for:

- internal collection of waste containers, replace used bags and containers with the new bags and containers and their transport to the central waste storage facility of the hospital on a daily basis;
- liaise with the supplies department to ensure that an appropriate range of bags and containers for health care waste, protective clothing, and collection trolleys are available at all times;
- prevent all unsupervised dumping of waste containers on the hospital grounds.

Role of Maintenance Department

Maintenance is responsible for:

- collaborating with housekeeping, nursing staff or other appropriate groups in selecting equipment and ensuring early identification and prompt correction of any defect;
- carrying out inspections and regular maintenance of the plumbing, heating, and refrigeration equipment, and electrical fittings and air conditioning; records should be kept of these activities;
- developing procedures for emergency repairs in essential departments;
- ensuring environmental safety outside the hospital, e.g., waste disposal, water sources, in close collaboration with the waste management officer.

Additional special duties include:

- participation in the choice of equipment if maintenance of the equipment requires technical assistance, inspection, cleaning and regular replacement of the filters of all appliances for ventilation and humidifiers;
- testing autoclaves (temperature, pressure, vacuum, recording mechanism) and regular maintenance (cleaning the inner chamber, emptying the tubes);
- calibrating mercury devices and ensuring proper handling of mercury;
- monitoring the recording thermometers of refrigerators in pharmacy stores, laboratories, the blood bank and kitchens;
- regularly inspecting all surfaces – walls, floors, ceilings, to ensure they are kept smooth and washable;
- repairing any opening or crack in partition walls or window frames;
- maintaining hydrotherapy appliances;
- notifying infection control of any anticipated interruption of services such as plumbing or air conditioning.

Role of Nursing Administrator

The senior nursing administrator and the hospital manager are responsible for training nursing staff, medical assistants, hospital attendants, and ancillary staff in the correct procedures for segregation, storage, transport, and disposal of waste. They should therefore:

- liaise with the Emergency Medical Officer and the advisers (Infection Control Officer, Chief Pharmacist and Radiation Officer) to maintain the highest standards by promoting the development of infection control committee;
- participate in staff introduction to, and continuous training on the handling and disposal of health care waste;
- liaise with department heads to ensure coordination of training on waste management activities, other waste management issues specific to particular departments, etc.;
- do surprise checks/monitor the system of health care waste management;
- supervising the implementation of techniques of new borns operating suite, intensive care units;
- promoting the development and improvement of nursing techniques and on going review of aseptic nursing policies with approval by the Infection Control Committee;
- also responsible for supervising the implementation of techniques for the prevention of infections in specialized areas such as OTs, the ICUs, the maternity units and newborns.

These responsibilities of the nursing administrator ensures infection control in patient care practices and prevents spread of infection in the hospital.

Role of Chief Pharmacist

The Chief Pharmacist is responsible for the sound management of pharmaceutical stores and for pharmaceutical waste minimization and obtaining and storing and distributing pharmaceutical preparations which limit potential transmission of infection. His/her duties are to:

- liaise with department heads, the waste management officer, the Nursing Administrator, and the Hospital Manager, giving advice, in accordance with the national policy and guidelines, on the appropriate procedures for infection control and pharmaceutical waste disposal;
- coordinate continuous monitoring of procedures for the disposal of pharmaceutical waste;
- ensure that personnel involved in pharmaceutical waste handling and disposal receive adequate training;
- ensuring the safe utilization of genotoxic products and the safe management of genotoxic waste.

The chief pharmacist also has functions of infection control by participating in hospital sterilization and disinfection practices through participation in:

- development of guidelines for antiseptics, disinfectants, and products used for washing and disinfecting the hands;
- guideline development for reuse of equipment and patient materials;
- developing the waste management system, namely, for the adequate disposal of obsolete drugs and vaccines;
- quality control of techniques used to sterilize equipment in the hospital including selection of sterilization equipment (type of appliances) and monitoring.

Role of Radiation Officer

The duties and responsibilities of the Radiation Officer are the same as those of the Pharmaceutical Officer but also relate to radioactive waste.

Role of Store In-charge

The Supply Officer should liaise with the waste management officer to ensure a continuous supply of the items required for waste management (plastic bags and containers of the right quality, spare parts for on-site health care waste treatment equipment, etc.). These items should be ordered well in time to ensure that they are always available, but accumulation of excessive stores should be avoided. The Supply Officer should also investigate the possibility of purchasing environment friendly products (e.g. PVC-free plastic items and mercury free products).

Role of Hospital Engineer

The Hospital Engineer is responsible for installing and maintaining waste storage facilities and handling equipment that comply with the specifications of the national guidelines. She/he is also accountable for the adequate operation and maintenance of any on-site waste treatment equipment and is responsible for the staff involved in waste treatment, ensuring that:

- Staff receive training in the principles of waste disposal and are aware of their responsibilities under the hospital waste management plan;
- Staff operating on-site waste treatment facilities are trained in their operation and maintenance.

1.3.5 Waste Handlers: An Important Group

Waste handlers are an important group. As you are aware waste handlers (sanitary staff, conservancy staff, *safai karmacharis*) are the key persons in health care waste management as is evident from following tasks analysis chart in any health care establishment.

Table 1.1: Task Analysis Chart for Waste Handlers

Steps	Doctors	Nurse Staff	Paramedical	Waste handlers
Concept	Yes	Yes	-	-
Training	Yes	Yes	Yes	Yes
Staffing	Yes	Yes	-	-
Segregation	Yes	Yes	Yes	Yes
Collection/Containment	-	-	-	Yes
Storage	-	-	-	Yes
Chemical treatment of sharps/plastics	-	Yes	Yes	Yes
Transportation	-	-	-	Yes
Sharp Burial	-	-	-	Yes
Equipment operation (Incinerator, Autoclave, etc.)	-	-	Yes	Yes
Loading/Unloading of waste in equipment	-	-	-	Yes
Wards and departments cleanliness	-	-	-	Yes
Waste audit	-	Yes	Yes	Yes
Monitoring	Yes	Yes	Yes	Yes
Record keeping		Yes	Yes	Yes

Senior member of sanitary staff must form part of infection control/health care waste management committee. In the developing countries sanitary staff generally comes from lower strata of society and, therefore, there is a need to involve them throughout the process of health care waste management. Their participation will raise their self-esteem, as they will realize that they are equal and important partners in health care waste management. Training in safe handling waste is a must as among waste handlers, awareness of the need of safety may decrease with time which will increase the risk of injury. Periodic refresher training, weekly group demonstration and correction on the job is recommended.

The following motivational measures will be helpful in long-term sustainenance of health care waste management in any health care establishment:

a) In monthly health care waste management committee meeting involve sanitary staff and supervisor.

b) Best performers name be published in hospital newsletter.

c) Whenever new equipment/concept has to be incorporated in the system obtain waste handlers views as they have to handle it.

d) Financial as well as non-financial incentives in the form of recognition should be offered to waste handlers periodically.

e) Be a part of monitoring team as cross monitoring by waste handlers will ensure good segregation practices.

Training of waste handlers should cover the following areas:

a) Hazards of mismanagement of health care waste

b) Wearing of protective clothing/equipment

c) Appropriate cleaning and disinfection procedures

d) Colour coding of waste bags, segregation procedures

e) Handling of sharps

f) Safe internal transportation and internal storage of wastes

g) Loading/unloading and cleaning of health care waste management equipment like trolleys, shredder, incinerator, autoclave, hydroclave, etc.

1.3.6 Waste Audit

A waste management programme will not succeed until the programme is reviewed regularly and corrective actions are taken for anomalies. It is suggested that hospital waste management programme must receive support and commitment of top management of hospital. Waste audit exercise must be undertaken to review following:

- Quantum of waste
- Category of waste
- Disinfection process
- Waste movement
- Status of equipment like needle destroyers, incineration, microwave, etc.
- Condition of protective clothing
- Incidence of sharp injuries

Internal Waste Audit

Health care waste management committee has to conduct regular evaluation of the process, involve people and correct the deficiencies in the system and update it. The handling and disposal of clinical waste is of little interest to nursing and medical staff and consequently is generally performed poorly. An annual audit as suggested at Edgware General Hospital Middle sex, U.K., consists of two key elements:

a) The first involves the visit of senior nurse in infection control to wards and analyzing the provisions for handling clinical waste with the senior nursing staff of the ward. In this way the users suggest improvements.

b) The second element of the audit is the report and its distribution to the hospital administration, senior nursing and domestic staff. This provides tangible evidence of problems and forms a basis for cooperation.

External Audit

External audit is carried out by external agencies like the State Pollution Control Board/ Committee and NGOs and individuals. These agencies visit the health care establishment to assess the situation and basis of their findings, exercise their powers under the Gazette notification on health care waste management of various countries in South-East Asia for grant of authorization.

Check Your Progress 3

1) What are the tasks of Infection Control Committee?

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2) Enumerate members of health care waste management committee.

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3) What are the parameters which need monitoring by the waste management officer?

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1.4 LET US SUM UP

In this unit you have learnt about the managerial and administrative issues involved in health care waste management. For proper management of health care waste, it is essential to lay down a health care waste management system which consists of various sub-systems of generation, segregation, collection, transport and final disposal of health care waste management. It was also brought out that this system requires periodic evaluation and impact assessment. Model formats for data collection required for evaluation (see Annexure) were developed; these can be modified to suit any health care establishment. We also discussed about the key personnel involved in health care waste management. Organizational structure required for the systems was laid down with job descriptions of each functionary. Importance of health care waste management committee, infection control committee and their conjoint action was stressed. You have also learnt about the role of waste handlers as an important group in management of health care waste management system. Finally procedure and importance of waste audit was discussed.

1.5 KEY WORDS

Disinfectant : Chemical agent that is able to reduce the viability of micro-organisms.

Disinfection : Treatment aimed at reducing the number of vegetative micro-organisms to safe or relatively safe levels.

Handling : The functions associated with the movement of solid waste materials, excluding storage, processing and ultimate disposal.

Hazard : Intrinsic potential property or ability (e.g. of any agent, equipment, material, or process) to cause harm.

Micro-organism : Any micro-biological entity, cellular or non-cellular, capable of replication or transferring genetic material.

Monitoring	:	The measurement of a concentration or other parameter (radiation or radionuclide concentration in the context of radioactive waste management) for purposes of assessment or control of environmental quality or exposure and the interpretation of such measurements. Monitoring can be continuous or non-continuous.
Radioactive Waste	:	Material that contains, or is contaminated with, radionuclide at concentrations or activities greater than clearance levels and for which no use is foreseen.
Residue	:	The material remaining after combustion of wastes such as ash or slag. Also refers to materials extracted from a liquid or gas stream.
Recycling	:	A term embracing the recovery and reuse of scrap or waste material for manufacturing or other purposes.
Risk	:	Probability that a hazard will cause harm and the severity of that harm.
Segregation	:	The systematic separation of solid waste into designated categories.
Sterilization	:	A reduction in micro-organisms of more than 10^6 (more than 99.9999% of the microorganisms are killed), achieved by physical, chemical or mechanical methods or by irradiation.
Storage	:	The placement of waste in a suitable location or facility where isolation, environmental and health protection, and human control (e.g. monitoring for radioactivity, limitation of access) are provided. This is done with the intention that the waste will be subsequently retrieved for treatment and conditioning and/or disposal (or clearance of radioactive waste).
Waste Generator	:	Any person, organization or facility engaged in activities that generate waste.
Waste Management	:	All the activities, administrative and operational, involved in the handling, treatment, conditioning, storage and disposal of waste (including transportation).

1.6 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) A system is essentially a set or assemblage of interconnected, interdependent, things that form a complex unity. These things may be physical such as the parts of an automobile engine or they may be biological like components of human body.

2) There are certain basic principles which must be followed while laying down the system of health care waste management in any health care set up. These are:

   a) Conducting a waste audit

   b) Minimization and recycling of waste wherever possible

   c) Identification of points of generation of waste

   d) Segregation of waste at source

   e) Compiling inventory of waste

f) Disinfection at the point of generation

g) Waste transportation on site and off site

h) Waste treatment on site/off site

i) Final disposal

j) Occupational safety

k) Continuous monitoring of the system

l) Training of staff

3) Check list for systems approach:

a) Assignment of waste management responsibility to personnel

b) Allocation of resources—human and financial

c) Minimization of waste

d) Segregation of waste

e) Safe collection, handling, storage and disposal of waste

f) Monitoring the system.

Check Your Progress 2

1) Four main categories of personnel in hospital are involved in health care waste management:

a) Hospital managers and administrative staff

b) Doctors

c) Nurses and assistant nurses

d) Cleaners, porters, auxiliary staff and waste handlers.

2) Evaluation is the process of determining the degree of success in achieving predetermined objectives. Measurement of action against accepted criteria and interpretation of relationship amongst them is also called evaluation.

3) a) To safeguard interest of recipients of hospital care which is the moral and legal obligation of administrative and professional authorities.

b) To ensure that hospitals render safe and efficient medical services to patients.

c) To locate inadequacies and shortcomings of hospital staff, its plant and machinery, its working system.

d) To provide authorities a sound appraisal system comprising of evaluating knowledge, attitude and practice towards effective evaluation of staff at various levels, hospital administrator, individual physicians, nurses and paramedical workers.

Check Your Progress 3

1) Hospital Infection Control Committee has the following tasks:

a) Formulate simple, effective and practical policies for infection control and surveillance with the help of suggestions and cooperation of every specialist.

b) It is responsible for producing infection control manual giving clear policies of antibiotic use, waste disposal protocols, high-risk areas, isolation practices, universal precautions, etc.

c) Meet every month to review and evaluate the surveillance and infection control policies and measures.

d) Circulate a monthly infection control bulletin informing all the staff of the occurrence and remedial instructions based on site specific, ward specific and type specific incidence rates of Hospital Acquired Infection (HAI) reported by Infection Control Team (ICT).

e) Advice head of the establishment on deploying resources, manpower and purchase of equipment and materials, etc.

2) The head of the hospital should form a waste management team to develop a waste management plan. The team should have the following members:

a) Head of Hospital (as Chairman)

b) Heads of Hospital Departments

c) Infection Control Officer

d) Chief Pharmacist/Medical Stores In-charge

e) Radiation Officer/Physicist

f) Nursing In-charge (Senior Nursing Officer)

g) Officer In-charge of Operation Theatres (Senior Nursing Officer)

h) Hospital Manager

i) Hospital Engineer

j) Financial Controller

k) Waste Management Officer (if already designated).

3) Parameters to be monitored by the waste management officer:

- Waste generated each month, by waste category:
  - In each department;
  - Segregation, treatment and disposal methods.
- Financial aspects of health care waste management:
  - Direct costs of supplies and materials used for collection, transport, storage, treatment, disposal, decontamination, and cleaning;
  - Training costs (labour and material);
  - Costs of operation and maintenance of on-site treatment facilities;
  - Costs for contractor services like cost for centralized facilities.
- Public health aspects:
  - Incidents resulting in injury, "near misses", or failures in the handling, separation, storage, transport or disposal system, which should also be reported to the Infection Control Officer; this will be the basis for preventive measures to prevent recurrences.
  - Regulatory compliance
  - Training and monitoring

1.7 FURTHER READINGS

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WHO, "Management of Waste from Hospitals and Other Health Care Establishments", *Euro Report and Studies 97;* 1985, 1-61.

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A Waste Audit Questionnaire

A: General Information

Hospital (name, location): ....

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Type of hospital (tick one):

- Specialist ☐
- General ☐
- University (training/provincial) ☐
- Regional ☐
- District ☐
- Sub-district ☐

No. of in-patients: __________ /day

No. of out-patients: _________ /day

No. of beds (total): _________ /day including

a) _______ in ______________ ward
(No. of beds) (type of ward)

b) _______ in ______________ ward
(No. of beds) (type of ward)

c) _______ in ______________ ward
(No. of beds) (type of ward)

d) _______ in ______________ ward
(No. of beds) (type of ward)

B: Type of solid waste produced and estimated quantity (Consult classification and mark × where waste is produced)

	Waste Category								
Sources	General	Pathalo-gical	Radio-active	Chemical	Infectious	Sharp	Pharma-ceutical	Pressurized countainer	Est. quantity (kg/day)
Patient Services									
Medical									
Surgical									
Operating Theatre									
Recovery/Intensive Care									
Isolation Ward									
Dialysis Unit									
Oncology Unit									
Emergency									
Outpatient Clinic									
Autopsy room									
Radiology									
Laboratories									
Biochemistry									
Microbiology									
Haematology									
Research									
Pathology									
Nuclear medicine									
Support Services									
Blood Bank									
Pharmacy									
Central Sterile Supply									
Laundry									
Kitchen									
Engineering									
Administration									
Public areas									
Long-term health care									

C: Waste segregation, collection, storage and handling

Describe briefly what happens between segregation (if any) and final disposal of:

Sharps ....

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Pathological waste ....

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Infectious waste ....

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Radioactive waste ....

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Chemical waste ....

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Pharmaceutical waste ....

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Pressurized containers ....

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General waste ....

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D: Waste segregation, collection, labelling, transport and disposal

Handling of segregated waste	Sharps	Pathological waste	Infectious waste	Radio-active waste	Chemical waste	Pharmaceutical waste	Pressurized containers
Indicate by × the type of waste (if any) i.e. segregated from general waste stream. Where is the segregation taking place (i.e. operating room, Laboratory, etc.)?							
What type of containers/bags (primary containment vessels) are used to segregate waste (bags, cardboard boxes, plastic containers, metal containers, etc.)? Describe accurately.							
What type of labelling, colour-coding (if any) is used for marking segregated waste? Describe.							
Who handles (removes) the segregated waste (designation of the hospital staff member)? Is the waste handler using any protective clothing (gloves, etc.) during waste handling? Yes/No.							
What type of containers (plastic bins, bags, cardboard boxes, trolleys, wheelbarrows, etc.) are used for collection and internal transport of the waste? Describe. Where is the segregated waste stored while awaiting removal from the hospital or disposal? Describe							
Describe briefly the final disposal of segregated waste (taken to municipal landfill, buried on hospital grounds, incinerated etc.)							

E: Personnel involved in the management of hospital solid waste

1) a) Designation of person(s) responsible for organization and management of waste collection, handling, storage, and disposal at the hospital administration level.

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b) General qualification and level of education of designated person.

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c) Has he/she received any training on hospital waste management? Yes/No
If yes, what type of training and of what duration?

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2) Indicate the number of persons involved in the collection, handling and storage of hospital waste, their designation, their training in solid waste handling and management and the number of years of experience of this type of work.

Number	Designation	Training	Experience

3) Do the waste management staff have job descriptions detailing their tasks? Yes/No

4) Are instructions/training given to newly hired waste management staff? Yes/No

Hospital waste management policy

1) Is the administration aware of any legislation applicable to hospital waste management? Yes/No.

If yes, please list the legislative Acts:

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2) Are you aware of a document outlining the hospital waste management policy guidance? Yes/No.

If yes, give title of document:

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3) Is there a manual or guideline document on management of hospital wastes available?

   a) In the Ministry of Health? Yes/No.

   If yes, give title of document:

   b) In your hospital? Yes/No.

   If yes, give title of document:

4) a) Does your hospital have a Waste Management Plan? Yes/No.

   If yes, please attach a copy

   b) Does your hospital have a Waste Management Team? Yes/No.

   If yes, please list the members by designation:

	Designation	No.
Team leader:	....	....
Team members:	....	....
Waste handling staff:	....	....

5) Has any training/awareness programme been imparted to all the hospital staff about hospital waste management. If yes, kind of training/awareness programme conducted.

6) Are there clearly defined procedures for collection and handling of wastes from specified units in the hospital? Yes/No.

7) Are there waste management responsibilities included in the job descriptions of hospital supervisory staff (Head of Hospital, Department Heads, Matron/Senior Nursing Officer, Hospital Engineer, Infection Control Officer, Pharmacist, Laboratory Supervisor, etc.)? Yes/No.

   If yes, can you provide sample copies.

8) How are the present waste collection, handling, and disposal responsibilities defined in the job descriptions of the staff involved? (Cite appropriate statement or provide copies.)

UNIT 2 INTEGRATED INFECTION CONTROL MANAGEMENT

Structure

2.0 OBJECTIVES

After going through this unit, you should be able to:

- explain the sources of hospital acquired infection;
- enumerate the principles of infection control;
- undertake precautions while handling waste; and
- advise safety measures to waste handlers including use of safety gears.

2.1 INTRODUCTION

Infections acquired in the health care setting are the infections which patients acquire from health facilities and these were not being incubated at the time of entry. The emergence of life threatening infections such as severe acute respiratory syndrome (SARS) and re-emerging infectious diseases like plague and tuberculosis have highlighted the need for efficient infection control programmes in health care settings and capacity building for health care workers so that they can implement them. A breach in implementation of infection control practices facilitates transmission of infection from patients to health care workers, other patients and attendants. It is, therefore, important for all health care workers, patients, their family members, friends and close contacts to adhere to the infection control guidelines strictly. It is also imperative for health care administrators to ensure implementation of the infection control programme in health care facilities. In this unit you will cover various aspects of infection control through proper health care waste management practices.

2.2 INFECTION IN HOSPITAL

Hospitals are meant to cure infections, but due to mismanagement of waste and lack of universal precautions the hospitals become sources of infection. This section will give you an insight into the sources of infections and principle of infection control.

2.2.1 Sources of Infection

The sources of the infection may be as follows:

- A case or carrier
- Improperly sterilized instruments and dressings
- Fomites such as clothes, bed linen, books, toys and so on
- Vehicles, food, milk, water, blood and blood products.

Health care waste is a major source of infection and is generated from different health care facilities such as:

- Hospitals
- Health Clinics
- Dental Clinics
- Dispensaries
- Blood Banks
- Medical and Bio-medical Laboratories
- Biotechnology Laboratories and Institutions
- Medical Research Institutions
- Dialysis Centres
- Military Medical Services
- Animal Research and Testing

2.2.2 Types of Microbial Agents in Hospital

The types of microbial agents causing hospital infections can be classified as under:

a) **Bacterial**

i) ***Staphylococcus***

This is the most common source of the hospital infections such as septic lesions and acute gastroenteritis due to food poisoning.

ii) ***Pseudomonas pyocyaneous***

Cause of secondary infection in burns, wounds and urinary infections.

iii) ***Escherechia coli***

Gram negative organism, responsible for catheter associated infections of urinary bladder.

iv) ***Salmonellae***

Infections caused by the food poisoning group are not uncommon, introduced into a hospital by carriers and then spread from patients by faecal contamination or may be introduced in food items.

v) ***Shigellae***

Infection causing bacillary dysentery, organism usually found in faeces of sick but may be found in faeces of convalescent or asymptomatic carrier.

b) **Viral**

Viral infections such as HIV, HBV and HCV, and influenza are important from nosocomial infection point of view.

c) **Other**

Other infections such as Ricketsial, fungal etc.

2.2.3 Hospital Acquired Infection

Hospital acquired infection can be defined as an infection acquired by the patient in the hospital, manifestation of which may occur during hospitalization or after his discharge. It should not be confused with the infection with which he may have come to the hospital for its treatment. Besides increasing the morbidity and mortality, hospital infection prolongs the stay of the patient in the hospital, which means considerable economic consequences to the patient, the hospital, the community and the country.

2.2.4 Susceptible Groups

Hospital acquired infections can be caused by bacteria, viruses, fungi or parasites. These micro-organisms may already be present in the patient's body or may come from the environment, contaminated hospital equipment, health care workers or other patients. Depending on the casual agents involved, an infection may start in any part of the body.

All individuals exposed to hazardous health care waste are potentially at risk. The main groups who are susceptible to the risk are the following:

- Patients
- Medical doctors, nurses, health care auxiliaries and hospital maintenance personnel
- Visitors to health care establishments
- Workers in waste handling, transportation and waste disposal facilities
- Rag pickers.

2.2.5 Principles of Infection Control

The infections acquired in health care setting can be greatly minimized by observing some simple principles. They are:

a) **Infection Control Measures**

- Each institution should establish an appropriate infection control policy (ICP) and programme. A mechanism should be set up for planning, implementing and monitoring the evaluation of ICP and its programmes.
- Hand washing is the most simple and cost effective measure and must be encouraged.
- Disinfectants should be prepared and used according to the guidelines.

b) **Patient's Admission**

A patient should not be admitted into a hospital unless it is absolutely necessary and he/she should be discharged as early as possible to reduce the risk of infection.

Hygienic Environment

Health care facilities should be kept clean and void of virulent organisms by proper house keeping. Cleaning of premises and room floors with water and detergent is recommended. Cleaning with a disinfectant is usually not necessary unless there is spillage with potential infectious material. Architectural design of a health care facility should permit good ventilation. Proper waste disposal, water treatment, disinfection and sterilization of equipment can reduce the risk of infection among patients, health care workers and community. To minimize the spread of infection, it is important that hospitals/health centres and the surroundings remain clean and no waste is spilled anywhere outside or inside the hospital premises. A clean hospital has positive effects on its patients and its personnel too.

c) **Monitoring of Infectious Agents**

Micro-organisms responsible for infections in health care settings may originate from patients, the environment or health care workers. Their sources of infections are to be identified and specific measures must be taken appropriately to prevent their spread. To prevent spread of infections microbiologic sampling should be directed towards evaluation of contaminants known to be associated with the risk of nosocomial infection.

d) **Waste Reduction and Reuse**

There is a growing trend in health care settings to provide or use disposable materials in all aspects of work. Some are quite necessary for proper infection control and worker and patient safety. Hospitals should select a mixture of disposable and reusable material depending upon their situation, e.g., General Wards and OPD can use mostly reusable items but casualty departments may incorporate more of the disposable items. More waste means more expense on waste disposal. Reuse not only reduces disposal cost but also reduces procurement cost for medical items. Waste can also be minimized by recycling certain waste such as glassware, plastic material etc. after proper cleaning and disinfection.

2.2.6 Hospital Infection Control Guidance Care for Patients with Probable SARS

As you are aware of recent incidence of Serious Acquired Respiratory Syndrome (SARS) in SEAR countries, WHO framed a guideline to SARS patient care.

WHO advises strict adherence with the barrier nursing of patients with SARS using precautions for airborne, droplet and contact transmission. Nurses should rapidly divert persons presenting to their health care facility with flu-like symptoms to a separate assessment area to minimise transmission to others in the waiting room. Suspect cases should wear surgical masks until SARS is excluded.

Patients with probable SARS should be isolated and accommodated as follows in descending order of preference:

1) negative pressure rooms with the door closed
2) single rooms with their own bathroom facilities
3) cohort placement in an area with an independent air supply and exhaust system.

Turning off air conditioning and opening windows for good ventilation is recommended if an independent air supply is unfeasible. Wherever possible, patients under investigation for SARS should be separated from those diagnosed with the syndrome.

Disposable equipment should be used wherever possible in the treatment and care of patients with SARS. If devices are to be reused, they should be sterilised in accordance with manufacturers' instructions. Surfaces should be cleaned with broad spectrum (bactericidal, fungicidal and virucidal) disinfectants of proven efficacy.

Patient movement should be avoided as much as possible. Patients being moved should wear a surgical mask to minimise dispersal of droplets. National Institute of Occupational Safety and Health, USA (NIOSH) standard masks (N95), often used to protect against other highly transmissible respiratory infections such as tuberculosis, are preferred if tolerated by the patient. All visitors, staff, students and volunteers should wear a N95 mask on entering the room of a patient with confirmed or suspected SARS. Surgical masks are a less effective alternative to N95 masks.

Hand washing is the most important hygiene measure in preventing the spread of infection. Gloves are not a substitute for hand washing. Hands should be washed before and after significant contact with any patient, after activities likely to cause contamination and after removing gloves. Alcohol-based skin disinfectants formulated for use without water may be used in certain limited circumstances. Health care workers are advised to wear gloves for all patient handling. Gloves should be changed between patients and after any contact with items likely to be contaminated with respiratory secretions (masks, oxygen tubing, nasal prongs, tissues). Gowns (waterproof aprons) and head covers should be worn during procedures and patient activities that are likely to generate splashes or sprays of respiratory secretions.

Health Care Worker's must wear protective eye wear or face-shields during procedures where there is potential for splashing, splattering or spraying of blood or other body substances.

Health Care Worker's are advised to wear masks whenever there is a possibility of splashing or splattering of blood or other body substances or where airborne infection may occur. Particulate filter personal respiratory protection devises capable of filtering 0.3µm particles (N95) should be worn at all times when attending patients with suspected or confirmed SARS.

Standard precautions should be applied when handling any clinical wastes. All waste should be handled with care to avoid injuries from concealed sharps (which may not have been placed in sharps containers). Gloves and protective clothing should be worn when handling clinical waste bags and containers. Where possible, manual handling of waste should be avoided. Clinical waste must be placed in appropriate leak-resistant biohazard bags or containers labelled and disposed off safely.

Check Your Progress 1

1) Enumerate the sources of infection in a hospital.

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2) List the main groups of people who are susceptible to hospital acquired infections.

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3) What are the principles of infection control?

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2.3 INFECTION CONTROL PRECAUTIONS IN DIFFERENT AREAS WITHIN THE HEALTH CARE FACILITY

The following sub-section will help you in understanding the infection control precautions to be followed in specific areas within the hospital.

2.3.1 Operation Theatre

In Operation Theatre (OT) the following precautions should be observed:

- Proper hand washing using soap and water. (Fig. 2.1)
- Use of Gloves—the wearing of gloves reduces contamination of hands with blood but reduce chances of infections by penetrating injuries caused by needles and other sharp instruments, broken glass or plastic. It is important to remember that gloves are meant to supplement and not to replace hygienic practice of proper hand washing.
- Use of properly fitting masks.
- Use of aprons and gowns.
- Precautions for parenteral and other invasive procedures.
- Training the staff about health care waste management.

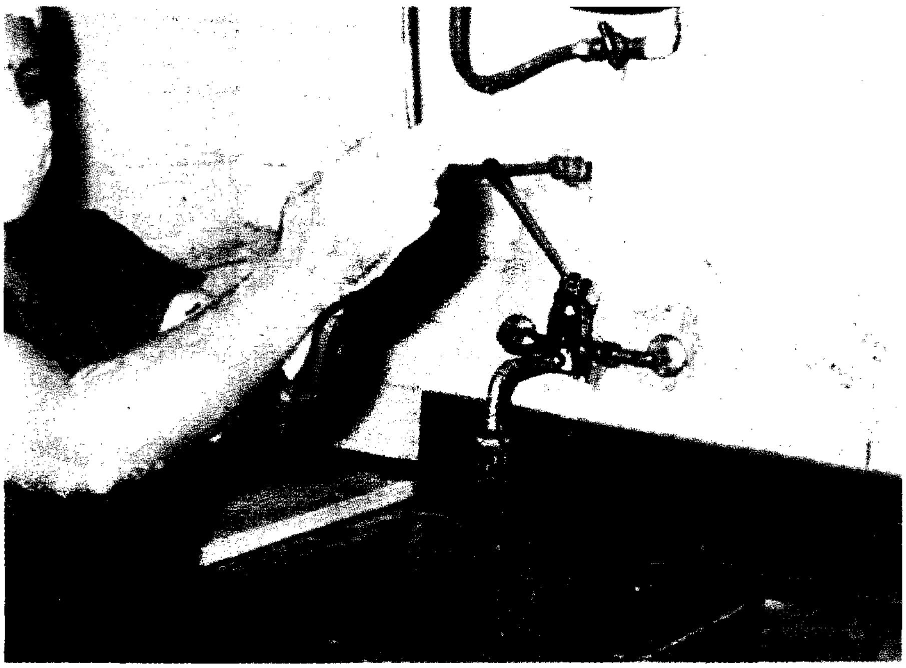


Fig. 2.1: Hygienic hand washing

2.3.2 Wards

- Only sterile instruments and material (Cotton, wool and other dressing material) should be used. Antiseptic lotions and antibacterial creams must also be used.
- All materials and instruments used and removed during the dressing should be disinfected before disposal.
- The waste should be segregated at source in coloured containers/bags. (Fig. 2.2)
- The containers should be properly labeled and covered.
- The waste bins should be washed and cleaned regularly.
- The waste should not be stored for more than 48 hours.
- Training the staff about proper health care waste management.

Fig. 2.2: Use of coded coloured containers for segregation

2.3.3 Laboratories

The key elements in maintaining a safe laboratory are:

- Adequate training (Fig. 2.3)
- Good emergency procedures
- Use of biological safety cabinets where recommended
- Avoidance of risks from aerosols by use of appropriate equipment
- Wearing protective clothing and when necessary, gloves and masks
- Effective hand washing
- Appropriate staff health programme
- Safe transport of specimens and instruments
- Decontamination of work surfaces, specimens and instruments
- Safe disposal of infected waste.
- Safe use and disposal of sharp instruments and needles
- Avoidance of eating, drinking and smoking or mouth pipetting in the laboratory.

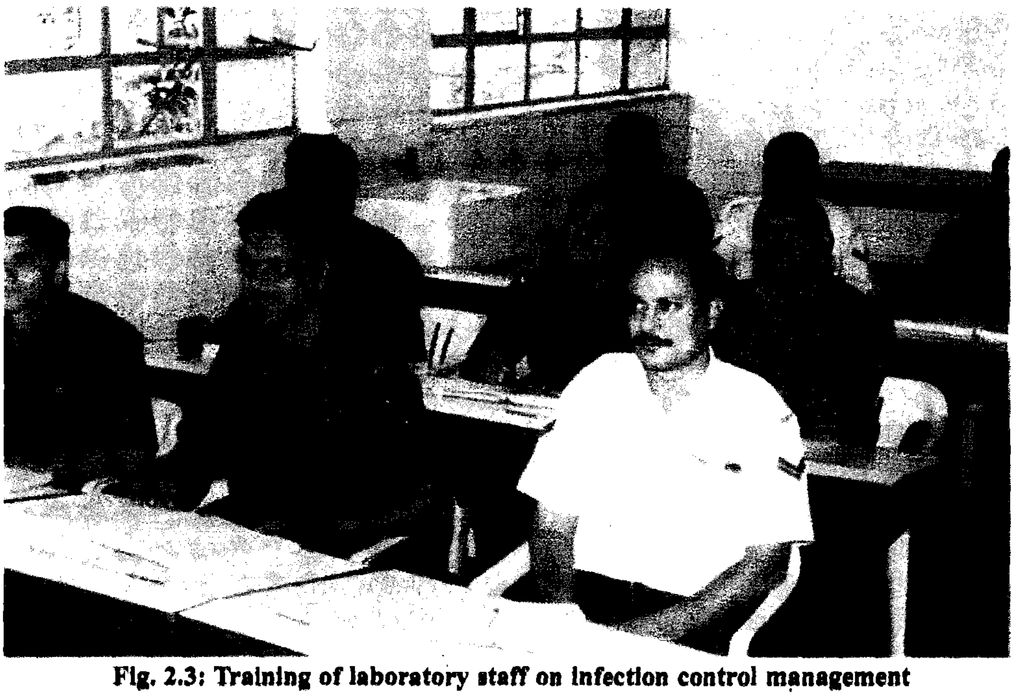


Fig. 2.3: Training of laboratory staff on infection control management

The general laboratory work precautions are:

- Entry to the laboratory/work area should be restricted only to persons who have been advised of the potential hazards and are trained to handle infectious material.
- Laboratory door should be closed and should have a **'Biohazard, No Admission'** sign to prevent unauthorized entry. The laboratory should be kept clean, neat and free from extraneous materials and equipment.
- Staff should wear a fully covered laboratory coat, preferably a wrap around gown that could be removed and left back when leaving the laboratory.
- Gloves should be worn for all manipulation of infectious material.
- Work surfaces should be disinfected with 1000 PPM (parts per million) hypochlorite solution when procedures are completed at the end of each working day.
- Use of needles, syringes and other sharp instruments should be with utmost care.
- Do not recap used needles and do not remove needles from syringes.
- Hands should be washed frequently and touching of mouth, nose, eye, etc., should strictly be avoided.

Guidelines for collection of blood samples:

- Use gloves and take special care if there are cuts or scratches on the hands.
- Take care to avoid contamination of hands and surrounding area with the blood.
- Use disposable/autoclaved syringes and needles.
- Use 70 per cent ethanol or isopropyl alcohol swabs/sponges for cleaning the site of needle puncture.
- Use thick dressing pad or absorbent cotton below the forearm when drawing blood and tourniquet above.
- Tourniquet must be removed before the needle is withdrawn.
- Place dry cotton-swab and flex the elbow to keep this in place till bleeding stops.
- Place used needles and syringes in a puncture resistant container containing disinfectant.
- Do not recap used needles and do not remove needles from syringes.
- Use disposable screw-capped vials to avoid risk of leakage or spills.
- Seal specimen containers securely. Wipe off the exterior of the container free of any blood with a disinfectant.
- These vials should preferably be placed in small plastic bags, which should be appropriately tied.
- Plastic boxes with proper 'caution' labels should be used for transporting the specimen in the laboratory.
- Wash hands following completion of blood collection.
- In the event of needle stick/other skin puncture/wound, wash thoroughly with soap and water and let blood flow freely. Then apply iodophor/tincture of iodine.
- All things contaminated with blood must be regarded as infectious.

- Report all accidental exposure to the authorities.
- No paper work to be done on potentially contaminated surfaces.
- Label all specimen carefully without soiling the test request forms.
- Decontaminate by autoclaving all potentially contaminated material used in the laboratory before disposal or discard in a bucket containing sodium hypochlorite solution. (Fig. 2.4)

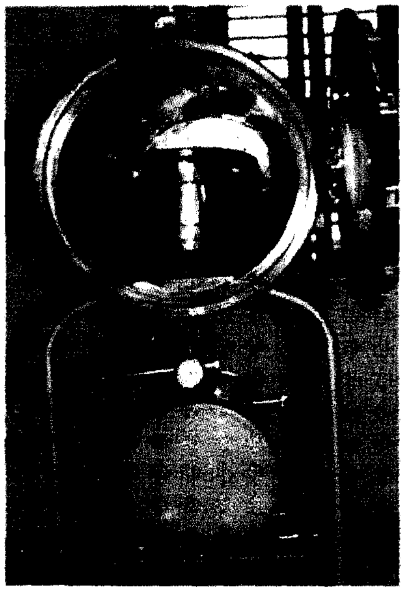


Fig. 2.4: Autoclave

2.3.4 Blood Banks

Only autoclaved/pre-sterilized disposable needles and syringes must be used for collection of blood. All precautions such as use of gloves, mask should be strictly followed for collection of blood including disinfection of skin.

2.3.5 Precautions while Handling Sharps

- Always dispose off your own sharps. (Fig. 2.5)
- Never pass used sharps directly from one person to another.
- During exposure-prone procedure, ensuring that the operator has the best possible visibility, e.g., by positioning the patient, adjusting good light source and controlling bleeding should minimize the risk of injury.

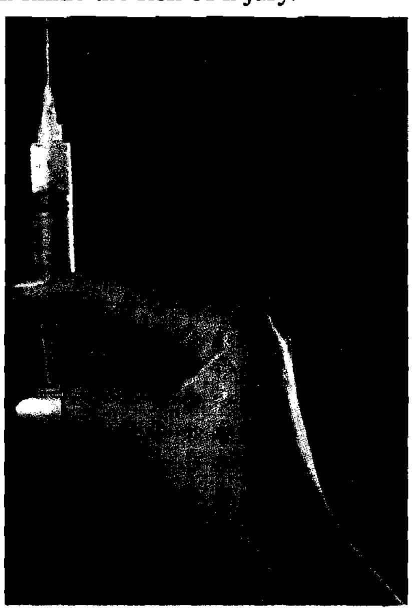


Fig. 2.5: Sharps

- Protect fingers from injury by using forceps instead of fingers for guiding suturing.
- Never recap, bend or break disposable needles.
- Directly after use, place needles and syringes in a rigid container until ready for disposal.
- Locate sharps disposal containers close to the point of use, e.g., in patient's room, on the medicine trolley and in treatment room, etc.
- Dispose used sharps in a puncture-resistant container.
- Never place used sharps in other waste containers.
- Keep all sharps and sharps disposal containers out of the reach of children.
- Prevent overflow by sending sharps disposal containers for decontamination or incineration when three-quarters full.

The Do's and Don'ts while handling syringes and needles are shown in the following table:

Do's	Don'ts
Pass syringes and needles in a tray	Never pass syringe and needle directly to next person
Put needles and syringes in 2 per cent hypochlorite solution if needle cutter is not available	Do not bend or break used needle with hands
Remove cap of needle near the site of use	Never test the fineness of the needle's tip before use with bare or gloved hand
Pick up open needle from tray/drum with forceps	Never pick up open needle by hand
Destroy syringes by burning their tips if cutters not available	Never dispose it off by breaking it with hammer/stone.

2.3.6 Precautions in Transportation

- Segregated wastes should be transported within the facility from the point of generation to the final waste disposal site in a covered trolley.
- The trolley should be labeled with a biohazard symbol.
- All bags should be fastened properly.
- The containers should be tight lidded and there should not be any spillage.
- All the specimens must be properly labeled and placed in a double chambered packet.
- Sharps should always be transported in puncture proof containers.
- Hazardous waste even after decontamination should never be transported with general municipal waste.

Transport Vehicle

- There should be a dedicated vehicle for the collection of waste.
- Inner body of the vehicle should have minimum joints to prevent harbouring of micro-organisms.

- Bio-medical hazard sign, name, address and phone number of the operator shall be displayed on the vehicle.
- It should be a closed vehicle.
- The inner covering of the vehicle should be smooth.

2.3.7 Precautions while Handling Spillage and Gas Waste

- Spills of the potentially infected material should be covered with paper towel/blotting paper/news paper.
- One per cent sodium hypochlorite solution must be poured on and around the spill area and covered with paper. Keep it covered for 10 minutes. After 10 minutes, the paper/towel should be removed with gloved hands and discarded in infectious waste.
- Waste anaesthetic gases such as N_2O (Nitrous Oxide) can cause harmful effects. It is worthwhile to take measures to contain its use. One such step which is being adopted by the anaesthesiologists is use of intravenous anaesthetic agents, low flow techniques, use of Oxygen air combination, etc.
- Operation room personnel are exposed to low concentration of the anaesthetic gases and vapours. Trace gases in OT are likely to have adverse effect on the staff which range from poor reproductive outcome, birth defects, impairment of skilled performance, cancer and other systemic diseases. Regulatory agencies in the USA recommended that in any location in which inhalation anaesthetics are administered, there should be an adequate and reliable system for scavenging waste anaesthetic gases.

2.3.8 Accident Reporting

When any accident occurs at any institution or facility or any other site where bio-medical waste is handled or during transportation of such waste, the accident should be reported to the waste management officer and appropriate measures should be taken to avoid such accidents. Authorized person shall then report the accident in Form No.1 (Annexure I) to the prescribed authority as per the Bio-Medical Waste (Management and Handling) Rules 1998 forthwith. At the same time efforts should be taken to prevent any such injury.

2.3.9 Post Exposure Prophylaxis

Assessment of the risk for HIV/Hepatitis B infection resulting from the exposure and the infectivity of the exposure source are key determinants of offering post exposure prophylaxis (PEP). Health care workers (HCW) are normally at a very low risk of acquiring infection during management of the infected patient. Most exposures do not result in infection. The risk of infection varies with the type of exposure and other factors such as:

- The amount of blood involved in the exposure.
- The amount of virus in the patient's blood at the time of exposure.
- Whether PEP was taken within the recommended time.

Prevention is the mainstay of strategy to avoid occupational exposure to blood/body fluids. All the bio-safety precautions must be practiced at all times for all patients blood and body fluids while providing medical services.

Following steps to be taken on exposure to HIV infected blood/body fluids and contaminated sharps:

Immediately Following on Exposure

- Needle-sticks and cuts should be washed with soap and water.
- Splashes to the nose, mouth or skin should be flushed with water.
- Eyes should be irrigated with clean water, saline or sterile irrigants.
- Pricked finger should not be put into mouth.

Reporting of the Exposure

Report the exposure to the appropriate authority and condition must be treated as an emergency. Prompt reporting is essential because in some cases, HIV post exposure prophylaxis (PEP) may be recommended and it should be started as soon as possible, preferably within a few hours. Initiating treatment after 72 hours of exposure is not recommended. The report should be submitted as per Form No. 2. (Annexure II)

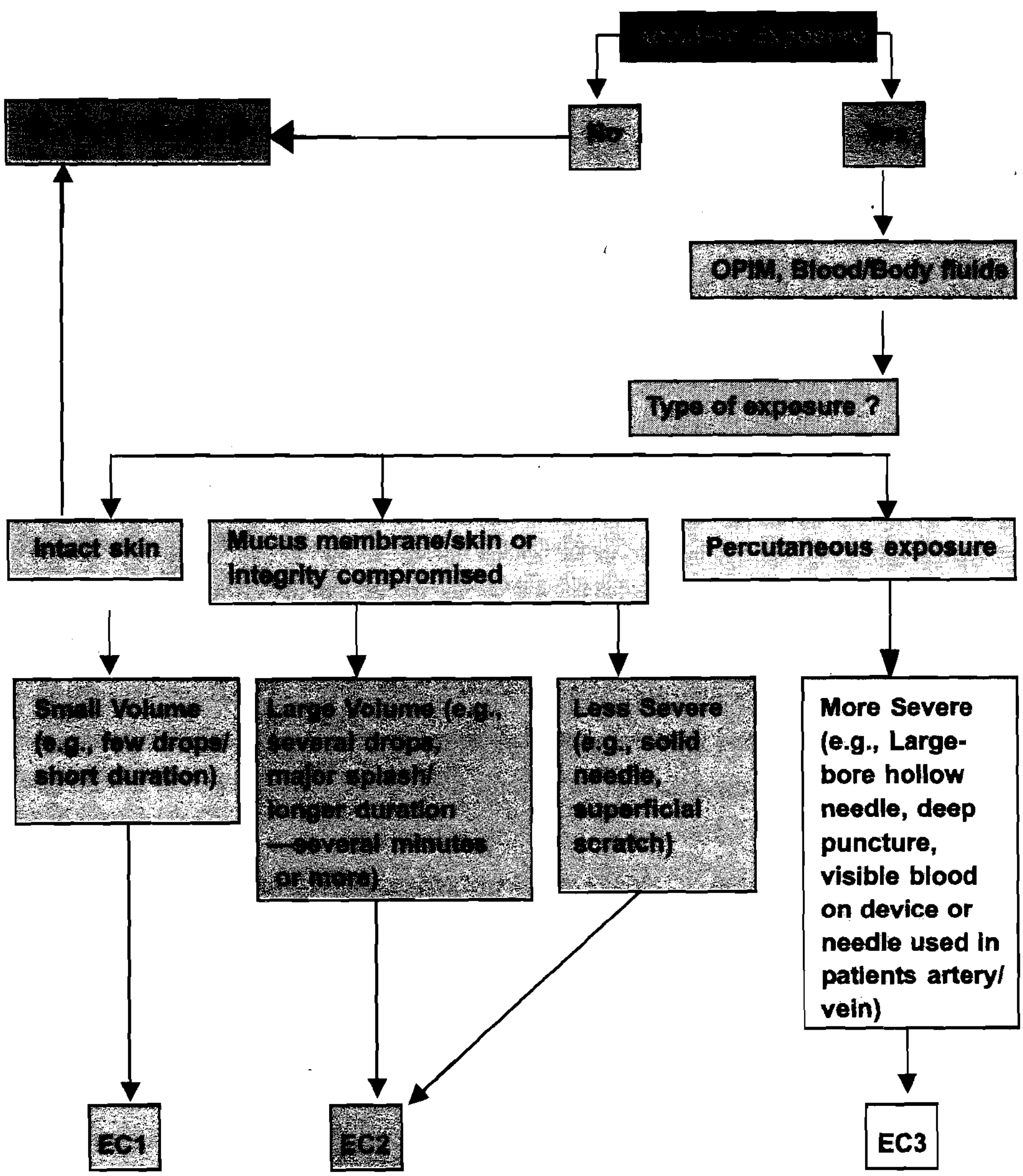
Post Exposure Prophylaxis

The decision to start PEP is made on the basis of degree of exposure to HIV/ Hepatitis B and the HIV status of the source from whom the exposure/infection has occurred.

Determination of the Exposure Code (EC)

Exposure code can be defined as per the flow chart given below. It may be classified into three categories, EC1, EC2 and EC3, depending upon the nature of exposure.

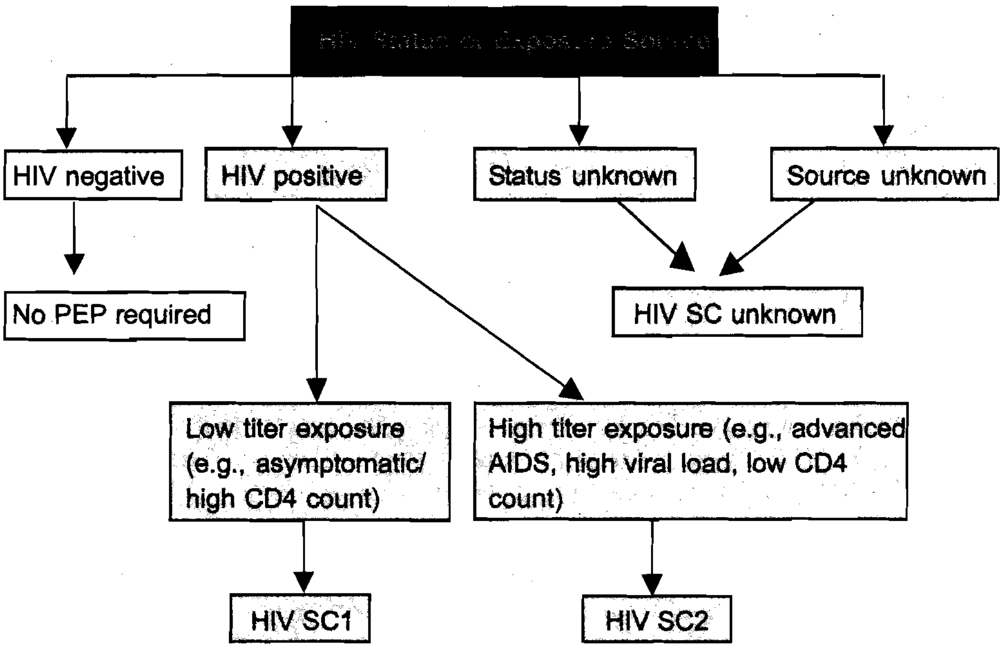
Exposure Code (EC) is the source material, blood, body fluid, other potentially infectious material (OPIM) or an instrument contaminated with one of these substances.



Determination of HIV Status Code (HIV SC)

The main purpose of determining HIV status code is to know the HIV status of source of exposure. It may be classified into three categories—HIV SC1, HIV SC2 and HIV SC Unknown.

HIV STATUS CODE



Determination of PEP Recommendation

EC	HIV SC	PEP Recommendation
1	1	PEP may not be warranted
1	2	Consider Basic Regimen (Negligible risk)
2	1	Recommend Basic Regimen (most exposures are in this category)
2	2	Recommend expanded regimen
3	1 or 2	Recommend expanded regimen
2/3	Unknown	If setting suggests a possible risk (epidemiological risk factors) and EC is 2 or 3, consider basic regimen
• Basic regimen: (300 mg/twice a day)		Zidovudine (AZT)—600 mg in divided doses or 200 mg/thrice a day for 4 weeks + Lamivudine (3 TC) – 150 mg twice a day for 4 weeks
• Expanded regimen : (4 weeks therapy)		Basic regimen + Indinavir – 800 mg/thrice a day, or any other protease Inhibitor.

Testing and Counselling

The health care provider should be tested for HIV as per the following schedule:

- Base-line HIV test — at the time of exposure
- Repeat HIV test — at six weeks following exposure
- 2nd repeat HIV test — at twelve weeks following exposure

On all three occasions, health care workers must be provided with a pre-test and post-test counselling. HIV testing should be carried out on three ERS (Elisa/Rapid/Simple) test kits or antigen preparations. The health care workers should be advised to refrain from donating blood, semen or organs/tissues and abstain from sexual intercourse. In case sexual intercourse is undertaken a latex condom be used consistently. In addition, women health care workers should not breast-feed their infants during the follow-up period.

Duration of PEP

PEP should be started, as early as possible, after an exposure. It has been seen that PEP started after 72 hours of exposure is of no use and hence is not recommended. The optimal course of PEP is not known, but 4 weeks of drug therapy appears to provide protection against HIV. If the HIV test is found to be positive at any time within 12 weeks, the health care workers should be referred to a physician for treatment.

Pregnancy and PEP

Based on limited information, anti-retroviral therapy taken during 2nd and 3rd trimester of pregnancy has not caused serious side effects in mothers or infants. There is very little information on the safety in the 1st trimester. If the health care workers is pregnant at the time of exposure to HIV, the designated authority/physician must be consulted about the use of the drugs for PEP.

Side Effects of PEP Drugs

Most of the drugs used for PEP have usually been tolerated well except for nausea, vomiting, tiredness or headache.

Steps to be undertaken by the infection control officer on receiving information about exposure:

- All needle-stick/sharp injuries should be reported to the State AIDS Control Societies giving the Exposure Code and the HIV Status Code.
- The State AIDS Societies should in-turn inform the National Agency [like National AIDS Control Organization (NACO) in India] about the cases periodically.
- A register should be maintained in all hospitals and at the level of the State AIDS Control Societies.
- In India NACO has decided to supply PEP drugs to all cases in government hospitals through the State AIDS Control Societies.
- Infection control officers in all hospitals have also been directed to ensure that PEP drugs are available at all times in the hospital.

Check Your Progress 2

1) Name the chemical commonly used for disinfecting a spill in the laboratory.

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2) Enumerate the factors on which the post exposure infection risk varies.

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3) What is the recommended time for starting PEP?

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4) PEP should be given for how long?

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2.4 SAFETY MEASURES FOR WASTE HANDLERS

To minimize the risk of infections associated with health care waste, it is important to provide necessary safety measures to the health care workers. This section highlights on the safety measures to be taken to ensure safe waste management practices.

2.4.1 Principles

It is mandatory for all health care facilities to monitor the health of all waste handlers from time to time. It is not important only for worker's point of view but also for employer's point of view and to avoid hospital acquired infections from the infected personnel to others/patients. It is advisable that the base line serum samples are collected from personnel engaged in infectious diseases, laboratories/wards and stored for determining the base line antibody titres. This may be very important in personnel who are working with HIV, Hepatitis B and C viruses, tuberculosis, Brucella, etc.

Safety measures for waste handlers include a wide variety of safety precautions that are to be undertaken, either singly or in combination, depending on the type of hazard, by all medical, nursing and paramedical workers as well as by patients, attendants, ancillary staff and administrators in a hospital. The general principles of safety measures for waste handlers are:

- Hand washing facilities
- Use of personal protective measures
- Observance of precautions for invasive procedures
- Adequate awareness and training
- Good emergency procedures
- Safe transport of the wastes
- Decontamination of work surfaces, specimens and instrument
- Safe disposal of infected waste
- Avoidance of eating and drinking in hospital premises
- Availability of immediate first aid measures

- Good house keeping facilities
- Adequate laundry facilities
- Good environmental sanitation including safe water supply, proper ventilation in health care facility.

2.4.2 Safety Clothing and Protective Gear

There has been much debate about the order for putting on and taking off personal protective equipment. The following sequence is given as an example when full personal protective equipment is worn:

- Wash hands
- Wear set of thin clothes before entering the changing room
- Wear boots or shoe covers with trousers tucked inside
- Wash hands
- Wear cap
- Wear the mask
- Wear an impermeable apron if necessary
- Wear the gown
- Wear protective eye wear/goggles
- Wash hands and dry them
- Wear gloves with gown sleeve cuff tucked into glove

The key principle while personal protective equipment is removed is that the wearer should avoid contact with blood, body fluids, secretion, excretions and other contaminants, when hands get contaminated, they are decontaminated with 70 per cent alcohol solution.

Use of Full Personal Protective Equipment

Boots/Shoe Covers

Boots/shoe covers are used to protect the wearer from splashes of blood, body fluids, secretions and excretions. Waterproof boots should be worn for heavily contaminated, wet flooring and floor cleaning.

Selecting Boots/Shoe Covers

Shoe covers should be disposable and waterproof. Waterproof boots should be washable.

Wearing Boots/Shoe Covers

Wear waterproof boots if needed or wear shoe covers over your personal shoes so as to cover your shoes adequately.

Removing Boots/Shoe Covers

Remove shoe covers first with gloved hands and discard. Remove boots last, before leaving the room and decontaminate. Wash hands thoroughly.

Caps

Caps that completely cover the hair are used when splashes of blood and body fluids are expected. They should protect the hair from aerosols that may otherwise lodge on the hair and be transferred to other parts of the health care worker such as face or clothing; by the hands or onto inanimate objects.

Selecting Cap

Use a disposable, waterproof cap of an appropriate size which completely cover the hair.

Wearing Cap

Wear before masking. Place or tie cap over the head so as to cover hair adequately.

Removing Cap

Remove cap after removing mask. Remove by holding inside of the cap and folding inside out. Discard in proper container. Wash hands immediately.

Masks

A surgical mask protects health care providers from inhaling respiratory pathogens transmitted by the droplet route. It prevents the spread of infectious diseases such as varicella (chickenpox) and meningococcal diseases (meningococcal meningitis). An N95 mask protects health care providers from inhaling respiratory pathogens that are transmitted via the airborne route. This helps to prevent the spread of infectious diseases such as TB, MDR-TB and SARS. (Fig. 2.6)

Fig. 2.6: Use of masks

In order to prevent the spread of infection, the appropriate mask should be worn by health care providers and visitors when attending to a patient suffering from a communicable disease i.e. spread via the airborne or droplet route. Disposable masks are for single use only and should be discarded after 4-6 hours use or as recommended by the manufacturer. They should not be stored in bags and re-used, shared or hung around neck, etc. If a mask is splashed wet, it should be changed using clean gloves and strict hand washing.

Wearing the Mask

Wash hands and dry. Remove the clean mask from the container with clean hands. If glasses are worn, fit the upper edge of the mask under the glasses. This will help to prevent them from clouding over. A secure fit will prevent both the escape and the inhalation of micro-organisms around the edges of the mask and fogging of the eye glasses.

The mask should completely seal the face at all times to ensure effective filtering of micro-organisms.

Removing the Mask

Wash hands and remove mask keeping outside of the mask in, handle only the strings. Discard in an appropriate bag/container and seal the bag.

Apron

An apron protects the wearer and the uniform from contact with the contaminated body fluids. Plastic aprons are used over the gown when caring for patients where possible splashes with blood and body substances may occur. Need not be used if the gown is of impermeable material.

Selecting the Apron

Select water repellent, plastic aprons, which are disposable. If disposable ones are not available then reusable plastic aprons can be used.

Size

Long enough to protect the uniform but the gown should not touch the ground. Should cover the front and sides. It should open in the back. A tie around the waist keeps the apron in place.

Wearing the Apron

Wash hands. Ensure that the sleeves are rolled above the elbows before putting on the apron. Wear the apron over the uniform and tie around the waist at the back.

Removing the Apron

Wash hands and dry. Remove touching only the inside part of apron. Discard folding the outside part in. Decontaminate or dispose according to the health care facility guidelines. Wash hands thoroughly before touching anything else.

Gown

Gowns made of impervious material are worn to protect the wearer's clothing/uniform from possible contamination with micro-organisms and exposure to blood, body fluids secretions and excretions. The gown should be used only once for one patient and discarded or sent for laundering. Health care workers should remove gowns before leaving the unit.

Selecting a Gown

Gowns should be clean and non-sterile. The gown should be impervious and water repellent. It should be long enough to cover the clothing of the wearer and should have long sleeves and high neck. Disposable gowns are preferable. If they are not available, cotton reusable gowns can be used with a plastic apron underneath.

Wearing the Gown

Wash hands, and dry. Hold the gown at the neck on the inside permitting to unfold. Slide hands and arms down the sleeves. Fasten the ties at the neck. Overlap the gown at the back as much as possible and secure the waistband. Request assistance to fasten the neck and the waist ties.

Removing the Gown

Remove the gown after removing gloves. Untie the waist-band with a gloved hand if it is tied in front before removing the gloves. Remove gloves and wash hands. Untie the neck-ties (be sure not to touch outside of the gown). Slide the gown down the arms and over the hands by holding in inside of the sleeves. Hold the gown with both the hands (inside the shoulders) at the shoulder seams. Turn the gown inside out (contaminated side in). The hands are then brought together and the gown is rolled and discarded appropriately in the container provided. If reusable—discard if visibly contaminated. If there is shortage of gowns they may be reused during one shift for the same patient. Hang gown with outside facing in when not in use. Discard at the end of each shift. Wash hands thoroughly before touching anything else.

Remove a soiled gown as promptly as possible and wash hands immediately to avoid transfer of micro-organisms to other patients or environments.

Protective eye wear/goggles should be worn at all times during patient contact when there is a possibility that a patient's body fluids may splash or spray onto the caregiver's face/eyes (e.g., during throat, endotracheal and tracheostomy suctioning, removal of indwelling catheter, etc.). The amount of exposure can be reduced through the use of protective eyewear. Full face shields may also be used to protect the eyes and mouth of the health care worker in such high-risk situations.

Ordinary spectacles do not provide adequate protection, although care givens may wear their own glasses with extra protection added at the sides. Goggles that fit over glasses are available. Protective eyewear should be changed after each shift. Protective eyewear should be washed and decontaminated after removal and in between use.

Selecting Protective Eyewear

Goggles should be made of clear polycarbonate plastic with side and forehead shields.

These should be optically clear, anti fog and distortion-free. Disposable goggles are preferred but reusable ones can be used after cleaning and decontamination.

Wearing Protective Eyewear

Wear the eyewear by securing it over the bridge of the nose and also over the mask.

Removing Protective Eyewear

Remove and place in appropriate container for cleaning and decontamination prior to reuse by next person.

Gloves

Use gloves when there is potential exposure to blood, body fluid, excretions of secretions. Change gloves between patients, between tasks and procedures on the same patient, and when they become soiled. Remove gloves promptly after touching contaminated items and environmental surfaces and before moving to another patient. Remove gloves before leaving the patient's bedside and wash hands immediately. After glove removal and hand washing ensure that hands do not touch potentially contaminated environmental surfaces or items in the patient's room. Discard gloves after attending to each patient. (Fig. 2.7)

Fig. 2.7: Use of gloves

The reuse of single-use gloves is not recommended.

Selecting Gloves

Use disposable gloves that are clean/non-sterile for routine care of the infectious patients. Sterile for invasive procedures.

Use heavy-duty rubber gloves for cleaning instruments, handling soiled linen or dealing with spills of blood and body fluids. They can be washed and reused. Choose gloves that fit properly. Check there is no puncture in gloves. Do not use gloves if they are torn, as punctured gloves do not provide protection. (Fig. 2.8)

Fig. 2.8: Change of gloves after surgery

Clean, non-sterile, disposable, single use gloves are recommended for routine care of patients with highly transmissible infections.

Wearing Gloves

Wash hands and dry them. Pick up the first glove by its cuff. Wear the first glove. Bunch the glove up and then pull it onto the hand; ease fingers into the glove. Repeat for the other hand.

Removing Gloves

When removing personal protective equipment, remove gloves first. Grasp the outside of one glove, near the cuff, with the thumb and forefinger of the other hand. Pull the glove off, turning it inside out while pulling and holding it in the hand that is still gloved. Hook the bare thumbs or finger inside the remaining glove and pull it off by turning it inside out and over the already removed glove to prevent contamination of the ungloved hand. Roll the two gloves together taking care not to contaminate the hands. Discard appropriately. Wash hands or decontaminate with 70 per cent alcohol hand rub/solution.

Check Your Progress 3

1) Enumerate the important personal protective clothing.

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2) What type of gloves are recommended for routine care of patients with highly transmissible infections?

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3) What are the characteristics of a mask which ensures effective filtering of micro-organisms?

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4) What are the characteristics of good eyewear?

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2.5 LET US SUM UP

In this unit you have learnt that hospital acquired infections can be controlled through proper management of health care waste. It is essential to know the sources of infection, type of microbial agents prevailing in health care setting and the susceptible groups. The important components described in the unit, which need emphasis are:

- Principles of infection control.
- Precaution to be taken by health care worker while handling waste specially in Operation Theatre, Laboratories and Blood Banks.
- Reporting of accidents and needle stick injuries.
- Use of safety clothing and principles of safety measures for waste handlers.

2.6 KEY WORDS

Carrier : A carrier is defined as "an infected person or animal that harbours a specific infectious agent in the absence of discernible clinical disease and serves as a potential source of infection for others".

Case : A case is defined as "a person in the population or study group identified as having the particular disease, health disorder or condition under investigation".

Disinfection : Disinfection is the killing of infectious agents outside the body by direct exposure to chemical or physical agents.

Exposure : Exposure is defined as a percutaneous injury, contact of mucous membrane or non-intact skin or contact with intact skin when the duration of contact is prolonged with blood or other fluids.

Hazardous Waste : Hazardous waste is defined as the waste which can cause injuries or other hazards to health care workers but is not infectious.

Health Care Worker : Health care worker is defined as any person whose activities invoke contact with patients or with blood or other body fluids from patients in a health care or laboratory setting.

Infectious Waste : Infectious waste is defined as the waste which is capable of transmitting infection such as HIV, Hepatitis B.

Invasive Procedure : An invasive procedure is defined as surgical entry into tissues, cavities or organs or repair of major traumatic injuries.

Segregation : Segregation is separating the different types of waste at the point of generation to avoid mixing of infectious waste with non-infectious waste.

Sterilization : Sterilization is the process of destroying all harmful microbes including spores from an object.

2.7 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) The sources of infection in a hospital may be:
   - A case or carrier
   - Improperly sterilized instruments and dressings
   - Fomites such as clothes, bed linen, books, toys, etc.
   - Food, milk, water, blood and blood products

2) The main groups of people who are susceptible to hospital acquired infection are:
   - Patients
   - Doctors, nurses, laboratory staff and other paramedical staff
   - Visitors to health care establishments
   - Workers in waste handling, transportation and waste disposal facilities
   - Rag pickers

3) The principles of infection control in a hospital are:
   - Establishment of infection control policy
   - Policy on patient's admission and discharge
   - Maintenance of hygienic environment in the hospital
   - Monitoring of infectious agents
   - Policy on waste reduction and reuse.

Check Your Progress 2

1) One per cent sodium hydrochlorite is the most commonly used disinfectant for clearing spills. It should be poured on and around the spill area and cover with paper/towel and leave it for 10 minutes.

2) The risk of infection varies with the type of exposure and other factors such as:
   - The amount of blood involved in the exposure
   - The amount of virus in the patient's blood at the time of exposure
   - Whether PEP was taken within the recommended time

3) As early as possible but within 72 hours.

4) PEP should be given for 4 weeks following an exposure.

Check Your Progress 3

1) The important personnel protective clothing includes cap, mask, goggles, apron, gloves, grown and gum boots.

2) Clean, disposal, single use gloves.

3) The mask should completely seal the face at all times to ensure effective filtering of micro-organisms.

4) The good protective eyewear should be made of clear polycarbonate plastic with side and forehead shield. They should be optically clear, antifog and distortion free.

2.8 FURTHER READINGS

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Center for Disease Control and Prevention, *Guidelines for Infection Control in Health Care Personnel,* 1998.

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WHO, *Practical Guidelines for Infection Control in Health Care Facilities,* WHO Regional Office for South-East Asia, New Delhi and Western Pacific Manila, 2004: 2.

WHO, *Prevention of Hospital Acquined Infections: A Practical Guide*, 2nd edn., Geneva, 2002.

FORM No. 1

Accident Reporting

1) Date and time of accident:

2) Sequence of events leading to accident:

3) The waste involved in accident:

4) Assessment of the effects of the accidents on human health and the environment:

5) Emergency measures taken:

6) Steps taken to alleviate the effects of accidents:

7) Steps taken to prevent the recurrence of such an accident:

Date .... Signature....................

Place............. Designation...................

FORM No. 2

Reporting of Needle Stick Injuries

Name and Full address of Hospital: ....

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Needle Stick Sharp Injury Protocol:

Name of health care worker: ....

Category of health care worker: ....

Employment No.: ....

Date of Needle Stick/Sharp Injury: ....

Date of Reporting to Casualty: ....

Site and Depth of injury: ....

Nature of injury : Needle Prick/Sharp Cut/Laceration/Splash of Fluids/Splattered Glass

Action taken in casualty :

Hep. B vaccination given: Yes/No

HBIG: Yes/No

If Immunized : Date .... Intradermal/Intramuscular

Anti HBsAg Titre ....

HbsAg Positive/Negative

HIV antibody Positive/Negative

Information about source of contamination (if available)

- Whether the patient has symptoms of HIV infection or no symptoms
- Serum sent for: (Reports to be entered in follow up visit)

  01. Anti-HIV
  02. HBsAg
  03. Anti-HCV
  04. CD4/CD8 counts

UNIT 3 DISINFECTION AND TRANSPORTATION

Structure

3.0 OBJECTIVES

After going through this unit, you should be able to:

- describe the principles of disinfection and understand briefly different treatment methods and the need for shredding;
- understand transportation of waste within and outside the health care facility; and
- enumerate the importance of proper waste storage areas in health care establishments.

3.1 INTRODUCTION

As you know **health care waste** is defined as the total waste stream from a health care establishment, research facilities, laboratories, and emergency relief donations. Health care waste can further be divided into:

a) **General waste,** comprises of around 85 per cent of the total health care waste and includes packaging material, office supplies and food waste.

b) **Infectious waste** comprises of around 15 per cent of the total health care waste. This waste stream comprises of hazardous and infectious waste stream, which requires special treatment and disposal methods.

Proper management of health care waste can minimize the risks of transmission of infections both within and outside health care facilities. The first priority is to segregate waste, preferably at the point of generation, into hazardous and non-hazardous components. Other important steps are the institution of a sharps management system, waste reduction, avoidance of hazardous substances whenever possible (e.g., PVC-containing products, mercury thermometers), ensuring worker's safety, providing secure methods of waste collection and transportation, and installing safe treatment and disposal mechanisms.

In the earlier units you have learnt about different aspects of management of health care waste such as the importance of health care waste management and infection control. This unit will further help you in understanding the importance of proper disinfection, storage and transportation of health care waste in controlling infections.

3.2 DISINFECTION AND MUTILATION

In this section you will learn about the importance of disinfection and mutilation for proper management of health care waste.

3.2.1 Disinfection and Mutilation

The scientific basis for sterilization and disinfection have been developed only during the last 200 years but the emperical practice of sterilization has been in vogue for last many centuries. Alexander the Great used to boil water before drinking. Desiccation and balsams of dead body (mummification) was an art known to Egyptians to preserve dead bodies. Later scientists like Lister, Pasteur and Koch brought this science on sound footings and soon sterilization became a must in all medical and surgical procedures. Now with the growing hazards due to medical waste, disinfection and sterilization are important methods used for rendering the waste non-infectious before its final disposal.

3.2.2 Principles of Disinfection

Selection of sterilization (defined as the destruction of all micro-organisms including spores) or disinfection (defined as the destruction of micro-organisms but not usually spores) procedure depends on the type of sterilization/disinfection efficiency required for the said procedure.

Some general principles must be followed when using disinfectants:

- Every hospital should implement a formal written policy for its disinfection and sterilization procedures. Among other things, the policy should specify:
  - what disinfectant should be used for a particular purpose,
  - safety aspects when using a particular disinfectant,
  - methods for preparing an accurate use dilution of the disinfectant, and
  - the correct exposure time for each disinfectant and procedure.
- The contact times and concentrations recommended by the manufacturer must be strictly followed. Some disinfectants, such as alcohol and phenols are strongly affected by dilution. Others, such as formaldehyde and quaternary ammonium compounds (QACs) are less affected.
- Frequency of use is also a factor to consider. All disinfectants that are used more than once for disinfection or sterilization lose their potency, mainly because of the dilution resulting from immersion of pre-cleaned wet instruments and the accumulation of organic material. The frequency of use should determine the periodicity with which the disinfectant needs to be replaced.

On the basis of the cidal activity for each group of micro-organisms, the disinfection process can be classified into low, intermediate and high levels. These levels of disinfection provide hospital personnel with a practical guideline for selecting appropriate germicides for the disinfection of medical equipment and hospital surfaces.

3.2.3 Types of Disinfection Agents

Types of disinfection agents can be classified as:

- Natural agents
- Chemical agents
- Physical agents

Natural Agents

Sunlight

Direct and continuous exposure to sunlight is destructive to many disease-producing organisms. The ultraviolet rays of sunlight are particularly lethal to bacteria and some viruses.

Air

Exposure to open air causes drying of moisture and hence is lethal to many bacteria.

However in practice the natural agents cannot be totally depended upon for disinfection.

Chemical Disinfection

Chemical disinfection, used routinely in health care to kill micro-organisms on medical equipment and on floors and walls, is now being extended to the treatment of health care waste. Chemicals are added to the waste to kill or inactivate the pathogens it contains, this treatment usually results in disinfection rather than sterilization. The chemical disinfectants should be selected on the basis of its effectiveness, simplicity and cost.

Types of Chemical Disinfectants

The types of chemicals used for disinfection of health care waste are mostly alcohol, aldehydes, chlorine compounds, ammonium compounds and phenolic compounds.

Do's and Don'ts of Disinfectants

DO take care to measure your disinfectant correctly.

DO add the disinfectant to the right amount of water or any other dilutant to make a solution for use.

DO use a clean, dry pot or bucket for the solution.

DO wash away dirt, where you can, before using disinfectant.

DO discard your disinfectant solution when you have finished the day's work.

DO remember that if disinfectants are used carelessly they may grow microbes and spread infection.

DO make fresh disinfectant regularly.

DON'T use a disinfectant for sterilization.

DON'T store instruments or cleaning tools in disinfectant.

DON'T top up a disinfectant solution.

DON'T bring your own disinfectant to the hospital; use only those supplied to you in the hospital.

DON'T use two disinfectants together, unless one of them is alcohol (or is only recommended by the manufacturer).

DON'T add your detergent to a disinfectant; this may put both of them out of action.

DON'T expect any disinfectant to make dirt safe.

a) ***High-Level Disinfectants***

Glutaraldehyde

Glutaraldehyde is a saturated dialdehyde that destroys micro-organisms through alkylation of their sulfhydryl, hydroxyl, carboxyl, and amino groups. Glutaraldehyde has efficient bactericidal, fungicidal and virucidal activity but slow micro-bactericidal activity (>30 minutes). In order to improve tuberculocidal activity, compounds can be mixed with phenols or alcohol. The contact times necessary for achieving high-level disinfection vary according to the formulation, ranging from 20 to 90 minutes. At longer contact times (6 to 10 hours), glutaraldehyde is also a sterilant. Once activated, these solutions have a shelf life of 14 to 28 days, depending on intensity of use, accumulation of organic material, and innate degradation of the germicide mixture. Glutaraldehyde-based germicides have broad applications in the hospital setting. They are widely used for the disinfection or sterilization of endoscopes, respiratory therapy and anesthesia equipment, and sharp surgical instruments.

Formaldehyde

Formaldehyde is a compound chemically similar to glutaraldehyde but a less potent germicide. It is a high-level disinfectant at 8 per cent combined with 70 per cent alcohol and an intermediate-level disinfectant when used at 4 to 8 per cent in water. It inactivates micro-organisms by alkylation of amino and sulfhydryl groups of proteins and ring nitrogen atoms of purine bases. Although it is bactericidal, tuberculocidal, fungicidal, virucidal and sporicidal, its applications in the hospital setting are limited because of its carcinogenic potential and the irritating fumes associated with its use. Aside from the gaseous formaldehyde system mentioned earlier, its main application is in the disinfection of dialysis systems and hemodialysis filters. For optimal disinfection of these systems, a 4 per cent formaldehyde solution with a minimal contact time of 24 hours is recommended. Extreme precautions must be taken to rinse the dialysis equipment thoroughly before use to avoid potential health hazards for patients.

Peracetic Acid

Peracetic acid is becoming increasingly popular as a hospital disinfectant. It is sporicidal, bactericidal, virucidal, fungicidal and tuberculocidal at relatively low concentrations (less than one per cent). It is effective in the presence of organic matter and at low temperatures and has no harmful decomposition products (acetic acid, water and oxygen). Its mode of action is believed to be the disruption of sulfhydryl and sulfur bonds in proteins and enzymes. Several formulations available in the market are combinations of low concentrations of peracetic acid (<1.0 per cent) and hydrogen peroxide (1.0 per cent). The result is a rapid, broad spectrum germicide that may be used for the disinfection or sterilization of critical and semi-critical items. Contact time for these formulations is approximately 25 minutes and the maximal reuse period is 14 days. Peracetic acid may also be used at low concentrations (50 ppm) as a laundry disinfectant instead of chlorine.

Hydrogen Peroxide

Hydrogen peroxide is a bactericidal, virucidal and fungicidal agent. At high concentrations, it is also sporicidal. Its mode of action involves the production of hydroxyl free radicals that destroy membrane lipids, DNA and other essential cell components. It has been used in the hospital as both a disinfectant and an antiseptic. However, unsatisfactory results have been reported with the use of pure preparations of hydrogen peroxide. The presence of inactivating levels of catalase in tissue and the cytotoxicity of 3 per cent hydrogen peroxide have rendered it ineffective as an antiseptic. As a disinfectant, it provides good disinfection of surfaces and medical equipment from a microbiologic standpoint. Its major disadvantage is that residuals of the disinfectant have been reported to cause adverse effects in patients. Hemolysis has occurred in hemodialysis patients who were exposed to residual hydrogen peroxide in their equipment and peroxide enteritis associated with faulty rinsing procedures has been reported among patients in a gastrointestinal endoscopy unit. Available formulations are hydrogen peroxide in a concentration of 7.5 per cent or mixtures with peracetic acid (0.08 per cent peroxyacetic acid and 1.0 per cent hydrogen peroxide). Both can be used for the sterilization or disinfection of critical and semi-critical items. Contact time is 30 minutes for the 7.5 per cent hydrogen peroxide formulation and 25 minutes for the mixture. If the pure hydrogen peroxide formulation is used, all equipment must be thoroughly rinsed before being used for patients.

b) ***Intermediate and Low-level Disinfectants***

Chlorine Compounds

The most commonly used chlorine disinfectants in the hospital are the hypochlorites, mainly sodium hypochlorite and the organic chlorine-releasing agents such as sodium dichloroisocyanurate. Their advantages are low cost, rapidity of action and broad antimicrobial activity; their disadvantages, particularly for the hypochlorites, are their corrosiveness, inactivation by organic matter and chemical instability. Chlorine compounds are powerful oxidizing agents that oxidize thiol groups and halogenate amino groups in proteins. The biocidal component of all chlorine compounds is hypochlorous acid (HOCl), which dissociates in a pH-dependent manner into H^+ and OCl^-. Sodium dichloroisocyanurate has a more stable and prolonged effect, because it produces acidic solutions (pH 5.5 to 6.5) with about 90 per cent undissociated HOCl, whereas inorganic hypochlorites release only 10 per cent undissociated HOCl.

From a strictly microbiologic point of view, chlorine compounds are actually sterilants, because their spectrum includes vegetative bacteria, mycobacteria, bacterial spores, viruses, protozoa and fungi. However, they are extremely corrosive and irritating to personnel at high concentrations. Their applications are limited to situations requiring an intermediate level of activity such as the decontamination of blood and body fluid spills; items such as bedpans, urinals and kidney bowls; and culture spills in the microbiology laboratory. They are also useful for routine disinfection of hospital surfaces. The applications of chlorine compounds are discussed further in the sections on decontamination of medical equipment and disinfection of the hospital environment.

Alcohol

Ethyl alcohol and isopropyl alcohol at a concentration of 70 per cent are intermediate-level disinfectants. They are bactericidal, fungicidal, and virucidal and have excellent activity against *Mycobacterium tuberculosis*. Their activity is extremely rapid and their mode of action is denaturation of proteins. Because they lack sporicidal activity, alcohol are not recommended for sterilizing critical medical devices. Rapid evaporation makes them inadequate for use on environmental surfaces. Alcohol may be used for the disinfection of non-critical and some semi-critical devices such as thermometers and stethoscopes by submerging precleaned items for at least 10 minutes. Because alcohol cause damage to lensed instruments and tend to harden rubber materials, they should not be used to disinfect these items.

Phenol Compounds

Phenol and its derivatives are intermediate to low-level disinfectants that are useful primarily for the disinfection of environmental surfaces and non-critical devices. They are tuberculocidal, fungicidal, virucidal and bactericidal but have no activity against spores. The mode of action of phenol at high concentrations is that of a protoplasmic poison that penetrates and destroys the cell wall and precipitates cellular protein. In lower concentration, this disinfectant inactivates essential enzyme systems. Important features of phenol are that it remains active when in contact with organic material and it is difficult to rinse from most materials. Because the residuals may cause irritation, these compounds are not suitable for the disinfection of medical devices that come in contact with living tissue. Moreover, the use of phenolic detergents on infant bassinets and incubators has been associated with hyperbilirubinemia, which precludes the use of phenol in nurseries. As discussed later, the primary use of phenol compounds is as environmental and laboratory detergents and disinfectants.

Iodophors ·

An iodophor is a combination of iodine and a carrier that allows continuous release of small amounts of iodine in solution. The cidal effects of iodine involve the disruption of protein and nucleic acid structure and synthesis. These compounds are intermediate to low-level disinfectants but are mainly used as antiseptics. Their hospital applications for disinfection are limited because they may corrode certain metallic instruments that are disinfected for long periods. Also, non-metallic items such as plastics and rubber may be discoloured or stained when disinfected with these compounds.

Quaternary Ammonium Compounds

A number of Quaternary Ammonium Compounds (QACs) are formulated for use in hospitals; most contain benzalkonium chloride and cetylpyridinium chloride. These germicides are low-level disinfectants that are bactericidal, fungicidal, and virucidal against viruses with lipid envelopes. Their mode of action involves disruption of the cell membrane, denaturation of essential cell proteins, and inactivation of enzymes. In the laboratory, these compounds initially appeared to be rapidly bactericidal against test bacteria in suspension tests. However, subsequent studies showed that contact with hard water, soap, protein, cotton, or gauze reduced or nullified the germicidal properties of QACs. Moreover, gram-negative bacteria, particularly *Pseudomonas* and *Proteus* sp., are capable of growing in these solutions. Because contaminated solutions were implicated in several outbreaks, the Centers for Disease Control recommended the withdrawal of QACs as hospital antiseptics and disinfectants in 1976. Today, QACs are used only for cleaning hospital environmental surfaces.

Tables 3.1 and 3.2 show the recommended dilutions for some commonly used compounds and disinfection procedure for some commonly used hospital items respectively.

Table 3.1: Recommended Dilutions for Some Commonly Used Disinfectants

Name of Disinfectant	Available chlorine	Required chlorine	Required chlorine contact period	Amount of disinfection to be dissolved in 1 ltr of water
Sodium hypochlorite	5 per cent	0.5 per cent	30 min	100 ml
Calcium hypochlorite	70 per cent	0.5 per cent	30 min	7.0 gm
Sodium hypochlorite powder	—	0.5 per cent	30 min	8.5 gm
Sodium Dichloro isocyanurate (NaDCC) tablets	60 per cent	0.5 per cent	30 min	4 tabs
Chloramine	25 per cent	0.5 per cent	30 min	20 gm

Table 3.2: Procedure of Disinfection of Certain Commonly Used Hospital Items	
General use items	**Disinfection**
Bath water	Add savlon when necessary
Bed pans	Wash with hot water and dry Disinfect with phenol after use by infected patients Autoclave
Bowls	Wash with hot water and keep dry Autoclave
Crockery, Cutlery	Wash with hot water/detergent and keep dry
Floors	Vacuum clean Mop with hot water and detergent
Furnitures	Damp dust with detergent/phenol/ 2 per cent Lysol
Mattresses/Pillows	Use water impermeable cover Wash cover with detergent and keep dry Disinfect with phenol/ 2 per cent Lysol
Trolley tops	Wipe with warm water and detergent to remove dust and keep dry
Thermometers	Wash with warm water/detergent and keep dry
Endoscopes/ Arthroscopes/ Laparoscopes/ Fiberoptic Endoscopes	Immerse in 2 per cent Cidex solution Use latex gloves, eye protection plastic covering mask while handling Alternatively, use ethylene oxide sterilization
Endotracheal suction catheter	Should be disposable
Endotracheal tubes	Recycled after cleaning and autoclaving
Ambu Bags	Ideally heat disinfect Immerse in 2 per cent glutaraldehyde and wash with sterile distilled water to reduce respiratory irritation
Oxygen delivery face mask	Wash and dry Use 70 per cent isopropyl alcohol to remove mucus
Suction drainage bottles	Ideally autoclave
Ventilatory circuits, respiratory equipment in Neonatal/Paediatric unit	Heat disinfection for 800° F for 30 min and Autoclave or Ethylene oxide sterilization
Incubators	Clean thoroughly with warm water/soap Use 70 per cent isopropyl alcohol
Humidifiers	Empty daily refill with sterile water Disinfect when contaminated with 1per cent Sodium hypochlorite Autoclave
Urinary Catheter	Should be disposable

Physical Agents

Physical agents are usually preferred over chemical agents for performing sterilization. Heat is a very important physical agent for sterilization. Heat is the most reliable and widely used means of sterilization according to its antimicrobial activity through destruction of enzymes and other essential cell constituents.

Disinfection by Application of Heat Energy

Generally, sterilization is best achieved by physical methods such as steam or dry heat, which are less time-consuming and more reliable than chemical germicides.

Methods

Dry Heat

The main principle is thermal inactivation by oxidation. Its major advantage is that, it is non-corrosive with simple design and principle, however, it is less effective than moist heat and requires longer times and/or higher temperatures. It is generally used for materials that are damaged by or are impenetrable to moist heat.

Moist Heat

It causes irreversible coagulation of (microbial) proteins and is more rapid and more effective than dry heat.

Hot Air Oven

It works at 160-180°C for 2-4 hours by penetrating water-insoluble materials (e.g., grease and oil) and is less corrosive to metals and sharp instruments than steam. Its main disadvantage is slow diffusion, penetration and loading. It is not suitable for reusable plastics. Its main uses are for anhydrous materials, such as oils, greases and powders, laboratory glassware, instruments and closed containers.

Boiling

It is done at 100°C for a minimum time of 10-30 minutes. But the whole process is cumbersome and not practical for everyday lab use also it does not have reliable sporicidal effect. It is mainly used for small instruments and equipment.

Incineration

Its main principle is oxidation of waste to ashes (burning) at very high temperature of 1000°C. Incineration reduces volume of waste up to 95 per cent. It is used for destroying all kinds of hospital waste, but with the environmental and health concerns associated with incineration of plastics/chlorinated compounds—like the emission of dioxins and furans resulting in cancers and endocranial disorders incineration should be restricted only to anatomical waste. Its improper use may lead to emission of pathogens in smoke and requires transport of infectious waste.

Red-heat Flame

It works by oxidation to ashes (burning). The process is very rapid. However, initial contact with flame can produce aerosols and there is also a possibility of accidental fire. It is used for inoculating loops and needles.

Pasteurization

Its principle is heating to below boiling point (generally 77°C) for up to 30 minutes. It can be used on heat sensitive liquids and medical devices. It is a low cost alternative but does not have reliable sporicidal effect. It is used for milk and dairy products and some heat-sensitive medical equipment.

Autoclaving

It works on the principle of steam under pressure. It is utilized for penetration of sterile glassware, media and instruments, decontamination of reusable supplies and equipment and decontamination of infectious waste. Its main advantage is that minimal time is required and it is most dependable sterilant for lab use. Steam (moist heat under pressure) is inexpensive and effective device for sterilization. Both may be used for linens, metallic surgical instruments, glass, fluids, some plastics and for treatment of waste. Steam autoclaves are routinely used at 121°C for time intervals that range from 15 to 30 minutes depending on the items to be sterilized.

Moist heat has the advantage of quickly penetrating all types of materials and is relatively unaffected by the presence of organic material.

Ultraviolet Light (Germicidal Lamps)

The light (approximately 257 nm wave length) emitted by UV lamps is germicidal, and can be used to effectively eliminate pathogenic micro-organisms on exposed surfaces and in air. However, UV light generally has poor penetrating power unless accentuated by other physical/mechanical means. Recent advances in UV light technology that incorporate the use of simultaneous ultrasound waves have shown effective results and may offer a cost effective and practical alternative to traditional steam autoclaving for certain applications.

UV light can also present skin and eye burn hazard if used improperly and factors such as lamp age and poor maintenance can reduce performance.

Miscellaneous Physical Methods

Infrared radiation: used for heat treatment of small metal and glass items.

Microwaves: used for treatment of liquids, nonmetallic objects, and biohazardous waste.

Gamma irradiation: disrupts DNA and RNA in living organisms, and is used by hospital and laboratory suppliers for materials that do not tolerate heat and pressure (i.e., autoclaving) or chemical treatments.

Membrane filtration: physically removes particulates (e.g., micro-organisms) from heat-sensitive pharmaceutical and biological fluids. The size of the particles removed is determined by the pore size of the filter membrane.

Flash Sterilization

For emergencies, a cycle temperature of 132°C may be used to shorten sterilization time, a procedure known as flash sterilization. The Association of Operating Room Nurses has established the following minimal parameters for flash sterilization at 132°C:

- 3 minutes for non-porous items and 10 minutes for porous items in gravity displacement autoclaves
- 4 minutes for both nonporous and porous items in pre-vacuum autoclaves.

Flash sterilization has a lower margin of safety because minimal times are used and items are unwrapped.

Dry Heat Sterilizers

For the sterilization of temperature-sensitive medical devices, available options include the use of a sterilization system (ETO, gaseous formaldehyde with steam, plasma gas or peracetic acid) and immersion of the instruments in a liquid sterilant.

If financially feasible, a sterilization system is preferred. Its use eliminates the potential for human error during the preparation, handling or exchanges of the chemical sterilants. It also reduces possible toxicity to the health care workers in-charge of the process.

Disinfection by Microwaves

Microwaves are high frequency electromagnetic waves which are generated by a special magnetron tube. As the electrons leave the central cathod, they are inducted into a circular motion by a magnetic field, the result of which is generation of microwave energy within a very narrow bandwidth.

Process of Disinfection

Microwaves are introduced in a special chamber where the waste is kept. They cause the molecules within the waste to vibrate. This generates heat from within the matter itself which heats the material inside out. Uniform heating of the matter ensures that all the microbes are killed and a high level of disinfection is achieved.

The method is ideal for disinfecting infectious plastics, such as blood and urine bags, catheters and tubings where the steam or the chemical disinfectant cannot penetrate. However, it needs a constant supply of power and the initial cost is high. This treatment cannot be used for cytotoxic, hazardous or radioactive waste.

You shall be learning more in detail about these treatment techniques in Unit 2, Block 2 of this course (BHM-002).

3.2.5 Mechanical Processes: Shredding and Mutilation

Mechanical destruction of waste renders it unrecognizable and is an important part in the treatment processes though it cannot be considered a treatment process by itself. Different kinds of mechanical processes such as shredders, grinders and hammer mills are commonly used mechanical destruction processes. In general size reduction is accomplished by either shearing the material between two surfaces (shredders) or by impact against a solid surface (as in hammer mills). A screen is usually added to control the size of particles that exit the device. Sometimes, a ramp is used to push the waste through the shredder or grinder.

Shredders are designed with hardened steel cutting knives, hooks, disks or blades mounted on rotating shafts. These knives cut against stationary knives on the casing (single shaft shredders) or against other knives mounted on one or more counter rotating shafts (multiple shaft shredders). Because waste material can get lodged between the blades, many shredders used for medical waste are equipped with reverse action, e.g., when an overload occurs, the normal rotating motion is stopped and a reverse rotating motion is used to clear the obstruction. This action may be repeated several times automatically. If the blockage is still not removed, the shredder shuts off and the operator is sent an audio-visual or electronic alert. Removing the blockage then requires manual operation. Shredders generally operate at low speed and high rotation force.

Grinders refer to size-reduction equipment using a series of rollers that operate at high speed. Terms like crusher and pulverizer are also used. When the rollers are equipped with teeth or knives, they operate much like multiple shaft shredders, which is why the term shredder and grinder are sometimes used interchangeably. A hammer mill is another mechanical shredding device and has a rotating shaft with swinging T-shaped steel hammers or beaters mounted on it. As the hammer mill rotates at high speed, waste is crushed by the hammers against a plate. Hammer mills tend to be noisier and use more energy.

Check Your Progress 1

1) What is the principle of functioning and use of an autoclave?

....

....

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2) What is the process of disinfection in a microwave?

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....

....

....

3.3 STORAGE AND TRANSPORTATION

Now you will learn about the importance of proper storage and transportation of health care waste.

3.3.1 Storage: Time and Principles, and Climatic Effects

Storage of waste forms an important part in the cycle of health care waste disposal. Every point of generation, such as ward, laboratory, operation theatre, etc., should have recepticals for storing the wastes that are generated at that point of generation.

The containers should be preferably lined with plastic bags as it helps in containing the waste properly and is convenient to unload the bin. Plastic bags may be suspended inside a frame or be placed inside a sturdy container. A lid should be provided to cover the opening of the bag at the top.

Each container may be clearly labeled and have distinct colours based on the kind of waste contained. This system helps in effective segregation, distinct collection and transportation of waste and tracking of waste if necessary for final treatment and disposal. For example, if a sanitary worker is injured by a syringe or blade that has been put into a bag rather than into the correct sharps container, it is possible to determine the origin of that waste and identify the members of staff who were responsible for that ward. It may also help in knowing the type of infection that may have been transmitted.

Also different kinds of recepticals should be used to contain different type of waste like sharps should be stored only in puncture proof containers as they minimize the chances of needle stick injuries caused while collection and transportation of sharps. Similarly if the waste (like used syringes/gloves) are to be chemically disinfected at source, they should be contained in a twin bin with outer rigid bin and perforated inner bin. The inner bin containing the waste is pulled leaving behind the disinfectant in the outer bin, thus making it convenient for the sanitary worker to handle the waste.

Table 3.3: Types of Containers for Different Waste Streams

Waste	Type of Container		
	Point of Generation	Transportation	Final Storage Site
1) Sharps	PPC (Punture Proof Container)	PPC in a wheel barrow trolley	PPC
2) Infectious waste (with chemical treatment at point of generation)	Plastic twin bins (perforated inner bin and rigid outer bin)	Plastic/metallic bin in a wheel barrow/ trolley	Plastic/metallic bin
3) Infectious waste (with no chemical disinfectant at the point of generation	Plastic/metallic bin lined plastic bag	Plastic/metallic bin in a wheel barrow/ trolley	Plastic/metallic bin
4) General waste	Plastic/metallic bin lined plastic bag	Plastic/metallic bin in a wheel barrow/ trolley	Plastic/metallic bin

Health Care Waste Storage Area Audit

Objective of the Audit

To provide important information required for assessing the need for improvements and special adaptations as well as training and capacity building efforts for proper implementation of an improved health care risk waste management system.

Who should fill in the Audit Form

It is suggested that the hospital administrator delegates the filling in of the form to a relevant person or persons with suitable assistance from waste handlers for measuring and verification.

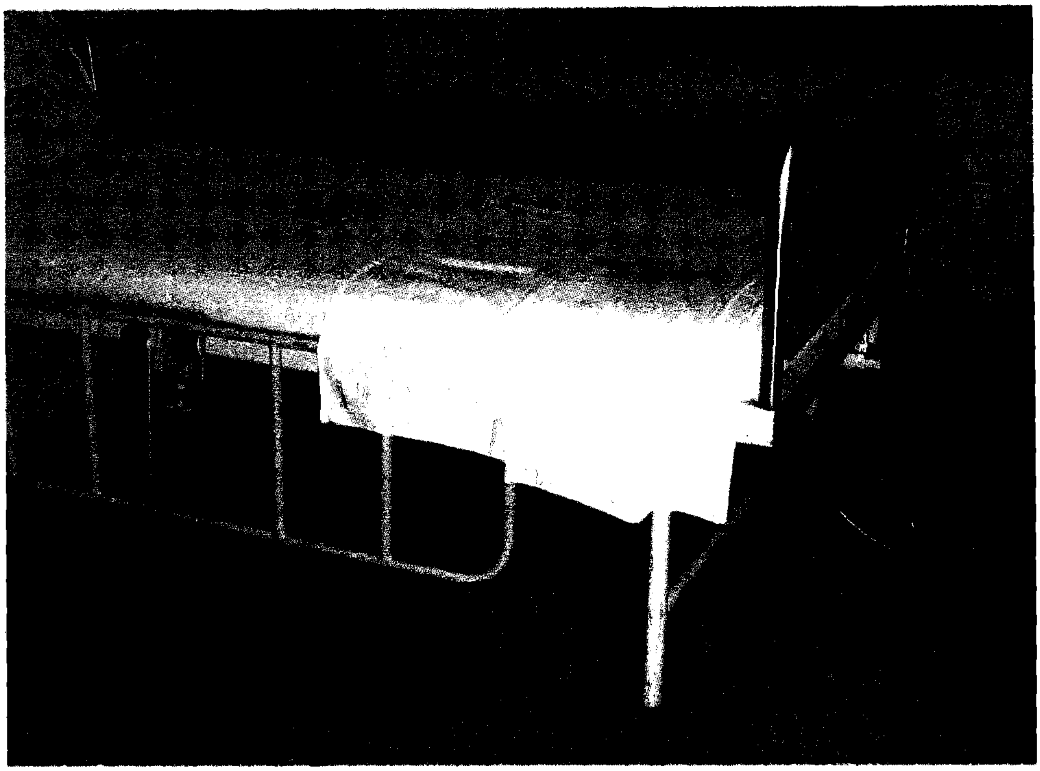

Fig. 3.1: Waste contained at the point of generation
(Source: Sundram Medical Foundation, Chennai, India)

For each health care waste service delivery site:

— Hospital

— Community Health Centre

— Smaller Clinic, or

— Other units to be included in the health care waste collection services please indicate the following information:

1) *General Site Specific Information*

- Name of Health Care Facility: ....

  Region and District: ....

  Type of Health Care:

- Facility:

Hospital	☐
Special Hospital	☐
CHC	☐
Other Clinic	☐
Mortuary	☐
Laboratory	☐

Other:.................................

- Number of beds (if applicable): ....
- Typical bed occupancy (per cent): ....
- Number of out-patients per year: ....and per month.............
- Number of nurses (All categories): ....
- Number of doctors: ....
- Number of general assistants: ....and ward helpers.............
- Number of other non-medical staff: ....
- Number of nursing students per year: ....
- Name and contact details of health care waste Officer/Assistant health care waste officer/s or infection control nurse, head of the cleaning department/ contact person:

  ....

  Tel. No. : ....Fax No. : ....
- Address : ....

  ....

  ....
- Name and contact details of hospital administrator or Clinic Manager and Regional Manager:

  ....

  Tel. No. : ....Fax No. : ....
- Number of wards: ....
- Typical number of beds per ward: ....
- Number of operating theatres: ....
- Type of services (tick):

  Emergency Room ☐

  Oncology ☐

  Surgery ☐

  Renal ☐

  Maternity ☐

  ICU ☐

  Radiology ☐

  X-ray ☐

  Laboratory ☐

  Pharmacy ☐

  Other:...

- Number of floors: ....
- Number of independent buildings with wards: ....
- If not a hospital: number of examination rooms: ....

2) *Intermediate Storage Room in the Facility*

- Number of sluice rooms/intermediate storage rooms: ....
- Number of dedicated intermediate waste storage rooms (IWSR), other than sluice rooms: ....
- Typical average dimension of sluice metres room/IWSRs: .... metres by ....metres
- Dimensions of smallest sluice room/IWSRs: ....metres by ....metres
- Dimensions of biggest sluice room/IWSRs: ....metres by ....metres
- Typical width of doors/passages to sluice rooms/IWSR: .... metres
- Smallest width of doors/passages to sluice rooms/IWSR: ....metres

3) *Internal Transportation Routes and Access*

- Can all waste generating wards be accessed by trolleys, e.g., via lifts/ramps: Yes/No
- Longest transportation route from Ward to Central Waste Storage Area: metres
- Number of ramps used on the route from wards to the Central Waste Storage Area:
- Steepest incline of ramps that shall be meters trolleys on the collection route: per cent (or 1 in 10, in 20, etc.)
- Width of smallest ramp/passage to be used during the collection route:
  Number of dedicated service lifts metres

4) *Central Waste Storage Area and Waste Disposal*

- Is the Central Waste Storage Area fully enclosed and lockable? Yes/No
- Is the stored area protected against the elements of weather? Yes/No
- How is health care waste stored before collection (tick)?

  Skip (Large Metal/Plastic Container) ☐

  Wheeled bins ☐

  Black plastic bags ☐

  Other:...

- Dimensions of the Central Waste Storage Area?........metres by................ metres
- Does Central Waste Storage Area have lighting and electricity outlets? Yes/No
- Does Central Waste Storage Area have tap water/wash basin? Yes/No

- Is the Central Waste Storage Area directly accessible by a truck (gross vehicle mass approx. 10,000 kg)? Yes/No
- How high above ground level is the floor of the central storage area (0 = on ground level): ....centimeters
- Is there a truck loading-bay? Yes/No
- Is the Central Storage Area used for storage of (tick):

Infectious waste	☐
Hazardous waste	☐
Cardboard	☐
Food waste	☐
Glass	☐
Paper	☐
Pharmaceutical waste	☐
Pathological waste	☐
Other:	

- Is pathological waste stored separately in a freezer at a morgue? Yes/No
- Is a freezer, other than at the morgue, available for storage of pathological waste? Yes/No
- Distance from Morgue to the Central Waste Collection area by internal roads: ....metres
- Is there a paved passageway/road between hospital/clinic and central storage area? Yes/No

Recommendations for Storage Facilities for Health Care Waste

- The storage area should have an impermeable, hard-standing floor with good drainage; it should be easy to clean and disinfect.
- There should be a water supply for cleaning purposes.
- The storage area should afford easy access for staff in charge of handling the waste.
- It should be possible to lock the store to prevent access by unauthorized persons.
- Easy access for waste-collection vehicle is essential.
- There should be protection from the sun.
- For the storage of waste for period more than 24 hours refrigeration should be provided so that the temperature does not exceed +10°C . The storage of biological waste might require low temperature volumes.
- The storage area should be inaccessible for animals, insects and birds.
- There should be good lighting and at least passive ventilation.
- The storage area should not be situated in the proximity of fresh food stores or food preparation areas.
- A supply of cleaning equipment, protective clothing, and waste bags or containers should be located conveniently close to the storage area.

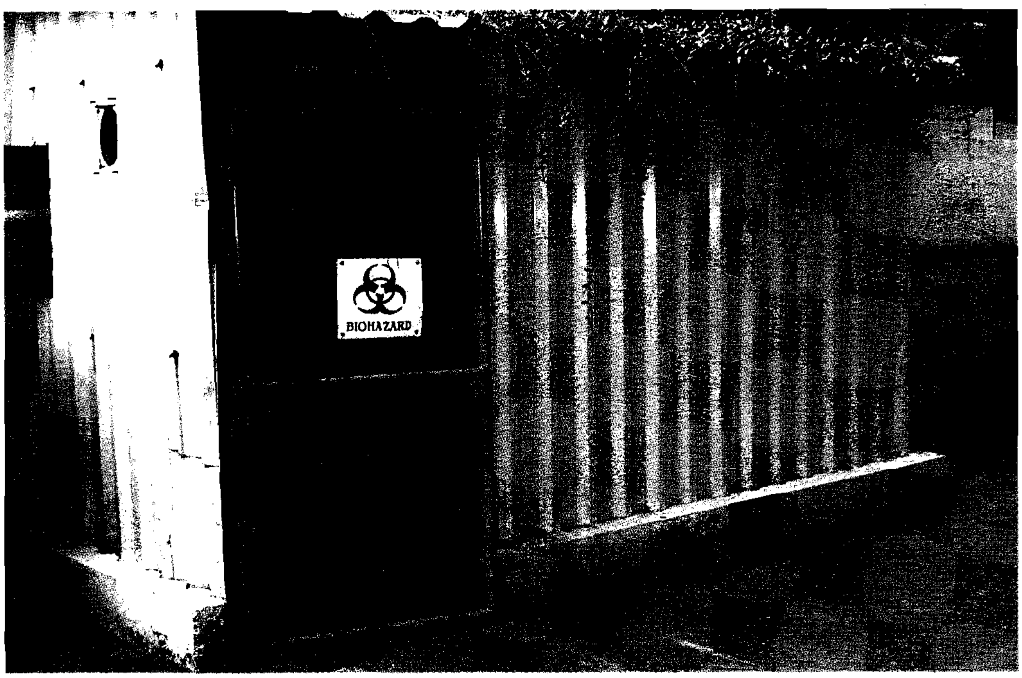

Fig. 3.2: Final waste storage area in the health care facility
(***Source:*** *Sundaram Medical Foundation, Chennai, India)*

Check Your Progress 2

1) Why should each waste bag be labelled when sent for final disposal?

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2) What is the important requirement if waste is stored for more than 24 hours?

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....

3.3.2 Transportation of the Waste

In this sub-section you will learn about transportation of health care waste from the point of generation to its final disposal. You will learn how transportation of waste should be done in organized manner and what special precautions should be taken while transporting the waste. Special emphasis should be laid on safety of health care workers, patients and community, waste should be transported through routes that are not commonly assessed by visitors and patients in the health care settings. Waste should never be mixed while transporting and should be preferably carried in closed containers on vehicles exclusively used for transportation of waste to prevent access to and direct contact with the waste. To ensure safe transportation of waste adequate measures in terms of design and capacity building must be taken to prevent any accidental spillage.

The proper collection and transportation of waste is an important component in health care waste management. Its implementation requires the direct involvement of the health care facilities, maintenance services, housekeeping services, and cooperation of all the health care personnel.

Health care waste collection practices should be designed to achieve an efficient movement of waste from point of generation to final disposal while minimizing the risk to personnel. Collection and transportation of waste is further divided into on-site and off-site based on their place of transportation.

On-site Transportation of Health Care Waste

On-site transportation is the transportation of waste within the health care setting, i.e., from point of generation to final waste storage site in the health care facility. The local collection of waste within the hospital should be provided by housekeeping staff, from point of use to the waste collection point. Once the waste bags are about three-quarters full they should be tightly closed or sealed and transported to the immediate storage or final storage loaded into trolleys/barrows by housekeeping staff. These containers are then carried to a central waste storage compound by housekeeping staff for subsequent disposal/treatment.

Transportation of waste within the health care establishments should be by means of:

- Wheeled trolleys, containers or carts that are not used for any other purpose and meet the following specifications:
  - No sharp edges that could damage waste bags or containers during loading and unloading
  - Easy to clean
  - Easy to load and unload
  - The vehicles must follow specific routes within the health care facilities to reduce the vehicle passage of loaded carts through wards and other clean areas. The waste should be transported at such times when there is minimum traffic of patients, hospital staff and visitors.
- The vehicle should be cleaned and disinfected daily with an appropriate disinfectant. All waste bags seals should be in place and intact at the end of transportation.
- Transport equipment should be easy to move and manoeuvre and should be able to get access to all places from which health care waste is to be collected or to which health care waste is to be delivered. This includes allowance for elevator sizes in the event of multistorey buildings.
- Wherever practical, all internal transfer/transport of health care waste should be based on wheeled transportation to secure best possible ergonomics for workers while securing cost-efficient and flexible collection. Manual transport of health care waste should be avoided wherever practical, with heavy or awkward lifts and manipulations not being permitted under any circumstances.
- Workers transporting the waste should be equipped with appropriate personal protective equipment including heavy-duty gloves, boots, etc., protecting themselves from any injury.

Minimal Observance for Waste Collection and Transportation

- Each health care facility should have a health care waste management plan which should include collection points and routes of waste transport. A time table of the frequency of collection should also be set-up.
- Provide heavy duty gloves, industrial boots and apron for waste collectors.
- Ensure that waste containers are appropriately sealed, removed and replaced immediately when they are no more than three-quarters full.
- Ensure that hazardous/infectious health care waste and non-risk health care waste are collected on separate trolleys which should be marked with the corresponding colour (black/yellow) and washed regularly.

Fig. 3.3: Internal Transportation of Waste
(*Source: Airforce Command Hospital, Bangalore, India)*

Labelling

Labelling is important especially in case of any liability, accident. Full and correct labelling allows the origin of the waste to be traced. Labelling also warns the health care staff and the general public of the hazardous nature of the waste.

All waste bags or containers should be labelled with basic information on their content and on the waste producer. This information may be written directly on the bag or container or on pre printed labels, securely attached.

Minimal Observance for Waste Segregation and Labelling

- **Establish a three-bin system with appropriate labelling in all the health care facilities as follows:**
  1) **General health care waste (green bags/bins; no symbol)**
  2) **Potentially infectious health care waste (yellow and red bags/bins; bio-hazard symbol)**
  3) **Used sharps, including broken glass (puncture proof containers; bio-hazard symbol).**
- **Ensure awareness and training for medical staff and waste managers for waste segregation and labelling.**

The labels should carry information about the waste category:

- Date of collection
- Place in health care facility where produced (of ward)
- Waste destination

Fig. 3.4: Bio-hazard Symbol

Off-site Transportation of Health Care Waste

The health care waste generator is responsible for the safe packaging and adequate labelling of waste to be transported off-site for treatment and disposal. Packaging and labelling should comply with the national regulation governing the transport of hazardous wastes and maintaining that it presents no danger to the public during transport. Likewise, the waste generators are ultimately responsible for ensuring that their wastes are properly treated and disposed off in an approved disposal facility.

While transporting the waste the health care authorities, the transporter and the evaluation agency should be able to track the waste any time during transportation. Once the waste is loaded in the vehicles the transporter shall provide the waste generator with a copy of the consignment note. This note includes the following information:

- The name, address, telephone number and accreditation/authorization number of the transporter, unless the transporter is the generator.
- The type and quantity of waste transported.
- The name, address and telephone number of the generator.
- The name, address, telephone number, permit number and the signature of an authorized representative of the approved facility receiving the waste.
- The date that the waste is collected or removed from the generator's facility, the date the waste is received by the transfer station, or point of consolidation, if applicable, and the date that the waste is received by the treatment facility.

Off-site Transportation Vehicles

Collection vehicles used for the transport of health care wastes should not be used for the transport of any other material that could be seriously affected by contamination such as food, livestock, people or retail goods. The vehicle should have an enclosed leak proof body and capable of being locked to secure the waste. Waste can be loaded directly to especially designed vehicle, but it is safer to place them first in containers (e.g., cardboard boxes or wheeled, rigid, lidded plastic or galvanized bins). Infectious and pathological waste should be bagged in appropriate coloured-coded bags or other special containers when transported. Each package should be marked or coded for easy identification. Containers should be leak-proof and be fitted with self-sealing lid and be tight enough to withstand being spilled in the vehicle. The design of the collection vehicle must confirm to the specification mentioned in section below.

Fig. 3.5: External transportation vehicle

3.3.3 Specificity of Transport Vehicles

- Each vehicle used to transport infectious waste must meet a minimum of these requirements:
  - — The vehicle shall have a fully enclosed, leak proof cargo-carrying body which protects the waste from animals, vectors, weather conditions and minimizes exposure to the public;
  - — The containers of waste shall be loaded and unloaded so that no compaction or mechanical stress of the waste occurs during handling or during transit;
  - — The cargo-carrying body shall be maintained in a sanitary condition and disinfected immediately after each unloading and as spills are detected;
  - — The cargo-carrying body shall be designed to prevent discharge of infectious waste, especially fluids, into the environment;
  - — The cargo-carrying body shall be decontaminated of visible debris after each unloading;
  - — The cargo-carrying body shall have doors which close tightly and can be sealed with a tamper resistant seal or otherwise secured if left unattended while carrying infectious waste;
  - — Identification must be permanently affixed to the cargo-carrying body on two sides and the back in letters a minimum of three inches in height which state:
    - i) The name of the transporter;
    - ii) The transporter's department issued registration number;
    - iii) The words INFECTIOUS WASTE, MEDICAL WASTE, or BIO-HAZARDOUS WASTE or BIO-MEDICAL WASTE.
- If a transporter transports or stores infectious waste and other solid waste in the same cargo-carrying body, each waste must be managed as infectious waste.
- If a transport vehicle is used to store infectious waste, such storage must, at a minimum be in a location:
  - — inside a building with limited access and is locked when unattended;
  - — outside which is secured by a barrier which limits access and must be locked when unattended.
- All drainage from the cargo-carrying body shall discharge directly or through a holding tank to a department approved sanitary sewer system or approved container for appropriate treatment.

3.3.4 Exclusive Transports

- Length of service routes shall be kept consistent with the proper operation of vehicles and/or equipment in order that the area or route services can be completed during a normal operating day.
- All collected shall be properly deposited at an approved facility.
- Unless an emergency, such as inclement weather, equipment breakdown or accident warrants, no waste shall be allowed to remain or be stored in any transport units in excess of 24 hours.
- No solid waste vehicle shall be used for waste transportation if the design of the vehicle is such that any solid waste material will leak or cause emissions.
- No vehicle used for waste transportation, shall be used beyond its design capabilities or in such a manner that littering, leakage, spillage or emissions there from of wastes will occur.

- All solid waste vehicles used for the transportation of waste shall be maintained in good working condition to protect the health and safety of the workers and citizens and to provide prompt and efficient service.
- Tarpaulins or covers shall be provided and used as needed while transporting solid wastes.

Routing

Health care waste should be transported through the quickest or shortest possible route and should be planned before the trip begins. After departure from the source, every effort should be made to avoid further handling. If handling cannot be avoided, it should be pre-arranged and take place in adequately designed and authorized premises. Handling requirements can be specified in the contract established between the waste generator and the transporter.

An efficient and effective collection system route should consider the following:

- Collection schedule either by route or zone.
- Assignment of personnel responsible for the zone or area.
- Logical planning of the route (should avoid passing the collected package of waste on congested area).
- Collection system route must be laid out from the farthest point of the designated transfer station and as collection progresses towards the collection storage area.
- Routes drawn shall be practicable and must consider the logical progression of health care waste throughout the area.
- Revised routing plan should be established due to circumstances arising to alteration in the original routing plan.
- Suggested collection frequency on room to room basis is once every shift or as often as necessary. Time of collection regardless of category should be at the start of every shift.

Minimal Observation for Off-site Transportation

- Ensure that the responsible authorities always approve the off-site transportation plan before any transit occurs.
- Ensure health care waste is collected routinely.
- The waste is carried in secure leak proof containers.
- Health care facility is aware of the final disposal of its waste.

Points to be Remembered

- The containers to be puncture proof and bags to be sturdy, leak proof for high risk waste.
- The bags to be tied by the neck while transportation.
- Transportation trolleys and specific lifts or timings to be designated.
- Staff handling this to wear protective clothing, gloves, mask, aprons, etc.
- If bags tear or get contaminated they be placed with new clean bags (double bagging)
- Never allow any person to put hands inside the bag.
- Stringent Infection Control Policies to be formed and implemented.

Check Your Progress 3

1) Who is responsible for transportation of waste within the premises?

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2) Which type of hospital waste can be transported with the general municipal waste?

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3.3.5 Hazardous Signposting

In the event of an accidental spill of infectious waste the following action shall be taken:

a) The contaminated area shall be immediately evacuated, if required;

b) The contaminated area shall be cleared and, if necessary, disinfected;

c) Exposure of staff shall be limited to the extent possible during the clean-up operation, and appropriate immunization carried out, as may be required;

d) Any emergency equipment used shall be immediately replaced in the same location from which it was taken.

- All hospital staff members shall be properly trained and prepared for emergency response, including procedures for treatment of injuries, clean-up of the contaminated area and prompt reporting of all incidents of accidents, spillages and near-misses.

- The Waste Management Officer shall immediately investigate, record and review all such incidents to establish causes and where necessary shall amend the waste management plan to prevent recurrence.

3.3.6 Record Keeping and Reporting

A person or municipality that transports waste shall make and maintain an operational record each day that residual waste is collected or transported, or both. The daily operational record shall be kept in the cabin of each transportation vehicle on the date of collection or transportation. The record shall include the following:

i) The types or classifications of waste transported.

ii) The weight or volume of the types of waste transported.

iii) The name, mailing address, telephone number of each generator of transported waste.

iv) The name and location of a facility that has received, or will receive the waste.

v) A description of handling problems or emergency disposal activities.

vi) The name and address of the person or municipality collecting or transporting the waste.

3.3.7 Accident Reporting System

Accidental Exposure to Biohazardous Agents

Reporting Actions

Personnel who, in the course of duty, are accidentally exposed to a biohazardous agent should immediately initiate emergency decontamination, shower (if necessary), and then report without delay to their immediate supervisor. In the event that an injury accompanies an exposure or a substance enters the eye, mouth, lungs, or penetrates or comes in contact with the skin, the supervisor should direct disinfecting procedures and see that the employee reports without delay to the appropriate medical authority. In case of doubt regarding the seriousness of exposure the physician should determine if the risk is significant enough to require medical attention. If not significant, the employee should still report the exposure to their supervisor, in writing if so requested.

Individual Responsibility

For the protection of each individual and their co-workers reporting responsibility begins with any individual involved in an accident, exposure, or suspected hazardous situation. The action taken may vary with the laboratory unit, but in general the individual should report as soon as possible to the supervisor in order to begin the reporting process.

Principal Investigator/Supervisor Responsibility

It is the responsibility of the supervisor to develop an emergency plan which covers contingencies which may arise in the event of an accidental exposure. The copies of the exposure treatment protocol should be circulated to all. The supervisor should insure that all personnel in case of an emergency are aware of physician to be contacted. This information shall also be on file with emergency health services.

Medical Authority

In the event of an exposure to a biohazardous agent, the supervisor or employee shall immediately contact the health services. The attending physician will determine if the exposure is of sufficient risk to require medical treatment. If medical attention is required, the arrangements for treatment should include an assessment of risk to fellow workers assisting the patient and the precautions required to prevent the exposure of other persons encountered on the route to the medical facility.

Requirements for Reporting

As outlined above, all accidents, exposures, and potential hazards should be reported. Under normal circumstances such reports are made on the appropriate accident form. Obviously, however, severe situations may occur in such emergencies, telephone communications must be used to secure immediate medical care, decontaminating procedures, for the spilled waste and other repair procedures.

Check Your Progress 4

1) What should be written on the vehicles transporting health care waste?

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2) What are the minimal observations for off-site transportation?

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3.4 LET US SUM UP

In pursuing their aims of reducing health problems and eliminating potential risks to people's health, health care services inevitably create waste that may itself be hazardous or infections in nature. This unit thus focuses on the importance of disinfection of infectious waste produced from health care activities. You have learnt that chemical disinfection, used routinely in health care to kill micro-organisms on medical equipment, is now being extended to the treatment of health care waste. Chemicals are added to waste to kill or inactivate the pathogens it contains; this treatment usually results in disinfection rather than sterilization. Generally, sterilization is best achieved by physical methods such as autoclaving or dry heat, which are less time-consuming and more reliable than chemical germicides.

Wherever bio-medical waste is generated, safe and reliable methods for its storage and transport are, essential. Inadequate and inappropriate handling and transport of health care waste may have serious public health consequences and a significant impact on the environment. Separate vehicles should be used for transport of bio-medical waste with proper labeling and drivers should be trained for actions to be taken in case of any accident. The unit also provide an approach for disinfection and transport of biomedical waste that is safe for the waste handlers, the public and the environment and at the same time being cost effective and practical.

3.5 KEY WORDS

Animal Bio-medical Wastes : Waste that consists of animal tissues, organs, body parts, carcasses, bedding, fluid, blood and blood products, items saturated or dripping with blood, body fluids contaminated with blood and body fluids removed during surgery, treatment, autopsy or for diagnosis that contain or are suspected of containing a serious pathogen.

Bio-medical Waste : Waste that is generated during the diagnosis, treatment or immunization of human beings or animals, or in research activities pertaining thereto, or in the production or testing of biologicals.

Collection : The act of removing accumulated solid waste from the point of collection and transporting it to a solid waste management facility; collection may also occur at centralized points where generators deliver their solid waste.

Collection Frequency : The number of times per week that collection service is provided.

Decontamination : A process that removes micro-organisms from an object, rendering it safe for handling.

Disinfection : Disinfection refers to procedures which reduce the number of micro-organisms on an object or surface but not the complete destruction of all micro-organism or spores.

Disposal : Intentional burial, deposit, discharge, dumping, placing, or release of any waste material into or on air, land, or water.

Facility : A site where infectious waste is generated, stored, decontaminated, incinerated or disposed.

Garbage : Unwanted animal and vegetable wastes resulting from the, handling, preparation, cooking, and consumption of food, swill and carcasses of dead animals, and of such a character and proportion as to be capable of attracting or providing food for vectors, except sewage and biosolids.

Germicide : A chemical agent that destroys micro-organisms on either inanimate objects or living tissue.

Halogenated Plastics : Refers to a type of plastic that contains halogen atoms such as chlorine or fluorine. Combustion of these types of plastic materials results in the generation of acid gases such as hydrogen chloride. Examples of these types of plastic include polyvinyl chloride and fluorocarbon compounds such as Teflon.

Handling : The functions associated with the movement of solid waste materials, excluding storage, processing and ultimate disposal.

Hazard : Intrinsic potential property or ability (e.g., any agent, equipment, material, or process) to cause harm.or damage to health of people and/or to the environment.

Infectious Agent : An organism that is capable of producing infection or infectious disease in humans.

Infectious Waste : Laboratory waste, blood, regulated body fluids, sharps, and research animal waste that have not been decontaminated.

Non-halogenated Plastics : Refers to a type of plastic which does not contain atoms of halogens such as chlorine or fluorine. Examples of these types of plastic include polyethylene, polycarbonate and polystyrene.

Pathological Waste : Human tissues and body parts removed accidentally or during surgery or autopsy intended for disposal.

Radioactive Waste : Material that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels and for which no use is foreseen.

Radionuclide : A nuclide (i.e., an atom of specified atomic number and mass number) that exhibits properties of spontaneous disintegration, liberating energy, generally resulting in the formation of new nuclides, and accompanied by the emission of one or more types of radiation.

Recycling : A term embracing the recovery and reuse of scrap or waste material for manufacturing or other purposes.

Residue : The material remaining after combustion of wastes such as ash or slag. Also refers to materials extracted from a liquid or gas stream.

Sanitary Landfilling : An engineered method of disposing of solid waste on land in a manner that protects the environment, e.g., by spreading the waste in thin layers, compacting it to the smallest practical volume, and covering it with soil by the end of each working day, constructing barriers to infiltration, evacuating the gases produced.

Scavenging : The manual sorting of solid waste at landfills and removal of usable material.

Segregation : The systematic separation of solid waste into designated categories.

Sewerage : A system for the collection and transport of sewage, including conduits, pipes and pumping stations.

Sharps : Items that can induce subdermal inoculation of infectious agents, including needles, scalpel blades, pipettes, and other items derived from human or animal patient care, blood banks, laboratories, mortuaries, research facilities, and industrial operations.

Source Reduction : The design, manufacture, acquisition, and reuse of materials so as to minimize the quantity and/or toxicity of waste produced at the place of origin.

Sterilization : A process that kills all micro-organisms, including bacteria, viruses, spores and fungi.

Storage : The placement of waste in a suitable location or facility where isolation, environmental and health protection and human control are provided. This is done with the intention that the waste will be subsequently retrieved for treatment and conditioning and/or disposal.

Waste Generator : Any person, organization or facility engaged in activities that generate waste.

Waste Management : All the activities, administrative and operational, involved in the handling, treatment, containment, transportation, storage and disposal of waste.

3.6 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Autoclave works with the principle of disinfection based on steam under pressure.

   It is utilized for:

   a) Sterilization of glassware

   b) Media and instruments

   c) Decontamination of reusable supplies and equipment

   d) Decontamination of infectious waste

2) Microwave causes the molecules within the waste to vibrate. This generates heat from within the matter itself thus heating the material inside out.

Check Your Progress 2

1) The reason for this labelling is that it may be necessary to trace the waste back to its source.

2) For the storage of waste for period more than 24 hours, refrigeration should be provided so that the temperature does not exceed +10°C in the waste storage room.

Check Your Progress 3

1) The local collection of waste within the hospital should be provided by staff, from point of use to the waste collection point to final disposal site in the facility.

2) The medical wastes, except the general and non-hazardous wastes, should never be transported with general municipal wastes, and these should be kept separate at all stages.

Check Your Progress 4

1) The name of the transporter; the transporter's Department issued registration number; and the words INFECTIOUS WASTE, MEDICAL WASTE, or BIOHAZARDOUS WASTE should be mentioned on the vehicle.

2) Minimal observations for off-site transportation:

   - Ensure that the responsible authorities always approve the off-site transportation plan before any transit occurs.
   - Ensure health care waste is collected routinely.
   - Waste is carried in secure leak proof containers.
   - Health care facility is aware of the final disposal of its waste.

3.7 FURTHER READINGS

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UNIT 4 CAPACITY BUILDING, TRAINING AND MONITORING

Structure

4.0 OBJECTIVES

After going through this unit, you should be able to:

- comprehend the need for improving awareness about health care waste management;
- enumerate the contents of health care waste management in a training syllabus;
- define the principles and broad contents of training of each category of staff in a hospital;
- describe the role of WHO and other agencies in health care waste management; and
- explain the methodology of monitoring the health care waste management system.

4.1 INTRODUCTION

In pursuing their aims of reducing health problems and eliminating potential risks to people's health, health care services inevitably create waste that may itself be hazardous to health. Inadequate and inappropriate handling of health care waste may have serious public health consequences and a significant impact on the environment. Sound management of health care waste management is thus crucial for safeguarding the environment and health of the community at large. Effective waste management programmes require multisectoral cooperation and interaction at all levels.

In the previous units of this block you have learnt about the role of management and infection control in health care waste management. This unit will focus on the need for capacity building on health care waste management for its successful implementation. You will learn that first step in achieving safe management of health care waste management is to improve awareness about the subject among health care functionaries and the public. You will learn about importance of health care waste management as a subject in different curriculums in medical, nursing and paramedical level. Establishment of a National policy and a legal framework, training of personnel and raising public awareness are essential elements of successful health care waste management. According to the 'polluter pays' principle, each health care establishment should be financially liable for safe management of any waste it generates. You will learn about various costs involved in health care waste management. Many countries do not have appropriate regulations to enforce safe management of health care waste. An essential issue is the clear attribution of responsibility of appropriate handling and disposal of waste. To have a standard of waste management systems in the health care facilities, it is important to have accreditation system adopted by these facilities. Policies for safe management of waste should be generated and coordinated globally and the management practices implemented locally.

Role of international agencies and NGO's in proper management of waste has been described in detail. All members of the relevant authority responsible for infection management should be aware of their responsibilities and adequately trained in their respective day-to-day duties. Training, why it is needed, who should be trained and what should be the methodology for it, has been explained. Without monitoring there is no mechanism for evaluating the success. You will learn more about waste performas required for monitoring, tracking policies, periodicity of monitoring and methods for the same in this unit.

4.2 IMPROVING AWARENESS

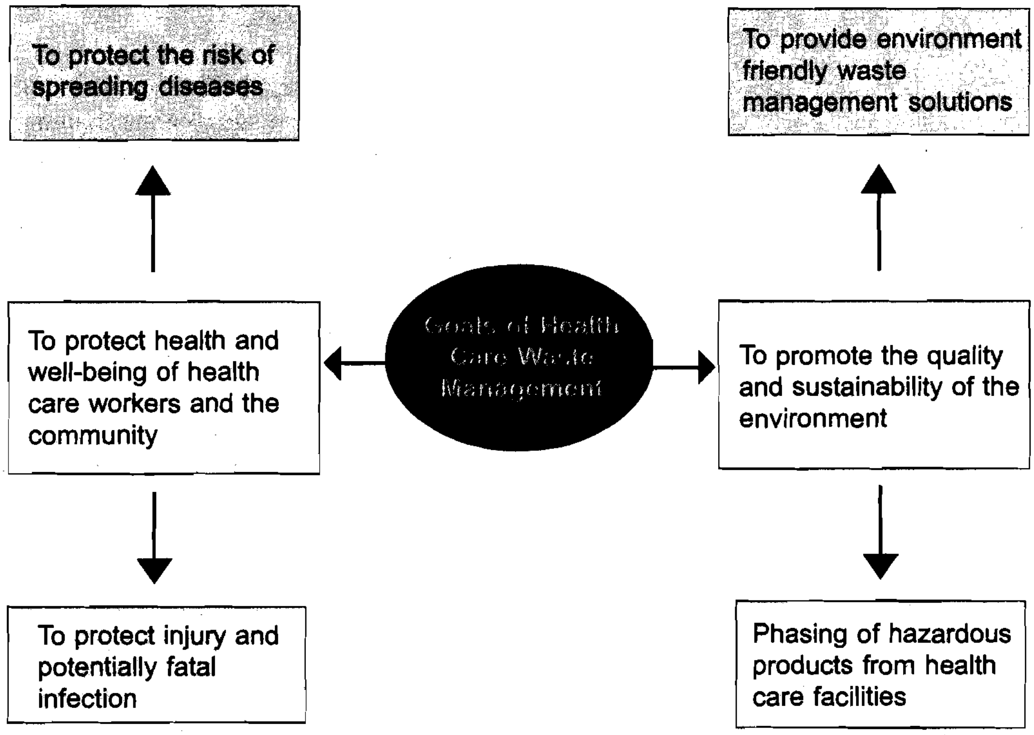
You are aware by now that due to the hazards associated with health care waste it has to be handled with sound and safe methods. Inadequate handling of health care waste may have serious public health consequences and impact on the environment. Health care waste management is, therefore, an important and necessary component of environment and health as discussed in Block 3 of Course 1 (BHM-001).

Hospitals have responsibility and a "duty of care" for the environment and public health, particularly in relation to the waste they produce. They also carry a responsibility to ensure that there are no adverse health and environmental consequences as a result of waste handling, treatment and disposal activities. Unfortunately, health care waste management is, in many regions, not yet carried out with a satisfactory degree of safety.

Awareness of the risks related to health care waste and training about safe practices is essential in obtaining both commitment and behaviour change by all involved in the management of health care waste.

4.2.1 Health Care Waste Management as a Subject

The main goal of health care waste management is the protection of public health. Other priorities include promotion of environment quality and sustainability and the support of economic productivity.



To achieve the above-mentioned goals, health care waste management needs to be promoted as a subject and should aim at the following:

- Raise awareness on public health and environment hazards that may be associated with inappropriate segregation, storage, collection, transport, handling, treatment and disposal of health care waste;
- Provide information on hazards and sound management practices of health care waste for the formulation of policies and the development or improvement of legislation and technical guidelines;
- Identify waste management practices and technologies that are safe, efficient, sustainable (environment friendly), economic and culturally acceptable;
- Assist the health care facilities to identify the systems suitable for their particular circumstances;
- Enable managers of health care facilities to develop their waste management plans;
- Formulate training programmes for the different categories of staff that handles, treat or dispose off health care waste.

Following steps should be taken to address health care waste management at different levels:

- Advocacy targeting policy makers and health care facility managers regarding the risk and responsibilities related to health care waste.

- Inclusion into the curricula of nurses, doctors and health care managers
- Development of a national training package, adapted to various professional categories
- Development of a 'train-the-trainers' programme
- Education of workers and the community on the risks associated with health care waste and about safe health care waste management practices.

In order to achieve acceptable practices and compliance with regulation, it is essential for all managers, doctors and other personnel involved to receive appropriate training. To ensure that all the health workers are trained a "Train the Trainer" programme should be initiated regionally and competent institutions or centres for programme should be identified. The hospitals must have well planned awareness and training programme for all categories of personnel including administrators to make them aware about safe hospital waste management practices. Training on the subject should be conducted category wise, taking into consideration requirements of each category and method of delivery of knowledge to them.

Education is a process of bringing about a desired change in the behaviour of the learner. To achieve this broad aim we need more specific goals. Educational objectives have been classified into three main domains based on the behavioural changes expected to be brought about in the learners:

a) **Cognitive Domain:** The objectives pertaining to this domain deal with knowledge. It is domain of intellectual activity. Under cognitive domain following sub objectives have been identified:

   i) Acquisition of knowledge and ability, to recall and retrieve the appropriate knowledge.

   ii) Comprehension (transfer, interpretation, extrapolation). Ability to comprehend a communication, to make use of an idea without necessarily relating it to others.

   iii) Application: Ability to use facts, principles, theories in concrete situations.

   iv) Analysis: Ability to break down a body of data or problem into component.

   v) Synthesis: Ability to assemble parts of information into a unified and coherent whole.

   vi) Evaluation: Ability to judge the reliability, utility and merit on the basis of established criterion.

b) **Psychomotor Domain:** Domain of practical skills or psychomotor domain means performance of routine actions carried out by health care workers like proper segregation of health care waste, handling of sharps, disinfection, aseptic precautions. Simplified hierarchical levels of learning practical skills are:

   i) Observation: Simply observing the skill being performed

   ii) Imitation: Performing the tasks on dummy

   iii) Performing under observation

   iv) Do independently

   v) Do automatically

c) **Affective Domain:** The objectives relating to this domain are attitudinal in nature and deal with humane aspects of performance of an act. The hierarchical levels of developing attitudes is as follows:

   i) *Receiving:* Being aware of an idea, e.g., aware about hazards of health care waste.

   ii) *Responding:* Being willing to accept an idea, respond to it, e.g., finding out problems in health care waste management.

   iii) *Valuing:* Accepts the idea as a worthy exhibiting preference over others, e.g., safe handling of sharps prevents injuries and encouraging others to follow safe practices of sharps handling.

   iv) *Organization:* Conceptualizing a value and organizing it into related values, e.g., accepting safe practices even during emergency situation.

   v) *Internalization of value complex:* Integration of the value into a philosophy in such a way that it becomes a consistent and predictable behavioural characteristic, e.g., practicing safe and correct health care waste management as a way of life automatically.

At all levels, educational objectives mentioned above will impart health care waste management syllabus a purpose and give direction to the health care waste management educational process thus maximizing output.

4.3 TRAINING

You have already learnt about the need for proper health care waste management. To achieve this system it is important to address the issue to different health care workers and the community. As health care waste management has not been an integral part of the learnings of the health care professionals, knowledge needs to be provided through different channels to change their attitude and develop skills for health care waste management. Training is one of the most efficient tool to impart this necessary change in the health care workers.

The objectives of training on health care waste are:

a) To prevent exposure from health care waste and related health hazards; this exposure may be voluntary, in the case of scavengers, or accidental, as a consequence of unsafe disposal methods.

b) To create awareness and foster responsibility among patients and visitors to health care establishments regarding hygiene and health care waste management.

c) To inform the public about the risks linked to health care waste, focusing on people living or working in close proximity to, or visiting, health care establishments, families of patients treated at home, and scavengers on waste dumps.

Before starting a training programme it is important to understand the training needs for health care waste management in a health care facility. Based on these needs the training programmes for different levels of health care providers can be planned.

Box 4.1: Identifying Training Need Gaps for Health Care Waste Management in a Health Facility

Knowledge Gaps: There is a set of basic information that all categories of health workers should know about health care waste management. This includes basic knowledge of types of health care waste, segregation of health care risk waste. Occupational health and safety issues, use of specific equipment, etc.

Skills Gaps: Skills are distinguished from knowledge by being something "you can do" rather than something "you know". Skills include correct use of equipment and the implementation of procedures, e.g., closing liners correctly, loading sharps correctly in sharps containers and completing an accident report form.

Attitude Gaps: For effective health care waste management it is essential that health workers hold positive attitudes towards care of the environment, occupational health and safety and teamwork.

Worst-case Scenarios: This category describes situation when the performance of the health care waste management system is seriously undermined and jeopardized. For example, there is no collection by the service provider, or no provision of equipment.

Inter-relations: Inter-relations is concerned with staff relation, especially those that adversely have impact on the performance of the health care waste management system such as poor communication between general assistants, nurses and doctors.

Technology Gaps: The specifications, standards and appropriateness of equipment all have impact on the performance of the system.

Policies and Procedures Gaps: Policies, guidelines, procedures and/or codes of practice are essential to support any health care waste management system. Policy and procedure gaps happen where policies and/or procedures are missing. Often policy and procedures for health care waste management are written into one document called a Code of Practice.

Organizational, Management and Supervisory Gaps: These gaps relate to the management function as a whole. The Code of Practice referred to above would normally be expected to describe the organizational structures necessary to support health care waste management at a health facility level. This includes roles of senior management, all categories of staff, the role of the occupational health and infection control committee and the service contract with the service provider.

A policy for the management of health care waste cannot be effective unless it is applied carefully, consistently, and universally. Training health care personnel in implementing the policy is thus critical if a waste management programme is to be successful. The overall aim of training is to develop awareness of the risk to improper management, safety, and environmental issues and having a sound system relating to health care waste, and how these can affect employees in their daily work. It should highlight the roles and responsibilities of health care personnel in the overall management programme. Health and safety at the workplace and environmental awareness are the responsibility of all and in the interests of all.

4.3.1 Training Tools

For maximum effectiveness, all information should be displayed or communicated in an attractive manner that will hold people's attention.

a) Information on, and justification for, all aspects of the health care waste policy;

b) Information on the role and responsibilities of each hospital staff member in implementing the policy;

c) Technical instructions, relevant for the target group, on the application of waste management practices.

Training tools for different health care workers and the public depend on their skills, knowledge and attitude. Training and awareness among the general public can be conducted by spreading information on health care waste management practices by:

- Multimedia presentations
- Videos on good and bad health care waste management practices.
- Inviting health care workers from other institutions.
- Practical demonstrations for better understanding of principles of health care waste management such as segregation, transportation etc.
- Field visits.
- Hands on training.

Testing the participants at the end of the course, by means of simple true/false or multiple-choice questions, often provides an incentive for learning, and allows the course organizers to assess the knowledge acquired by the participants.

4.3.2 Training Different Health Care Providers

All health care providers should be trained on health care waste management on the basis of the existing knowledge, attitude and job descriptions. Each group of health care professionals require a different approach. Thus it is advisable to target training for each group separately.

Separate training activities should be designed for, and targeted to:

a) Hospital managers and administrative staff.

b) Medical doctors;

c) Nurses and assistant nurses;

d) Laboratory technicians

e) Cleaners, porters, auxiliary staff, and waste handlers.

Trainers of the Programme

The trainers can be from the health care facilities or outside with preferably some experience in setting waste management system and have some teaching experience and be familiar with the hazards and practices of health care waste management.

Training Responsibility

The infection control officer or the waste management officer should be given responsibility for all training related to the segregation, collection, storage, and disposal of health care waste and occupational safety issues. He should ensure that staff at all levels are aware both of the hospital waste management plan and policy and of their own responsibilities and obligations in this regard. A record should be kept of all training sessions, and the content of training programmers should be periodically reviewed and updated where necessary. While training different health care providers following recommendations can be considered.

Health Care Waste Management as a Curriculum of Medical, Nursing and Paramedical Staff

Medical Doctors

Doctors from the onset of their carriers perform dual duties not only as doctors but also as administrators e.g. as soon as they pass out from medical college they become in-charge of Primary Health Centre or Municipal Clinic. Inclusion of health care waste management as subject in their curriculum from the point of view of all three educational objectives mentioned above i.e. cognitive, psychomotor and affective will help them develop attitude for safe management of health care waste.

They act as role models and also provide training for nurses, paramedical workers and waste handlers subsequently. In their administrative capacity they will have to monitor the entire health care waste management in their clinics, nursing homes, hospitals or any other health care establishments in which they are working. They are also decision makers and lot of their decisions can affect the proper functioning of waste system.

Awareness developed during MBBS and postgraduate courses will help them not only in administrating good waste management practices, but also in setting up good systems. It will help them in taking decisions regarding purchase of medical consumables as well as equipment so as to minimize the waste and prevent hazardous chemicals entering into inventory of hospitals. Syllabus of health care waste management applicable to MBBS students and postgraduate students could cover the following topics in the lectures and workshop:

a) Definition of health care waste; hazards and public health impacts of health care

b) Introduction to International Regulations

c) Current national and local legislation

d) Health care waste management programme for a health care establishment

e) Health care waste management plan

   i) Action plan for implementation of national health care waste management

   ii) How to improve health care waste management plan of different kinds of health care establishments

f) Waste segregation

g) Handling, storage and transportation

h) Treatment and disposal options

i) Application of treatment and disposal methods to health care waste categories

j) Treatment and disposal considerations: major urban hospitals, smaller or remote establishment

k) Waste water management

l) Worker's health and safety and emergencies

m) Waste management, related costs

n) Waste minimization, recycling etc.

o) Training and capacity building

p) National programme for health care waste management

q) Evaluation of the course.

The hazards relating to health care waste, the regulatory issues and the operational practices can be presented through formal teaching and illustrated by visual aids. If the students apply health care waste management principles to their own tasks and ensures that this is done correctly, the learning will be detailed and long lasting. Problem solving approach at MBBS and PG level should be adopted. A first step in problem solving is to encourage students to answer questions based upon local problems during the lectures. At post graduate level a scenario should be developed, which will be based directly on material that has already been presented formally, structured questions will then be asked, which will lead to particular solution. Then they should be required to tackle real issues, preferably local in origin, where the students develop the questions to be asked, seek the information required and find a solution himself or herself. Postgraduate guides can help by developing small groups and initiating group discussions.

At postgraduate level to develop awareness, knowledge, and attitude, efforts should be made to allot projects pertaining to their own speciality, e.g., waste disposal in labour room, importance of universal precautions and bio-safety guidelines in laboratory, etc. Waste management should be integrated with infection management to provide a broader perspective of the issue to the medical staff.

Evaluation is an important part of learning process. It aims at assessing the extent to which the syllabus objectives have been attained and at determining the quality of the teaching. The evaluation results will allow the course to be improved or adapted as necessary for future use.

Nursing Staff

When dealing with nursing students, it is important to understand that they are responsible for the well being of the patient in a health care establishment. They have to be trained for development of psychomotor as well as affective skills. Waste management being part of their day to day operations, it is necessary for them to reinforce their learning on the deleterious health effects of improper segregation, disinfection and waste storage. Along with the introduction into the nursing curriculum on the job training during their hospital phase should be encouraged. The goals of syllabus for nursing professionals are given in Table 4.1.

The modes for dissemination of knowledge and skills can be imparted through slides showing current situation and correct methods of waste disposal, flow charts about health care waste management, standard operating procedure for disposal of each type of waste, disinfection procedures etc. should be utilized for training nurses and nursing aids. On the job training for handling equipment like needle cutter, destroyer, coloured plastic bags, bins etc., preparation of sodium hypochlorite solution and other disinfectant solution, visit to institution where good health care waste management is in practice, interaction with nurses of that hospital are some of the tools which should be utilized for training the nurses.

Paramedical Staff

Paramedical staff like laboratory assistants, ward boys, nursing aids, blood bank technician should essentially follow the syllabus designed for nurses however psychomotor aspects like actual learning by doing should be practiced. Paramedic courses must contain specific portion of the specialty concerned like laboratory waste management, blood and body fluid spills, cleaning spills, use of biosafety guidelines, importance of personal protective equipment. Pictograph slides, actual equipment handling, demonstration to small groups about use of personal protection equipment, methods of waste segregation are some of the important tools utilized while imparting training to them. Documentary film, visit to institutions where successful health care waste management exists will help reinforcing their learning. Periodic on the job assessment helps strengthen their psychomotor component of training.

Table 4.1: The Course Content for Nursing Professionals

Lessons	Topic	Contents	Instruction tools and other resources	Goals
1	Introduction	Risk due to improper waste management practices. Impact of health care waste on health care workers.	Slides and videos are the most important tool in this session.	Knowledge about importance of health care waste management and the legislations.
	Legislation	Introduction to legislation. Duty of care principles.		
2	Waste Management at the point of generation	Importance of segregation, Principles of segregation, Colour codes of waste containers and bags	Pictograph slides explaining what should be done with the waste. Equipment like needle, cutter/ destroyer. Different coloured bins/ plastic bags. Chemical disinfectant like bleaching powder solution. Protective gear.	Skills for developing a proper waste management system.
	Sharps management	Different kinds of waste receptacles e.g. sharps containers, twin bins etc. Sharps handling and mutilation. Use of puncture proof containers, needle cutters and destroyers		
	Disinfection	Different types, potency and efficiency. Preparation methods and frequency of preparation.		
3	Waste storage and transportation	Waste storage and means of waste transportation.	Documentary/film from a health care establishment which has a waste management system functioning. Filed visit.	Knowledge about waste treatment and disposal methods. Their role in monitoring and implementing the system.
	Waste treatment and disposal	Different treatment and disposal options.		
	Accident reporting	Accidental spill management of body fluids and heavy metals like mercury, needle stick injuries.		
	Universal Precautions	Principle of infection control and universal precautions.		
	Monitoring the system	Need and importance of monitoring the system. Monitoring mechanism.		

Auxiliary Nurse Midwives (ANM's)

As most of the health care delivery system in rural areas is taken care by ANM's it is important to train them about health care waste management and provide them with practical guide on managing waste. As in preventive care the glass syringes are being replaced by auto-disable syringes the bulk of waste will increase in immunization programmes thus a greater need for proper waste management. To ensure proper waste management it is necessary to create awareness among ANMs and Multipurpose Health Worker about the use and disposal of AD syringes and other waste being generated in the Sub-centres (SCs) and Primary Health Centres (PHCs). Waste management should be incorporated in the ANM training courses, at the time of induction and on-site training at SCs and PHCs.

Housekeeping Staff

During the training sessions, it is necessary that the ward boys/housekeeping staff understand the subject. The subject should focus on the importance of waste management in terms of worker safety and that the benefit of proper waste management for the well being of workers and the community at large. They should also be made aware that it is a part of their work and not perceive it as additional task.

Table 4.2: Course Content for Paramedical and Housekeeping Staff

Lessons	Topic	Contents	Instruction tools and other resources	Goals
1	Introduction	The problems of improper waste management and how it can lead to infection within the hospital and to its handlers. Explain waste management practices in the health care establishment. (response from the staff)	Slides and videos are the most important tool in this session.	Knowledge about proper waste management and its benefit to them and the community. To understand the difficulties faced by them while dealing with the system.
2	Waste Management at the point of generation Sharps Management Collection and Transportation of the waste	The need and importance of segregation, types of containers, sharps management, transportation methods Precautions to be taken while handling waste. Type of disinfection to be used is to be explained to them. Methods to deal with spills and cleaning floors, proper mutilation, protective clothing and preparation of chemical disinfectant solution are some of the main topics, which are included in this section. Handling infectious and non-infectious waste, waste treatment and disposal methods, mutilation waste composting and final disposal methods should be detailed.	Pictograph slides explaining what should be done with the waste. Samples of different types of sterile waste for segregation Equipment like needle/ cutter/ destroyer. Different coloured bins/plastic bags. Chemical disinfectant like bleaching powder solution etc. Protective gear. Interaction with a staff member from a health care establishment where the scheme is in place. Documentary/film from a health care establishment, which has a waste management system functioning.	Able to identify all types of waste according to the type of disposal practice required. Knowledge of colour codes for each waste type Skills for secure waste collection and transportation Prepartion and use of chemical disinfectant solution Importance of use of protective gears when they are handling the waste. Ward boys should understand that the nurses would be helping them implement and follow the waste management scheme.
3	Feed back session	Getting a feedback of the system and welcoming their ideas as they are very innovative and can provide simple and easy solutions.	Same as in Session 2 except for the invited person.	Reinforce the system and the responsibility of the work. Should clear out any doubts. They should be felt important and as a part of monitoring system.

Staff Transporting Waste

The health care establishment itself may carry out the transportation of waste, or it may contract this operation to an "Authorized" waste transporter. Drivers and waste handlers should be aware of the nature and risks of the transported waste. In particular, transport staff should be trained in the procedures listed below:

- Correct procedures for handling, loading, and unloading waste bags/containers.
- Procedures for dealing with spillages or other accidents; written instructions for these procedures should be available in the transport vehicle.
- The wearing of protective clothing and strong footwear at all times.
- The availability at all times in dedicated waste collection vehicles of spare plastic bags, protective clothing, and the cleaning tools and disinfectants needed to deal with any spillage that occurs during loading, transport, or unloading.
- Documentation and recording of health care waste, e.g. by means of a consignment note system, to allow waste to be traced from the point of collection to the final place of disposal.

The head of the health care establishment should liaise with the transport contractor to ensure that members of the waste collection crew are well trained.

Treatment Plant Operators

Qualified operators are needed for running treatment technologies like incinerators and autoclaves. If no qualified operators are available, health care establishments should arrange to train an adequate number of personnel. Treatment plant operators should have received technical education to at least secondary school level, and should be specifically trained in operation and maintenance of the treatment facilities. Some of the areas requiring training are:

- General functioning of the treatment facility and different treatment technologies, including heat recovery and the flue-gas cleaning technologies where appropriate;
- Health, safety, and environment implications of treatment operations;
- Technical procedures for operation of the plant;
- Emergency response, in case of equipment failures and alarms
- Maintenance of the plant and record keeping;
- Surveillance of the quality of ash and emissions, according to the specifications.

Refresher Programme

Periodic repetition of the courses should be carried out as this provides refreshment training as well as orientation for new employees and for existing employees with new responsibilities, it will also update knowledge in line with policy changes. Follow up trainings are instructive for trainers, indicating how much information has been retained by the participants and the likely need for the future courses.

Box 4.2: Topics for Training

Training of Administrators
- Importance of health care waste management
- Existing legislation
- Roles and responsibility of all health care providers
- Allocating adequate funds for health care waste management
- Ensure training for all health care workers
- Appoint a nodal officer
- Importance of monitoring the system regularly
- Occupational safety
- Final treatment of disposal options and concept of centralized facility
- Ensure immunization and post measures in case of injuries
- Waste minimization concept
- Coordination between different departments to ensure proper waste management systems

Training of Doctors
- Need for health care waste management
- Existing legislation
- Roles and responsibilities of different health care workers – emphasis on duty care principle
- Segregation at source
- Proper containment of waste
- Sharps management
- Occupational safety
- Monitoring of the system
- Waste minimization concept
- Final treatment and disposal options

Training of Nurses
- Need for health care waste management
- Existing legislation
- Roles and responsibilities of different health care workers – emphasis on duty care principle
- Segregation at source
- Proper containment of waste
- Sharps management
- Occupational safety
- Monitoring and supervising the system
- Waste minimization concept
- Final treatment and disposal option

Training of Waste Handlers
- Waste containers and bags are covered, sealed and labeled at the time of collection
- Replace the bags when 3/4th full
- Carry sharps in puncture resistant containers
- Never mix waste at the time of collection and transportation
- Use service lift and ramps only for transportation of waste
- Appropriate cleaning and disinfection procedures for waste treatment and accidental spillages
- Always wear protective gears while handling waste
- Never dispose infected waste into municipal dumps
- Ensure disinfection and mutilation of infections waste before its final disposal
- Store waste in secure area
- Monitor the system by reporting any mixing of waste lack of supplies etc. to the supervisor

Check Your Progress 1

1) Explain the aims of health care waste management as subject?

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2) Describe the contents of health care waste management syllabus as applicable to MBBS.

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4.4 ACCREDITATION OF HEALTH CARE ESTABLISHMENTS

To achieve quality in disposal of health care waste the health care establishments should have a transparent holistic approach in the services they provide including management of their waste in an environmentally friendly manner. The promise of quality management in all the aspects no matter how small will help the health care facility create a niche for itself. Every health care facility, which takes care of people, should also take care of the environment.

Hospital certification or accreditation is a process whereby a hospital is objectively judged against an accepted level of performance and is evaluated to determine the appropriateness of organizational structure, facilities and outcome. In the process, the facility is informed of weaknesses in its operations and given advice on how to correct the detected problems. Health services accreditation encourages professional participation from within the institution but is subject to external and objective control. In the management of any type of system like health care waste management; success can most readily be attained if appropriate goals are first established. The development of appropriate health care waste management standards provides these goals. Hospital administrators may then focus on attaining these levels of care, that although challenging are achievable. A successful certification programme is educational in nature rather than punitive. The standards that are developed should facilitate improvement in quality of care, must be realistic and achievable within the available resources.

For a sound health care waste management system the following steps should be considered in the building design of a health care facility:

a) Separate corridor, lift in vertical rise building and ramp for transfer of hospital waste.

b) Adequate access for vehicles to service area, pickup point of waste for off-site and on-site transportation.

c) Ventilation and cooling requirements in storage areas.

d) Washing and changing facilities for the staff.

e) Fire resistant construction of waste storage area.

f) At least 48 hours storage capacity for the waste.

g) A separate storage area for recyclable materials.

h) Ensure power supply, fuel storage, water supply and drainage.

i) The workload for final disposal (on-site) facilities should be accurately assessed to plan for size of the treatment technology.

j) The location of the on-site treatment facility needs to be carefully planned so that criteria such as accessibility, distance from kerb side, surrounding environment and availability of water, electricity and drainage are adequately represented.

k) A committee, knowledgeable about the requirement of waste management technologies should carry out the equipment planning. Vendor analysis should be meticulously done.

l) The building should use environment friendly chemicals and paints, the use of harmful pesticides should be discouraged.

The following details on process factors must be checked before certifying a health care facility from health care waste management point of view:

a) Organization of collection and storage facilities:

    i) Drawings of establishment showing designated bag holder sites for every ward and department in the hospital building.

    ii) Drawing of central storage site for health care waste. Details of the type of containers, security equipment and arrangement for washing and disinfecting waste collection trolleys should be checked.

    iii) Refrigerated facility for central storage if storage is likely to exceed 48 hrs must be ensured.

    iv) Drawing showing the paths of collection trolleys through the hospital with clearly marked individual collection routes.

    v) A collection timetable for each trolley route, the type of waste to be collected, the number of wards and departments to be visited on one round.

b) Design specification should be checked for the following:

    i) Bags: colour coding, gauge, and suitability for steam penetration and biohazard/ cytotoxic symbol

    ii) Containers: Size, shape, colour, puncture resistant container of sharps and biohazard label.

    iii) Trolleys: Capacity and number of the trollies, wheeled easily washable.

c) Capacity in terms of material:

    i) Quantity and cost of bags, containers, trolleys.

    ii) Quantity and cost of sharp containers, personal protection equipment, and chemicals for disinfection.

    iii) Cost of waste treatment and disposal equipment, sharps pit etc.

d) Human resource job description and responsibilities:

    i) Number of personnels specially appointed for safe waste management/infection control systems.

    ii) Definitions of responsibilities, duties and codes of practice for each type of category of personnel.

    iii) Definition of the responsibilities of hospital attendants, ancillary staff in special areas and wards.

e) Procedures, policies and practices:

    i) Plan diagram showing procedure for waste segregation. Check actual flow by sample check.

    ii) Plan showing procedure for segregation, storage and handling of waste treatment arrangements such as chemical disinfection and autoclaving.

iii) Monitor procedures for disposal of each category of waste.

iv) Waste treatment standards as per the regulations

v) Emergency procedures for spillage etc.

vi) Check contents of training programme and courses. Check the evaluation results of the programme.

For improving the waste management system at national level, progressively there should be an attempt to develop state as well as national standards on the outcome and process criteria so that process of certification of a facility becomes easier from health care waste management point of view.

4.5 ROLE OF INTERNATIONAL AGENCIES

"Nothing on earth is more international than disease" said Paul Russell. Health and disease have no political or geographical boundaries. Disease or health hazard in any part of the world is a constant threat to other parts. The origin of international health cooperation dates back to 1851, when an international sanitary conference the first of its kind was convened in Paris. International agreement has been reached on a number of underlying principles that govern either public health or safe management of infectious/hazardous waste.

a) The Basel convention, ratified by more than 170 countries, concerns the trans-boundary movements of infectious/hazardous waste.

b) The 'Polluter Pays' principle implies that all producers of waste are legally and financially responsible for the safe and environmentally sound disposal of the waste they produce.

c) "Precautionary principle" when the magnitude of a particular risk is uncertain, it should be assumed that this risk is significant.

d) The "Duty of Care" principle stipulates ethical responsibility while caring for infectious/hazardous waste.

e) The "Proximity Principle" recommends that treatment and disposal of hazardous waste should take place at the closest possible location to the source.

The United Nations Conference on the Environment and Development (UNCED) in 1992, led to the adoption of Agenda 21, which recommends a set of measures for waste management. The recommendations may be summarized as follows:

- Prevent and minimize waste production
- Reuse or recycle the waste to the extent possible
- Treat waste by safe and environmentally sound methods
- Dispose of the final residues by landfill in confined and carefully designed sites.

4.5.1 World Health Organization (WHO)

There are different international agencies actively working on health care waste management. The efforts of some international organizations are described below.

For many years the WHO has advocated that health care waste should be regarded as special waste and a working group on hospital waste management in 1983 produced a recommendation on this subject. WHO is engaged in development of following aspects within health care establishments regarding health care waste management internationally:

a) Awareness generation about health care waste management

b) Planning of health care waste management system and formulating policies at National, State and individual level.

c) Implementation of health care waste management plans.

d) Management of health care waste management system in terms of monitoring and evaluation.

e) Impact assessment on health care workers, patients and community.

f) Capacity building, training of the staff

g) Developed many documents and booklets on safe management of health care waste. The WHO's work and publications on health care waste management are available at WHO's website www.healthcarewaste.org

Some of their publications on health care waste management are:

List of Publications

- Safe management of wastes from health care waste activities: http://www.who.int/water_sanitation_health/medicalwaste/en/
- Teachers Guide: Management of wastes from health care waste activities: http://www.who.int/water_sanitation_health/medicalwaste/wsh9806/en/
- Health care waste management rapid assessment tool (Excel format): http://www.who.int/docstore/water_sanitation_health/documents/Healthcare_waste/HCWMtool(3r).xls
- Waste from health care activities: Fact sheet 253, October 2000: http://www.who.int/inf-fs/en/fact253.html
- Decision-making guide for managing health care waste from primary health care centers: http://www.who.int/water_sanitation_health/medicalwaste/hcw/en/
- Review of health impacts from microbiological hazards in health care wastes: http://www.who.int/water_sanitation_health/medicalwaste/hcw2/en/
- Aide memoire for a national strategy for health care waste management: http://www.who.int/docstore/water_sanitation_health/Documents/Healthcare_waste/AideMem.pdf
- Teaching material to illustrate the Teacher's guide on the management of wastes from health care activities: http://www.who.int/docstore/water_sanitation_health/medwaste/index.htm
- Guidelines for safe disposal of unwanted pharmaceuticals in and after emergencies:

  http://www.who.int/docstore/water_sanitation_health/Documents Health care waste/Unwantedpharm/unwantpharm.doc
- Management of health care wastes policy analysis: http://www.who.int/water sanitation_health/medicalwaste/en/Polanalysis.pdf
- Database on practical options for health care waste management: http://www:healthcarewaste.org/
- Guidance for the development of National Action Plans: http://www:healthcarewaste.org/
- Management of waste from immunization activities. Practical guidelines for planners and managers: http://www:healthcarewaste.org/
- Starting health care waste management in medical institutions: a practical approach: http://www:healthcarewaste.org/
- Practical Guidelines for infection control in health care facilities, WHO SEARO, wpro 2004.
- Mercury in Health Care, Policy Paper, WHO, 2005, http://who.int/water_sanitation — health/medical waste/mercury polpaper.pdf
- Safe Management of Bio-Medical Sharps Waste in India—A report on Alternative Treatment and Non-Burn, Disposal Practices, WHO-SEARO, 2005.

WHO's Policy Paper on Safe Health Care Waste Management, August 2004

Unsafe Health Care Waste Management Leads to Death and Disability

Health care activities lead to the production of waste that may lead to adverse health effects. Most of this waste is not more dangerous than regular household waste. However, some types of health care waste represent a higher risk to health. These include infectious waste (15 per cent to 25 per cent of total health care waste) among which are sharps waste (one per cent), body part waste (one per cent), chemical or pharmaceutical waste (3 per cent), and radioactive and cytotoxic waste or broken thermometers (less than one per cent).

Sharps waste, although produced in small quantities, is highly infectious. Poorly managed, they expose health care workers, waste handlers and the community to infections. Contaminated needles and syringes represent a particular threat and may be scavenged from waste areas and dump sites and be reused. WHO has estimated that, in the year 2000, injections with contaminated syringes caused:

- 21 million hepatitis B virus (HBV) infections (32 per cent of all new infections);
- 2 million hepatitis C virus (HCV) infections (40 per cent of all new infections);
- 260,000 HIV infections (5 per cent of all new infections).

Epidemiological studies indicate that a person who experiences one needle-stick injury from a needle used on an infected source patient has risks of 30 per cent, 1.8 per cent, and 0.3 per cent respectively to become infected with HBV, HCV and HIV. In 2002, the results of a WHO assessment conducted in 22 developing countries showed that the proportion of health care facilities that do not use proper waste disposal methods ranges from 18 per cent to 64 per cent.

Health Care Waste Management may also Represent a Risk to Health

Health care waste management options may themselves lead to risks to health and no perfect readily achievable solution to manage health care waste exists. Health care waste, whether generated at smaller rural clinics or larger facilities, can be managed where adequate well-operated infrastructures exist. However, the volumes of waste generated within large facilities and targeted public efforts (e.g., immunization campaigns) are more challenging, particularly in developing countries where resources may be limited. In these difficult situations for which waste disposal options are limited, small-scale incinerators have been used and are still used as an interim solution in less developed and transitional countries. However, small-scale incinerators often operate at temperatures below 800 degrees Celsius. This may lead to the production of dioxins, furans or other toxic pollutants as emissions and/or in bottom/fly ash. Transport to centralized disposal facilities may also produce hazards to health care handlers, if not safely managed.

Balancing Risks to Make Sound Policy Decisions in Health Care Waste Management

In addition to risks to health from infectious agents, long-term low-level exposure of humans to dioxins and furans may lead to impairment of the immune system, and impaired development of the nervous system, the endocrine system and the reproductive functions. Short-term high level exposure may result in skin lesions and altered liver function.

The International Agency for Research on Cancer (IARC) classifies dioxins as a "known human carcinogen". However, most of the evidence documenting the toxicity of dioxins and furans is based upon studies of populations that have been exposed to high concentrations of dioxins either occupationally or through industrial accidents. There is little evidence to determine whether chronic low-level exposure to dioxins and furans causes cancer in humans. Overall, it is not possible to estimate the global burden of diseases from exposure to dioxins and furans because of large areas of uncertainty.

In the last 10 years, the enforcement of stricter emission standards for dioxins and furans by many countries significantly reduced the release of these substances into the environment.

In several Western European countries where tight emissions restrictions were adopted in the late 1980s, dioxin and furan concentrations in many types of food (including breast milk) have decreased sharply.

WHO has established tolerable intake limits for dioxins and furans, but not for emissions. The latter must be set within the national context.

Guiding Policy Principles

In view of the challenge represented by health care waste and its management, WHO activities are oriented by the following guiding principles:

- Preventing the health risks associated with exposure to health care waste for both health workers and the public by promoting environmentally sound management policies for health care waste;
- Supporting global efforts to reduce the amount of noxious emissions released into the atmosphere to reduce disease and defer the onset of global change;
- Supporting the Stockholm Convention on Persistent Organic Pollutants (POPs);
- Supporting the Basel Convention on hazardous and other waste; and
- Reducing the exposure to toxic pollutants associated with the combustion process through the promotion of appropriate practices for high temperature incineration.

Strategy

To better understand the problem of health care waste management, WHO guidance recommends that countries conduct assessments prior to any decision as to which health care management methods be chosen. Tools are available to assist with the assessment and decision-making process so that appropriate policies lead to the choice of adapted technologies. WHO proposes to work in collaboration with countries through the following strategies:

Short-term

- Production of all syringe components made of the same plastic to facilitate recycling;
- Selection of PVC-free medical devices;
- Identification and development of recycling options wherever possible (e.g.: for plastic, glass, etc.); and
- Research and promotion on new technology or alternative to small-scale incineration.

Until countries in transition and developing countries have access to health care waste management options that are safer to the environment and health, incineration may be an acceptable response when used appropriately. Key elements of appropriate operation of incinerators include effective waste reduction and waste segregation, placing incinerators away from populated areas, satisfactory engineered design, construction following appropriate dimensional plans, proper operation, periodic maintenance, and staff training and management.

Medium-term

- Further efforts to reduce the number of unnecessary injections to reduce the amount of hazardous health care waste that needs to be treated;
- Research into the health effect of chronic exposure to low levels of dioxin and furan; and
- Risk assessment to compare the health risks associated with: (1) incineration; and (2) exposure to health care waste.

Long-term

- Effective, scaled-up promotion of non-incineration technologies for the final disposal of health care waste to prevent the disease burden from: (a) unsafe health care waste management; and (b) exposure to dioxins and furans;

- Support to countries in developing a national guidance manual for sound management of health care waste;
- Support to countries in the development and implementation of a national plan, policies and legislation on health care waste;
- Promotion of the principles of environmentally sound management of health care waste as set out in the Basel Convention; and
- Support to allocate human and financial resources to safely manage health care waste in countries

4.5.2 Other UN Agencies

United Nations Children's Fund (UNICEF) is one of the specialized agencies of the United Nations. UNICEF works in close collaboration with WHO, and the other specialized agencies of the United Nations like UNDP, FAO and UNESCO. UNICEF strives to improve the situation of children and women. UNICEF activities cover programmes assisting child survival, protection and development; interventions like immunization, improved infant feeding practices, child growth monitoring, home based diarrhoea management, drinking water, environmental sanitation, birth spacing, education of girls and income generating activities for women.

As full partners in primary health care, UNICEF and WHO are involved in Global immunization campaign, hence main work concerning health care waste management is related to management of wastes from immunization campaign activities. To ensure safe immunization UNICEF is promoting auto disable syringes as this reduces the chance of reuse of unsterile injections and the risk of infections. UNICEF in collaboration with WHO has also developed a guidance document: Management of wastes from immunization campaign activities: Practical guidelines for planners and managers for waste being generated from immunizations settings.

UNICEF is also promoting sustainable health care waste management systems focusing on eliminating unnecessary injections, proper product purchasing (e.g. bundling syringes with safety boxes), conducting proper segregation and containerization (method and physical properties), having a secure system of storage and transportation to treatment and disposal sites, providing workers (at all levels) with adequate training and education and applying the necessary reinforcement to maintain the system.

The other international agencies like the World Bank, United States Agency for International development, Department of International Development, United Kingdoms, European Commissions etc. have also been addressing the issue for proper injection and environment management in their health system aided projects. The focus of these agencies primarily being on ensuring occupational and patient safety along with sustainable development.

4.6 ROLE OF NON-GOVERNMENT ORGANIZATIONS

The role of Non-Government Organizations (NGOs) has been well recognized by the Government and the International Agencies largely in implementing social sector reforms. The role of NGOs has also been recognized in implementing sound health care waste management systems. They have been proactive in providing economically viable and environmental friendly solutions, which are safe for the health care workers and the community at large. They act as pressure groups to create the necessary change in policy like eliminating toxins and introducing non-burn treatment technologies. NGOs have also been actively involved in creating awareness, training and monitoring health care waste management systems for the Government, health care facilities and the community itself.

Some NGOs working in different field of health care waste management in India are:

a) **Toxics Link/Srishti:** It is an environmental group working for a toxics free environment. In its many areas of work toxics free health world has been of prime importance. It has been one of the pioneering organization working towards improving health care waste management practices since as early as 1995. It has actively worked towards the introduction of alternative treatment technologies into the country (India). As a part of its research, the organization has initiated a campaign towards better medical waste management throughout the country. They address on occupational safety issues, use of toxics free products and non-burn technologies for sound health care system. The organization has provided extensive training to different stakeholders and developed model hospitals for health care waste management.

b) **Centre for Environmental Education**: Centre for Environment Education (CEE) is a national institution established in 1984 and supported by Ministry of Environment and Forest, Govt. of India. The main aim of CEE is to create environmental awareness among children, youth, decision makers and the general community. It is also actively working towards establishing better health care waste management systems. In its efforts CEE has developed a National Kit of Educational Material on Biomedical Waste Management funded by World Health Organization (WHO) and Ministry of Environment and Forests (MoEF), Government of India.

Check Your Progress 2

1) What are the objectives of training on health care waste management.

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2) Enumerate the steps which need to be planned in a hospital building from health care waste management point of view.

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4.7 FUNDING AND BUDGETING A HEALTH CARE WASTE MANAGEMENT SYSTEM

In this section we will discuss the economics of health care waste management systems. According to the "Polluter Pays" principle, each health care establishment should be financially liable for the safe management of any waste it generates. A health care establishment has to consider different factors that will influence the cost of health care waste management system. Before planning a health care waste management system the health care establishment should carry a waste audit and then broadly list all the items/commodities/accessories required for establishing a health care waste management system. The costs of separate collection, appropriate storage, on-site handling, transportation and waste management equipment like needle cutters are internal to the establishment and paid as personnel and supplies costs; the costs of off-site transport, treatment, and final disposal are external and paid to the personnel contractors who provide the service. The costs of construction, operation, and maintenance of systems for managing health care waste can represent a significant part of the over-all budget of a hospital or health care establishments. They should be covered by a specific allotment from the hospital budget. The total costs are generally made up of the elements listed below, all of which have to be carefully considered if the most cost-effective option is to be selected:

The cost for establishing a health care waste management is mainly based on the following different cost heads:

a) Initial capital investment

b) Amortization over the effective life of plant and equipment

c) Operating costs for such elements as personnel and consumables

d) Utility requirements (fuel, electricity, water etc.)

e) Contractual and overhead costs.

f) Cost for compliance of the regulations

g) Miscellaneous cost like cost of Training

Along with the items listed above, Table 4.3 gives a detailed list of different heads to be included while calculating the total cost towards waste management.

Table 4.3: Costs of Construction and Operation of a Health Care Waste Treatment facility Plant

Site	**Financing**
Cost of land	Interest
Rights of way	Taxes
Site preparation and infrastructure	Accounting and audit fees
Provision of utilities to site	**Direct operating costs**
Consultancy fees	Manpower requirements (manager, operators, drivers)
Environmental/waste management	Yellow/red/blue bags with tags for infectious wastes
Consultant	Black bags for non-risk waste
Engineering	Sharps containers
Architectural	Transportation costs
Legal fees	Utilities (fuel, water, electricity)
Construction costs	Chemicals (for flue-gas cleaning)
Incinerator other technology building	**Indirect operating costs**
Waste storage room	Training
Offices	Treatment Technology maintenance and parts replacement
Technology	Vehicle maintenance
Cost of Incinerator/Autoclave	Uniforms and safety equipment
Freight and storage charges	Ash disposal cost
Waste transport costs	Compliance monitoring of flue-gas emissions
Waste collection trucks	Project management and administrative costs for the organization responsible for the execution and long-term operation for the project
Bins/containers for transporting waste from hospitals to treatment technology site	
Bag holders to be located at all sources of waste in hospitals	
Weighing machines for weighing waste bags	
Refrigerators for storage of waste if necessary	

Channels of Financing

As pollution pay principle applies to all the health care establishments generating waste it is important for the health care establishments to allocate sufficient funds for a sound health care waste management system. There are different ways for generating funds for establishing a proper waste management system. Funds may come from the private sector or from one or more levels of government. For government owned health care establishments, the government may use general revenues to pay the cost of the waste management system while the private health care establishments may generate their own finances for waste management. The government can also reduce duties/taxes on the treatment technologies equipment used for waste treatment, thus reducing the cost of waste treatment and providing incentives for establishing sound waste management systems.

Over the past few years privatization has been increasingly adopted in a number of countries as an alternative method of financing various types of public works, including for health care waste management. Under such an arrangement a private entity finances, designs, builds, owns and operates the treatment facilities and sells its collection and disposal services to government and private health care establishments. The following are probably among the main reasons for considering privatization:

a) Inability of hospitals to raise the needed capital;

b) Expected greater efficiency in the private sector because of fewer constraints than in the public sector.

c) Transfer of responsibility for proper operation and maintenance to an organization with more resources for minimizing risk.

A disadvantage of privatization is the potential loss of overall control by the responsible public agency. It should be possible to minimize this by addressing the following issues in the agreement between the private operator and the public agency.

a) Minimum level of service, especially with regard to reliability, safety, public health risks, and future expansions

b) Regular inspection and regulatory control.

The feasibility of cooperation between local health care establishments should be explored as another means of minimizing costs. Certain basic principles should always be respected in order to minimize these costs:

a) Waste minimization, segregation, and recycling, can greatly reduce disposal costs.

b) Designing all elements of the system to be of adequate capacity will obviate the need for subsequent costly modifications.

c) Future trends in waste production and the likelihood of legislation becoming more stringent should be foreseen.

The financial resources available from the public and private sector will necessarily influence the choice of system and the standards of operations.

Cost Estimation

As you have learnt about different cost heads for a waste system. All hospitals need to establish accounting procedure to document the costs they incur in managing health care waste. Accurate record-keeping and cost analysis must be undertaken by the health care establishments. Health care waste costs should be the subject of a separate budget line. All the cost incurred presently and in the future should be analyzed and included in the budget.

If a waste treatment project is undertaken by a private concern, charges for the service should be computed, so that all costs can be recovered from those using the services. To ensure that the project is self-supporting, charges should reflect the full cost of operations, maintenance, depreciation, debt amortization, and interest. The inclusion of an amortization factor ensures the availability of funds for future plant and equipment replacements. If the charges levied do not cover all costs, the system will need to be subsidized and financing plans should be designed accordingly.

Example of capital and operating costs in Indian rupees incurred at Air Force Command Hospital Bangalore, India, a recently completed WHO collaboration project for health care waste management have been shown at Table 4.4.

Table 4.4: Costing of Health Care Waste Management System at Air Force Command Hospital, Bangalore, India (A WHO Collaboration Project)

Initial Investment (in Rs.)	INR (Rs.)
Incinerator PD-6	21,30,724.00
HEW 25 Hydraulic waste sterilizer unit (Advanced Autoclave)	46,38,000.00
Shredder	2,78,888.00
*Microwave M-10 Metka	7,99,940.00
*Autoclave	31,500.00
*Needle destroyer (06)	7,390.00
Needle destroyer (50)	1,25,000.00
Cost of Rickshaw for transportation	9,800.00
Weighing scale	Govt. supply
Recurring Investment (Yearly Expenditure)	
Protective clothing	
Apron	3,360.00
Caps	1,200.00
Shoes	12,800.00
Gloves	4,400.00
Masks	2,120.00
Goggles	800.00
Filters	350.00
Cost of containers	
Drum 200 ltrs.	3,520.00
Drum 90 ltrs.	66,584.00
Pearl pets	10,010.00
Buckets 20 ltrs.	68,634.00
Sieved buckets	5,200.00
Cost of biodegradable bags	
Red 5 ltrs.	1,151.10
Red 20 ltrs.	6,594.60
Yellow 20 ltrs.	2,731.80
Red 100 ltrs.	8,541.00
Green 100 ltrs.	15,490.60
Blue 100 ltrs.	11,169.00
Cost of chemicals	
5 per cent Sodium, Hydrochlorite	59,300.00
Savlon concentrated	5,577.00
Cresol white	51,480.00
Sodium Hydroxide	5,200.00
Common Salt	800.00
Bleaching Powder	1,000.00
Personnel cost of 3 employee (for transportation, loading/unloading of wastes in Incinerator, Hydroclave, Shredder, Vermi composting)	52,704.00
AMC of equipment after warranty period	
Incinerator (Comprehensive)	55,000.00
Advanced Autoclave 2 per cent of the cost	- NA -
Microwave	25,000.00
Maintenance of shredder, autoclave, needle destroyer under Service Workshop	- NA -

*Funded by WHO

The cost of construction, operation and maintenance of system for managing health care waste represents a significant part of overall budget of a hospital if health care waste management system is implemented properly. Government of India in its pilot project for hospital waste management in government hospitals has estimated Indian Rupees 8.5 million as capital cost for setting up of health care waste management in 1000 bed super speciality teaching hospital which includes on-site final disposal of health care waste.

Common Regional Facility for Final Disposal of Infectious Health Care Waste

Hospitals, private practitioners, emergency care centers though aware of local rules do not have the time or resources to arrange for satisfactory disposal of health care waste. Self-contained on-site treatment methods may be desirable and feasible for large health care facilities. They are not practical or economical for smaller institutions. An acceptable centralized bio-medical waste treatment facility should be in place which will provide free supply of colour coded bags, daily collection of infectious waste, safe transportation of waste to off-site treatment facility and final disposal with suitable and acceptable technology as per local laws. Many cities in India have implemented common regional facility for final disposal of health care waste. These facilities are charging health care establishment's at the rate of Indian rupees 15-20 per kg. Thus with the centralized facilities catering large number of health care institutions, the cost of waste treatment will reduce considerably for the health care institutions.

4.8 MONITORING

For success of a health care waste management system it is very important to monitor the system. The system will collapse if it is not monitored and supervised on a day-to-day basis. Different kinds of monitoring are advised for the sound implementation of the system.

4.8.1 System Monitoring

Regular monitoring must be performed in each institution with regard to health care waste management.

The importance of monitoring lies in the fact that it provides:

- Feedback to the state of affairs in the various stages of health care waste management.
- Information on the trends of waste generation for proactive future action.
- Information on the areas of weakness and strength so as to reinforce the management system with appropriate corrective actions.
- Information on the effectiveness of various health care waste management strategies.
- Information on the achievements of stated targets and standards.

Monitoring is the measure of success or failure of the waste management system and also provides timely inputs for progressive improvement of the health care waste system. Three types of monitoring mechanism need to be enforced for the progressive improvement and sustainability of the health care waste management. They are:

- Baseline monitoring
- Compliance monitoring
- Impact monitoring

Baseline Monitoring

Baseline monitoring monitors the changes in baseline health care waste management systems. The following parameters should be monitored to examine changes in baseline health care waste management systems:

- Waste handling and management practices at health care institutions
- Present practices/trend of waste handling in institutions
- Air quality at treatment facility
- Water quality at treatment facility, or at landfill site

Compliance Monitoring

Compliance monitoring ensures that all the parties concerned in the health care waste management system follow the provisions of guidelines or rules. Compliance monitoring should be done at two stages, one during construction of treatment unit or facility and another during the operation of entire operation.

In the health care facility:

- Preparation of waste management plan by health care establishments
- Training to all employees
- Follow up of occupational health and safety requirements
- Waste segregation in all areas of health care establishments, use of proper container, and labeling
- System for transportation of infectious hazardous waste within health care establishments
- Disinfection and destruction of sharps
- Use of proper storage facility
- Collection schedule
- Emergency response and accident reporting
- Record keeping

Impact Monitoring

Impact monitoring identifies any positive or negative changes that have been brought by the established health care waste management system. The following parameters could be monitored to evaluate the impact of health care waste management system:

- Opinion of patients and visitors
- Opinion of workers in health care establishment
- Opinion of outside agency
- Inventory of waste handled
- Payment by health care establishment to service providers, etc.

Monitoring the Effectiveness of Health Care Waste Management System

Without monitoring there is no mechanism for evaluating the success of the management system or measures taken to minimize or avoid certain effects from the waste in the waste management facilities. Monitoring the effectiveness of the system provides important information that allows for more effective planning or provides timely corrective actions to improve the environmental performance of the management facility.

A comprehensive lists of indicators for compliance, and impact monitoring must be developed for effective monitoring of health care waste management. It is envisioned that monitoring protocol shall be established for different levels of national, district, local level institutions, and government agencies.

4.8.2 Day-to-Day Monitoring

Day-to-day monitoring essentially consists of operational monitoring based on pre-planned policies and action plan for health care waste management. Important role played in day-to-day monitoring is by ward masters/managers, senior staff nurse, departmental heads and waste management officer. Day-to-day monitoring starts from health care waste generation, collection, handling, transportation, temporary storage, transportation to on-site/off-site final disposal options and operations of final disposal facility along with inventory management of the equipments, bags, bins etc. required for waste management. The following procedures need day-to-day monitoring by:

1) **Ward Managers**

   a) Ensure segregation at the point of generation.

   b) Ensure that adequate waste containers are kept with appropriate colour coding and labeling at all strategic areas and not overflowing.

   c) Monitor the workers for observance of universal health precautions and wearing of personal protective equipment while carrying out procedures and handling of sharps and health care waste.

   d) Ensure timely supply of personal projective equipment.

   e) Ensure labeling and quantifying of the different type of waste.

   f) Monitor management of spills if any of blood body fluids like chemicals and heavy metals like mercury inside the department and check whether they are as per policy.

   g) Ensure record keeping in appropriate file/computer.

2) **Sanitary Supervisor**

   a) Ensure waste handler replaces the bin and bag of correct colour coding and labeling.

   b) Replace the damaged bins immediately.

   c) Ensure collection of infectious, sharps and pathological waste in separate recepticals in timely and safe way.

   d) Monitor frequency of collection of waste from wards and departments.

   e) Ensure waste handlers collect the waste from bins and carry them in the waste trolley without spillage.

   f) Ensure waste handlers use-designated routes for waste transport.

   g) Maintain the record of the segregation of waste at kerb side/temporary storage area.

   h) Ensure trolleys for waste transport are cleaned by waste handlers at temporary storage area/kerb side after unloading of their waste bags.

   i) Briefing about health care waste management during daily meetings.

3) **Nursing In-charges**

   a) Ensure proper segregation of wastes at source.

   b) In case of on-site treatment of sharps ensure destroying the needle and nozzles of syringes after use in the ward and segregation and collection of sharps in puncture proof containers.

   c) Check and ensure placement of bins and bags regularly.

   d) Supervise the work of cleaners and ward boys.

   e) Motivate patients, attendants and visitors to follow waste management standards.

4) **Waste Management Officer**

   a) Monitoring the entire waste disposal operation daily.

   b) Sample check daily of sharp collection, transportation, removal of waste from critical care areas, final disposal of waste.

   c) Monitor daily removal of waste from kerb side/temporary storage area for final disposal.

   d) Check record maintenance.

   e) Check daily supplies for waste management are available.

   f) Post prophylaxis measures if required for accidental injury while handling waste

   g) On-site training

For day-to-day monitoring proforma in Table 4.5 and 4.6 can be modified and used by the health care facility.

4.8.3 Periodic Monitoring

Periodic monitoring of certain aspects of health care waste management should be carried out at supervisory level, and managerial level. The managerial staff should periodically monitor the waste management system at:

1) Different points of generation
2) The waste transportation system
3) Final disposal site
4) Occupational safety issues
5) The other broad areas for periodic checks:

   a) Records of sharps/needle stick injury must be checked, analyzed and information utilized for improving the health care waste management

   b) Records of sterilization, chemical disinfections, incinerator/medical waste sterilization unit, autoclave and microwave operations must be periodically checked so that system can be improved.

   c) Check documentation periodically.

   d) Ensure running of training capsules and check the evaluation proformas of the participants.

   e) Periodic monitoring of the waste disposal equipment for proper ash removal from incinerator, filters cleaning, preventive maintenance of equipment like hydroclave, autoclave etc.

   f) Periodic monitoring of financial aspects must be carried out e.g. costs for materials, consumables etc. Annual maintenance costs for equipment, cost for transportation.

4.8.4 Waste Proforma

It is important to keep track of the waste generated at different point of generation. Different sample waste proformas, which should be used for documentation, are tabled below. The information collected by these performas can be used to analyze the waste management system in the health care facilities and further help in the hospital to improve its waste management system.

Table 4.5: Proforma Seeking Information on Hospital Waste Management Practices

1.	**General Information**	
	Name of the hospital:	
	Type:	
	Address:	
	No of beds:	
	No. of staff :	
	Doctors:	
	Nurses:	
	Paramedical staff: (Ward boys and Housekeepers)	
	Authorization for operating waste management system:	
	Waste Management Committee formed and number of	
	members:	
	Dedicated employees for waste management:	
	Infection Management Policy:	
	Services provided:	
	No. of in-patients/month:	
	No. of out-patients/month:	
2.	**Information for Waste Assessment**	
2.1	***Waste Generation***	
	Different Categories of waste generated:	
	Infectious waste:	
	Infected plastic:	
	Sharps:	
	General waste:	
	Any Other:	
2.2	***Waste Collection at Source***	
	Segregation at source	
	Waste containers provided	
	Container description/location	
	Puncture resistant container for sharps:	
	Protective gears provided:	
	Equipment for waste sharps management—needle cutter/destroyer/ any other:	
	Chemical disinfection of waste at source (name and Conc. of the disinfectant):	
2.3	***On-site Transportation***	
	Mode of waste transportation:	
	In trolley/wheel barrows—closed/open/manually:	
	Different trolleys for each waste type:	
	Waste transportation by Lift/ Ramp/ Stairs:	
	Protective gears provided:	

2.4	***Final Treatment and Disposal***	
	Treatment technologies available:	
	Incinerator/ Autoclave/ Microwave/ Chemical Disinfection: (description)	
	Off-site waste treatment services/ (Centralized facility services) Cost of treatment (Rs.) Offer satisfactory services	
	Secured/Open Waste storage area:	
	Final disposal of General waste/Office waste/ Kitchen waste	
	Final disposal of hazardous substances	
2.5	***Occupational Safety***	
	Personal Protective Gears used:	
	Vaccination for Hepatitis-B/Tetanus:	
	Post Prophylaxis measures:	
	Accident Reporting Format/Person:	
2.6	***Economics of Waste Management***	
	Initial cost:	
	Recurring cost:	
2.7	***Any Other Information***	

Table 4.6: Proforma for Waste Quantification Recording

Date	Waste collection	Infectious waste (kg)	Sharps waste (kg)	Any other (kg)	Total (kg)

The health care facilities should also have a accident reporting format to keep track of any accidents relating to health care waste management. The following format can be modified and used.

ACCIDENT REPORTING FORMAT

1. Date and time of accident:
2. Sequence of events leading to accident:
3. The waste involved in accident:
4. Assessment of the effects of the accidents on human health and the environment:
5. Emergency measures taken:
6. Steps taken to alleviate the effects of accidents:
7. Steps taken to prevent the recurrence of such an accident:

Date .... Signature ....

Place .... Designation ....

Apart from internal monitoring carried out by Waste Management Officers, Head of the institution, periodic monitoring can be done by external agencies as is done by NGOs and Regulatory Bodies. They periodically check entire health care waste management system of hospitals and also common biomedical waste treatment facilities.

4.8.5 Sign Posting

Sign posting for health care waste management starts right from departments and wards.

a) Bins and bags should be colour coded as per the local regulations. See Fig. 4.1.

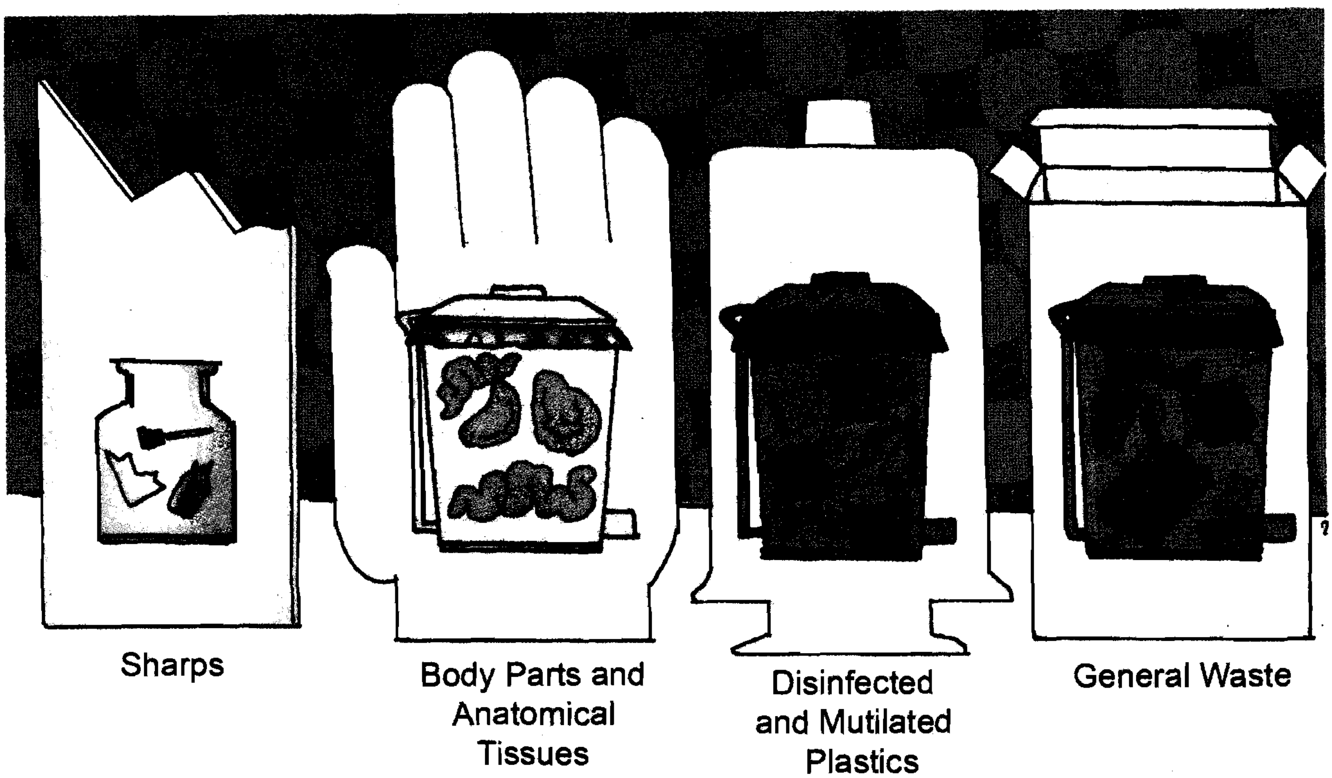

Fig. 4.1: Sign Posting

b) Boards or posters or wall painting should be displayed with special instruction on waste management at different departments and wards especially at OPD, emergency, patient waiting, labor room etc.

c) Printed instructions with guidelines should be hanged at waste generation-sites e.g. Path department, blood bank etc.

d) All the waste transportation trolleys must be sign posted for biohazard symbol.

e) Kerb site storage areas also must be painted with warning signs and instructions.

f) Waste treatment technology site as well as common biomedical waste treatment facilities should have warning boards of biohazard.

g) Transport for offsite waste transportation also must possess biohazard symbol and warning sign painted on its body. It should also have transporter's name, contact address and telephone number in case of emergency.

h) All sign posting should be readable in day and in night. It should also be in local language.

Fig. 4.3: On-site transport vehicle for infectious waste
(Courtesy: Sundram Medical Foundation, Chennai, India)

4.8.6 Record Keeping

Asign a person preferably with computer skills to keep record on waste quality, quantity, related operating cost, source of origin and method of disposal etc. Effective waste management requires accurate record keeping to:

a) Document compliance of the programme

b) Identification of high risk waste, relation to its site of production and storage

   - Amounts of waste generated in each department
   - Amounts of waste generated for entire facility

c) Trends of change in waste generation pattern

d) Initiatives on waste minimization

e) Use of environmentally safe health products

f) To identify types and quantity of waste generated

g) Direct cost of supplies for materials and equipment, disposal, transportation and training

   - Direct costs for supplies and material used for collection, transport, storage, treatment, disposal, decontamination and cleaning
   - Costs for labour and materials for training
   - Cost for labour and materials for occupation health activities such as immunization, needle sticks and other injuries
   - Costs to repair and maintenance of treatment technologies
   - Cost for contractor services.

h) Cost for prevention of waste related injury and illness

i) Repair and associated costs for treatment technology

j) To face and identify the cost during any unavoidable accident

k) Future plans for expansion investment and sustainability

Annual inspection based on annual report as shown below should be carried out by the regulatory authority such as pollution control boards. Punitive action as per the local law can be taken against the defaulters.

ANNUAL REPORT
(As per the Biomedical Waste, Rules in India)

1) Particulars of the applicant:

   a) Name of the authorized person (Occupier/Operator):

   b) Name of the Institution: Address

      Tel. No.

      Telex No.

      Fax No.

2) Categories of waste generated and quantity on a monthly average basis:

3) Brief details of the treatment facility:

   In case of off-site facility:

   a) Name of the operator:

   b) Name and address of the facility:

      Tel. No.___________ Telex No.___________ Fax No.___________

4) Category wise quantity of waste treated.

5) Mode treatment with details:

6) Any other information

7) Certified that the above report is for the period from ....

Date .... Signature ....

Place .... Designation ....

Effective health care waste management requires accurate record keeping to assess success of waste minimization efforts. The health care waste management policy should identify such persons who will help in maintaining the records.

4.8.7 Tracking Policies

The record maintained by the health care facilities not only help the health care facilities but also the implementing agencies to track the waste generated by the facility. The tracking policy can be used for fixing responsibility and identifying mistakes and finally improving the system.

Check Your Progress 3

1) List the various components involved in health care waste management costing.

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2) What are the parameters for monitoring compliance of health care waste management in the health care facility?

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4.9 LET US SUM UP

In this unit you have learnt about the importance of capacity building, training and monitoring for a successful waste management system. Awareness and training for safe practices is essential in obtaining both commitment and behaviour change by all involved in the management of health care waste. You have also learnt about different channels of addressing the issue by advocacy with policy makers and health care facility managers and community. The importance of inclusion in the curricula of nurses, doctors and health care managers, development of training package adapted to various categories in health care establishment, provision of sufficient financial resources for capital and operational sustenance and monitoring and evaluation of waste production, destination, safety and efficiency of the system was discussed.

4.10 KEY WORDS

Colour Code : The identification and segregation of waste materials in different containers as per different colour. It easily indicates the categories of waste.

Handling : The functions associated with the movement of solid waste material, excluding storage, processing and ultimate disposal.

Health Care Establishment : It includes hospital, clinic, research laboratory or any other. health care facility.

Storage : The placement of waste in a suitable location or facility where isolation, environmental and health protection and human control (e.g., limitation of access) are provided.

Sweeper/Cleaner : Health care workers who are involved in waste collection.

Treatment : Any method, technique or process for altering the biological, chemical or physical characteristics of waste to reduce the hazards it present and facilitate, or reduce the volume of waste.

Waste Generator : Any person, organization or facility engaged in activities that generate waste.

4.11 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Health care waste management as subject should aim at the following:

   - To raise awareness on public health and environment hazards that may be associated with inappropriate segregation, storage, collection, transport, handling, treatment and disposal of health care waste;
   - To provide information on hazards and sound management practices of health care waste for the formulation of policies and the development or improvement of legislation and technical guidelines;
   - To identify waste management practices and technologies that are safe, efficient, sustainable, economic and culturally acceptable;
   - To enable the staff to identify the systems suitable for their particular circumstances;
   - To enable managers of health care establishments to develop their waste management plans.
   - To enable trainers to develop training programmes for the different categories of staff that handle, treat or dispose off health care waste.

2) Syllabus of health care waste management applicable to MBBS students and postgraduate students should be as follows:

   a) Definition of health care waste; hazards and public health impacts of health care.

   b) Introduction to International Regulations

   c) Current national and local legislation

   d) Health care waste management programme for a health care establishment

   e) Health care waste management plan

      i) Action plan for implementation of national health care waste management

      ii) How to improve health care waste management plan of different kinds of health care establishments

   f) Waste segregation

   g) Handling, storage and transportation

   h) Treatment and disposal options

   i) Application of treatment and disposal methods to health care waste categories

   j) Treatment and disposal considerations: major urban hospitals, smaller or remote establishment

   k) Wastewater management

   l) Worker's health and safety and emergencies

   m) Waste management, related costs

   n) Waste minimization, recycling, etc.

   o) Training and capacity building

   p) National programme for health care waste management

   q) Evaluation of the course.

Check Your Progress 2

1) The objectives of public education on health care waste are the following:

   a) To prevent exposure to health care waste and related health hazards; this exposure may be voluntary, in the case of scavengers, or accidental, as a consequence of unsafe disposal methods.

   b) To create awareness and foster responsibility among hospital patients and visitors to health care establishments regarding hygiene and health care waste management.

   c) To inform the public about the risks linked to health care waste, focusing on people living or working in close proximity to, or visiting, health care establishments, families of patients treated at home, and scavengers on waste dumps.

2) As far as health care waste management is concerned a new hospital or existing hospital should plan the following in its buildings:

   a) Separate hospital waste corridor, separate lift in vertical rise building, separate ramp.

   b) Fire resistant construction of waste storage area.

   c) Adequate access for vehicles to service area, pickup point of waste for offsite and on-site transportation.

   d) Ventilation and cooling requirements in storage areas.

   e) Washing and changing facilities for the staff.

   f) At least 48 hours storage capacity for the waste.

   g) A separate storage area for recyclable materials.

   h) The need for the power supply, fuel storage, water supply and drainage.

   i) The workload for final disposal (on-site) facilities should be accurately assessed to plan for size of the treatment technology.

   j) The location of the treatment facility needs to be carefully planned so that criteria such as accessibility, distance from kerb side, surrounding environment and availability of water, electricity and drainage are adequately represented.

   k) A committee knowledgeable about the requirement of waste management technologies should carry out the equipment planning. Vendor analysis should be meticulously done.

   l) The building should use environment friendly chemicals and paints, the use of harmful pesticides should be discouraged.

Check Your Progress 3

1) Total costs of health care waste management

   b) Initial capital investment

   c) Amortization over the effective life of plant and equipment

   d) Operating costs for such elements as labour and consumables

   e) Utility requirements (fuel, electricity, water etc.)

   f) Contractual and overhead costs.

   Miscellaneous cost such as fee for operation to the Govt. and cost of training.

2) At the source of waste generation following parameters should be monitored:

- Preparation of waste management plan by health care institutions
- Training to all employees
- Follow up of occupational health and safety requirements
- Waste segregation in all areas of health care institution, use of proper container, and labeling
- System for transportation of hazardous/infectious waste within health care institutions
- Disinfection and destruction of sharps
- Use of proper storage facility
- Collection schedule
- Record keeping
- Emergency response
- Training

4.12 FURTHER READINGS

Pruss, A., Giroult, E. and Rushbrook, P. (eds.), *Safe Management of Wastes from Health Care Activities,* WHO, Geneva, 1999.

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Rahman Saiedur, A.K.M. (ed.), *Situation Assessment and Analysis of Hospital Waste Management (A pilot study).* Line Director, Hospital Services, Directorate General of Health Services Mohakhali, Dhaka, Bangladesh, 2000.

The Gazette of India, *Bio-medical Waste (Management and Handling) Rules 1998,* Government of India, Ministry of Environment and Forests, New Delhi, India, 1998.

WHO, *Safe Health Care Waste Management: An Aide Memorie for a National Strategy for Health Care Waste Management,* Geneva, 2003.

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UNIT 1 MANAGING WASTE WATER FROM HEALTH CARE FACILITIES

Structure

1.0 OBJECTIVES

After going through this unit, you should be able to:

- enlist the hazards due to waste water from health care facilities;
- comprehend the functioning of waste water treatment systems in health care facilities; and
- describe case studies for waste water treatment systems.

1.1 INTRODUCTION

Human development and population growth exert many and diverse pressure on the quality and quantity of water resources and on access to them. No where are the pressures felt so strongly as the interface of water and human health.

Infectious water-related diseases are a major cause of morbidity and mortality worldwide. A significant proportion of this immense burden of disease (2 million deaths/year from diarrhoeal diseases) is caused by water-related pathogens, such as typhoid and cholera, newly-recognized pathogens and new strains of established pathogens.

The health care facilities cater to patients with different ailments including those with water borne diseases. The waste waters coming from the health care facilities thus have a large population of the water borne pathogens. Treatment of these waters is essential to ensure reduction of pathogens in the water being discharged from the health care facilities. This unit addresses the hazard caused by waste water from health care facilities in detail and further helps you in understanding the waste water treatment systems.

1.2 CHARACTERISTICS AND HAZARDS OF WASTE WATER FROM HEALTH CARE FACILITIES

Along with the solid bio-medical waste, health care activities also generate waste water or liquid waste or effluents. The waste water from health care set ups is as hazardous as solid waste. Waste water generated by a hospital is in fact more hazardous than industrial origin and residential areas as it may contain toxic chemicals, laboratory reagents, medicines, disinfectants and also infectious pathogens from patients.

The characteristics and hazards of waste water from health care establishments can be classified as hazards caused by:

- microbiological pathogens
- hazardous chemical waste
- pharmaceutical waste
- cytotoxic waste
- radioactive waste.

Microbiological Pathogens

The principal area of concern is waste water with a high content of enteric pathogens including bacteria (*E. coli, Salmonella typhi, Shigella, Vibrio cholerae, Campylobacter* and others), viruses (Rota, Hepatitis A), protozoa (*Entamoeba histolytica, Giardia lamblia*) and helminthes (Hookworm, Tapeworm). Contaminated *E.coli* waste water is produced by wards treating patients with enteric diseases and is a particular problem during outbreaks of diarrhoeal disease.

Another upcoming infectious bacterial hazard is the presence of multiple drug resistant (MDR) bacteria (bacteria which are resistant to most of the available antibiotics) in hospital effluent. In a study, the MDR bacterial population in hospital effluents ranges from 0.58 to 40 per cent for ten hospitals studied while it was less than 0.00002 to 0.25 per cent for 11 sewage samples from the residential areas.[1] Further, the MDR bacteria carried simultaneous resistance for most of the commonly used antibiotics and obviously the spread of such MDR bacteria to the community is a matter of grave concern. Further, in most South-East Asia Region countries poor sanitation and open waste water sewer lines run parallel with drinking water pipelines thus hazards due to waste water are increased. In addition underground tubewells can also be contaminated with faecal flora and pathogens from hospital sewer lines.

Hazardous Chemical Waste

The literature on hazardous chemicals in hospital waste water reveals presence of platinum, medicines and disinfectants like gluteraldehyde and heavy metals like mercury. The disposal of hazardous chemicals requires special precautions. Generally, conditions for discharge may include restrictions on pollutant concentrations, content of suspended solids, temperature, pH and sometimes rate of discharge.

Pharmaceutical Waste

Pharmaceutical waste such as outdated or counterfoil drugs in solid form is best treated and disposed by returning to the supplier or by incineration. Small quantities can also be landfilled and buried in hospital premises. Moderate quantities of

[1] Chitnis, V., *et al.*, "Hospital Effluent: A Source of Multi Drug Resistant Bacteria", *Current Sciences*, 79 (7), Oct. 2000: 535-540.

relatively mild liquid or semi-liquid pharmaceuticals such as solutions containing vitamins, cough syrups, intravenous solutions, eye drops (but not antibiotics or cytotoxic drugs) may be diluted in a large flow of water and discharged into municipal areas.

Cytotoxic Waste

Cytotoxic waste used for cancer treatment, should never be landfilled or discharged into the sewerage system. Disposal options include return to the original supplier and incineration at high temperature (1200°C). Certain cytotoxic drugs can undergo chemical degradation methods, which convert cytotoxic compounds into non-toxic, non-genotoxic compounds. It involves use of Potassium Permagnate ($KMnO_4$), Sulfuric Acid (H_2SO_4) and Hydrobromic Acid (HBr). It should be noted that neither incineration nor chemical degradation currently provides a completely satisfactory solution for the treatment of waste, spillages or biological fluids contaminated by antineoplastic agents. Until such a solution is available, hospitals should use the utmost care in the use and handling of cytotoxic drugs as these cytotoxic waste could induce mutations in the nearby flora and fauna. Special care should be taken in hospitals, which are admitting cancer patients only.

Radioactive Waste

Radioactive waste is generated by laboratories and hospitals during diagnostic, therapeutic or research activities. The safe management of radioactive waste should ideally be the subject of a national strategy with an infrastructure that includes appropriate legislation, competent regulatory and operational organizations and adequate personnel.

Radioactive waste should be categorized on the basis of the available options for treatment, conditioning, storage and disposal. Possible categories are half life, activity and radionuclide content, physical and chemical form, liquid aqueous and organic, non-homogenous particles (e.g., containing sludge or suspended solids). Liquid wastes should be collected in suitable containers according to its chemical and radiological characteristics, volume, handling and storage requirements. Spent sealed sources should be kept under shielding. If at all possible, left over sources should be returned to suppliers in shielded sealed containers.

Liquids that are immiscible with water such as scintillation counting residues should not be discharged to sewers but treated by an alternative method, e.g., incineration, absorption. Higher level radioactive waste of relatively short half life (e.g., from Iodine-131 therapy) and scintillation counting residues contaminated oil should be stored for decay in marked containers under lead shielding, until activities have reached authorized clearance levels. Radioactive waste resulting from cleaning up operations after spillage or other accident should be retained in suitable containers unless the activity is clearly low enough to permit immediate discharge.

It is not usually necessary to collect and confine patient's excreta after diagnostic procedures, although ordinary toilets used by such patients should be checked regularly for radioactive contamination by competent staff (e.g., the Radiation Officer). In the case of therapeutic procedures involving radionuclides, hospital toilets must be checked for radioactive contamination after each use by patients, unless every patient has an individual toilet. Some countries require the use of separate toilets equipped with delay tanks and or special treatment systems for patients undergoing radiotherapy.

1.3 WASTE WATER MANAGEMENT

Considering the hazards caused by waste water all liquid wastes must be adequately treated for safe, permitted discharge to public sewers or directly to surface waters. Treatment levels and point of discharge should be established through regulations.

There could be two options of waste water treatment systems followed in the health care facilities based on the connectivity to the main sewage treatment system.

Waste water being discharged from the health care facility should comply with effluent concentration limits as recommended by the state regulations. As an example Table 1.1 shows the effluent concentration limits as prescribed by USEPA (United States Environment Protection Act).

Table 1.1: Liquid Effluent Concentration Limits for Health Care Facility

Parameter	Units	Limit
pH	Units	6-9
Biochemical Oxygen Demand (BOD)	mg/l	50
Chemical Oxygen Demand (COD)	mg/l	250
Oil and grease	mg/l	10
Total Suspended Solids (TSS)	mg/l	20
Cadmium (Cd)	mg/l	0.1
Chromium (Cr)	mg/l	0.5
Lead (Pb)	mg/l	0.1
Mercury (Hg)	mg/l	0.01
Chlorine, total residual	mg/l	0.2
Phenols	mg/l	0.5
Fecal Coliform	MPN/100ml	400
Dioxins and furans	ng/l	0.3

MPN: Most probable number
Source: IFC Environmental Guidelines for Health Care Facility, May 2003.

1.3.1 Connection to a Municipal Sewage Treatment Plant

It is acceptable to discharge the sewage of health care establishments to municipal sewers without pretreatment, provided that the following requirements are met:

- The municipal sewers are connected to efficiently operated sewage treatment plants that ensure at least 95 per cent removal of bacteria;
- The sludge resulting from sewage treatment is subjected to anaerobic digestion, leaving no more than one helminth egg per litre in the digested sludge;
- The waste management system of the health care establishment maintains high standards, ensuring the absence of significant quantities of toxic chemicals, pharmaceuticals, radionuclides, cytotoxic drugs, and antibiotics in the discharged sewage;
- Excreta from patients being treated with cytotoxic drugs may be collected separately and adequately treated (as for other cytotoxic waste).

If these requirements cannot be met, the waste water should be managed and treated as recommended in sub-section below.

In normal circumstances, in the waste water treatment the usual secondary bacteriological treatment of sewage is properly applied, complemented by anaerobic digestion of sludge, can be considered as sufficient. During outbreaks of enteric disease, usually in summer time because of warm weather and in autumn because of reduced river water flow, effluent disinfection by chlorine dioxide, sodium hypochlorite or by any other efficient process is recommended. If the final effluent is discharged into coastal waters, disinfection of the effluent will be required throughout the year.

1.3.2 On-site Treatment of Waste Water

Many health care facilities in particular those that are not connected to any municipal treatment plant, have their own sewage treatment plants. Efficient on-site treatment of hospital sewage should include the following operations:

Primary Treatment

Primary treatment is to reduce oils, grease, fats, sand, grit, and coarse (settleable) solids.

Grit Removal

This stage typically includes a grit channel where the velocity of the incoming waste water is carefully controlled to allow grit and stones to settle but still maintain all organic material within the flow. Grit and stones need to be removed early in the process to avoid damage to pumps and equipment in the remaining treatment stages.

Screening or Maceration

The grit free liquid is then passed through fixed or rotating screens to remove larger material such as rags. Screenings are collected and may be returned to the sludge treatment plant or may be disposed off off-site to landfill or incineration. Maceration in which solids are cut into small particles through the use of rotating knife edges mounted on a revolving cylinder is used in plants that are able to process this particulate waste. Macerators are, however, more expensive to maintain and are less reliable than physical screens.

Sedimentation

In almost all plants there is a sedimentation stage where the sewage is allowed to stand in large tanks so that faecal solids can settle and floating material such as grease and plastics can rise to the surface and can be skimmed off. The main purpose of the primary stage is to produce a generally homogeneous liquid capable of being treated biologically together with a sludge that can be separately treated or processed. Primary settlement tanks are usually equipped with mechanically driven scrapers which continually drive the collected sludge towards a hopper in the base of the tank from where it can be pumped to further sludge treatment stages.

Secondary Biological Purification

Most helminthes will settle in the sludge resulting from secondary purification, together with 90-95 per cent of bacteria and a significant percentage of viruses, the secondary effluent will thus be almost free of helminthes, but will still include infective concentrations of bacteria and viruses. The basic steps of secondary treatment include:

Roughing Filters

Roughing filters are intended to treat particularly strong or variable organic loads. They are typically tall columnar filters filled with open synthetic filter media to which sewage is applied at a relatively high rate. The design of the filters allows high hydraulic loading and a high flow of air. The resultant liquor is usually within the normal range for conventional treatment processes.

Activated Sludge

The settled sewage liquor is run into deep tanks and air or oxygen is forced through the liquor from diffusion blocks on the base of the aeration tanks or alternatively by the use of deep aeration cones which draw up the liquor and spin it into the air. In both cases, a biotic floc is created which provides the required substrate.

Filter Beds

In older plants and plants receiving more variable loads, filter beds are used where the settled sewage liquor is spread onto the surface of a deep bed made up of coke (carbonized coal) or rocks with high surface areas. The liquor trickles through this bed of rocks and is collected in drains at the base. These drains also provide a source of air, which percolates up through the bed, keeping it aerobic. Biological film comprising of bacteria, protozoa and fungi forms on all the rock surfaces and this provides the required biological treatment capability to effect the reduction in organic content.

Tertiary Treatment

The secondary effluent will probably contain at least 20 mg/litre suspended organic matter, which is too high for efficient chlorine disinfection. It should, therefore, be subjected to a tertiary treatment, such as lagooning; if no space is available for creating a lagoon, rapid sand filtration may be substituted to produce a tertiary effluent with a much reduced content of suspended organic matter (10 mg/litre).

Chlorine Disinfection

To achieve pathogen concentrations comparable to those found in natural waters, the tertiary effluent needs to be subjected to chlorine disinfection to the breakpoint. This may be done with chlorine dioxide (which is the most efficient), sodium hypochlorite, or chlorine gas. Another option is ultraviolet light disinfection.

Sludge Treatment

The sludge from the sewage treatment plant requires anaerobic digestion to ensure thermal elimination of most pathogens. Alternatively, it may be dried in natural drying beds and then incinerated together with solid infectious health care waste. On-site treatment of hospital sewage will produce a sludge that contains high concentration of helminthes and other pathogens.

To explain further the steps of establishing and running a waste water treatment facility in an health care facility, a detailed case study—Effluent treatment plant: Why and How? has been presented in the unit that will help you in understanding the wastewater system better.

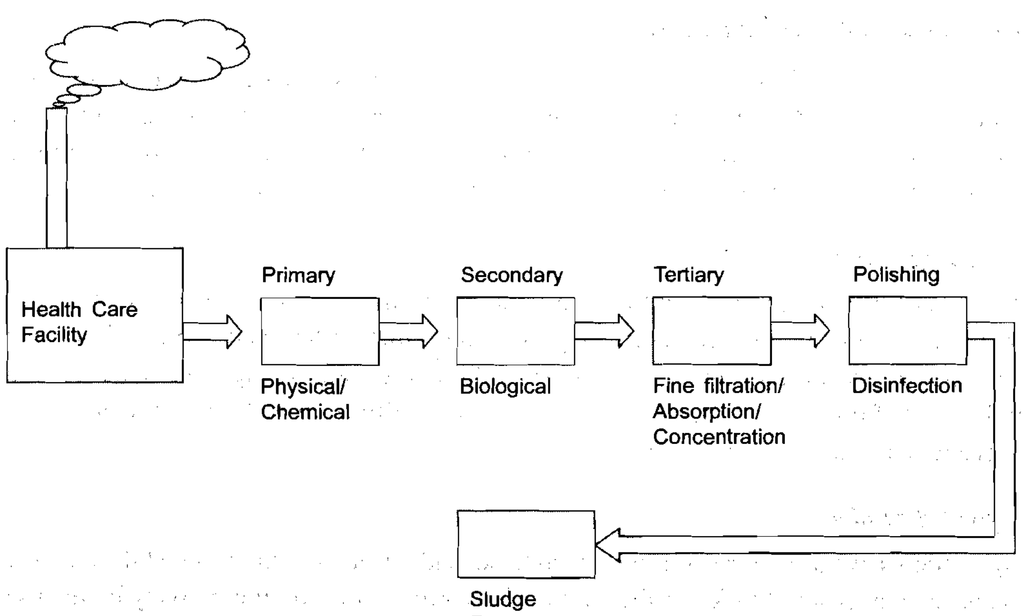

Fig. 1.1: Schematic diagram of sewage treatment plant

Pictorial Presentation of Effluent Treatment Plant (ETP)

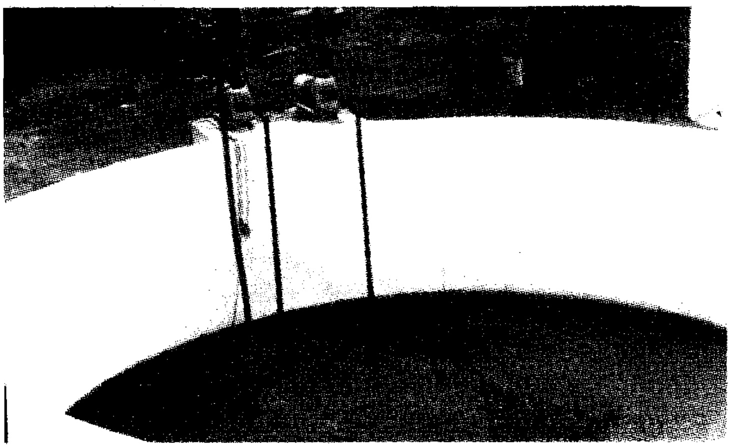

Fig. 1.2: Collection tank of ETP

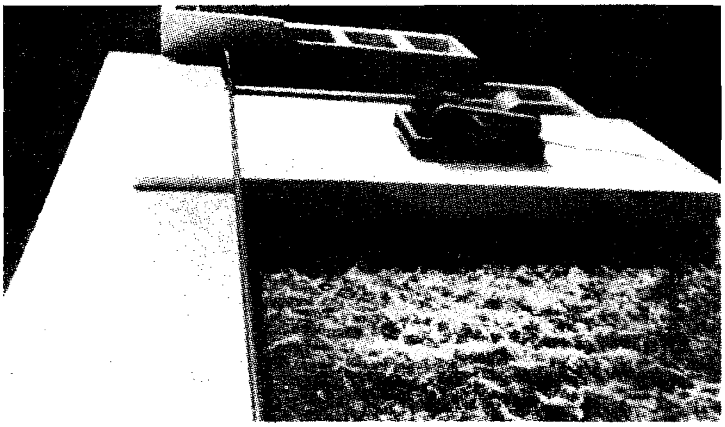

Fig. 1.3: Aeration tank of ETP

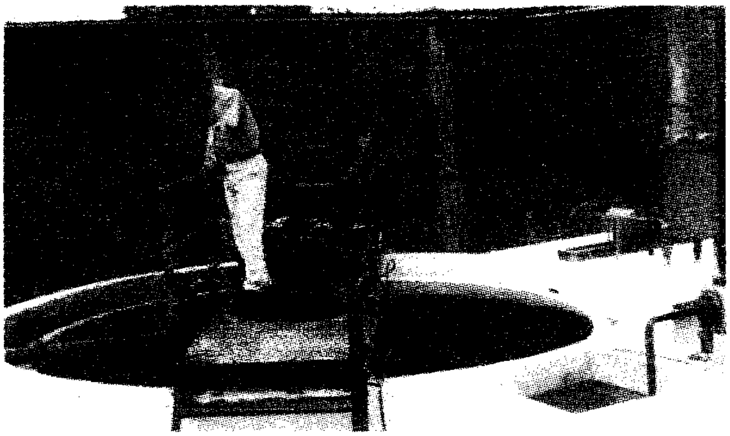

Fig. 1.4: Clarifier tank of ETP

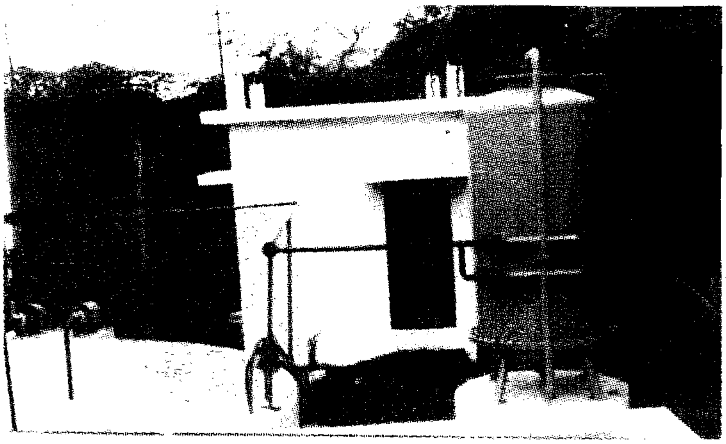

Fig. 1.5: High pressure filter tank of ETP

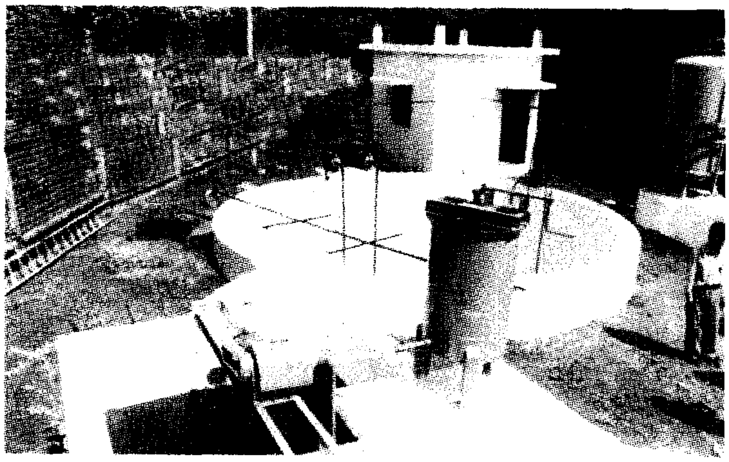

Fig. 1.6: Chlorination tank and field Q.C. lab of ETP

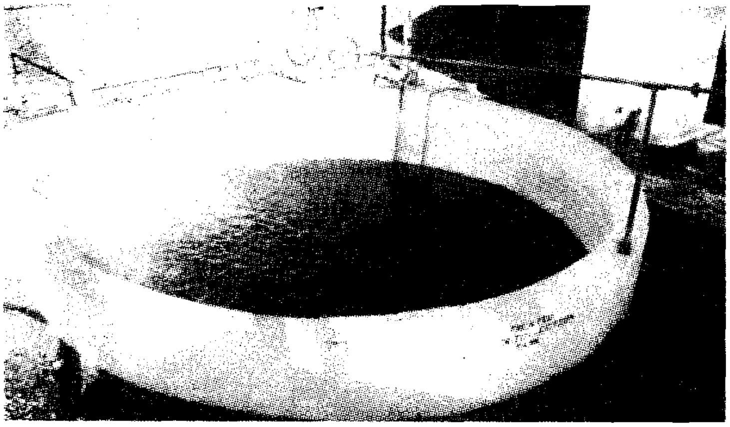

Fig. 1.7: Clean treated water tank after passage through the ETP

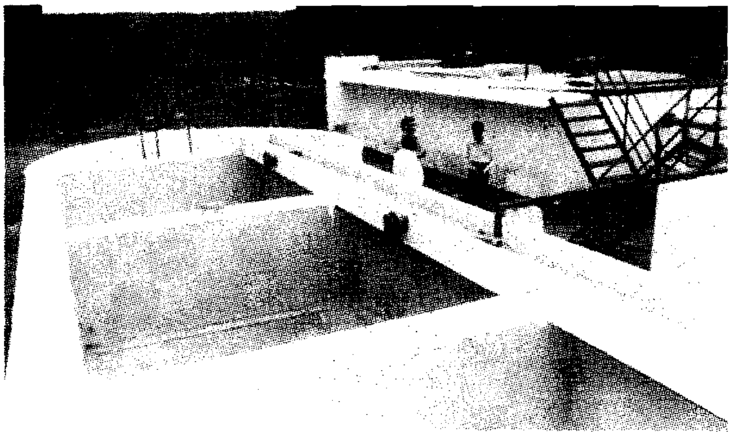

Fig. 1.8: Sludge tank before filling sludge

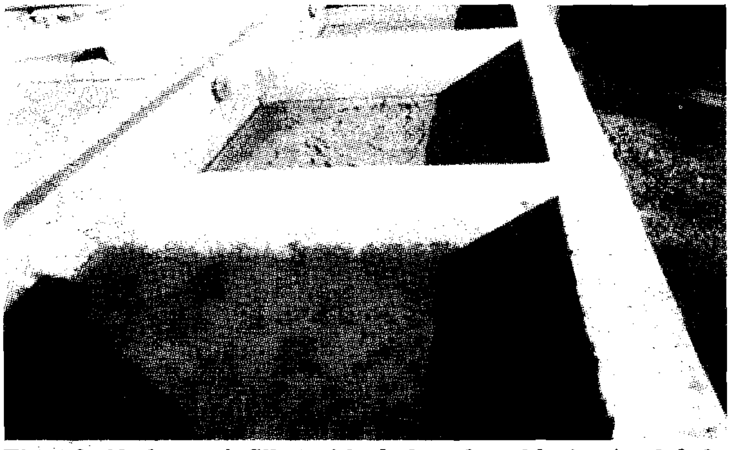

Fig. 1.9: Sludge tank filled with sludge after chlorination left for drying

[*Source:* Fig. 1.2 to 1.9, Choithram Hospital and Research Centre, Indore]

1.4 MINIMAL WASTE WATER TREATMENT SYSTEMS

Some of the minimal waste water treatment systems to be followed where there are no proper waste water treatment systems include:

1.4.1 Lagooning

In a region or an individual health care establishment that cannot afford sewage treatment plants, a lagooning system is the minimal requirement for treatment of waste water. The system should comprise two successive lagoons to achieve an acceptable level of purification of hospital sewage. Lagooning may be followed by infiltration of the effluent into the land, benefiting from the filtering capacity of the soil. There is no safe solution for the disposal of sewage from a hospital that cannot afford a compact sewage treatment plant and that has no space available to build a lagooning system.

1.4.2 Minimal Safety Requirements

For health care establishments that apply minimal programmes and are unable to afford any sewage treatment, the following measures should be implemented to minimize health risks:

- Patients with enteric diseases should be isolated in wards where their excreta can be collected in buckets for chemical disinfection; this is of utmost importance in case of cholera outbreaks and strong disinfectants will be needed.
- No chemicals or pharmaceuticals should be discharged into the sewer.
- Sludges from hospital cesspools should be dehydrated on natural drying beds and disinfected chemically (e.g., with sodium hypochlorite, chlorine gas, or preferable chlorine dioxide).
- Sewage from health care establishments should never be used for agricultural or aquacultural purposes.
- Hospital sewage should not be discharged into natural water bodies that are used to irrigate fruit or vegetable crops, to produce drinking water, or for recreational purposes.

Small-scale rural health care establishments that apply minimal waste management programmes may discharge their waste water to the environment. An acceptable solution would be natural filtration of the sewage through porous soils, but this must take place outside the catchment area of aquifers used to produce drinking water or to supply water to the health care establishment.

1.4.3 Sanitation

In many health care establishments in developing countries, patients have no access to sanitation facilities. Excreta are usually disposed off in the environment, creating a high direct or indirect risk of infection to other people. Human excreta are the principal vehicle for the transmission and spread of a wide range of communicable diseases, and excreta from hospital patients may be expected to contain for higher concentrations of pathogens, and therefore to be far more infectious than excreta from households. This underlines the prime importance of providing access to adequate sanitation in every health care establishment, and of handling this issue with special care. The faecal-oral transmission route—and other routes such as penetration of the skin—must be interrupted to prevent continuous infection and reinfection of the population.

Check Your Progress

1) The hazards of waste water generated from the health care facility are due to:

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....

2) List the steps of waste water treatment system within the health care facility.

....

....

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....

3) What are the minimal safety requirements to minimize health risk from waste waters in health care facility?

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....

1.5 CASE STUDY

[A case study from Choithram Hospital and Research Centre, Indore, India[1]]

1.5.1 Introduction

Bio-medical waste can be a hazard to the hospital staff and community. So far, solid infectious and hazardous waste has received greater attention than the liquid waste in the form of effluent. The study revealed that besides deviations in the physico-chemical parameters such as pH, suspended solids, biological oxygen demand (BOD) and chemical oxygen demand (COD), hospital effluent has a high load (0.58 to 40 per cent) of multiple drug resistant (MDR) bacteria. Hence, the effluent discharged from health care facilities can be a grave hazard to the community.

With this threat, an appropriate effluent treatment plant was planned in the health care facility.

The study was carried in a 350-bedded tertiary care centre with a huge campus and green belt spread over 22 acres of land and the water requirement of the hospital exceed 5,00,000 liters/day. The municipal water supplies and the tubewells were inadequate and with the scanty rainfall and increased city population, the tubewells were also giving reduced water yield resulting into water crisis for the hospital activity. Hence, the hospital decided to commission an effluent treatment plant (ETP) with the following objectives:

- To make the effluent safe with reference to physico-chemical characteristics.
- To inactivate the viable MDR bacteria in the effluent.
- To recover 3,00,000 liters/day of treated effluent water for irrigation of green belt and sanitary cleaning purpose.
- To use sludge from the ETP as manure for the green belt.

[1] Chitnis, V., *et al.*, "Effluent Treatment Plant Why and How?" *Journal of Academy of Hospital Administration,* pp. 33-37; Volume 14, No. 1, January-June 2002 *(www.indmedica.com/jaha).*

1.5.2 Hospital Water Consumption Pattern

Daily Hospital Water Requirement: Patients, relatives, hospital activity and residential area use 3,54,000 liters of water (Breakup shown in Table 1.2). Irrigation of gardens and green belt use 1,46,000 liters of water. Total daily water requirement: 5,00,000 liters.

Table 1.2: Water Consumption and Effluent Generation at Choithram Hospital and Research Centre from eight different Sources

Area	Consumption (litres/day)	Effluent (litres/day)
Laundry	23,000	20,000
Boiler	9,000	5,000
A.C. Plant	12,500	10,000
Public toilet	12,500	11,000
Canteen	12,500	11,000
Dialysis	4,500	4,000
Operation theatre	9,000	8,000
Labour room	4,500	3,000
Burn unit	4,500	3,000
Pathology	12,500	11,000
CSSD	4,500	3,000
Total	**5,00,000**	**3,39,000**

1.5.3 Establishing of Effluent Treatment Plant

The ETP plant was designed and erected at the hospital by an external firm. The construction of the ETP completed in 6 months at the cost of 30,000 US$ and commissioned in November 2001. The schematic flow sheet of ETP is depicted in Fig. 1.10.

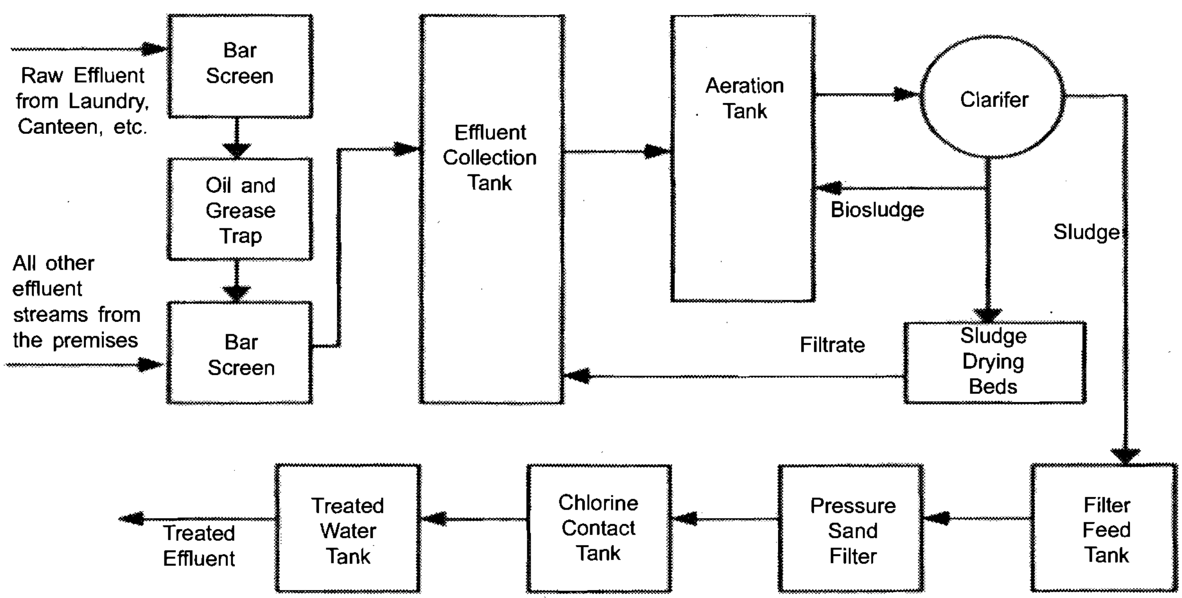

Fig. 1.10: Schematic flow sheet of effluent treatment plant

Principle and Functioning of ETP

Bar Screens: For screening and removal of coarse suspended solids from the effluent while it passes through the bar scanner.

Oil and Grease Trap: Removes the floating oil and grease from the effluent.

Equalization Tank: Collects and equalizes the raw effluent.

Aeration Tank: Mixes the effluent and provides excess of air (oxygen). The aerobic bacteria in the biomass oxidize the suspended and dissolved organic matter. The organic matter is biodegraded by the bacterial mass. Complex carbon compounds are degraded and CO_2 generated. Complex organic nitrogen compounds are degraded to form ammonia, nitrite and nitrates.

Clarifier Tank: Separates suspended biological material. Part of the sludge is returned to aeration tank to provide biomass for the treatment and excess is flown to sludge drying bed.

Filter Feed Tank: The treated effluent is stored before passing to pressure sand filter.

Pressure Sand Filter: Removes the fine suspended matter from the treated effluent.

Chlorine Contact Tank: Chlorine is added continuously to inactivate the microbial population.

Clean Treated Effluent Water Tank: Holds water before lifting to high level storage tanks.

The analysis of the hospital effluent before and after effluent treatment is shown in Table 1.3. All the physico-chemical parameters are absolutely within the specified limits after the effluent treatment. The chlorination results in complete inactivation of the MDR bacteria and thus makes the effluent water safe.

Table 1.3: Physico-chemical and Bacteriological Analysis of Effluent Water

Parameter	Value before ETP	Value after ETP	Limit
Total viable bacterial count	9×10^4	Nil	-
MDR Coliform (%)	1.5	Nil	Nil
Chemical Oxygen Demand (mg/liter)	280	22.56	<250
Biological Oxygen Demand	45	3.6	<30
Total Solids	1066	630	<2200
Total dissolved solids (>mg/ltr.)	942	630	<2100
Total suspended solids (mg/ltr.)	124	<2	<100
pH	7	8.8	6.5-9

The daily input of effluent is approximately 3,39,000 liters/day and approximately 3,00,000 liters of treated water is recovered. The treated effluent water is used for irrigation and sanitary cleaning and as a result of which the hospital no more faces the water shortage. Further, more than 5000 kg. of dried sludge is available per month to use as manure for the gardens.

The cost analysis of the ETP as seen in Table 1.4 is quite impressive and confirms that ETP is an economically viable proposal.

Table 1.4: Cost Effective Analysis of ETP

Expenses per month (in INR)		Savings per month (in INR)	
Particulars	**Amount**	**Particulars**	**Amount**
Running and maintenance cost	23,700	Saving per month of 9 million liter water	94,500
Electricity	60,000	Sludge	3,000
Consumables (including bleaching powder)	3,000		
Total	**86,700**	**Total**	**97,500**
		Balance (Saving)	**10,800**

The effluent treatment plant, as seen presently, removes the organic suspended impurities, improves physical and chemical characters of the effluent and subsequently allows disinfection with low concentration of chlorine. The resultant water can be used for irrigation and sanitary work.

Benefits of the ETP

1) The physico-chemical parameters remain well within the specified limits of discharge into sewage.
2) MDR bacteria inactivated completely—microbiological safety achieved.
3) Effluent water can be recycled for the use of irrigation, washing and sanitary cleaning.
4) Sludge is a bye-product that can be used as manure.
5) ETP is a cost effective proposal for the clean and green environment.

1.6 LET US SUM UP

In this unit you have learnt about the hazards of waste water generated in the health care facility and the different ways to minimize these hazards. Through the case study presented in the unit you have learnt about the establishment and running of ETPs and their benefits to the health care facility and the community at large.

1.7 KEY WORDS

Biological Oxygen Demand : The amount of oxygen required by aerobic micro-organisms to decompose the organic matter in a sample of water, such as that polluted by sewage. It is used as a measure of the degree of water pollution.

Chemical Oxygen Demand : The amount of oxygen needed to oxidize reactive chemicals in a water system, typically determined by a standardized test procedure. The chemical oxygen demand (COD) test is commonly used to indirectly measure the amount of organic compounds in water. Most applications of COD determine the amount of organic pollutants found in surface water (e.g., lakes and rivers), making COD a useful measure of water quality.

Multidrug Resistant Bacteria : Multidrug resistant strains of micro-organisms are bacterias that develop resistant to most of the available antibiotics in the waste water.

Sewage Treatment : Sewage treatment is the process that removes the majority of the contaminants from waste water and produces a liquid effluent suitable for disposal to the natural environment and also produces a sludge.

1.8 ANSWERS TO CHECK YOUR PROGRESS

1) • Microbiological pathogens
   • Hazardous chemical waste
   • Pharmaceuticals
   • Radioactive isotopes
   • Cytotoxic waste

2) The waste water treatment requirements in a health care facility are:

   a) Connection to main sewage line of the municipal corporation and if not connected to main sewage line.

   b) On-site treatment option which includes the establishment of an Effluent treatment plant.

3) The minimal safety requirements to minimize health risk from waste waters in health care facility are: Sanitation, Lagooning and other minimum safety requirements as described in the unit.

1.9 FURTHER READINGS

Gazette of India, *Bio-medical Waste Management and Handling Rules, 1998.*

McRae G., Shaner, H. (1996), *Guidebook for Hospital Waste Reduction Planning and Programme Implementation*, American Hospital Association.

Pruss, A., Giroult, E., Rushbook, P. (eds.) (1999), *Safe Management of Wastes from Health Care Activities*, Geneva, WHO.

WHO (2003), *Emerging Issues in Water and Infections Disease*, Geneva.

WHO (1989), *Health Guidelines for the Use of Waste Water in Agriculture and Aquaculture*, Geneva.

UNIT 2 MANAGEMENT OF WASTES FROM IMMUNIZATIONS

Structure

2.0 OBJECTIVES

After going through this unit, you will be able to:

- describe different areas of immunization waste generation in health care settings;
- formalize strategies and techniques to safely manage wastes from immunization campaign; and
- enumerate successful case studies on managing waste from immunization by non-burn technologies.

2.1 INTRODUCTION

By now you have learnt about different aspects of health care waste management. In this unit you will learn how to handle waste from immunizations. The introduction of auto-disable syringes for immunization programmes in developing countries has increased the urgency to address the issue regionally. The unit also addresses the hazards of waste due to its improper disposal and also the strategies and techniques to safely managê wastes from immunizations.

As you know immunization is one of the most cost-effective public health interventions to reduce childhood mortality and morbidity due to Vaccine Preventable Diseases (VPD).

To prevent VPD, WHO in 1970's at the end stage of the global campaign to eradicate small pox launched the Expanded Programme on Immunization (EPI). Coverage for basic vaccines was an estimated 5 per cent in developing countries at that time. The EPI goals were to ensure that every child received protection against childhood tuberculosis, polio, diphtheria, pertussis, tetanus and measles by the time he or she was one year of age and to give tetanus toxoid vaccinations to women to protect them and their newborns against tetanus.

During 1980's, national immunization programmes in developing countries made substantial progress in meeting the EPI goal. As immunization coverage in developing countries soared, EPI was helping to lay the foundation for other primary health care services. By 1990's average reported coverage for the six antigens was over 70 per cent. As a result of the increase in coverage, the incidence of vaccine-preventable diseases began to fall dramatically.

The global efforts on supporting immunization programmes were further strengthened by the formation of Global Alliance for Vaccines and Immunization (GAVI). GAVI is a coalition of governments and international, bilateral and private sector partners with the purpose of helping countries strengthen immunization services and introduce new and underutilized vaccines.

The new opportunities put forth at the turn of the century have set the stage for great strides in national immunization programmes.

Immunization coverage in South Asia has increased dramatically during the last 25 years from less than 5 per cent to around 50 per cent at present. While the increase in numbers has been impressive, the fact remains that 50 per cent of the children in the region remain un-immunized. At the same time the amount of waste generated due to immunizations has increased tremendously, which needs to be managed effectively.

As shown in Table 2.1, improvements in immunization rates in South Asia resulted in a dramatic reduction in the occurrence of vaccine preventable diseases.

Table 2.1: Trends in Reported Number of Measles Cases

Country/Year	1980	1988
Pakistan	28,600	2300
Bangladesh	11,100	6500
India	114,000	34,000
Total	**153,700**	**42,800**

Source: *WHO Vaccine Preventable Disease Monitoring System, 1999 Global Summary*

In India after the EPI was launched in 1978, the Universal Immunization Programme (UIP) was introduced in 1985-86. The UIP envisage achieving and sustaining universal immunization coverage in infants with three doses of each of DPT and OPV and one dose of measles and BCG vaccination and in pregnant women with two doses or booster dose of tetanus toxoid. Table 2.2 shows the recommended inmunization schedule by WHO.

Table 2.2: The Recommended Immunization Schedule by WHO

Age	Vaccines
Birth	BCG
	OPV0
	HepB*
6 Weeks	DTP1
	OPV1
	HepB*
	Hib1**
10 Weeks	DTP2
	OPV2
	HepB*
	Hib2**
14 Weeks	DTP3
	OPV3
	HepB*
	Hib3**
9 Months	Measles
	HepB*
	Yellow Fever***

Only three doses of hepatitis B vaccine are needed for full protection. Hepatitis B vaccination schedules vary by country to country.

*Hep B – Hepatitis B

** Hib – Haemophilus influenzae type b

*** In countries where indicated.

2.2 MANAGING WASTE FROM IMMUNIZATIONS

In the subsequent paragraphs we will discuss about the problem due to immunization waste and the probable solutions.

2.2.1 Magnitude of the Problem

The management of waste from health care facilities and immunization programmes has been elevated to serious public health concern. Particularly in the wake of introducing Auto-disable (AD) syringes for immunization programmes. This would increase the quantity of waste generated manifold. There is a recognized need for programmes and protocols for safe handling, treatment and disposal to accompany the rollout of these efforts.

In a country like India where the average birth rate is 25 per 1000 population, between 210 and 250 million AD syringes will be used per annum. Coupled with the curative injections, it is estimated that almost 2150 tonnes of plastics, 613 tonnes of needles and 20 tonnes of glass waste need to be disposed per annum. As these immunizations are carried out in 550 thousand sites located in rural and urban settings, managing this waste is a national challenge. In the urban areas the waste can be treated and disposed off with the existing facilities, however, in the outreach areas which generate around 80 per cent of the immunization waste, such treatment facilities might not be available and thus the need to provide solutions for waste being generated in rural health care settings. The stakeholders need to formulize strategies to handle waste in this multi-layered system. Box 1 describes the multi-layered system of primary health care in India.

Box 1: Multi-layered Primary Health Care System in India

District Hospital: District hospitals are large hospitals usually with bed strength of over 300 and are located at the district headquarter levels.

Sub-district Hospital: Sub-district hospitals are usually 100-300 bedded and are located at the division headquarter level in each district.

Community Health Centre (CHC): CHCs are 30-bedded hospital/referral unit for 4 PHCs. They have 30 in-door beds with OT, X-ray lab and other facilities. There are 3043 CHCs in the country. It caters to a population of 80,000-1,25,000.

Primary Health Centre (PHC): A referral unit for six sub-centers. It has around 4-6 beds. Manned with a medical officer in-charge and 14 subordinate paramedical staff. The activities of the PHC involve curative, preventive, promotive and family welfare services. There are 22,842 PHCs functioning in the country. A PHC caters to a population of 20,000-30,000.

Sub-centre: Most peripheral contact point between PHC and community. Manned with one female MPW/ANM and one male MPW. There are 1,37,311 sub-centers functioning in the country. Sub-centers cater to a population of 3000-5000.

Rural population covered by a	General areas	Tribal and hilly areas
Sub-centre	5000	3000
Primary Health Centre	30000	20000
Community Health Centre	120000	80000

1) Number of sub-centers per PHC: 6
2) Number of PHCs per CHC:4
3) Rural population covered by a:
   - MPW (F): 5000
   - MPW (M): 5000

Source: Rural Health Statistics in India, March, 2002.

2.2.2 Need for Managing Waste from Immunization

The World Health Organization (WHO) estimates that at least 50 per cent of the world's 16 billion injections administered each year are unsafe—posing serious health risks to recipients, health workers and the public. Most injections given for therapeutic may be unnecessary, ineffective or inappropriate. (Simonsen, 1999)

Injections are given both for curative and preventive health sector. Vast majority around 95 per cent is given in curative care, immunization accounts for around 3 per cent of all injections with the reminder for other indications, including injections of blood, blood products and contraceptives. Of the total injections administered worldwide an estimated 4.5 billion injections are given in India each year and immunization injections would amount over 210 million.[1] On an individual basis it is estimated that an average Indian receives 5.8 injections per year. Overuse of injections and unsafe practices are common in developing countries like India where approximately 60 per cent injections are administered with reused equipment. In India, the curative injections form a major proportion of the total injections given which again is due to the high injection prescriptions. More than 60 per cent[2] of the total injections given in India are unsafe resulting in the spread of blood borne pathogens causing deadly infections such as hepatitis B, hepatitis C and HIV. Thus an urgent need exists to use injections safely and appropriately, to prevent infections from blood borne pathogens.

The different risks associated with unsafe injections are:

1) **Occupational Risk**

During the handling of wastes, health care personnel and waste handlers can come in contact with waste if it has not been collected properly and transported safely. Many injuries occur from sharps, when they are not handled properly at the time of administration or disposal. When sharps are not collected and transported in puncture resistant containers, no personal protection devices are used and no disinfection and mutilation of sharps is carried out, they can cause immense risk to the health care workers and the community.

2) **Risk to the Public**

If the syringes generated during the immunization programmes are not managed safely, there is a strong possibility of the same syringes coming back to the market. The reuse of syringes by the general public represents one of the greatest public health problems related to health care waste in developing world. WHO estimated that, in 2000 worldwide, injections with contaminated syringes caused about 23 million infections of hepatitis B and C and HIV (Kane *et al.*, 2000)

3) **Indirect Risks via the Environment**

In addition to risks from direct contact with health care waste, waste can also contaminate the environment, such as air and water pollution caused by burning of waste and indiscriminate disposal of waste.

When waste is disposed in a pit, which is not lined or too close to water sources, the water may become contaminated. As the same water may be used as drinking water, for irrigation, waste may indirectly impact the health. If waste is incinerated or burnt, the air is likely to become contaminated by a large number of pollutants and can cause serious illness to people.

2.3 INDIAN REGULATIONS REGARDING WASTE DISPOSAL

As discussed earlier, the Bio-medical Waste (Management and Handling), Rules in India were framed in 1998. These Rules cover the entire country and all the health care facilities. Later amendments were made to the rules (as discussed in BHM-001, Block 4, Unit 1) and different guidelines were prepared such as for siting and operation of centralized facilities, design and construction of incineration and also with the vast number of syringes generated due to immunization. Central Pollution Control Board (CPCB) has formulated guidelines for disposal of bio-medical waste generated during Universal Immunization Programme.

[1] *Safety of Injections*, WHO/EHT/04.04

[2] *India National Injection Safety Assessment: A Study of the India CLEN Programme Evaluation Network* (Draft Report) 2003.

The categories of waste as per Schedule 1 of the Bio-medical Waste (Management and Handling) Rules, 1998 which would be included as part of immunization waste are described in Table 2.3.

Table 2.3: Waste Categories Generated due to Immunization Waste

Waste Category	Description	Treatment Option (as per Rules/guidelines)	Disposal (as per Rules/guidelines)
4	Sharps Waste	Chemical Disinfection/ Autoclave/Microwave/ Hydroclave and mutilation	Recycling/Municipal landfill/Deep burial
7	Plastic Waste	Chemical Disinfection/ Autoclave/Microwave/ Hydroclave and mutilation	Recycling/ Municipal landfill
6	Bandages/Swabs	Chemical Disinfection/ Autoclave/Microwave/ Hydroclave and mutilation	Municipal landfill

Due to the health and environment hazards associated with open burning and incineration, the immunization waste management guidelines recommend only non-burn technologies for treating immunization waste. The same stance of using only non-burn technologies have been recognized globally by different governments and international organizations.

Check Your Progress 1

1) What are the risk associated due to immunization waste?

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2) List the waste streams generated during immunization.

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2.4 TREATMENT TECHNOLOGY OPTIONS FOR SAFE MANAGEMENT OF WASTE

Till recently, not much thought was given to the ways of managing immunization waste. The use of glass syringes eased the load of waste management on the Auxiliary Nurse Midwife (ANM), however, after the introduction of disposable syringes majority of the injections (68 per cent) given in our country are through plastic disposable syringes. The most common practice resorted to disposal of these syringes was to open burning or use of single chambered incinerators. Now with the growing awareness of the hazards associated with burn technologies alternate non-burn technologies are being used for treating bio-medical waste.

The alternatives to burn technologies include autoclaves, microwaves, chemical disinfection technologies and other low cost alternative technologies with potential applications in rural areas as has been discussed in Course 2 (BHM-002), Block 2, Unit 3 entitled Innovative Concepts and Possibilities. Some of the technologies presently used for waste disposal in rural areas are as discussed below:

2.4.1 Technologies Used at the Point of Generation

Mechanical Needle-cutters and/or Hub Cutters

Use a system to cut off needles or needle tips from syringes. The needle is rendered unusable and no metal piece remains at the tip. These devices are of low cost but they entail some risk of needle stick injury to the worker. Some hospital workers have found that the blade in these units tend to get dull after some usage. The cut needle parts can be further disinfected soaked in chemical disinfectant before final disposal. These mechanical cutters are a viable option for the rural settings, as they require no electricity for their operation.

Electric Spark Systems Needle Destroyer

These devices typically use internal electrodes, which produce an electrical spark to melt and burn off the ends of the needle for a few seconds at very high temperatures. They range from battery run portable devices to plug-in desktop units. Most are automated for one-hand quick operation to prevent needle-stick injuries and minimize the time it would take for the health care functionary to destroy the injection unit.

Managing of sharps waste has also been discussed in detail in Course 1 (BHM-001, Block 2, Unit 2).

2.4.2 Portable Steam Treatment Unit and Traditional Grinder

Autoclaves are standard equipment in hospitals and have been used for many years by health care providers to sterilize reusable medical instruments and glassware. In the last few decades, they have also been used to treat medical waste. An autoclave consists of a metal chamber sealed by a charging door and surrounded by a steam jacket. Steam is introduced into both the outside jacket and the inside chamber where waste is exposed to high temperatures for a specific period of time. A simpler version called a retort, shown in Fig. 2.1 does not have an outer jacket. Autoclaves range in size from small portable units to vast chambers capable of treating several tonnes of medical waste per hour.

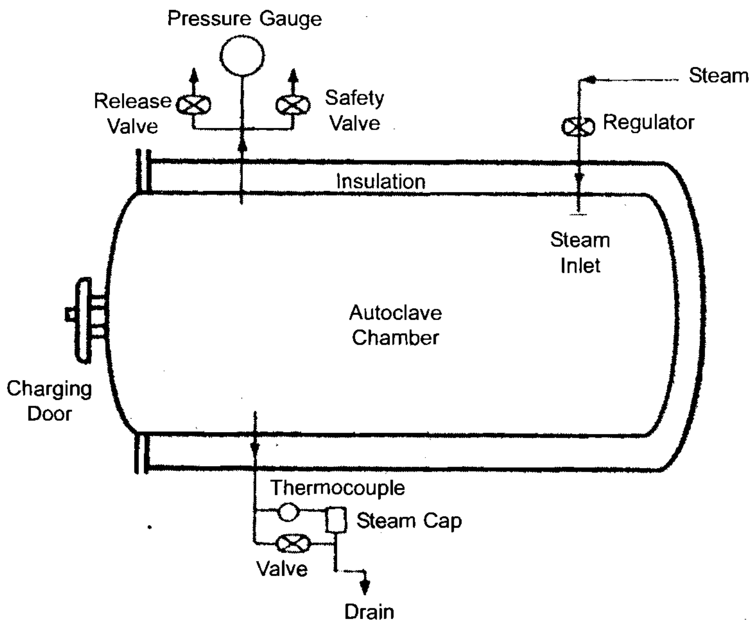

Fig. 2.1: Line diagram of an autoclave

Used or reconditioned autoclaves can be purchased at much lower cost for treating medical waste. In clinics and rural health centers where electricity may be available for a few hours of the day, it could be possible to transport a small portable autoclave to treat sharps waste. It may be necessary to use autoclavable liners to prevent waste from sticking to the inner walls of metal trays to facilitate removal of the treated waste. Alternatively, for small waste loads, the sharps waste could be collected in a metal container with an opening to allow the penetration of steam thus eliminating the cost of safety boxes.

One advantage of autoclaves is that the equipment has simple engineering and can be manufactured locally in developing countries with alight industrial manufacturing sector. It may also be possible to build gas fired or kerosene-fueled autoclaves for areas that do not have electricity. Whether using gas, kerosene, electricity, locally available steam, or other energy sources, autoclaves should be tested under representative conditions to ensure microbial inactivation. Autoclaves should be tested periodically (e.g., on a monthly basis) as part of an inspection and maintenance schedule.

Traditional methods could be explored and modified for use as supplementary technologies for crushing or grinding needles and syringes after autoclave. Many rural agricultural communities have traditional small scale mills and grinders, combining a portable autoclave an efficient waste treatment option can be made available. These simple supplementary technologies remove both the biological and physical hazards and prevent reuse. The residues from the physical destruction process could then be disposed off in burial pits or landfills.

2.4.3 Technologies Used for Final Disposal

Cement Encasing

In areas where volume is not a primary concern, cement encasing or cement encapsulation of sharps is an option. This method is safe as long as workers are careful in handling and transporting the waste and standard safety procedures are followed when working with cement. The size of the trench encase is based on the amount of waste to be disposed off for a specific period. As storage area will be required to accumulate the waste for that period, the size of the encase will also be based on this factor. Waste that may decompose and emit odours should be disposed in other ways unless they are generated shortly before encapsulation. The cement encasing method involves:

1) Digging—a trench large enough to hold the accumulated waste;

2) Adding a cement mixture at the bottom of the trench and allowing it to harden;

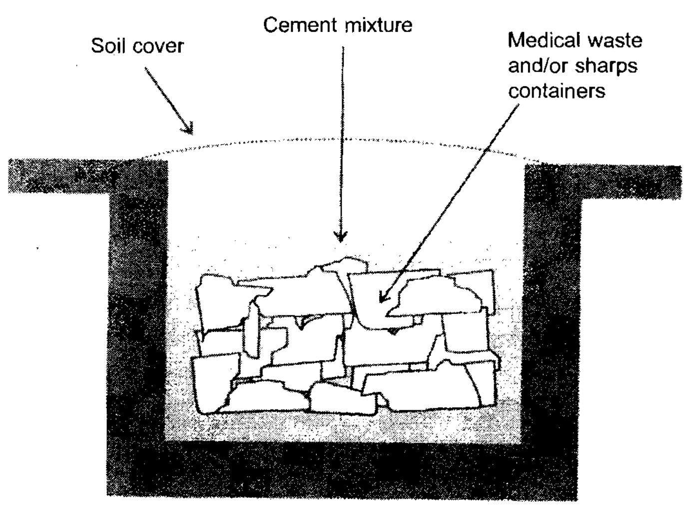

Fig 2.2: Cement encapsulation

3) Carefully placing the waste inside the trench;

4) Encasing the waste completely with the cement mixture;

5) After the cement has hardened, it should be covered on top with about 15 cm of soil.

A typical recipe for the cement mixture is: 1 part cement; 1 part lime; 4 parts sand; one-third to one-half part water. Using lime, which has disinfectant properties, enables cement to retain water thereby allowing the cement mixture to flow easily and fill-up voids and empty spaces in the waste.

Encapsulation with Immobilizing Material

Another method involves placing the sharps waste in hard containers such as metal drums (up to three-quarters full) and adding an immobilizing material such as bituminous sand, clay or cement mortar. The container or drum is then sealed and buried in a trench or transported to the local landfill.

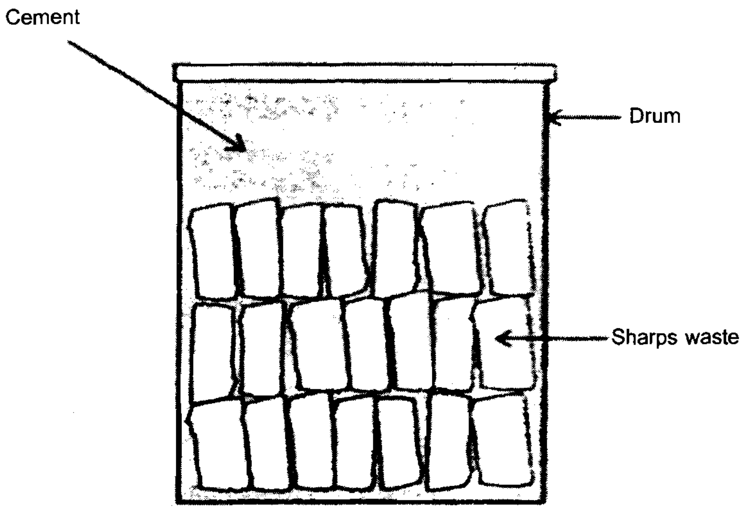

Fig 2.3: Encapsulation in metal drums

Waste Burial Pit with Concrete Cover

Small clinics or rural sites that generate small volumes of waste may use on-site waste burial pits in areas where the water table is not near the surface. The pit should have proper drainage and should not be located in an area that floods. It should also be downhill or down gradient from any nearby wells and about 50 meters away from any water sources such as rivers. The method involves:

1) Digging a pit 1 to 2 meters wide and 2 to 5 meters deep;

2) Lining the bottom of the pit with clay or a low-permeable material, if available so that the waste does not leach;

3) Constructing an earth mound at the mouth of the hole to prevent surface water from entering the pit;

4) Constructing a fence or barrier around the area to keep animals, scavengers, and children away;

5) Periodically placing batches of waste inside the pit and covering each batch with a 10 cm layer of soil, or as an alternative, a mixture of lime and soil can be used as a covering layer; and

6) When the pit is about 50 cm of the ground surface, covering the waste with soil and permanently sealing it with cement.

Fig. 2.4 shows the basic design of a burial pit for disposal of general soiled bandages, bloody gauze, small tissues, etc. The bottom of the trench should be about 1.5 meters above the water table. Information on the depth of the water table in the area may be available from the water authority. The main purpose of the concrete or cement cover is to prevent scavenging. The clay layer helps prevent contamination of the groundwater. Adding lime provides a level of disinfection and discourages scavenging by animals while the pit remains open. The burial pit should only be used for infectious waste and not regular garbage to keep it from filling up quickly. The preferred method of sealing is to use cement. Another alternative is to embed a sheet of wire mesh within a final 50 cm layer of soil cover.

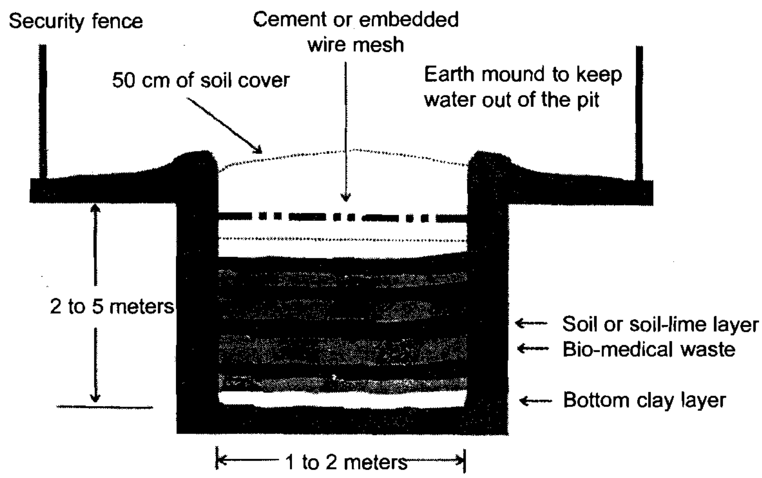

Fig. 2.4: Waste burial pit

Check Your Progress 2

1) Describe briefly the technologies used at the point of generation for treating injection units.

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2) What are the final waste disposal technologies for waste generated from rural settings?

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2.4.4 Centralized Bio-medical Waste Treatment Systems

Urban areas these days are mostly served by centralized bio-medical waste treatment facilities. These facilities have a combination of treatment technologies and collect waste from different generation points like hospitals, clinics, etc., and bring it to the facility for final treatment. They charge a nominal fee for the services provided. You have already learnt in detail about the guidelines for common bio-medical waste treatment facility in Course 1 (BHM-001), Block 4, Unit 1. These guidelines are framed to help in establishing and running a centralized facility. Some PHCs (Primary Health Centres) in the semi-urban area can have access to these treatment facilities. Having access means that this treatment facility lies within a reasonable distance from the PHC. The treatment facility may require the PHC to pay for treatment of the waste.

Some facilities in industrialized countries have combined this approach of centralized facility with providing supplies for reusable sharps containers thereby minimizing cost and environmental impact in the long term. In one commercial operation, e.g., reusable sharps containers are collected and replaced with clean ones. The sharps waste is then brought to a centralized plant where the waste is treated using a combination of steam sterilization and hammer mill grinding. They offer different sizes and configurations of reusable sharps containers to adapt to the specific needs. Another commercial operation provides an integrated recycling and waste management service to a wide range of health care facilities. Their reusable sharps container has a horizontal opening for sharps, tamper proof side locks, overfill protection, leak proof seals to prevent leakage during transport, thick puncture-resistant walls, and a design to allow the containers to be stacked for storage or transport without additional packaging. The containers are collected and transported to facilities that have automatic loading, dumping and washing of the sharps containers. The sharps waste is then treated in autoclave-based or disinfectant-based technologies followed by grinding.

2.5 COMPARISON OF VARIOUS METHODS FOR PROCESSING/DISPOSAL OF IMMUNIZATION WASTE

The following table will help you in understanding the various waste treatment and disposal options used for immunization waste management:

Table 2.4: Comparison of Various Methods for Processing/Disposal of Immunization Waste

Methods	Strengths	Weaknesses
Encapsulation A process in which full safety boxes or disinfected needles are placed within high-density plastic containers or metal drums. When full, an immobilizing material such as cement or clay is added and the container is disposed off in landfill sites or waste burial pits.	• Simple • Low cost • Prevents unsafe needle and syringe reuse • Prevents sharp related infections/injuries • Can be effective interim methods in rural areas	• No volume reduction • Requires land
Needle removal Manual needle removal devices	• Prevents needle reuse • Reduces occupational risks to waste handlers • Disinfected and mutilated plastic and steel may be recycled for other uses after treatment • Manual technologies available	• Potential needle stick injuries during removal • Safety profile not established • Requires further final treatment and disposal

Methods	Strengths	Weaknesses
Needle Destroyer The needle is inserted into a closed box and makes contact with an electrical device that destroys it	• Almost completely destroys the needle • Plastic syringe can be recycled after disinfection	• Requires electricity
Steam sterilization Autoclave	• Autoclaves have been used successfully for decades to treat sharps and non-immunization health care waste • Sterilizes used injection equipment • Plastic may be recycled for other uses after separation • They cost less than incinerators to build, operate and maintain • Autoclaves do not need constant supervision • Autoclaves work well at provincial or district level • They are available in wide range of capacities • When used with shredders, they remove both physical and biological hazards associated with sharps waste • Environment friendly technologies	• Requires electricity • Requires further treatment to avoid reuse (e.g., shredding)
Sharps pit Sharps after disinfection and shredding can be disposed in concrete pit	• Easy to build • Interim solution for disposal of sharps within the health care facility	• Requires Land • No volume reduction

2.6 CASE STUDIES OF SUCCESSFUL NON-BURN IMMUNIZATION WASTE MANAGEMENT SYSTEMS

Health care institutions worldwide have taken efforts to find solution to the problem of managing waste from immunization. Three successful case studies of managing waste from immunization by non-burn treatment system have been discussed below:

2.6.1 Himalayan Institute Hospital Trust, Dehradun, Uttranchal, India

Himalayan Institute Hospital Trust (HIHT) is a 700-bedded multi-disciplinary hospital in the State of Uttranchal, India has successfully proved that effective planning can help manage the huge quantity of waste from immunization generated at outreach locations without using burn technologies. The Rural Development Institute (RDI) is the rural outreach department of the HIHT, which has been undertaking immunization activities since 1994. The hospital has managed waste generated from approximately 33,45,000 syringes over a period of 8 years.

Fig. 2.5: Waste management at outreach clinics
[*Source:* Himalayan Institute Hospital Trust, Dehradun, Uttranchal, India]

At the outreach clinic, waste generated is primarily of two types—the cotton swabs and the injection units. The health workers carry a bucket with yellow liner to contain the cotton swabs generated and a sharps container for the injection unit. After administering the injection, the injection unit is dropped in the sharps container. This tin container is 16 inches in length and 23 inches in breadth and has a small circular opening at the top through which the injections are dropped in. This sharps container can hold approximately 200 used syringes at a time. A lock can close the main lid of the container. The metal container has been designed by the hospital people and has evolved over the years. The metal sharps container costs the hospital Rs. 150 (US$3) to be manufactured. There are forty sharps container in use in the hospital and they are reused after disinfection.

Final Disposal

The sharps containers are brought back to the center and their contents are autoclaved and shredded. The waste contractor comes every alternate day to collect the treated and shredded waste from the hospital, and the hospital earns around Rs. 50,000 (US$ 1000) an year from this waste.

The contractor takes the shredded waste to his facility and segregates the plastic from the metal by emptying the content in a tub of water. The tub is big enough to hold

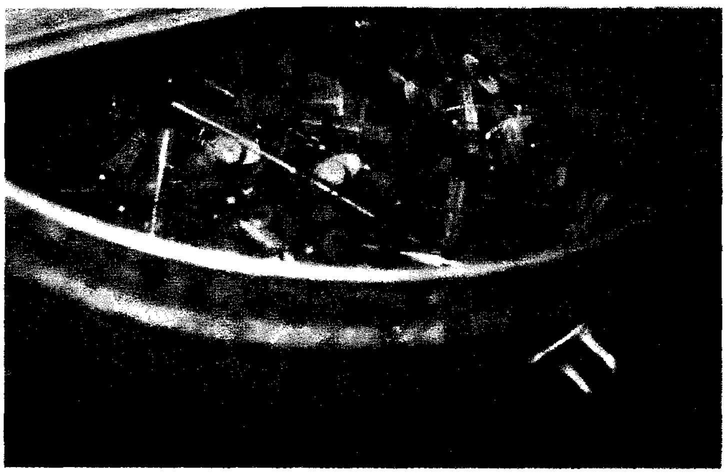

Fig. 2.6: A full sharps container
[*Source:* Himalayan Institute Hospital Trust, Dehradun, Uttranchal, India]

50 litres of water. The metal due to its weight settles down, while plastic floats on top. With the help of a sieve, the contractor scoops out the plastic, and subjects it to drying. After drying the plastic waste is sold to recycling plants while the metal is deep buried at an identified site.

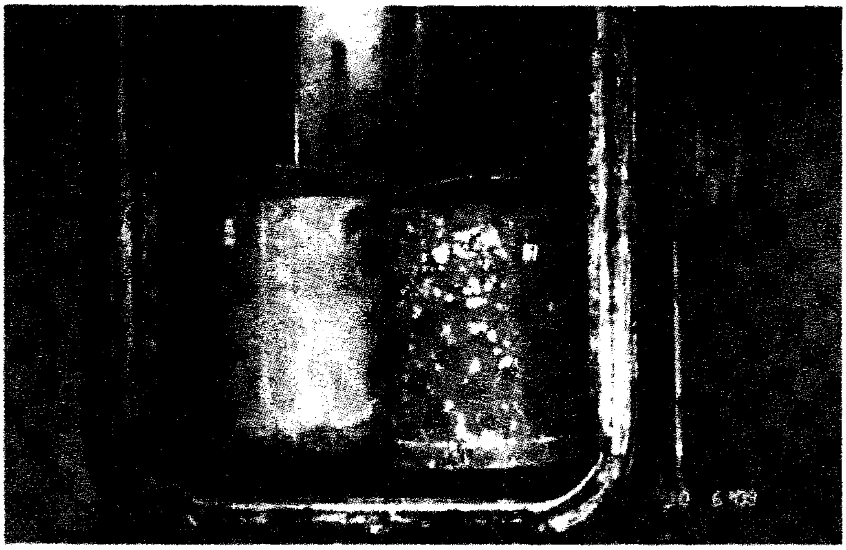

Fig. 2.7: Autoclaving of used sharps
[*Source:* Himalayan Institute Hospital Trust, Dehradun, Uttranchal, India]

Fig. 2.8: Segregation of plastic and metal by gravity displacement in water
[*Source:* Himalayan Institute Hospital Trust, Dehradun, Uttranchal, India]

A system like this of sharps collection, transport and centralized treatment can serve both urban and rural needs. In case of immunization campaigns, the transport system can be organized in conjunction with the delivery of vaccine supplies and sharps containers. The sharps containers are brought back to the centralized facility that uses an autoclave or an advanced form of autoclave for treatment.

Key Strengths

1) System has successfully run for eight years.
2) Centralized treatment and disposal of waste generated at scattered sources.
3) No extra transport cost associated with waste management.
4) Environmentally safe treatment.
5) Material recovery through recycling plastic.
6) Economic benefits.

2.6.2 Program for Appropriate Technology in Health (PATH): Partnership Project with Government of Andhra Pradesh, India

The Partnership Project between PATH and Andhra Pradesh Government aimed at creating a 'model immunization programme' to incorporate new policies, methods and procedures for modern immunization systems.

Project Objectives

- Strengthen routine immunization services
- Introduce Hepatitis B Vaccine as a part of routine immunization
- Promote safe injection practices
- Create a name-based registry for tracking immunization of every child

The State of Andhra Pradesh in India started using Auto-disable (AD) syringes in its immunization programme. For the first year, the purchase of AD was supported by PATH, in the second year 20 per cent contribution came from Government, which would double to 40 per cent in the third year and finally in the fifth year Government would take over the responsibility of purchasing AD syringes.

In a pilot project for managing waste spanning six months PATH introduced 250 Balcan needle cutters in Mehbubnagar district of Andhra Pradesh. Trainings were conducted to ensure that the staff is aware of the method to use of the cutters and disposal of the waste generated. The Government complimented the efforts of PATH, by construction of sharps pit in each primary health care centre of the district, so as to ensure that the sharps collected in the needle cutter can be emptied in the pit. The pit has the provision of locking.

The plastic component of the syringes was stored for six months and at the end of this period the bulk waste was handed over to a centralized facility, which treated and shredded it before disposing it. Around 1.7 million syringes were disposed during the pilot project.

The needle cutters are currently made available only at the primary health centres, therefore, when the ANM gives immunization at sub-centres/outreach, she carries the syringe back to the PHC in a puncture proof container. This glass shaped container can hold approximately twenty syringes and fits in the handbag of the ANM. The ANM brings this container back to the PHC (either the same day or the following day) and uses the Balcan cutters to destroy these used syringes. The plastic component is stored in red coloured plastic bags whereas the metal sharps are put in the pit. The nurses have been trained on the importance of prevention of stick injuries as well as of reporting them. There is also a provision of tally chart, which details the number of injections given in each centre, and therefore at the end of the pilot project calculations can be made regarding the number of syringe waste generated and similar efforts can be duplicated.

This model has successfully demonstrated that non-burn solutions work good for routine immunization settings.

Key Strengths

1) Centralized treatment and disposal of waste generated at scattered sources
2) Environmentally safe treatment
3) Material recovery
4) Training of staff on safety issues

5) Separation of needle from plastic part of the syringe

6) Accident reporting, needle stick injuries recorded

7) ANM friendly

2.6.3 Philippines Measles Elimination Campaign

The adverse health and environmental impacts associated with incineration, Stockholm Convention on Persistent Organic Pollutants and the banning of incineration under the 1999 Philippine Clean Air Act challenged the health care providers to seek no incineration methods for treating medical waste in Philippines. Philippines became the first country to deal with waste from a nationwide vaccination programme without resorting to incineration or open burning. The Philippine Follow-up Measles Elimination Campaign (PMEC) targeted an estimated 18 million children during the month of February 2004. In a little over a month, the PMEC generated an estimated 19.5 million syringes collected in 1,62,000 safety boxes, amounting to about 8,10,000 liters or 1,30,000 kg of sharps waste. Also produced were an additional 7,40,000 liters or 72,000 kg of non-hazardous waste (empty vaccine vials and ampoules, syringe wrappers, empty vitamin capsules, cotton swabs, syringe caps, and packaging).

Fig. 2.9: Children being vaccinated during the campaign

The measles campaign done by the Department of Health, in collaboration with Health Care without Harm and the World Health Organization presented an opportunity to demonstrate and document waste management and disposal without incineration or open burning during a mass immunization campaign.

The study examined waste management practices during the PMEC in 19 documentation sites representing a wide range of geographic, socio-economic, and ethnic conditions. Each location was required to develop microplans for the management of immunization waste. The guidebook recommended the collection of used auto-disable syringes in 5-liter safety boxes, and their treatment and disposal using one of the following methods:

- Treatment in an autoclave facility
- Treatment in a microwave facility
- Encasement in a concrete septic vault
- Burial in a waste pit.

Filled safety boxes were transported, at the end of each day. The storage boxes were sealed with tape, labeled, and transported to temporary storage areas or central storage facilities. The transport and storage of safety boxes were conducted with little or no problems.

Many urban and rural areas that had access to centralized treatment facilities opted to use autoclaves/microwaves.

Poor communities in remote rural regions buried their waste in pits. Two basic waste burial pit designs were used—pits constructed with a cement floor and pits with bottom clay layers. The purpose of the cement or clay flooring was to minimize groundwater contamination. All pits were between 2 to 55 meters above the water table.

An analysis of costs showed that the simple clay-lined burial pits were the cheapest, followed by centralized treatment using autoclave or microwave technology. The most expensive methods were concrete encasement and waste burial pits with cement floors.

Nine needle-stick injuries were documented in 18 of the documentation sites—1.5 needle-sticks per 10,000 syringes used. The few accidents and needle-stick injuries reported were caused by improper handling of sharps waste or the use of old, less sturdy safety boxes. Data from the documentation sites show that the cradle to grave management of immunization waste was completed relatively safely and with minimal impact on the environment. The PMEC waste management study shows that it is indeed possible to treat waste from mass immunizations successfully, while remaining in full compliance with the incinerator ban under the Philippine Clean Air Act.

Key Strengths

1) Environmentally safe

2) Material recovery, in some cases

3) The waste disposal options applied in wide range of settings

Check Your Progress 3

1) What are the key strengths of Philippines immunization programme?

....

....

....

2) How is the waste from immunizations managed in your health care facility?

....

....

....

2.7 LET US SUM UP

In this unit you have learnt that the management of wastes from immunization and other health programmes is a serious public health issue. As increasingly large numbers of single-use syringes are generated, especially in global immunization campaigns, new focused attention is needed to develop the best methods and technologies to manage these wastes. Reliance on old procedures or technologies will no longer suffice in approaches to improve global health. You know by now that continued reliance on highly polluting combustion technologies, such as incinerator, is particularly alarming thus we need to focus on alternative low cost solutions.

Through this unit you have learnt about safe technologies that are used in rural and urban areas for treatment and disposal of medical waste. You have learnt that for rural areas and low-income developing countries, low-cost alternatives include—cement encasing, encapsulation with immobilizing agents, waste burial pit with concrete cover, small portable steam treatment units with traditional grinders, point-of-use sharps technologies, and treatment in a centralized treatment technology such as an autoclave and shredder. The use of these low-cost non-burn technologies has also been discussed in the unit with the help of successful case studies for management of immunization waste. These case studies provide us a model for managing immunization waste successfully with using non-burn technologies.

2.8 KEY WORDS

Alternative Technologies	:	These are non-burn waste management technologies used for treating waste instead of burn technologies like incineration
ANM	:	Auxiliary Nurse Midwife
BCG	:	Bacillus Calmette-Guerin (BCG) vaccine
CHC	:	Community Health Centre
DPT	:	Diphtheria Pertusis Tetanus
Immunization	:	It is a process of giving vaccine and it prepares the immune system to ward off a disease
MHW	:	Multi-purpose Health Worker
OPV	:	Oral Polio Vaccine
PHC	:	Primary Health Centre
SC	:	Sub-Centre
Sharps Pit	:	Pit used to disposal of disinfected sharps (injections) after use

2.9 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) The risks associated due to improper handling of immunization waste include occupational risk to the health care workers, risk to the patients, environment and to the public.

2) The wastes generated during immunization are sharps, plastic syringes and needles, bandages/swabs.

Check Your Progress 2

1) The technologies used at the point of generation for mutilation of sharps are mechanical cutters and needle spark systems.

2) Encapsulation, encasing and deep burial are used for final disposal of sharps.

Check Your Progress 3

1) The key strengths of Philippine Immunization campaign are:

a) Environmentally safe

b) Material recovery, in some cases

c) The waste disposal options applied in wide range of settings.

2) The answer to this will be based on your personal observations.

2.10 FURTHER READINGS

Guidelines for Disposal of Bio-medical Waste Generated during Universal Immunization Programme by Central Pollution Control Board, India, 2004.

MoHFW, *Draft Immunization Policy: 2003,* Govt. of India.

Reaching Children with Immunization in South Asia: World Bank paper.

Safety of Injections: WHO-UNICEF-UNFPA joint Statement on the use of auto-disable syringes in immunization services.

Toxics Link, *Managing Immunisation Waste the Right Way, 01/01/2004*

USAID, *Immunization Essentials—A Practical Field Guide,* Oct. 2003.

WHO, *Management of Solid Health Care Waste at Primary Health Care Centers: A Decision-Making Guide.* Geneva, 2004.

WHO, *Management of Wastes from Immunization Campaign Activities: Practical Guidelines for Planners and Managers,* Geneva, 2004.

WHO,. *Managing Immunisation Waste Poses a Significant Challenge to Health care Organizations,* 2003, www.who.int/immunization_safety/waste_management/

Annexure

Safety of Injections

WHO-UNICEF-UNFPA joint statement* on the use of auto-disable syringes in immunization services

1. The reuse of standard single-use disposable syringes[1] and needles places the general public at high risk of disease and death.

2. The auto-disable syringe, which is now widely available at low cost, presents the lowest risk of person-to-person transmission of blood-borne pathogens (such as Hepatitis B or HIV) because it cannot be reused. The auto-disable syringe is the equipment of choice for administering vaccines, both in routine immunization and mass campaigns.

3. "Safety boxes", puncture-proof containers—for the collection and disposal of used disposable and auto-disable syringes, needles and other injection materials—reduce the risk posed to health staff and the general public by contaminated needles and syringes.

4.
   - WHO, UNICEF and UNFPA reaffirm the current policy that auto-disable syringes, vaccines and safety boxes should continue to be supplied as a "bundle" *(see box, page 41)* for all elective and emergency campaigns.
   - UNICEF reaffirms its current policy that UNICEF programme funds cannot be used to procure standard disposable syringes for any immunization purpose.
   - UNICEF announces that, as of 1 January 2001, no procurement service contracts[2] for standard disposable syringes will be entered into.
   - WHO, UNICEF and UNFPA urge that, by the end of 2001, all countries should use only auto-disable syringes or syringes which are designed to be sterilized. Standard disposable syringes should no longer be used for immunization.
   - WHO, UNICEF and UNFPA urge that, by the end of 2003, all countries should use only auto-disable syringes for immunization.

5. All partners of immunization services are requested to finance not only the vaccines, but also the safe administration of vaccines, auto-disable syringes and safe management of waste. Partners should do this by planning and implementing the above strategy, as well as by supporting related training, supervision and sensitisation activities.

*This joint policy statement revises and replaces the document *WHO-UNICEF policy statement for mass immunization campaigns,* WHO/EPI/LHIS/97.04 Rev.1. It is issued by the World Health Organization, Geneva, Switzerland (Department of Vaccines and Biologicals), the United Nations Children's Fund (UNICEF Programme Division, New York, USA and UNICEF Supply Division, Copenhagen, Denmark) and the United Nations Population Fund, New York. This policy is also the adopted practice of the International Federation of Red Cross and Red Crescent Societies in their operations.

Background

Information reaching WHO, UNICEF and UNFPA consistently highlights the widespread occurrence of unsterile injection practices and identifies a major cause as insufficient supplies of syringes and needles[3]. Unsafe injections can result in the transmission of blood-borne pathogens from patient-to-patient, patient-to-health worker and, more rarely, health worker-to-patient. The community at large is also at risk when injection equipment is used and then not safely disposed off. In many instances, used equipment is reused, sold or recycled because of its commercial value. The imperative to improve safety of injections in immunization services is underlined by the publication of articles in the WHO Bulletin (October 1999) which show that, although immunization injections are thought to be safer than curative injections, around 30 per cent of immunization injections are still unsafe. Much evidence of reuse of disposable syringes exists and even recent country reviews suggest that sterilization of syringes and maintenance of sterilization equipment is not systematic.

Last year, in the developing world, routine immunization of children under one year and immunization of women of child bearing age with tetanus toxoid (TT) accounted for over one billion injections. In addition to routine immunizations, measles control/ elimination activities and disease-outbreak control operations together delivered more than 200 million injections in the same year.

Hepatitis vaccine is now in use in half of the developing countries and Hib, measles-mumps-rubella (MMR) and pentavalent vaccines are already widely used in the Americas. Acceleration of special activities which aim at the elimination of maternal and neonatal tetanus and at better control of measles has begun. And a Global Alliance for Vaccines and Immunization (GAVI) is being formed to assure access to new vaccines for many of the poorest countries where the vaccines are needed most.

These increases of immunization services, including the elimination and control campaigns, offer an opportunity for improvement and make it imperative that injections are made safe for people.

The disease burden associated with unsafe injection practices has been estimated[4] and the cost implications of treatment of these diseases has been quantified[5]. Each unsafe injection costs governments between three to five times the extra cost of auto-disable syringes (which guarantee a sterile injection), not to mention the toll in terms of human suffering.

Strategy

Over the past years, WHO, UNICEF and UNFPA have launched a number of initiatives which aim to improve the safety of injections. The most recent was the precursor to this joint statement in 1997[6] which related to the use of auto-disable syringes and safety boxes in immunization campaigns. That policy has assured the simultaneous budgeting and parallel purchasing and shipping of sufficient syringes and safety boxes for each consignment of vaccines for mass campaigns. Now, with a broad experience of the use of this equipment in the field, is the time to consolidate a policy to cover all administration of vaccine.

WHO and UNICEF have agreed to implement a strategy to ensure that special attention is paid to the safe administration of vaccines, both in routine immunization services and during mass campaigns. The policy statement (on page 38) defines the position of WHO and UNICEF and is intended as a guide to other partners of immunization services, including national ministries of health.

In addition to this policy statement, WHO and UNICEF recommend that:

- Countries exert maximum effort to ensure that procedures for injection safety are rigorous—this includes routine use and monitoring of indicators of sterilization while sterilizable equipment is still used. Partner agencies involved in immunization programmes in countries should provide maximum support for the strengthening of safe injection practices.
- Urgent attention be given to develop appropriate tools (current monitoring tools are still insufficient to objectively demonstrate compliance to safe injection practices).
- Agencies supporting immunization services be encouraged to provide time-limited financial support to countries procuring standard disposable syringes for immunization until government-won budgets can be increased to cover the additional cost of auto-disable syringes.
- Agencies supporting immunization services which fund the purchase of locally-manufactured standard disposable syringes for immunization should assist countries with technology transfer to enable them to switch to auto-disable syringes in the shortest possible time.
- Used auto-disable syringes should be deposited in safety boxes without re-capping, burned locally and the remains buried underground—until improved disposal methods are developed. Urgent attention should be given to develop improved means for effective, safe and environmentally acceptable waste processing and final disposal of auto-disable syringes.

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Ibrahim Osman
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Cooperation and Development (NSCD),
International Federation of Red Cross
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Footnotes

[1]Auto-disable (A-D) syringes conform to the WHO/V&B Performance Specifications E8/DS1 and DS2 and include pre-filled pouch-and-needle injection devices. This statement applies only to available supplies of A-D syringes.

[2]UNICEF procurement service contracts cover the procurement of supplies and equipment by UNICEF as a service to governments and other organizations.

[3]Review: Unsafe injections in the developing world and transmission of blood-borne pathogens, Simonsen L (Ph.D.), Kane A, Lloyd J, Zaffran M, Kane M (M.D.), *WHO Bulletin* October 1999.

[4]Unsafe injections in the developing world: Region based estimates of the transmission of blood-borne pathogens, Kane A *et al.* *WHO Bulletin* October 1999.

[5]Direct and indirect costs of alternative injection technologies used in immunization services, Ekwueme *et al.* (Unpublished study with WHO, October 1999.)

[6]Safety of Injections: WHO-UNICEF policy statement for mass immunization campaigns, WHO/EPI/LHIS/97.04 Rev.1—replaced by this statement, WHO/V&B/99.25.

The term "bundling" has been chosen to define the concept of a theoretical "bundle" which must comprise each of the following items:

- Good quality vaccines
- Auto-disable syringes
- Safety boxes

The implication is that none of the component items can be considered alone; each component must be considered as part of a "bundle" which contains the other two. "Bundling" has no physical connotation and does not imply that items must be "packaged" together.

Copies and information may be requested from:
World Health Organization (WHO)
Department of Vaccines and Biologicals, 20 Avenue Appia, CH-1211 Geneva 27, Switzerland
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United Nations Children's Fund (UNICEF)
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United Nations Children's Fund (UNICEF)
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United Nations Population Fund (UNFPA)
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International Federation of Red Cross and Red Crescent Societies (IFRC)
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Ordering code: WHO/V&B/99.25.
Printed: December 1999

WORLD HEALTH ORGANIZATION

Injection Safety

AIDE-MEMOIRE

for a national strategy for the safe and appropriate use of injections

A safe injection does not harm the recipient, does not expose the provider to any avoidable risks and does not result in any waste that is dangerous for other people.

Worldwide, each year, the overuse of injections and unsafe injection practices combine to cause an estimated 8 to 16 million hepatitis B virus infections, 2.3 to 4.7 million hepatitis C virus infections and 80,000 to 160,000 HIV infections*. Among unsafe practices, the re-use of syringes and/or needles without sterilization is of particular concern.

Injection-associated transmission of bloodborne pathogens can be prevented through the development of a strategy to reduce injection overuse and achieve injection safety and its implementation by a national coalition, with the assistance of a coordinator.

The three elements of a strategy for the safe and appropriate use of injections are described in detail overleaf:

- Behaviour change among patients and health care workers to decrease injection overuse and achieve injection safety
- The availability of necessary equipment and supplies
- The management of sharps waste.

Words of advice

- **Conduct an initial assessment**
- **Secure government commitment and support for the safe and appropriate use of injections**
- **Establish a national injection safety coalition, coordinated by the Ministry of Health**
- **Develop a national policy and plan**
- **Develop a systematic strategy for behaviour change among patients and healthcare workers to decrease injection overuse and achieve injection safety**
- **Ensure the continuous availability of injection equipment and infection control supplies**
- **Set up a waste management system for the safe disposal of sharps**
- **Monitor the impact of activities on injection frequency, injection safety and injection-associated infections**

Checklist

National policy on the safe and appropriate use of injections

- ❑ Assessment of injection practices
- ❑ Coordination of injection safety
- ❑ Multidisciplinary national coalition
- ❑ National policy and plan
- ❑ Costing, budgeting, and financing
- ❑ Three-point strategy for the prevention of unsafe injection practices
- ❑ Monitoring and evaluation

Behaviour change

- ❑ National behaviour change strategy
- ❑ National standards for injection safety
- ❑ Incorporation of safe injection practices into minimum standards of care
- ❑ Promotion of safe technologies
- ❑ Promotion of rational use of injections
- ❑ Other components of behaviour change

Equipment and supplies

- ❑ Auto-disable (AD) syringes for immunization
- ❑ Appropriate types of syringes and needles for curative care
- ❑ Norms and standards for equipment
- ❑ Central bulk procurement, including safety boxes
- ❑ Central management of storage
- ❑ Efficient distribution system

Management of sharps waste

- ❑ Policy for sharps waste
- ❑ Assessment of waste management system
- ❑ Selection of appropriate waste disposal systems
- ❑ Regulatory framework
- ❑ Adequate resources
- ❑ Implementation of waste management system
- ❑ Training and supervision

* Kane A et al. Bull World Health Organ. 1999; 77: 801-807.

Key elements

National policy on the safe and appropriate use of injections

It is the responsibility of governments to ensure the safe and appropriate use of injections.

The achievement of this goal requires the establishment of a national multidisciplinary coalition involving different departments of the Ministry of Health and other stakeholders, such as non-governmental organizations and associations, and private healthcare providers.

The coalition should be coordinated by a Ministry of Health team and should receive political support, adequate funding and trained staff.

Important activities include:

- Initial assessment of injection frequency, breaks in injection safety and adverse events associated with injections, including a behavioural and systems analysis
- Establishment of an injection safety unit to coordinate departments of the Ministry of Health, including health promotion, immunization, family planning, essential drugs programmes, health care service delivery, nosocomial infections, blood transfusion service and waste management
- Establishment of a national coalition, including WHO, universities, non-governmental organizations, behaviour change specialists and associations (e.g. consumers, public and private health care workers, traditional practitioners)
- Development of a national policy and plan (including costing, budgeting, and financing) by the national coalition, within the Ministry of Health's overall plan of action
- Prevention through behaviour change to reduce injection overuse and achieve injection safety; provision of sufficient quantities of injection equipment and infection control supplies; and management of sharps waste
- Monitoring of the impact through process indicators (injection frequency and injection safety) and outcome indicators (incidence of injection-associated infections, rational use of injections)

Behaviour change

The foundation for the safe and appropriate use of injections is a behaviour change strategy targeting consumers as well as public, private and lay health care workers.

Important activities include:

- Development of a national communication and behaviour change strategy on the basis of behaviour and systems analysis
- Definition of national standards for safe injection practices
- Incorporation of injection safety into minimum standards of care
- Promotion of safe technologies
- Promotion of the rational use of injections within essential drug programmes (e.g. restriction of unnecessary injectable drugs) and with the private sector
- Addressing issues that may lead to poor injection practices, including attitudes, emotions, incentives, beliefs, power relationship, norms and systems

Equipment and supplies

Eradication of the re-use of syringes and needles without sterilization requires the continuous, sufficient availability of injection equipment and infection control supplies in all health care facilities.

Important activities include:

- Adoption of auto-disable (AD) syringes for immunization
- Selection of appropriate types of syringes and needles for curative care (sterilizable, disposable or auto-disable)
- Enforcement of international norms and standards by the national regulatory authority
- Central bulk procurement of injection equipment and infection control supplies, including safety boxes
- Central management of storage
- Efficient distribution system to ensure continuous, sufficient availability in all health care facilities nationally

Management of sharps waste

The efficient, safe and environmentally-friendly management of sharps waste is the only means of ensuring that disposable syringes and needles are not re-used and do not lead to accidental needlestick injuries.

Important activities include:

- Formulation of a policy stating that disposal is part of the syringe lifecycle and that health care services have a duty to manage sharps waste
- Assessment of the waste management system, including expressed and real needs
- Selection of appropriate waste disposal systems for all levels of health care facilities
- Implementation of a regulatory framework
- Identification of human and financial resources required
- Implementation of a waste management system
- Training and supervision

Additional information on the safe and appropriate use of injections can be obtained on the World-Wide Web at www.injectionsafety.org and on the Safe Injection Global Network internet forum at sign@who.int

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UNIT 3 OCCUPATION AND PATIENT SAFETY

Structure

3.0 OBJECTIVES

After going through this unit, you should be able to:

- describe occupational risks to waste handlers;
- define occupational health and injury issues; and
- describe patient safety and related issues.

3.1 INTRODUCTION

Health care facilities in the course of daily work generate waste that must be disposed off safely. The handling and management of health care waste can be hazardous to the worker, patient, community and environment. Risks to health care waste workers include possible exposure to infectious or chemical agents and physical injury with sharp objects, such as needles, scalpels, glass and others. The ever increasing incidence of adverse events in health care has led to the emergence of an international drive to create a "culture of safety'. The fifty-fifth World Health Assembly in 2002 adopted a resolution urging countries to pay the closest possible attention to the problem of patient safety and strengthen safety and monitoring systems. The resolution requested World Health Organization (WHO) to take a lead in building global norms and standards and supporting country efforts in developing patient safety policies and practices. Any capacity building programme and/or guidance document attempting to focus on patient safety, must include concerns and aspects of occupational health, medical waste management, and environmental protection.

The primary goal in health care waste management is to eliminate the hazards of health care waste to health care personnel, waste workers and patients by adopting a combination of strategies and approaches discussed in this unit.

3.2 OCCUPATIONAL RISKS TO WASTE WORKERS

In health care facilities the health care worker is directly responsible for collection, transport, treatment, packaging and off-site shipment of wastes from health care facilities.

3.2.1 General Risks of Health Care Waste

The primary goal here is to eliminate the hazards of health care waste by providing information to increase awareness among waste workers on the proper handling of hazardous and infectious waste. The secondary goal is to eliminate the hazards by providing the following to the employers of waste workers:

1) Employers' responsibility and their role in protecting waste workers.
2) Necessary guidelines to create and implement policies that protect waste workers.
3) Information on how to involve waste workers in preventive policies and how to encourage proactive action.
4) Employers should also be informed that the training of all health care workers is an essential step in order to assure worker safety.

Any time health care waste is handled, transported or treated, waste handlers are at risk of exposure to blood borne pathogens (biological hazard), skin puncture, muscle strain (physical hazard), splash/contact with waste chemicals (chemical exposure) and potentially radioactive exposure. Table 3.1 provides the major waste categories, their descriptions, risk associated with them and some examples.

Sharps (needles, vials, infusion sets, scalpels, knives, blades, broken glass, etc.) are less than one per cent of health care waste volume yet they comprise of 90 per cent or more of the biological risks. This is because through needle stick injuries, sharps provide portal of entry (an opening or a door for pathogens to enter from) and mode of transmission. For this, a thorough and well-implemented sharp waste policy is critical.

3.2.2 Risk of Incineration of Health Care Waste

Incineration and open burning of health care waste produces smoke and emits pollutants that can threaten waste workers as well as patients, other health care workers and the community at large. Since many hospitals and health care clinics are situated within the cities, towns, and rural communities, on-site incinerators are often found adjacent to homes, schools, market places, and other centers of activity, providing a large receptor population for toxic pollutants. Table 3.2 lists some of the pollutants emitted from incineration and open burning.

Incinerator emissions have serious adverse consequences on waste workers, local communities near and far, and the environment. Pollutants from incineration include Persistent Organic Pollutants (POPs) such as dioxins and furans, which are especially dangerous because they bio-accumulate, bio-magnify, resist decomposition and are capable of being transported great distances threatening public health and ecosystems around the world. Very low concentrations of dioxins, e.g., have been linked to cancer, immune system disorders, diabetes, birth defects, and other health effects. Medical waste incinerators are also a leading source of mercury in the environment.

Table 3.1: Waste and Types, Risks and Examples of Hazardous Waste		
Waste Category	**Potential Risks and their Health Effects**	**Examples**
Biological	Exposure to pathogens, most often from needle stick injuries, can result in contraction of HIV/AIDS, hepatitis B, hepatitis C and other blood borne diseases. Biological waste includes pathological and infectious waste.	Pathological waste includes human and animal tissues, body fluids including sputum, cerebrospinal fluids, secretions, blood, blood products, placenta, etc. Infectious waste includes waste suspected to contain pathogens, e.g., laboratory cultures, waste from isolation wards, tissues (swabs), materials or equipment that have been in contact with infected patients.
Hazardous	Exposure to hazardous chemicals can result in burns and severe skin reactions, poisoning, allergies and asthma. Chemotherapeutic waste has reproductive and carcinogenic hazards. Mercury causes neurological and nephrological damage especially in fetuses and newborns.	Chemical waste includes disinfectants, cleaning chemicals, chemotherapeutic drugs, laboratory chemicals and reagents, film developer and solvents. Mercury can be found in thermometers, blood pressure gauges and dilators. Broken thermometers are a large source of mercury exposure to waste workers.
Radioactive	Exposure to radiation can result in immediate reactions, destruction of tissue and sickness, as well as long-term disease and possible genetic damage.	Radiation exposure includes radioactive isotopes, unused liquids from radiotherapy or laboratory research, contaminated glassware, packages or absorbent paper, and urine and excreta from patients treated or tested with unsealed radio nucleotides.
Physical	Physical injury includes getting suck or cut by a harp; potential for straining muscles carrying heavy loads of waste (especially back injuries); injuries associated with transporting the waste (rolling over toes with a cart, getting fingers caught in a dumpster lid, etc).	Sharps include needles, vials, infusion sets, scalpels, knives, blades and broken glass.

3.2.3 Risks Beyond the Health Care Settings or "Downstream" Risks

Risks to waste workers outside the health care setting are similar to those of waste workers within a health care facility (e.g., cuts, needle sticks, chemical exposure). The risks of injury or illness may decrease since because many of the pathogens become less virulent over time and chemicals become diluted by being mixed in with other wastes.

Here are some common risks associated with exposure and handling of health care wastes outside of health care facilities. Community members may also be exposed to these risks.

- Used but intact medical devices (e.g., IV bags and tubing, syringes) have value if recovered, as they can be cleaned, repackaged and resold to unsuspecting buyers.
- Municipal waste scavenging directly exposes the scavenger to pathogens in the waste, especially through accidental contact with sharp objects such as glass or needles. Even if the pathogens did not originate in the health care setting, sharps from health care waste provide portal of entry.
- Many products disposed off by health care facilities can cause harm if used inappropriately. Reusing containers that contained disinfectants or other chemicals, e.g., can create unintended chemical exposures. Inappropriate use of discarded pharmaceuticals can create adverse health impacts.

Table 3.2: Typical Pollutants from Medical Waste Incinerators

Pollutants	Examples/Notes	Potential Risks/Health Effects
Dioxins and furan	2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (TCDD)	Cancer, endocrine disruptions (diabetes, endometriosis), immune system disorders
Other organic compounds	Benzene, carbon tetrachloride, chlorophenols, trichloroethylene, toluene, xylenes, trichlorotrifluroethane, polycyclic aromatic hydrocarbons, vinyl chloride	
Heavy metals	Arsenic, cadmium, chromium, copper, lead, mercury, manganese, nickel	Mercury is associated with nervous system disorders particularly affecting developing fetuses and small children. Lead at low concentrations can cause anemia and reduced IQ in children
Acid gases	Hydrogen chloride, hydrogen fluoride, sulfur dioxides, nitrogen oxides	
Carbon monoxide	A common product of incomplete combustion	Chronic exposure to carbon monoxide at low concentrations may aggravate heart disorders
Pathogens	Found in the residues and exhaust of incinerators operating in conditions of poor combustion	
Particulate matter	Fly ash	
Bottom ash	Residues usually contaminated with dioxins, furans, other organics, leachable heavy metals	

Communities are also at risk of water and food contamination:

- Water supplies are at risk of contamination if chemical wastes seep into water sources.
- Food supplies can be contaminated if health care waste is inappropriately fed to animals or applied to crops.

Health care waste poses a greater risk "downstream" if:

- The wastes are not separated, treated, packaged and labeled for movement outside the facility.
- No infrastructure for collection, transport, treatment and disposal exists outside the health care facility.
- The waste is valuable to scavengers, drug users looking for syringes and pharmaceuticals, or recyclers.
- No regulatory and corresponding enforcement structure directs proper waste handling, arrangement and hazard control.

3.3 HEALTH AND INJURY ISSUES

The occupational health for all was approved at 2nd meeting of WHO Collaborating Centres in Occupational Health in Beijing, China, 11-14 October, 1994. The meeting recognized the urgent need to develop occupational health at a time when rapid changes in working life are affecting both the health of workers and the health environment in all countries of the world. Making working conditions safe and healthy—the rational of occupational health is in the interests of workers, employers and government, as well as the public at large.

The main problems for occupational safety are unwillingness to recognize occupational causes of injuries or health problems and failure to report them even when recognized. As a result the burden of diseases due to occupational exposures is normally underestimated.

In many developing countries, waste pickers find their livelihood through sorting and recycling of secondary materials. They are exposed to high occupational health risks, including risk from contact with sharps, solid and infected matter, paper that may have become saturated with toxic materials, bottles with chemical residues, metal containers with residue pesticides and solvents, bandages (containing pathogenic organisms) from hospitals, and batteries containing heavy metals.

Occupational Health and Injury Issues

Some of the more commonly reported occupational health and injury issues related to health care waste management are:

- Needle stick injuries leading to hepatitis B, HIV and tetanus infection;
- Back and joint injuries from lifting heavy waste-filled containers and driving heavy landfill and loading equipment;
- Respiratory illness from ingesting particulates, bio-aerosols, and volatile organics during waste collection and from working in smoky and dusty conditions at open dumps and incineration site;
- Infections from direct contact with contaminated material, dog and rodent bites, or eating of waste-fed animals;
- Injuries at dumps due to surface subsidence, underground fires, and slides;
- Headaches and nausea from anoxic conditions where disposal sites have high methane, carbon dioxide, and carbon monoxide concentrations; and
- Lead poisoning from burning of materials with lead-containing batteries, paints and solders.

From the information available, most occupational health and injury problems could be minimized by simple safety procedures that cost little; and most environmental impacts could minimize by closing open dumps and environmentally unsafe practices like open burning and uncontrolled incineration. Most importantly, workers in developing countries need to wear protective gear, particularly gloves and face masks. Disposal sites need daily cover and proper control of contaminated leachate. Waste pickers need to be managed; children and domestic animals should not be working on disposal sites. By rearranging the disposals layout, implementing modest sorting facilities, and allowing only registered adults, the waste pickers could have improved access to recyclables and decreased health risk. Provision of water supply for washing, sanitation and hygiene education are also highly recommended for waste pickers.

3.3.1 Environmental Health and Injury Issues

Some of the more commonly reported environmental health and injury issues in health care waste management are:

- Contaminated leachate and surface runoff from land disposal facilities affecting down gradient ground and surface water quality;
- Vector-borne disease abundance and pathogen survival in the waste;
- Volatile organic compounds in air emissions inconclusive evidence on altered cancer incidence, birth defects, and infant mortality, as well as psychological stress for those living near hospital waste disposal facilities and inadequately controlled incinerators;
- Animals feeding on hospital waste providing a food chain path for transmitting animal and human diseases;
- Uncollected wastes retaining water and clogged drains, thus leading to stagnant waters which encourage mosquito vector abundance;
- Uncollected wastes providing food and breeding sites for insect, bird and rodent disease vectors.

There appears to be global relationship (not yet precisely quantified) between exposure to hospital waste and increased health and injury risk. The risk is greatest in developing countries where the contact between the health care waste worker and waste is greatest and the level of protection is least.

To complicate the exposure risk to workers and pickers, their personal hygiene is often inadequate. Washing facilities are not typically provided for these people to use at the work place, in order to clean themselves before going home (often by public transportation). To some extent, this is due to inadequate education on hygiene and health relations. Study by US Agency for International Development indicates that cost-effective investment in sanitation requires hygiene promotion and education to achieve successful mortality and morbidity reductions.

Check Your Progress 1

1) What are the kinds of risks associated with health care waste management?

....

....

....

2) What are the occupational risks due to health care waste management?

....

....

3.4 STEPS FOR IMPROVING OCCUPATIONAL SAFETY

The poor state of infrastructure and equipment, unreliable supply and quality of drugs, shortcomings in waste management and infection control, poor performance of personnel because of low motivation or insufficient technical skills and severe under financing of essential operating costs of health services make the probability of adverse events and expose workers to occupational risk.

3.4.1 Developing Hospital Safety and Health Programmes

Safety is a fundamental principle of patient care and a critical component of quality management. Its improvement demands a complex system, wide effort, involving a broad range of actions in performance improvement, environmental safety and risk management, including infection control, safe use of medicines, equipment safety, and safe clinical practice.

The diverse safety and health concerns in health care facilities are traditionally divided into hazards that pose an immediate threat and hazards that cause long-term health problems. Safety hazards include sharp-edged equipment, electrical current, and floor surfaces that can contribute to slipping or tripping. Health hazards are often more difficult to identify than safety hazards. They may result in an immediate illness or in the long-term development of disease. Although a needle puncture may result in hepatitis in 90 to 180 days, exposure to excess radiation or to some chemicals may not result in any noticeable health effects for 20 to 30 years. Thus workers may appear and feel healthy when, in fact, their health is being seriously threatened. Because workers are often exposed to hazards for which the effects are not well known, they may have difficulty associating a new illness with past work place exposures.

Steps for Developing Safety and Health Programmes

This section contains steps for developing safety and health programmes to identify and control occupational hazards within the hospital setting. These steps are summarized in Table 3.3. Personnel trained in occupational safety and health are needed to design, implement, and manage such a programme.

Enlisting Administrative Support

Developing an appropriate and useful safety and health programme for a hospital or health facility requires the involvement of a safety and health committee, health care waste management and infection control groups to be members that represent workers and supervisors from all departments in the hospital. Such involvement is essential because workers frequently observe real and potential hazards than supervisory staff, the employee health service, or other safety and health personnel do not recognize. To be effective, committee members should be knowledgeable in occupational safety and health, and have explicit responsibilities and appropriate authorities.

Identifying Hazards

Hazards identification involves not only recognizing the hazards themselves but also learning their specific characteristics and identifying the population at risk so that control programmes can be designed.

Walk-Through Inspections

Hospital safety and health personnel should conduct an initial survey of safety hazards. The hospital safety and health committee should assist with this in consultation with workers from each department. The first step in identifying hazards is usually a physical inspection called a walk-through survey. Persons conducting the survey actually walk through the unit and note as many hazards as possible.

Table 3.3: Checklist for Developing a Hospital Safety and Health Programmes

Item	Components/Tasks
1) Administrative Support	Develop a safety and health programme. Appoint a safety officer, if possible a member of the health care waste management, infection control committee. Allocate funds to evaluate and monitor hazards, implement controls, and conduct health examinations.
2) Hazard Identification	Conduct periodic walk-through inspections. Obtain material safety data sheets (MSDSs) and other information on potential hazards and hazardous materials/substances. Maintain a log of hazardous chemicals and materials that are used or stored in each department. Ensure proper and safe disposal of these substances and their containers.
3) Hazard Evaluation	Conduct safety inspections and industrial hygiene monitoring of potential hazards and determine needs for hazard controls. Conduct medical evaluations. Select appropriate medical surveillance programmes.
4) Training	Develop and begin a training programme for workers, based on job responsibilities, include medical waste management.
5) Controls	Select appropriate control measures and implement controls and medical surveillance programmes as determined in Item 3 above.
6) Programme Evaluation	Review results of periodic safety inspections, industrial hygiene monitoring, and medical surveillance programmes to find patterns of hazards, to measure the success of the safety and health programme, and to determine the effectiveness of controls. Change the safety and health programme as new materials or procedures are introduced or as new hazards are identified in the review process.
7) Record-keeping	Maintain records of results for all surveys, evaluations, monitoring, corrective actions, and worker medical examinations. Records must be maintained in accordance with applicable local, national regulations.

During a walk-through survey, survey personnel should communicate with supervisors and workers in each department, follow a checklist, and ask any additional questions that may arise. e.g., have common health problems being noticed among the workers in the department? Do any hazards from waste or hazardous materials exist that are not on the checklist? How is the department different from a typical department of its type? A diagram of each department should be developed to include the number and location of workers and the sources of potential exposure.

3.5 GUIDANCE AND POLICY

In this section we shall discuss about general guidance and policy and specific guidance and policy.

3.5.1 General Guidance and Policy

Waste workers tend to be the lowest paid and least educated workers in health care institutions. In some cases they speak a different language than the primary language used in the facility, and their level of literacy may be low or absent. However, without trained, motivated waste workers, health care facilities would not operate and perform adequately and overall safety of other staff, patients and the community would be at risk.

Health care policies are needed to protect health care waste workers since they perform some of the most hazardous jobs at health care facilities and because of their low status tend to be otherwise neglected. Treating waste workers with proper respect and recognizing their contribution to the mission of the organization is one of the best ways to reinforce and encourage good and safe practices.

This sub-section will provide the basic principles for protecting health care waste workers laying the foundation for an effective occupational health and waste management policy. The next sub-section will build on this foundation by providing the detailed practices and policies necessary to best protect waste workers.

Commitment is Key

To most effectively protect waste workers and other staff, commitment of time, energy and resources need to be given by all staff and management to production and implementation of occupational health and waste management policies. Without this commitment, adequate policies will not be in place and the waste workers and other staff will be exposed to unnecessary risks. Supportive and competent management is needed to assure general support and implementation of the mentioned policies. In short, commitment and leadership are a must first step.

Policy and Procedures

Written and formalized occupational health and waste management policies are needed. Documentation provides for the maintenance and improvement of policies over time even though staff changes. Written procedures assist both workers that can follow written instructions as well as provide a good reference for supervisors who must verbally deliver information to workers that cannot read the policies.

Occupational health policies to protect waste workers should:

- Include the goals and mission of the facility and the particular department if applicable.
- Emphasize that safe handling and disposal of waste is responsibility of all staff.
- Reinforce that the health and protection of waste workers is dependent on the actions of all staff. Proper segregation of waste and implementation of policies is necessary to protect co-workers that come in contact with the waste later on ("downstream").
- Provide regular training on the identification and control of occupational hazards and proper waste handling.
- Give instructions on how to respond to and report unsafe practices, spills, injuries or other accidents. Waste workers should be encouraged to report incidences.
- Provide continuing reinforcement for positive behaviour and blame free support and monitoring by supervisors throughout the system and especially when accidents occur or policies are not followed.

- Include enforcement for when mistakes are repeated over time, despite efforts to train, correct actions or improve policies. The staff should understand that their actions endanger their follow workers, their community and the environment.
- A feedback system to evaluate and improve policies, in particular, when mistakes and accidents occur.
- Provide hepatitis B and tetanus immunization programme for waste workers.
- Be clear, consistent and thorough including step by step procedures and instructions that waste workers and other staff can follow to get their work done.
- Reinforce policies and trainings by posting reminders of the hazards and policies on educational wall boards, and clear labeling on materials, containers, doors of storage areas, etc.

Occupational health and waste workers policies should also include information on:

- The nature and hazards of wastes generated and handled.
- How to properly and safely handle these hazardous waste to minimize contact and risk.
- The placement, use and removal of sharps containers.
- Clear and consistent labeling of various waste types. Picture and symbols should be used to include workers that cannot read in the system.
- Universal Precautions (UP) and how to follow them.
- Use of Personal Protective Equipment (PPE) including gloves, masks, gowns, aprons, shoe covers and equipment for moving the waste safely.

Training and Education

The best policies and management systems will fail if all staff does not receive proper training of the developed policies and procedures. Waste worker safety depends on the quality of training and education of all staff on medical waste and occupational health policies. Proper training and education should:

- Be for all staff. More than one curriculum will be necessary to address the diverse needs and skills of the many staff groups (e.g., waste workers, nurses, doctors, administrators).
- Involve waste workers and all other staff groups in development of training programme and to provide feedback in order to modify and improve trainings.
- Include pictures, posters in the worksite to reinforce safe practices.
- Provide concrete links between actions of staff and their respective effects on waste workers "downstream".
- Contain hands on experience and active learning exercises to cement skills through practice and creative thinking. Props and real life examples are effective. Workers can e.g. walk through a ward and be asked to identify the different waste types and to evaluate management practices.
- Assure that the curriculum and training tools address the needs of staff that are illiterate or speak other languages.

Create a system that assures prompt training of new staff members and routine training of all staff with written documentation including staff attendance, outline of material presented, note skills demonstrated, and date of training.

Hierarchy of Controls

While creating policies to protect waste workers, it is critical to keep in mind that certain controls are consistently more effective than others in protecting waste workers. This is referred to as the "Hierarchy of Controls". Below you will find the

Hierarchy of Controls from most to least effective in protecting waste workers. Ideally policy makers create and enforce the more effective controls whenever possible.

Most Effective

Elimination of Hazard: The best way for a health care facility to reduce risks or exposures is to eliminate the hazardous and toxic products in use. This includes using non-toxic products for cleaning, needleless injection and IV systems, and retractable needles.

Substitution for Less Hazardous Treatment Options: The occupational risks of waste treatment can be minimized by using autoclaves instead of incinerators or chemical disinfectants to disinfect health care waste.

Engineering Controls Use Technology to Filter Out or Remove the Hazard: Examples include ventilation systems that filter out airborne bacteria and viruses such as tuberculosis, needles that retract, sheathe or blunt immediately after use, and lifting devices.

Administrative Controls: Administrative controls are policies that aim to limit exposure of waste workers to the hazard. Examples include comprehensive immunization programmes for all waste workers against tetanus and hepatitis B, removal of all unsafe devices, consistent training of proper handling, transporting and treatment of health care waste, and a waste management committee.

Work Practice Controls: Work practice controls are policies that dictate activities by waste workers and other staff that protect the waste workers. Examples include not overfilling sharp and other waste containers, refusing to handle waste if sharps are sticking out, placing disposal bins at levels that can safely be emptied, and depositing sharps in proper containers immediately after use.

Personal Protective Equipment (PPE): PPE provides barriers and filters between the worker and the hazard. Examples include masks to prevent airborne exposure, eye goggles and gloves to provide a barrier to blood or chemical splashes and gowns.

Least Effective

3.5.1 Specific Guidance and Policy

To ensure safety of the health care workers specific guidelines and policies have to be framed by the health care facilities. Some of the specific guidelines are:

- Universal precautions need to be taken by all health care workers while handling and disposing waste. Since medical and other staff does not always know if a patient has a blood borne disease, all blood and body fluids need to be treated as if they contained these pathogens. This principle of treating all blood and body fluids as potentially infectious is called Universal Precautions.
- Heavy duty puncture resistant gloves must be worn when handling biohazards and chemical wastes.
- Hand Washing: It is important to remember that gloves are not a substitute for proper hand washing. Wash hands with soap and water after handling wastes. Water and soap should be available wherever wastes are handled or stored.
- Masks: Fluid impermeable masks should be worn when there is a possibility of splash from handling wastes. Respirators or masks with protection from bio-aerosols such as tuberculosis should be worn when transporting infectious waste.

- Prevention is cost effective:
  - Properly label all health care wastes to minimize confusion
  - Establish strict protocols for handling radioactive waste to allow for half life/ decay time prior to handling waste
  - Establish procedures for disposing of pharmaceutical wastes, especially chemotherapy.
- Sharps should be segregated at source and placed in a puncture proof container immediately after use.
- Overall sharps containers are hazards. Replace sharps containers at fill line or when 2/3 full. If the sharps container is at fill point, **do not** place sharps in the container but instead contact management for replacement. If the sharps container is filled to the top or higher, contact management and do not handle the sharps.
- If you see sharps sticking out of a trash bag, do not pick up the bag. Report to supervision for safe handling.
- Never put your hand inside any container; either dump the contents of container into a larger container and remove the bag.
- Never put your hand in area that you cannot see.
- Use trolley or wheeled carts to transport waste instead of bare hands.
- Immediately report a sharps prick to management.
- Never recap needles.
- Sharps should be placed in containers at the time of use to reduce stick injury. If you are faced with a pile of sharps on a tray or otherwise outside a rigid container, contact management. Extreme care needs to be taken and thongs or other objects should be used in such immediate cases. However, policies need to be implemented that eliminate such practices.

Identification and Management of Health Care Waste Types

Bio-hazardous Wastes Including Sharps

Bio-hazardous or infectious waste has a potential to infect a worker with a harmful biological agent, usually a virus such as hepatitis B or C, HIV, and tuberculosis. These agents cannot live outside the human body for long, but during the time that they are still alive, the pathogens can cause disease if it is spread or transmitted.

Bio-hazardous waste is created when any item used in medical care becomes contaminated, or covered with any bio-hazardous material such as blood, body fluids or tissue. Any type of item could become bio-hazardous waste once it is contaminated. Contamination occurs both during routine procedures such as vaccinations or blood draws, or in emergency situations, such as cleaning up a blood spill. While contaminated waste is potentially infectious, only a small percentage of the wastes generated at a health care facility may contain these harmful disease causing agents, or pathogens. Body fluids, tissues and blood are also considered bio-hazardous waste.

Health care facilities should separately collect, transport and treat bio-hazardous waste and sharps. Extreme care and caution needs to be taken with sharps waste management. Although a very small portion of the waste stream (about one per cent), sharps is responsible for majority of disease transmission due to health care waste.

Chemical Wastes Including Disinfectants Used for Waste Treatment

Disinfectants are used in the routine cleaning, spill clean up for the actual disinfection of bio-hazardous waste. These materials are effective disinfectants and kill most pathogens. These chemicals are usually corrosive or toxic to humans and these precautions should be taken when using these types of materials, because they are corrosive to the eyes and respiratory system. Some of the chemicals are:

- Glutaraldehyde
- Sodium Hypochlorite (bleach)
- Per Acetic Acid
- Hydrogen Peroxide

Care should be taken when handling these materials, and gloves and eye protection are critical in preventing a splash.

Special Chemicals: Chemotherapy and Hazardous Drugs, Mercury

Chemotherapy drugs are used to kill cancer cells in humans, and can be very toxic to the healthy cells of other people if they come into contact with waste chemotherapy drugs. Mercury is a chemical that accumulates in the body and poisons the central nervous system.

You have already read in detail about use, disposal and alternatives to mercury in Course 1 (Unit 1, Block 3, BHM-001).

Radioactive Wastes

Radioactive materials are sometimes used in the diagnosis or treatment of some diseases. While a short-term exposure to a radioactive material can save a person's life, a long-term exposure can cause serious harm to a person. Capturing and keeping the radioactive materials where they are used, and storing them in a secure place at the health care facility is critical in keeping them from entering into the environment, where they might expose people to harmful doses of radioactivity. Radioactive materials can be stored until the radioactivity decays, or goes away. When no radioactivity is detected, the item can be disposed off as solid waste.

Waste Segregation and Labeling

Health care wastes need to be properly separated at the source where they are generated.

Wastes need to be properly segregated in order to:

- Maximize safe handling for waste handlers both in the health care facility or in an off-site facility.
- Minimize potential harm to the environment.
- Avoid the dangers of combining wastes.
- Contain costs of disposal.

Segregate and Label

- Sharps in puncture containers immediately after use.
- Health care waste contaminated with blood and body fluids.
- Chemical wastes from laboratories that are corrosive, toxic, reactive or ignitable. These chemical wastes need to be properly stored in secure settings to protect the general public and rag pickers from exposure.

The use of coloured bag systems for collecting the waste helps label the waste. Yellow or red are often used for biohazard waste and green/black/clear bags are used for regular refuse. Yellow/purple/black are often used for hazardous chemical waste.

Symbols that can be used to label the waste include:

- Universal biohazard waste symbol
- Universal radioactive waste symbol
- Skull and crossbones to designate something as toxic to health

Adequate and Secure Storage for Waste

It is very important that health care wastes be secure to protect the public. This means secure from unauthorized personnel and from random access from animals, such as dogs, cats, birds, etc. Used sharps must be kept secure to prevent anyone from purposely or unintentionally recovering the used needles and reusing them. Body parts and other pathological waste must be kept secure until disposal either through cremation or burial. In some cases it is useful to have the health care waste refrigerated if the pick up time is going to be delayed. Waste should not be stored with other items such as food and refrigeration, if used, should be dedicated to waste storage only.

Secure storage includes properly locating waste storage areas, installing warning signs, fencing off storage areas, and providing locks to doors. For facilities located adjacent to rivers or other bodies of water relied on by the community, this need for careful and secure storage is enhanced, as the risk of contaminating a valuable community resource increases.

Secure storage also means careful evaluation of the types of wastes being stored and the compatibility of wastes being stored. It is ideal to store the biohazard waste separately from the chemical and radioactive wastes.

Factors to be Considered in Prevention

Overview of a safe, integrated waste management system:

- Health care wastes need to be managed from point of generation (patient's bedside or physician's office) to point of disposal including the following components:
  - A labeling system with signs,
  - Leak proof and secure containers,
  - Equipment for transporting waste, and
  - A designated plan for secure disposal.
- Instruct staff regarding how to manage the types of waste they generate, from bandages, syringes, needles and tubing to a variety of chemicals and even radioactive materials.
- Workers using hazardous materials including those generating wastes, collecting and managing wastes need appropriate protection from immunizations to personal protective gear and education.
- Secure methods of transport and adequate equipment to allow waste collectors to safely collect and transfer the wastes are essential.
- Finally, being able to send all of the waste streams out of the facility for final treatment and disposal is dependent on a seamless interface with a municipal or private waste management system that coordinates waste collection and disposal for the community.

The steps listed above provide a "system" for safely managing the wastes. Key factors include worker awareness of hazards, education and the ability to protect themselves as an integral part of carrying out their jobs.

Wastes Treatment and Disposal

Incineration causes environmental hazards due to burning of waste. While other technologies may not burn the waste to destroy it, they may use corrosive chemicals or very hot steam to disinfect waste. Disinfecting chemicals such as bleach require safe handling and disposal. Steam needs to be handled with respect as well since a waste handler can receive serious burns from steam under high pressure. Procedures need to be defined to control environment and occupational hazard due to the treatment technologies.

When wastes are treated by disinfection or sterilization, they can usually be disposed off as solid waste. It is important that the operators of the receiving landfill or the facility understands the process in which the waste was treated and take adequate precautions.

3.6 PATIENT SAFETY

Health care and health care waste, associated infection are a major issue in terms of patient safety. Indeed the way health care wastes are managed at a particular facility can affect the health of patients and complicate a significant proportion of patient care deliveries. Infections add to the burden of resource use, promote resistance to antibiotics, and contribute to unexpected patient deaths. Hand hygiene, a very simple action, results in reduced infection rates and enhanced patient safety across all settings, from advanced health care systems to local dispensaries in developing countries. Hand hygiene remains the primary measure to reduce infection and the spread of antimicrobial resistance, but health care workers adherence to good practice is extremely critical. Adherence must be multimodal and include staff education and motivation, the use of performance indicators, and a strong commitment by stakeholders (e.g., hospital management, community leaders).

3.6.1 World Alliance for Patient Safety

WHO launched a World Alliance for Patient Safety on the 27th October, 2004. The fundamental purpose of the Alliance is to facilitate the development of patient safety policy and practice it in all WHO member states. Each year the Alliance will deliver a number of work programmes covering systemic and technical aspects of patient safety. A key programme for the Alliance is the delivery of a "Global Patient Safety Challenge". The topic chosen for the first challenge is health care associated infections and the title of the challenge is "Clean Care is Safer Care". The intention will be to embrace a number of existing WHO strategies/guidelines in the areas of infection prevention, blood safety, procedure related safety, waste management, etc., and to develop WHO guidelines for hand hygiene. Together, these strategies will be supported internationally to encourage their use by all countries. In addition, the implementation of the strategies will be closely monitored in six districts, one in each WHO region, to assess their impact.

Objectives for 2005

- Designate hand hygiene as a patient safety priority worldwide.
- Initiate clinical governance for hand hygiene promotion at all levels of health care settings.
- Develop comprehensive hand hygiene promotion guidelines that include staff education and motivation to promote behavioural modification, facilitate system changes, highlight the use of performance indicators, and stimulate stakeholder support.
- Issue recommendations and develop instruments for continuous, long-term monitoring and feedback mechanisms, as well as outcome measures, to monitor progress.

Implementation strategies include:

- Behavioural change
- Education/Training
- Process indicators
- Outcome indicators
- Marketing
- Advocacy
- Regulation
- Economical aspects/Cost benefit analysis
- Health care setting management

3.6.2 Model Injection Centre (MIC)

World Health Organization (WHO) and Safe Injection Global Network estimates that over 16 billion injections are administered each year of which 4.2 billion are given in India alone. A recent study conducted by India Clen/World Bank also quotes that two out of three injections given are unsafe posing serious health hazards to recipients, health workers and the community.

A study was conducted by Program for Appropriate Technology in Health (PATH) and Academy for Nursing Studies at Hyderabad, Andhra Pradesh, India on injection practices in 2003-2004. This study indicated a need for developing a communications strategy to address the stakeholders, the patient, the health care worker and the community. The importance of patient safety and injection safety. PATH in collaboration with Niloufer Hospital attached to Osmania Medical College, Hyderabad set up a center called Model Injection Centre (MIC) at Niloufer Hospital, Hyderabad. The concept of safe injections is practiced on the clients visiting this institution and demonstrated to all those health providers who visit the MIC.

This center caters to the training needs of both the private and public sector and will build awareness among the professionals, private practitioners, medical, nursing and paramedical students. This center addresses all three components of injection safety issues:

- **Safe to the recipient:** The injection, administered to the client, should be safe. At MIC safe injection practices are adhered to and all immunization injections are given by Auto-Disable (AD) syringes and curative injections by sterile disposable injections.
- **Safe to the health staff:** Needle stick injury is the commonest form of injury to the health worker mainly due to recapping. This is addressed by training and on job correction. Minimizing injections and promotion of safe disposal of used syringes will indirectly contribute to health worker safety.
- **Safe to community:** Unsafe disposal techniques cause risk to the community and so, at the MIC used injections are mutilated beyond use, segregated into metal and plastic, disinfected and disposed off separately as per the bio-medical waste management rules.

The following outline is followed in the MIC for patient flow. This is adopted from the outreach immunization clinic model. A dedicated coordinator is appointed by the institution to assist in the whole process till this becomes an integral part of the Niloufer Institution. Simultaneously a dedicated nurse from the staff of Niloufer is appointed who will slowly over a period of six months take over from the coordinator.

The model injection center, demonstrates a clean injection area/zone. The patient's movements are guided through entrance to pass through the immunization room, antenatal/curative sections and will pass through the counseling table where he/she will be explained about what precautions to take, when to come next, importance of avoiding injections and demanding oral medication and so on before exit. Some take away messages are posted all along the client flow and a provision of take home pamphlets for general public also is available. The MIC offers an opportunity to observe safe injections being practiced.

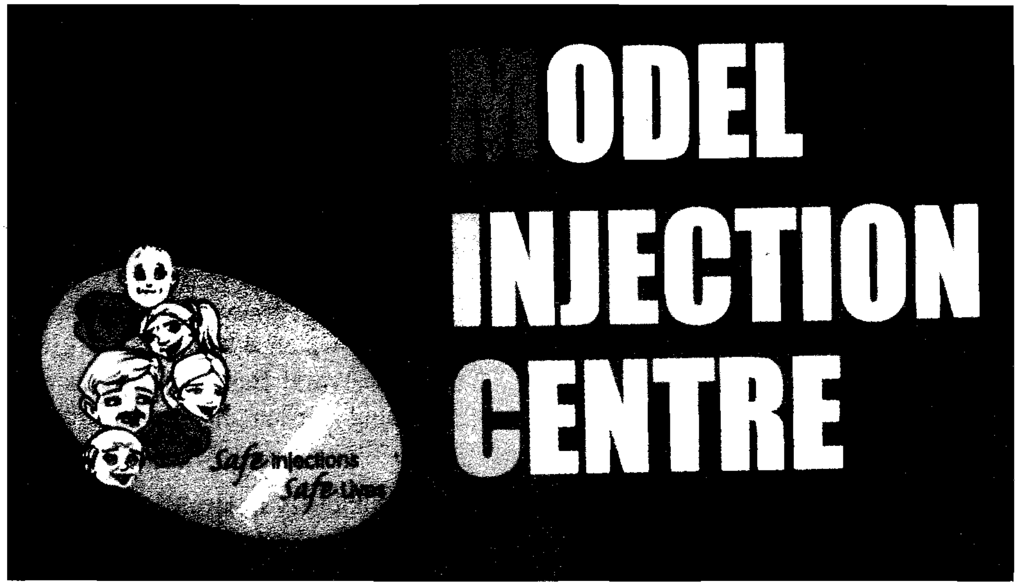

Fig. 3.1: Poster of Model Injection Centre

The following are the highlights of the MIC:

a) Clean area as a safe injection zone/area

b) Use of sterile injection equipment

c) Patient counselling

d) Safe administration practices

e) Appropriate containment of sharps

f) Safe disposals of sharps

g) Promotion of rational injection use

Other highlights are:

Training for students-doctors and nurses: Demonstration for members of the professional bodies like Indian Medical Association, Indian Academy of Pediatrics, Trained Nurses Association of India (TNAI), A.P. Nursing Homes Association and private practitioners etc. Trained health personnel at the hospital will hold demonstration and training once a week, on prior appointment coordinated through PATH or Model Injection Centre coordinator.

Promotion of rational injection prescription with emphasis on oral medication: If the oral alternatives are available, those should precede the injections. Through MIC, Niloufer Hospital attempts to promote rational injections and sustainable it with oral alternatives to minimize injections.

Build awareness among the general people about safe injections: MIC will play a lead role in behaviour change related to injection safety. General public will be exposed to the need of oral alternatives; benefits and dangers arising out of injections and thereby need for minimizing injections through visual communication package on a video. Apart from posters and pamphlets, take away materials are available for people, for reading and information sharing. This will lead to minimizing the number of injections and related problems.

Regular trainings to the professionals: MIC plans to train the staff to hospital initially in batches so that the institute practices safe injections. Later it has planned training and demonstrations to nursing, medical and paramedical professionals.

Protecting Patients from Toxins in Plastic

Are you aware of health hazards posed by DEHP?

By Susan Wilburn, Ann Melamed and Barbara Sattler

Specialists for Occupational Safety and Health, American Nurses Association and Health Care Without Harm;

American Journal of Nursing, April 2002, Volume 102, Issue 4

The mother of a baby in my care asked for phthalate-free care. What does this mean? Di (2-ethylhexyl) phthalate or DEHP—is not yet a household word among nurses, but it can be found in many health care products, including IV tubing, IV bags, and feeding tubes. A member of a group of chemicals known collectively as phthalates, DEHP is a chemical compound added to polyvinyl chloride (PVC) plastic during the manufacturing process to make the final product flexible, strong, and moldable into various shapes and designs. By weight, DEHP makes up 20 to 40 per cent of PVC products on average. DEHP poses risks to health and human development because it does not bind with plastic, so it can leach out of PVC medical products during medical procedures. During medical interventions such as hemodialysis or Extra Corporeal Membrane Oxygenation (ECMO), that require long-term exposure to N lines DEHP exposure is significantly increased. Pediatric and in-utero exposures are of the greatest concern. The multiple, relatively high-level exposures that can occur in the neonatal intensive care unit are potentially at or in excess of levels equivalent to those known to cause adverse health effects in relevant animal studies.

Adverse effects in exposed rats have included suppressed or delayed ovulations, suppressed testradiol production, polycystic ovaries, reduced kidney function, kidney atrophy, reduced liver function, respiratory distress, and decreases in heart rate and blood pressure, as well as testicular damage in their male offspring. While there is an absence of data on effects in humans, the nature of the effects on animals with systems similar to human systems has led the Food and Drug Administration (FDA) and the U.S. National Toxicology Programme to conclude that humans face similar risks from DEHP exposure. In January 2002, Health Canada, the national health agency (similar to the U.S. Department of Health and Human Services), reiterated these concerns in a report from its expert advisory panel on DEHP in medical devices. The Health Canada report calls for the substitution of less toxic, non-DEHP containing devices in the treatment of pregnant women, breast-feeding mothers, infants, prepubescent males, and patients undergoing cardiac bypass hemodialysis or heart transplant surgery. Specifically, the report states "Alternate measures are immediately justifiable and should be introduced as quickly as possible to protect those subpopulations at greatest risk, namely, the fetus, newborns, infants and your children receiving transfusions, car-diopulmonary bypass, exchange transfusion, hemodialysis, TPN (total parenteral nutrition) and lipophilic drug formulations."

As frontline care providers, nurses should take the following steps to learn more about the risks of DEHP and to protect their patients, substitute non-DEHP and non-PVC products when caring for vulnerable populations. (Go to www.sustainablehospitals.org and www.noharm.org/library/docs/Going_Green_3-5_PVC_Alternatives.pdf for guidance).

- Read package inserts—if the product calls for non-DEHP tubing or is lipophilic, which increases its leaching potential, use administration sets made from alternative materials such as polypropylene.
- Urge the FDA to require labeling of products that contain DEHP. Work with your institution's purchasing department to obtain samples of alternative products and get involved in training colleagues when a new product is implemented.
- Volunteer to work in your unit on clinical trials of alternatives to PVC-containing products. Report adverse reactions to DEHP to the FDA Med Watch programme (go to www.fda.gov/medwatch). Learn more about environmentally preferable products. A good place to start is the web site of Health Care Without Harm (go to www.noharm.org).

Check Your Progress 2

1) What are the symbols used while handling different waste types?

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2) What are the objectives for patient safety by WHO for year 2005?

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3) What are the highlights of the Model Injection Centre established by PATH?

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3.7 LET US SUM UP

In this unit we have discussed the issues of occupational and patient safety in health care facilities. You have learnt that the health care waste workers are exposed to different risks in the health care facility, these risks need to be addressed and policies spelled out in the health care facility to minimize and overcome these risks. Along with addressing the occupational risk it is equally important to address the issue of patient safety and provide simple but viable solutions to ensure the safety of the patients and the community at large.

3.8 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) The risks associated due to health care waste are risk of exposure to blood borne pathogens (biological hazard), skin puncture, muscle strain (physical hazard), splash/ contact with waste chemicals (chemical exposure) and potentially radioactive exposure.

2) The occupational risks due to health care waste are:

- Needle stick injuries leading to hepatitis B and with HIV and tetanus infection;
- Back and joint injuries from lifting heavy waste-filled containers and driving heavy landfill and loading equipment;
- Respiratory illness from ingesting particulates, bio-aerosols, and volatile organics during waste collection and from working in smoky and dusty conditions at open dumps and incineration site;
- Infections from direct contact with contaminated material, dog and rodent bites, or eating of waste-fed animals;
- Injuries at dumps due to surface subsidence, underground fires, and slides;
- Headaches and nausea from anoxic conditions where disposal sites have high methane, carbon dioxide, and carbon monoxide concentrations; and
- Lead poisoning from burning of materials with lead-containing batteries, paints and solders.

Check Your Progress 2

1) Some of the symbols used while handling waste are:

- Universal biohazard waste symbol
- Universal radioactive waste symbol
- Skull and crossbones to designate something as toxic to health

2) The objectives for patient safety as defined by WHO for the year 2005 are:

- Designate hand hygiene as a patient safety priority worldwide.
- Initiate clinical governance for hand hygiene promotion at all levels of health care settings.
- Develop comprehensive hand hygiene promotion guidelines that include staff education and motivation to promote behavioural modification, facilitate system changes, highlight the use of performance indicators, and stimulate stakeholder support.
- Issue recommendations and develop instruments for continuous, long-term monitoring and feedback mechanisms, as well as outcome measures, to monitor progress.

3) The following are the highlights of the Model Injection Centre:

a) Clean area as a safe injection zone/area

b) Use of sterile injection equipment

c) Patient counselling

d) Safe administration practices

e) Appropriate containment of sharps

f) Safe disposals of sharps

g) Promotion of rational injection use.

3.9 FURTHER READINGS

Mc. Rae. Glenn and Mahamodi, Firuzeh, *Waste Worker Safety: Preventing Health Risks from Handling and Treating Health Care Waste* (Draft Report), Health Care Without Harm, 2005.

WHO, "Global Patient Safety Challenge, 2005-2006: Clean Care in Safer Care", *World Alliance for Patient Safety.* World Health Organization, Geneva.

World Alliance for Patient Safety, Forward Programme 2005, World Health Organization, Geneva, www.who.int/patientsafety

WORLD HEALTH ORGANIZATION

Infection control

AIDE-MEMOIRE

For infection prevention and control in a health care facility

Health care-associated infections lead to death, disability and excess medical costs. Introduction of new technologies, in the absence of infrastructure to use them safely, may lead to adverse events. Infection prevention and control maximize patient outcomes and are part of the government's responsibility to provide effective, efficient and quality health services. They must be achieved through collaboration with the public and private sectors. Health care facilities must execute infection prevention and control policies supported by institutional management. An overall approach to an infection prevention and control policy at the health care facility level is based upon:

- Management;
- Information, Education and Communication (IEC);
- Continuous availability of essential equipment and supplies;
- Surveillance.

Examples of core infection prevention and control interventions are listed overleaf. In addition, specific activities include:

- Health care worker protection;
- Isolation protocols for specific infectious diseases (e.g., tuberculosis, SARS) and high-risk settings (e.g., dialysis);
- Rational use of anti-microbials;
- Safe and appropriate use of injections and infusions;
- Safe and appropriate use of blood and blood products;
- Hospital sanitation.

Words of advice

- **Conduct an initial assessment**
- **Establish an infection prevention and control committee coordinated by the infection prevention and control officer**
- **Formulate an Action Plan, with costing, budgeting and financing**
- **Develop an IEC strategy for health care workers and strengthen supervision**
- **Ensure the continuous availability of supplies and equipment for patient care management**
- **Surveillance**
- **Confirm value through monitoring, providing data and measuring the impact of interventions**

☑ Checklist

Management

- ☐ Infection prevention and control policy, with committee and officer
- ☐ Initial infection control assessment
- ☐ Assignment of responsibilities
- ☐ Choice of appropriate technologies
- ☐ Costing, budgeting and financing
- ☐ Quality standards
- ☐ Monitoring and supervision
- ☐ Performance assessment

Information, Education and Communication (IEC)

- ☐ Adoption of best practices standards
- ☐ Standard precautions
- ☐ Pre-service training
- ☐ In-service training

Equipment and supply

- ☐ Establishment of a list of essential infection control equipment and supplies
- ☐ Forecasting of needs
- ☐ Costing, budgeting and financing
- ☐ Procurement
- ☐ Inventory control and stock management
- ☐ Maintenance

Surveillance

- ☐ Surveillance
- ☐ Feedback
- ☐ Outbreak investigation
- ☐ Evaluation using indicators of:
  - Structure
  - Process (practices)
  - Outcomes (incidence of infections)

Core infection prevention and control interventions for health care facilities at a glance

Specific interventions	*Target groups*	*Equipment and supply needs* *	*Critical process indicators for monitoring*
Hand hygiene	▪ All health care workers † ▪ Visitors ▪ Patients	▪ Clean running water ▪ Soap (mounted preferable) ▪ Sinks or basins ▪ Towels ▪ Alcohol-based solutions	▪ Proportion of staff observed performing hand hygiene before attending patients
Personal protective equipment	▪ All health care workers †	▪ Gloves ▪ Gowns	▪ Proportion of staff observed wearing gloves when exposure to blood or body fluids is anticipated
Isolation precautions	▪ Nurses ▪ Physicians ▪ Nursing aids ▪ Other	▪ Gloves ▪ Gowns ▪ Masks ▪ Eye protection	▪ Average time between admission and isolation for tuberculosis patients
Aseptic technique	▪ Nurses ▪ Physicians ▪ Laboratory technicians ▪ Dental surgeons	▪ Antiseptics ▪ Sterile gloves ▪ Sterile devices and instruments ▪ Sterile barrier devices	▪ Proportion of intravenous lines inserted using aseptic technique
Cleaning and disinfection	▪ Nurses ▪ Nursing aids ▪ Housekeeping staff ▪ Laboratory staff	▪ Cleaning fluids ▪ Cleaning equipment ▪ Disinfectant	▪ Proportion of rooms appropriately disinfected after patients' discharge
Sterilization	▪ Sterilization staff ▪ Nurses ▪ Laboratory technicians ▪ Dental surgeons	▪ Autoclaves and steam sterilizers ▪ Test strips ▪ Chemicals	▪ Proportion of sterilized devices whose sterility is documented with test strips
Waste management	▪ Health care workers ▪ Waste handlers ▪ Logisticians	▪ Sharps boxes and other collection containers ▪ Storage space and container for interim storage ▪ Final disposal options ▪ Personal protection equipment for waste handlers	▪ Presence of health care waste in the surroundings of the health care facility
Antibiotic use protocol	▪ Physicians	▪ Essential list of antibiotics	▪ Proportion of prescriptions including an antibiotic
Immunization and exposure management	▪ All health care workers †	▪ Hepatitis B vaccine and other appropriate vaccines	▪ Three-dose hepatitis B vaccine coverage among nurses, physicians and laboratory technicians

* *Key indicator: Proportion of essential supplies stocked out.*
† *Include nursing staff, physicians, dental staff, laboratory staff, housekeeping staff, waste management staff and morgue staff.*

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UNIT 4 SUCCESS STORIES

Structure

4.0 OBJECTIVES

After going through this unit, you will be able to:

- elabarate waste management systems in different health care facilities; and
- role of different stakeholders in raising awareness and providing scientific solutions towards sound health care waste management systems.

4.1 INTRODUCTION

After having learnt about different aspects of health care waste management, now we will discuss initiatives being taken by different health care institutions, governments, international organizations and non-governmental organizations towards building good workable systems of waste management. Such initiatives are models for others who are working towards establishing health care waste management systems. Through this unit we present to you such examples, which can be modified and replicated for establishing a sound health care waste management system in different health care facilities.

4.2 ST. STEPHEN'S HOSPITAL, DELHI

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Pediatric Consultant and Nodal Officer for Bio-medical Waste Management
St. Stephens Hospital, Delhi

St. Stephen's Hospital is a 595 bedded multi-specialty tertiary care hospital located in old Delhi serving to all sections of society. Established in 1885, it is the oldest hospital of Delhi and today it is the largest hospital in the voluntary sector.

4.2.1 Health Care Waste Management

Health care waste, being biohazardous, has a higher potential for infection and injury than any other kind of waste. Proper disposal of waste entails development of cost effective methods that are applicable to large, medium and small scale settings in India.

This success story gives an outline of management of various streams of waste in a large hospital setting. The evolution of improved waste management at St Stephen's Hospital will be discussed. The key factors in improvement of the standards were commitment from the management and a regularly trained and disciplined workforce.

Important features of the programme are:

- Good segregation at source.
- Mutilation of all potentially reusable items such as syringes and needles at site of generation by simple technology such as syringe and needle destroyers.
- All potentially reusable and contaminated plastic items are disinfected by chemical disinfectants.
- Centralized facilities are used for waste that needs incineration.
- Separate housekeeping staff designated for infectious waste disposal.

In India, concern for medical waste was an outcome of judicial and NGO response. A step forward has been made in India in the field of medical waste management. But there remains much scope for improvement in this field. This is of importance in India for the following reasons:

1) The prevalence of blood borne diseases such as HIV, hepatitis C and B is relatively high.
2) A problem unique to developing countries such as India is that medical waste is a source of livelihood for many of the poor, and they are at risk as they separate the waste manually.
3) The illegitimate reuse of medical items needs to be stopped.
4) Waste management requires judicious use of scant resources.
5) Environmental pollution from indiscriminate disposal of medical wastes must be reduced.
6) Good waste management will reduce infection both in the hospital and to the public.

Initiatives taken at St. Stephen's Hospital

Till 1995, most of the medical waste was thrown in the municipal dump in front of the hospital. Rag pickers could be seen sifting through this waste. Certain waste such as placental tissues and other body parts were burned in an open area in the hospital premises. In 1995, the hospital acquired a single chambered incinerator. At this stage there was no segregation of hospital waste and most of the waste continued to be thrown in the municipal dump while certain waste from the operation theatres and the labour rooms were incinerated. In 1997, to keep up with legal requirements, the hospital bought a double-chambered incinerator.

To have an effective waste management system in a hospital requires a leader committed to this. It also requires investment in both manpower and physical resources.

In January 1999, the Deputy Director established the Hospital Infection Control Committee. Waste management comes under the purview of this Committee. It is comprised of representatives from the Hospital Management, Engineering, Laboratory, Nursing, Hospital Consultants and Housekeeping Services. This committee meets monthly; policies are formulated and problems discussed.

A Nodal Officer for bio-medical waste management was appointed as per the Delhi Pollution Control Committee rules and a full time Infection Control Nurse was appointed. This core group was made responsible for active training and ensuring implementation of policies and enforcement of waste disposal practices within the hospital. Also there is an audit of waste disposal practices.

Training

To implement an effective waste management system, it requires the participation of every employee in the institution. Regular training and auditing is necessary. It is essential to see that supplies are available and problems are sorted out as they arise.

There is regular training carried out for all staff at St. Stephen's Hospital. Training sessions for Nursing and Housekeeping is through interactive modes of plays and skits. To ensure the nurses learn about bio-medical waste management from the beginning of their carrier, waste management has also been incorporated in the nursing school curriculum.

Table 4.1: Different Categories and Number of Staff in St. Stephen's Hospital

Category of staff	Number of staff
Doctors	261
Staff Nurses	370
Paramedics	120
Housekeeping	293
Student Nurses	150
Total	**1194**

Some of the topics covered during the training are as follows:

- Segregation of waste at source
- Management of blood spills
- Proper use of chemicals for waste management
- Occupational Health and Safety

Segregation

Good segregation ensures that only that part of health care waste which may give rise to a potential risk hazard receives special treatment. This results in economical savings to the hospital. It also prevents chlorinated plastics from being incinerated and releasing toxic dioxins and furans into the atmosphere.

Waste is segregated at source of generation by nurses, doctors and technicians.

There are reusable plastic buckets lined with colour-coded bags at different work stations.

- **Yellow bags** are for the incinerable infectious waste.
- **Blue bags** are for the infectious plastic waste. Chlorinated plastics cannot be incinerated; they are disinfected with chemical treatment or autoclaved. All these items are mutilated after use before being disinfected.
- **White bags** are for uninfected plastic waste such IV bottles, which are cut using a scissors and are sold for recycling.
- **Black bags** contain items similar to household waste and go to the municipal dump.
- **Sharps** are mutilated in the needle-tip and syringe destroyer. The metal component is stored and transported in puncture proof container while the syringe is mutilated and disinfected with chemical disinfectant and transported in blue bags.
- **Cardboard cartons** are used to transport broken ampoules and vials.

Transport

Infectious waste: There is a separate team of four housekeeping staff to transport infectious waste from all the areas in the hospital to the waste staging area. The staff from the centralized facility clear this waste daily.

Noninfectious waste: Black bags and white bags containing non-infectious waste are transported by the ward boys.

Centralized Agency

The infectious waste (Blue and Yellow bags) are collected from the hospital waste staging area daily by agents from the centralized facility.

Recycling Health Care Waste

The hospital invites closed tenders and sells items to the appropriate bidder.

Non-patient contact sources of waste are scrap metal aluminum cans, cardboard and packaging material, plastic and glass intravenous bottles. Certain other items, which could be infectious medical waste such as syringes, are disinfected by chemical means or the autoclave and mutilated prior to being sold for recycling.

Every 15 days the items are cleared. Four internal auditors oversee the weighing and sale.

The health care waste which belongs to the household general category is cleared by an agency, which clears this waste four times in the week and transports it to the municipal dump.

Conclusion

Good waste management requires a leadership committed to it. Resources and manpower have to be allocated for this. This is an evolving field in India and good waste management in hospitals will improve occupational health and safety, reduce infection in patients and the community and reduce environmental pollution. It is important for all health care establishments to establish good waste management practices.

4.3 SUNDARAM MEDICAL FOUNDATION, DR. RANGARAJAN MEMORIAL HOSPITAL, CHENNAI

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Sundaram Medical Foundation, Dr Rangarajan Memorial Hospital, Chennai

Sundaram Medical Foundation, Dr. Rangarajan Memorial Hospital is a 150 bed, private hospital located in Chennai, Tamil Nadu. This "not for profit" organization is established to provide quality health care, which is cost-effective and community-centered, mainly for the lower and middle-income group of people in the community.

4.3.1 Health Care Waste Management

The concept of health care waste management at Sundaram Medical Foundation, started off in a small way in the year 1996. The Hospital Infection Control Committee realized the importance of proper collection, segregation, transportation and disposal of waste. The hospital followed a system wherein the used needles were collected in puncture proof containers, needle burners were used in certain wards along with disinfection in certain other wards. Once the sharps disposal had been standardized, the Hospital Infection Control Committee focused its attention on the proper segregation and disposal of the other infectious/non-infectious waste. Difficulties were noted in implementing a uniform system throughout the hospital, for the different types of waste generated. At this juncture, the need for thorough training and implementation of a sound system in this area was strongly felt by the hospital. The hospital initiated a system of health care waste management in collaboration with an NGO Srishti (Toxics Link) one of the pioneers in the field of health care waste management. During the process of implementation waste audit was carried to assess the needs of the hospital. Based on audit the procurements of waste treating equipment, manpower required for running the system, training and monitoring schedules were prepared. Now the hospital with dedicated manpower and committed administration, adequate waste treatment equipment, regular training of all health care functionaries and routine

Fig. 4.1: Segregation of waste

monitoring of the system has a well established health care waste management system.

The following system of health care waste management has been established in the hospital:

Segregation at Source

1) Each nursing station is provided with five pedal bins and a large plastic container.
   - Three medium sized bins are lined with different colour coded bags:
     - General waste are collected in the bin with black lining
     - Infected cotton wastes are collected in the bin with yellow lining
     - Pathological tissues/body parts are packed in double yellow bags
     - Infected plastic items are collected in bins with red lining
   - Two small sized pedal bins one for metal sharps and the other for broken glass and ampoules, have been provided with inner thick, puncture proof containers
   - One large plastic drum is used for collecting used IV bottles.
2) In the wards, individual patient beds are provided with only one medium sized bin with black cover for general waste disposal. In case of patients with open wounds or those who require surgical dressing another bin with yellow cover is provided for disposing infected cotton waste.

Fig. 4.2: General waste bin at the patient's bedside

3) In Emergency Room, ICU and IMCU individual patient beds are provided with three medium sized pedal bins with colour codings for easy and quick disposal of infectious and general waste.

Collection and Transportation

Collection and transportation of waste from the point of generation to final disposal within the health care facility is carried by well-trained personnel from the housekeeping

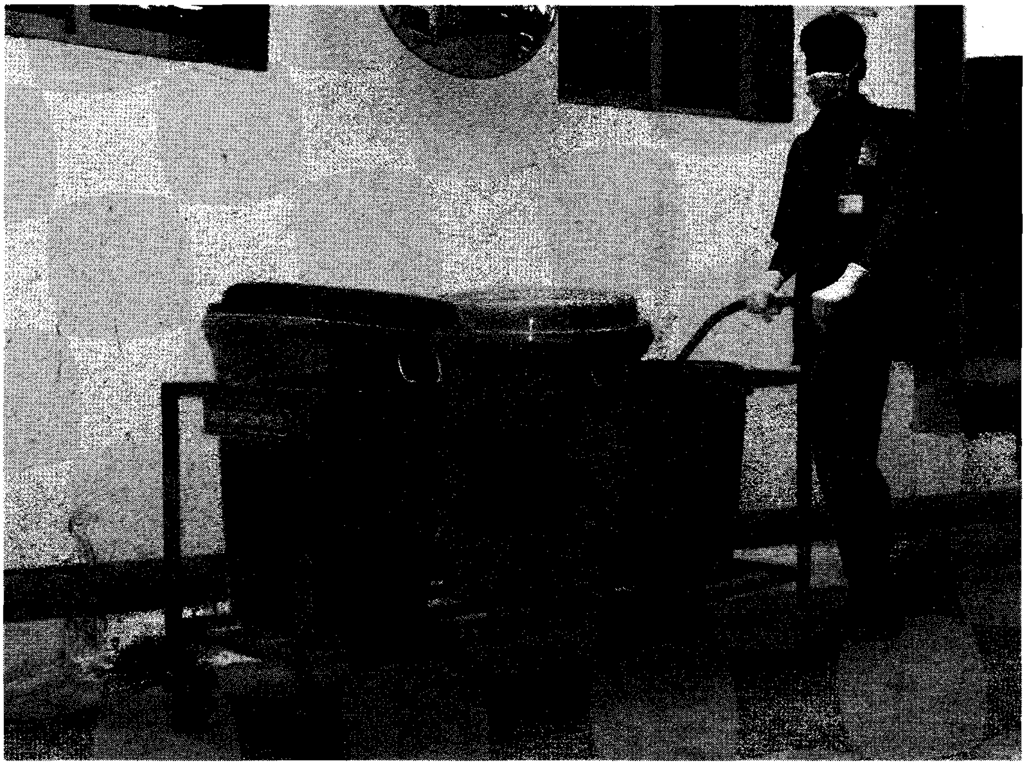

Fig. 4.3: Transportation of waste in the hospital

department. Three housekeeping staff have been exclusively trained in the collection, transportation and final disposal of waste. Waste is collected twice a day in the wards and more frequently in areas like ICU/IMCU and Emergency Room.

Waste is transported in a trolley with three large sized bins of red, yellow and black colour from the wards and all other areas of the hospital to the final disposal. The housekeeping personnel, who are involved in the waste collection, transportation and final disposal, are provided with the necessary protective gears.

Final Disposal

Waste storage area is constructed at the backyard of the hospital where the waste is finally stored before leaving the hospital. Here different large sized colour coded bins are provided for final storage of waste before its disposal. Near the final waste storage area a shed is also provided for a dedicated waste autoclave (capacity of 25 litres) and shredder. The disinfected needle and syringes are shredded to prevent reuse.

Final Waste Treatment

1) ***Plastic Waste***

a) *Plastic Waste (Infectious)*

- Plastic wastes are collected from the respective areas by the housekeeping staff.
- The collected wastes are transferred to a similar bigger container and autoclaved or disinfected by soaking in sodium hypochlorite for a minimum period of five hours.
- The solution is then drained into the neutralizing tank.
- The wastes are shredded using the shredding machine.
- The crushed disinfected wastes are handed to the sub contractor.

Fig. 4.4: Waste shredder

Fig. 4.5: Final waste storage area

b) *Plastic Waste (Non-infectious)*

Non-infectious plastic wastes are collected from respective areas and handed over to sub-contractor.

2) ***Cotton Waste***

Cotton waste are collected from the respective areas and are incinerated.

3) ***Glass and Ampoules***

Glass and ampoules are collected from respective areas and handed over to sub-contractor for final disposal.

4) ***Sharps***

- Sharps collected in the puncture proof containers are collected by the dedicated waste collection housekeeping personnel.
- The collected sharps are transferred to a bigger stainless steel container autoclaved or disinfected by soaking in sodium hypochlorite for a minimum period of 5 hours.
- The solution is then drained into the neutralizing tank.
- The sharps are shredded using the shredding machine.
- The crushed sharps are packed in double cardboard boxes, sealed and sent to M/s. Brakes India Ltd., foundry for melting. A receipt is obtained in duplicate from the concerned person in the foundry after handing over the boxes.

5) ***Pathological Waste***

- Removed pathological wastes are to be discarded in a double yellow coloured bag with disinfectant.
- They are then handed over for deep burial or sent to the electrical crematorium along with the request for deep burial/cremation signed by Consultant/Housekeeping Staff.
- Records are maintained for the same.

6) ***General Waste***

General waste collected from all the areas of the hospital in black bags are handed over to the Corporation on a daily basis.

Evolving Waste Disposal System at Sundaram Medical Foundation

Since, 21st July, 2003 Sundaram Medical Foundation has joined the Central Bio-medical Waste Treatment Facility [G.J. Multiclave], according to the instructions given by the Tamil Nadu Pollution Control Board (TNPCB). The wastes are as usual segregated in colour-coded bags and handed over to the central facility on a daily basis. The wastes are weighed before collection in the presence of the housekeeping supervisors and records are maintained for the same. The general waste is handed over to the Corporation as before.

The needles are disinfected by soaking them in sodium hypochlorite before they are handed over to the central facility.

Monitoring and Record Keeping

The hospital follows a system of monitoring and record keeping as described below:

Maintenance of Records

- The wastes are weighed category wise and records are maintained for the same.
- The weighing is done under the supervision of the housekeeping supervisor, in-charge of the final disposal of waste.
- Income and expenditure of bio-medical waste management is maintained by the Housekeeping Department.

Monitoring and Reporting

- Monitoring of the waste segregation in the entire hospital is done by the Infection Control Nurse on a daily basis.
- The Infection Control Nurse reports to the Chair Person of the Hospital Infection Control Committee (HICC) everyday.

- Any accidents due to waste handling are reported to HICC and necessary action is taken.
- All the health care workers involved in waste handling are immunized with Hep B vaccine.
- Smaller issues pertaining to waste segregation and Infection Control are sorted out by the Infection Control Nurse herself at the site without delay.
- Important issues pertaining to waste segregation and Infection Control are discussed and sorted out in the HICC meeting held once in a month.
- Departments/Wards with best infection control practices are awarded a rolling trophy for good performance.

Awards and Recognition

In August 2001, Sundaram Medical Foundation has been chosen as a role model hospital by the Tamil Nadu Pollution Control Board for "Initiating the Best Practices in the field of Bio-medical Waste Management", after a survey of 40 health care facilities in Chennai.

4.4 CHOITHRAM HOSPITAL AND RESEARCH CENTRE, INDORE

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Choithram Hospital and Research Center (CHRC), Indore (MP, India) is a 350-bedded tertiary care center in central India established in 1979. CHRC has well equipped ICU, ICCU, burn unit, PICU, dialysis unit and other wards.

4.4.1 Health Care Waste Management

The hospital has a well-established waste management system as hospitals are the prime generators of health care waste. Health care waste management is an integral part of hospital infection control programme of the hospital and therefore critically linked to the quality of patient care, worker health and safety.

In the hospital a Hospital Infection Control Committee (HICC) has been functioning since 1997 with the following members:

- Chairman – Director Medical Services
- Coordinator – HOD Microbiology
- Secretary – Infection Control Nurse
- Members – OT Superintendent
- Matron
- Sister In-charge
- In-charge Central Supply Department CSSD
- House Manager and House Keeper

The co-opted members include Principal College of Nursing, Surgeon, Physician, Pediatrician and Maintenance Manager. Along with other infection control issues waste management is a part of HICC. Thus, HICC has been handling the health care waste management from 1999 onwards and in consideration of the expanded activities a full-fledged infection control department was established.

As per the Bio-medical Waste (Management and Handling) Rules, 1998 a waste management programme was launched at CHRC, which was initiated with a waste audit. The waste audit was conducted by the infection control nurse under the guidance of the Chairman and the Microbiologist of the hospital. The total bio-medical waste generated at CHRC is as shown in Table 4.2. The main features of the bio-medical waste management programme are as shown in Table 4.3.

Table 4.2: Bio-medical Waste Generated at Choithram Hospital and Research Centre, Indore

(Jan to Dec. 2004)

Category	Waste/day (kgs.)	Waste/year (kgs)
Human anatomical waste	1.5 (I) 1	547.5
Animal waste	0	0
Microbiology waste	20 (I)	7300
Waste sharps	Needles and metals (I) 2 kg + IV glass bottle 40 kg + glass bulbs and ampoules 5 kg	17155
Discarded medicines and cytotoxic drugs	0.200 (H)	73
Soiled waste	25 (I)	9125
Solid waste (disposable)	30 kg (I) @	10950
Liquid waste	Hospital (I, H) effluent 3,50,000 litres + residential area 1,00,000 litres.	16,42,50,000 litres
Incineration ash	0	0
Chemical waste	(H)	8520 litres

@: Polythene bags 5 kg + PVC IV bottles and hangers 7 kg + urobags and tubings 11 kg + syringes 5 kg + plastic sample containers 2 kg = 30 kg
I = Infectious and H = Hazardous

The health care waste management program at CHRC includes training, waste segregation, handling, record keeping, security and health safety. One of the first incinerators in India was commissioned in the hospital way back in 1979 when health care waste management was hardly heard of in India. The incinerator has stopped working due to lack of gas scrubbers and heavy maintenance costs. Thereafter the waste incinerable is sent to the central waste treatment facility for final disposal, which is charging Rs.14 per kg of waste.

Training

The success of any waste management programme depends on proper training given to the hospital staff including doctors, nurses and other health care workers. Orientation lectures by infection control nurse are given to the new staff about health care waste management to increase their awareness about the subject and make them familiar with the practices followed in the hospital. The lectures cover the importance of bio-medical waste management rules and possible infectious and chemical hazards. Posters have been printed in English and Hindi (Local language) and these posters have been pasted in all the departments and wards.

Table 4.3: Bio-medical Waste Management at Choithram Hospital and Research Centre, Indore

	Category 1	Category 2	Category 3	Category 4	Category 5	Category 6	Category 7	Category 8	Category 9	Category 10
Waste type	Human anatomical	Animal	Microbiology	Sharps	Cytotoxic, medicines	Soiled waste	Solid disposable	Liquid	Incineration ash	Chemical
Source	OT – Surgical, gynaec., Labour room, Dentistry	NIL	Microbiology laboratory	All wards, OT, ICU, Blood Bank, pathology sample collection	All wards, Cancer patients	Maternity, ICU, OT, all wards	Blood banks, all wards	All hospital	NIL	All wards, pathology, x-ray, incinerator, electric generator, boiler machinery
Collection	Tissues in 1 per cent formalin. After 6 months tissues washed with water and incinerated. Amputation gynaec. waste in yellow bags		Collected in metal trays and containers	Plastic bins	Plastic bins	Red bags	Blue bins network	Sewer line	—	Metal containers
Quantity/day	1.5 kg	0	20 kg	47 kg	0.2 kg	25 kg	30 kg	3,50,000 litres	—	8520 litres
Transport	Trolleys, hand delivery		In trays by sanitary worker	Special bucket lined trolley	Special bucket lined trolley	Trolleys	Trolleys	Cement pipes	—	Trolleys
Treatment	Incineration at central waste treatment facility		Steam sterilization (Autoclave) in microbiology department	Steam sterilization (Autoclaving) for needles and blades. 1 per cent hypo for glass bottles	Secured landfills	Incineration at central waste treatment facility disinfection, shredding in shredder	1 per cent hypochlorite plant	Effluent treatment	—	No treatment, returned to supplier if possible
Disposal	Ash to secured landfill		Autoclaved biodegradable waste to compost pit	Needles to cement underground, secured pit. Glass bottles recycled	Secured landfill	Ash secured landfill	Recycling	Waste water to ETP for gardening sludge as manure	Secured landfill	Recycling wherever possible else emptied in the drain

Segregation of Waste

Proper segregation of waste at the point of generation is the key for successful health care waste management. Waste is handled by the nurses/doctors before waste transportation by sanitary workers to waste storage area. The waste storage area is located 100 meters off the main hospital building. Waste storage area has walled sections for storage of different categories of waste. The waste is transported in trolleys with covered bins by a separate waste channel route, which has no contact with the patient area. One dedicated sanitary worker is responsible for collecting waste sharps, needles, blades, vials, injection bulbs and plastic disposables like tubing, syringes. Plastic and glass material is stored separately in the central waste storage area. Plastic waste is treated with hypochlorite in a cemented tank before shredding. Similarly, glass items are disinfected with hypochlorite before sale for recycling purpose. The needles are collected by a deputed sanitary worker and autoclaved in a metal container in the microbiology department. The needles are finally disposed in a cemented underground tank. A specially designed caged trolley is used for storage of infectious waste before incineration. It prevents waste from being messed up by animals.

Record Keeping

Housekeeping department maintains separate registers for:

- Waste generation
- Needle stick injury
- Chlorination of drinking water supply
- Autoclaving
- Incineration
- Disinfectant usage
- Recycling of treated waste
- Effluent treatment plant monitoring

The registers are daily perused by the matron, HICC Coordinator and Director Medical Services. The written documentation helps in the monitoring of the medical waste management programme. Drawbacks and lacunae are noted down and suitable steps are taken for improving the system.

Security

Security round the clock is available in the hospital. No goods can leave the hospital campus without being checked in the security department. Ragpickers are not allowed to enter the hospital area.

Health and Safety

The safety of employees and patients is given a priority in the hospital. Chlorinating drinking water supply collected in central underground water tanks is done daily. The new bags of calcium hypochlorite are tested for the chlorine concentration in the microbiology department. Fresh solutions of chlorine are added to the underground tanks as per the level of water. The residual chlorine concentration attained in the water supply is checked at 10 different points throughout the hospital by housekeeping staff.

Every needle stick/sharp injury is immediately attended by the infection control nurse. A rigid and efficient protocol for the management and the follow up of needle stick injury has been set up as per national guidelines. A needle stick injury reporting register is also maintained by the HICC and treatment is given as per guidelines for

HIV/Hepatitis B. Hepatitis B vaccination is administered to all the hospital staff at hospital expenditure. All the necessary requirements like gloves (plastic/rubber), gowns, face masks and boots are provided to the waste disposal staff and other staff as per requirement.

The other important aspects of waste management like monitoring of waste disposal practices, financial involvement of bio-medical waste management at CHRC have also been undertaken in the bio-medical waste management programme. These aspects have helped a lot in improving the programme.

With this background of health care waste management programme and research work on health care waste, a video has been prepared by CHRC which explains the system of waste management in the hospital.

Reasons of success in Bio-medical Waste Management at Choithram Hospital and Research Centre, Indore are:

1) Reduce (proper segregation)
2) Reuse (glass ware, plastic ware)
3) Recycle (plastic/glass)
4) Commitment of hospital management with active participation of Microbiologist.
5) Strong and active infection control committee with two dedicated infection control nurses.
6) Continuous training for doctors, nurses, paramedical staff and sanitary workers.
7) Continuous research and waste audit.

4.5 AMRITA INSTITUTE OF MEDICAL SCIENCES, COCHIN

Dr. Sanjeev Singh
Medical Administrator
Amrita Institute of Medical Sciences, Cochin

Amrita Institute of Medical Sciences (AIMS) is a tertiary super specialty university hospital. It is extended in an area of 40 acres and has extensive infrastructure comprising of 22 modern operating theatres, 135 well-equipped Intensive Care beds, a reference diagnostic Clinical Laboratory, including advanced Molecular Biology and Cytogenetics Labs, a state-of-the-art filmless Diagnostic Imaging Centre, Medical College, Dental College, Nursing College, Pharmacy School and Research Facility. Patient care is enhanced by a fully computerized and networked Hospital Information System and a fully digitized Radiology Department. The full range of primary and specialty care medical services provides cross specialty consultation, which assures outstanding treatment for each patient.

- Total beds: 800
- Total intensive care beds: 135
- Total inpatients in 2004: 33,915
- Total outpatients in 2004: 3,82,649

4.5.1 Health Care Waste Management

The Bio-medical Waste (Management and Handling) Rules, 1998 make it mandatory for all health care facilities to provide a sound system of health care waste management. The focus till now has been on solid waste management, but with the hazards associated with liquid waste and the existing legislation making it mandatory for the health care facilities to establish waste water treatment systems. Such efforts have been taken by Amrita Institute of Medical Sciences (AIMS), Cochin to establish waste water treatment system.

Waste Water Treatment System

Here at AIMS, the waste water treatment process is of eight stages. At present a total capacity of treating about 4,50,000 lts of water. The health care facility in place of the old natural system of using micro-organism, is using a more scientific system of treating waste. The process is explained below:

1) ***Screening***

Effluent water coming from various parts of the hospital is first passed through a small tank having a screen made of parallel bars with 10 mm gaps. This screen will separate big solids like cloths, cotton, plastic, paper, etc., present in the waste water.

2) ***Collection Tank***

This big tank will collect the waste water after screening. This collection tank will help in regulating the input to the aeration tank. Also, big sediment particles like mud, glass, etc., get collected in this tank and can be removed from time to time. Floating particles escaping from the screening can also be skimmed off from this tank.

3) ***First Filtration***

Waste water from the collection tank is continuously pumped in to a small filtration tank, fitted with a mesh having hole radius 3-mm. The pumping speed is regulated at about 10,000 lts. per hour. Water passes through the filter and flows into the aeration tank.

4) ***Aeration***

Aeration is performed in a 2,50,000 lts. tank, fitted with four surface aerators. By using a commercial micro-organism, called "Effective Micro-organism", which is a bacteria selectively cultured from many natural aerobic bacteria, using Japanese technology. This product has increased the efficiency of the plant. Initially the plant was using natural organisms, grown by fermenting a solution of cow dung. But now the effective capacity of the plant is about 4,00,000-5,00,000 liters. There is practically no foul smell, lesser sludge production, and lesser incidents of breakdowns.

The standard is to retain 20 per cent of the sludge while cleaning, to ensure sufficient quantity of the bacteria in the system.

5) ***Clarification***

Aerated water is removed from the tank at a rate similar to the input (10,000 lt) in to the clarification tank. This is a circular sludge separator with a conical bottom. The shape is such that sludge is collected at the bottom and water escapes through the top outlet.

6) ***Chlorination***

The next step is disinfection. Clean water from the sludge separator is collected in a tank and treated with sodium hypochlorite. This ensures the removal of any micro-organisms present, including pathogens.

7) ***Final Filtration***

Lastly, the water is passed through a sand filter. The top of this filter is covered with a layer of activated charcoal. This ensures pure and colourless output.

8) ***Disposal***

Treated water is disposed by dilution into the nearby backwaters.

System Maintenance of ETP

Once the system has been started and stabilized, the following things are done in definite intervals:

a) Chemical analysis and checking of pH, COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand).

   The composition of the liquid waste produced from the hospital is never constant. It varies with many factors. To avoid this, we measure the composition from time to time. The holding time inside the circulation tank is adjusted as per the new composition, through controlling the flow rates of input and output.

b) Cleaning of sedimentation tank.

   It should be done with minimum disturbance to the aeration system.

c) Cleaning of filters (coarse and fine).

d) Refilling of charcoal in decolourizing unit.

System Breakdown

This condition is generally created by the uncontrolled acidity in the aeration tank, resulting in considerable destruction of the aerobic micro-organisms. Symptoms are generally foul smell, colour changes, etc.

In most cases of breakdowns, the system is stabilized by:

a) Checking the pH.

b) Correcting the pH.

c) Give continuous aeration and monitor the changes.

If the problem is severe, the system shuts down the input, dilute the contents and aerate after pH control. Under extreme conditions, it is better to remove and dispose the contents in the tank, clean it and start afresh.

This waste water treatment system has helped the health care facility to built a good liquid waste management system and ensure that the water being discharged by the facility is safe to the environment and community.

Check Your Progress 1

1) What are the important features of waste management in St. Stephen's hospital?

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2) The Hospital Infection Control Committee in Choithram Hospital include:

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3) How is waste segregated at source in Sundaram Medical Foundation?

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4.6 PHASING OF MERCURY IN HEALTH CARE SETTINGS

Mercury is an environmental toxin and causes wide range of health related disorders to the human being and its surroundings. The hazards caused by mercury have been well recognized by the health sector and the public awareness of the same has stimulated a phasing out of mercury from the health care settings. Questions were raised in the Indian Parliament about the hazards of mercury and the policy of the Government to minimize the hazards due to mercury. This triggered a policy on use of mercury in health care settings.

4.6.1 World Health Organization: Mercury in Health Care

Policy Paper, August 2005

Background

Mercury is a naturally occurring heavy metal. At ambient temperature and pressure, mercury is a silvery-white liquid that readily vaporizes and may stay in the atmosphere for up to a year. When released to the air, mercury is transported and deposited globally. Mercury ultimately accumulates in lake bottom sediments, where it is transformed into its more toxic organic form, methyl mercury, which accumulates in fish tissue.

Mercury is highly toxic, especially when metabolized into methyl mercury. It may be fatal if inhaled and harmful if absorbed through the skin. Around 80 per cent of the inhaled mercury vapour is absorbed in the blood through the lungs. It may cause harmful effects to the nervous, digestive, respiratory, immune systems and to the kidneys, besides causing lung damage. Adverse health effects from mercury exposure can be: tremors, impaired vision and hearing, paralysis, insomnia, emotional instability, developmental deficits during fetal development, and attention deficit and developmental delays during childhood. Recent studies suggest that mercury may have no threshold below which some adverse effects do not occur.

Contribution from the Health Care Sector and Regulation

Health care facilities are one of the main sources of mercury release into the atmosphere because of emissions from the incineration of medical waste. The Environment Minister of the Canadian province of Ontario declared on December 2002 that emissions from incinerators were the fourth-largest source of mercury. In the United States, according to US Environmental Protection Agency (EPA) in a 1997 report, medical waste incinerators may have been responsible for as much as 10 per cent of all mercury air releases.

Health care facilities are also responsible for mercury pollution taking place in water bodies from the release of untreated waste water. According to a 1999 report, health care facilities may also have been responsible for as much as 5 per cent of all mercury releases in waste water. Environment Canada estimates that more than one-third of the mercury load in sewage systems is due to dental practice.

Dental amalgam is the most commonly used dental filling material. It is a mixture of mercury and a metal alloy. The normal composition is 45-55 per cent mercury; approximately 30 per cent silver and other metals such as copper, tin and zinc. In 1991, the World Health Organization confirmed that mercury contained in dental amalgam is the greatest source of mercury vapour in non-industrialized settings, exposing the concerned population to mercury levels significantly exceeding those set for food and for air.

(***Source:*** http://www.who.int/ipcs/publications/cicad/en/cicad50.pdf)

According to a report submitted to the OSPAR Commission, in the United Kingdom, annually 7.41 tonnes of mercury from dental amalgam are discharged to the sewer, atmosphere or land, with another 11.5 tonnes sent for recycling or disposed with the clinical waste stream. Together, mercury contained in dental amalgam and in laboratory and medical devices, account for about 53 per cent of the total mercury emissions.

Waste incineration and crematoria are also listed as major sources of mercury emissions. Many countries, such as Armenia, Cameroon, Ghana, Honduras, Pakistan, and Peru, recognize the contributions from hospital thermometers, dental amalgams, hospital waste and/or medical waste incinerators but lack quantitative data. Despite the lack of data, there is good reason to believe that mercury releases from the health sector in general are substantial.

Some countries have restricted the use of mercury thermometers or have banned them without prescription. A variety of associations have adopted resolutions encouraging physicians and hospitals to reduce and eliminate their use of mercury containing equipment.

Occupational Health Hazard

The most common potential mode of occupational exposure to mercury is via inhalation of metallic liquid mercury vapours. If not cleaned up properly, spills of even small amounts of elemental mercury, such as from breakage of thermometers, can contaminate indoor air above recommended limits and lead to serious health consequences. Since mercury vapour is odourless and colourless, people can breathe mercury vapour and not know it. For liquid metallic mercury, inhalation is the route of exposure that poses the greatest health risk.

A variety of studies demonstrate that mercury containing health care equipment will invariably break. Small spills of elemental mercury on a smooth, non-porous surface can be safely and easily cleaned up with proper techniques. However, beads of mercury can settle into cracks or cling to porous materials like carpet, fabric or wood, making the mercury extremely difficult to remove. Spilled mercury can also be tracked on footwear. Inadequate cleaning and disposal may expose already compromised patients and health care staff to potentially dangerous exposures.

Alternatives

A recent study found that at least one manufacturer of the non-mercury alternative was identified where the cost differences between mercury and non-mercury technologies were minimal. The research findings suggest that many non-mercury alternatives are available to address the full range of functions required by consumer products. For health care, these include blood pressure devices, gastrointestinal devices, thermometers, barometers, and in other studies, include the use of mercury fixatives uses in labs.

Both mercury and aneroid sphygmomanometers have been in use for about 100 years, and when working properly, either gives accurate results. Of all mercury instruments used in health care, the largest amount of mercury is used in mercury sphygmomanometers (80 to 100 g/unit), and their widespread use, collectively make them one of the largest mercury reservoirs in the health care setting. By choosing a mercury-free alternative a health care institution can make a tremendous impact in reducing the potential for mercury exposure to patients, staff and the environment. Aneroid sphygmomanometers provide accurate pressure measurements when a proper maintenance protocol is followed. It is important to recognize that no matter what type of blood pressure measurement device is used both aneroid and mercury sphygmomanometers must be checked regularly in order to avoid errors in blood pressure measurement and consequently the diagnosis and treatment of hypertension.

International Conventions

The UNEP Governing Council concluded that there is sufficient evidence of significant global adverse impacts from mercury to warrant further international action to reduce the risks to humans and wildlife from the release of mercury to the environment. The UNEP Governing Council decided that national, regional and global actions should be initiated as soon as possible and urged all countries to adopt goals and take actions, as appropriate, to identify populations at risk and to reduce human-generated releases.

Strategy

To understand better the problem of mercury in health care sector, it is recommended that countries conduct assessments of current mercury usage and waste management programmes. WHO proposes to work in collaboration with countries through the following strategic steps:

Short-term: Develop mercury clean up and waste handling and storage procedures. Until countries in transition and developing countries have access to mercury free alternatives it is imperative that safe handling procedures be instituted which minimize and eliminate patient, occupational, and community exposures. Proper procedures should include spill clean up response, educational programmes, protective gear, appropriate waste storage containment, staff training, and engineered storage facilities. Countries that have access to affordable alternatives should develop and implement plans to reduce the use of mercury equipment and replace them with mercury-free alternatives. Before final replacement has taken place, and to ensure that new devices conform with recommended validation protocols, health care facilities will need to keep mercury as the "gold" standard to ensure proper calibration of mercury sphygmomanometers.

Medium-term: Increase efforts to reduce the number of unnecessary use of mercury equipment. Hospitals should inventory their use of mercury. This inventory should be categorized into immediately replaceable and gradually replaceable. Replaced devices should be taken back by the manufacturer or taken back by the alternative equipment provider. Progressively discourage the import and sale of mercury containing health care devices and mercury use in health care settings, also using global multilateral environmental agreements to this end. Provide support to countries to make sure that the recovered mercury equipment is not pushed back in the supply chain.

Long-term: Support a ban for use of mercury containing devices and effectively promote the use of mercury free alternatives. Support countries in developing a national guidance manual for sound management of health care mercury waste. Support countries in the development and implementation of a national plan, policies and legislation on mercury health care waste. Promote the principles of environmentally sound management of health care waste containing mercury, as set out in the UN Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal. Support the allocation of human and financial resources to ensure procurement of mercury free alternatives and a sound management of health care waste containing mercury.

4.6.2 Mercury Reduction at St. Stephen's Hospital

Dr. Ann Mathews
Pediatric Consultant and Nodal Officer for Bio-medical Waste Management
St. Stephen's Hospital

As described earlier St. Stephen's Hospital is a 595 bedded tertiary hospital catering to different strategy of the society. They are a pioneer in health care waste management and have taken a step ahead by phasing out mercury in their hospital.

Mercury is an environmental toxin that causes a wide range of adverse health effects in humans. Three forms of mercury (elemental, inorganic, and organic) exist and each has its own profile of toxicity. Exposure to mercury typically occurs by inhalation or ingestion. Readily absorbed after its inhalation mercury can be an indoor pollutant, e.g. after spills of elemental mercury in the hospital from mercury containing thermometers and sphygmomanometers. Minimizing mercury exposure is, therefore, essential as it impacts the lives of patients, employees, community members and future generations. This is a description of methods used at St. Stephen's hospital to minimize exposure to mercury. An initial step was creating awareness among staff of adverse effect of mercury, followed by measures of how to handle mercury spills. The hospital is now working at phasing out mercury containing products such as thermometers and sphygmomanometers.

Bioaccumulation of Mercury in the Food Chain

Mercury is released into the atmosphere by indiscriminate incineration of hospital waste, once mercury enters in the aquatic systems, mercury changes it form and becomes methyl mercury. This results in its building up (Bioaccumulation) as it goes up the aquatic food chain from plankton to small fish to predator fish. As fresh-water and ocean fish may contain large amounts of mercury, children and pregnant women can have significant exposure after ingestion of fish. Many aspects of development, particularly, brain maturation; can be disturbed by the presence of mercury.

Sources of Mercury in Hospital

Elemental Mercury

Elemental mercury in liquid form is found in the thermometers, barometers and other instruments. Dental amalgam, a composite metal that is about 50 per cent mercury, has been used to fill decayed teeth since the 1820s. Fluorescent light bulbs and disks (button) batteries also contain mercury. Indiscriminate disposal of these is a major source of environmental mercury contamination when they are buried in landfills or burned rather than recycled.

Mercury is used in the health care sector in:

- Thermometers
- Blood pressure apparatus
- Feeding tubes
- Dilators and Batteries
- Dental amalgam
- Fluorescent tubes
- Laboratory chemicals like Zenkers solution and histological fixatives

Table 4.4: Amount of Mercury in Medical devices	
Instrument	**Mercury in Gms.**
Clinical thermometer	0.61 gms/thermometer
Sphygmomanometers	60 gms/BP apparatus

Handling Mercury Spills

Till two years ago there were no rules and procedures at St. Stephen's Hospital for handling broken thermometers and subsequent mercury spills resulting from this. The sweeper most likely would sweep the mercury into a corner or put it into any of the waste streams resulting in the mercury going into either the municipal dump or for incineration.

Toxics Link an environmental NGO was instrumental in sensitizing the hospital about the adverse effects of mercury. The hospital initially conducted regular training sessions of all doctors and nurses in the hospital to raise its staff's awareness about mercury and its hazards.

A mercury spill programme was initiated in the hospital since 2002. Through this programme nurses are instructed how to handle mercury spills resulting from broken mercury thermometers and sphygmomanometers at the hospital. Though handling of mercury spills is very time consuming procedure the nurses have been implementing this rule. After the programme was initiated in the hospital, nurses have collected approximately 1.6 kg of spilt mercury over a period of 18 months. This has been handed over to a thermometer-manufacturing unit.

Policy for handling of mercury spills are as follows:

1) Nurses are instructed to wear gloves and mask.

2) A stiff paper is used to pick up the mercury droplets.

3) A syringe containing water is used to suck the mercury.

4) The mercury is then collected in a glass container containing water which is sealed with scotch tape.

Phasing Out of Mercury from the Hospital

The administration took the decision to gradually phase out mercury thermometers and sphygmomanometers.

The mercury thermometer comes at a cost of Rs. 13/- whereas the digital thermometer comes at a cost of Rs 216/- but due to the risk from mercury to the health care workers and the community the hospital has decided to phase out mercury from the hospital.

The hospital used to purchase at least a kilogram of elemental mercury every year to calibrate the mercury sphygmomanometers. This puts the personal carrying out this procedure at risk from mercury inhalation. The purchase of mercury has now been stopped. All the sphygmomanometers, which need calibration, are now being replaced by the aneroid sphygmomanometers.

Items such as fluorescent bulbs and batteries are issued from the store only for exchange for the old ones from the ward. This ensures that these items are not going into either the landfill or for incineration but are sent for recycling.

Table 4.5: Phase out of Mercury Thermometers				
Year/Thermometers procured	2002	2003	2004	2005
Mercury thermometers	687	120	34	0
Digital thermometers		50	65	54

Table 4.6: Phase out of Mercury Sphygmomanometers						
Year/Sphygomanometers procured	2000	2001	2002	2003	2004	2005
Mercury sphygmomanometers	14	15	10	15	0	0
Aneroid sphygmomanometers					3	20

Conclusions

Mercury in all its forms is toxic. We have made efforts to reduce exposure to the patients, children and public at Stephen's Hospital.

The hospital contributed to reduce the amount of mercury in the waste stream by the following steps:

1) Educating Hospital Staff.

2) Having a mercury spill programme in the hospital.

3) Phasing out of mercury-containing devices such as thermometers and sphygmomanometers from the hospital.

4.7 COMMON TREATMENT FACILITY IN SOUTH INDIA

Pruthvish, Girish, Hemanth, Narendranath, Gopinath and Shiva Ram
Health Care Waste Management Cell
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Common bio-medical waste treatment facilities (CBWTF) are established to provide final waste treatment to different health care facilities. These CBWTF cater to a large number of health care facilities across a specified area in a district/city. The following case study is about a common treatment facility in South India where 5000 family practitioners and nursing homes, private and government hospitals, blood banks, laboratories—numbering about 500 exist. The city where this CBWTF is located has two common treatment facilities. The CBWTF is located about 25 km away from the city limits. The health care facilities in the city have been divided into two halves by the common facility providers with equal number of beds being distributed to the two facilities. The agency whose case study follows is a multiproduct entrepreneur company and is new to the area of waste management.

The common facility provider management found it very difficult to find land for the treatment facility when the management mentioned about waste management, the communities were apprehensive and did not offer them land. They had to wait from January 2001 to March 2002 to procure land. Support of State Government, Karnataka Industrial Area Development Board helped them in procuring land belonging to its area of operations for the common facility. After approval of the design, plan and proposed operations by Pollution Control Board the agency started its functioning from September 2002.

The plant is located about 25 km from the City and is spread in an area of one acre. Important points in the plant include incinerator, landfill facility, autoclave, shredder, vehicle wash platform, tank with sodium hypochlorite solution, one room to store incinerator ash, rest room, security base. The plant can handle output of 15,000 beds. Presently it is catering to about 4,800 beds at the rate of Rs. 4 per bed.

Table 4.7: Staff Structure in the Centralized Bio-medical Waste Facility

Staff structure in the centralized bio-medical waste facility	Number
Drivers	13
Pickers	5
Operators	6
Supervisors	3
Customer Care	1
Accounts	2
Marketing	2
Plant Manager	1
Director	1
Total	**34**

Difficulties Faced

- Wrong declaration of number of beds by the health care settings
- No regular/proper payment by health care facilities
- Health care settings do not enroll voluntarily
- Difficulty of completeness of payments especially from government undertakings
- Frequent traffic jams
- Traffic police charges because of vehicle stoppage while door-to-door collection is made
- Un-segregated waste from health care facilities
- Rumours/Gossip in the community of neighbourhood.

Enrollment of Health Care Settings Over the Years

First 6 months: 35

Year I: 100

Year II: 250

Year IV: 350 (Mostly family practitioners)

Waste Collection and Transportation Pattern

To cover the entire area for waste collection total kilometers run is about 880 km. The agency utilizes two enclosed trucks (vans – TATA 407) and 4 autos (Piajo). In one day

Table 4.8: Cost of Installation and Running of the Facility	
A. Cost of Installation	**Cost (INR)**
Land, 1 acre	20,00,000
Construction and roads Fence, buildings, sump, etc.	68,00,000
Autoclave	8,00,000
Shredder	2,00,000
Incinerator	55,00,000
Landfill facility	4,00,000
Total	**1,77,00,000**
B. Running Cost	
Transportation	4,00,000
Electricity	
Disinfection	
Annual Maintenance	
Marketing Cost	
Other expenses	
Salary	3,00,000
Total Cost	**7,00,000**

around 1300 kgs of waste is collected every day and about 950 kgs is infected waste and 200 kgs plastics. Segregation is insisted at source within the health care facility and no segregation is carried at the plant site.

Waste Treatment and Disposal at the Facility Site

- Red bags containing bandage cloth, cotton, linen goes for incineration.
- Blue bags containing recyclable plastic are autoclaved, shred and sent for recycling. At the plant site, decontamination of all plastic waste is made in a plastic tank.
- Yellow bags containing human body parts, tissues, etc. goes for incineration.
- Puncture proof white bags containing sharps/needles goes for landfill. Decontamination is done with sodium hypochlorite solution.
- Incinerator ash is sent to a place 500 km away where facility of 200 acres of land is available for scientific landfilling facility. The city where CBWTF is located does not have landfilling facility for the civic body.

Safety Devices

Safety devices supplied include caps, masks, apron, boot, uniform, gloves. Staff in the plant uses it meticulously. The management is not happy about their usage by pickers while collecting the same.

Welfare Measures

Provident Fund, Insurance, Treatment for Illness and Minimum Wages include the compensation package to staff. Staff undergoes pre employment and periodic medical check up in a District Hospital set up near the Plant site. Routine blood tests are done during check up. Tetanus toxoid and hepatitis B are the protective vaccines being used.

Points to Ponder

- No serious health problems noticed among staff so far.
- The plant is able to meet recurrent expenditure now.
- Capital cost is yet to be recovered.
- Agency feels continued community education and counselling is needed for neighbouring villages where the plant is located to take them into confidence for the plant establishment.

4.8 ROLE OF SRISHTI/TOXICS LINK IN HEALTH CARE WASTE MANAGEMENT

Ratna Singh
Toxics Link, Delhi

In India there was no legislation on bio-medical waste till the Ministry of Environment and Forest came up with the first draft rules in 1995. The rules recommended on-site incinerators for all 30 bedded and above hospitals. Acting on these, in a Public Interest Case of Dr. BL Wadhera Vs. Union of India (UOI), the Supreme Court of India, in March 1996, ordered that this rule be implemented in the city of Delhi. Srishti (Toxics Link) intervened with a Public Interest Litigation (PIL) for review of this order and asked for inclusion of alternative technologies and their standards, both of which were agreed to, incinerators at individual facilities will be discouraged and have also limited the categories of waste that need treatment through this technology. Thus non-burn technologies will now treat 90 per cent of the waste and burn technology will just be an option for the remaining 10 per cent. Earlier this was in vice-versa order.

With the notification of the Rules, the organization took upon the responsibility to assist the institutes for sound health care waste management practices, which were in adherence to the Rules. Various model hospitals in the country were established, which acted as learning centers for the other hospitals. Also platform to these institutes were provided and seminars were organized to solve problems, which the hospitals were facing.

Over the years various newer issues have been taken up by the civil societies, which raises the level of debates in the country. Terms like dioxin, occupational safety which earlier found no mention are a part of the vocabulary of the health care workers.

Amongst new subjects, we have highlighted the issue of usage of mercury recently. Documentation was carried out in select hospitals of Delhi, which highlighted the usage of mercury in the hospital, the disposal pattern, awareness of its hazards amongst the staff particularly the nurses, government policies and international trends.

Similar information was generated from dental clinics for use of dental amalgam.

After collection of this data a report was published and was submitted to the government with the aim of bringing about policy changes for the use of this hazardous substance. This report was widely covered by the media and was raised in the parliament.

Another strategic intervention has been the dialogue with the government to stop open burning of syringes generated during the immunization campaign. This was a major victory for the Indian anti-toxics movement. The campaign engaged not only at the local level but also on the ground for three years with a multi-pronged strategy. Thereafter the CPCB produced a guideline, which includes non-burn waste management techniques and adapts measures which are easy to adapt in local conditions, safe and economical.

Thus non-government organizations (NGOs) have helped galvanize the interest of government officials, bilateral and multi-lateral funding agencies, industry, media and health care sector.

The efforts of these organizations has resulted in progressive national law on waste management and handling, the 1998 Bio-medical Rules, now makes it mandatory for all institutional health care providers to segregate their waste in specified categories, disinfect the waste, transform discarded products so they cannot be re-used, and safely dispose off all bio-medical waste. There are provisions for alternate technologies such as autoclaves, microwaves, and chemical disinfection, off-site treatment and a ban on the combustion of polyvinyl chloride (PVC) plastics. Non-compliance results in strict penalties.

The success of India's bio-medical waste management effort results in large part from the involvement of a wide range of stake holders e.g. the health care sector has to develop waste management systems, train personnel, and equip facilities. The pollution control boards need to implement effective and fair regulations. State health departments deal with budgets and the establishment of model health care facilities. The private sector is called on to develop centralized waste treatment operations and to make available safe and appropriate technologies.

In all these processes, NGOs and civil society play a critical role by providing information, bringing people together, and serving as a watchdog for every step of the way.

Below are some posters produced by Srishti/Toxics Link on different Health Care Waste Management issues.

Fig. 4.6: Poster for Waste Segregation

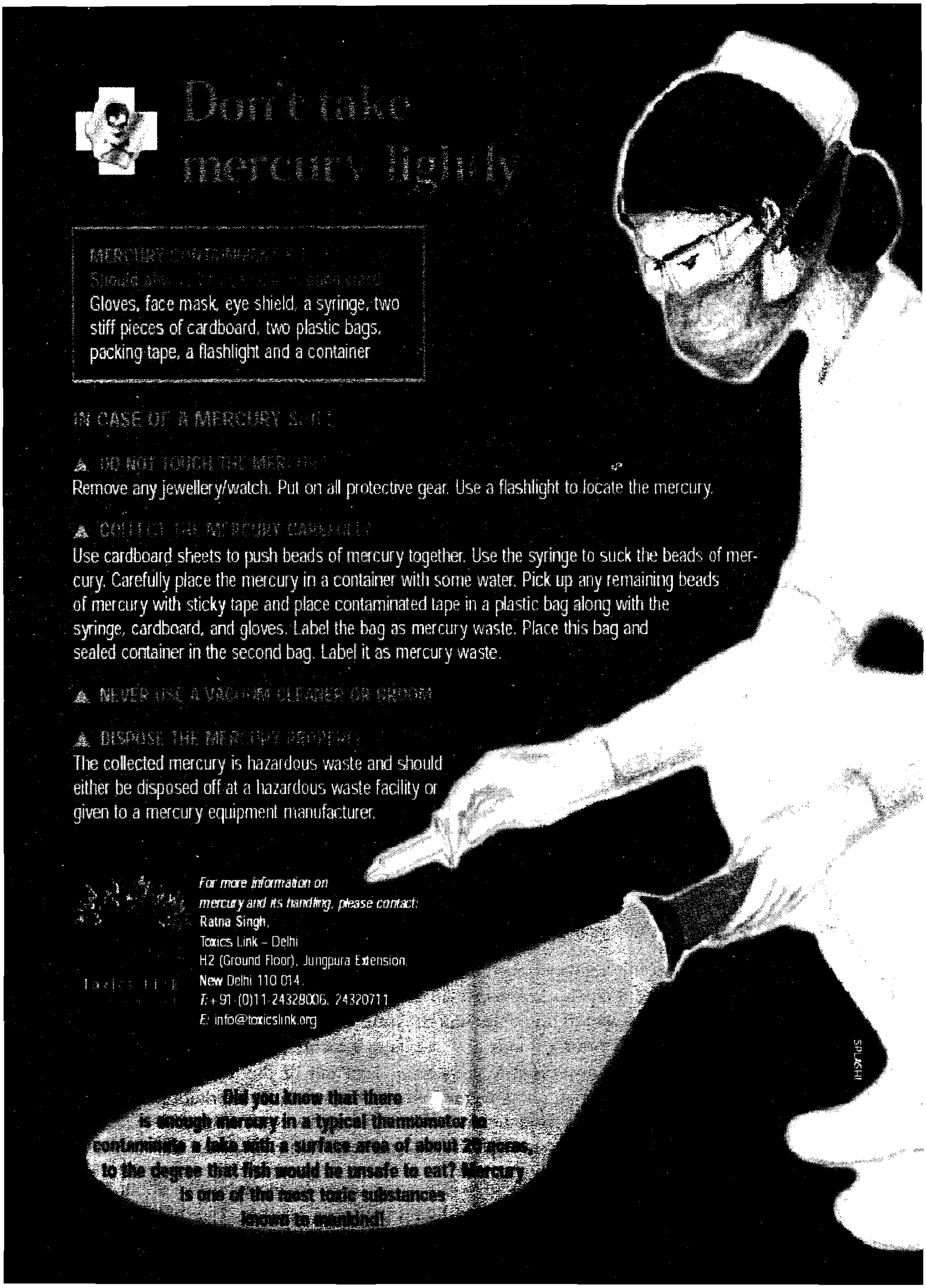

Fig. 4.7: Poster for Containment of Mercury Spills

4.9 DISPOSAL OF WASTE DURING TSUNAMI IN STRUCK ZAINOEL ABIDIN HOSPITAL IN BANDA ACEH, INDONESIA

Valerie Chambard, John Keith, Erik Norremak, David Newgreen,
WHO Indonesia, March 2005

A significant pile of medical waste was located outside the Zainoel Abidin Hospital pharmacy warehouse. Most of the medical waste consisted of bottles of saline and dextrose solutions and disinfectants (lisol, formalin, alcohol and others). There were also various other pharmaceuticals, some outdated, and medical supplies such as IV tubes. The waste included significant amounts of unused but tsunami damaged hypodermic needles and some laboratory chemicals. After disposal, the volume was determined to be about 78 cubic meters (35 to 40 tonnes). Much of the waste was clearly damaged by tsunami waters and appeared to have been purchased prior to the tsunami.

The pile of waste was not in a secure location. Scavengers had discovered the pile and it was reported that active scavenging was occurring. This situation presented a significant public health risk since the use or resale of outdated or damaged medicines, sharps, and hazardous materials by scavengers can present risks to the scavengers and unsuspecting recipients. In view of this immediate risk, it was determined that removal of the waste to a safe location (preferably safe disposal) was necessary as soon as possible.

After studying the situation with the local authorities and experts, it was decided to dispose off the waste in the city landfill, burying it in a secured manner to assure that material was not accessible to scavengers.

Banda Aceh Municipality constructed two pits near the northern (most remote) section of the city landfill. One pit was for solid waste, one for liquid waste. Each measured roughly 4 m × 10 m and 1.5 m deep. WHO representatives inspected the pits for suitability.

Banda Aceh Municipality provided a work crew of about 15 workers to remove the waste, and three 6 m^3 dump trucks to transport it to the landfill. Arrangements were made previously with the Spanish Army to provide assistance by operating two Bobcat loaders to pick up waste. The labour crew manually carried the solid or boxed waste to the dump trucks, and most of the liquid bottles were transported by the Bobcats. The labour crew cleaned the area following the removal.

Safety precautions were taken during the removal operation. WHO representatives and a pharmacist with AusAid inspected the waste prior to pick up. Hazardous chemicals, gas cylinders and flammable liquids were segregated from the waste; this was a relatively small volume and is now stored in a secure location at the hospital warehouse for later safe disposal. On-lookers were kept out of the area to the extent possible. Workers without good boots were excluded from the job. Workers were provided latex gloves if they did not have their own, and dust masks were offered. Bobcat drivers wore masks and safety glasses. WHO representatives also had gloves and boots.

Thirteen dump truck loads of waste were taken to the landfill—about 78 m^3. Solid waste was dumped in one pit and liquid bottles in another. The waste was mixed with soil by a bulldozer and much of the waste was crushed under bulldozer treads. After filling the pits, the waste was covered with soil and rubble so that it was generally covered by about one meter of material. Scavengers were kept away during the dumping operation by two policemen. It was decided that burning was not necessary since the waste was well mixed with mud and debris and was well buried, such that it will not be accessible to scavengers.

There should be no environmental impact from the disposal as the groundwater under the landfill is saline and hazardous chemicals were segregated. Also, the area is remote from any residences and is part of a much larger landfill operation.

Check Your Progress 2

1) What are the sources of mercury in a health care facility?

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2) How can an NGO bring changes to the waste management system in a health care facility?

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....

4.10 LET US SUM UP

This unit is a compilation of success stories of different health care facilities, stake holders and NGOs in providing good health care waste management practices. These success stories will help you in initiating such systems in your facilities and provide education to different health care functionaries, patients and the community about the need and importance of health care waste management.

4.11 KEY WORDS

AIMS : Amrita Institute of Medical Sciences

CBWTF : Common Bio-medical Waste Treatment Facilities

CHRC : Choithram Hospital and Research Centre

HICC : Hospital Infection Control Committee

NGO : Non Governmental Organization

4.12 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1) Important features of waste management in St. Stephen's Hospital are:

- Good segregation at source.
- Mutilation of all potentially reusable items such as syringes and needles at site of generation by simple technology such as syringe and needle destroyers.
- All potentially reusable and contaminated plastic items are disinfected by chemical disinfectants.

- Centralized facilities are used for waste that is incinerated.
- Separate housekeeping staff designated for infectious waste disposal.

2) The members of Hospital Infection Control Committee at Choithram Hospital include:
   - Chairman – Director Medical Services
   - Coordinator – HOD Microbiology
   - Secretary – Infection Control Nurse
   - Members – OT Superintendent
   - Matron
   - Sister In-charge
   - In-charge Central Supply Department CSSD
   - House Manager and House Keeper

3) In Sundaram Medical Foundation the waste is segregated into:
   - General waste are collected in the bin with black lining.
   - Infected cotton wastes are collected in the bin with yellow lining.
   - Pathological tissues/body parts are packed in double yellow bags.
   - Infected plastic items are collected in bins with red lining.
   - Two small sized pedal bins one for metal sharps and the other for broken glass and ampoules, have been provided with inner thick, puncture proof containers.
   - One large plastic drum is used for collecting used IV bottles.

Check Your Progress 2

1) Mercury is used in the health care sector in:
   - Thermometers
   - Blood pressure apparatus
   - Feeding tubes
   - Dilators and Batteries
   - Dental amalgam
   - Fluorescent tubes
   - Laboratory chemicals like Zenkers solution and histological fixatives

2) The role of NGO in health care waste management is explained as a case study of the role of Srishti/Toxics Link. Similar experiences can be drawn from the NGOs and civil societies.

UNIT 1 TRAINER'S GUIDE

Structure

1.0 OBJECTIVES

After going through this unit, you should be able to:

- design and plan a training programme for waste handlers in your institution;
- conduct a training programme for waste handlers in your institution; and
- evaluate a training programme for waste handlers in your institution.

1.1 INTRODUCTION

In the previous blocks you have learnt in detail about the subject of health care waste management (HCWM). After having mastered the subject you are expected to teach the same to your subordinates and also to the waste handlers on ground the importance of information, dissemination and training on health care waste management for effectively running the HCWM system in the health care facility.

You have to understand the subject and all related topics conceptually and then explain them to the waste handlers in the language and manner that is easily understood by them. The language and means may be different but the importance and the crux of the matter should not change in the process.

Most importantly as the subject of waste handling both within the hospital as well as the society is looked at with some disdain, it is your duty to explain the topic with the same passion as you may explain a clinical process. The subject must never be laughed at and never should your attitude or body language convey any negative impression of health care waste. What the waste handlers will remember will be your behaviour and facial expression and not the text you taught them.

In addition you have the difficult task to motivate the staff working in HCWM facility by empowering them with knowledge and at the same time making them feel proud of the skill that they have in handling such a sensitive issue of the health care institution.

The language or medium that you use must be simple, clear with only one meaning, more pictorial and preferably in demonstration form rather than pure theory.

1.2 WHO ARE THE LIKELY LEARNERS

To prepare a talk one has to know the target audience. Similarly to plan a teaching programme for waste handlers one has to know their general characteristics.

A waste handler is likely to be:

- of any age—from a fresher joining your institute to a man about to retire
- of any educational background—from completely illiterate to a middle school pass person
- of lower socio-economic group
- with or without motivation
- with or without knowledge of English.

All these make the task of training the waste handlers an arduous one. The training will have to be simple, explanatory with examples and demonstrations, repetitive but interesting, in the language they understand preferably pictorial, limited to that having practical application, and incorporating the principles of adult teaching. In addition some reference material for future must be given and educative charts displayed around the place of work for continuous education.

1.3 METHODS OF TEACHING

Teaching is systematic way of giving information to a person about a subject or skill. The method of teaching will depend upon the type of course/ training, level of training, receptivity and motivation of the learners, content of the course and many other aspects including preference of the trainer. In generic terms the types of teaching fall under the following types:

- Instructor-Centered
- Content-Centered
- Student-Centered
- Teacher-Student-Content-Centered.

In the case of waste handlers training, a content-centred or teacher-student-content-centred approach is considered appropriate.

Further under each approach of training there are many methods. Each method has certain advantages and disadvantages, based on which the appropriate method has to be applied to a particular learner group. You may use one or more of these methods for training the waste handlers.

1.3.1 Lecturing

Lectures are a common teaching strategy in colleges, universities and large gatherings. This is when the trainer or faculty delivers a verbal presentation (may be integrated with visual presentation).

Why Lecture?

Advantages

- Most common and familiar mode of teaching.
- With reference notes it can be a well structured method of coverage of topic.
- Is online. That is the faculty can apply information collected recently/ real time and give relevant examples or problems.

Disadvantages

- With untrained lecturer, the method can be monotonous and boring.
- There are no prompts except notes.
- Without slides it becomes difficult for a new learner to assimilate information delivered through a lecture.

1.3.2 Tutorials

Tutorials can be defined as small group teaching. Effective tutorials can be one of the best ways for students to learn about a given topic. They also allow you, the tutor, to discover any misconceptions and blocks to learning that the students might have. Tutorials are designed to encourage the exchange of ideas and provide an environment where students have the potential to develop analytical skills, team work, skills in cooperative learning and resolving differences, the ability to talk in front of and listen in groups. Hence in the kind of set up that we are planning of a tutorial may be a more appropriate mode of teaching than lecture.

Advantages

- Better interaction: Ideally a tutorial offers a forum i.e. more conducive to and less threatening for student discussions and interactions.
- Individualised attention.
- Tutorials can offer an opportunity for demonstrations, expansion and elaboration on student understanding.
- Provide a more effective forum for the giving and getting of feedback for both students and teachers.
- Allow students to explore the relevance of knowledge within the context of a course, lecture or topic.
- Provide an opportunity for students to use evidence to substantiate their commitment to an idea.

1.3.3 Discussion

Discussion is an examination of topic by argument or a debate. It is different from tutorial, in that here there is no tutor and trainee but two or more equals, may be with a moderator. It is useful in higher studies, decision-making, and problem-solving scenarios. A group discussion may be used in the training programme on the last day of training capsule when the learners are fully informed of the subject and have their own opinions. This discussion can be used for clearing of their doubts and for confidence building.

1.3.4 Demonstration

To demonstrate is to show. Demonstration is the method of teaching where a process or equipment is shown as it works or how it works. This also like tutorial requires a tutor or demonstrator who is in command and who explains the process to learners. This is an essential part of waste handlers training as the primary aim in such training is imparting working or functional knowledge.

The waste handlers must be demonstrated all types of wastes and all the steps of waste management (segregation at the point of generation, disinfection, collection, transportation, final treatment and disposal). They should then be demonstrated the various processes at HCWM and the functioning of various equipment in use at the treatment site. The handlers must be shown safe practices, use of protective clothing, record keeping, house keeping, and maintenance of various equipment.

Demonstration is the most effective tool in teaching of skills and that also in adult groups. It satisfies the issues required in adult teaching such as relevance and practicability. Hence adequate time must be kept aside on all days of training for demonstrations. This should also be used in periodic training of use of existing or new equipment.

1.3.5 Work Based Experiential Learning

Work based experiential learning is a significant part of many academic programmes and is highly valued by students and employers. Effective work experience involves meaningful work, induction, assessment, reflection and debriefing, and monitoring of the quality of outcomes.

Benefits of Work-Integrated Learning for Employers

- Extra workers at low cost.
- The opportunity to give a potential recruit a trial without obligation.
- Using students' reflection on work experience as a recruitment criterion.
- Having a pool of potential recruits with some general awareness of work-place culture.
- An injection of new ideas.
- Developing links with higher education institutions.
- Staff development opportunities that arise from employees monitoring students.
- Working in a setting in which to put theory into practice.
- Developing an awareness of work-place culture.
- An appreciation of the fluidity of a rapidly changing world of work.
- An opportunity to develop a range of personal attributes.
- The development of key interactive attributes.

1.4 CRITICAL ELEMENTS OF LEARNING

There are four critical elements of learning that must be addressed to ensure that participants learn. These elements are:

1) Motivation
2) Reinforcement
3) Retention
4) Transference

1.4.1 Principles of Adult Learning

Compared to children and teens, adults have special needs and requirements as learners. As per Malcom Knowles, following are the characteristics of adult learners:

- Adults are autonomous and self-directed. Hence must get participants' perspectives.
- Adults have a foundation of life experiences and knowledge. Hence they need to connect learning to this knowledge/experience base.
- Adults are goal-oriented. They usually know what they want. Hence the programme should be clearly defined.
- Adults are relevancy-oriented. Learning has to be applicable to their work.
- Adults are practical. They may not be interested in knowledge for its own sake.
- Adults need to be shown respect. They should be treated as equals in experience and knowledge and allowed to voice their opinions freely in class.
- Another aspect of adult learning is motivation. At least five factors serve as sources of motivation for adult learning:
  - Social welfare—to improve ability to serve mankind, prepare for service to the community, and improve ability to participate in community work.
  - Social relationships—to make new friends, to meet a need for associations and friendships.
  - External expectations—to comply with instructions from someone else; to fulfil the expectations or recommendations of someone with formal authority.
  - Social welfare—to improve ability to serve mankind, prepare for service to the community, and improve ability to participate in community work.

- Personal advancement—to achieve higher status in a job, secure professional advancement, and stay abreast of competitors.
- Escape/Stimulation—to relieve boredom, provide a break in the routine of home or work, and provide a contrast to other exacting details of life.

In the waste management setting, all the above may be motivating reasons. Also as the attention holding in case of adults is much less than the children or young adults, extensive use of audio-visual aids will go a long way in making the training interesting for adults.

1.5 AUDIO-VISUAL AIDS

Use of Audio-visual Aids

When asked often the students say that "The courses I remember are the ones where the professor talked, used videos, did demonstrations, used overheads and did other things to save us from just listening to him droning on." Teaching with audio-visual aids is always more effective as it simultaneously sends input through more than one sensory organ. This is all the more important in training such as for waste handlers as the reception level in such subjects is less than school children and also it makes the topic more interesting.

The following audio-visual aids must be profusely used in teaching the waste handlers:

- Chalkboards
- Over head projector (OHP) and transparencies
- Slides with slide projectors
- Videotapes, Films and videodiscs
- Computers with or without LCD projectors
- Flipcharts
- Posters

1.5.1 Advantages and Disadvantages of Various Audio-visual Aids

There is a wide variety these days in the choice of audio-visual aids. The appropriate aid will have to be chosen by the trainer depending on the facilities, the finances available with the institution, the type of learners, and his personnel preferences.

Sl.No.	AV Aid	Advantages	Disadvantages
1.	Chalkboards	• Very low initial and recurring cost • Easy availability • Real time teaching	• Legibility depends on handwriting of teacher • Loss of eye contact • Material has to be pre-planned
2.	Over head projector (OHP) and transparencies	• Serves as prompter • Students can see transparencies better than chalkboards in large classrooms • Easy to prepare • Long lasting	• Material has to be pre-planned • High recurring cost • Power requirements
3.	Slides with slide projectors	• Better presentation • Easy of operation • Serves as prompter • Long lasting	• Material has to be pre-planned • Less material per slide • High initial and recurring cost
4.	Videotapes Films and Videodiscs	• Medium is entertaining • Catches maximum attention of the viewer • Learner recollects by example • Easy to carry over long distance • Education level of learner not important	• No written material • Expensive to create • Specific and expensive requirements for projection • If movies or tapes are not already available it may be too expensive to rent one
5.	Computers with or without LCD projectors	• Better presentation • Easy of operation • Serves as prompter • Long lasting • Low recurring cost • Easy to make copies or handouts	• Material has to be pre-planned • Less material per slide • High initial cost • Specific infrastructure requirements
6.	Flipcharts	• Flipcharts can be prepared ahead or used to record classroom discussion and are easily referred to again • They are less formal than overheads • Easy to handle	• Difficult to prepare • Limited information • Not useful for larger groups
7.	Posters	• Easy to prepare • Low initial and recurring cost • No trainer required if prepared well • Good for mass communication	• Impersonal • Learner has to understand on own • Prone to damage and spoiling

1.5.2 Tips to Use Audio-visual Aids

- K.I.L.L. (Keep It Large and Legible). Audio-visual tools are of no use if all students can't see them.
- PLAN AHEAD. When preparing a class, it is useful to plan out what you will want to write on the chalkboard.
- MAKE EYE CONTACT FREQUENTLY. Instructors need to regularly observe student non-verbal behaviour and use eye contact to keep students involved.
- LIMIT INFORMATION ON EACH TRANSPARENCY/SLIDE. Since we can process no more than seven bits of information at a time, a single transparency should contain no more than four to six major points. Charts or tables with a great deal of information should be broken into smaller pieces using an enlarging copier.
- BE AWARE OF STUDENTS' VIEW. It can be hard to remember not to stand in front of the image and block students' view.
- DON'T READ THE TRANSPARENCIES. Talk about the material using the transparency as a launching pad rather than writing out the entire thought on it and reading it to the audience.
- ALLOW TIME TO COPY IT DOWN. Students take very seriously whatever is written on the board or presented on transparencies. Be sure to allow them time to copy it all down. Be alert to occasions where you have given them too much to copy.

1.6 PRINCIPLES OF EFFECTIVE COMMUNICATION

- **Sender must be clear in his mind about the purpose of this communication**—so the trainer must prepare the topic and the modality of teaching prior to entering the class.
- **Avoid unnecessary technical jargon**—Although the meaning of certain technical words is essential to be explained, waste handlers should be spoken in the language and at their level without too many technical words.
- It is most essential to consider the needs of receiver.
- Tone of voice, choice of language and congruency between what is said and how it is said influence the reactions of receiver.
- **Ensure it is communication and not transmission of information** —communication is only complete when the subject is understood by the receiver.

- **Emotion and interpersonal relationship**—a cordial interpersonal relation with trainees is essential for them to be attentive and motivated to earn.
- **Motivate them to listen and not hear.**

1.6.1 Concept of Participatory Learning

As is evident from the phrase, participatory learning is a joint activity where the student is as actively involved in the training programme as the teacher. It is not a one-way flow of lecture from the trainer but an interactive session to discuss the topic. This is most important in adult learning programmes and in situations of on-job training. Training of waste handlers is both and hence ideally suited for participatory learning. For the teacher this means that she/he needs to sharpen its "listening capacity". Indeed, if there is no perception that communication is effectively going two ways, there will be less participation and the training results will be poor.

Participatory learning combines an ever-growing toolkit of participatory and visual methods with natural interviewing techniques and is intended to facilitate a process of collective analysis and learning. The approach can be used in identifying needs, planning, monitoring or evaluating projects and programmes. Whilst a powerful consultation tool, it offers the opportunity to go beyond mere consultation and promote the active participatory learning in the issues that concern them.

A promising method to obtain strong interest and commitment from the learners is to start the training session with a "What do we actually know about HCWM?" session. The participants will write their responses on anonymous cards that will be put on a board for everyone to see. Once all cards are collected, they are grouped by themes. This exercise will show that the learners are actually quite knowledgeable, as a group. We do not start from zero!

1.7 TRAINING PLAN

As the objective here is to impart working and practical knowledge to the waste handlers the structure of this exercise should be with more emphasis on practical aspects and theory just adequate to understand the subject. Duration of this training programme should be enough to introduce the subject to an *ab initio*, show the practical demonstrations and also give a hands on experience. It should not be so long that a person new to the field looses interest or is unable to hold attention.

1.7.1 Duration

The suggested duration of training of waste handlers should be for duration of three days with flexibility to increase it by one day to clarify any not understood issues. The broad schedule of the training should be as follows:

Day 1: Theory class for 2 hours followed by practical demonstration in the wards or departments.

Day 2: Theory class for 2 hours followed by practical demonstration in the HCWM treatment facility.

Day 3: Theoretical post training evaluation for 1 hour followed by practical evaluation in wards, kerbside points, and at treatment site.

1.7.2 Syllabus

- Introduction to health care waste management and governing rules
- Categories of hospital waste and method of segregation
- Disinfection at site, transportation, and collection
- Sharp and plastic waste handling
- Final disposal of various types of waste based on multioption approach
- Protective clothing, safe practices, injury reporting
- Practical demonstration of each of the above
- Visit to wards and various department producing hospital waste for on-job learning and demonstration
- Visit to hospital waste management site for on-job learning and demonstration
- Visit to another institution or a common treatment facility for demonstration of large scale practices

Sample Time Table

Time	Topic	Trainer	Venue	AV Aids required

1.7.3 Checklist

For the training to be standardised and for ease of the trainer a checklist of actions is suggested. This may be used as such or modified by you depending on the local conditions and resources available.

Administrative Clearance

This would be in the form of permission for conduct of training programme, for sparing the waste handlers from their routine work for the entire duration of training, and for expenses likely to be incurred in the conduct of training.

Resource Identification

Besides yourselves you may want to incorporate some other resource persons from either within the hospital or from outside for conduct of the training programme. They have to be informed in advance along with the time table.

Venue

The venue for the theoretical classes, the practical demonstrations and the site visit should be informed via the time table of the course.

Logistic Arrangement

Logistic arrangements are more relevant in case of trainees coming from outside the organization, especially if you are conducting the course on a regional or zonal basis. Here arrangements would have to be made for accommodation, transportation, food, etc.

Pre-training Evaluation

A pre-training evaluation is essential to assess the knowledge level of the trainees and to structure the programme at that particular level. This is usually done in a written questionnaire pattern, but in the setting of waste handlers may be done verbally as question-answer session.

Post-training Evaluation

A post-training evaluation is done after the completion of training capsule to assess the level of gain by the trainees. It is useful when used in comparison to the pre-training evaluation to assess the gain of each trainee. However, also it is important to know whether the waste handlers have reached a particular knowledge level to function efficiently and safely in a hospital waste management department.

Resource Material for Training

Although the study material of this course contains all i.e. required for conducting of the training programme, you may find it more convenient to make your own notes in advance of the topics that are to be covered in this training programme.

1.8 EVALUATION

What is Evaluation of Teaching?

Evaluation in education entails gathering evidence about the impact of teaching, topic and course design on students' participation and achievement and the appropriateness of content and processes for intended purposes. Effective evaluation of teaching and topics is the basis of good educational practice. There are many possible purposes for assessing, sources of information and uses for which the evidence might be used. Evaluation needs to be deliberate and a continuous process.

Why Conduct Evaluation?

To judge the efficacy of specific teaching strategies, approaches and innovations in making the subject understood to learners. It can also be done by the organization as a performance appraisal tool of the teachers. What decisions can be based on the data?

- Changes to course structure
- Changes to teaching processes
- Changes to teaching content
- Changes to assessment tasks
- Changes to student work load
- Changes to student staff interactions
- Staff Development

Tools and Methods Used to Evaluate Training

A number of tools and methods can be used to evaluate training.

Evaluation Forms

Evaluation forms can be used to evaluate trainees' perceptions of all aspects of training, from an individual training session to a whole course or progmmme. Short questionnaires can be developed using a mix of qualitative and quantitative questions, so that a clear picture of trainees' views of training inputs and processes can be gained. Evaluation forms can tell us to what degree the trainees felt their training needs were met by the course. For an example of a training session evaluation form, refer to the ones provided in this manual. A list of possible questions to include in the form is also provided in Annexures 1, 2 and 3.

Follow-up Questionnaires

Short questionnaires can be developed and sent out to trainees up to six months after the training. Trainees may be asked about the degree to which they have been able to implement the skills and knowledge gained through the course and to identify barriers they have experienced in their implementation. These questionnaires are a good method of assessing training outcomes, although there may not be many trainees who complete and return the questionnaires.

Analysing Evaluation Results

Qualitative Analysis

For each qualitative question collect all the answers from each trainee. Review these answers and identify themes amongst the responses. Identify the most frequently mentioned points. Summarise the main responses for each question, add in any other supporting information, contextual information or observations that may help to explain or support the findings of the analysis. Qualitative analysis can be time-consuming but may provide rich and in-depth information.

Quantitative Analysis

Quantitative questions must first be marked—a score is assigned for each possible response, e.g. a 'yes' response might be allocated a score of one (1) and a 'no' response allocated a score of two (2). The correct response to a multiple-choice question might be allocated a score of one (1) and incorrect response a zero score. For "Likert"-type questions that provide a range of possible responses (e.g. from 'a little' to 'a lot'), each possible response is allocated a score, e.g., from 1-4, with the most positive response having the highest score. All the scores a trainee's questionnaire are added to give a total for that trainee, in some instances the trainee is given a code number, e.g., when marking pre- and post-course tests. Group means (or averages) can then also be compared before and after training. For those who have access to statistical packages, a paired t-test may be used to identify areas where statistically significant changes have occurred.

Interpreting a Poor Evaluation Result

When a training session is evaluated poorly, it is important for the trainer to analyse the results to understand whether the training needs to be improved or whether the result reflects other events that have impacted on the training but are outside the control of the trainer.

The trainer should not be disheartened at critical comments made in evaluations. In some evaluation forms there are specific questions relating to what the trainees felt could have been done better. Even the most experienced trainers can get critical comments. These should not be taken personally and should be seen as an opportunity to improve the course based on comments in the evaluation.

Direct Observation: Training Skills Checklist

Date:

Session name:

Presenter's name:

☐ Session/Course plan prepared

☐ Topic introduced and outline provided of rationale, aims, objectives and content

☐ Teaching resources set up and ready at the start of the presentation

☐ Use of pre- and post-training test measures to assess change in trainees' knowledge (where appropriate)

☐ Use of variety of teaching aids

☐ Encouragement of audience participation

☐ Use of non-verbal communication skills (eye contact maintained with the group, body language, voice projection)

☐ Responded to questions

☐ Presented content in a logical sequence

Self-assessment Sheet

Ask yourself the following questions at the end of the teaching/training session and enter the answers into the reflective leaning journal. Can you identify areas for improvement? What will you do differently next time?

- Did I follow the four-step plan in preparation for my session by:
  - Assessing
  - Planning
  - Implementing
  - Evaluating
- Did I introduce the topic for discussion and outline rationale, aims, objectives and content?
- Did I use teaching aids correctly?
- Did I maintain eye contact with groups at all times?
- Was I enthusiastic?
- Did I smile?
- Did I respond to questions with warmth and enthusiasm?
- Did I present the content in a logical sequence?
- Did I attempt to link material by way of examples?
- Did I use the appropriate language level?
- Did I maintain the interest of the group?
- Did I coordinate the activities appropriately?
- Did I encourage all members to participate?
- Did I involve all group members?
- Was I sensitive to everybody's needs?
- Did I use variety in my presentation?
- Did I provide adequate feedback?
- Did I meet the objectives of my session?
- Was the evaluation material I used appropriate for this group?
- Was my session well timed?
- Did I allow for pause time between questions?
- Was the method of presentation appropriate?
- Did I meet the learning needs of the group?
- What could I have done better?

Teaching Session Evaluation Form

Here are some possible questions you could include in the evaluation form to ask about your session. It is suggested you select what you need and develop a questionnaire based on the nature of the teaching session concerned.

- Did this session meet your expectations? If not, why?
- Can you make any suggestions for improvement that would meet your expectations?
- How did you feel about this session?
- Explain more about what led you to feel this way?
- Were there times when you wanted to participate but didn't?
- What helped you to participate?
- What hindered you from being more active?
- What were the strong points of this session?
- What were the weak points of this session?
- How could the next session be improved?
- Were the objectives of this session met?
- What new information have you learned?
- What attitudes or values have you examined or defined?
- What behaviours will you change as a result of this session?
- What have you learned from this session that you can apply to your work situation and/or life situations?
- Were the sessions too long, too short or just right?
- Was the information given appropriate to your learning needs? If not, what information do you need?
- Was there information you should have known prior to this session? If so, what information specifically?
- Was there appropriate use of teaching aids?
- Was the presentation of information appropriate? If not, why not? Can you make any suggestions?
- Was the language used appropriate to your level of understanding? If not, why not?
- Was the timing of the session appropriate for you?

- Was the environment comfortable for you?
- Was the venue suitable for you?
- Did the trainer speak audibly and clearly?
- Any other comments?
- Were you able to obtain assistance when you needed it?

Health care waste affects all

UNIT 2 TRAINING MANUAL FOR WASTE HANDLERS ON HEALTH CARE WASTE MANAGEMENT

Structure

2.0 Training Objectives and Methodology

2.1 Lessons

1. Attitudinal Change—Concept of Clean and Unclean Practices
2. Waste and its Kinds
3. Hazards of Waste
4. Preventing Infections
5. Hand Washing
6. Use of Gloves
7. Segregation
8. Infectious Waste Management
9. Collection and Storage
10. Transportation within the Health Care Setting
11. Management of Sharps
12. Management of Metal Sharps
13. Management of Glass Sharps
14. Management of Plastics
15. Management of Liquid Waste
16. Use of Disinfectants
17. Management of Soiled Linens
18. House Keeping
19. Record Keeping
20. Duties of Employees

2.2 Concluding Session

2.3 Further Readings

2.0 TRAINING OBJECTIVES AND METHODOLOGY

Learners Objectives

At the end of four day training, the participants should be able to:

- define health care waste;
- list the hazards of health care waste;
- steps/precautions to be taken while collection and transportation of waste;
- comprehend various occupational safety measures;
- list protective devices used for waste handling and why are they important;
- list and understand the use of different equipment used for waste management;
- help the waste manager in developing an efficient system for health care waste management;
- understand the role of different employees in waste management;
- assist maintenance of records, maintain simple records and monitor the system;
- develop attitude and skills to segregate waste/collect waste/transport waste safely; and
- do's and don'ts of health care waste management.

Teaching Approach

Fix the learning objectives together with the participants, based on a group assessment of their existing knowledge on health care waste management.

Methodology

- Informal, participatory teaching using local language
- Demonstration
- Observation
- Discussion
- Site visit to a health care facility

Teaching Aids

- Flipchart/manual
- OHP/transparencies
- Waste management equipment for practical exposure like waste bins, needle cutters and protective gears
- Playing card for practicing segregation
- Flipchart with pictures and material in front as well talking points repeated behind the chart to the trainer.

Suggested Trainer Profile

Waste manager/senior nurse/doctor/person with some experience in waste management.

Participant Profile

- Waste handlers involved in handling waste in wards/Operation Theatre/Laboratory/Blood Bank/X-ray Room/Labour Room
- Waste handlers involved in transportation and final disposal of waste
- Waste handlers working within the health care facility in waste store room and are involved in operation and maintenance of waste treatment technologies
- Waste handlers carrying out activities outside the health care setting specially the centralized facility workers involved in transportation and final disposal of waste.

Suggested Venue

Preferably a health care facility

No. of Lessons: 20 and field visit of a health care facility

Suggested Duration of Course: 4 days

Each lesson to last for 30 minutes with 30 minutes for practical/ discussion; 5 lessons per day × 4 days i.e., 4 days for 20 lessons followed by half day field visit.

Depending on the convenience, staggered training may be adopted; but keeping continuity and presence of same trainees/trainers is vital. If staggered method is adopted, it should preferably not last more than a month except for refresher inputs.

LESSON 1

Attitudinal Change: Concept of Clean and Unclean Practices

Some houses are kept clean, some houses not

Some hotels are kept clean, some not

Some Hospitals are kept clean, some not.................... **why?**

List the Reasons

— Lack of resources e.g. finance

— Lack of equipment like bins, trolleys, broom, buckets

— Lack of knowledge, training

— Lack of attitude

— Scarcity of water

— Lack of monitoring by senior staff

— Any other reasons

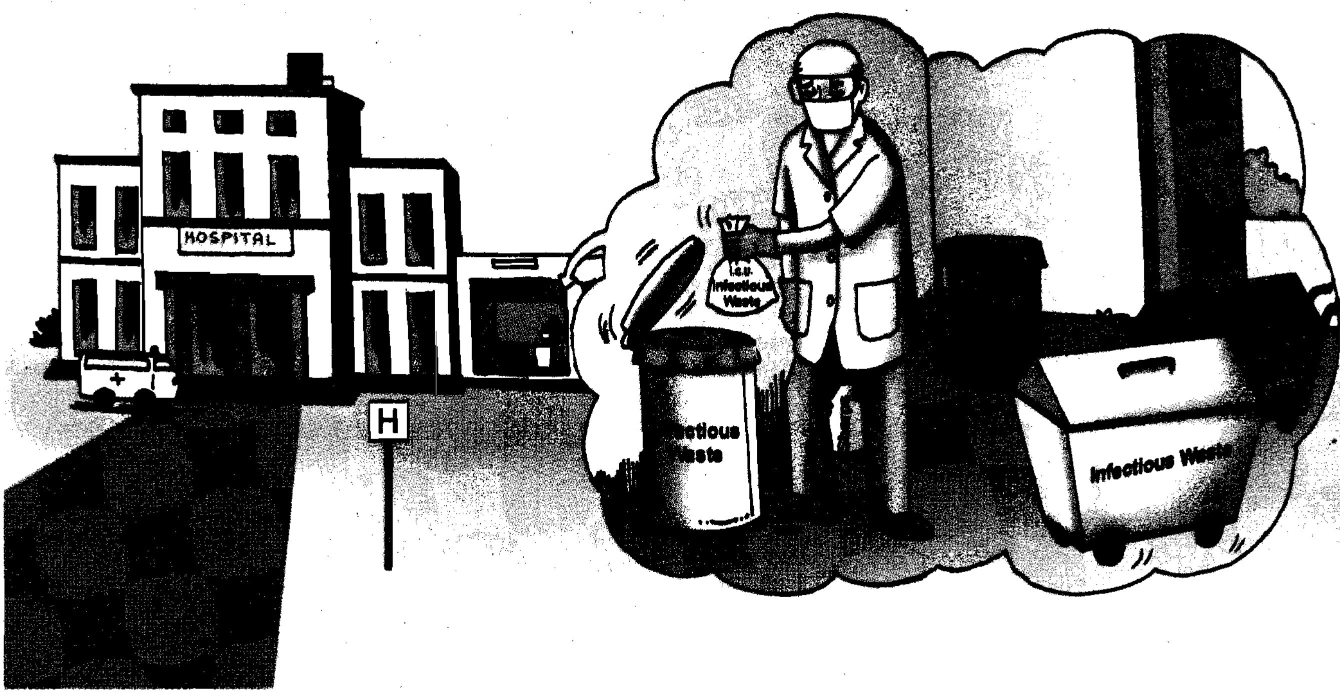
Much depends on attitude change

SWOT (Strengths, weaknesses, opportunities and threats) analysis of picture of waste management is facilitated by the trainer.

After the session the trainee will be able to:

Correlate the different reasons for mismanagement of waste and importance of positive attitude towards waste management.

Good Practice



Final disposal of waste in the health care facility

LESSON 2

Waste and its Kinds

What is waste?

Open question is put and reactions are elicited.

Anything, which is not of immediate use–we call it waste.

What kinds of waste are found/generated in health care facilities? List them:

Used syringes with needles

Used needles

Sharps waste like used scalpel and blades

Food waste (left over food, coconut shells, paper cover, leaves)

Packaging waste–cartons, paper, syringe wrappers, thermocols

Plastic–plastic envelops, bags, plastic syringes, IV tubes

Glass–pieces of glass (while breaking ampoules), empty glass bottles, used slides, tops of nails, broken/discarded glass syringes, slides

Cotton–pieces of cloth, sanitary napkins, used dressing, etc.

Tablet cover, external covers of medicine bottles

Used needles, tops of vials, used scalpel

Excised organs, placenta, sutures removed

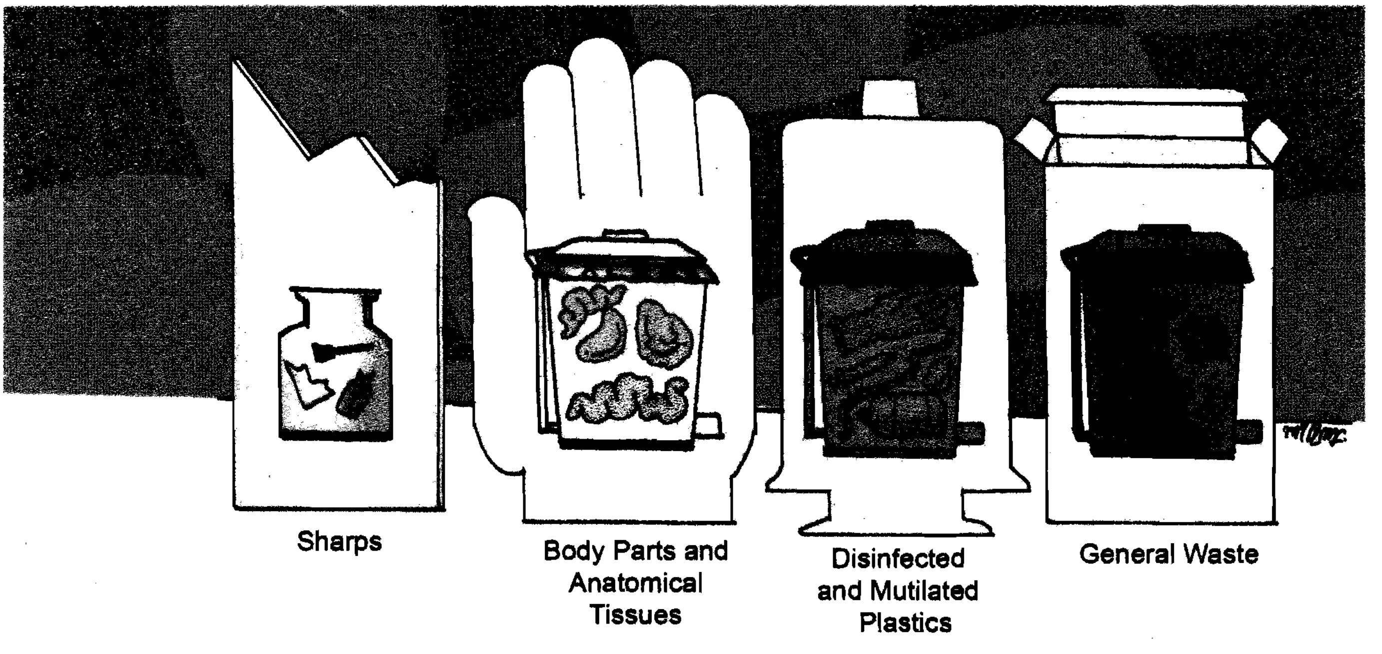
Blood, pus, wound discharges, other secretions, etc.

Urine, faeces

Discuss the quantity, type, and current methods of management practiced at present in their hospital after having a list of different waste types. The concept of infected waste and general waste to come here.

After the session the trainee will be able to:

List the different waste streams generated in their health care facility.



Waste and its kind in a health care facility

LESSON 3

Hazards of Waste

What happens if we do not manage waste properly?

Hazards to different health care workers, patients and the community due to waste.

Soil, water and air pollution caused by health care waste

Hazards to patients

Hazards to relatives of patients

Hazards to the health care facility staff

Fire hazards

Aesthetics

Hazard to community in general

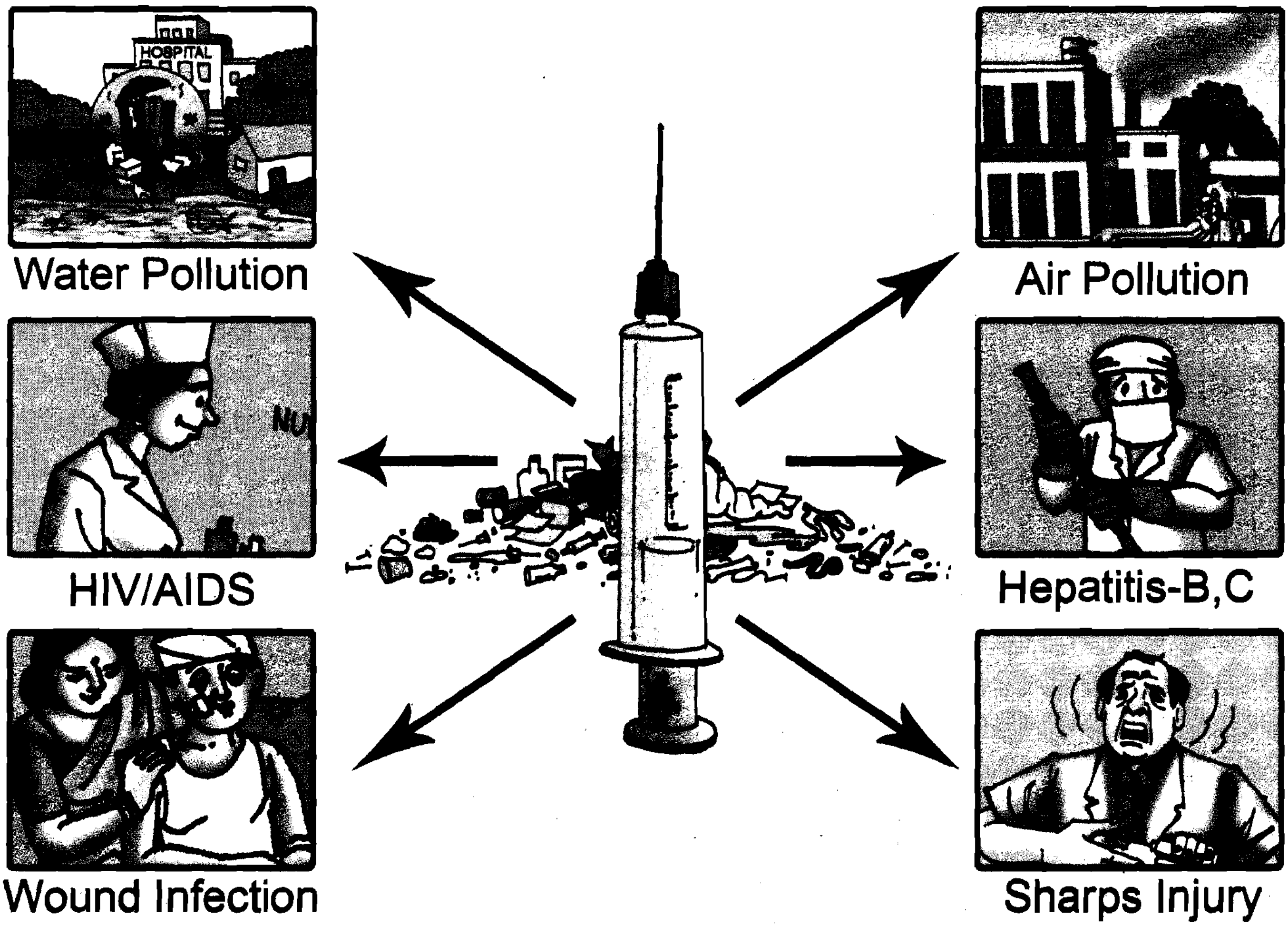
Any other reactions

Discussion is facilitated to arrive at hazards to different stakeholders, patients and occupational safety concerns

Concept of: Infected waste and general waste, methods to minimise the hazards and importance of waste management to come here

After the end of the session the trainee will be able to:

Enumerate the hazards of waste.



Hazards of health care waste

LESSON 4

Preventing Infections

What is infected waste?

Waste that is capable of transmitting infection is infectious waste.

What diseases can occur/be transmitted if we handle infected waste with bare hands? List them.

Injuries/Hepatitis B/Hepatitis C/AIDS, other diseases to be discussed here.

How this can be prevented?

— Segregation and containment at source
— Use of protective devices: gloves/boots/masks/apron
— Managing liquid waste spills properly
— Taking immunization
— Reporting injuries and taking advise
— Proper treatment and disposal of waste

Hand washing, use of gloves, mask, boots, disinfection, practice of Universal Precautions constitute barrier for transmission of infection

After this session the trainee will be able to:

Enlist infected waste generated in their facilities.

Steps to prevent hazards associated with waste.

Use of protective gears

LESSON 5

Hand Washing

Hand washing is an important practice, which will act as a barrier for acquiring infection.

Does this kill germs?

For routine hand washing use soap and water without a germicide, e.g., soap, powdered soap, liquid soap.

In high risk areas (OT/ICU/Laboratory), use soap containing chloroxide/iodophor. Alcohol can be used if soap is not available. Glycerine can be used subsequently.

One should wash hands

Before starting work, when hands are visibly dirty, after blowing one's nose, after handling garbage/waste, before eating/drinking, before/after touching/dressing wounds.

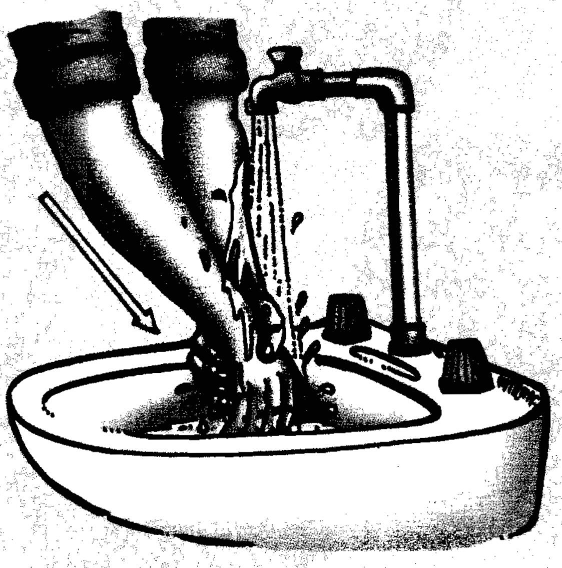
After handling dirty equipment—urine can/dressings/bed pan/ linen, before and after collecting specimen for lab examination, after contact with mucous membrane/blood and body fluids.

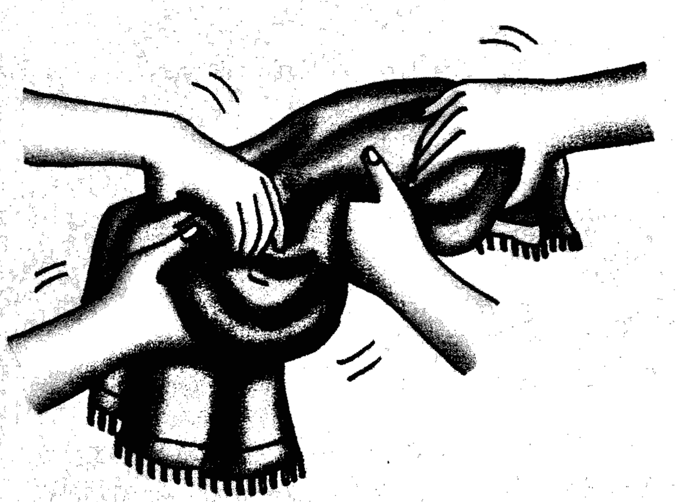
Hand washing facilities to be conveniently located, running water to be available, hands should be dried after washing, hot air drying facilities are preferable, individual/paper towels are to be used.

After the session the trainee will be able to:

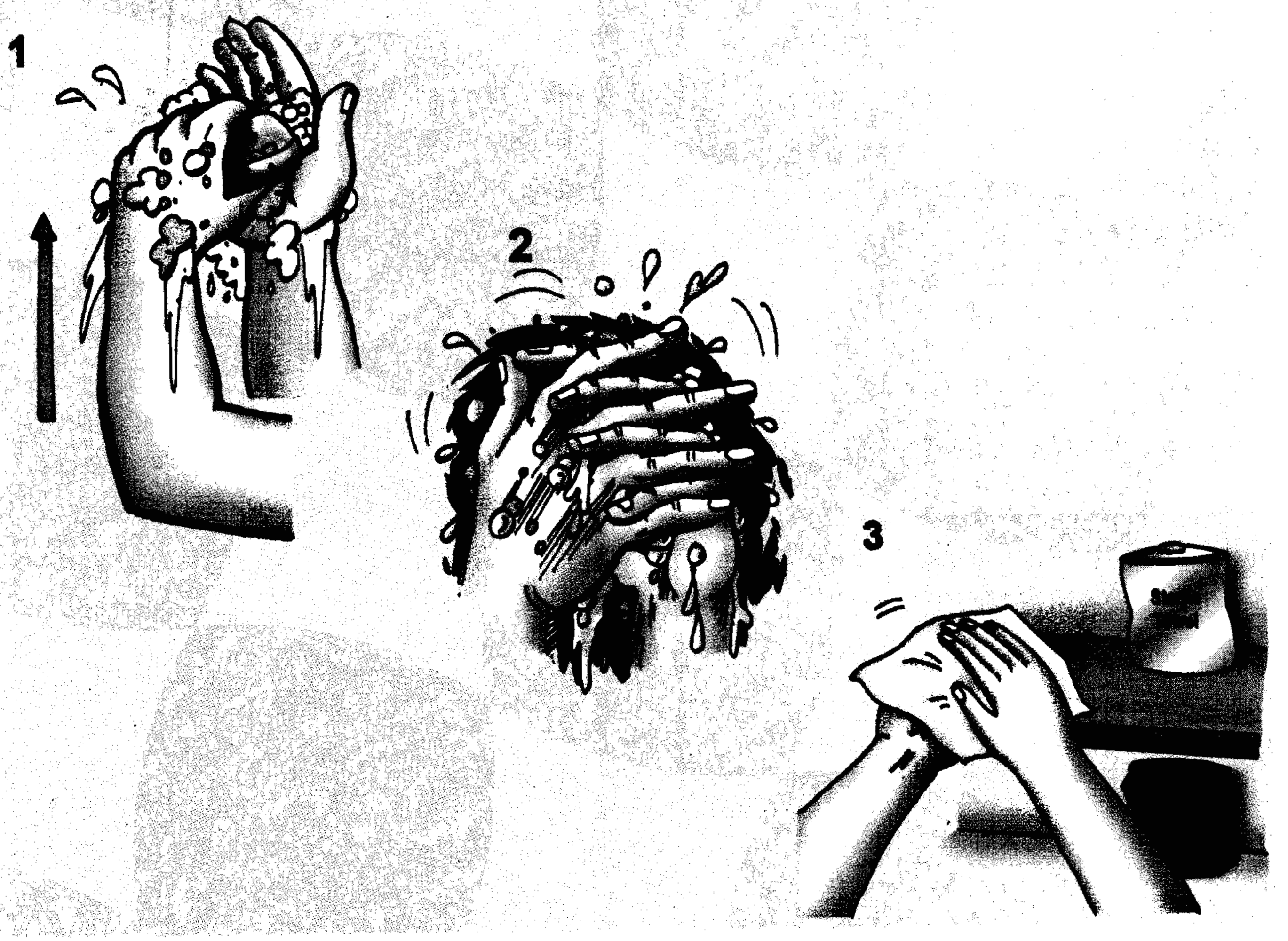
Highlight the need and importance of hand washing in containing infections.

Bad Practice





Good Practice



Hand washing

LESSON 6

Use of Gloves

Reuse of single-use gloves should not be done.

Use disposable gloves that are clean/ non-sterile for routine care of the patients.

Sterile gloves are used for giving injection, inserting a catheter, etc.

Use heavy-duty rubber gloves for cleaning instruments, handling soiled linen or dealing with spills of blood or body fluids. They can be washed and reused.

Choose gloves that fit properly.

Check there is no puncture in the gloves. Do not use gloves if they are torn, as punctured gloves do not give protection.

Wearing Gloves

Wash hands and dry them.

Pick up the first glove by its cuff.

Wear the first glove. Bunch the glove and then pull it into hand, ease fingers into the glove.

Repeat for the other hand.

Removing Gloves

When removing personal protective equipment, remove gloves first.

Grasp the outside of one glove, near the cuff with the thumb and forefinger of the other hand. Pull the glove off, turning it inside out while pulling and holding it in the hand that is still gloved.

Hook the thumb or finger inside the remaining glove and pull it off by turning it inside out over the already removed glove to prevent contamination of ungloved hand.

Roll the two gloves together taking care not to contaminate hands.

Discard the glove to the container.

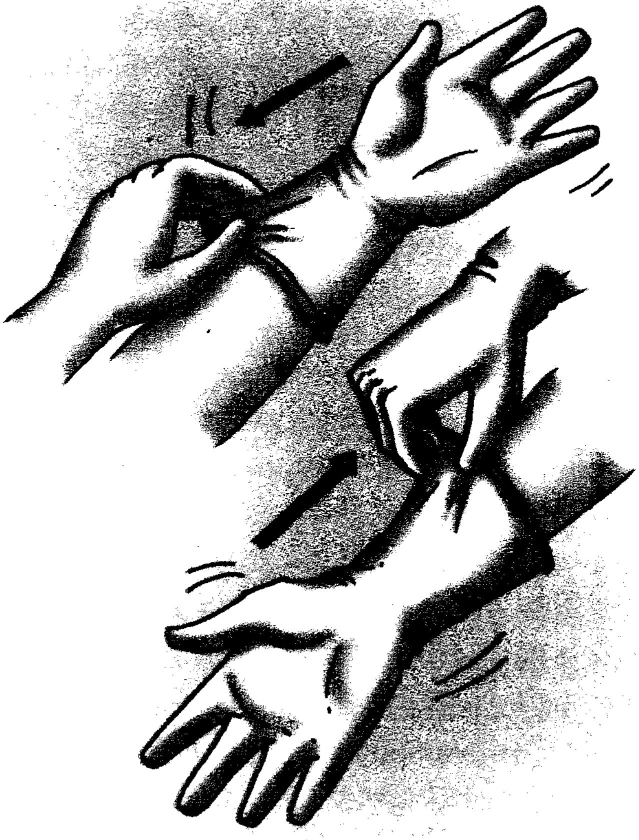
Wash hands.

Tips for the Trainer

The trainer will conduct demonstration of use of gloves/masks/gown/apron and goggles. Trainees repeat its use.

After the session the trainee will be able to:

Practice proper method of wearing and removing gloves and other protective gears.



Wearing Gloves

Removing Gloves

LESSON 7

Segregation

What is segregation?

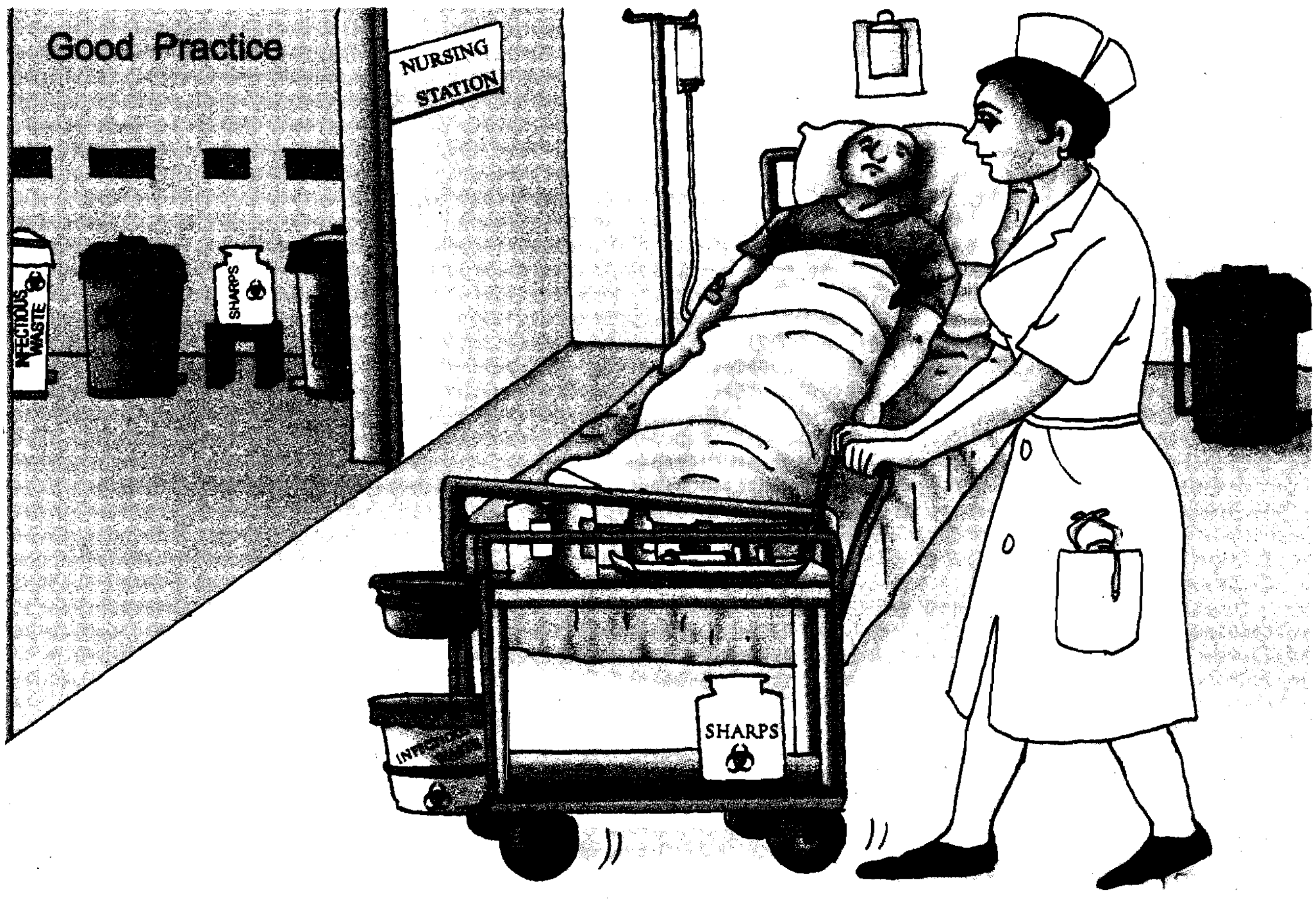
Not all waste from health care facilities is hazardous. It is likely that only 15 per cent of waste generated in a hospital is infectious/hazardous. If infected waste gets mixed with general waste, entire waste becomes infected. Segregation of waste and containment of waste helps avoid this.

What are the advantages of segregation? How do we segregate?

Segregation limits infectious waste. That means less infected waste to manage. As we are preventing general waste from becoming mixed with infected waste and getting large quantity of infected waste.

By segregating waste:

- We are reducing quantum of infected waste
- We are making way for management of general waste separately
- We are reducing load and cost of management of infected waste
- We are improving cleanliness of the surroundings within and outside the health care settings
- We are keeping ourselves away from contact with infected waste.



Segregation of waste at source

What may be a good method to segregate?
Segregation at the point of generation is desirable. Following is a useful categorization method:

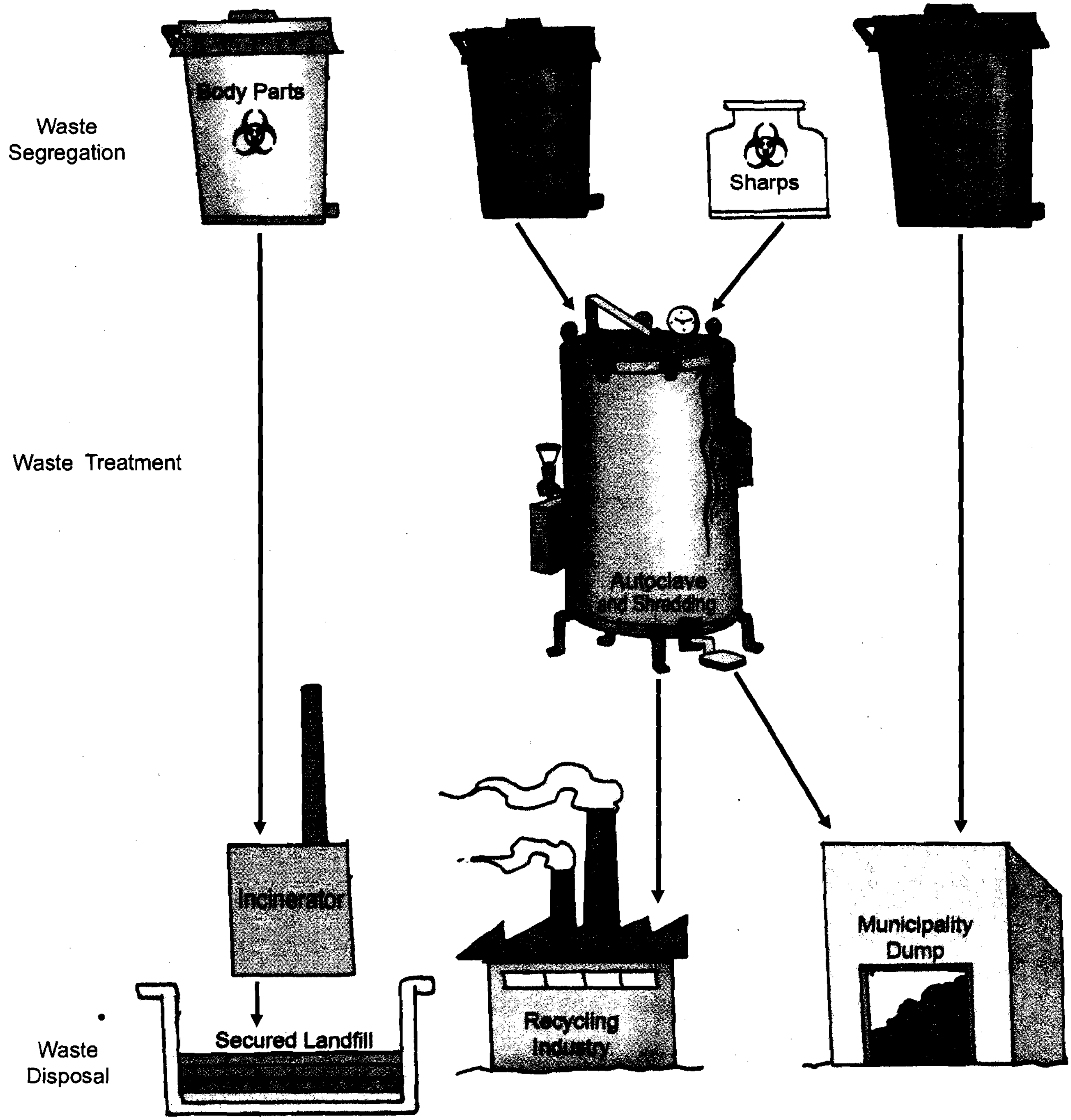
- We are keeping ourselves away from contact with infected waste
- Infectious waste (tissue sections, swabs, cotton, gauze/ other dressing materials, etc.)
- Solid waste (plastic tubing, decontaminated syringes, IV fluid containers)
- General dry waste
- General wet waste
- Contaminated linen
- Intact glassware
- Sharps waste
- Other hazardous waste

It is useful to take note of prevailing legislations of the respective country while suggesting colour codes. A chart is made and put up at the point of segregation and collection of waste.

After the session the trainee will be able to:

Differentiate different categories of waste for segregation.

Explain the importance of segregation in health care waste management.



Steps of waste management in health care facility

LESSON 9

Collection and Storage

How do you collect waste in your health care facility?

Use of bins

Proper evacuation of bins

Cover for bins, foot operated bins

Plastic bins

Metal bins

Cardboard box as bins

Plastic cover within bins—usefulness

Use of hard duty gloves, hand washing after waste disposal

Bins with covers—usefulness/availability/requirement

Foot operated bins—usefulness/availability/requirement

The collection of waste can be demonstrated to the waste handlers by using a set of bins, used for waste collection.

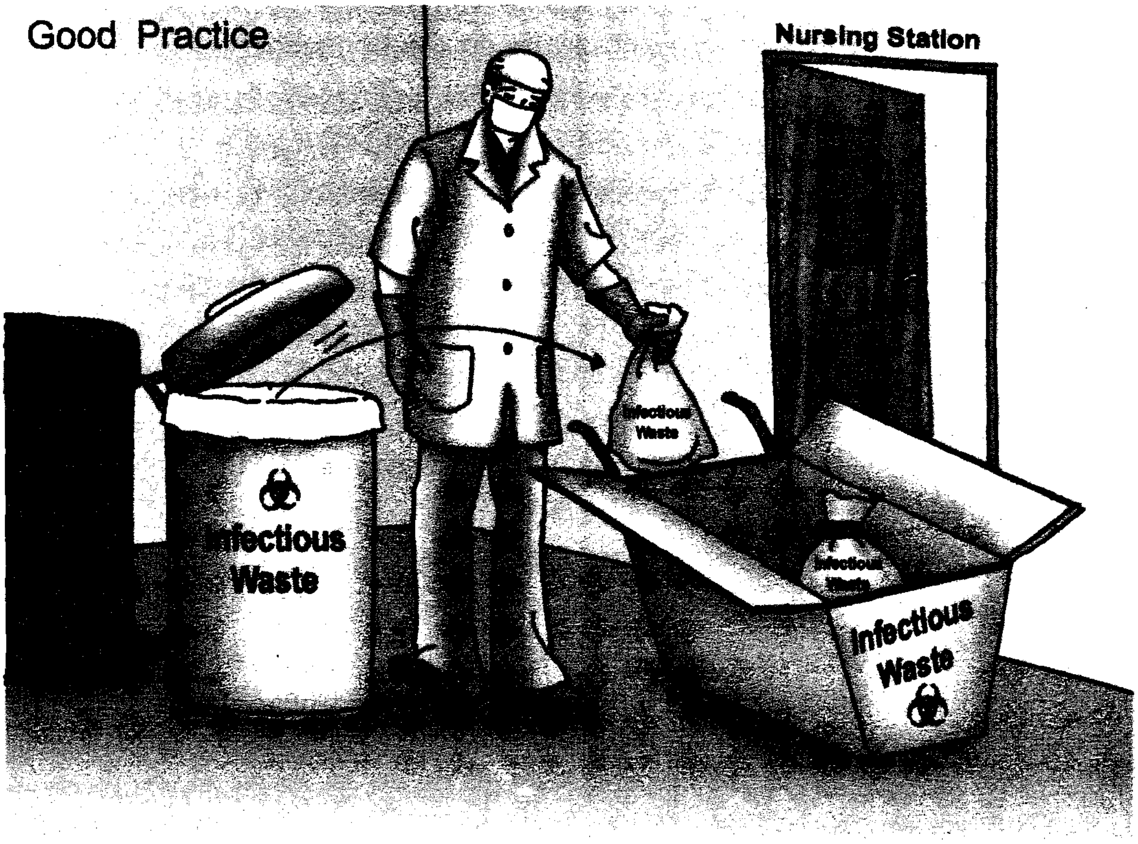
How do you store waste in your health care facility?

Never store waste beyond 48 hours

Store waste in secure containers/room (access only to the employees handling waste)

After this session the trainee will be able to:

Describe good waste collection and storage practices.



Waste collection

LESSON 10

Transportation within the Health Care Setting

How do you transport waste in your facility?

a) Closed trolley is preferable to open trolley. An open trolley encourages spillage.

b) Suitably designed trolleys and containers and their proper use prevent spillage/accidents and injuries.

c) Transportation receptacles must match the segregation categories and transfer of waste need to be done to matching receptacles meticulously from point of generation to trolley and from trolley to storage room/van depending on the system adopted.

d) Separate service lifts/ramps to be used always for transportation of waste.

Personnel in the waste store room/who transport waste within the health care setting/outside the health care setting need to:

— Wear gloves, mask, apron, gown, and boots

 a) The risk of spills/splash exposures necessitates the wearing of face and eye protection

 b) Carrying bags by hand is to be minimized and where it cannot be avoided, apron and protective gears to be worn

 c) Protective gears to be worn even if process involves wheeling a locked garbage bin to the household areas

— Wash hands thoroughly after the activity/before eating/drinking food

— Be immunized against typhoid, tetanus, Hepatitis B

— Report any illness/injury (minor/major) to the management of the hospital

Segregated waste is to be collected periodically and in a secure manner:

— Collection and storage processes should be streamlined to reduce manual handling.

— The use of smaller mobile garbage units greatly reduces the handling and lifting of waste.

— Wherever loads exceed 16 kgs, team handling/mechanical handling is to be instituted. Wheeled bins should not be lifted.

After this session the trainee will be able to:

Enumerate the type of waste transportation vehicle and precautions to be taken while transporting the waste.

Bad Practice

Transportation of waste

Lesson 11

Management of Sharps

Staff is facilitated to discuss:

After the ampoules are opened, how are they disposed off?

After the vials are opened, how are they disposed off?

How are the metal parts of the vials disposed off?

After the consumption of capsules and tablets how and where foils are disposed off?

What is done to glass bottles? Do you use the saw to cut open the ampoules? Usage of covering ampoules with a wet cloth while breaking open the vials—advantages and disadvantages.

Can we keep a cardboard box where broken glass is exclusively stored? Is it feasible?

Can we keep a separate cardboard box to exclusively store metal sharps? What metal sharps do we come across? How are sharps handled in immunization settings?

Are they destroyed after each use or in bulk?

Is it a good practice to destroy sharps in bulk?

Introduce the concept of AD syringes, waste from immunizations.

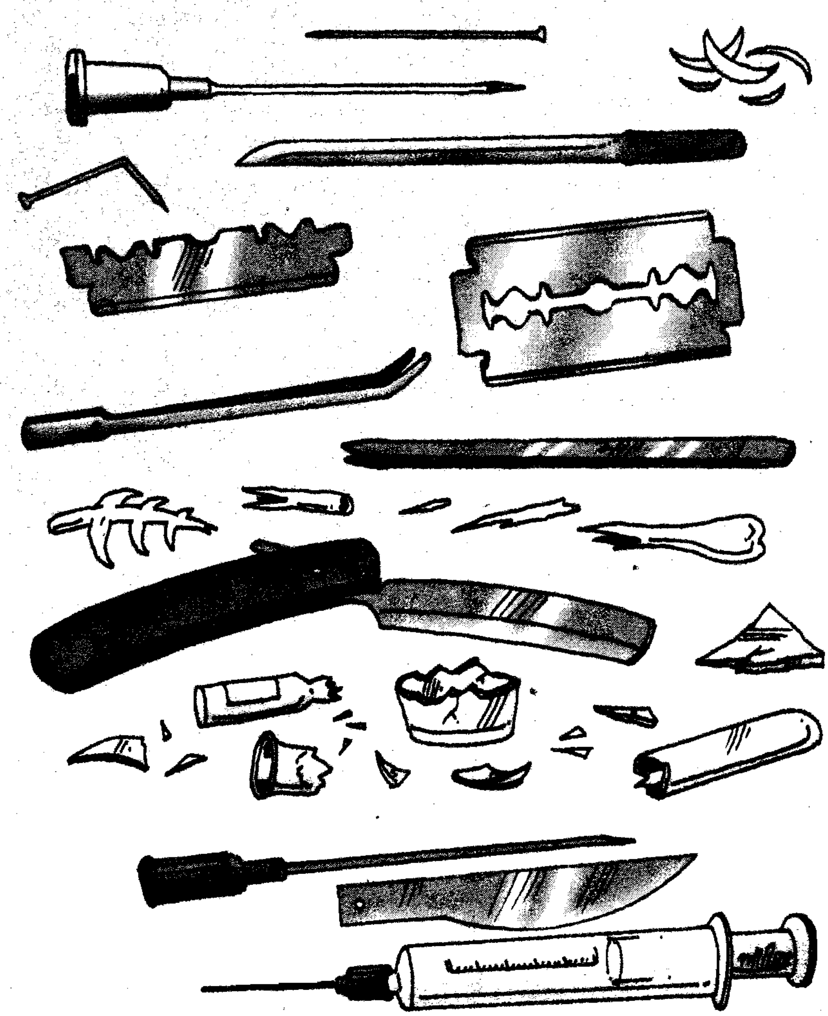
Where are the sharps generated in a hospital?

Do we injure ourselves often?

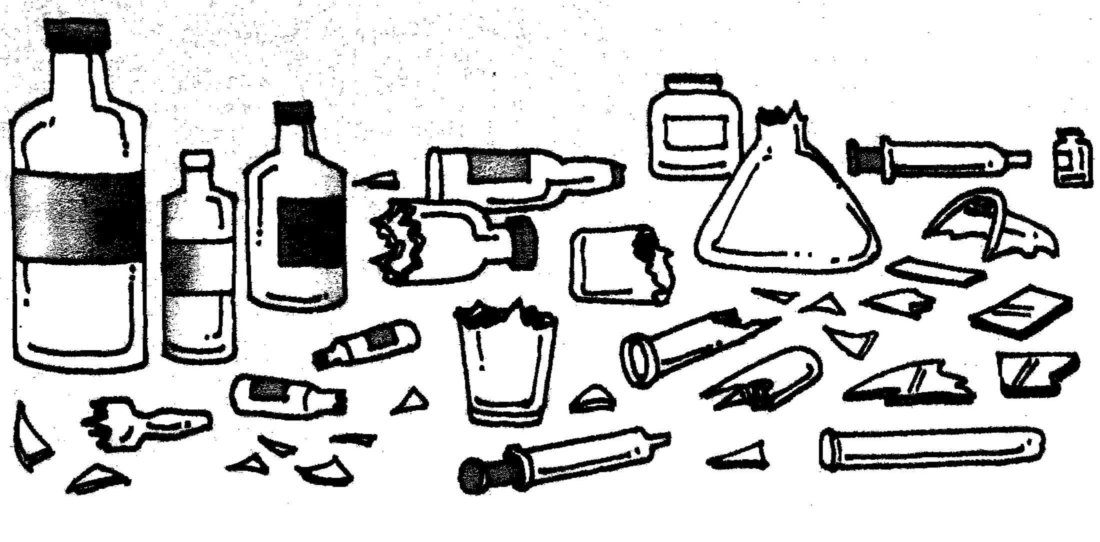
What is containment? Is containment possible in a health care facility? Can we use deep burial methods for disposing broken glass/contain metal sharps? What is a needle burner? Should we remove needles from plastic syringes? Can we reduce waste by reducing use of plastic syringes?

After this session the trainee will be able to:

Discuss the modes of containment for broken glass and metal sharps.



Sharps waste



Broken glass

LESSON 12

Management of Sharps: Metal Sharps

Tips for Waste Sharps Management

Needles, scalpel, razor blade, tops of vials are commonly noticed waste sharps in health care settings.

Pieces of bone, pieces of glass (broken ampoules) nail are also wasting sharps generated in health care settings.

Sharps are capable of causing injuries or introducing infection by piercing the skin or mucus membrane. They may be used/ unused. They may cause injury before, during or after handling. They need to be collected separately/exclusively and contained in a cardboard box/puncture resistant containers such as plastic bins, thick cardboard box, bottle, galvanized iron bin.

***Step 1:* Be aware, Beware**—waste sharps can injure or infect.

***Step 2:* Segregation**—collection separately, in puncture proof containers reduces chances of injury.

***Step 3:* Decontaminate**—
decontamination/disinfection reduces chances of infection.

Suggested Procedure

Chemical Treatment

1 per cent hypochlorite solution or 2 per cent bleach (freshly prepared)—**one heaped teaspoon of bleaching powder**—in 1 litre of water

Minimum Contact Period: 60 minutes

Before removing the needle from the syringe.

Flush it with disinfectant fluid.

Discard needle into the waste sharps container.

Remove plunger from the barrel of the syringe before immersing it in the liquid disinfectant.

If the container is medium or large in size, drain the disinfectant fluid every day. Make a hole in the cap, use a strainer, and use double containers.

Autoclaving

At 121 degree centigrade, 15 Pound Pressure, 60 minutes

***Step 4:* Deform/Destroy:** This reduces the chance of needle stick injury.

Deforming/destroying: By using a mechanical/electrical needle removal devices.

Always use instruments; use heavy-duty gloves; do not use bare hands.

***Step 5:* Contain:** Use a heavy-duty puncture proof resistant container to collect waste sharps. A narrow mouthed container facilitates collection, minimizes/ obstructs unnecessary handling/removal.

Bad Practice

Good Practice

Sharps management

If the waste sharps consist of broken glass, secure the area, wear gloves/ boots; collect with a spatula and discard into waste sharps container.

Step 6: **Label:** Use a blue/white translucent container or label the container properly (visible and legible label).

Step 7: **Transport:** Use heavy-duty gloves while handling waste sharps, especially during transportation. Use a trolley when distance to reach final point is far. Transport sharps in secure puncture resistant container by wearing heavy-duty gloves. Preferably transport in trolleys and keep away from body while handling waste.

Step 8: **Final Disposal:** Mutilation/ shredding prevents reuse. Send the disinfected sharps to a recycler or bury in a concrete pit or encapsulate them.

Alternately

At the point of use mutilate the infection units by needle cutter/puller/destroyer before sending for final disposal.

Sharps are important cause of concern in health care settings. Even if they make up only a small proportion of the total waste, they should be handled with due precautions. In a Community Health Centre/Primary Health Centre/Sub-centre, one may find the following method also useful:

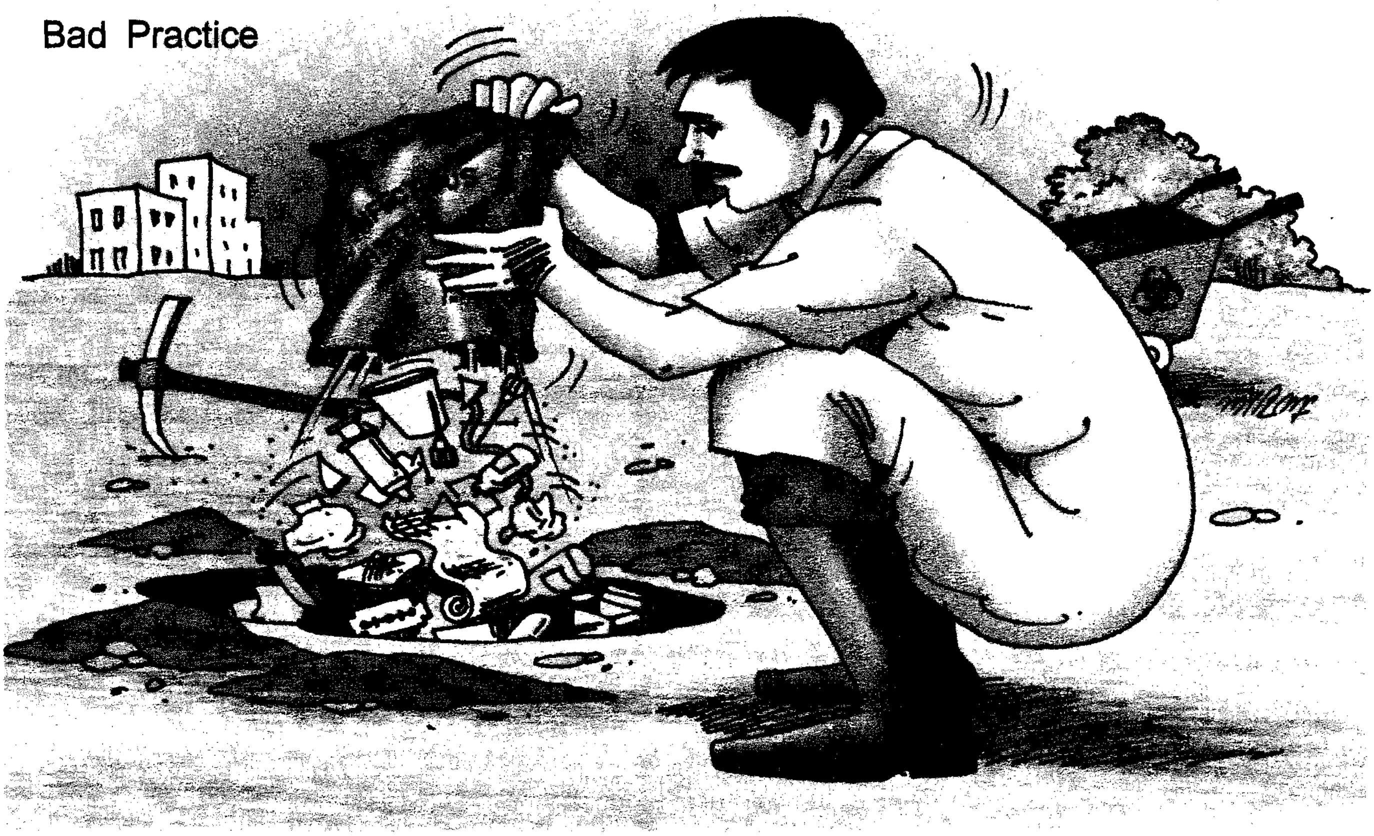
— A circular or rectangular pit is dug. It can be lined with brick masonry and concrete rings. It is felt that dogs or even ragpickers may try to dig the pit. The pit is covered with a heavy concrete slab with centrally placed galvanized steel pipe with an internal diameter up to 20 mm, projecting about 1.5 meters above the slab. Only needles and scalpel blades (i.e., without syringe bodies or drip tubing) are dropped down into the pit, where they are inaccessible.

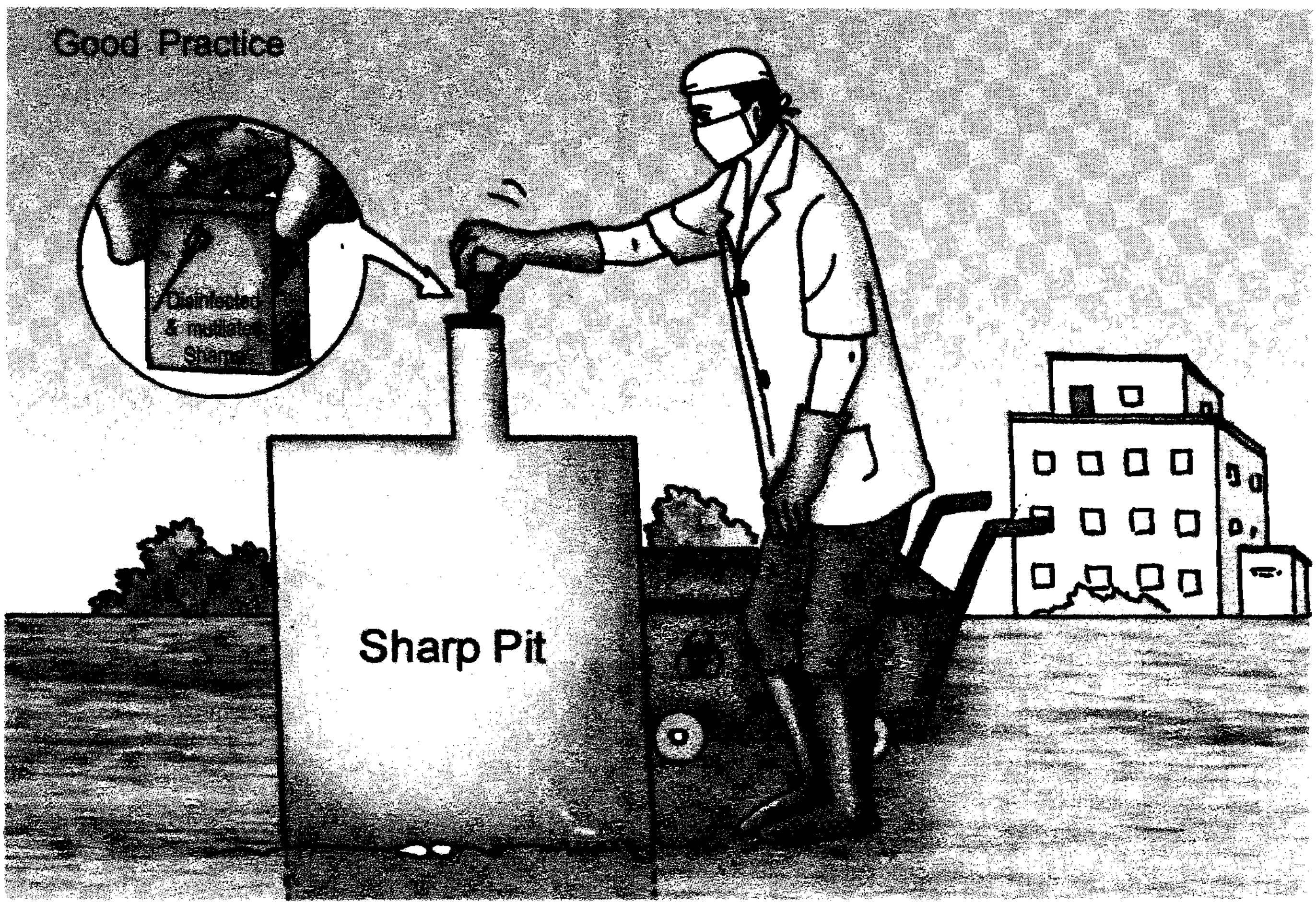
— When the pit is full, it can be sealed completely and another can be prepared for further use.

— The filled up pit may be emptied and alternate approaches to be determined what to do next, e.g., road crinkler; making cement blocks or bailed out and sent to common facility for final disposal.

After the session the trainee will be able to:

Enumerate different waste sharps and methods of containment and disposal of sharps.





Final disposal of sharps

LESSON 13

Management of Glass: Broken Glass and Intact Glassware

Broken glass: often is the result of breaking the ampoules without using saw and glass instruments like thermometers. Accidentally, bottles may fall and break. This is to be treated like any waste sharp;

Use of heavy-duty gloves and careful handling are must.

Intact glassware: IV bottles and other glassware constitute one of the most important types of waste. They may/may not be contaminated. It is necessary that they be decontaminated and shredded before they are send for recycling. Selling these items is the usual practice in most health care settings.

Small glass bottles (e.g. penicillin bottles, eye drop bottles) are often used as specimen collection bottles

Option for Disposal

— Collected in boxes, transported to nearby plastic recyclers; once a month

— Use plastic shredder and make it into small pieces; collect and sent to plastic recyclers.

Containers in laboratories or sold for reuse. It is necessary that they be decontaminated before they are used as specimen containers, sold or reused for other purposes like decoration.

For decontamination of intact glassware, it may be useful to consider:

— Washing with soap and water

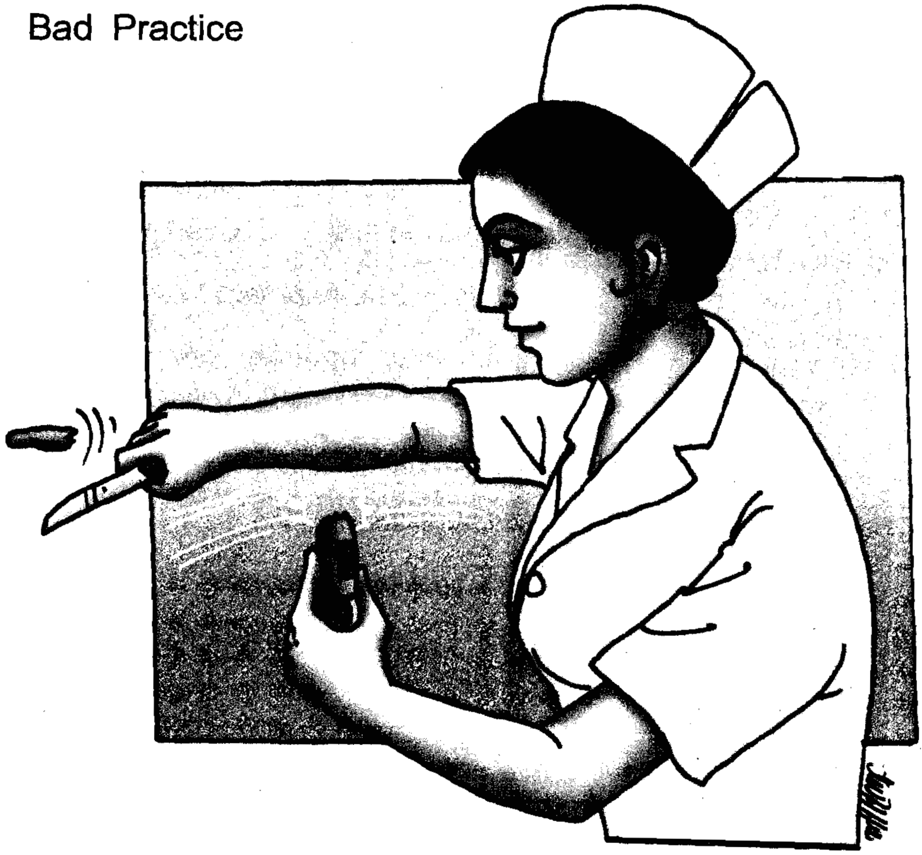
— Boil them/soak in bleaching powder solution for 1 to 2 hours.

— Autoclave the glassware

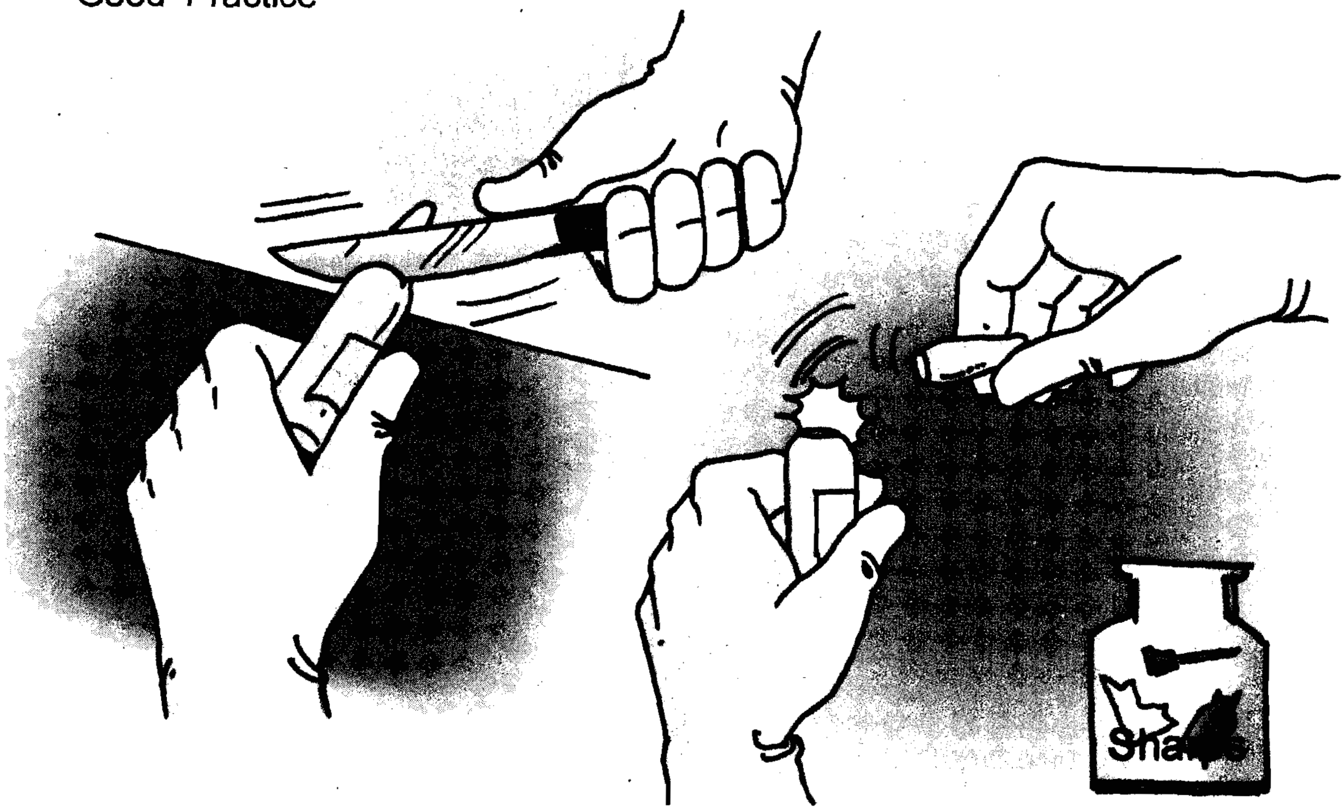
After the session the trainee will be able to:

Describe the methods of decontamination and disposal of glassware.

Bad Practice



Good Practice



Breaking ampoules

LESSON 14

Management of Plastic

Plastic waste found in health care facility; how its use can be reduced; how is it disposed at present; advantages and disadvantages of present method;

List the plastic waste material generated in the health care system.

How much it is?

Can it be collected; contained in a bin separately?

Can we send it to nearby plastic recycler? Is it a feasible option?

Is deep burial a better option?

Can we reduce use of plastics?

What are the hazards of incinerating plastics?

Following options are discussed and conclusions made by consensus:

Reduce use of plastics

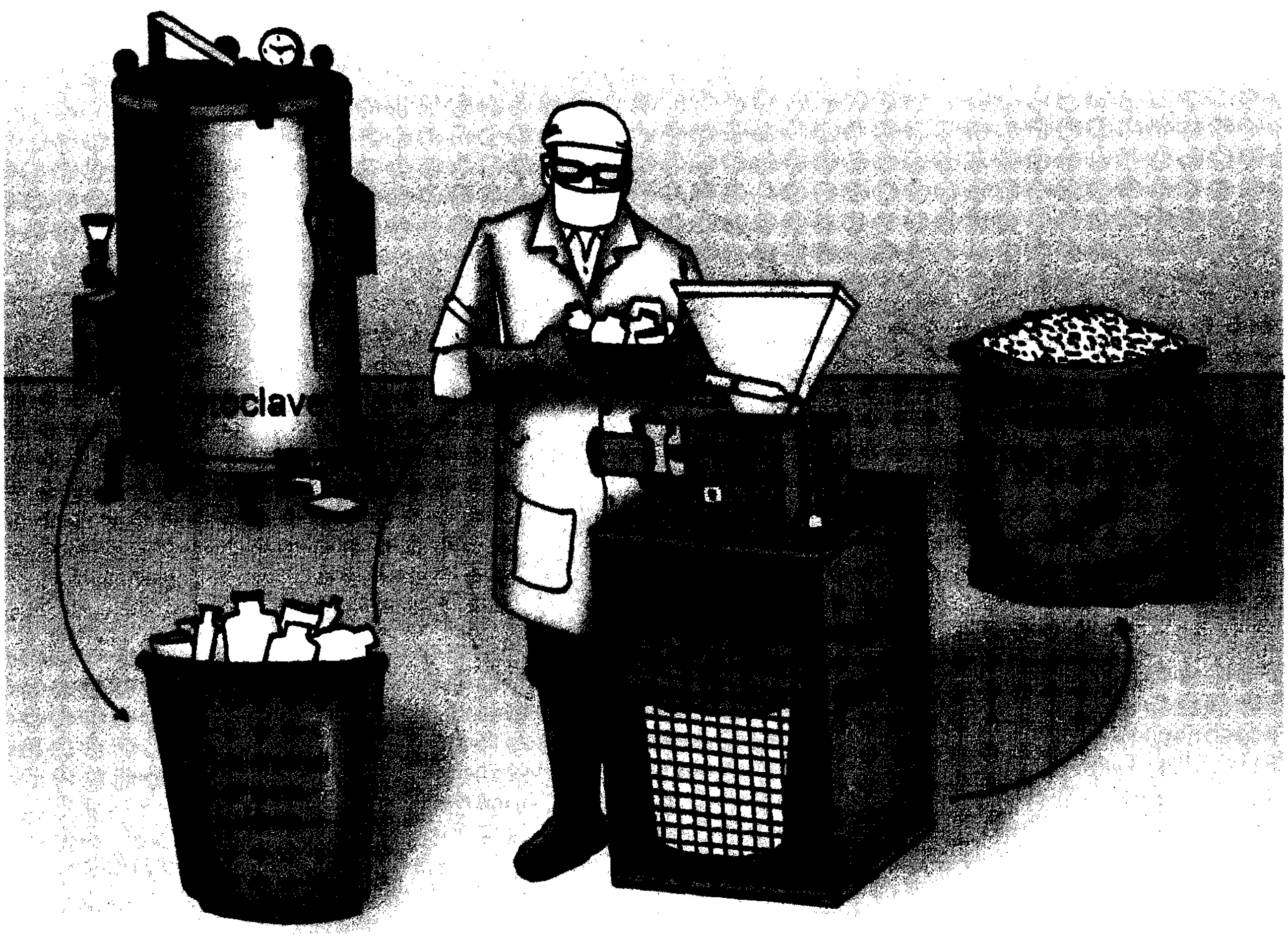
Value of segregation

Is it possible to recycle?

Is it possible to reuse some plastic material?

After the session the trainee will be able to:

List different plastic waste generated in health care systems.
Steps to manage plastic waste in the health care facility.



Disinfection and shredding of plastics

Disinfection of used plastics

Lesson 15

Management of Liquid Waste

What constitutes liquid waste?

Blood, plasma, pus, any discharge from wounds/mucous membranes, chemicals. In principle, urine and faeces also constitute liquid waste.

Following activities/situations result in generation of liquid waste:

Remains of lab samples; samples after subjecting for examination; spills of samples while carrying; spills in lab; wound dressing/invasive procedures/delivery/surgery/trauma due to accidents/blood bank procedures/haemorrhagic diseases/trauma to health care personnel in health care settings, waste water from toilets, laundry, wash rooms, wash basins.

What is the usual practice?

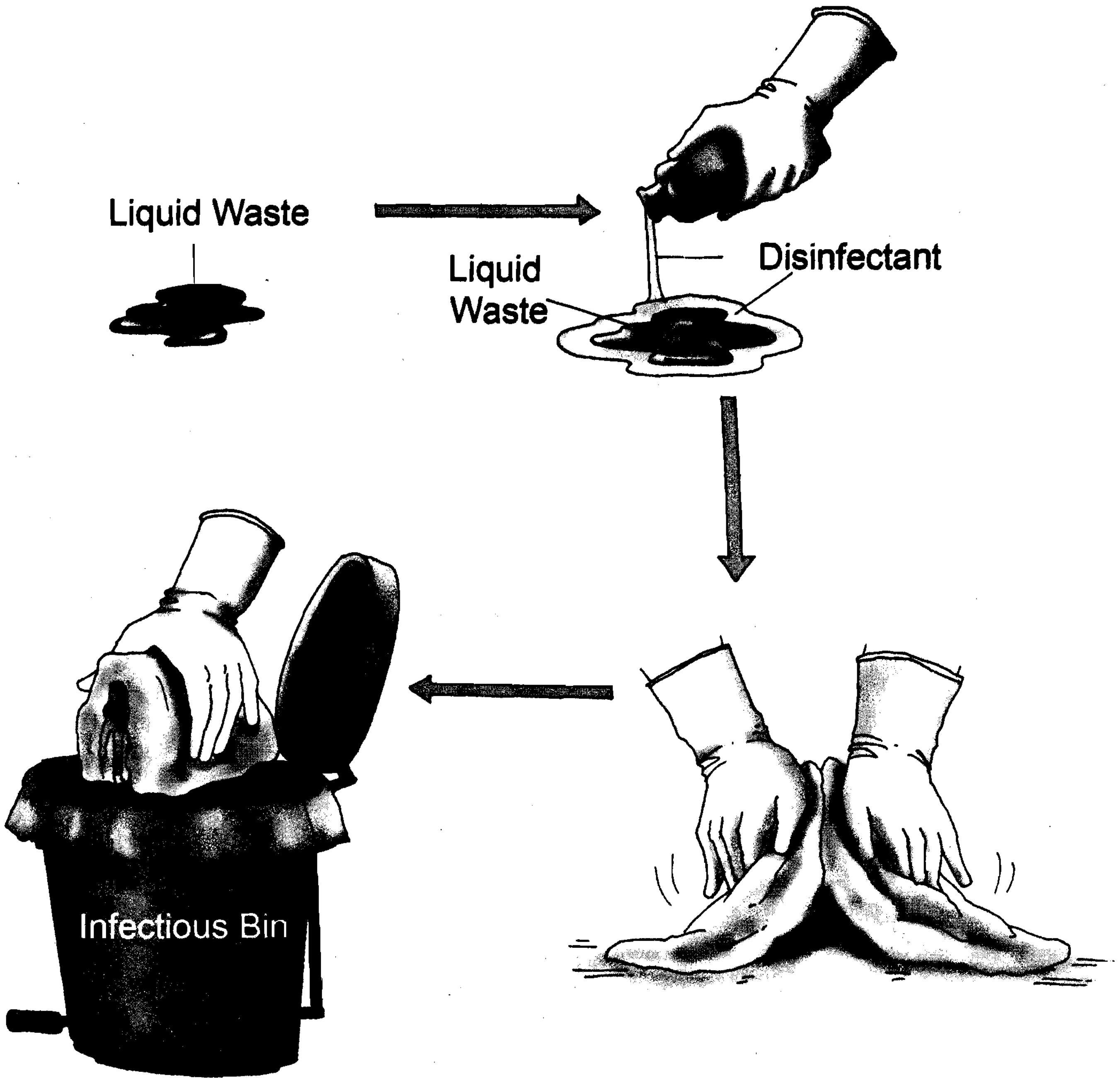
Treating it casually; and to leading it to underground drainage system wherever it exists; throwing it indiscriminately to open drain, closed drain; washing hands with soap and water (often practiced). Often gloves not used by lab/nursing/doctor/helper staff.

Bio-medical waste management rules say—liquid waste needs to be decontaminated before disposal. Pour equal quantity of disinfectant, as the spill/liquid waste irrespective of quantity; leave a contact period of 30 minutes; where posibble lead to underground drainage or collect in swab and dispose in bin.

The trainer will discuss the rules regarding liquid waste management there.

After the session the trainee will be able to:

Identify the areas of liquid waste generation in the health care facility and steps for managing liquid waste.



Management of body-fluid spills

LESSON 16

Use of Disinfectants

What is disinfection of waste?

Disinfection is chemical treatment of waste to reduce its infectivity.

The most practical use for liquid disinfectants is surface decontamination and decontaminating wastes prior to final disposal. If liquid disinfectants are used, they must be effective against the organism(s) present. No liquid disinfectant is equally useful or effective under all conditions and for all viable agents.

List commonly disinfectants used

Sodium hypochlorite solution

Cresol

Savlon

Bleaching Powder solution

Cresol (white)

a) Supplied in 25 per cent strength

b) Uses: disinfection of soiled linen (clothing) in wards

c) Preparation: 1 litre chemical in 9 litres of water gives 2.5 per cent ready to use solution

d) Method of Use: soiled linen should be immersed deep into 2.5 per cent cresol solution for 45 minutes to 2 hours

e) Disposal: underground drainage system

Savlon

a) Supplied in 7.5 per cent strength

b) Uses: disinfection of metal and glassware sharp

c) Preparation: 100 ml in 200 ml of water

d) Frequency of use: twice a week

e) Disposal: drainage system

Sodium hypochlorite

a) It contains chlorine and is supplied in 5 per cent strength

b) Use: 1 per cent disinfection solution for treating plastic waste such as tubing, syringes and rubber waste

5 per cent used for contaminated surfaces

c) Preparation: 1 Litre of 5 per cent chemical in 4 litres of water gives 1 per cent ready to use solution

d) Frequency of use: twice a day in preferably in a twin bucket containing sieved inner container

e) Disposal: drain out in sewage lines

Useful tips

Powerful disinfectants are hazardous and toxic; many harmful to skin and mucous membrane

Hypochlorite solution and Bleaching powder solution should be stored in dark and covered always

Hypochlorite, Savlon causes corrosion of metal sharps resulting in spoiling of containers.

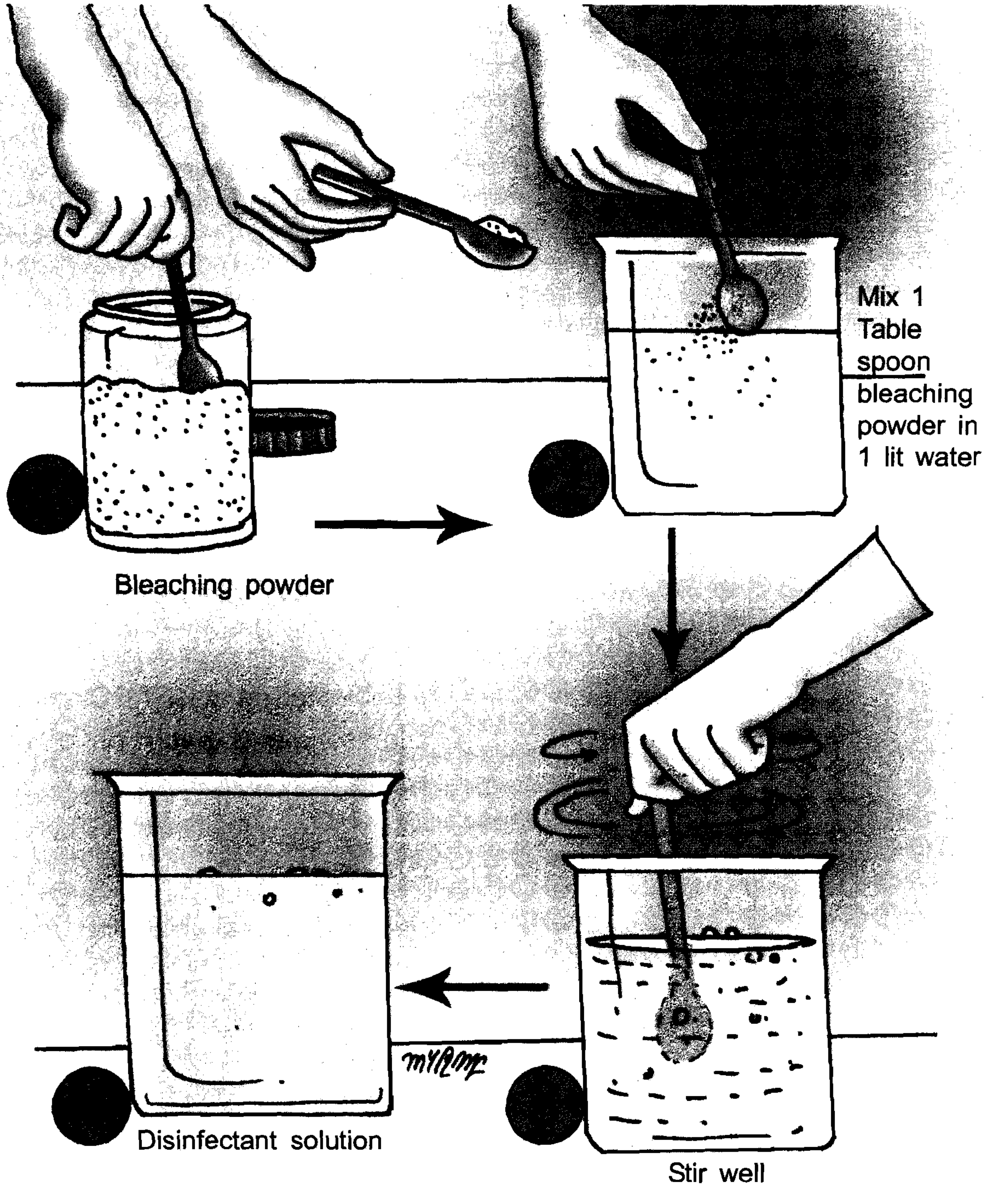
Tips for the trainer

The trainer is suggested to take stock of current practices, depending on available resources, these disinfectants are to be adopted for use. Bleaching powder solution needs to be kept in mind wherever resources are limited. It is as effective as others and strength can be adjusted by evaluation of disinfectants by different methods.

Trainees repeat the process.

After the session the trainee will be able to:

Demonstrate preparation of different disinfectant solutions and describe their use for infection control.



Preparation of bleaching powder solution

LESSON 17

Management of Soiled Linens

Handle soiled, contaminated linen as little as possible.

Wear gloves while handling soiled and contaminated linen

While carrying or transporting linen, place wet linen in leak-proof bags. Fold the linen with wet parts inside, and surround with dry linen when leak proof bags are not available.

Bag linen at the location where it is used. Do not sort linen in patient areas.

Wash and launder in hot water (at least 71°C or 160°F). If only cold water is available, use bleach or other chemical disinfectants along with soap and detergents.

After the session the trainee will be able to:

Demonstrate the proper method of managing linen.

Management of Soiled Linen

LESSON 18

House Keeping

The greatest risks of house keeping exposure to infectious agents are via needle stick injury e.g. improperly packaged waste sharps. Therefore all sharp instruments and equipment including needles and syringes must be disposed off in puncture resistant containers.

Small waste containers, which can be easily held away from the body, should be used in order to avoid injuries.

Do not insert bare hands into wastebaskets.

Use cleaning equipment to clean the underside and other inaccessible areas of cupboard.

Do not clean by hand.

House keeping refers to a situation where everything has a place and everything is in its place after use. It is everyone's responsibility to help designated house keeping staff to help better house keeping

After this session the trainee will be able to:

Demonstrate good house keeping practices and help the house keeping managers with maintaining proper stocks and providing feedback of the system.

Good house keeping practice

LESSON 19

Record Keeping

Health care waste is harmful. It is to be handled/managed meticulously. Keeping track of amount generated, amount sent for disposal will help plan waste management system better. It helps to know load of waste/needed resources to manage in terms of equipment and manpower.

What counts will be useful?

Number of different counts of bags, counts of trolley trips, actual weighment of different colour bags.

Trainer explains to the trainee's records, which are normally kept. It should essentially include:

a) Waste quantification Register

b) Category wise recording of waste generated

c) Injury register—Describes type, nature and treatment (e.g. Tetanus Toxoid, antibiotics, dressing, PEP given)

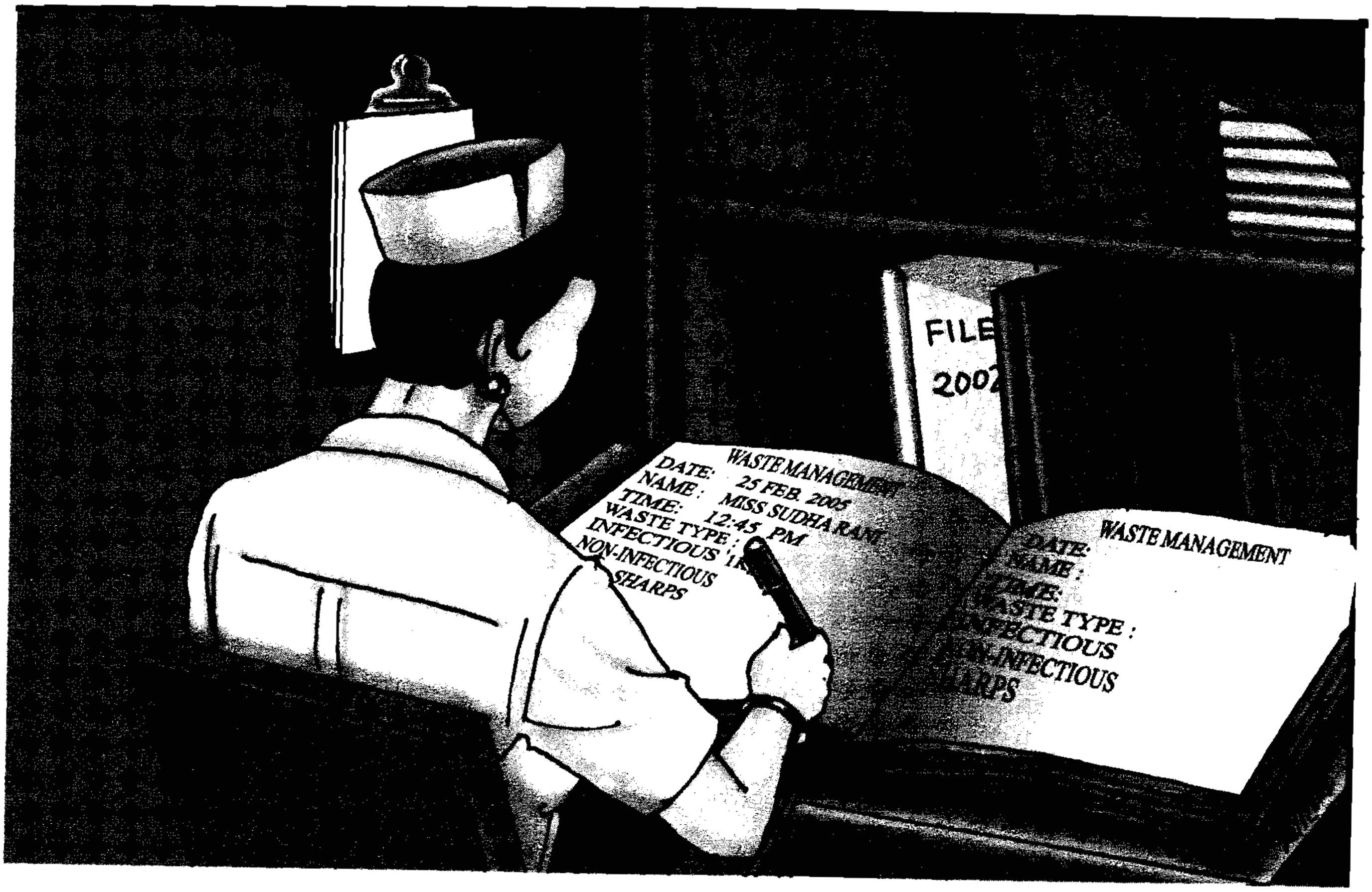
d) Log book of tracking of waste: Waste movement from different points of generation to waste storage room/ transportation.

Waste handlers help the waste manager in keeping these records accurately. Also, waste handlers who are literate assist the waste manager by actual recording. In other places, they report to nurse/waste manager to record.

Accident reporting/injury register should be provided at different locations within the health care settings. A point person be appointed to record the injuries and help in assisting subsequent treatment for the injury.

After this session the trainee will be able to:

Help in maintaining proper waste management records and report any accidents occurring due to health care waste.



Record keeping

LESSON 20

Duties of Employees

What are the duties of employees with respect to health and safety measures?

Responsibility of each health care worker for ensuring sound waste management system.

Discussion is made and following is arrived at:

All personnel especially ward boys, waste handlers who come in direct contact with waste need to:

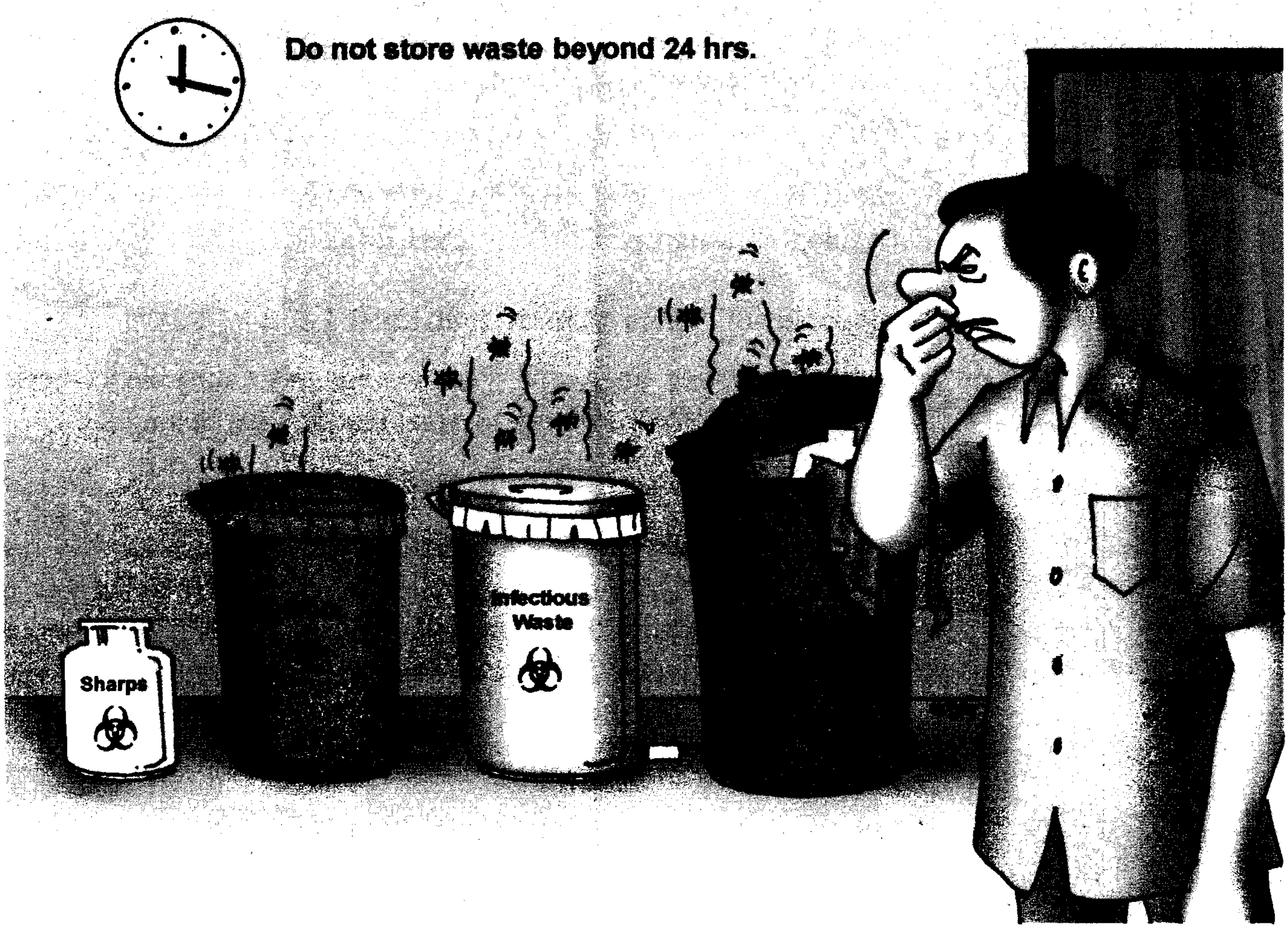
— Wear gloves, mask, gown, apron, and boots

— Undergo medical examination once a month

— Be immunized against tetanus, typhoid, hepatitis B

— Wash hands thoroughly after waste handling activities.

Report any illness/injury (major/minor) to the management of the hospital.



Manage waste now—It is our responsibility

2.2 CONCLUDING SESSION

The concluding session of the training includes the field visits, development of action plan and feedback on the training.

Field Visit

After the hands-on training with the health care workers a field visit of the waste handlers will help them in better understanding the issue. Some tips for the field visit are:

- Brief the health care workers about the field visit.
- Make groups and visit different areas in the health care facility.
- Assist the waste handlers in recording their field observations with the help of pre-structured form.
- Falicitate discussions based on their observations in the field.
- Develop an action plan for establishing a waste management system
- Develop an action plan at individual level.

Development of Action Plan at Individual Level

Steps for developing an Action Plan for commissioning better health care waste management systems in your Health Care Setting:

Step I

Meet your immediate supervisor in the organization, confer with him learnings in this course and take him/her to confidence. Enlist few of your colleagues/others in the organization whom you think are likely to react to you positively. Make a presentation to them and all your colleagues–formally/informally.

This kind of preparation will be useful as waste management is an attitudinal issue.

Step II

Plan a meeting with Infection Control Committee and personnel in charge of waste management along with your immediate Superior, Nursing Chief and Head of the Institution. Plan a situation analysis exercise to find out:

- Number of points of generation of waste
- Practice of segregation
- Practice of collection
- Containers used

- Final management procedures
- Procedure of liquid waste management
- Procedure of disinfection
- Procedure of decontamination
- Management of plastic/sharps/intact and broken glass
- Human resource directly handling waste
- Safety practices/devices used, etc.
- Training status of staff

Method can be interaction in a meeting; focus group discussion with Helper staff/Nursing staff/Lab staff/Doctors/Office staff; formal survey using a questionnaire, over a period of 10 to 15 days. Alternatively, a team of three people—a doctor, a nurse and a helper staff take a round in all locations—points of generation and make a survey.

It is useful to make SWOT (Strength, Weakness, Opportunity and Threat) analysis sitting with staff of each ward/point of generation of waste—which may be lab/operation theatre/OPD, etc. This exercise may take a couple of days, but worthwhile to involve every one in planning/strengthening the system.

Always remember—waste management is the responsibility of all from Chairman to helper in your set up.

Step III

Prepare a report, share with the group, which participated in the meeting. Prepare a waste map indicating points of generation of waste; transport route. Identify good and negative points in the existing system and find solutions to negative points including necessary action and required resources—manpower, money, and materials. Prepare a plan, set small targets to achieve, e.g., in a setting where waste management is very poor, it is useful to start with building a system for one kind of waste, e.g., sharps—develop a system. It is likely that staff themselves will evolve better systems for all wastes in a few days time.

Remember! Small, incremental changes make difference. Attempt towards perfection is perfection itself.

Step IV

Constitute a waste management committee which may a be a separate committee or a sub-committee within infection control/maintenance or administration or housekeeping committee in your institution. You will find details of such a committee in other modules. The committee may decide frequency of meetings, roles and responsibilities.

Step V

Develop following system over a period of time taking help from members of the committee. Following may be a good plan:

First Month

Design a system for segregation, display in all points of generation, and train one person from each point of generation. Trainer's guide and waste handler's manual will be useful for you to identify resource and plan training in your set up. Use the system for 3 months; take feed back from each point of generation and adopt as a general rule in your set up.

Fourth Month

Design a better system for transportation based on your situation analysis, use the system for 3 months, take feedback from people involved in transportation from each point of generation and then adopt it as a rule.

Seventh Month

Design a system for liquid waste management. Seek the support of your supervisor and Head of the Institution to initiate an effluent treatment plant, if it does not exist already. It is cost intensive, but need to be introduced. Till it is in place, use of bleaching powder/sodium hypochlorite/other agents will help.

Eighth Month

Arrive at/review existing standard operative procedures for waste management, disinfection, decontamination, safety devices used and display in all points of generation of waste, use it for three months, take feedback and adopt.

Eleventh Month

Review system of waste quantum reporting/injury reporting by staff in all points of generation of waste. It is essential that an injury register and waste management register is maintained in each point of generation of waste and even nil reporting is made everyday. It is essential that these registers are reviewed by Head of the Clinical Dept./Service Dept.

once a week and reviews (immediately) if an injury is reported. System of Post Exposure prophylaxis for prevention of HIV/AIDS is to be essentially introduced—without scaring/causing apprehension to the staff.

Twelfth Month

Review universal precautions for prevention of HIV/AIDS followed in the institution. It may be displayed in each point of generation of waste, used, reviewed and adopted.

Thirteenth Month

It is useful to do an evaluation of systems of health care waste management and critically review the knowledge, attitude and practices of staff. Replanning for year II may be part of this exercise.

These are to be tailor-made to suit your setting.

Always remember! These steps are not prescriptive for your setting.

Some steps can be simultaneous. All steps can be simultaneous if you have a system, adequate resources already. Remember—training, retraining must be the rule. A demo point of generation—if developed with model procedures will save your training time. You may consider visit to demo point must for all new staff, all new medical and nursing interns and students. This visit may precede formal training.

If your institution is too large, you may start working in few points of generation—develop model pockets—you will wonder—small steps, incremental steps, make difference.

Trainer will facilitate a discussion among all waste handlers to list what did they learn in the training as well list the learning points:

1) Segregation at source
2) Sharps Management
3) Occupational safety
4) Secure collection and transportation
5) Final treatment and disposal
6) Hospital hygiene

Also, waste handlers will share what changes they will adopt at individual level.

Pre- and Post-test Questionnaire

Pre- and post-test questionnaire with simple questions can be circulated among the participants to assess their knowledge on health care waste management.

A sample questionnaire is attached below which can be modified and used by the trainer. The responses to the questionnaire will help in identifying the training needs and addressing them during the future training sessions.

Sample Questionnaire

1) What is your role in health care waste management system in your facility?

2) Describe three main steps of health care waste management cycle?

3) Name the protective gears worn while handling waste.

4) Segregation of waste should be carried at:

    a) Point of generation

    b) Transportation of waste

    c) Final disposal

    d) All of the above

5) Name five waste types to be disposed in infectious waste bin?

6) Name five waste types to be disposed in non-infectious waste bin?

7) List three hazards associated with health care waste.

8) Sharps are collected in ________________ containers.

9) How do you transport sharps from your ward to final disposal site.

10) Describe the steps of waste collection from the point of waste generation to the final disposal of waste within your hospital.

2.4 FURTHER READINGS

Experiences during implementation of Malleswaram Project.

Government of India (1998), *National Guidelines on Hospital Waste Management based upon the Bio-Medical Waste (Management and Handling Rules) 1998.*

Health Care Waste Management Cell, Dept. of Community Medicine, *Health Care Waste Disposal–An Exploration,* M.S. Ramaiah Medical College, Bangalore (1997).

Health Care Waste Management Cell, Dept. of Community Medicine, *Thirteen Steps Towards Better Waste Management in PHCs,* M.S. Ramaiah Medical College, Bangalore (2003).

Ministry of Environment and National Resources, Sri Lanka, *National Strategy for Solid Waste Management.*

Pruthvish *et al., Information and Learning Units for Safe Management of Health Care Waste–A Training Manual,* Health Care Waste Management Cell, Dept. of Community Medicine, M.S. Ramaiah Medical College, Bangalore, India.

Srishti/Toxics Link, *Medical Waste Fact Sheet,* December 2002, *Waste Fact Sheet No. 17,* July 2003.

Waste Concern Report on a Cross Sectional Survey of Selected Health Care Establishments for the Situation Analysis of Bio-medical Waste Management in Dhaka City, www.wasteconcern.org

WHO (2001), *Decision Making Guide for Managing Health Care Waste from Primary Health Care Centers, Vaccines and Biologicals (VAB) Protection of Human Environment (PHE).*

WHO (2003), SARS Team of South East Asia and Western Pacific Regions of WHO, *Practical Guidelines for Infection Control in Health Care Facilities* (Draft).

WHO (Copenhagen), "Starting Health Care Waste Management in Medical Institutions–A Practical Approach", *Health Care Waste Practical Information Series No. 1.*

Take Home Message

Employee's role and responsibilities:

— The employees need to meticulously comply with specifications under waste management plan of the Health Care Institution.

— Universal precautions for prevention of infectious diseases.

— Reporting of injuries/illnesses.

— Usefulness and need for use of protective devices.

— Post exposure prophylaxis for prevention of HIV/AIDS, Hepatitis B, C.

— Preplacement and periodic medical examinations.

— Immunization against tetanus, typhoid and hepatitis B.

Hence all personnel especially ward boys, waste handlers who come in direct contact with waste need to:

— Wear gloves, mask, gown, apron, and boots.

— Undergo medical examination once a month.

— Be immunized against tetanus, typhoid, hepatitis B.

— Wash hands thoroughly after waste handling activities.

Report any illness/injury (major/minor) to the management of the hospital.

Certificate in Health Care Waste Management (CHCWM)

ASSIGNMENTS 2011

CHCWM/AS 1-2

School of Health Sciences
Indira Gandhi National Open University
Maidan Garhi, New Delhi-110 068
2011

Dear Student,

There are two assignments in total and **both** these assignments are compulsory for the successful completion of the programme. Please note that the assignments carry a weightage of 30% marks towards the final evaluation in theory component and ***submission of related assignments is a prerequisite*** for appearing in theory term-end examination for respective papers. A minimum of 40% marks per assignment is required for successful completion of the Programme. The subject area of assignments and its last date of submission are mentioned below:

Last date of submission of assignment	Course code	Block	Max marks
May 31st, 2011	BHM 001	1,2,3,4	30
May 31st, 2011	BHM002	1,2,3,4	30

Please take note of the following points before writing your assignments:

- Use only foolscap size paper for writing your responses. Only handwritten assignments will be accepted. Typed or printed copies of assignments will not be accepted.
- Tie the pages after numbering them carefully.
- Write the question number with each answer.
- ***All the questions are compulsory.***

Assignment of BHM 001 and BHM 002 will be evaluated for 30 marks each.

Suggestions for writing an assignment:

Read the assignments carefully. Go through the units on which the answers are based. Draw a rough outline of your answer. Make a logical order. Then write your answer neatly and submit. Give illustrations and tables wherever necessary. Do not copy the answers from the Blocks.

Answer each assignment in separate sheets. On the first page of the assignment response sheet, write the course code, course title, assignment code, name of your programme study centre and date of submission. Your Roll No., Name and Full address should be mentioned in the top right corner of the first page. The first page of your response sheet should look like the format given.

Course Code ____________________	Roll No.
____________________________	
Course Title ____________________	Name
____________________________	
Assignment Code ________________	Address

Please **submit the assignments (answer sheets) to your Programme In-charge only.** You may keep a xerox copy of the answer sheets for future reference. If any problem regarding the writing and submission of the assignments please contact the:

Dr. Ruchika Kuba

Programme Coordinator

Certificate in Health Care Waste Management

School of Health Sciences

IGNOU, Maidan Ghari

New Delhi- 110068

Email: rkuba@ignou.ac.in

Assignment 1

BHM 001: Fundamentals: Environment and Health, Health Care Waste Management Regulations

Course Code: BHM-001
Assignment Code: BHM-001/AS-1
Maximum Marks: 30
Due Date: May 31st , 2011

Answer all the questions

Marks 6×5=30

Answer the following question within 50-100 words

1) Explain the terms- trophic level, food chain, food web and bio magnification

2) Write short note on management of radioactive waste

3) Effect of mercury on environment and health

4) Hospital acquired infection

5) What is the current status of biomedical waste management in Maldives