UNIT 14 EFFECTS OF SOIL AND WATER POLLUTION

Structure

14.1 INTRODUCTION

Environment includes water, air and land and inter relationship which exists among them and human beings, other living creatures, plants, micro-organism and property. Environmental pollutant means any solid, liquid or gaseous substance present in such concentration as may be or tend to be injurious to environment. Environmental pollution means the presence of pollutant(s) in the environment. Pollutants released to environment are interchanged between three components of environment viz. air, water and soil and ultimately find their entry into water system and hence result in the exposure of animals and humans.

Soil pollution is usually a consequence of insanitary habits, various agricultural practices, and incorrect methods of disposal of solid and liquid wastes, but can also result from fallout from atmospheric pollution. It is closely linked with the ultimate fate of those substances that are unlikely to undergo the natural recycling processes.

Objectives

After studying this unit, you should be able to:

- define environmental pollutant and environmental pollution,
- explain the pollution cycle and general health effects of pollution,
- classify biological agents producing various diseases,
- describe the hazards due to chemical and radioactive pollution,
- explain the soil pollution by biological disease agents,
- explain solid wastes pollution,
- discuss the effects of agricultural chemicals on humans and animals, and
- describe the total effects of water and soil pollution on the health of humans and animals.

14.2 INDUSTRIAL POLLUTION CYCLE

Pollutants in Soil and Water

Pollutants released to soil, however, enter into animals and humans through food. Fig. 14.1 gives route of exposures of pollutants in animals and human.

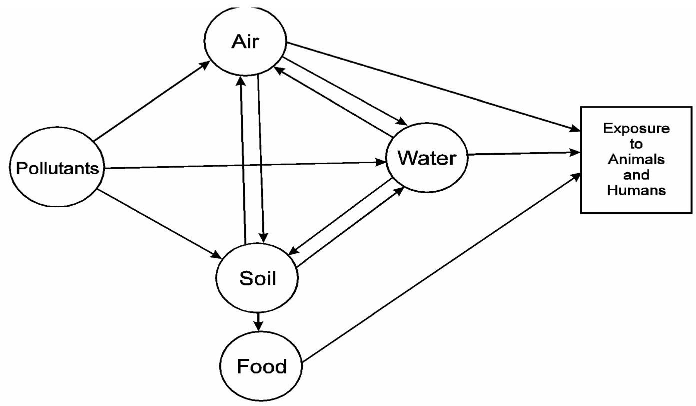

Fig. 14.1: Route of Exposures of Pollutants in Animals and Humans

Industries are the major source of environmental pollution. They pollute air, soil and water. These pollutants are subjected to treatment as control measures. However, with all the efforts of pollution control, the end results are air pollution and pollution of surface and ground water. Industrial pollution cycle is illustrated in Fig 14.2

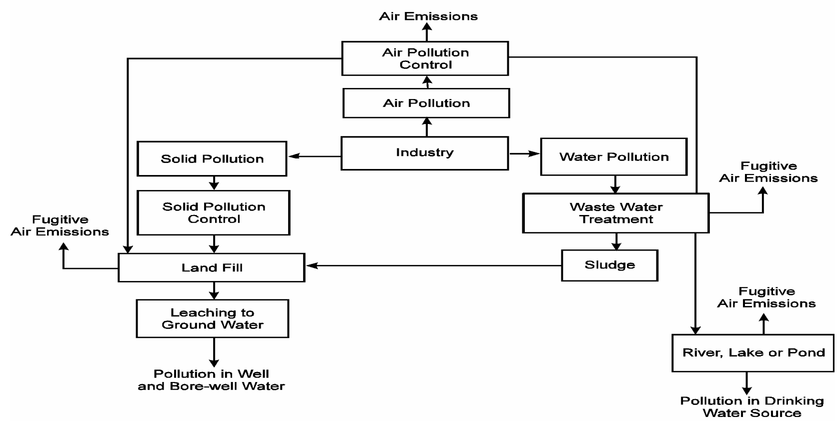

Fig. 14.2: Industrial Pollution Cycle

Adverse effects of pollutants on the health of animals and humans depend on the type of pollutant, duration of exposure and their concentration. Toxic pollutants in higher concentration may cause instantaneous death. The same pollutants in low level may produce reversible or irreversible health impairment and several diseases. Fig.14.3 gives adverse effects of pollutants on animals and humans.

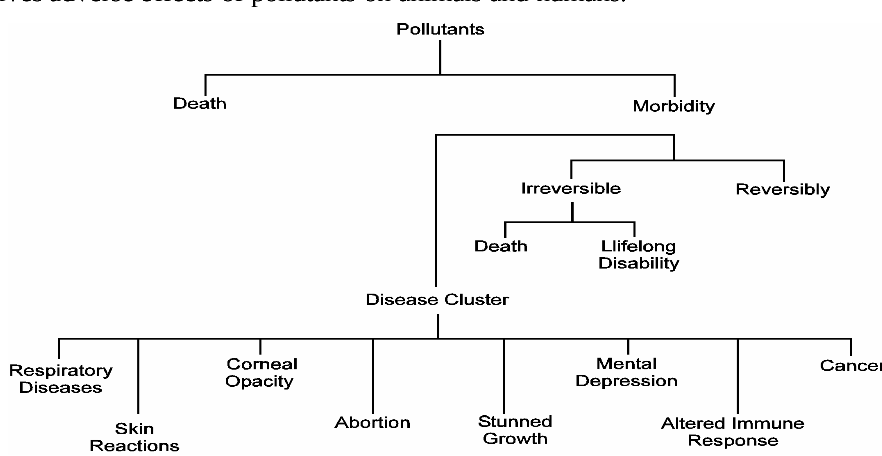

Fig. 14.3: Adverse Effects of Pollutants on Animals and Humans

Exposure from Water Pollutants

Pollutants in water to which animal and human are most likely exposed can be categorised into eight groups:

1. ***Domestic pollutants***: These include detergents, pigments and propellants.
2. ***Naturally occurring substances***: Several toxins are produced by plant and animals which enter into water system and produce ill effects on health.
3. ***Food additives***: Some food additives such as preservatives are converted into toxic compounds. For example, the nitrate which is added to meat to give red colour, is converted to highly toxic nitrosamines. Several bacterial toxins are also generated.
4. ***Stimulants***: Nicotine released from tobacco and other stimulant drugs and their metabolites are included in this group.
5. ***Industrial wastes***: Unutilised materials from various industries are released into drains and are called *industrial wastes*. Heavy metals and organics are the principal toxic components of industrial wastes.
6. ***Pesticides***: These include bacteriocides, herbicide, fungicides, rodenticides and insecticides. Arsenicals and mercurials are the inorganic pesticides whereas organochlorines, organophosphates and carbamates are the pesticides of organic origin.
7. ***Medicaments***: Drugs are the integral part of human life. These drugs and their metabolites also produce adverse effects.
8. ***Radioactive waste***: Nuclear power plants use radioactive substances as nuclear fuel. Several electronic gadgets also use radioactive substances. They are also used in laboratories and hospitals. These activities discharge wastes containing *alpha*, *beta* and *gamma* emmiters, which produce ill health effects. Fig. 14.4 illustrates how animals and humans are exposed from various pollutants.

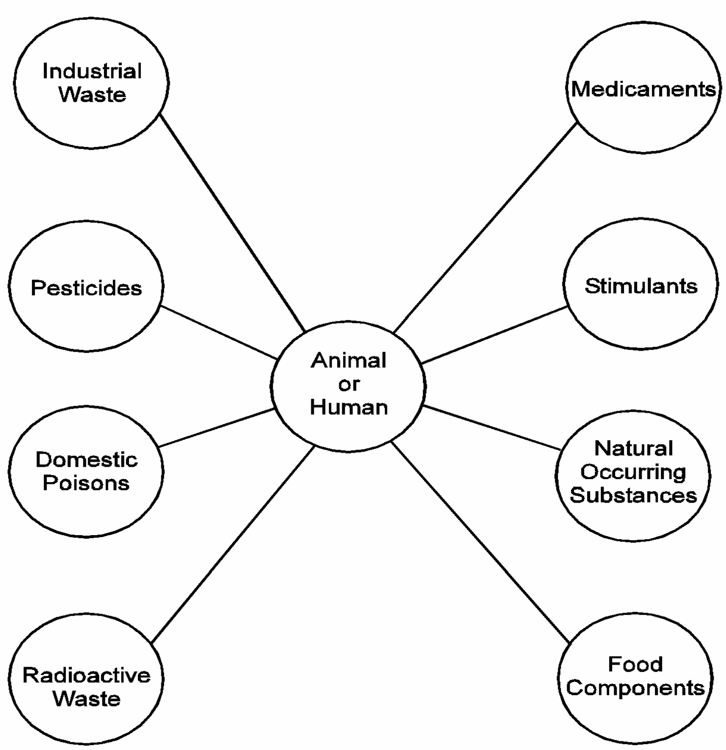

Fig. 14.4: Exposure to Human and Animal from Water Pollution.

SAQ 1

What are various components of the environment?

....

....

SAQ 2

Name five pollutants to which animal and human are likely to be exposed.

....

....

....

....

14.3 WATER-RELATED DISEASES

Human health is affected by water pollution either through its direct ingestion or its use in personal hygiene, agriculture, industry and recreation. Water associated health hazards may be divided into two categories:

- Hazards from biological agents
- Hazards from chemical and radioactive pollutants

14.3.1 Biological Hazards

(i) Water associated hazards from ingestion of biological agents

The principal biological agents transmitted through ingestion are:

- pathogenic bacteria
- viruses
- parasites

Pathogenic bacteria: Pathogenic bacteria, transmitted directly by water or indirectly through water to food, constitute one of the principal sources of morbidity and mortality in many developing countries. They include the causative agents of disease like *cholera, typhoid, diarrhoea, dysenteries* and *other enteric infections*. Bacterial infections, especially those caused by the *salmonella group* may also be transmitted by shellfish grown in contaminated waters, unless a sufficient period is allowed for self-cleansing in tank containing pathogen-free water treated with chlorine or by ultraviolet light. The principal diseases attributed to the ingestion of water borne bacteria are given below:

- Cholera
- Typhoid fever
- Bacillary dysentery

- Paratyphoid fever
- Gastroenteritis
- Infantile diarrhoea
- Leptospirosis
- Tularaemia

Viruses: The most commonly present viruses in polluted water and sewage are *enterovirus*, *adenovirus, recovirus*, and *virus of infectious hepatitis*. There is ample epidemiological evidence that infectious hepatitis occurs due to intake of polluted water.

Parasites: The most common parasite, which is ingested through water is *Entamoeba Hystolytica*. This parasite is the causative agent of both intestinal amoebisis and extra-intestinal forms of the disease, such as amoebic liver abscess. It is wide spread throughout the warm countries of the world and at other places where sanitary conditions are poor. Fine filtration, as practices for the removal of bacteria, is both effective and essential against the vegetative and encysted amoeba. The guinea worm causes *dracontiasis*. This parasite is transmitted mainly through open village wells, step wells and ponds infested with the copepod intermediate host.

Some intestinal helminthes such as *Ascaris lumbricoides* and *Trichuris trichiurs* may also be water borne, although ingestion of contaminated soil is the normal means of transmission. *Distomatosis* is another parasitic disease that may be caused by taking contaminated water containing cysts. *Hydatid* disease is occasionally transmitted to humans and animals through drinking water contaminated with the excreta of the primary hosts.

(ii) Health hazards from biological agents transmitted through water contact other than ingestion.

In countries like India, water in rivers, ponds, canals and lakes is used for ablutions, washing of cloths, disposal of human excreta and various other domestic uses. These waters, thus, become highly polluted and serve as an important vehicle for the transmission of enteric infections, such as *cholera*, *typhoid, fever* and the *dysenteries*. The communicable diseases such as *schistosomiasis* are spread by the penetration of parasites into the skin and certain mucous membranes.

Schistosomiasis is a chronic, insidious, debilitating disease that may cause serious pathological lesions, sapsenergy, lowers resistance and reduces output of work. The accelerated construction of artificial lakes, reservoirs and water impoundment to meet the needs of agriculture and industry leads to an increase in fresh water snail populations and corresponding increase in sehistosomiasis if preventive measures are not taken.

The disease in humans is chiefly due to three species of nematodes, namely S*ehistosoma mansoni*, S.*Japonicum* and S.*haematobium*. The first two species give rise to intestinal manifestations while the third is the causative agent of *genitourinary* or *vesical sehistosomiasis*. The eggs released in faeces or urine, hatch on reaching a free body of water, where they penetrate the snails. From snails they emerge in the form of cercariae and infect humans. Penetration through the skin occurs during wading, bathing etc. Water flowing with only a very gentle current, as in slow moving canals, is preferred by all species of aquatic snail hosts.

Other parasitic diseases where entry is through the skin are *encyclostomiasis* and *stronglyoidiasis*. Necator americabus and Ancylostoma duodenale are the hook worms (round worms) responsible for most cases of *ancyclostomiasis*. The eggs passed in the faeces of the infected persons hatch and larvae emerge that develop into filariform stage which infect the humans. *Strongyloidiasis* is caused by the nematode strongyloides intestine, which inhabits the submucous tissue of the small intestine. The mode of transmission is identical to that of *ancylostomiasis*. Water serves as medium where these infective agents are swallowed and infection is usually acquired by skin penetration from soil or by auto infection in the case of *strongyloides*.

Leptospirosis is the principal bacterial infection transmitted from vertebrate animals to humans through direct contact with water. The natural hosts are wild and domestic animals that excrete leptospires in urine and the humans are infected through the skin and mucous membranes by contact with water from contaminated ponds, canals, rivers etc.

(iii) Health hazards by water associated insect vectors

The most wide spread disease caused by water associated vectors is malaria, which is transmitted by the *anopheline* mosquito. *Onchocerciasis* or river blindness, is associated, under natural conditions with clear springs running over rocky beds. In artificial works of water resources development, the same conditions may arise on dam spillways or concrete lined channels if suitable precautions are not taken. The disease transmitted by black files is of considerable health, social and economic importance in the vic inity of breeding ground for the vectors where large preparation of the resident population may become partially or completely blind. Other disease of similar nature includes *yellow fever* transmitted by water breeding mosquito; trypanosomiasis, or *sleeping sickness* and *filariasis*.

Filariasis, which affects more than 250 million people throughout the world, continues to be one of the major parasitic infections. The causative organisms of the disease are *Wuchereria bancrofti* and *Brugia malayi*. The amount of infection and disease is increasing due to vast popultion movements and growth of urban ghettos in which breeding sites for the major vector, *Cultex pipiens fatigans* have greatly increased.

Nuisance Organisms

They are certain organisms which pose indirect hazards. They may make safe water unpalatable or unattractive, or interfere with treatment and distribution processes. Such organisms include biological slimes that accumulate on the interior surface of mains and upon which methane utilizing bacteria may grow. Algae and bryozoal growths such as *Plumatella* may interfere with the operation of filter, mollusks may choke mains, crustaceans and nematodes, which are not pathogenic may harbour bacteria and viruses in their intestines. Harbouring of bacteria and viruses in the intestines, protects possible pathogens from destruction by chlorine. Certain algae may impart bad tastes and odour to water. Some of the nuisance organisms normally found in drinking water and their effects are given in Table 14.1.

Table 14.1: Nuisance organisms and their effects

Organisms	Effects
Biological slimes	• Choking of treatment plants and distribution systems. • Support for methane utilizing bacteria • Risk of rendering water unacceptable
Molluscs Plumatella, Algae Assellus	• Choking of water mains • Interference with filtration • Risk of rendering water unacceptable

Nematodes	• Possible concentration of pathogens

14.3.2 Chemical and Radioactive Hazards

Some chemical pollutants (e.g., nitrate, arsenic and lead) when present above a certain level may be toxic when ingested through water. However, other constituents such as fluorides may be essential to health and are beneficial if present in small concentrations but toxic if taken in larger amounts. Certain other substances or chemical characteristics may affect the acceptability of water for drinking purposes. They include substances which cause bad odour or taste, acidity or alkalinity, anionic detergents, mineral oils, phenolic compounds, and naturally occurring salts of magnesium and iron, as well as sulphate and chloride ions, if present in excessive concentrations. Both international and national criteria and standards have been established to provide a basis for the control of human exposure to many of these substances through ingestion of polluted water. Ingestion is, however, only one possible pathway to exposure. Man can be exposed to water pollutants through other types of direct contact, e.g., in recreation or the use of water for personal hygiene. The possible health implications of these non-drinking uses of water (including agricultural and industrial uses) are less well understood, and no international criteria or guidelines exist for the control of such exposure.

In addition to the possible effects of ingestion and other direct water contacts, chemical water pollutants may influence man's health indirectly by disturbing the aquatic ecosystems or by accumulating in aquatic organisms used as human food. For some pollutants, at the levels now existing in water bodies, these effects may be the most important public health aspects of water pollution, and should be considered particularly for compounds of toxic metals and organochlorine pesticides.

The various chemical and biochemical transformations that pollutants may undergo in the aquatic environment also deserve attention. Chemical change may affect their biological availability or toxicity, which may be either enhanced or reduced. Degradation or transformation products may appear that may be more toxic than the original pollutant. Little is known of these physical, chemical and biological processes and their mechanisms, yet they are essential to the understanding of the health implications of chemical water pollution.

Many water pollutants also appear in water and food, which are often more important sources of intake. Such pollutants include metals, organic substances resistant to biodegradation, and radionuclides. The assessment of pollutant levels in water should always be made in relation to the actual intake of drinking water and to the body burden resulting from other sources in a given locality.

Specific Pollutants

A few specific pollutants which are toxic and may be transmitted from source to humans by water are discussed below:

(i) Nitrates

The concentration of nitrates in surface waters is usually below 5 mg L^{-1}. Much higher concentrations are sometimes found in groundwaters. The consumption of water (or baby food preparations) with a high nitrate concentration may result in infant *methaemoglobinaemia*.

(ii) Fluorides

Fluorides occur naturally in many public water supplies and are regarded as essential constituents of drinking-water, particularly with regard to the prevention of dental caries in children. If the concentration of fluorides in drinking water is less than 0.5 mg L^{-1}, the incidence of dental caries is likely to be high. When present in concentration above 1.5 mg L^{-1} it can cause endemic cumulative fluorosis with resulting skeletal damage. It has therefore been recommended that the fluoride content of water should be kept within well-defined limits, which varies with water temperature.

(iii) Arsenic and selenium

Concentration of arsenic in surface water bodies is usually low. High concentrations have been associated with endemic arsenic poisoning and the so-called "blackfoot" disease. Arsenic is also known to accumulate in some marine organisms such as clams and shrimps.

Selenium seems to counteract arsenic toxicity. The specific protective action of selenium against the toxic effects of cadmium and mercury seems well established. Selenium levels in water appear to be subject to natural control by adsorption by sediments and precipitation. Selenium is a micronutrient in trace amounts but at higher concentrations, it may have adverse effects on mammals. Some studies have indicated that selenium increased the susceptibility to dental caries in early life.

(iv) Heavy metals

Heavy metals and their salts unlike most other pollutants occur naturally in the environment. They include all metals with atomic numbers greater than 23 and specific gravity more than 5. Heavy metals have attracted much concern because they are non-degradable, persist in nature for a long period, toxic to living organisms at fairly low concentrations and tend to either biologically magnify or accumulate in plants and animal tissues.

Surveys of **mercury** in natural waters have indicated its level to be generally below 0.1 $\mu g\ L^{-1}$. The average concentration of mercury (mainly of natural origin) in sea-water is of the order of 0.03 $\mu g\ L^{-1}$, but in contaminated areas, such as Minamata Bay in Japan, levels as high as 1 – 10 $\mu g\ L^{-1}$ were observed.

In both marine and fresh water environments (bottom sediments), most organic mercury compounds, except alkylmercury, decompose to give the inorganic form, which then gradually changes into the simplest alkylmercury, namely methylmercury, $(CH_3)_2Hg$. Methyl mercury is a very toxic compound having a high tendency to accumulate throughout the aquatic food chain. It appears that these transformations take place only if the mercury concentration is above 1 – 10 mg L^{-1}.

The well-known outbreak of *methylmercury* poisoning in Japan in following the consumption of polluted fish and shellfish was the result of discharge of mercury with wastewater into the sea. In water and soil, inorganic compounds of mercury are converted to organic compounds of mercury which are much more toxic than the inorganic ones. Our body has got the natural protective systems and it detoxifies mercury by binding it with S, Se and protein. The sulfahydryl group in the protein binds with mercury and makes it non-toxic, see Fig.14.5.

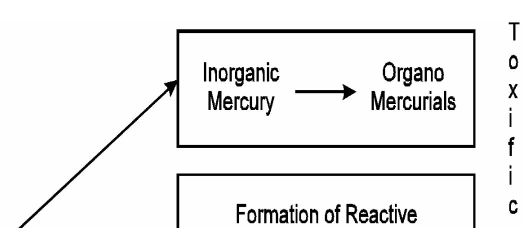

Fig. 14.5: Toxification and detoxification of mercury and chlorinated hydrocarbons in soil and water.

In addition to other sources, the **lead** content of drinking water may be due to the use of lead pipes or of plastic pipes stabilized with lead compounds. Natural and untreated water supplies contain about 0.01 – 0.03 mg L^{-1} of lead. The estimated average daily intake of lead from water (0.01 – 0.1 mg) is small, as compared with the total average daily intake form all sources, including urban air (0.33 – 0.44 mg). The possibilities of exposure to le ad are from storage battery production, lead smelter, paints and pigments. Target organs of toxicity of lead are bone marrow, muscles of stomach, gut and central nervous system as shown in Fig. 14.6. Lead accumulates in oysters and other shellfish. Little is known of the possible chemical transformations of lead in the aquatic environment.

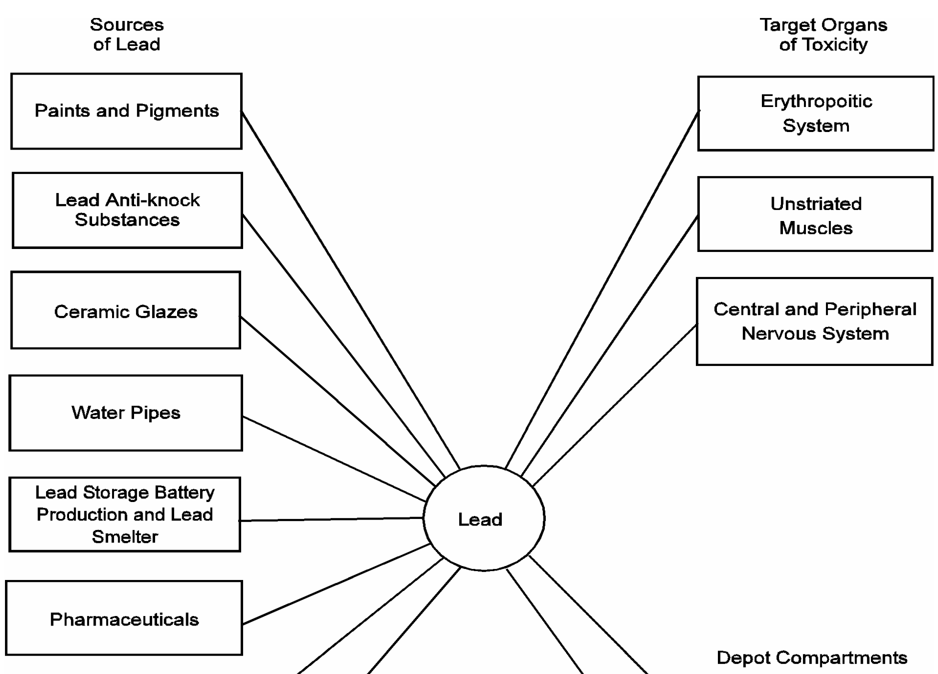

Fig. 14.6: Effect of Lead Present in Soil & Water on Animal & Man

Cadmium levels ranging from less than 1 $\mu g\ L^{-1}$ up to more than 10 $\mu g\ L^{-1}$ have been reported both in natural waters and in water consumed by humans. In addition to industrial discharges, metal and plastic pipes constitute a possible source of cadmium in water. Like other metals in solution, cadmium tends to be absorbed by suspended particles and in bottom sediments. For this reason, even in polluted rivers, the cadmium levels in the water phase may be below the detection limit. Irrigation water containing suspended solids casued pollution of rice paddy soils surrounding the Jinstsu River in Japan, the area where "*itai-itai*" disease had occurred.

The concentration of **nickel** in water, ranges from 1-70 $\mu g\ L^{-1}$. Our knowledge of the possible chronic effects of small quantities of nickel in environmental samples, including food and water, is very limited and much more research is needed. Other toxic elements and their compounds are found in natural and polluted water, usually in very small concentrations. They include *barium, beryllium, cobalt, molybdenum, tin, uranium, vanadium* and many others. Sufficient information is not available to assess their effects on health and to enable the safety levels to be determined.

(v) Water hardness and cardiovascular disease

Reports from several countries have shown an inverse statistical association between the hardness of drinking water and the death rate from cardiovascular diseases. Areas supplied with soft drinking water almost consistently experience a significantly higher prevalence of either arteriosclerotic heart disease, or degenerative heart disease, hypertension, sudden deaths of cardiovascular origin, or a combination of these.

There are also indications from one study that, in certain cities, where the water had become softer during the past few decades, the mortality from cardiovascular diseases increased, while the opposite was true for cities where the water had become harder. A few experiments on animals tend to confirm the view that soft water may be one of the factors responsible for the development of *atherosclerosis*.

However, the conclusion that soft water has harmful effects in human cardiovascular disease is based solely on circumstantial evidence and statistical associations; there is till no definite information as to which water components may be "protective" or "harmful", whether these are major constituents or trace elements, and whether it is their presence or absence that is responsible for the effects. The evidence for a possible connection between certain water characteristics and the development of cardiovascular disease is nevertheless suggestive enough to justify deeper studies.

(vi) Organochlorine compounds

Several groups of organochlorine compounds, are of interest in water pollution. They include *insecticides* such as DDT, aldrin, and endusulfan; chlorinated phenoxyacetic acids used as *herbicides* (e.g. 2,4,5-T); and *fungicides*, such as hexachlorobenzene and pentachlorophenol. Chlorinated aromatics are used mainly in industry and include chlorinated napthalenes and biphenyls.

There are two main sources of organochlorine pesticides in water: run-off from agricultural land and discharge of industrial wastes (from the manufacture and formulation of pesticides or their use as mothproofing chemicals). Because of their low solubility in water and tendency to be absorbed on solid surfaces, only traces of these compounds are found in raw and treated water. Residues reported in water surveys are mainly of insecticides carried on particulate matter suspended in water. However, much larger quantities may be found in mud and bottom sediments.

In the effluents of municipal sewage plants and in receiving waters, concentration of polychlorinated biphenyls (PCBs) typically ranges from a few ng L^{-1} to μg L^{-1} levels. They participate with sludge and are adsorbed by clays to such an extent that only barely detectable traces appear in the drinking water. Like some other organochlorine compounds, they are soluble in fat and hence tend to accumulate in aquatic animals.

Biochemical breakdown of some organochlorine compounds is slow, the time required for 50% degradation being of the order of 0.05-2 years. The compounds released to water and soil undergo conversions and result in the formation of substances with increased or lower toxic qualities. Toxification and detoxification both occur together, see Fig.14.5. Sources of organochlorine pesticides exposure, target organs of toxicity and deposition compartments have been illustrated in Fig.14.7.

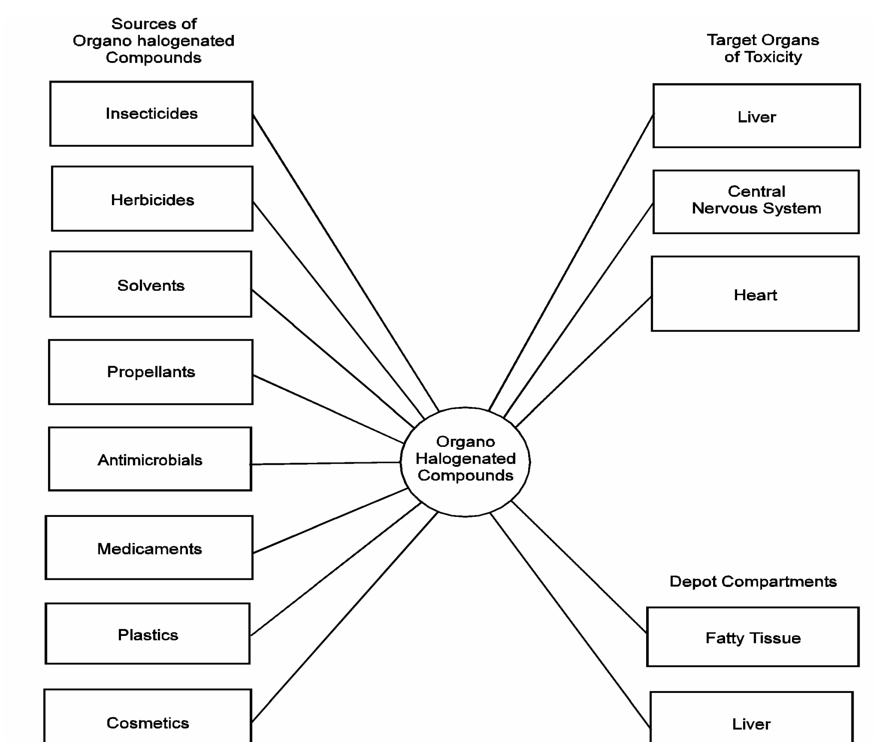

Fig. 14.7: Effect of Organo Halogenated Compounds Present in Soil and Water on Animal and Humans

(vii) Polynuclear aromatic hydrocarbons

Many polynuclear aromatic hydrocarbons (PAH), particularly benzo [a] pyrene (BP), have been found in water and other environmental media. Their solubility in pure water is very low, but it can be increased by the presence of fairly high concentrations of anionic detergents. This adsorption of PAH on surfaces is an important characteristics, both in relation to their presence in water and their removal in water treatment processes. The stability of PAH is affected by light and oxygen. The health significance of traces of carcinogenic PAH in fresh waters is not known. They are also present in the marine environment. BP contents upto 400 $\mu g\ kg^{-1}$ of dry sample have been detected in marine plankton.

(viii) Anionic detergents

Residues of alkyl benzene sulfonate (ABS), used as the surface-active component in synthetic detergent mixtures, cause foaming, particularly in turbulent reaches of rivers, and interfere with sewage-treatment processes and the self-purification of streams.

The introduction of more easily biodegradable linear alkyl sulfonates (LAS) in the 1960s has greatly helped to reduce these effects.

Detergent "builders" are chelating agents that produce a marked improvement in detergent properties. The most effective and the most widely used compound is sodium tripolyphosphate (STP). Ordinary sewage treatment processes do not remove phosphates and nitrates, and their increased levels in many lakes and rivers cause *eutrophication*. It is proposed that phosphates in detergents may be replaced by substances such as sodium salt of nitrilotriacetic acid (NTA). The toxicological data for NTA are incomplete, however, NTA alters the toxicity of metals by affecting their entry into the body, as well as their distribution and concentration in the tissues and poses a potential human hazard.

(ix) Radio nuclides

The radioactivity in natural sources of water is usually low and of no immediate health significance, except where water is drawn from deposits of highly radioactive minerals. Pollution by radioactive wastes, however, may be highly dangerous and should be dealt with at source rather than treating the water supply. Radioactive materials may be ingested directly through water supplies, but they may also be present in more concentrated form in fish, in shellfish (^{65}Zn), in edible seaweeds (^{108}Ru) or in plants irrigated with contaminated water.

The most common naturally-occurring radionuclides present in drinking water sources are ^{226}Ra and ^{222}Rn, ^{232}Th and its decay products, and to a lesser extent ^{236}U. The concentrations of natural radioactive substances in water available for public water supplies differ greatly. About 10% of ^{226}Ra present in bones is thought to originate from the water supply. Artificial radioactive substances in water are derived from the fallout from nuclear testing, discharges from nuclear power reactors and reprocessing plants, and the disposal of radioactive wastes. The radionuclides of importance are ^{90}Sr, ^{137}Cs and to some extent ^{131}I, but the concentrations of these radionuclides in drinking water are normally very low.

SAQ 3

Cholera is caused by which one of the following:

(i) Parasites
(ii) Pathogenic bacteria
(iii) Viruses

……………………………………………………………………………………………

SAQ 4

Name two diseases caused by water associated insect vectors.

……………………………………………………………………………………………

SAQ 5

Which chemical pollutant causes methaemoglobinemia in infants.

……………………………………………………………………………………………

SAQ 6

Name the metals associated with following diseases/episodes:

(i) Minamata
(ii) *Itai-itai*

……………………………………………………………………………………………

SAQ 7

Fill in the blanks:

________________(i)_________ is used as an insecticides, ______(ii)__________

As fungicide and ________________(iii)_____________________ as a herbicide.

14.4 WATER-RELATED DISEASE AND SEASONAL VARIATIONS

Climatic variations can be devastating for the individual as well as for entire society. Inspite of the conspicuous relationship between climatic seasonality and human well-being, little attention is paid to this problem.

During the dry season, the amount of accessible water gradually decreases. The sources which can supply water throughout the year are intensively used and their pollution by humans and animals tends to increase. Decreasing quantity of water in combination with increasing amounts of pollutants leads to a concentration of pollutants. Since the temperature in the water rarely exceeds the level at which the pathogens die quickly, a deterioration of water quality is likely to occur. The general improvement of the environmental situation during the dry season is thus not likely to occur in the water sources.

During the transitional period to the wet season, intensive farming activities restrict the capacity to carryout household activities and hygiene care. This results in the breeding of mosquitoes in large numbers and consequently spread of diseases. With the onset of the rains, water quality is at its worst. Pollutants are washed out in surface water sources. Pit latrines overflow and collapse, thereby contributing to the pollution. During the wet season, the amount of available water will gradually increase and the amount of pollutants becomes less significant through dilution. Together with an improvement in accessibility, the water situation improves during rainy season. Most of the hardship is, however, associated with the wet season. It is not uncommon for the prevalence of diseases to double during the wet season as compared to the dry season. The relative abundance of water during the rainy season is more hazardous to health than is the situation during the dry season. The advantage of having easy access to water during the wet season is outweighed by a host other negative circumstances.

Although total morbidity and many diseases vary closely with rainfall, there seems to be somewhat deviant pattern with regard to the prevalence of diarrhoea. Diarrhoeal diseases have their lowest incidence during cool and dry period. They then start to increase during the dry season and reach a peak at the beginning of the wet season.

SAQ 8

Give reasons for deterioration of water quality during dry season.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

SAQ 9

Write causes of water quality deterioration during rains.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

14.5 ADVERSE EFFECTS OF SOIL POLLUTION

It is estimated that about one third of the world's population is infected by hookworm while one out of every four people in the world may be infected with *Ascaris lumbricoides*.

The soil is becoming increasingly polluted with chemicals which can reach the food chain, surface water, or ground water, and ultimately be ingested by man. The pollution of soil is associated mainly with the following:

(i) The use of chemicals, such as fertilisers, pesticides and growth-regulating agents in agriculture.
(ii) Large masses of waste materials from the mining of coal and minerals and the smelting of metals which are dumped on land. Toxic or harmful substances can be leached out of such materials which enter the soil.
(iii) Domestic refuse and solids resulting from the treatment of sewage and industrial waste dumped on land including heavy metals and products of the petroleum industry.
(iv) Pathogenic micro-organisms which are major cause of pollution. Intestinal parasites constitutes the most important soil pollution problem, as a result both of the improper disposal of human excreta, wastewater and solid wastes, and of incorrect agricultural practices.

14.5.1 Soil Pollution by Biological Disease Agents

Biological agents that can pollute the soil and cause disease in humans and animals can be divided into three groups:

(i) Pathogenic organisms *excreted by humans and transmitted to humans* by direct contact with contaminated soil or by the consumption of fruit or vegetables grown in contaminated soil (*man-soil-man*).
(ii) Pathogenic organisms of *animals, transmitted to humans* by direct contact with soil contaminated by the wastes of infected animals (*animal-soil-man*).
(iii) Pathogenic organisms found naturally in *soil* and *transmitted to man* by contact with contaminated soil (*soil-man*).

Let us now study about them in detail.

(i) Man-soil-man

Enteric bacteria and protozoa**:** Enteric bacteria and protozoa can contaminate the soil as a result of: (a) insanitary excreta disposal practices or (b) the use of night soil or sewage sludge as a fertilizer, or the direct irrigation of agricultural crops with sewage. Soil and crops can become contaminated with the bacterial agents of *cholera*, *salmonellosis*, *bacillary dysentery* (*shigellosis*), *typhoid* and *paratyphoid fever*, or with the protozoan agent of *amoebiasis*. However, these diseases are most often water-borne, and transmitted by direct person-to-person contact, or by the contamination of food. Flies that breed in, or come into contact with, faecal contaminated soil can serve as mechanical carriers of disease organisms.

Parasitic worms (helminths) **:** Soil-transmitted parasitic worms or geo-helminths are characterized by the fact that their eggs or larvae become infective after a period of incubation in the soil. Infections with such helminthes on the whole provide, by their prevalence and intensity, an index of a community's progress towards a desirable level or sanitation. From the stand point of the prevalence and severity of such infections, the most important soil-transmitted helminthes are *Ascaris lumbricoides (roundworm), Trichuris trichura (whipworm), Necator americanus,* and *Ancylostoma duodenale*, the last two being the causative agents of hookworm disease. An additional species that is less widely distributed and less restricted to soil transmission is *Strongyloides stercoralis.*

The free-living stages of soil-transmitted helminthes have to face many natural hazards. Because of its particular requirements, each species tends to occur in broad ecological conditions permitting maximum survival and development is narrow, however, and it depends more on the micro-environment than on the macro-environment. The optimum conditions for each species are related to rainfall, atmospheric temperature, vegetation, sunlight and air movement, as well as to the texture, moisture, and structure of the soil. It is for this reason that eggs of *Ascaris lumbricoides* have been found to survive at extremely low air temperature under a thick cover of snow, and that hookworm disease does not occur everywhere in moist tropical regions and is also found outside the tropics.

There appears to be little doubt that infections, whether heavy or moderate, with intestinal geo-helminths constitute a continuing drain on the host's supply of nutrients, particularly proteins and certain vitamins. Malnutrition may also be induced or aggravated by the resulting impairment of the digestion and absorption of essential nutritional substances. The sucking motions of hookworms may lead to the loss of large quantities of blood and iron. Those people who take inadequate iron in food as is the case in many rural populations, such blood loss is of great importance in causing anaemia in the tropics. The amount of nutrients lost to human beings throughout the tropical world as a result of intestinal geo-helminths is of formidable proportions. If diverted from the parasites to their human hosts, it would bring considerable benefits to their health.

***Contamination of soil and crops*:** Human faeces is a valuable fertilizer. The contents of latrines, septic tanks, and sewage systems are therefore frequently used as fertilisers for crops. In areas subject to water shortages, the reclamation of wastewater often provides a valuable additional source of water for irrigation, but unless certain precautions are taken this practice is dangerous to health. Soil and crops may thus be contaminated by pathogenic enteric bacteria, protozoan parasites, such as *Entamoeba histolytica* and the larvae of *intestinal helminths*, leading to direct transmission either by contact or by the ingestion of uncooked vegetables.

Untreated domestic sewage or night soil usually contains the complete spectrum of pathogenic micro-organisms harboured by the community. Conventional sewage treatment processes cannot remove all these pathogenic organisms, but it is generally accepted that the extent of removal of coliform organisms serves as an indication of the efficiency of such processes from a bacteriological point of view. It has been found that, in primary sedimentation, a 30-40% reduction in the numbers of coliform organisms can be achieved, while in most full biological treatment processes the reduction is about 90%. Stabilization ponds with a 30-day detention period have generally shown more than 99% reduction of coliform organisms.

Various control methods have been devised on the basis of studies made on the viability of pathogenic organisms and their resistance to detrimental environmental factors and to chemicals. It is observed that *Salmonella* organisms persist for upto 70 days in soil irrigated with sewage under moist winter conditions and for about half that length of time under drier summer conditions. *Ascaris* eggs can withstand more than two year's exposure on field in temperate regions, and it has been reported that even dried, digested sludge from some sewage treatment plants contains viable eggs of this parasite. Methods characteristic of each species of soil-transmitted pathogen are therefore, required for the effective treatment of sewage effluents used for irrigation purposes.

The problem of the unsupervised scattering of fresh, untreated nightsoil and raw sewage still remains.

(ii) Animal-soil-man

In a number of zoonoses (diseases of animals transmissible to humans), the soil may play a major part in transmitting the infective agent from animal to humans. Some such diseases are explained below:

Leptospirosis: This disease affects both animals and humans in all parts of the world. The epidemiology of the disease follows a pattern characteristic of zoonoses, namely animal to animal and animal to humans. *Leptospirosis* constitutes a major problem in cattle and a problem of undetermined size in swine. In some areas, sheep, goats, and horses become infected. Rodent carriers include rats, mice, and voles. The dispersion of leptospires is associated with specific environmental conditions, particularly those that bring animal carriers, water, mud, and man together. Animal carriers often excrete a profusion of leptospires – upto 100 million ml^{-1} in the urine. If this is excreted into water or mud that is neutral or slightly alkaline, the leptospires may survive for weeks. Susceptible animals and humans entering vary from an inapparent reaction to an acute fulminating fatal disease. Leptospires usually enter the body through the mucous membranes or broken or macerated skin. Agricultural workers in irrigated fields, and in rice and cane fields in particular, often become infected.

Anthrax**:** The number of reported cases of anthrax in humans is relatively small as compared to other zoonoses: nevertheless, anthrax is still of importance both as a human disease and because of its economic impact on animal husbandry. The spores of *Bacillus anthracis* are very resistant to chemical and environmental influences and can survive for years in certain soils and in animal products, such as hides, hair and wool. When anthrax infections in livestock become established in a district, a relatively permanent enzootic focus of infection is created because of the long period for which the spores can remain viable in the soil.

Q Fever**:** Q fever, caused by the rickettsia C*oxiella burnetii*, is an important public health problem affecting almost all the countries of the world. Rickettsiae may be present in soil and dust, where they can survive for long periods, since they are highly resistant to drying. This is particularly important in those countries where ewes are brought into yards to lamb. Very high concentrations of rickettsiae may then be present in the dust of such yards, which is therefore, highly infective when sheltered from direct sunlight.

Cutaneous larve migrans**:** Cutaneous larve migrans, or creeping eruption, is a common infection of man in warm climates where dog and cat hookworms (*Ancylostoma braziliense*) are widespread. Humans become infected by the entry of the hookworm larvae into the skin, causing dermatitis of varying intensity. Infection is usually found among those exposed to animal faeces, especially children on beaches, lawns or playgrounds where larvae are present. Soil disinfection can be practiced in selected areas.

Other diseases**:** Among other diseases that follow the sequence animal-soil-man, are as follows:

Visceral larva migrans due mainly to *Toxocara canis, Listeriosis, Clostridium perfringens* infections, lymphocytic choriomeningitis, South American types of haemorrhagic fever, tuberculosis, salmonellosis, and tularaemia.

Although most of these diseases and infections are transmitted predominantly by direct animal-man contact, or though the contamination of food by animal droppings and wastes, soil pollution also plays an important part.

(iii) Soil-man

***Mycoses*: **Most of the serious subcutaneous, deep-seated and systemic mycoses are caused by fungi and actinomycetes that grow normally as saprophytes in soil or vegetation. Under certain circumstances, however, they become pathogenic and invade specific tissues or entire system.

The usual modes of transmission are by inhalation of spores or by penetration of the skin following an injury. Thus, mycetomas are produced when various mycetes penetrate the skin through puncture wounds, such as those caused by thorns. As with chromomycosis and other fungal diseases, they are common among those who walk barefooted or are inadequately protected by shoes or clothing. They cause long periods of disability ending. If left untreated, in the amputation of the affected limbs. Coccidioidomycosis is due to the fungus *Coccidioides immitis*, which is found in arid and semi-arid regions in the top few inches of soil and in the vicinity of rodent burrows. In the heat of early summer, the little ground cover that exists withers and dies; wind then disturbs the surface dust and lifts the spores into the air. The same process is involved in infections with many other fungi that grow in soil (geotrichosis), on leaf mould or decaying fruit (phycomycosis), on soil enriched by excreta from chickens, other birds, or bats (histoplasmosis), in the nests and manure of pigeons (cryptococcosis), in vegetable compost (aspergillosis), or on timber or water seepage (sporotrichosis).

The *ecology* of most of these free-living organisms potentially pathogenic to man and the *pathogenesis* of the diseases they produce are still far from being elucidated. Such mycoses have up to now been a neglected field of medicine, but nevertheless constitutes world-wide or regional problems of great magnitude affecting, in particular, workers engaged in digging operations or agriculture.

***Tetanus*:** Tetanus is an acute disease of humans induced by the toxin of the *tetanus bacillus* growing anaerobically at the site of an injury. The organism has a world-wide distribution, though cases of the diseases are comparatively infrequent today. It is an occasional disease among farmers, especially when the wounds are contaminated with manured soil. The infectious agent, *clostridium tetani*, is excreted by infected animals, especially horses. The immediate source of infection may be soil, dust, or animal and human faces.

***Botulism*:** This is a frequently fatal type of poisoning caused by bacterial toxins produced by *Clostridium botulinum*. The reservoir of the organism is soil and the intestinal tract of animals. The toxin is formed by the anaerobic growth of spores in food, which is the immediate source of poisoning. The disease is usually transmitted by the ingestion of uncooked food from jars or cans imperfectly sterilized during canning, the canned or preserved food having been infected with contaminated soil.

14.5.2 Soil Pollution and Solid Waste Disposal

***Urban areas*:** The land serves as a major repository for the solid wastes of urban and industrial area. Solid wastes disposal in metropolitan areas has a number of public health implications. The problem or greatest concern stems from the fact that, with increasing urbanization and the consequent increase in the area occupied by buildings, the land available for depositing wastes is correspondingly reduced. In highly industrialized countries, even the solid wastes from agriculture can become a problem, particularly when livestock and poultry wastes near urban centers become a breeding ground for flies and cause a serious odour nuisance on decomposition.

The problem of land pollution by wastes differs from those of water or air pollution, since the polluting material remains in place for relatively long periods of time unless removed, burned, washed away, or otherwise destroyed. Insects and rodents, which breed in such dumps, and odours from decomposing organic matter or from slow smouldering fires, can cause severe nuisance and public health problems. With the increasing utilization of land for urban development, pressure to dispose of solid wastes by methods other than land disposal has led to new pollution problems. *Improper incineration* can lead to severe air pollution, while discharge into water leads to over loading of treatment facilities and to increased pollution in already heavily burdened water courses.

***Agricultural land pollution*:** In the past, nutrient materials in the agricultural economy followed a clearly defined cycle: from the land to plants, from plants to animals, and then back to the land again. The use of chemical fertilisers has short-circuited this cycle, and many agricultural areas now have large surpluses of plant and animal wastes that, unless properly disposed of, can cause soil pollution. The problem becomes particularly severe where urban areas border on agricultural land. In these fringe areas, agricultural solid wastes may ultimately have to be handled in the same way as urban wastes. As agriculture becomes more intensive, so that increasing quantities of synthetic materials, such as pesticides, nutrients, and control agents, are used, chemical soil pollution coupled with increasing amounts of excess organic waste materials leads ultimately to severe land pollution problems in agricultural areas.

14.5.3 Soil Pollution by Toxic Chemicals

Agricultural chemicals: Fertilisers are intended to fortify the soil for the raising of crops, but incidentally may contaminate the soil with their impurities. Irrigation of farmlands and orchards may do this if the source of water is polluted by industrial wastes that contain synthetic organic chemicals. During the last few decades herbicides, insecticides, fungicides, soil conditioners, and fumigants have produced intentional alterations of agricultural, horticultural, and silvicultural soils. The chemicals used may pollute the soil and water.

Fumigants and soil conditioners are unstable and are metabolized by the micro-organisms of the soil. For example, even the chlorinated phenol derivatives, such as polychlorophenoxyacyl acids, used as herbicides, are metabolized by special strains of bacteria that adapt themselves to use them as nutrients. This holds true also for dinitro-*o*-cresol and allied compounds. The bacterial and fungal flora of the soil are much richer in numbers than the flora of water courses, even when these are contaminated by organic matter. It is therefore, possible for chemicals that can remain unchanged for a long time in water to be rapidly degraded by microbial activity in the soil. For, example, if a soil is "fed" with chemicals such as phenols, bacteria that thrive on naturally occurring phenols will multiply.

Ideally, only such chemicals should be employed as have been proved to be readily attacked and degraded by the common soil micro-organisms. Compounds of lead and mercury – the mercurials being mostly organic compounds – and salts of arsenious acids are likely to accumulate as persistent soil contaminants and to introduce lead, mercury, and arsenic into plant products. The present trend in the manufacture of pesticides for use in agriculture is to synthesize short-lived degradable compounds because this minimizes the persistence of residues of pesticides and their degradation products on food and forage crops. Little is known, however, about the breakdown products of many of these chemicals. In some cases, new toxic breakdown products can be formed in the soil although little of the original toxic compound can be detected.

Among the organic pesticides that resist bacterial degradation and have no inert end-products, the most important ones are the chlorinated hydrocarbons, e.g., DDT, lindane, aldrin, and dieldrin. Remnants of these stable pesticides appear to be bound to or adsorbed on soil particles, which are made up of inorganic minerals coated with organic compound. These chemicals may contaminate root crops grown in soils of this kind; for example, lindane can taint carrots or beets. The behaviour of chemicals that do not affect the quality or reduce the yield of crops can escape notice, but true absorption and incorporation of these pollutants by plants is unlikely to occur in normal practice. About 4 to 5 % of the insecticide remains in the soil after five years. Some of the degradation products are more toxic to insects than the original insecticides themselves, while others may be completely non-toxic.

Solid wastes from industry: Leachate from industrial solid wastes may contain poisonous chemicals in solution; these may be concentrated in nature by various organisms in the human food chain. It has been observed that the disposal of industrial solid wastes constitutes a major source of land pollution by toxic chemicals. Some 50% or more of the raw materials used by industry ultimately become waste products, and that about 15% can be considered deleterious or toxic.

The wastes have, in certain instances, given rise to severe problems of soil pollution, either by poisoning the soil or crops, or by eventual entry into ground-water and surface water sources. Observation of the contamination of farmland in the neighbourhood of chemical factories has indicated that there is a potential danger of fallout from the plume emitted by the smoke-stacks of chemical works. This applies mainly to inorganic contaminants.

***Radioactive materials*:** Radioactive materials can reach the soil and accumulate there, either from atmospheric fallout from nuclear explosions, or from the release of liquid or solid radioactive wastes produced by industrial or research establishments. The two most important radionuclides with long half- lives produced by nuclear fission are ^{90}Sr (half-life 28 years) and ^{137}Cs (half-life 30 years). Fallout of relatively recent origin and discharges from nuclear reactors also contain a number of other radionuclides of importance from the ecological point of view, e.g. ^{131}I, ^{140}Ba + ^{140}La, ^{106}Ru + ^{106}Rh, ^{144}Ce + ^{144}Pr, etc. These radionuclides contribute primarily to the gamma radiation emitted by the radioactive material accumulated in the soil. ^{14}C has also to be taken into account; it is produced from nitrogen in the air by neutron-proton processes, e.g., during the explosion of a hydrogen weapon, and also by cosmic radiation. It participates in the carbon metabolism of plants, and is thus also introduced into animals and the soil. Levels are not expected to become high enough, however, for adverse effects to occur.

Concentrations of radioactive *strontium* in the soil are generally a function of the amount of precipitation, since this element is brought to the soil primarily by rain. Within the soil, the deposited ^{90}Sr is held firmly by electrostatic forces in the upper few inches. If soil is eroded, the deposited radionuclides are called away with the slit and clay. Radioactive cesium is held even more lightly by the soil than strontium; however, certain plants, e.g., mushrooms and lichens, accumulate cesium, and high concentrations of this element can be reached in animals that feed on these plants. Levels of radiation from fission products deposited in the soil by fallout in the northern hemisphere are about 10-30 % of those due to natural radioactive substances in the soil. Many authorities feel that there is very little evidence to date to show that this increase in radiation levels could affect soil fauna or their predators, but increased radioactive fallout could in time result in levels of soil contamination high enough to cause concern.

SAQ 10

What are the components which cause soil pollution?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

SAQ 11

Name the groups of biological agents that can pollute the soil and can cause diseases.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

SAQ 12

What are reasons of severe land pollution?

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

SAQ 13

Name organic pesticides which resist bacterial degradation.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

SAQ 14

(e) Name two most important radionuclides having long half-life.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

14.6 SUMMARY

Pollutants released to environment are interchanged between its three components viz. air, water and soil and ultimately result in the exposure to animals and humans. Adverse effects of pollutants on the health of animals and humans depend on the type of pollutants, duration of exposure and their concentration. Human health is affected by water pollution either through its direct ingestion or its use personal hygiene, agriculture, industry and recreation.

Water associated health hazards are divided into two categories viz. hazards from biological agents and hazards from chemical and radioactive pollutants. The principle biological agents transmitted through ingestion are: pathogenic bacteria, viruses and parasites. These agents produce several diseases like cholera, typhoid, infectious hepatitis, amoebic lever abscess etc. Heavy metals, organochlorine compounds, polynuclear aromatic hydrocarbons, anionic detergents and radionuclides cause reversible and irreversible health impairment. Climatic variations also play an important role on the effect of pollutants on animal and human health.

Pollution of the land by the biological agents of disease remains one of the major causes of debilitating infections in the rural and semi-rural areas inhabited by the majority of the world's population. Land pollution by toxic chemicals from agriculture and industry, leading to the contamination of soil, food, and water, may prove to be a significant hazard to health in the more industralised areas of the world. The problems arising from the dumping on land of the ever-increasing amounts of domestic and industrial solid wastes will become more acute as world population and the degree of urbanization increase.

14.7 TERMINAL QUESTIONS

1. Give a short account of water associated health hazards.
2. Briefly describe the health hazards by water associated insect vectors.
3. What are heavy metals? What are the toxic aspects of these metals?
4. What are organochlorine compounds. Give their health effects.
5. Describe the biological agents causing disease in the humans and animals through soil pollution.
6. Give a short account of soil pollution by toxic chemicals and their effect on animal and human health.

14.8 ANSWERS

Self-Assessment Questions

1. air, water and soil
2. Any five out of the following:
   (i) domestic pollutants,
   (ii) naturally occurring substances,
   (iii) food additives,
   (iv) stimulants,
   (v) industrial wastes,
   (vi) pesticides,
   (vii) medicaments and

(viii) radioactive wastes

3. (ii)

4. The two diseases are malaria and filariasis

5. Methaemoglobinamia is caused to babies due to excessive nitrate in water.

6. (i) Mercury
   (ii) Cadmium

7. (i) DDT
   (ii) Hexachlorobenzene
   (iii) 2, 4, 5-T

8. The reasons are: (i) decrease in the accessible quantity of water, and (ii) concentration of pollution from animal and human and growth of athogens due to favourable conditions.

9. Washing out of pollutants in surface water, overflowing and collapsing of latrines are the causes of water quality deterioration.

10. The components which cause soil pollution are:
    i) fertilisers and growth regulatory agents,
    ii) waste materials from mining of coal and minerals and smelting of metals and
    iii) domestic refuse and solids from sewage and industrial wastes.

11. Biological agents that can pollute the soil and cause disease are:
    i) pathogenic organisms as excreted by humans and transmitted to humans,
    ii) pathogenic organisms of animals transmitted to humans, and
    iii) pathogenic organisms found naturally in soils and transmitted to humans.

12. The reasons for severe land pollution are:
    i) short, circuiting the normal cycle of nutrient transfer due to the use of chemical fertilisers,
    ii) improper disposal of plant and animal waste,
    iii) disposal of urban solid waste on agricultural land without treatment, and
    iv) application of increasing quantity of synthetic materials on land.

13. Organic pesticides which resist bacterial degradation are:
    (i) DDT, (ii) lindane, (iii) aldrin and (iv) dieldrin

14. Radionuclides with long half-lives are 90Sr with half-life of 28 years and 137Cs with-half life of 30 years.

Terminal Questions

1. Pathogenic bacteria, viruses and parasites are the cause of water associated health hazards. *Pathogenic bacteria* constitute one of the principal sources of morbidity and mortality. Principal diseases attributed to the ingestion of water borne bacteria are: cholera, typhoid fever, bacillary dysentery, paratyphoid fever, gastroenteritis,

infantile diarrhoea, leptospirosis and tularaemia. Infectious hepatitis is caused due to the presence of virus in water. Entamoeba hystolytica is a parasite which is responsible for intestinal amoebisis and amoebic lever absces. Guinea worm is another parasite which causes dracoritiasis. Intestinal helminths are also known to be entering human body through contaminated water. Dismetosis and hydatit disease are occasionally transmitted to humans and animal through drinking water.

2. Malaria is the most wide spread disease caused by water associated insect vector through anopheline mosquito. Black fly is responsible for the spread of onchocerciasis or river blindness. Other diseases of similar nature include yellow fever transmitted by a water breeding mosquito, trypanosomiasis are sleeping sickness and filariasis. Culex pipiens fatigana is the major vector responsible for the spread of filariasis.

3. Heavy metals include all metals with atomic number greater than 23 and specific gravity more than 5. These metals have attracted much attention because they are non-degradable, persist in nature for long periods, toxic to living organisms at fairly low concentrations and tend to either biologically magnify or accumulate in plants or animal body.

4. Organochlorine compounds associated with impairment through water pollution are: DDT, aldrin, endosullfan, chlorinated phenoxyacetic acid, hexachlorobenzene, pentachlorophenol, chlorinated naphthalenes and biphenyls. These compounds enter water bodies via run off from agricultural land and industrial discharge. Biochemical break down of some of the organochlorine compounds is slow and they are known to produce chronic health effects. The compounds released to water and soil undergoes conversion results in the formation of metabolites with increased or decreased toxic effects.

5. Biological agents that can pollute the soil and cause disease in humans and animals are: (i) pathogenic organisms excreted by man and transmitted to man by direct contact with contaminated soil or by the consumption of fruit or vegetables grown in contaminated soil, (ii) pathogenic organisms of animals transmitted to man by direct contact with soil contaminated by the wastes of infected animals and (iii) pathogenic organisms found naturally in soil and transmitted to man by contact with contaminated soil.

   Etiteric bacteria, protozoa, parasitic worms and larvae of intestinal helminthes are the major causative agents. Leptospirosism, anthrax, Q-fever, cutaneous larvae migrans, micosis, tetanus and botulism are the diseases caused by biological agents.

6. Herbicides, insecticides, fungicides, soil conditioners, fumigants and fertilisers are added to soil for various purposes. These compounds are metabolised by micro-organisms of the soil and contaminate the soil and ground water. Excessive application of nitrogenous fertilisers is known to increase the level of nitrate in ground water and consequent development of methaemoglobinemia in infants using this water. Compounds of lead and mercury, the mercurials being mostly organic compounds and salts of arsenious acids are likely to accumulate as persistent soil contaminants and to introduce lead, mercury and arsenic into plant products.

14.9 SUGGESTED READINGS

1. *Francis K.V. Leh and Richard K.C. Lak; Environment Pollutions, "Sources, Health Effects, Monitoring and Control"; Charles C. Thomas Publisher Springfield, Illinois, USA (1974)*
2. *Health Hazards of the Human Environment, World Health Organisation, Geneva (1972)*
3. *R. Feachem, E. Burns, D. Curtis, S. Cairncross, M.K. Khan, A.Cronin, D. Lamb, P. Cross and H. Southall; Water Heal th and Development - An Interdisciplinary Evaluation; Tri--med Bool(s Limited, London (1977)*
4. *H.F. Ludwig, D.W. Evans, W.I. Brokelm and B.N. Lohani; Manual of Environmental Technology in Developing Countries; South Asian Publishers Pvt. Ltd., New Delhi (1991)*
5. *R. Feachem, M. McGarry and D. Mara; Water, Wastes and Health in Hot Climates; John Willey and Sons, London (1977)*