UNIT 2 INTRODUCTION TO ENVIRONMENTAL HEALTH

Structure

2.0 INTRODUCTION

Human beings are exposed to different substances everyday through the air, water, soil and some of them may exert toxic effects. Environmental pollutants are increasingly introduced in the environment due to human activities. Such pollutants can exert various effects on the different organs in our system. We can be exposed to toxicants at any stage of our life. If our immune system is good enough then we may be able to overcome the toxic effects. It depends on our metabolism and genetic make-up. Some toxicants can be biotransformed by the liver and excreted from the system. While some others can be lodged permanently in the various organs and it may be even fatal. Rachel Carson is considered the mother of environmental toxicology. Her book Silent Spring published in 1962 brings out the toxic effects of the pesticide DDT (dichlorodiphenyltrichloro ethane) and challenged the practices of agricultural workers. Ecotoxicology involves the study of toxicants on living systems. It is a multidisciplinary science and involves both toxicology and ecology disciplines. What do ecotoxicological studies focus on? Scientists test the effect of certain chemicals, biological agents and their spores on living systems *in vitro*(for example in lab mice or rabbits) and see their effects. Dose-response is an important aspect that ecotoxicologists study. This unit introduces you to ecotoxicology and some concepts useful for your study. We will also understand the behavior of some substances that are toxic to human health.

Let us now understand these in detail in the following paragraphs.

2.1 OBJECTIVES

After reading this unit, you should be able to:

- define ecotoxicology;
- explain the different concepts and terminologies used in ecotoxicology;
- differentiate the various biodegradable and non-biodegradable substances;and
- describe the influence of environmental factors on toxicity.

2.2 DEFINITIONS

Let us now learn about some definitions and terms commonly used in ecotoxicology.

a) *Ecotoxicology:* This is a sub-discipline of environmental toxicology. This deals with the harmful effects of toxicants at ecosystem and population levels.

b) *Toxicologists* are scientists who deal with the study of toxicants and toxins.

c) *Toxicant:* Substances that are toxic are termed toxicant. They can be hazardous and poisonous to the environment and human health.

d) *Toxins:* These are produced naturally by living organisms. For example,Aflatoxins, Ochracin.

e) *Xenobiotic* derived from the Greek word'xeno' meaning 'foreigner' is a foreign substance entering our systems.

f) *Terrestrial toxicology* refers to the exposure totoxic compounds and their effects in terrestrial ecosystems.

g) *Aquatic toxicology* involves the study of effects of toxic chemicals on organisms in the aquatic environment.

h) *Chemodynamics* is the study of the release of toxic chemicals in the environment and its distribution, degradation patterns, and fate in the environment.

2.3 CONCEPTS AND PRINCIPLES IN ECOTOXICOLOGY

Let us first understand the term toxicology and its historical development. Historically the science of toxicology dates back to very early periods when humans used toxic plants and animal extracts in hunting and warfare. There are mentions of poisons and toxic substances by Hippocrates, Aristotle, and Theophrastus way back in 400 BC. Scriptures and records indicate that by 1500 BC hemlock, opium, arrow poisons, and certain metals were also used to poison enemies or for state executions. Some of the notable poisoning victims include: Socrates, Cleopatra, and Claudius. The basic concepts in toxicology evolved after Renaissance and Age of Enlightenment. The study of Paracelsus and Orfilaare of utmost importance in the field of toxicology.Paracelsus

reported that the dose of a chemical is an important factor for the human body's response. This is now known as the dose-response relationship. It is an important concept in toxicology. Thus Paracelsus is considered as one of the founders of modern toxicology. His well known quote says that "All substances are poisons; it is the dose that makes the poison". There are many medicines that we use which are safe at recommended doses but is toxic at higher dosage. Orfila, a Spanish physician who worked at the University of Paris in the early 19thcentury brought out the systematic correlation between the chemical and biological properties of poisons and showedthe effects of poisons on specific organs. He identified the science as a discipline. Later on in the 20th Century advancements in genetics, and molecular biology paved the way for further toxicological research and understanding.

Truhaut in 1969 coined the word 'ecotoxicology'. It originated from the two words 'ecology' and 'toxicology'. After industrial revolution, so many pollutants and chemicals have been released and this has polluted our natural environment. The subject ecotoxicology,has focused on these growing concerns of contaminants in our ecosystems, the distribution and fate of these contaminants and their effects on humans. Thus, the discipline of ecotoxicology forms a part within the subject of environmentaltoxicology. It also refers to 'the study of harmful effects of chemicals onecosystems'. Rachel Carson the biologist writer was influential in modern ecotoxicology and for starting various movements for bringing about awareness on the state of the environment. Human activities have resulted in heavy metal pollution,smog, acid rain, acidification of oceans and soil pollution. All these have serious consequences on all levels in the ecosystem. The nature of the pollutant, its characteristics, phase association, its movement along the different components of the biosphere are very important factors to be considered in ecotoxicological studies. The pollutant may be in the solid, liquid or gaseous form. Further, the exposure, bioavailability and dose, exposure routes and pathways are also very important factors. Let us now learn the various substances that cause ecotoxicity in the following paragraphs.

Activity

Assume that a family has eight members. It consists ofa grandfather and grandmother aged 85 and 80, father and mother aged 45 and 40, aunt aged 53, three children aged 3, 8 and 16. They live along the coast and are fond of eating fish everyday. If they were exposed to a toxic fish food, who do you think will be affected the most in the family and why? Write down with explanations.

Plants, animals and human beings are exposed to different toxic substances. Such harmful toxicants can affect individual species, at community level and bring about a reduction in the species diversity and abundance. They bring about changes in the population dynamics affecting the ecosystem and reducing the productivity and stability.

2.3.1 Toxic effects on Ecosystems:

Natural calamities allow ecosystems to adapt naturally through time and enable them to resist the changes and they can recover from the same. On the other hand, toxic substances can threaten the stability of ecosystems and result in serious consequences and irreversible changes. These changes include decline of forests (acid rain, pollutants), loss of fish production in a stream (heavy metal pollution), loss of timber growth, decline

in predatorpopulations (due to the effects of pesticides, DDT), loss in species diversity, and so on. Therefore toxicants cause loss to the aesthetic, fucntional and commercial value of ecosystems.

2.3.2 Toxic effects on Communities:

Pollutants and toxicants can affect communities. For example, a toxic substance can eliminate a species or promote the growth of undesirable species (weeds) in a community. It will disturb the food web dynamics. Also species interactions are affected and nutrient dynamics can be disturbed or altered. When an apple orchard is sprayed with toxic chemicals, many plants and bees may be lost along with the pest of interest. This is therefore an ecologically unsound practice.

2.3.3 Biological factors affecting toxicity:

There are several biological factors affecting toxicity. This includes the species, variations among different strains, sex of the species, age, human variability, metabolism of an individual, diet and nutritional status of an organism and the overall physiological condition of the organisms. Let us understand each one of these.

(1) *Age:* For example, some toxicants exert more toxic effects among the old and elderly. This is because they have reduced detoxication abilities, impaired renal excretion functions, decreased blood flow and lesser amounts of total plasma proteins.People with disease history of liver hepatitis or tumours cannot biotransform the toxic substances. In the same way those who have kidney failure or disease cannot excrete the toxicants. Heart failure and circulatory failure can impair the body's detoxification capacities. Also newborn, infants and children below the age of 10 are vulnerable and susceptible to toxic effects.

(2) *Diet:* People who are malnourished and are compromised in diet cannot biotransform toxicants due to reduced enzyme activities i.e. cytochrome activity. In Africa several people especially children suffer from Kwashiorkor (protein deficiency) and it is attributed to the toxin Aflatoxin B1. The mycotoxin is not metabolized and detoxified from the body due to the disease.

(3) *Sex variabilities:* It has been observed that male rats metabolize toxic substances more easily than females in laboratory studies. It may be similar in human beings too. Females may be susceptible to toxic agents more easily than men and this may be due to the activity of testosterone hormone.

Check your progress Exercise 1

Note: a) Write your answer in about 50 words.

b) Check your progress with possible answers given at the end of the unit.

1. Explain the term toxicology and ecotoxicology with suitable examples.

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2.4 TYPES OF TOXIC SUBSTANCES

2.4.1 Degradable Substances

These substances can be easily broken down into simpler, harmless, ones by the action of microbes. Some examples of biodegradable substances include domestic wastes, agricultural waste, crop residues, cotton cloth, animal bones, wool, leaves, garden waste, leather, paper and so on. Biodegradable waste can be composted or incinerated. We can also obtain manure and biogas from these wastes. In general biodegradable wastes are non-toxic to the environment and human health. Let us now understand about these substances in detail in the following paragraphs.

(1) *Kitchen waste:* Vegetable and fruit peelings, boiled grains, eggshells, coffee and tea sediments, bones from fishes/ meat/chicken, biscuits, bread, are all degradable and we can easily construct a 2 feet x 2feet pit in our home backyards and compost our kitchen wastes. Within a week or so, we can obtain good quality manure that can be used for our plants in the garden. That way we can recycle our wastes into useful manure. Vermicomposting can also be employed to hasten the process of composting using earthworms – the farmer's friends.

(2) *Paper:* All types of paper, cardboard, cartons, chalk boxes, tissues, paper towels are all biodegradable and it can be degraded by soil microbes.

(3) *Cloth:* Cotton cloth, jute, pure silk fabrics, natural fabrics are degradable and subject to the action of microbes which break them down to simpler substances.

(4) *Agricultural waste:* Crop residues, farm material, haystacks, rice husks are all biodegradable and can be put into a pit and it will degrade slowly by the action of soil microorganisms.

(5) *Garden waste:* Leaf litter, twigs, branches, hedge trimmings, grass cuttings, flowers, fruits all are degradable.

2.4.2 Non-degradable Substances

These substances cannot be broken down into simpler, harmless ones. Some examples include plastics, pesticides, heavy metals, aluminium cans, polythene bags, glass, and so on.Non-biodegradable wastes are toxic to the environment and human health. They persist in the environment for several years. Let us now understand about these substances in detail in the following paragraphs.

(1) *Heavy metals:* Metals are non-degradable substances and cannot be degraded in the environment. They persist for several years and are commonly released from industrial activities causing toxicity to health and environment. The heavy metals include all metals with atomic numbers greater than 23 (with a few exceptions). The metals are classified as "heavy metals" if in their standard state they have a specific gravity of more than 5 g/cm^3. Heavy metals accumulation in soils and plants can influence their photosynthesis, gaseous exchange, and nutrient absorption abilities (Devkota et al. 2000, Baker, 1981). Heavy metals are hazardous and toxic to man and other living organisms. Most of them are slow poisons as they accumulate in the body and cause serious disorders. For example,

the heavy metals cadmium and arsenic are highly toxic. They have been reported in groundwater and soils.

(a) *Arsenic:* The regions in West Bengal have groundwater containing high levels of arsenic and it has caused arsenicosis. It can leach into water from arsenic containing rocks, arsenic fertilizers, lead arsenate insecticides, pesticide sprays, arsenic-containing fossil fuels, and leaching of mine tailings and smelter runoff. Chronic high-level exposures can cause abnormal skin pigmentation, hyperkeratosis, nasal congestion, abdominal pain and in long-term cancers. Urinary bladder, lung and skin cancers. Approximately thirty countries world over are affected by arsenic poisoning.

(b) *Cadmium*: Itenters the food chain through industrial activities. It can accumulate in the tissues of aquatic organisms. Cadmium contaminated rice in Japan caused the disease Itai-Itai. The disease was characterized by severe damage to the kidneys, joint pain and arthritis.It is also used in the manufacture of rechargeable batteries, tobacco smoke and some alloy productions.Cadmium affects the bones and kidneys as it causes bone mineralization.

(c) *Chromium:* It is used in fertilizers, in the production of paints, electroplating industries, tanning industry, wood preservatives and paper and pulp industries. Chromium toxicity causes chlorosis and necrosis in plants and is toxic to humans causing several skin ailments.

(d) *Lead:* In the same way lead is another heavy metal of concern. It can contaminate water from lead pipes, lead solder, leaded gasoline, lead containing paints and so on. Lead is used in the manufacture of batteries, pesticides, fertilizers, used in metal plating, smelting of ores and in factories. Chronic exposure to lead causes, dyslexia, sleeplessness, hallucinations, psychosis, kidney and brain damages. It also causes neurological damage and can penetrate the placental barrier and cause teratogenesis (birth defects).

(e) *Mercury:* Mercury is highly toxic. It is used in plastic manufacturing industries, in the manufacture of vinyl chloride and is reported to cause neurotoxicity (toxicity to the nervous system). Mercury contamination is noted in the marine environment. Mercury exists as organic compounds, metallic elements and inorganic salts. They have different levels of toxicity and bioavailability. They biomagnify in the food chain. One such toxic exposure to mercury contaminated fishes was the Minamata disease that occurred in Japan affecting several people with paralysis and neurological damage.

(2) *Petroleum and oil pollutants:* They are hydrocarbon containing compounds and are not degradable. Oil spillage occurs in marine ecosystems during transport, cleaning and accidental leakage. The sea animals, such as sea-gulls, turtles, mussels, are also affected by their toxicity. Hydrocarbon pollution due to oil tankers spillage etc can cause smothering of benthic organisms (clams, oysters, worms). Hydrocarbons are cellular/ sub cellular poisons. They induce tumour development in clams, fishes, mussels. Benzapyrene, benzanathroceneare potent carcinogens. These pollutants destroy the coating on the birds that help in insulation; as a result the birds lose buoyancy and sink. These pollutants also cause necrosis, epinasty (downward curvature of leaf), chlorosis (yellowing of leaf), abscission (dropping of leaves), damage to the cuticles and stomata in plants.

(3) *Volatile organic compounds (VOCs)*: They include halogenated solvents and petroleum products. They are used in several industries such as paint, printing, pigment manufacturing. They are also used as solvents for cleaning. Some important VOCs include: trichloroethylene, toluene, benzene, chloroform, methylene chloride, xylene, tetrachloroethylene,1,1,1-trichloroethane,ethylbenzene, trans-1,2-dichloroethane, dichloromethane, and vinyl chloride. High levels of exposure to VOCs can result in headache, impaired cognition, kidney toxicity, cancer and reproductive disorders.

(4) *Solvents:* Many types of solvents are used which have systemic toxic effects on nervous system and the blood. Benzene is used in the rubber, canning, printing, shoe manufacturing industries. Benzene affects the hematopoietic tissue in the bone marrow and is an immunosuppressant. Benzene exposure results in decrease of white blood cells, red blood cells and platelets. Continued exposure causes severe bone marrow damage, aplastic anemia and leukemia. Other toxic solvents include: aliphatic hydrocarbons, halogenated aliphatic hydrocarbons, aliphatic alcohols, glycols, glycol ethers and aromatic hydrocarbons.

(5) *Pesticides:*These are a group of agrochemicals used in agriculture. Chemical herbicides, insecticides, fungicides, nematicides, rodenticides are all used and they exert toxic effects. They are applied on the plant seeds or foliage and finally they reach the soil system. Pesticide residues accumulate in the biosphere remain for several years. After the Second World War, many countries suffered from food shortage and organochlorine pesticides such as DDT i.e. dichlorodiphenyltrichloroethane were introduced. It bioaccumulates in the food chains. Persistent pesticides may accumulate in the bodies of animals and over a period of time increase in concentration if the animal is unable to flush out the toxins leading to bioaccumulation. When an affected animal is eaten by a carnivore, the pesticide is further concentrated in the carnivore. This phenomenon of increasing in the concentration of a nondegradable substance along the food chain is called 'Biomagnification'. DDT prevents the shelling of bird eggs.

(6) *Plastics*:They are found everywhere and due to their non-biodegradable nature plastic has been banned world-wide. Plastics enter our water systems, soil and they are discharged from domestic, industrial, medical, agricultural set-ups. Plastic microbeads, bottles and bags adversely affect wildlife habitats and the ecosystems. Millions of tonnes of plastic wastes enter the marine system and choke the marine animals.

(7) *Radioactive materials:*They are produced from nuclear explosions, atmospheric fallout from nuclear dust, discharges from radioactive laboratories etc. Uranium, Thorium, Radium, and Cesium are commonly found in the environment that keep emitting radiations and persist for a long time. They are known to bioaccumulate in plants. The ingestion of food containing radiations can cause mutations and genetic disorders.

(8) *Dioxins:* Dioxins are toxic chemical compounds and they cause disruptions in hormones, reproductive system, and immune system and also cause developmental disorders. They are also carcinogenic. They are persistent organic pollutants and are of several types which include (1) polychlorinated dibenzo-p-dioxins, (2) polychlorinated dibenzofurans, (3) polychlorinated biphenyls (PCBs). PCBs are used in the manufacture of phenols, cyanides, plasticizers, solvents, and numerous

industrial chemicals. They arealso used as coolants in electrical transformers. PCB's are stable, lipophilic, and are broken down slowly in tissues. They are found to bioaccumulatein very high concentrations in fishes and waterfowl.

(9) *Polycyclic aromatic hydrocarbons:* Incomplete burning of coal, oil and gas, waste, garbage, tobacco, volcanoes, forest fires, automobile exhaust, etc results in the formation of Polycyclic aromatic hydrocarbons (PAHs). They are also found in many food items like vegetable oils, fish, meat, beverages, smoked, grilled fish and meat. PAHs are normally found as a mixture containing two or more of these compounds, do not dissolve easily in water and stick to solid particles and settle down the bottoms of lakes and rivers. In the soil, PAHs stick tightly to particles and contaminate ground water. They can cause cancer and birth defects.

Case Study 1: Endosulphan poisoning in Kasargod, India

Endosulfan an organochlorine pesticide was extensively sprayed aerially in the cashew plantations of Plantation Corporation of Kerala (PCK) spread over 2209 hectares in various divisions of Kasargod district, Kerala. Endosulfan is slated to be phased out globally under the Stockholm Convention 2001, to which India is a signatory. The pesticide is classified as an organochlorine compound and its breakdown products are persistent in the environment, with an estimated half-life of nine months to six years. It is known to potentially bioaccumulate in humans and other animals, in the liver, kidneys and fatty tissue. PCK started using this pesticide in 1979 and unusual health disorders were reported from places like Vaninagar, Adur, Mulleria, Padre etc. The people were unaware that this was a lethal poison. A study conducted by the Centre for Science and Environment (CSE) confirmed the presence of high quantities of endosulfan in the samples of water, soil, fruits, mother's milk and blood in Kasargod. Further disorders of the central nervous system, cerebral palsy, mental and physical retardation, epilepsy and congenital anomalies like stag horns, liver cancer, blood cancer, infertility, miscarriages, hormonal imbalances, skin diseases and asthma have been reported. All these disorders were traced to endosulfan effects. After mass agitations and several reports by various agencies, the use of endosulfan was banned in Kerala in August 2001. Though, the state government has paid compensations, the rehabilitation of the living victims is really tough and challenging. Reports reveal that approximately, 224 people were critically affected and 226 have a 60 per cent disability. This tragedy was spread over 20 villages in the state.

Source: Baskar S and Baskar R. 2007

Check your progressExercise 2

Note: a) Write your answer in about 50 words.

b) Check your progress with possible answers given at the end of the unit.

1. Write short notes on biodegradable substances.

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2. Write short notes on non-biodegradable substances.

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2.5 INFLUENCE OF ECOLOGICAL FACTORS ON TOXICITY

Both biotic and abiotic factors affect the bioavailability and metabolism of toxic substances in the environment. Let us understand these in the following paragraphs.

2.5.1 Biotic factors affecting toxic response:

(1) *Microorganisms in influencing toxicity:* Anaerobic microorganisms carry out methylation processes in their metabolism and have the ability to convert less toxic chemical forms into toxic forms. The toxic forms can later be bioaccumulated in bodies of fishes, birds and higher organisms in the food chain and be lethal. A classic example of the Minamata disease is elucidated in the case study below.

Case Study 2: The Minimata Disease

In the Chisso factory, a vinyl chloride factory, built on the Minamata Bay of Kyushu, Japan mercuric chloride was used as a catalyst in the production of plastics. The byproduct - inorganic mercury was dumped into the bay. Between 1953 and 1961, scientists discovered that the fishes in the bay were lethargic and some were dead. The researchers explained that inorganic mercury had been converted to organic methyl mercury by the methylation process of the anaerobic microorganisms present in the bay waters. This organic mercury was toxic and bioaccumulated in the fishes and incorporated into the food chain. When humans consumed these fishes, it caused the Minamata disease. Paralysis, hearing and vision disorders, numbness, mental disorders, teratogenic effects, cellular distortions, cerebral palsy, etc characterized it. Similar case studies were reported in Japan when people consumed rice contaminated with cadmium, causing the Itai-itai disease, resulting in crippling of the legs.

Source: Baskar S and Baskar R. 2007

Bacteria and Archaea can tolerate toxic compounds and can convert them to simpler non-toxic forms through their metabolism.

(2) *Plants:*Plants can sequester toxins through their roots and are useful in phytoremediation of toxic soils. Plants can completely remove, transfer and stabilize, toxic compounds in the soil and groundwater. Mustard, hemp, pigweed, alpine pennycress plants hyperaccumulate toxicants. The process of phytoremediation is used in the restoration of abandoned metal mine sites where PCBs were dumped. Many plants can accumulate toxicants. They include Sunflower: accumulates arsenic; Willow: cadmium; alpine pennycress: zinc and cadmium; Indian mustard: lead. Also salt tolerant plants can sequester sodium chloride. Sunflowers are also efficient in removing strontium-90 and cesium-137. Plants can help in

phytostabilization of toxic compounds. They can reduce the mobility of substances in the environment. So the pollutants become less bioavailable.Plant roots can also secrete enzymes that degrade soil organic pollutants. Plant metabolisms involve phytotransformations. They degrade, inactivate and immobilize pollutants, pesticides, solvents, industrial chemicals and xenobiotics in the environment. Phytostimulationis useful in degrading hydrocarbons, polychlorinated biphenyls and polycyclic aromatic hydrocarbons. Hornwort is useful in phytostimulation. Halophytes, salt loving plants are useful in phytodesalinationprocesses to remove salts from water and soil.

(3) *Insects:* Butterflies can detect toxic compounds and sequester toxicants from their host plants. Examples include sequestration of pyrrolizidine alkaloids by the butterfly *Idea leuconoe*. They accumulate the toxins in their body tissues in all their life stages.

These are some examples of biota affecting toxicity in the environment.

2.5.2 Abiotic factors affecting toxic response:

The abiotic factors that influence toxicity include the temperature, pH, alkalinity, salinity, hardness and dissolved organic carbon.For example certain toxic agents may be oxidized or reduced due to environmental conditions.

(1) *Temperature:* Chromium is found in the environment basically in two valence states. They include the trivalent chromium (Cr III; less toxic form) and hexavalent chromium (Cr VI; highly toxic form). It is reported that high temperatures can result in the oxidation of trivalent chromium to hexavalent chromium. Now hexavalent chromium is the most dangerous state and it causes serious health disorders from dermatitis, nosebleeds, ulcers and liver and kidney failure. The metabolism rates increase two fold for every 10ºC especially in ectothermic organisms. This temperature increase results in changes in the respiratory rate, chemical absorption, detoxification and excretory rates of these organisms (Wright and Welbourn, 2009). The metabolism of an organism is influenced by temperature and also a P450 cytochrome enzyme is capable of increasing catalytic activity for converting procarcinogens (Wright and Welbourn, 2009). Giving an example; when *Oryziaslatipes* were exposed to diethylnitrosamine compounds, fewer liver tumours were observed in colder temperatures rather than in warmer temperatures (Wright and Welbourn, 2009). Also hotter temperatures may increase the metabolism or decrease certain compounds for example in the case of organochlorine pesticides. In the cells, hotter temperatures allow for the increase in lipid fluidity, membrane permeability and increased enzyme activities. In aquatic environments the solubility of the toxicants increases with higher temperatures.

(2) *Colour of substrates:*Researchers have observed that several invertebrates prefer the white colour substrates which may toxicants that have settled on the seafloor in salty waters (Sharapova, 2010). Therefore, bioaccumulation is influenced by environmental persistence, lipophilic and hydrophobic chemicals. Also different species eliminate chemical toxicants at different rates which affect bioaccumulation rates (Hodgson, E., 2010). Fishes are highly sensitive to toxicants in the aquatic environment when compared to other fauna.

(3) *pH and Alkalinity*are also important factors that influence toxicity in living organisms. In aquatic ecosystems when the pH is less than five, fishes are vulnerable to

permeability in gill epithelium and these results in the loss of electrolytes. The presence of hydrogen ions (H^+)in water affects the chemical speciation of certain toxic elements that can then bond on specific sites on the living organisms membranes. pHalso affects the bioavailability of lipophilic metal species such as aluminium.

(4) *Salinity:* Researchers have observed that in saline conditions such as in estuaries bioavailability and toxicity are affected. For example trace metals increase in lesser saline solutions and organophosphate compounds increase with salinity. Also in freshwater ecosystems, higher salinity affects cadmium bioavailability and toxic cadmium is made available for absorption by organisms. The toxic effects of metals such as zinc, mercury, copper, chromium, nickel, cadmium, increases with decreasing salinity. This may be because of the higher bioavailability of the free metal ion at lower salinities.

(5) *Hardness* is related to pH and alkaline conditions. Hardness affects the toxicity of organic surfactants.

(6) *Dissolved Organic Carbon* can influence metal complexes to be formed such as in copper. The level of copper toxicity in freshwater lakes is directly related to the DOC and pH levels. Also the metal concentrations in the environment and its mobilization are affected by pH, Eh, cation exchange capacity and other ionic factors. These are some abiotic factors that influence toxicity among organisms.

The common absorption routes of toxicants in the humans include the skin, lung, respiratory tract and the gastrointestinal tract.The mode of action of individual toxicants can be at the cellular level, the molecular level and also at the organ level. Each individual have their own unique immune system and the uptake, distribution, metabolism, mode of action, and excretion of the toxic substance depends on one's immunity. Toxic substances are eliminated, biotransformed and detoxified by the liver and kidneys.

2.6 LET US SUM UP

Ecotoxicologistsresearch and analyze the effects of toxic substances on individual organisms, on species in food webs, and predict the effects on ecosystem, wildlife populations and so on. They carry out toxicity testing and risk assessment on toxic chemicals. They also conduct research in rivers, estuaries, on organisms thriving there and record the effects. They trace the movement of these toxic substances through various food chains. In this unit we have discussed the importance of ecotoxicological studies, the various biodegradable and non-biodegradable substances and the influence of ecological factors on toxicity along with some important case studies useful for your study.

2.7 KEY WORDS

Ecotoxicology : This is a sub-discipline of environmental toxicology. This deals with the harmful effects of toxicants at ecosystem and population levels.

Ecotoxicity : It involves studying the effects of physico-chemical and biological stressors on ecosystems.

Xenobiotic : It is derived from the Greek word 'xeno' meaning 'foreigner' is a foreign substance entering our systems.

2.8 REFERENCES AND SUGGESTED FURTHER READINGS

Doull, J. Recommended limits for occupational exposure to chemicals. In Casarett and Doull'sToxicology: The Basic Science of Poisons, 6th ed., C. D. Klaassen, ed. New York: McGraw-Hill, 2001, pp. 1155–1176.

Hodgson, E., 2010: A Textbook of Modern Toxicology (4th Ed.). New Jersey and Canada: Wiley.

Hoffman, D. J., B. A. Rattner, G. A. Burton, and J. Cairns, eds. Handbook of Ecotoxicology,2nd ed. Boca Raton: Lewis, 2002.

Sharapova, T.A., 2010: Abiotic and Biotic Factors Affecting Zooperiohyton Development in a Waterflow of a Cooling Water Pool. Contemporary Problems of Ecology, 3:4, pp 495-497.

Wright, D.A. and Welbourn, P. (rev) 2009: Environmental Toxicology. Cambridge Environmental Chemistry Series 11. Cambridge University Press: New York.

2.9 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check your progress 1

1. Your answer should include the following points:
   - Definitions
   - Concepts
   - Principles

Answers to Check your progress 2

1. Your answer should include the following points:
   - Kitchen waste
   - Paper
   - Cloth
   - Agricultural waste
   - Garden waste
2. Your answer should include the following points:
   - Heavy metals
   - Petroleum and oil pollutants
   - Volatile organic compounds
   - Solvents
   - Pesticides
   - Plastics
   - Radioactive materials
   - Dioxins
   - Polycyclic aromatic hydrocarbons