UNIT 2 CHEMICAL TOXICANTS

Structure

2.0 INTRODUCTION

Toxicology is a branch of science which discuss about the source, physical and chemical properties, absorption and pharmacological activity. Chemical toxicology deals with the nature and reactions of toxic substances which involves the origin, exposure and degradation. Any substance whose physiological action gives adverse effects on health is a toxicant. Toxicity of a chemical is determined by many factors like dose, exposure route, and the individual susceptibility (response). Number of synthetic chemicals is produced on the global market and many other chemicals released as by-products. The vital elements like Fe, Cu, Zn, Mo, and Co,V, Mn etc., for biological systems may also show adverse effects above certain concentrations. Elements like As, Sb, Cd, Hg, Be, Al and Pb etc., exist in the atmosphere are not essential for biological system exhibit toxicity even at low concentrations.

2.1 OBJECTIVES

After studying this unit you will be able to:

- classify chemical toxicants;
- define toxicity, toxicant;
- describe various factors of route of exposure;

- describe toxic chemicals at home, food;
- differentiate between domestic and occupational toxicants and
- describe effects of drug and their management.

2.2 CLASSES OF CHEMICAL TOXICANTS

The chemical toxicants categorized under several classes based on their chemical composition and their mode of action. Any condition or disease that results from the exposure to a toxicant is known as toxicosis. The word toxicosis used as an alternative for poisoning or intoxication.

The broad classification of chemical toxicants is 1.Exposure classes 2. User classes.

Exposure Classes: The toxicants under this class are present in domestic and occupational environment. (Ex: food, water, air, soil).

User Classes: This type of toxicants include drugs of abuse, theraupeutic drugs, agricultural chemicals, food additives, metals, solvents and combustion products.

Dear learner we have studied the chemical toxicants in air, water and soil pollution units in course 1.In this unit we will discuss about other toxic exposures in our daily lives.

2.3 EXPOSURE CLASSES

The pollutants under exposure class are air, water and soil pollution has studied extensively in block 2, course 1. However, in this unit we will discuss some important points about them.

2.3.1 Types of Air Pollutants

Air pollutants are classified into following ways. They are:

Gaseous Pollutants: These pollutants are gases and vapors at normal temperature and pressure as well as vapors. The toxic air pollutants of greatest concern are carbon monoxide (CO), hydrocarbons, hydrogen sulfide (H_2S) nitrogen oxides, ozone (O_3), sulfur oxides, and CO_2.The concentrations of pollutants generally expressed as micrograms per cubic meter (ìg/m^3) or for gaseous pollutants as parts per million (ppm) by volume in which 1 ppm = 1 part pollutant per million parts (10^6) of air.

Particulate Pollutants: These are fine solids or liquid droplets that are suspended in air. They exist in various forms. In the form of dust where the particle size is about 100 µm in diameter and released into the atmosphere directly from substances like coal dust, ash, sawdust, cement dust, grain dust. In the form of fumes it exists as suspended solids with size less than 1 µm in diameter, released from metallurgical processes. In the form of mist, it exists as liquid droplets suspended in air with a size of less than 2.0 µm diameter. In the form of smoke it exists as solid particles from incomplete combustion of fossil fuels with a size of 0.05–1.0 µm diameter. In the form of aerosol it exist as a liquid or solid particles suspended in air or in any another gas with a size of <1.0 µm diameter.

2.3.2 Sources of Air Pollutants

Natural Pollutants: Examples of some of the natural pollutants are volcanic eruptions emits particulate matter as well as various gases like sulfur dioxide, hydrogen sulfide, and methane. Huge quantities of pollutants from forest and prairie fires release unburned hydrocarbons, CO, nitrogen oxides, and ash in the form of smoke. Dust storms produce particulate pollutants and aerosols in the form of salt particles produced by oceans. Plants and trees also produce particulate pollutants in the form of produce pollen and spores which cause respiratory and allergic reactions. By the atmospheric reactions with volatile organic compounds released by the trees produce blue haze over forested mountain regions.

Anthropogenic Pollutants: Anthropogenic pollutants released in to the atmosphere from three sources:

i) by burning fossil fuel for heating and power, or exhaust emissions from transportation vehicles that use gasoline or diesel fuels,

ii) industrial processes,

iii) mining and drilling.

The pollutants released from combustion are fly ash, smoke, sulfur, CO, CO_2 and nitrogen oxides. Combustion of coal and oil releases large amounts of sulfur and its oxides that contribute to the formation of acidic deposition. In addition to the fossil fuel combustion automobile exhaust include smoke, lead particles, CO, nitrogen oxides, and hydrocarbons. Industries emit pollutants like sulfuric, acetic, nitric, and phosphoric acids in effluents, solvents, resins, gases like chlorine and ammonia, and metals.

2.3.3 Examples of Air Pollutants

Carbon Monoxide: Once carbon monoxide enters into human body it readily combines with hemoglobin in the blood to form carboxyhaemoglobin, which prevents the transfer of oxygen to tissue thereby affects the cardiovascular function. The CO concentrations e”100 ppm it can cause headaches, dizziness, nausea, and breathing difficulties. Above 700ppm level is always fatal. **Sulfur Oxides** is released in to the atmosphere by industrial combustion of coal because coal containing the highest levels of sulfur. The oxides of sulfur enter the respiratory tract there by create irritation. **Nitrogen Oxides** found in photochemical smog which is also a respiratory irritant that leads to pulmonary edema and hemorrhage. **Ozone is** an oxidizing gas that is formed by photochemical reaction in the atmosphere. The ozone present in the troposphere is harmful and known as bad ozone. Whereas the ozone present in the stratosphere filters the incoming UV radiation known as good ozone. Good ozone is destroyed by chemical compounds like chlorofluorocarbons (CFCs). **Lead** is one of the harmful particulates in air pollutants which impair renal function, nervous system, reduce the development of red blood cells, and impair the nervous system that leads to mental retardation and blindness. Particles like dust and fibers from coal, clay, glass, asbestos, and minerals develop lung fibrosis. The most common disease observed in the coal miners is pneumoconiosis, silicosis is observed in inhaling silica-containing dusts and asbestosis from asbestos fibers are common industrial pollution diseases.

2.4 WATER AND SOIL POLLUTANTS

Surface water is polluted by various point or nonpoint sources. Effluents from an industrial plant or a sewage-treatment plant are a point source and pesticides and fertilizer runoff carried by rainwater into various water bodies is an example of a nonpoint source. Industrial contaminants such as organic waste, solvents, and inorganic wastes like toxic metals pollute the soil and water. In addition industrial accidents may lead to severe local contamination. In addition to the above mentioned pollutants pesticides, fertilizers, detergents, and metals are important pollutants released from urban areas. Perpetual fertilizers and pesticides which are applied directly to the soil in the course of action they move from the soil to the water and make the way to enter the food chain. In another way they leach out of the soil or runoff through rain and flow into the water systems.

2.4.1 Examples of Pollutants

There are various types of pollutants which show toxic effects on environment and human beings. Some of them are discussed in this unit.

Metal Toxicants: Metals toxicants mainly classified into three classes depend on their nature.

1) Metals that are suspected to be a carcinogen,
2) Metals that transport readily in soil, and
3) Metals that proceed through the food chain.

Lead: The sources of lead in water are from lead pipes and lead solder. Lead soil pollution is from seepage of lead from fallout from leaded gasoline and hazardous-waste sites. Lead poisoning has been common in children, particularly in older housing units and inner city dwellings, in which children may consume chips of lead contaminated paint. The toxicity of lead mainly damages hematopoietic system and the nervous system. At low levels of exposure, hyperactivity, decreased attention span, mental deficiencies, and impaired vision is observed in children. At high levels, encephalopathy occurs in both adults and children. Lead damages the arterioles and capillaries which lead to cerebral edema and neuronal degeneration.

Arsenic: Arsenic contamination is due to the leaching of pesticide sprays, released by combustion of arsenic containing fossil fuels, smelter and mine runoff. Toxic level exposures can produce abnormal skin pigmentation, hyperkeratosis, nasal congestion, and abdominal pain. Epidemiologic studies have connected chronic arsenic exposure to various cancers, including skin, lungs, and lymph glands in humans.

Cadmium is released from industrial effluents and enters into the water bodies untreated. This cadmium contaminated water is used for irrigation. The toxicity of cadmium is recognized in Japan after outbreak of the disease Itai-Itai. The people who suffer with this disease have combination of severe kidney damage and painful bone and joint and recognized that occurs in areas where rice is

contaminated with high levels of cadmium. The aquatic organisms can accumulate cadmium in their tissues, leading to increased concentrations in the food chain.

Mercury: Mercury poison is recognized after Minamata tragedy in Japan. In Japan, effluents from a chemical and plastics plant containing mercury were released into Minamata Bay. Bacteria in the aquatic sediments converted the mercury into methyl mercury and that was absorbed by aquatic animals. Consumption of mercury contaminated fish and shellfish by the people suffered with mercury poisoning, or Minamata disease that resulted in death.

Fertilizers: Not only the metal contamination observed in soil and water pesticides are also of major concern. The most toxic pesticides are organochlorine derivatives like DDT, aldrin, dieldrin, and chlordane due to their stability and persistence they can accumulate in food chains.

Fertilizers containing nitrates discharge from sewage treatment plants, and leachate from septic systems and manure leach from soils and enter water bodies. Phosphate fertilizers have a tendency to be absorbed and get accumulated. The increase in the nutrients like phosphates, leads to "algal blooms" or eutrophication, in water bodies. The algal bloom chokes off light penetration and lessens the atmospheric reoxygenation of the water that creates anaerobic conditions and finally death of many aquatic organisms occurs. The adverse health effects from nitrates in drinking water mainly are nitrosamine formation and methemoglobinemea. In human beings by the action of intestinal bacteria the nitrates will be converted to nitrites. These nitrite ions combine with hemoglobin to form methemoglobin, which decreases the oxygen-carrying capacity of the blood and resulting in anemia or blue-baby disease. It is particularly affected to young babies who consume water and milk-formula prepared with nitrate contains water. Some of the nitrosamines are known carcinogens. Oil and petroleum is everlasting pollutants where it is produced by vehicular oil emission or spillage from oil tankers. Oil slicks are very common and responsible for the deaths of many birds in the marine environment. Sea animals like crabs, shrimp and mussels are also affected by the toxic hydrocarbons they consume.

VOC: Volatile organic compounds (VOCs) are a group of halogenated solvents and petroleum products, which are used in large quantities by a many industries, like degreasing, dry cleaning and paint. The properties of VOCs allow them to move quickly into groundwater, and contaminate. The exposure of VOCs can cause headache, impaired cognition, and kidney damage and acute levels of exposure causes cancer, particularly childhood leukemia.

PCBs: Polychlorinated biphenyls (PCBs), phenols, cyanides, plasticizers, organic solvents, and other toxic chemicals that are used as coolants in transformers and are also by-products of the plastic, lubricant, rubber, and paper industries released into the water and contaminates the aquatic animals there by enters the food chain. They are stable, lipophilic in nature and metabolite very slowly in tissues cause tissue damage and responsible for death.

Dioxins: Dioxins are another group of toxic chemical released from industrial accidents and through use of the herbicide 2, 4, 5-T, that contaminates water and soil.

Check Your Progress 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) Define the following

i) Toxicity

.....

.....

.....

.....

ii) Toxicant

.....

.....

.....

.....

iii) Toxicosis

.....

.....

.....

.....

2) What are user and exposure class of chemical toxicants?

.....

.....

.....

.....

.....

.....

2.5 TYPES OF CLASSES

Dear Learners, let us know about types of classes in the following sentences:

2.5.1 Food Additives

Food additives are compounds which are deliberately added to the food products to improve the colour, texture, flavor, appearance and preservation. According to the WHO/FAO joint expert committee, “food additives are non-nutritive substances added intentionally to food, generally in small quantities, to improve its appearance, flavor, texture or storage properties. In view of the safety

requirement Joint FAO/WHO codex Alimentarious commission 1973 has proposed six general principles to be food additive.

1) All proposed food additives must be tested, evaluated toxicologically in all aspects with cumulative, synergetic and potentiating effects.
2) Food additives that are under safe level of intended use will be endorsed.
3) They should be re-evaluated periodically in view of use and safety.
4) Confirmation from CA Commission.
5) Justification should be based on :
    - Preservation and reduction at nutritional quality.
    - Special dietary food products.
    - Monitoring of quality, stability and organoleptic properties.
    - Quality of raw material for food products.
6) Temporary or Permanent approval.

2.5.2 Detergents

1) Detergents are the substances containing molecules which are amphiphilic in nature with a hydrophilic head group and a hydrophobic hydrocarbon tail. The detergents are classified into anionic, cationic, nonionic or amphoteric on the basis of hydrophilic head group. On the basis of chemical characteristics detergents are of two kinds.
2) Phosphate containing detergents
3) Surfactant containing detergents.

- Phosphate containing detergents are highly caustic in nature where as surfactant detergents are very toxic in nature. The phosphates detergents soften the hard water there by suspend dirt in water. The surfactant detergents increase the detergent properties like wetting, foaming, dispersing and emulsifying and helps in removing dirt.
- A large number of surfactant molecules are associated with other components to augment the detergency by which removal of dirt is difficult because of the strong attraction between dirt particles and the fabric but the penetration and adsorption of surfactant molecules onto the and fabric interface becomes very poor.
- Detergents comprise various molecules of surfactants. Surfactants are surface active promoter that is heterogeneous long chain molecule with hydrophilic and hydrophobic components. Surfactants properties like wetting, emulsifying, dispersive, foaming and foaming control ability can be modified by altering the hydrophobic and hydrophilic part. On the basis of this character and ionic (electrical charge) properties in the water surfactants are classified as i. Cationic surfactants ii. Anionic surfactants iii. Nonionic surfactants iv. Amphoteric surfactants.fig.1, table 1.

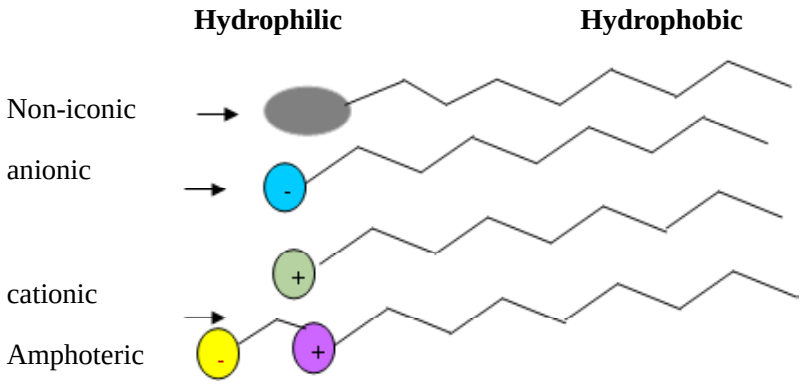

Figure 2.1: Properties in the water surfactants

Cationic Surfactants: Cationic surfactants comprises of a positively charged nitrogen atom and one long chain hydrophobic substituent. Examples are quaternary ammonium compounds with the general formula $R_4N^+X^-$, where X^- is a chloride ion and R is an alkyl group, alkyl trimethyl ammonium chloride, where R contains $C_{8\text{-}18}$ atoms like dodecyl trimethyl ammonium chloride (DDTMAC), dialkyl dimethyl ammonium chloride (DADMAC), and alkyl dimethyl benzyl ammonium chloride. These are commonly used in detergents as softeners.

Anionic Surfactants: Soaps are examples of anionic surfactants comprise of sodium, potassium, or ammonium group. The most commonly used hydrophilic groups are carboxylates, sulphates, sulphonates and phosphates. The anionic surfactants are effectively used to clean oily sand clay l suspension with different degrees on the basis of their chemical composition.

Nonionic Surfactants: This type of surfactants is nonionisable in solution and is effectively used in removing oily soils by the process of emulsification and solubilization. These can be mixed with anionic surfactants for cleaning oil soils. Examples are ethylene oxide, alcohol ethoxylates, alkyl phenol ethoxylates, fatty acid ethoxylates, monoalkanolamide ethoxylates, sorbitan ester ethoxylates, fatty amine ethoxylates and ethylene oxide-propylene oxide copolymers, glycol esters, glycerol esters, glycosides, sucrose esters, amine oxides and sulfonyl surfactants.

Amphoteric Surfactants: Amphoteric surfactants contain both cationic and anionic groups. Examples are the N-alkyl betaines, like laurylamidopropyl-dimethylbetaine.The. Amphoteric surfactants are pH dependent. In acidic solutions, they act as a cationic surfactant, whereas in alkaline solutions they behave like an anionic surfactant. Amphoteric surfactants are also termed as zwitterionic compounds. They are chemically stable and soluble in water and have affinity with other surfactants. The surface activity is depends on the separation of charge between the groups and maximum at the isoelectric point where it exist as zwitterion. Examples are N-alkyl amino propionates, amino dipropionate, alkyl imidazolines.These are also pH dependant. The pH affects their wetting, detergency, foaming abilities.

Along with these the surfactants contain;

Builders- to enhance the cleaning ability. Eg: Citrate,phosphate,sodium carbonate etc.

Antiredeposition Agents: to prevent removed soil from redepositing on cleaned fabrics.Ex: Carboxymethyl cellulose, sodium polyacrylate, polyethylene glycol polymers.

Zeolite: to sequester multivalent metal ions and prevents the anionic surfactants from precipitating out of the solutions.

Alkaline Agents: to remove oily soil containing fatty acids. Ex: Sodium carbonate and sodium silicates.

Processing aids: to provide required physical properties.Ex: sodium sulfate, water, alcohol, xylene sulphonate. Sodium sulfate provides crisp and free-flowing texture; alcohols regulate the viscosity and prevent product separation.

Colorants & Fragrances: to fetch uniqueness to the product especially blue colorants provide a desirable blue/white color to white fabrics. Fragrance conceals the chemical odour of the detergents.

Oxygen bleaches: to remove stain and soil by bleaching action. They contain inorganic peroxygen compounds like sodium perborate tetrahydrate and sodium percarbonate and hydrogen peroxide.

Enzymes: to break down complex dirt molecules, especially proteins like blood and grass. Examples: Protease, lipase and cellulose.

Table 2.1: Properties in the water surfactants

Type	Commercial and domestic examples	Major industrial examples
Anionic	Sodium linear alkylbenzene sulphonate (LABS); sodium lauryl sulphate; sodium lauryl ether sulphates	Petroleum sulphonates; linosulphonates; naphthalene sulphonates, branched alkylbenzene sulphonates; linear alkylbenzene sulphonates; alcohol sulphates
Cationic	Stearalkonium chloride; benzalkonium chloride	quaternary ammonium compounds; amine compounds
Non-ionic	Dodecyl dimethylamine oxide; coco diethanol-amide alcohol ethoxylates; linear primary alcohol polyethoxylate	alkylphenol ethoxylates; alcohol ethoxylates; EO/PO polyol block polymers; polyethylene glycol esters; fatty acid alkanolamides
Amphoteric	Cocoamphocarboxyglycinate; cocamidopropylbetaine	Betaines; imidazolines

Toxicity

The effluents containing surfactants from different sources released into water bodies and shows adverse effects on humans and ecosystems. The degree of toxic effect of surfactants to aquatic plants depends on its concentration. If the concentration of surfactants is high the growth of algae and other microorganisms

in water will diminish slowly, resulting in less productivity of water bodies, thereby impair the food chain of aquatic organisms. This is kind of toxicity increase the rate of membrane permeability thereby disintegrate the structure by material exosmose. In aquatic animals the surfactants enter through skin piercing, gills and animal feeding and thereby enter the food chain. The phosphorous in waste water inhibit the degradation of other toxic constituents. Surfactants stimulate emulsification and dispersion there by reduces the efficiency of sewage treatment. Long term use of surfactant causes skin irritation and allergy. Surfactants like sodium dodecyl benzene sulfonate (SDBS) absorbed by the skin and enter into the blood stream that can cause damage to the internal organs.

Types of Food Additives

According to Federal food, drug and cosmetic Act, five categories of compounds are associated with human food that includes GRAS.

Cat-I : Whose GRAS stature was reaffirmed.

Cat-II : No evidence of toxic hazard.

Cat-III : Additional studies are required for safety.

Cat-IV : Incomplete reaffirm safety. (Evidence of toxicity was reported)

Cat-V : No biological studies available.

Food Colors

Food colors are the natural pigments that are present in the fresh foods which disappear and show toxic effects due to the adverse physical and chemical processing methods. It decreases the visual perception of food product. At about 75% of food products are processed in developed countries. All Food manufacturers replace lost colour and appearance by additives. Food colors are used to restore the original appearance, uniformity and intensity of colour, preserve the flavor and to protect light sensitive vitamins, attractive appearance to colorless gelatin desserts and to identification.

Colorants Subject to Certification

They are very pure chemical with standardized color strengths. The raw materials used are 'Coal tar' dyes or by products of the petroleum industry. Where as certified colors are accessible as water soluble dyes or insoluble pigments. All soluble dyes are available as primary colors or addititive mixtures /with other certified colors.

Colorants Exclude from Certification

They will be classified as natural colors. According to colour additives amendment act of 1960 they or subject to surveillance by FDA.

They are (i) Non-Synthetic (ii) Nature identical (iii) Inorganic colour, which are extracted from animal, plant or mineral source.

Colourants Subject to Certification: The delisted by FDA are:

1) **FD & C Red No.1:** (Ponceau 3R, color index No. 16155). This is a disodium salt of 1 – Pseudocumylazo – 2- naphthol -3,6- disulfonic acid,

which is a dark red color dissolved in H_2O . It is proved to be a liver carcinogen.

2) **FD & C Red No. 2:** Amaranth color index no. 16185. Amaranth is reddish brown powder which is soluble in H_2O gives megenta red or bluish red colour. It is also proved to be a carcinogenetic.

3) **FD & C Red No. 3**: Erythrocine, color index no. 45430 xanthine group of dyes. It is a brown coloured powder and soluble in H_2O that yields red colour and fluorescence with 95% alcohol. Proved to be thyroid tumor, blood and gene mutations.

4) **FD & C Red No. 4**: Ponceau SX, color index no. 14700 originally approved food colour in butter and margarine. It is proved to be chronic follicular cystitis with hematomatoury Projections in to the Urinary bladder, hemosiderotic.

5) **FD & C Red No. 32:** (oil Red Xo, color index No. 12140) It is brownish red powder soluble in oil. Used to colour Oils, Fats, Waxes, Greases, acrylic emulsions, colour the oranges.It is proved to be cathartic,growth retardant,damage to liver & heart tissue.

6) **FD & D Red No. 40:** Allura Red AC. Color index No. 16035 used in cosmetics, drugs and food (soft drinks & cotton candy). Reported to be hyper active agent and growth retardant.

7) **Citrus Red No. 2:** (Solvent Red 80, color index No. 12156) It belongs to monoazodye group. Used to colour the skin of oranges to prepare orange marmalade. Proved to be adenocarcinoma,limphosarcoma and bladder cancer.

8) **FD & C Green No. 3:** (Fast green FCF color index No. 42053). Belongs to triphenyl methane group of dys. Reddish or brownish violet color, soluble in H_2O. It induce sister chromatid exchanges in bone marrow cells and produce sarcoma.

9) **FD & C Blue No. 2**: (Indigotin, Indigo carmine. Colour index No. 73015). It belongs to indigoid family of synthetic dyes soluble in H_2O yielding blue solutions proved to be innocuous and produce tumors at the site of application.

10) **FD & C Yellow No. 3 & 4**: Belong to monoazo group with yellow AB & yellow OB with colour index No. 11380, 11390. They used to colour oleomargarines. Proved to be liver and bladder carcinogens.

11) **FD & C Yellow No. 5**: (Tartrazine, CI no. 19140) orange yellow powder, soluble in H_2O. Proved to be allergic.

12) **FD & C Yellow No. 6**: (Sunset yellow FCF, color index no. 15985). Orange red powder soluble in H_2O gives orange yellow solution. It is proved to be allergic.

Toxicological characteristics of colorants except from certification are Annato extract, Anthocyamius, Dehychated beets, Chlorophyls, Caramel, Tumeric & Cakolene etc.

Acidulate and Sequestrates.

Acidulant are the food additives which are added as preservatives, chelating agent and anti oxidant synergist, flavouring agent's viscosity & melting modifiers and to control pH.

Examples of Acidulant :-

Inorganic Acids: Phosphoric acid and its derivatives, HCl & H_2SO_4.

Organic Acids: Citric acid, benzoic acid, sorbic acid, butyric acid and caprylic acid.

According to the FAO, 0.5% of phosphates are the tolerable level in the diet without any adverse effect. Higher levels may be tolerated if the other ions like Ca, Mg, and K maintained at required levels otherwise it produce adverse effects on physical and chemical characteristics and off flavors as well in food items. The approved dietary intake of phosphorous is <30mg/kg body wt/day in the nutrition of human beings. HCl and H_2SO_4 are not directly used as an acidulant but used in hydrolysis of proteins, starch and corn syrups. HCl & H_2SO_4 are corrosive to all body tissues. Inhalation causes lung damage and skin contact results in necrosis.**Vinegar** is a aqueous solution of acetic acid. It is used as acidifier, flavor enhancer, pickling agent and pH controlling agent. It is absorbed in the gastro intestinal tract and used up in oxidative metabolism, formation of glycogen intermediates of carbohydrates and synthesis of fatty acids and cholesterol. Acetic acid in H_2O or organic solvents is strongly corrosive to the skin causes tissue damage and produce canker sores. Lactic acid is present in pickles, beer, buttermilk and cheese. It is used as acidifier, antimicrobial agent, curing agent, flavoring and carrier agent. According to FAO/WHO the permissible limit of D (-) isomer is 100mg/kg/body/day.

Adipic Acid: It is one of the most important of aliphatic dicarboxylic acid used as leavening agent, neutralizing and flavoring agent. The permissible limits are.

Baked items – 0.05%

Non-alcoholic beverages – 0.005%

Condiment and relishes – 0.5%

Dairy products – 0.45%

Fats & Oils – 0.3%

Frozen dairy desserts – 0.0004%

Gelatin & puddings – 0.55%

Meat products – 0.3%

Above these limits it causes intestinal hemorrhage.

Allyl isothiocyanate: It is used as spice seasorings and condiments. It is formed from sinigrin by crushing the moistened mustard seeds.It is proved to be skin irritant and at high concentrations results in epithelial hyperlasia and uleers.

Cinnamyl Anthranilate: Is a synthetic flavoring agent used to provide grape or cherry flavor to beaverages, candy, puddings, and chewing gum at 1000 pm concentrations. Above this limit it is thought to be carcinogenic.

Menthol: It is a synthetic and natural constituent of peppermint oil used as flavoring agent in candies, chewing gum. It can cause sensitization reactions like urticaria. At high concentrations it causes heart fibrillation.

Monosodium Glutamate (MSG): MSG is liberally used in flavor enhancer in meat products. It provides Umami sensation generally called as a 5^{th} basic taste. At high concentrations, it causes Chinese restaurant syndrome (CRS) in sensitive population with symptoms like upper body tightness, warmth and feeling pressure.

Myristicin: Nutmeg oil, mace oil contains < 4% Myristicin. It has psychomimetic and narcotic properties. It is thought to cause headache, abdominal pain and nausea at high doses. At elevated levels cause liver damage & death.

Yeast: Yeast is used to ferment the baked food items. At high levels in food products causes high uric acid levels in blood. The urate oxidase enzyme is absent in human beings. During the fermentation of yeast, pharmacologically active amines and tyramine formed which are responsible for higher BP.

Parabenes: Parabenes are the esters of p-hydroxy benzoic acid (PHB) used an antimicrobial agent in food products, cosmetics and also known as paracepts or PHB esters. These are used in malt beverages and non carbonated soft drinks. At high concentrations, it can causes dermatitis.

Polycyclic aromatic hydrocarbon (PAH): PAH enters into the human food chain by (i) Polluted air on food crops. (ii) Heat processing of foods like roasting, smoking and grilling. iii.Preparing the food products above 400 ^{0}C resulting in significant formation of PAH like benzo [α] pyrene, dibenzo (α,β) anthraene, dibenzo [α,β] pyrene and benzo[α] fluro anthrene. All these compounds are potent carcinogens.

2.5.3 Cosmetics

Cosmetic products are the substances to be applied to the external parts of the human body including teeth and oral cavity for cleaning purpose, appearance, protecting and maintaining in good condition. Cosmetics are classified into two types.

1) Leave-on 2) Rinse-off

Cosmetics which are leave-on category can be intended to lasting for certain period on the skin like perfumes, cosmetics used for decoration, body and face creams. A rinse-off cosmetic is a product one which should be rinsed off after a period of time like shampoos, soaps, shower gels, ointments and toothpastes.

Recent years, cosmetics, and many other beauty products for personal care that do not fall within cosmetic regulation are noticed as emerging pollutants because they are constantly released into the terrestrial and aquatic environment. They are found to be persistent, bioactive, and bio-accumulate with potential adverse ecological and environmental impact. Substances like perfluroalkyl compounds, parabenes, organic UV filters and microplastics.

1) **UV Filters**

Cosmetic products like sunscreens and skin lotions contain benzophenones (BPs) have ultraviolet (UV) filter properties which absorb UV-A (315–400

nm) and UV-B (280–315 nm) radiation. They also used as additive in plastics, printing inks, shampoos, perfumes and photographic films to prevent UV light damage. The Benzophenones are highly lipophilic in nature and bioaccumulate in the human body by crossing dermal tissue. Studies proved that BP UV filters could be detected in the plasma, bile and urine after application. These filters also found in the surface waters there by enter in to the food chain. The concentration of BPs in sewage sludge exceeds 10 mg/kg of dry matter proved to be mammary cancer cell proliferation. The photo stability of UV filters plays an important role to absorb UV light.

2) **Inorganic Filters**

The inorganic filters present in sunscreen are TiO_2 and ZnO. The nano TiO_2 and ZnO particles are almost customarily present in sun blocker formulations because they nanoscale enhance skin retention, acceptance for consumers, and the UV depletion properties. By the process of immersion or abrasion after application these compounds released into the environment. The sewage treatment plants (WWTPs) expel most of the TiO_2 present in the sewage, but a small amount is released into natural water bodies where it aggregate and remain in suspension. The residues of TiO_2 released from sunscreen form aggregates submicron level which remains in suspension in fresh water, and in water bodies with high salt concentrations like sea they aggregate and progressively settle down and detained in the sediment.

By the photocatalytic reactions of UV radiation the nano TiO_2 and ZnO generates reactive oxygen species likes OÅ”$^{2"}$, Å”OH, and H_2O_2. The photoactivity of these species causes cellular damage and environmental toxicity. To prevent the production of ROS, TiO_2nanoparticles present in sunscreen are coated with silica and alumina and/or doped with manganese or vanadium, even though sometimes these coatings do not withstand contact with water.

These results suggest that the normal recreational activities in coastal resorts can result in the production of significant amount of H_2O_2 and consequent damage to or death of marine coastal phytoplankton; this could have reverberations on the marine food web, which relies on these microorganisms. The ZnO is extremely toxic to the aquatic animals like zebra fish, marine algae and sea urchins.

3) **Parabenes**

Parabenes are alkyl esters of the *para*-hydroxybenzoic acid which are used as preservatives due to their antimicrobial activity against yeasts, molds, and bacteria and their chemical stability, low toxicity, and low cost. They are extensively used in cosmetics, including powders foundations, , lipsticks, eye shadows, mascara, lip glosses and nail polishes, and in pharmaceuticals and personal care products such as lotions, sunscreens, cleansers, shampoos, deodorants, hair care products, and toothpaste. They are proved to have the potential to produce contact dermatitis, irritation, or photo contact dermatitis.

4) **Triclosan**

Triclosan (TCS), 5-chloro-2-(2, 4-dichlorophenoxy) phenol is a preservative used personal care products like hand soaps, shampoos, detergents,

toothpastes, sunscreen, and deodorants. The domestic sewage contains most of the TCS and enters into the aquatic environment in spite of the treatment. During sewage treatment TCS is converted into chlorinated derivatives that are more persistent and toxic to the aquatic life. It also enters into the terrestrial environments because of the sewage sludge application on farm land as a fertilizer. TCS is stable and lipophilic in nature due to which it bioaccumulate in algae, plants, earthworms, marine mussels, snails, amphibian larvae, fish, and marine mammals causes adverse ecological effects and alters benthic bacterial community composition, exhibits teratogenic effect. TCS has potential to impair thyroid function, endocrine disruption, oxidative stress, and liver carcinogenesis.

5) **Plastic Microbeads**

Plastic microbeads are pieces of plastic, spherical in shape, size varying from <mm-1mm. They are widely used in soaps, face wash, toothpaste, exfoliating scrubs and anti-ageing creams because exfoliating debris from the skin by replacing natural exfoliating materials like pumice, oatmeal, apricot husks. The microbeads are made by different types of plastic material. They are

Polyethylene (PE), polymethyl methacrylate (PMMA), Nylon, Polyethylene terephthalate (PET) and Polypropylene (PP).

When these products are washed down after use the microbeads in the products pass through sewage systems. Because of nonbiodegradable nature and very small size they enter into rivers and canals and finally into the sea and ocean that contribute to the plastic pollution. Because of the small size and large surface area plastic microbeads absorb POPs and other pollutants in aquatic environment. Aquatic species consume these microbeads by mistake since they are not able to distinguish between food and microbeads there by enter into the food chain and regularly consumed by people. The harmful toxic chemicals which are added during the manufacture of plastic like plasticizers and flame retardants which are drain out into water bodies and produce adverse effects by polluting them. These plastic microbeads block the intestine in marine animals, impair reproductive ability and reduce the growth rate.

Check Your Progress 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) Define food toxicology

.....

.....

.....

.....

.....

.....

2) What are the types of food additives?

.....

.....

.....

.....

.....

2.6 KEY WORDS

Acute Effect : Effect of finite duration occurring rapidly (usually in the first 24 h or up to 14 d) following a single dose or short exposure to a substance or radiation

Additive Effect : Consequence that follows exposure to two or more physicochemical agents which act jointly but do not interact: The total effect is the simple sum of the effects of separate exposures to the agents under the same conditions

Adverse Effect : Change in biochemistry, physiology, growth, development morphology, behavior, or lifespan of an organism which results in impairment of functional capacity or impairment of capacity to compensate for additional stress or increase in susceptibility to other environmental influences.

Air Pollution : Presence of substances in the atmosphere resulting ither from human activity or natural processes, in sufficient concentration, for a sufficient time and under circumstances such as to interfere with comfort, health, or welfare of persons or to harm the environment.

Bioaccumulation : Progressive increase in the amount of a substance in an organism or part of an organism that occurs because the rate of intake exceeds the organism's ability to remove the substance from the body.

Contaminant : 1. Minor impurity present in a substance. 2. Extraneous material inadvertently added to a sample prior to or during chemical or biological analysis 3. In some contexts, as in relation to gas cleaning equipment, used as a synonym for "pollutant", especially on a small scale. 4. Unintended component in food that may pose a hazard to the consumer

Detergency : The term 'detergency' is used to describe the process of cleaning by surface active agent. Detergency can be defined as removal of unwanted substance (soil) from a solid surface brought into contact with a liquid. The word 'soil' in connection with textile surfaces most frequently

denotes the unwanted accumulation of oily and/or particulate materials on the surfaces or interior of fibrous structure

Poison : Substance that taken into or formed within the organism impairs the health of the organism and may kill it.

Photostability : The term photostability means resistance to permanent structural and functional changes under the infl uence of solar energy.

2.7 LET US SUM UP

Chemical toxicants are released into the environment in different ways, and they can transport through many pathways and show adverse effects on the environment. A toxicant present in the environment at a given point in time, it can be stationary, it can be transported, or it can be transformed into another chemical species. The life cycle of a chemical depends on the physicochemical properties, characteristics of the environment to which it is released. The chemical toxicants released into the atmosphere exerts adverse effects on humans and other terrestrial and aquatic organisms like intentional ingestion, occupational exposure, environmental exposure, as well as accidental and intentional poisoning.

2.8 REFERENCES AND SUGGESTED FURTHER READINGS

Hemond, H.F., and E.J.Fechner. Chemical fate and transport in the environment. New York Academic Press,1994

Mackay, D.,W.Y.Shiu, and K.C. Ma.Physical-Chemical Properties and environmental fate and degradation hand book, CRC Press 2000.

Rand, G.M., ed. Fundamentals of aquatic Toxicology:Part II Environmental Fate,Washington DC;Taylor and Francis,1995.

2.9 ANSWERS TO CHECK YOUR PROGRESS

Answers to Check Your Progress 1

Your answer should include the following points.

1) a) Toxicity is the amount of poison that, under a specific set of conditions, will cause a detrimental effect (agents are usually compared on a mg/kg basis, toxicity is not the condition produced by the toxicant).

   b) Toxicant: Any substance whose physiological action gives adverse effects on health is a toxicant.

   c) Toxicosis: It is the condition or disease state that results from exposure to a toxicant. The term toxicosis is often used interchangeable with the term of poisoning or intoxication.

2) Exposure classes are the toxicants under this class are present in domestic and occupational environment. (Ex: food, water, air, soil).Where as User classes are the type of toxicants include drugs of abuse, therapeutic drugs, agricultural chemicals, food additives, metals, solvents and combustion products.

Answers to Check Your Progress 2

Your answer should include the following points.

1) It deals with natural contaminants, food and feed additives, and toxic and chemo-protective effects of compounds in food. Food Toxicology is involved in delivering a safe and edible supply of food to the consumer. During processing, a number of substances may be added to food to make it look, taste, or smell better. Fats, oils, sugars, starches and other substances may be added to change the texture and taste of food. All of these additives are studied to determine if and at what amount, they may produce adverse effects. A second area of interest includes food allergies. Almost 30% of the American people have some food allergy. For example, many people have trouble digesting milk, and are lactose intolerant. In addition, toxic substances such as pesticides may be applied to a food crop in the field, while lead, arsenic, and cadmium are naturally present in soil and water, and may be absorbed by plants. Toxicologists must determine the acceptable daily intake level for those substances

2) According to Federal food, drug and cosmetic Act, five categories of compounds are associated with human food that includes GRAS.

   Cat - I - Whose GRAS stature was reaffirmed.

   Cat – II - No evidence of toxic hazard.

   Cat – III - Additional studies are required for safety.

   Cat – IV - Incomplete reaffirm safety. (Evidence of toxicity was reported)

   Cat – V - No biological studies available.