UNIT 3 WATER POLLUTION

Structure

3.0 INTRODUCTION

Water pollution can be defined as the presence of any solid, liquid, gaseous material and the heat generated contaminants in such concentration that may drastically change the quality of water thereby impairing the utility of water. Water pollution problem has become more pressing nowadays because of increase in population growth and increased use of per capita material energy. This has resulted in increase in the production of by-products as effluents that reach water bodies and affect the entire biosphere. The water pollutants generated from human activities reach surface and ground water through various pathways. These pollutants are categorized as point and non-point sources. Effluents from factories, sewage systems are point sources where as agriculture run-off and atmospheric deposition are some of the examples of non-point sources. Water is an excellent solvent for many chemicals which have adverse health effects on the environment. Petroleum products, pesticide run-off and industrial chemicals pollute many water bodies even at low concentrations.

Dear learner, in this unit we would first learn about physico-chemical and biological parameters of water which is helpful in understanding the pollution levels of various water sources. The point and non-point sources of water pollutants, pollution parameters and waste water treatment methods are discussed in detail in different sections. We start with the study of physico-chemical parameters.

3.1 OBJECTIVES

After studying this unit, you should be able to:

- define various physicochemical parameters of waste water,
- define industrial effluents and describe their characteristics,
- explain the origin of pollutants in petrochemical industries,
- enlist various health effects of industrial pollutants,
- explain water pollutants due to agrochemicals
- List out the general characteristics of sewage, and
- Describe sewage treatment methods.

3.2 PHYSICO-CHEMICAL AND BIOLOGICAL PARAMETERS OF WATER

Water gets contaminated by human use for different purposes that include household, industry, agriculture, etc. The contaminated water is called the waste water which is required to be estimated by known methods of analysis. Quantitative analysis of waste water is indicated by predictable parameters which delineate the nature of waste and its potential impact on the health of environment and human health. The following are the physico-chemical and biological parameters:

Total Suspended Solids 2. pH 3. Dissolved Oxygen (DO) 4 Total Dissolved Solids (TDS) 5. Oil 6. Turbidity 7. Biochemical Oxygen Demand (BOD) 8. Chemical Oxygen Demand (COD)

Let us understand these parameters in detail.

Total Suspended Solids (TSS): The particles that are larger than 2 microns and non-filterable are considered as suspended solids. These particles may be sediments, sand, silt, plankton, algae, animal decay and chemical precipitates. The heavier suspended particles settled at the bottom of the water body over a period of time are known as **sediments** or **bedload**. The remaining particles which float in water are known as **colloids**.

Effects: The SS changes the colour and reduces the light penetration there by affecting the photosynthesis process where generation of oxygen ceases.

Hypoxic inadequate supply of oxygen at the tissue level

The increase in TSS increases the water temperature and decrease in dissolved oxygen levels. The high rate of heat absorption by TSS than clear water increases the temperature of surrounding water by the process of conduction there by decrease in dissolved oxygen levels. Another effect of increase in surface water temperature is the water **stratification**. Because of this, the lower layers of water become hypoxic for survival of the organisms.

pH: pH is a chemical parameter that values between 0 to 14 on a defined scale. It provides the intensity of acidity and alkalinity of a given water sample along a

logarithmic scale. It has direct influence on the treatment procedures. It provides critical information in the treatment of waste water which removes heavy metals or organic compounds. The effluents contain heavy and toxic metals in the dissolved form. These will be removed by altering the pH by different suitable methods. High or low pH of water may kill water organisms and sterilize the water bodies, thereby inactivate the vital microorganisms in waste water treatment.

Do you Know?

The lower the number, the more acidic the water is. The higher the number, the more basic it is. A pH of 7 is considered neutral. The logarithmic scale means that each number below 7 is 10 times more acidic than the previous number when counting down. Likewise, when counting up above 7, each number is 10 times more basic than the previous number. The pH measurement can be done by using electrometric technique.

Dissolved Oxygen:

Dissolved oxygen (DO) is non-compound, free oxygen in the stream of water which is an important criterion to assess the quality of water.

The dissolved oxygen for aquatic animals varies from species to species ranges 1-6 mg/L to 4-15 mg/L. The DO is required for microbial decomposition of organic material at the bottom of the water. The DO levels decrease with increase of temperature, concentration of salts and increase in pressure.

Do You Know?

Causes of low dissolved oxygen (DO) primarily result from excessive algal growth caused by phosphorus. Nitrogen is another nutrient that can contribute to algae growth. As the algae die and decompose, the process consumes dissolved oxygen. This can result in insufficient amounts of dissolved oxygen available for fish and other aquatic life. Dying off and decomposition of submerged plants also contribute to low dissolved oxygen. The process of decomposition is called **Carbonaceous Biochemical Oxygen Demand** (CBOD). Sources of phosphorus include discharges from municipal and private wastewater treatment, cropland and urban storm water runoff, and natural decay of vegetation. Direct discharge of pollutants from point source and non-point sources into a river segment add to its CBOD loadings, creating an oxygen demand that may depress DO below acceptable concentrations.

Total Dissolved Solids (TDS): It is a measure of organic and inorganic substance in a given liquid. TDS mainly constitutes calcium, magnesium, sodium, and potassium cations and carbonate, hydrogen carbonate, chloride, sulfate, and nitrate anions. The organoleptic properties (qualities like taste, colour, odour, feel, etc.) of water with respect to TDS are as follows:

<300mg/L - Excellent

300-600 mg/L –Good

600-900 mg/L –Fair

900-1200 mg/L –Poor

>1200 mg/l L -Unacceptable

TDS in water streams is generated from urban and agricultural run-off, sewage, industrial wastewater, road de-icing salts and natural sources.

Turbidity: Turbidity is the only parameter which has optical determination. It is an indicator of water quality on the basis of clarity and relatively estimated TDS in water. Turbid water looks cloudy, coloured because of suspended solids that is based on the amount of light scattered by these. In addition to the suspended solids, coloured dissolved organic matter (CDOM), fluorescent dissolved organic matter (FDOM) and dyes enhance the turbidity of water.

Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is the amount of dissolved oxygen required for microbial metabolism of organic compounds in water at certain temperature (~20^0C) and a period of time (~5 days). It is a chemical procedure to measure the quantity of dissolved oxygen that indicates the quality of water. It is dependant on temperature, pH, microorganisms and organic and inorganic materials.

Chemical Oxygen Demand (COD): It is the amount of oxygen required in chemical oxidation of organic matter present in water. It essentially indicates the amount of oxidizable pollutants in water body and thus helps to know the pollution levels.

Check Your Progress 1

Note : a) Write your answer in about 50 words.
b) Check your progress with possible answer given at the end of the unit.

1. List out physico-chemical parameters of the waste waters.

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2. What is the importance of pH in waster waters?

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3.3 TYPES OF WATER POLLUTANTS

As mentioned earlier, water can get contaminated by various means. There are a number of sources that are responsible for adding pollutants to the running water, underground water or a natural water body. Thus the pollutants can come from Food Processing, Petrochemical, Textile, Tanning, Paper, etc. industry and also from Agrochemicals and Sewage. The pollutants from all these sources are discussed in the following subsections.

3.3.1 Industrial Water Pollutants

Industrial development leads to industrial effluents, and the untreated effluents become responsible for water, soil and air pollution. The quantitative assessment depends on

the concentration of these effluents present in the waste water. The expression of concentration of impurities is either by mgL^{-1} or ppm or percent saturation.

According to the Press Information Bureau, Government Of India (GOI), Ministry of Environment and Forest (MoEF) 2016, the Ministry of Environment, Forest and Climate Change (MoEFCC) has developed the criteria of categorization of industrial sectors based on the Pollution Index (PI) which is a function of the emissions (air pollutants), effluents (water pollutants), hazardous wastes generated and consumption of resources. For this purpose the references are taken from the the Water (Prevention and Control of Pollution) Cess (Amendment) Act, 2003, Standards so far prescribed for various pollutants under Environment (Protection) Act , 1986 and Doon Valley Notification, 1989 issued by MoEFCC. The **Pollution Index** of any industrial sector is a number from 0 to 100 and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector and the following is the criteria on '**Range of Pollution Index** 'for the purpose of categorization of industrial sectors.

- Industrial Sectors having Pollution Index score of 60 and above – Red category
- Industrial Sectors having Pollution Index score of 41 to 59 – Orange category
- Industrial Sectors having Pollution Index score of 21 to 40 – Green category
- Industrial Sectors having Pollution Index score incl.&upto 20 – White category

This unit discusses about some of the industries which are under the category of Red.

3.3.2 Food processing industry

The waste from food and food processing industries are termed as by-products. These by-products have the properties of high water holding capacity, binding, gelling and thickening. Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), and Dissolved Oxygen (DO) are the important organic parameters to determine the liquid wastes from food industry.

The by-products from some of the food processing industries which pollute the water bodies are summarized in Table 3.1.

Table 3.1: **Some food processing industries and their by-products**

Industry	**By-Products/Wastes**
Fruit and Vegetable Industry	High amount in glucose, citric and linoleic acids, tocopherols, and isorhamnetin-O-(di-deoxyhexosyl-hexoside), polysaccharides (e.g. pectin, cellulose, hemicelluloses, lignin and gums) and phenolic compounds bound with skin, i.e. dihydrochalcones, flavonols and phenolic acids

Dairy Industry	Dairy effluents, fats, oil and grease, whey by-product contains solvent proteins like ²-lactoglobulin, ±-lactalbumin, immunoglobulin, bovine serum albumin, lactoferrin, and lactoperoxidase, high content of essential amino acids, urea, uric acid, creatine, creatinine and ammonia.
Grain Processing Industry	Rice bran, oil, tocotrienols ²-glucans, the spent grain rich in cellulose and non-cellulosic polysaccharides, the hot trub and the residual yeast, the powder of macaroni boiling water, slime and waste waters
Brewery and Winery Industry	Wine prunings, grape stalks, grape pomace and grape seeds, yeast lees, tartrate, carbon dioxide and wastewater
Meat Industry	Carcasses, skins, bones, meat trimmings, blood, fatty tissues, horns, feet, hoofs or internal organs that are rich in lipids, carbohydrates and proteins
Marine Industry	É-3 PUFAs from the livers of white lean fish, waste flesh parts of fatty fish, blubber of marine animals, hydrolysates from fish guts/ cleanings, peptides, and products from crustaceans such as chitosan, chitosan oligomers and glucosamines

Check Your Progress 2

Note : a) Write your answer in about 50 words.
b) Check your progress with possible answer given at the end of the unit.

3. What are sources of waste in fruit and vegetable industry?

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4. What is the range of pollution index?

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3.3.3 Pollutants from Petrochemical Industry

Petrochemical waste from production to refining is considered to be complex to treat among the industrial wastewaters. Occasionally these are released into the atmosphere by accidental discharges due to the technical error and abnormal operations from polyethylene and ethylene oxide glycol industries. These are highly industry specific and typically generate hazardous solid waste, sludges and colloids which contain huge quantities of heavy metals, toxic organic substances like polycyclic and aromatic hydrocarbons, phenols, metal derivatives surface-active substances, sulphides, naphthylenic acids and other chemicals which contaminate the water bodies that pose adverse consequences on the ecosystem.

3.3.4 Pollutants from Textile Industry

The textile industry is one of most rapidly developing important industry on the globe. It requires large volume of water for numerous unit operations and chemicals for various processes involves wet processing sequences. The waste generated by this industry has high negative impact on the environment since this industry plays a major role in the fashion garment that varies in type of demand and coloured fabrics. The textile processing produce loads of liquid, solid and gaseous waste in each step.

The textile industry uses natural fibres like wool, hair, silk, cotton and flax and synthetic fibres like rayon and nylon. These wastes have salts, surfactants, ionic metals and their complexes, toxic chemicals, emulsifiers, dispersants and biocides that contributes to BOD,foaming and effluent aquatic toxicity. The pollutants generated in various processes of the textile industry are listed in the Table 3.2.

Table 3.2: **Nature of effluents generated in the textile industrial processes**

Process	Pollutants
Energy production	Particulate matter, NO_X, SO2
Coating, drying and curing	Volatile organic compounds
Cotton handling activities	Particulate matter
Sizing	NO_x, SO_x, CO_x
Bleaching	Chlorine and Chlorine dioxide
Dyeing	H_2S
Printing and finishing	Hydrocarbons and NH_3
Chemical storage	VOCs

3.3.5 Pollutants from Tanning Industry

Tanning Industry is considered to be one of the major sources of pollution with a potential environmental concern. The leather production process consists of the following stages and used hazardous chemicals at every stage. These are 1. Preparatory stages 2. Tanning 3. Crusting and 4. Surface Coating (Fig. 3.3).

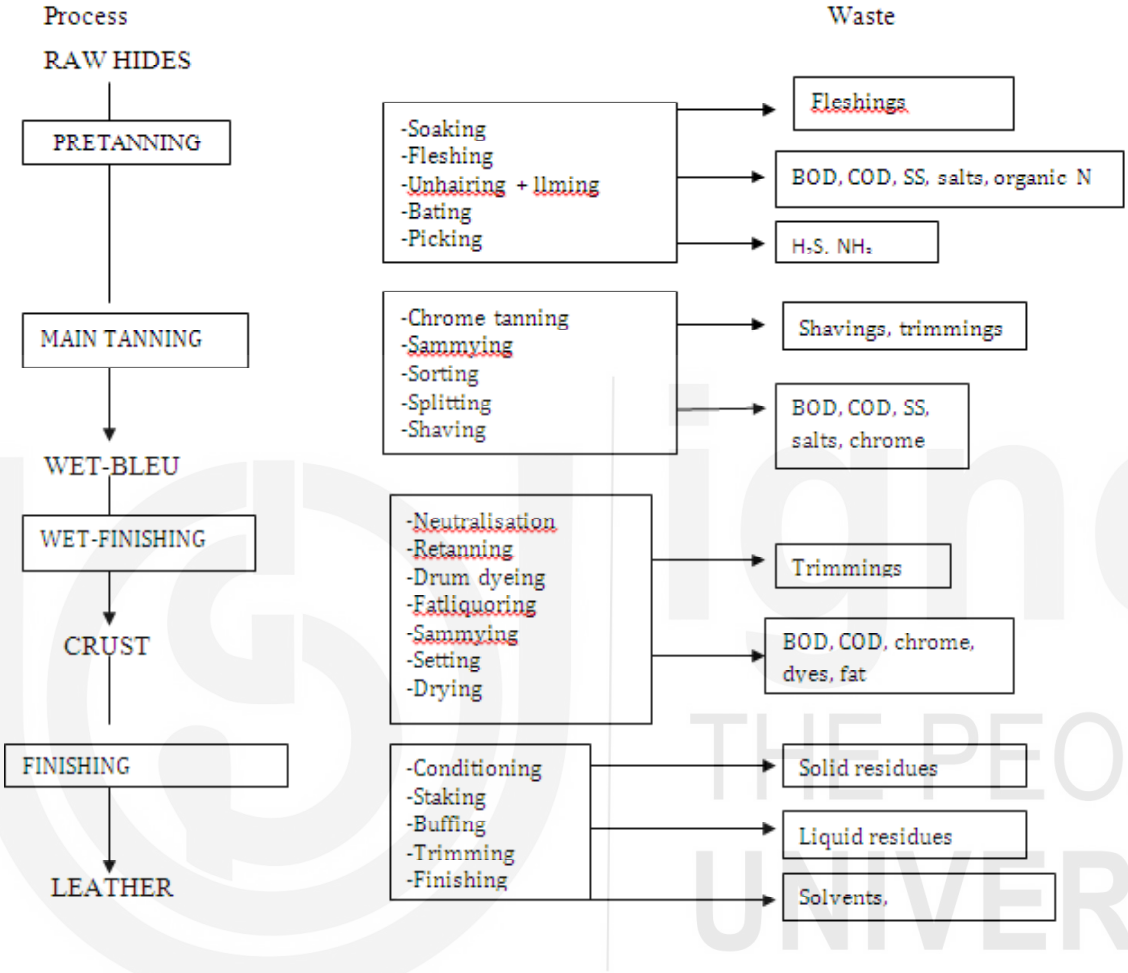

Fig. 3.3: Different stages in leather production process

Nature of Effluents: Approximately 80% of the organic pollutants, limed and non-limed waste is generated in the pretanning process. The waste water contains pollutants like salts (Cl), fats, proteins, preservatives (soaking); lime and ammonium salts, ammonia, protein (hair), and sulphides (fleshing, trimmingating); chromium(salts) and polyphenolic compounds (tanning); and dye and solvent chemicals (wet-finishing). Significant threat to environment and human health from tanneries have been observed because of chromium contamination, high chemical oxygen demand and BOD.

3.3.6 Pollutants from Paper and Pulp Industry

Paper and pulp industry is also one of the large industrial polluter to water, air and soil. The major process of a paper industry is depicted in **Fig. 3.4.**

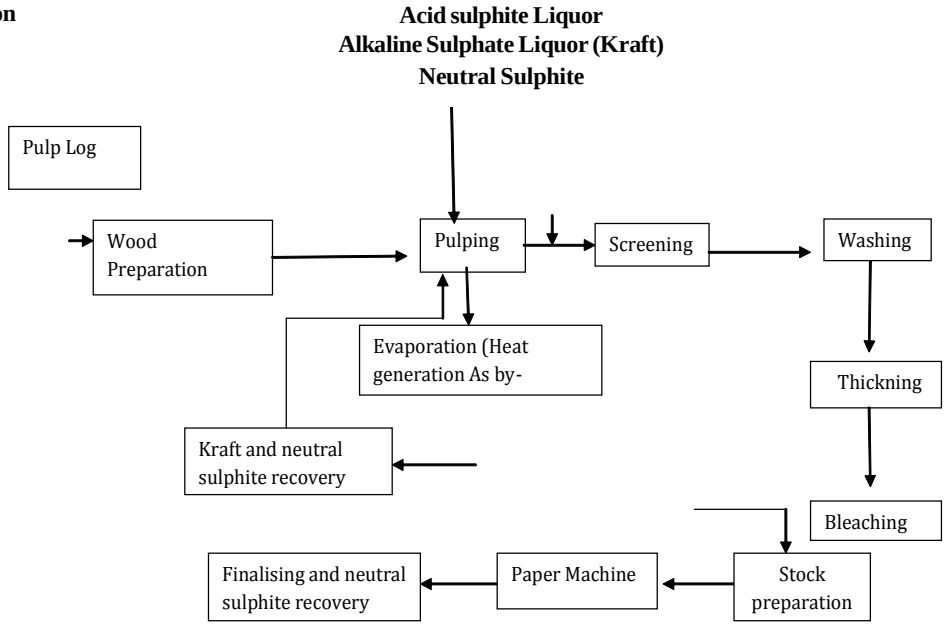

Fig. 3.4: Flow diagram of the processes in paper and pulp industry

Paper and pulp are manufactured from cellulosic fibres of wood, straw, cereal, reeds, jute, flax and esparto grass. These different raw materials used for different types of paper. For example, coarse type paper is generated from straw. Kraft, sulphite, neutral sulphite, soda, cold soda and ground wood are important pulps used to produce paper.

The major steps in the industry are raw material preparation, wood pulping, pulp bleaching and paper manufacturing. Raw material preparation includes debarking of wood, chipping of logs and screening of chips. The chemical pulping process fibres are released from the wood matrix since the lignin is eliminated by solubilizing in cooking liquor at elevated temperature.

Nature of Effluents

The major effluents from pulp and paper making are from wood preparation unit, screening and pulp cleaning unit, mechanical and chemical pulping, chemical pulping, textile fiber pulping unit, machine and bleaching waste which contains dissolved organic substances and suspended particles. They contain chlorine and chlorine based materials, sulfur, hydrogen sulfide and sulfur dioxide. The chlorinated compounds are mainly used in bleaching process of wood pulp and chemical pulp. The pollutants from bleaching process contain significant amounts of dioxins which belong to a group of POPs, with high toxic potentials. The waste waters contain various solids, nutrients; sulfur compounds and Dissolved Organic Matter (DOM). Nutrients like nitrogen and phosphorous cause eutrophication. DOM changes the ecological characteristics of water bodies that lead to the high levels of BOD which can cause the death of aquatic organisms, SO_2 released from the processing of sulphur compounds that makes the water bodies more acidic. Solid pollutants consist of clay particles, $CaCO_3$, titanium dioxide and fiber.

3.3.7 Water Pollutants due to Agrochemicals

The pesticides, biocides, manures and fertilizers are categorized under agrochemicals that are used to enhance the yield of the crop. The essential hydrological processes

that loop rainfall, runoff and leaching, and which bring about erosion and transport of chemically augmented soil particles, are important in aquatic contamination by fertilizer products. The major sources of pollutants due to pesticides are industries, agriculture, forestry and also air which becomes a means of spreading the pollutants. The dust particles in the air adsorb the pesticides from pesticides spray in agriculture, forestry and then contaminate water bodies, sediments and soil through rain water. The high quantity of the residual pesticide eventually be leached to aquifer levels and pollute the groundwater. The amount of pesticide leachability is measured in terms of the **groundwater ubiquity score** (GUS).

The GUS index can be written as

GUS = log (DT_{50}). [4–log(Ka)],Where DT_{50} and Ka are persistence and mobility respectively. The tendencies of groundwater contamination are (i) non-leacher (GUS < 1.8), (ii) transition (1.8 < GUS < 2.8) and (iii) leacher (GUS > 2.8).

Leaching of pesticides depends on the amount applied per area per year, application procedure, the solubility of the compound, how strongly it is bound by the soil and how quickly it degrades in the root zone. After a pesticide application a part of it may be lost to the atmosphere through volatilization, and a part is carried away to surface waters by runoff, or broken down by photolysis. The pesticides from the contaminated water are taken up by plants and animals and enter the food chain. Once they enter into the body they are tissue degradative, relatively stable and carcinogenic in nature. Some of them damage the liver and the nervous system. Further more, certain pesticides are found to alter the enzymatic activities of the body which leads to different types of diseases. Some of the commonly used pesticides and their health hazards are given in Table 3.3.

Table 3.3 : Most commonly used pesticides and their health hazards

Pesticide	**Diseases/Adverse effects**
Aldrin	Attacks the nervous system, convulsion, repeated dosage damages the liver, carcinogenic
Benzene hexa chloride (BHC)	Liver tumour
Captan	Abnormality in the eyes and brain, carcinogenic
Chlordane	Carcinogenic
DDT	Liver damage, carcinogenic
Dieldrin	Liver damage, carcinogenic, destroys enzymatic activities
Endosulfan	Carcinogenic
Hexa Chloro Benzene	Highly toxic, bone marrow damage, mutagenic, teratogenic, carcinogenic

Heptachlor	Liver damage, carcinogenic
Malathion	Low toxic but sometimes carcinogenic
Methoxychlor	Low toxic but sometimes carcinogenic
Mirex	Carcinogenic

Commercial fertilizers contain mainly potassium and nitrogen and phosphorous. Some of the fertilizers are identified as possible sources of water pollution. The improper dissemination causes adverse toxic effects on the environment and humans as well since these substances are toxic in nature. For example, surface water fertilization results in eutrophication, i.e., intense growth of algae which causes unmanageable changes to the biological equilibrium. These chemicals enter the water bodies by intentional or unintentional application for pest control. Globally many soils are deficient in phosphorous, which is required for plant growth. In its phosphate form, phosphorus is significant for cell's genetic material, and available as adenosine triphosphate (ATP), the energy carrier in cells. Phosphorous based fertilizer is the major contributor to run-off phosphorous pollution from the agriculture land and through manure into waterways. Excess phosphorus results into harmful algal blooms, known as **eutrophication**. The blooms consume much of the dissolved oxygen in the water, are lethal to fish and other plant life, also release toxins that are toxic to humans and animals. Toxic effects of potassium in humans are very rare since it is promptly excreted in the absence of pre-existing kidney damage. The impacts of some of the agrochemicals are listed in Table 3.3.

Table 3.4: Some agrochemicals and their impacts

Agrochemicals	**Impacts**			
	Ground water	**Surface water**	**Ecosystem**	**Humans**
Pesticides	Some pesticides may leach into groundwater and contaminate the drinking water causing human health problems.	Pesticides runoff contaminates the surface water and biota; Pesticides are also travel long distances as dust by wind and contaminate aquatic systems.	Pesticides inhibit the growth and causes reproductive failure. Consequent upon malfunctioning of ecological system in surface waters occurs by loss of top predators.	Adverse effects on human health by eating contaminated food like fruits, vegetables and fish, breathing contaminated air etc.,
Fertilizers **Nitrogen** based	Nitrogen fertilizers in any form leach in to groundwater and converted into nitrites by microorganisms that contaminate ground water.	Surface runoff carry nitrogen fertilizer to the water streams and lakes there by contaminates.	Nitrate can toxic to plants that causes stunted growth and excessive nitrate accumulates in the leaves of the crop.	Water with high quantity of nitrate and food consumed by humans and cattle gets converted into nitrites by microorganism's causes the disease

				methemogl-obinemea (blue baby syndrome) in children and by the formation nitrosamines have the same effect in cattle also.
Potassium based	Potassium is strongly held by clay particles in soil. Therefore, leaching of potassium through the soil profile and into ground water is important only on coarse-textured soils			Potassium toxicity causes chest tightness, nausea and vomiting, diarrhea, hyperkalaemia, shortness of breath and heart failure.
Phosphorous based	Leached phosphorus stored in bed sediments which is released back to the water column causing 'dead zones'. Phosphate fertilizer can also contribute heavy metal like cadmium to food chain. Cadmium is present in concentrations ranges between 5-280mgkg^{-1} in Rock phosphate.	Excess phosphorus caused harmful algal blooms known as eutrophication. The blooms consume much of the dissolved oxygen in the water, lethal to fish and other plant life, also release toxins that are toxic to humans and animals.	Excess of Phosphorous causes toxic algal blooms, loss of biodiversity and increased health risks for the plants, animals and humans that come in contact with polluted waters.	Excess of phosphate can cause health problems, such as irritation in eyes, kidney damage and osteoporosis.

Do You Know?

Methemoglobinemea is caused by high levels of methemoglobin in the blood. Methemoglobin is one of the forms of hemoglobin that contains the ferric [Fe^{3+}] ion and the affinity for oxygen of ferric iron is impaired and the binding of oxygen in the remaining heme sites that are in ferrous state within the same tetrameric hemoglobin unit will increase. Hypoxia will occur when methemoglobin concentration is elevated in red blood cells. This leads to an overall reduced ability of the red blood cell to release oxygen to tissues.

3.3.8 Sewage Water Pollutants Sewage includes domestic wastewaters and municipal wastewater that is produced by a population. Sewage contains organic wastes as well as chemicals pollutants. It consists of grey water, black water, soaps and detergents. Sewage is drained off in large quantities into rivers and other water bodies without treating. This causes adverse effects on biodiversity and humans. The characteristics of sewage water are as follows.

i. **Temperature, Odour and Turbidity**: The information about the temperature of sewage is helpful in measuring the solubility of oxygen, which affects sedimentation and rate of biological activity. At extremely low temperature viscosity increases and affects sedimentation adversely. The odour of old sewage is offensive and unusual smell observed in the case of industrial sewage water. Fresh sewage is highly turbid and grayish in colour.

ii. **Inorganic and Organic Matter:** The nitrogen compounds in domestic sewage are proteins, amines, amino acids, and urea formed by the bacterial decomposition of organic constituents. Nitrogen content in the untreated sewage is observed to be in the range of 20 to 50 mg/L measured as Total Kjeldahl Nitrogen(TKN). Phosphorus in domestic sewage arises from food residues containing phosphorus and their disintegration products. The huge quantities of synthetic detergents add substantially to the phosphorus content.

Organic constituents in the sewage are mainly proteins, carbohydrates and fats. The microorganisms metabolize sewage organic compounds for the source of energy by catabolism. Protein contains C, N, H and O and sometimes P. The source of nitrogen in the sewage is urea that decomposes immediately to CO_2 and NH_3. Proteins also release H_2S gas in the process of reduction. Carbohydrates contain C, H, O and mainly exist in the form of sugars and starch. By the bacterial action they produce organic acids and the pH of brackish sewage water is low when compared to the fresh sewage. Fats also contain carbon, hydrogen and oxygen. They form thin film and decompose to produce filthy smell.

The parameter that characterizes all sewage organic compounds is that which can be oxidized and contains organic carbon. Oxidation of organic compounds can be measured by 1) the Biochemical Oxygen Demand (BOD) and 2) the Chemical Oxygen Demand (COD) tests. Total Organic Carbon (TOC) test is the other test to measure the concentration of the organic material.

Biochemical Oxygen Demand (BOD): The BOD of the sewage is the amount of oxygen required for the biochemical decomposition of biodegradable organic matter under aerobic conditions. The established range of BOD for raw sewage is 100 to 400 mg/L.

Chemical Oxygen Demand (COD): The COD of the sewage is the amount of oxygen required for chemical oxidation. The established range of the COD of raw sewage is 200 to 700 mg/L. In BOD test, the oxidation of organic matter takes several weeks, whereas, biochemical oxidation of organic matter takes barely two hours.

iii. **Microorganisms**: Microorganisms found in sewage emerge from two sources. 1. soil and 2. sanitary waste. One milliliter of sewage ranges between 100,000

and 1 million microorganisms. Some of them considered as good bacteria that purify sewage. In anaerobic conditions they hydrolyze protein, reduce urea and emulsify fats. They also reduce sulphate and nitrates giving rise to CH_4, CO_2 and NH_3. They add nitrites, nitrates, CO_2 and H_2O. Some forms of parasitic bacteria produce toxins that are capable to cause diseases and infection in humans and animals. Pathogens commonly found in sewage are *E. coli*, *Salmonella, Shigella, Pseudomonas aeroginosa, Streptococcus, Mycobacterium* and *Giardia Lamblia.*

3.5 SEWAGE TREATMENT METHODS

The polluted water has to be treated by using different waste water treatment technologies depending upon the type of pollutants. The type of pollutants in waste is divided into four categories.

1. Debris and grit
2. Particulate organic material
3. Colloidal and dissolved organic material
4. Dissolved inorganic matter.

In addition to these pollutants raw waste water, pesticides, heavy metals and other toxic compounds are also present. The general procedure of sewage treatment is depicted in **Fig. 3.5.**

The sewage treatment invoves the following steps:

1. **Preliminary** treatment involves screening and settling process for the removal of debris and the grit.

2. **Primary** treatment for the removal of particulate organic matter involves floating process by primary clarifiers.

3. **Secondary** treament involves **trickling-filter system** or **activated sludge system** for the removal of colloidal and dissolved organic matter. Secondary treatment is also known as **biological treatment** because it uses organisms which are natural decomposers and detritus (waste) feeders. The principle behind this is creating such environment that enables these organisms to feed on the waste containing organic matter and break it down to CO_2, mineral nutrients and water in the process of cell respiration.

4. **Biological nutrient removal (BNR)** process for the removal of dissolved inorganic material involves various processes like denitrification for nitrogen containg pollutants and chemical filtration for phosphorus containg pollutants.

The secondary-treatment systems were designed for biological digestion and the secondary activated-sludge systems have been added, which remove both nutrients and oxidize detritus by the process known as biological nutrient removal.

Nitrogen: It is converted by bacteria (ammonia and nitrate) through denitrification process into nonnutritive nitrogen gas that is released into the atmosphere.

Phosphorus: In oxygen rich environment the bacteria absorb phosphate from solution and store it in their bodies. The raw sludge is treated with these phosphate containing bacteria producing a more nutrient-rich treated-sludge product and can be removed. Phosphorous can be eliminated by precipitating as calcium phosphate with lime or treat the effluent with ferric chloride, which produces insoluble ferric phosphate, or with an organic polymer, which gives rise to a **floc**.

5. Treatment of sludge: Anaerobic digetion,composting,and pasteurization procedures are used for the treatment of sludge. These are explained below.

   Anaerobic Digestion: Anaerobic digestion is a process of enabling the bacteria to feed on the detritus in the absence of oxygen. In the absence of oxygen, organic matter is broken down by anaerobic bacteria and decomposed to biogas which is a mixture of carbon dioxide, methane, and water. Because of its methane content, biogas is flammable and can be used for fuel.

   Composting: Another process used to treat sewage sludge is composting. Raw sludge is mixed with wood chips or some other water-absorbing material to reduce the water content. It is then placed in windrows – long, narrow piles that allow air to circulate conveniently through the material and that can be turned with machinery. Bacteria and other decomposers break down the organic material to rich humus-like material that makes an excellent treatment for poor soil.

   Pasteurization: After the raw sludge is dewatered, the resulting sludge cake may be put through ovens where the sludge is pasteurized to sufficiently kill any pathogens. The product is dry, odorless and the organic pellets are used as organic fertilizer.

6. **On-site** waste water treatment systems, **reconstructing wetland** systems are the alternate treatment methods.

7. **Ground water remediation** involves drilling wells, pumping out the contaminated water, purifying and reinjecting.

   You are aware that water pollution is one of the most burning problem across the globe. The intervention of the Government is a must and it has tried to enforce a number of Acts to streamline the procedures for reducing water pollution. In the next and the last section of the unit let us study about the Acts and the regulations formulated by the Government and analyse the role of stakeholders in the whole proces.

3.6 ROLE OF THE GOVERNMENT

1. In India Water (Prevention and Control of Pollution) Act 1974 has been enacted for the Prevention and Control of Water Pollution and the maintenance or restoration of the wholesomeness of water for the establishment.

2. Central Pollution Control Board (CPCB) under the Water Act 1974 advise the Central Government on any matter concerning the prevention and control of water pollution by collecting, compiling and publishing technical and statistical data relating to water pollution and the measures devised

for its effective prevention and control and prepare manuals, codes or guides relating to treatment and disposal of sewage and trade effluents and disseminate information (MoEF).

3. CPCB in association with state pollution control boards has been monitoring the qualities of water bodies under National Water Quality Monitoring Programme (NWQMP).

4. CPCB has identified many polluted rivers and preparing action plans for prevention and treatment of pollution.

5. Steps have been taken for the initiation of installation of online effluent monitoring system, issuance of directions to the industries for implementation of zero liquid discharge etc.

3.7 LET US SUM UP

Quantitative analysis of waste waters is indicated by predictable parameters which delineate the nature of waste and its potential impact on the health of environment and human health. The physico-chemical and biological parameters are total suspended solids, pH, dissolved oxygen, oil, turbidity, biochemical oxygen demand and chemical oxygen demand. The waste water from dairy includes huge amounts of nutrients like nitrogen and phosphorus. The waste water from petrochemical industries release huge quantities of heavy metals, toxic organic substances like polycyclic and aromatic hydrocarbons, phenols, metal derivatives, surface-active substances, sulphides, naphthylenic acids and other chemicals which contaminate the water bodies that pose adverse consequences on the ecosystem. This unit also discussed different pollutants from tanning industry, paper and pulp industry. The sewage treatment plant for treating the polluted water involves different stages like, preliminary, primary, secondary, biological removal of nutrients and sludge treatment. The unit finally discusses the role of the Government to mitigate the water pollution problem in the country.

3.8 KEY WORDS

Acidity : Quantitative capacity of aqueous solutions to react with hydroxyl ions.

Chemical Oxygen Demand : Measure of oxygen consuming capacity of substances present in the waste water.

Turbidity : Condition in waste water due to the presence of suspended particles resulting in the absorption and scattering of light rays.

Eutrophication : Eutrophication, or hypertrophication, is when a water body becomes nutrient rich that influence excessive growth of plants and algae.

Herbicide : A chemical used to kill or inhibit the growth of undesired plants.

Petrochemical : A chemical made from petroleum as a base raw material –include plasic, synthetic fibre etc.

pH : Scale used to designate the acidity or alkalinity of solutions or soil, expressed as the logarithm of the concentration of hydrogen ions.(H^{+}),pH 7 is neutral; values decreasing from 7 indicate increase in acidity, values increasing from 7 increasing alkalinity.

Persistent organic pollutants (POP) : Any member of a class of organic pollutants that are resistant to biodegradation and that are often toxic; for ex: DDT, PCBs and dioxin are POPs. Such chemicals may remain present in the environment for periods of years.

Phosphate : An ion composed of a phosphorous atom with four oxygen atoms attached. Denoted PO_4^{-3}, phosphate is an important plant nutrient. In natural waters, it is frequently the limiting factor; therefore, additions of phosphate to natural water are often responsible for algal blooms.

Pathogen : An organism, usually a microbe that is capable of causing disease.

Pasteurization : The process of applying enough heat to kill pathogens to extend the shelf life of the product.

Sludge cake : Treated sewage sludge that has been dewatered to make a moist solid.

3.9 REFERENCES AND SUGGESTED FURTHER READINGS

1. Fundamentals of Environmental Chemistry by A.K.De
2. Environmental Chemistry by Stanley Manahan
3. Textbook of Environmental Science by Pearson.

3.10 ANSWERS TO CHECK YOUR PROGRESS

1. a. Total suspended solids b. Total dissolved solids c. Dissolved oxygen d. Biological oxygen demand e. Chemical oxygen demand
2. One of the most important characteristics of industrial waste is their acid or alkali content. It provides critical information in treatment of waste

waters which removes heavy metals or organic compounds. The effluents contain heavy and toxic metals in dissolved form. These will be removed by altering the pH by different suitable methods. High or low pH of water may kill water organisms and sterilize the water bodies, thereby inactivate the vital microorganisms in waste water treatment.

3. High amount in glucose, citric and linoleic acids, tocopherols, and isorhamnetin-O-(di-deoxyhexosyl-hexoside), polysaccharides (e.g. pectin, cellulose, hemicelluloses, lignin and gums) and phenolic compounds bound with skin, i.e. dihydrochalcones, flavonols, and phenolic acids.

4. The Pollution Index PI of any industrial sector is a number from 0 to 100 and the increasing value of PI denotes the increasing degree of pollution load from the industrial sector and the following is the criteria on 'Range of Pollution Index 'for the purpose of categorization of industrial sectors.

   - Industrial Sectors having Pollution Index score of 60 and above - Red category
   - Industrial Sectors having Pollution Index score of 41 to 59 – Orange category
   - Industrial Sectors having Pollution Index score of 21 to 40 – Green category
   - Industrial Sectors having Pollution Index score incl.&upto 20 - White category

5. Eutrophication, or hypertrophication, is when a water body becomes nutrient rich that influence excessive growth of plants and algae.

6. Water with high quantity of nitrate and food consumed by humans and cattle gets converted into nitrites by microorganism's causes the disease methemoglobinemea in children and by the formation nitrosamines have the same effect in cattle also.