Unit 3

Environmental pollution:

- Sources of pollution- Natural sources, & Anthropogenic
- Pollutants- Classification & their effects on environment
- Air pollution-Composition of clean air, Sources of air pollution & Air pollutants, Effect of air pollution on humans, animals and plants & climate
- Water quality–Potable water, Wholesome water, Sources of water pollution Polluted water & Contaminated water,
- Common impurities in water (physical, chemical and bacteriological), Effects of impurities on humans & industrial use
- Soil Pollution-Sources, Effects & its control
- Noise pollution- Sources of noise, Effects on human health & its control

Numerical problems on pH, hardness of water, noise pollution

Environmental pollution

The word **"pollution"** is from Latin word pollutionem (make dirty)."Pollution is an undesirable change in the physical, chemical or biological characteristics of water, air and land (soil) which may cause potential health hazard of any living being or species or loss of cultural and natural assets".

Pollution of the environment directly leads to the ecological imbalance of the world. Progress in science and technology is leading to the pollution of environment. In the long run it may leads to the disaster of mankind and other living organisms. Speedy exploitation of natural resources by man disturbed the sensitive ecological balance between living and non-living component of biosphere.

Now a days it is becoming common to find warning boards in public places, stating "Water unfit for drinking", Do not eat fish caught here", "Water is unfit for recreation", "Air unfit for breathing", and so on.

The rapid progress in Industry, Agriculture, Transportation etc, are taken as the general criterion to measure the development of any nation.. All these activities have created adverse effect on the biosphere in one or the other way. Rapid industrialization and urbanization leads to depleted natural resource, contaminated surface (rivers) and ground water, contaminated soil, contaminated air (atmosphere) and depleted forest resources (animals, plant etc).

Polluant: Polluant is a substance that causes pollution. Pollution is caused by the addition of substances by human activity to the environment. When these substances are not removed, assimilated or decomposed by the nature (physical or biological process), the accumulation of these pollutants causes pollution. A pollutant may include any activity (sound) chemical, geochemical (dust), substances, biotic component or product, physical factor (light, heat) etc. that is released into the environment in such a concentration that may have harmful or unpleasant effects.

Pollutant is also defined as "any liquid, solid or gaseous substance present in such concentration as may be or tend to be injurious to the environment". Pollutants are the remaining of the things we make use and throw.

Sources of pollution: The sources of pollution is broadly classified into two groups

(a) **Natural sources:** The pollution originates from the natural calamities and processes such as volcanic eruptions (releases gases and ash), earthquake, forest fire, dust storm (deserts), cyst and pollens, spores decay of organic matter etc.

(b) **Manmade (artificial) or Anthropogenic sources:** The pollution originates due to the activities of man. Anthropogenic sources cover a wide range of sources. Since man has aggravated the problem of pollution due to multiple activities for his comfort and enjoyment. The sources are deforestation, industrialization, automobiles, nuclear explosions, over population, quarrying and mining, construction activities, wars agriculture (fertilizers and pesticides) etc.

Classification of pollutants: Pollutants are classified as follows

(a) Based on the form they exist

(i) Primary pollutants: These persist in the form in which they are added to the environment. Eg.DDT, Plastic.

(ii) Secondary pollutants: These are formed by interaction among the primary pollutants. For example, peroxy acetyl nitrate (PAN) is formed by the reaction of two primary pollutants, namely nitrogen oxides and hydrocarbons released from the motor vehicles in presence of sunlight.

(b) Based on biological degradability

(i) Biodegradable (Degradable) pollutants: They are actually waste products, which are slowly degradable by microbial action. They cause pollution when their production exceeds the capacity of the environment to degrade them. eg. Sewage.

(ii) Non degradable (non-biodegradable) pollutants: They are waste products, which are not decomposed or are decomposed very slowly. They include wastes (eg. plastics, glass, plastic bottles, polythene bags, used soft drink cans etc) or poisons (eg. pesticides like DDT, salts of heavy metals, radioactive substances etc). The non-biodegradable pollutants are difficult to manage and in most cases there is no treatment process to handle the anthropogenic input of such materials in the eco system.

(c) Based on their existence:

(i) Quantitative pollutants: These are the substances, which occur in nature but become pollutant when their concentration reaches beyond a threshold value in the environment. eg. Carbon dioxide, nitrogen oxide.

(ii) Qualitative pollutants: These are the substances that do not occur in the environment but are passed into it through human activity. E.g. Fungicides, herbicides, DDT etc.

(d) Based on their origin:

(i) Natural pollutants: Volcanic eruptions add tons of toxic gases and particulate matter n the environment.

(ii) Man made or anthropogenic pollutants: It is a man made pollutants such as industrial pollutants, agricultural pollutants, etc

Principal polluants: Varions polluants that cause environnemental pollution are

Deposited matter	Dust, smoke, soot, grit, tar
Gases	Carbon dioxide, carbon monoxide, sulphur dioxide, Ozone, ammonia, halogens (fluorine, chlorine, bromine, iodine).
Chemical compounds	Hydrogen fluoride, aldehydes, detergents, etc.
Acid droplets	Nitric acid, sulphuric acid, etc
Metals	Iron, zinc, nickel, cadmium, chromium, lead, mercury, etc.
Agrochemicals (poisons)	Pesticides, fungicides, herbicides, insecticides, etc
Organic substances	Acetic acid, benzene, ether, toluene, benzopyrenes, etc
Photochemical oxidants	Photochemical smog, peroxy acetyl nitrate (PAN),nitrogen oxides, etc.
Fertilizers	Nitrogen, phosphorous, potash, etc
Sewage waste, noise and heat, radioactive waste (iodine-131, cobalt-60, argon-41) etc.	

Human Activities & Impact on Environment:

Human activities and technological advancements made to enjoy luxurious life have caused severe in balances and disturbances in natural environment.

Although there are several individual human activities, which may cause environmental imbalances, they can be grouped in to the following four major types of actions.

(1) Agriculture: The development of agriculture has been the most important single event in the evolution of human culture. With the development and increase in human population, the agriculture on more and more land has been practiced to grow crops. Initially the humans have grown only food crops to eat but later on they have started growing several kinds of cash crops. Not only they have brought a large part of the forest land under agriculture, but also they have started using fertilizers and pesticides to increase the crop production per unit of agricultural area. The present mode of agriculture is highly mechanized as the modern technology is constantly inventing new & newer machines for agriculture. This has infact become virtually imperative as the human population is increasing day by day especially in developing countries.

Such industrialized agriculture is the root cause of environmental problems. Today's agriculture is consuming tremendous amount of energy particularly the fossil fuels like oil, petrol, diesel etc. These fuels are being used to run machines for agriculture and for the production of fertilizers & pesticides. These products are seriously polluting our environment & destabilizing it.

For e.g. the fertilizer residue draining into the streams & rivers add extra energy, which causes the Algae & Macrophytes (large plants) to bloom in aquatic eco systems. This modifies the entire eco system in the long run.

Similarly, the pesticides used for killing pests do not kill the pests alone but also kill some useful organisms like the honey bee, lady bird, beetles etc.

Besides killing useful organisms, they even kill the microorganisms present in the soil and thus the pesticides poison the whole terrestrial food chain.

The milk given by the cows & buffaloes is now found to contain pesticides since the vegetations eaten by these animals do contain pesticide sprayed by humans on vegetation. The pesticide poison has spoiled the drinking water & the entire food leaving all of us to undergo slow poisoning deaths.

The applications of pesticides have also resulted in the virtual extinction of several predatory (carnivores) birds like hawks, falcons, eagles etc.

Because of continuous increase in human population, many countries are forced to convert their forest areas, wetlands & other productive areas into agricultural lands.

This has resulted in changes in climate, hydrological cycle, and mineral resources.

This kind deforestation has lead to the extinction of several plants & animals species all over the world.

(2) Industrialization: Industrialization means development of industries of various kinds. These industries cause maximum environmental instability, by polluting water, air and land.

Industrial revolution with rapid growth of human population has increased the demand of raw materials and other resources by considerable extent. The rapid uncontrolled growth of the industries are contaminating and spoiling the precious water sources like rivers and lakes by throwing their wastewaters into water sources. This will ultimately make clean drinking water totally unavailable. Similarly, the industries are releasing several poisonous gases and substances in our atmosphere, there by polluting our air. Industries have also placed an extra-ordinary burden on our petroleum and oil reserves.

(3) Urbanization: The urbanization is the process of urban development, under which mass migration of people from rural areas to the industrialized urban areas take place due to the increased job opportunities. With such a fast urbanization taking place lot of land have been consumed to build giant urban centers. Precious farming land had been lost to urbanization.

Urbanization changes the green, wet and earthen land to concrete and asphalt paved land. These increases the rain's run off thereby increasing floods and reducing ground water recharge.

Urbanized areas produce enormous quantities of sewage and domestic waste waters, which on being discharged into the rivers, either in untreated or partly treated condition pollute the rivers and can totally modify the aquatic ecosystem.

Air pollution and land pollution, prevailing in urban centers, can also modify the ecosystem.

Urbanization modifies the nearby areas. For example, large amount of sand is removed from the rivers in construction activity which makes the river ecosystem unstable due to abnormal large pits created in the river bed.

Hills are destroyed to get stones for construction purposes. The removal of hills may change and modify the climate, not only locally but even regionally over vast areas, as the rainfall in plains becomes difficult to occur.

Another major requirement of urbanization is wood for furniture, doors. Windows, amirahs, cupboards etc. This demand is met by destroying the forest, which causes serious consequences for forest eco system. Any loss of forest will lead to the loss of beneficial effects of forest.

(4) Mining: Mining is the extraction of minerals & ores from the earth's crust. Mining provides coal for the energy, metals for making machines & engines, ores for making chemicals & fertilizers, clays for making crockery, rocks & stones for buildings, bridges & dams, the gold, diamond & other precious stones for jewelleries.

The exploitation of mineral resources has increased several times leading to large scale mining activities.

Mining whether it is at the surface or underground alters the whole landscape & the eco system existing at the place of mining which cannot be shifted any where.

The removal of minerals from the earth naturally upsets the existing land conditions and waste tailing produced in this process contain toxic chemicals like mercury & sulphides of iron. The waters in these areas have become very acidic. No plant grows & no animal

survives in such areas. Mining activity has given rise to vast areas of waste land that are now useless from the point of view of agriculture or agro forestry.

Air pollution:

The atmosphere is the thin layer of gases (air) that surrounds the earth surface. Air is defined as the invisible, tasteless and elastic mixture of gases. Air pollution is assuming global magnitude and it is not confined to any particular part of earth or country. Under ideal conditions, the air in the atmosphere has a qualitative and quantitative balance that maintains the well being of human, plants and materials. When the balance among the air components are disturbed, then air is said to be polluted.

Definitions:

(1) Air pollution is the presence in the ambient atmosphere of substances, generally resulting from the activity of humans, in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property (Indian standard institution).

(2) The presence in the outdoor atmosphere, of one or more contaminants such as **fumes, dust, gases, mist, grit, odour, smoke or vapors** in considerable quantities and of duration which is injurious to human, animal or plant life or which unreasonably interferes with the comfortable enjoyment of life and property (Perkins 1974).

(3) Substances introduced into the air by the activity of mankind in such concentrations sufficient to cause serious effects on his health, plants, property or interfere with the enjoyment of his property (Sharma and Haur 1997).

Composition of Air: Various gases are present in the atmosphere as shown in the table. The nitrogen gas is biologically inert but some bacteria and plants utilize it.

The oxygen is essential for all living beings.

Carbon dioxide is utilized in photosynthetic process of plants.

Trace gases (helium, neon, krypton, xenon, etc.) have little or no role with the living organisms. Atmospheric pollution is the addition of harmful gases by human activities.

Table: Normal composition of air

Gases	Percent (by volume)
Nitrogen	78.084
Oxygen	20.9476
Argon	0.934
Carbon dioxide	0.0314
Methane	0.0002
Hydrogen	0.00005
Other gases	Minute

Types of air pollutants: On the basis of physical state, air pollutants are of two types- gaseous and particulate.

(1) Gaseous pollutants: These pollutants are in gaseous state at normal temperature and pressure.

(2) Particulate pollutants: These pollutants occur as solid and liquid particles. They are of two types-settleable and suspended.

Settleable: The particles larger than 10 μm in diameter such as water drops, sand etc which settle down rapidly in still air, are called settleable pollutants.

Suspended: The smaller particles such as dust, smoke, etc. which remain suspended for long periods in the air are called suspended pollutants. These include soot, asbestos fibers, pesticides, some metals (including Hg, Pb, Cu and Fe) and also biological agents like tiny dust, mites and pollen. The larger suspended particles with more than 1μm in diameter are often called dust (solid) and mist (liquid). Aerosols, smokes and fumes are also suspended particles with a diameter less than 1μm.

Sources of air pollution: The sources that contribute pollutants to the air are as follows

(I) Stationary combustion sources: Burning of fuels in industries, residential establishments, hotels, bakeries, thermal plants and brick kilns contribute most of the gaseous and particulate pollutants in the air. Coal and wood are largely made of carbon mixed with

some incombustible minerals, sulphur and nitrogen. Therefore, when fossil fuels are burnt they produce a mixture of oxides of carbon, nitrogen and sulphur and water vapor. Burning of coal also produce mineral ash, some of which is discharged as fly ash.

(II) Mobile combustion sources: These include locomotives, automobiles, aircrafts, etc. With the rapid increase in vehicular traffic, automobiles have become the largest source of air pollution in cities.

(III) Industrial processing and other sources: The industrial processes involve metallurgical processing, welding, grinding, synthesis of chemicals, etc. These processes release several gaseous and particulate pollutants into the air. Gaseous pollutants of different types are released from the industries that process organic chemicals at high temperatures.

(IV) Secondary air pollutants: These are formed from primary pollutants by photochemical reaction.

Major air pollutants and their effects:

Air quality surrounding human has a direct impact on health and property. The health effects of air pollutants are classified as short-term effects and long-term effects. Elderly people and children often suffer more from the air pollution. The harmful effects of air pollution depend on the concentration of pollutants and duration of exposure. Following table gives common air pollutants and their effects.

Table: Common air pollutants, their sources and effects

Sl.No	Pollutants	Sources	Effects
1	Carbon dioxide, CO_2	Coal, petrol, oil, diesel combustion (automobile exhaust)	Green house effect
2	Carbon monoxide, CO	Burning of coal, petrol, diesel, automobile exhaust	Reduce oxygen carrying capacity of blood, causes headaches and drowsiness, fatal in high concentration
3	Oxides of sulphur, SO_2, SO_3	Coal and oil combustion	Acid rain that damages trees, plants, water bodies, materials, causes headache, aggressive asthma, vomiting and causes irritation of eyes, nose and throat
4	Oxides of nitrogen, NO_2, NO	High temperature burning in automobiles, burning of coal	Acid rain formation, effects plants, buildings, lakes, aggressive asthma.
5	Lead compounds	Burning of leaded petrol	Neural effects in children, effects on plants
6	Nuclear wastes	Nuclear weapon testing, nuclear power plants	Radioactivity, cancers, mutations, etc.
7	Suspended particles (ash, fly ash, etc.)	Burning of coal, manufacturing process	Eye irritation, aggravation of asthma, etc.
8	Ozone, O_3	Atmosphere chemical reaction of NO_2 and aldehydes	Global warming, damage to plants and materials.
9	Hydrocarbons	Burning of petroleum products, benzene, benzepyrene, etc.	Carcinogenic effect on human, causes eye irritations, respiratory distress, throat irritation, formation of Pan, effect on plants
10	Chlorofluorocarbons	Refrigerant, aerosole propellants, cosmetics, etc.	Ozone depletion.

Effect of air pollution on human health:

- Eye irritation
- Nose and throat irritation
- Irritation of respiratory tract
- Gases like H_2S, NH_3 and mercaptans cause odour nuisance even at low concentrations.
- Increase in mortality rate and morbidity rate.
- A variety of particulates particularly pollens initiates asthmatic attacks.

- Chronic pulmonary diseases like bronchitis and asthma are aggravated by a high concentration of SO_2, NO_2, particulate matter and photochemical smog.
- Carbon monoxide combines with the hemoglobin in the blood and consequently increases stress on those suffering from cardio vascular and pulmonary diseases.
- Hydrogen fluoride causes dieses of bone (fluorisis) and mottling of teeth.
- Carcinogenic agents cause cancer.
- Dust particles cause respiratory diseases. Diseases like silicosis, asbestosis etc, result from specific dusts.
- Certain heavy metals like lead may enter the body through the lungs and cause poisoning.

Effect of air pollution on vegetation:

- Dust, smoke and other particulate matter settle on the leaves of plants and reduce sunlight, there by retard photosynthesis.
- Sulphur dioxide causes chlorosis, plasmolysis, membrane damage and metabolic inhibition. The leaves often assume water soaked appearance. Fruit trees and cereal crops are more sensitive to oxides of sulphur. Therefore, they suffer a great loss in the areas around smelters and industrial belts.
- Fluorides destroy tissues in leaves causing necrosis of leaf margin and tips.
- Several plant species are also very susceptible to PAN in smog. PAN damages chloroplasts and thus the photosynthetic efficiency and growth of plants are reduced. It also inhibits electron transport system and interferes with enzymes that play important role in cellular metabolism.
- Hydrocarbons such as ethylene cause premature leaf fall, fruit drop, shedding of floral buds, curling of petals and discoloration of sepals.
- Ozone damage chlorenchyma and thus destructs the foliage in large number of plants.
- Lichens are very sensitive to air pollution. Their growth is inhibited in polluted air. The death of lichens in an area is an indicator of air pollution.
- Acid rain adversely affects terrestrial and aquatic vegetation. Low P^H also damage soil microbial community.

Effect air pollution on animals: Air pollution causes large-scale damage to livestock. The general effects of air pollution on domestic animals in and around industrial area are similar to those on human beings

- Ingestion of fluorine compounds deposited from the air on fodder causes fluorosis (excessive calcinations of bones and teeth). It also results in lameness, frequent diarrhea and loss of weight.
- Several airborne microbes cause diseases.

Effect air pollution on materials: Various material damage due to air pollution is as follows.

Materials	**Principle air pollutants**	**Effects**
Metals	SO_2, acid gases.	Corrosion, spoilage of surface, loss of metal tarnishing.
Building materials	SO_2, acid gases and particulates.	Discoloration and leaching
Paint	SO_2, H_2S and particulates.	Discoloration.
Textiles and textile dyes	SO_2, acid gases and NO_2 and ozone.	Deterioration, reduced textile strength and fading.
Rubber	Oxidants and ozone.	Cracking and weakening.
Leather	SO_2, acid gases.	Disintegration and powdered surface.
Paper	SO_2, acid gases.	Embitterment.
Ceramics	Acid gases.	Change in surface appearance.

Aesthetic loss due to air pollution: Air pollution has strong bearing on the aesthetic side of human life.

- A clear transparent atmosphere is aesthetically pleasing but is necessary for clear vision. A dust haze or hanging smoke blurs our views
- Foul odour emitted by industries, automobiles, dirty drains and garbage heaps make urban life unpleasant.
- Coal dust and their materials discharged from the industries settle down on the flour and other objects of houses and give dirty look.

Effect of air pollution on climate:

- Heat produced by the industrial plants raises the temperature of the area.
- Carbon dioxide content of the atmosphere is increasing due to destruction of forests and excessive burning of fossil fuels. It will lead to rise in global temperature by more than two or three degree due to green house effect. A rise in global temperature may result in melting of glaciers and polar ice caps, flooding of low-lying coastal plains and submersion of island. Rainfall pattern may also change, thus affecting agricultural out puts.
- Aerosols and Chlorofluorocarbons deplete ozone layer in the stratosphere, which permit most of the harmful ultraviolet radiation to reach the earth.

Water quality:

Water is essential to human life and to health of the environment. As a valuable natural resource, it comprises marine, estuarine, fresh water (river and lakes) and ground water environment, across coastal and inland areas. Water quality is commonly defined by its physical, chemical, biological and aesthetic characteristics. A healthy environment is one in which the water quality supports a rich and varied community of organisms and protects public health.

Water quality in a body of water depends upon the way in which communities use the water for activities such as drinking, swimming or commercial purposes.

Importance of water quality:

Most of the earth's water is in the oceans or in the form of ice. The largest volumes of fresh water are stored underground as ground water. Only a tiny fraction is present as fresh water in lakes, streams and rivers. But, it is this proportion, which is so important for many of our terrestrial ecosystem, including humans.

The quality of this fresh water is vitally important. We depend on surface and ground water sources for our drinking water. Our water resources are of major environmental, social and economic value and if water quality becomes degraded this resources will lose its value. Water quality is not only important to protect public health but also for the waters used for farming, fishing, mining, recreation, tourism etc. If water quality is not maintained, it is not just the environment that will suffer but also the commercial, domestic and recreational value of water resources will diminish.

Definitions:

Potable water: Water that is free from apparent turbidity, colour, and odour and free from any objectionable taste so that it consumed in any desired amount without concern for adverse effects on health is known as potable water.

Wholesome water: Water that does not contain harmful impurities and does contain other salts and minerals that are useful to health is known wholesome water.

Polluted water: Water containing any foreign matter (solid, liquid or gaseous) that is infectious or non-infectious and toxic or non-toxic that affects its beneficial usage is known as polluted water.

Contaminated water: Water that contains infectious agents or toxic matter that affects the health of the community and make the water unfit for its beneficial usage is known as contaminated water.

Common impurities in water and their effect on human health:

The various impurities present in water may be classified into the following three categories.

- **Physical impurities:** The physical impurities are those impurities that affect the physical characteristics of water such as colour, odour, taste and turbidity.
- **Chemical impurities:** The chemical impurities are those impurities that affect the **chemical characteristics** of water such as total dissolved solids and suspended solids present in water, pH value, hardness, chloride content, nitrogen content, etc.
- **Bacteriological impurities:** The bacteria are minute singe cell organisms that are universally found in water obtained from any source. They are very small measuring only 1 to 4 micron in length (1 micron = 10^{-6} m). As such they have to be examined under a microscope. The bacteria are usually classified according to their shapes, their oxygen requirements and their effect on mankind.

According to shape the bacteria are classified as cocci (round shaped), bacilli (rod shaped) and spiralla (spiral shaped).

According to oxygen requirements the bacteria are classified as aerobic bacteria, anaerobic bacteria and facultative bacteria.

Aerobic bacteria are those which require free oxygen for their survival, thus if present in water they consume dissolved oxygen from the water and decompose the organic matter present in water.

Anaerobic bacteria are those that flourish or thrive in the absence of free oxygen.

Facultative bacteria are those that can survive with or without free oxygen.

According to the temperature they flourish, the bacteria are classified as Psychrophilic, Mesophilic and Thermophilic.

- Psychrophilic which can persist at low temperatures of 10^0 C and 20^0C.
- Mesophilic which can persist at temperature of 20^0 C and 40^0C.
- Thermophilic which can persist at temperature of 40^0 C and 65^0C.

According to effect on mankind the bacteria may be classified as harmless bacteria and harmful bacteria. The harmless bacteria are called non-pathogenic bacteria or non-pathogens. These bacteria besides being harmless, under certain conditions are beneficial to human beings, animals and crops. The harmful bacteria are called pathogenic bacteria or pathogens. The pathogenic bacteria are the real foes of mankind, which may cause serious water borne diseases such as cholera, typhoid, dysentery, infectious hepatitis, etc. Generally non-pathogenic and pathogenic bacteria occur together, and hence the presence of large amount of non-pathogenic bacteria in a water sample indicates the possibility of the pathogenic bacteria being also present in the water sample.

Water pollution:

(1) Water pollution is the contamination of water by foreign matters such as physical matters, chemicals, microorganisms, sewage, industrial wastes or other wastes. Such matters deteriorate the quality of the water and renders it unfit for its best uses.

(2) Water pollution is change in physical, chemical and biological characteristics of water that may cause harmful effects on human, animal and aquatic biota.

Sources of water pollution:

(1) **Non point sources:** In non point source the point of entry of pollutant is not identifiable. The pollutants generated from a broad group of human activities and by natural processes. The pollutant sources are decomposed vegetable and animals, agricultural runoff, weathering products etc. Addition of these pollutants influence on the chemical characteristic, colour, odour, biological properties etc.

(2) **Point source:** The pollutants are added at a known point. The pollutants are collected and discharged at a single point. The sources are sewage, industrial radioactive mining etc. The pollutant sources are generated due to the activities of humans.

Major water pollutants: The major water pollutants are

(1) Sewage (Domestic wastewater, municipal wastewater): These are wastewater generated from domestic activities. It adds colour, taste, odour, organic and inorganic compounds, heavy metals, suspended solids, floating solids etc. To reduce the pollution treatment of wastewater is necessary.

(2) Agricultural waste: Agriculture is the single largest user of fresh water (surface and ground water) resources. Most of the agricultural water is recycled back to surface water and ground water. Modern agricultural practices are the main cause of water pollution. Agricultural practices such as applying chemical fertilizer, manure spreading, irrigation methods, pesticides, animal farming, aquaculture etc have wide impact on surface and ground water quality.

(3) Industrial waste: Most of the rivers, lakes and ground water are polluted by industrial wastewater. Industrial wastewater contains a variety of organic and inorganic pollutants such as suspended solids, metallic wastes, oil grease, phenols, toxic organic and inorganic, plastics, chemicals etc. Many of these pollutants are susceptible to degradation or slowly degrade to cause serious pollution problems.

(4) Radioactive substances: Radioactive substances are short or long lived products which are released from nuclear power plants, nuclear fuel processing and nuclear weapon tests. The long-lived products (uranium, strontium-90, thorium, cesium-137**)** will remain in the water for longer duration and contaminate the water for longer time.

(5) Petroleum products: This consists of hydrocarbons. These are slowly degradable. Crude oil is the major pollutant of sea, when a large tanker spills the oil when transporting. The major pollutants are oil, benzene, toluene, chlorinated solvents, biocides, plastics, pesticides etc. Chlorinated solvents are toxic at very low concentration.

(6) Thermal pollution: Release of heated water from chemical industries, thermal power plants, nuclear power plants etc leads to increase of temperature of water bodies which affects utilization of water for its best uses. It also affects the entire aquatic environment (increase in bacterial multiplication, consumption of dissolved oxygen, death of fish etc).

Types of water pollution: Water pollution can be classified into the following three categories.

(1) Physical pollution: The physical pollution of water is due to change in colour, turbidity, odour, taste, foam, thermal properties and conductivity.

(2) Chemical pollution: The chemical pollution of water is due to change in total solids, P^H , chlorides, nitrogen, phosphorous, fats, sulphates dissolved oxygen, chemical oxygen demand, biochemical oxygen demand, gases, metals etc. Pollution is caused by organic or inorganic or by both.

(3) Biological pollution: Biological pollution of water is caused by excretory products of humans, animals, birds, sewage and industrial waste water (tanneries, slaughter house, dairy etc). The main biological pollutants are bacteria, viruses, algae, protozoa, parasitic worm, fecal colifarms, streptococci etc. Contaminated water causes infection of intestinal system (dysentery, typhoid, cholera etc) infectious hepatitis etc.

Indicator of polluted water: Following are the important indicators of water pollution

- Colour and bad taste of drinking water.
- Increase in turbidity and floating solids (oil and grease).
- Offensive odour from water bodies.
- Growth of aquatic weeds (eutrophication) in water bodies.
- Decrease in aquatic animals (fish).
- Increase in temperature of water.

Effects of water pollution: The effects of water pollution depend on the type of pollutants present in water. Pollutants brings about physical and chemical changes that make the water unfit for drinking and harmful to aquatic life. The main effects of pollutants are as mentioned below.

(1) Effects on aquatic ecosystem: Presence of organic and inorganic wastes in water decreases the dissolved oxygen (DO) content of the water. Water having DO content below 8.0 mg/l may be considered as contaminated. Water having DO content below 4.0 mg/l is considered to be highly polluted. DO content of water is important for the survival of aquatic organisms. A number of factors like surface turbulence, photosynthetic activity, oxygen consumption by organisms and decomposition of organic matter determine the amount of DO present in water.

(2) Biological magnification: The phenomenon through which certain pollutants get accumulated in the tissue in increasing concentration along the food chain is called biological magnification. Many of the pesticides are non-degradable and their residues have long life. The organic chlorine compounds such as DDT, radionuclides etc are the most persistent pesticides. Once they are absorbed by an organism, they cannot be metabolized and broken down or excreted out. These pollutants get accumulated in fat containing tissues of the organisms. A classic example of biological magnification is the accumulation of DDT in the tissues of organisms of aquatic food chain.

(3) Eutrophication: The addition of inorganic compounds and decomposition of organic wastes in water bodies increase the nutrient content of water. It could profuse growth of algae especially the blue-green-algae, and may totally cover the water surface. This type of algal growth is called algal boom. The algal boom often releases toxins in water and inhibits the growth of other algae. Aquatic animals (fish) may also die due to toxicity or lack of oxygen. The process of nutrient enrichment of water, which often leads to the loss of species diversity, is called eutrophication.

(4) Effect on human health: A number of health hazards are caused due to various types of pollutants present in water. The important human health hazards related to water pollution are as follows:

- The water polluted with sewage usually contains pathogens like virus, bacteria, parasitic protozoa and worms. The sewage-contaminated water, therefore, is a source of water borne diseases like jaundice, cholera, typhoid, amoebiasis etc.
- The water contaminated with heavy metals can cause serious health problems. Mercury compounds wastewater converted by bacterial action into extremely toxic methyl mercury, which can cause numbness of limbs, lips and tongoue, deafness, blurring of vision etc.
- Presence of excess nitrate in drinking water is dangerous for human health and may be fatal for infants. It reacts with hemoglobin to form non-functional methaemoglobin and impairs oxygen transport. This condition is called methaemoglobinemia or blue baby diseases.
- Excess fluoride in drinking water causes dental fluorosis and skeletal fluorosis.
- Over exploitation of ground water may lead to leaching of arsenic from soil and rock sources and contaminate ground water. Chronic exposure to arsenic causes

black foot disease. It also causes diarrhea, peripheral neuritis, hyperkerotosis and also lung and skin cancer.

Water borne diseases: Water borne diseases are those that are transmitted by contaminated water. Water is a good carrier. Lot of disease causing bacteria will contaminate water. Communicable disease that may be transmitted by water includes bacterial, viral and protozoal infections.

(i) The disease caused by bacterial infection:

- Typhoid fever
- Paratyphoid
- Bacillary dysentery
- Cholera
- Salmonellosis
- Shigellosis.

(ii) The disease caused by viral infections:

- Infectious hepatitis
- Poliomyelitis

(iii)The disease caused by protozoal infections:

- Amoebic dysentery
- Giardiasis

Typhoid, paratyphoid, dysentery, gastroenteritis and cholera are transmitted by the fecal and urinary discharges of sick persons and carriers. Through careless disposal of the discharges or inadequate treatment of city sewage underground water may be contaminated to endanger well water supplies or streams and lakes may be affected to contaminate surface supplies. Prevention of water borne outbreaks of these diseases is primarily a matter of treating the water by different methods.

Effect of some impurities on human health:

Colour: Colour may be imparted to water by the presence of natural metallic ions (iron and manganese), peat (decayed vegetable matter), weeds, humus, plankton and industrial wastes. An undesirable appearance is produced by colour in water and people may not like to drink coloured water. Further coloured water may spoil the clothes washed in it and it may affect various industrial processes. As such colour should be removed from water to make it suitable for general and industrial purposes.

Taste and odour: The taste of water may be bitter, salty, sour and sweet. Similarly water may possess odour such as unpleasant, earthy, fishy, grassy, muddy, peaty and sweetish. Taste and odour are closely related and these may be imparted to water by the presence of dissolved gases such as H_2S, CH_4, CO_2, O_2 etc, combined with organic matter, mineral substances like NaCl, iron compounds, carbonates and sulphates of other elements, and phenol and other tarry or oily matter. It is evident that water to be supplied from a public water supply scheme should not have any undesirable taste and odour.

Turbidity: Turbidity in water is caused by suspended matter, such as clay, silt, finely divided organic and inorganic matter, soluble coloured organic compounds and plankton and other microscopic organism. Turbidity is an important consideration in public water supplies for three major reasons, such as aesthetic, filterability and disinfection. A turbid water has muddy or cloudy appearance and it is aesthetically unattractive. Filtration of water is rendered more difficult and costly with the increase in turbidity. In cases where turbidity is caused by sewage solids the disinfection of public water supplies may not be effective because many of the pathogenic organisms may be encased in the particles and protected from the disinfectant. As such the water supplied to the consumers from a public water supply scheme should be free from turbidity.

Total solids: The total solids present in water comprise total dissolved solids (TDS) and suspended solids. Out of the two the dissolved solids usually predominate and these mainly consist of inorganic salts and small amounts of organic matter. The suspended solids are usually present in small amounts.

For drinking water the amount of total dissolved solids should not exceed 500 mg/l. However, the amount total dissolved solids present in water in excess of 500 mg/l may be tolerated but it should not exceed 1500 mg/l, which is the maximum permissible limit for the total dissolved solids in water to be considered suitable for human consumption.

pH: pH is defined as the logarithm of the reciprocal of hydrogen ion (H^+ ions) concentration. The pH value of water is a measure of acidity and alkalinity of water.

The acidity in water is caused by the presence of mineral acids, free carbon dioxide, sulphates of iron, aluminium etc. The alkalinity in water is caused by the presence of bicarbonates of calcium and magnesium or by the presence of carbonates or hydroxides of sodium, potassium, calcium and magnesium.

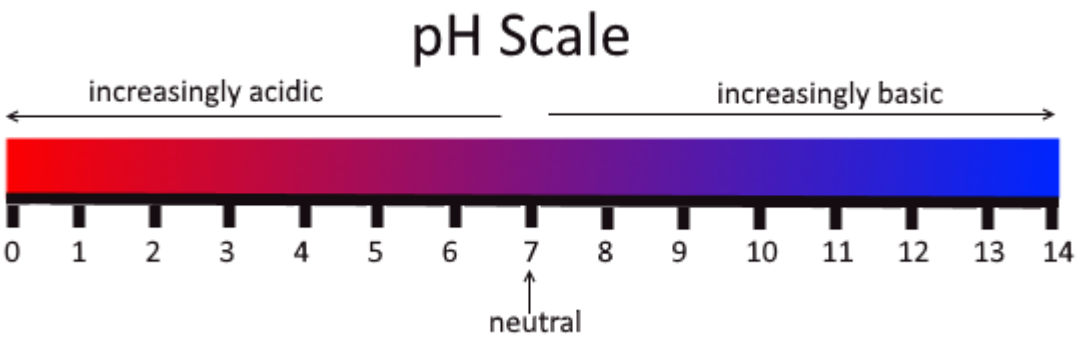

Figure shows the pH scale. The pH scale varies from 0 to 14 with 0 to 7 as acidic range, 7 as neutral and 7 to 14 as alkaline range. It may be observed from the pH scale that when the value of pH is equal to zero there is maximum acidity in water and when the value of pH is equal to14 there is maximum alkalinity in water.

For drinking water the value pH should be between 7.0 and 8.5.However, water having pH value less than 7.0 or more than 8.5 may also be accepted but the one having pH <6.5 or >9.2 is not suitable for human consumption and it should be rejected. Further from general considerations the waters having lower values of pH (i.e., acidic waters) may cause tuberculation and corrosion, while those waters having higher values of pH (i.e., alkaline waters) may cause incrustation, sediment deposits, difficulties in chlorination, certain physiological effects in human system, etc.

Hardness: Hardness is that characteristic of water that prevents the formation of sufficient lather or foam with soap. The presence of bicarbonates, sulphates, chlorides and nitrates of calcium and magnesium cause the hardness of water. The hardness caused by the presence of carbonates and bicarbonates of calcium and magnesium is known as carbonate hardness. The carbonate hardness is also known as temporary hardness because it can be removed by boiling the water or by adding lime to the water.

On the other hand the hardness caused by the presence of sulphates, chlorides and nitrates of calcium and magnesium is known as non-carbonate hardness. The non-carbonate hardness is also known as permanent hardness because it cannot be removed by simply boiling. It requires special treatment of water softening. The hardness of water is usually expressed in mg/l. A scale of hardness showing different levels of hardness of water is as follows.

Range (mg/l)	Hardness level
0-50	Soft
50-100	Moderately soft
100-150	Slightly hard
150-250	Moderately hard
Over 250	Hard

The excess hardness of water is undesirable because it causes more consumption of soap, modifies colour if used in dyeing work, carbonate hardness produces scale in boilers, causes corrosion and incrustation of pipes and makes food tasteless.

Chloride content: Chlorides are usually present in water in the form of sodium chloride (common salt). These impart a salty taste to water. The chlorides may be added to water due to solvent power of water dissolving salts from topsoils as well as from underground formations, intrusion of seawater into fresh water in the coastal regions, disposal of industrial and domestic wastes and human excreta into streams or rivers, etc. The presence of large quantity of chlorides in water indicates its pollution due to sewage, minerals, etc. The chloride concentrations of raw waters being used for public water supplies should therefore be tested regularly, so as to detect any sudden increase in their chloride contents and possibility of the organic pollution of the source of water.

Nitrates: The amount of nitrates in drinking water should not exceed 45 mg/l. The presence of excess amount of nitrates in drinking water may adversely affect the health of infants, causing a disease called ‘methemoglobinemia’ (commonly known as ‘blue baby disease’) which may result in the death of the child in extreme cases.

Fluorides: Fluoride is a mineral cation that is beneficial and as well as harmful to human. Desired concentration of fluorides in drinking water is 1 to 1.5 mg/l. A fluoride concentration of less than 1 mg/l may be harmful and may cause ‘dental carries’ (tooth decay) due to formation of excessive cavities in the teeth of young children during calcinations of permanent teeth. Therefore a minimum amount of fluoride is beneficial to fight against ‘dental carries’ (tooth decay). On the other hand excessive concentration of fluorides (greater than 1.5 mg/l) may be harmful, causing spotting and discolorations of teeth leading to a

disease called ‘dental fluorisis’. Consumption of excessive fluorides for long periods causes crippling of bones, a disease called ‘skeletal fluorisis’. Hence fluoride is called as doubled edged weapon.

Soil pollution:

Soil: Soil is one of the most significant ecological factors. It is an aggregation of unconsolidated mineral and organic particles produced by physical and biological process. It is a medium that supports the growth of plants, water, mineral supply and anchorage. Soil is also defined, as a highly generalized structure of the shallow upper layers of land surface of the earth, which by weathering of underlying rocks, intimate association with organic matter and with living organisms, has become a suitable habitat for the living beings.

Sources of soil pollution:

- Solid wastes
- Industrial wastes
- Agricultural practices
- Radioactive wastes
- Biological pollutants

Effects of soil pollution:

- Industrial wastes consist of chemicals that are extremely toxic and hazardous to living beings. Industries such as steel, fertilizers, pesticides, pulp and paper, refineries etc, discharge suspended solids, oil and greases, solvents, heavy metal, organic and inorganic pollutants, hazardous wastes and nondegradable compounds into soil. The toxicants are transferred to organisms present in soil and enter food chain, which leads to undesirable effects.
- Discharge of metallic compounds (Hg, Zn, Cd, Cr, Na, K, Cu, As etc) effects the beneficial microorganisms, worms and bacteria in the soil. Accumulation of these in the soil for long period may kill the living organisms and contaminate water.
- Utilization of sewage, septic tank effluent, sludge of municipal wastewater treatment for irrigation and manure for longer period will decrease the agricultural production and effects soil fertility.
- Radiation from radionuclides affects the soil fertility. This intense radiation affects the plant growth, production etc.

- Excessive use of nitrogenous fertilizers for agriculture leads to accumulation of nitrate in the soil and later percolates into the ground water and becomes toxic (>45 mg/l). This nitrates leads to blue baby diseases in newborn babies.
- Excess use of pesticides and insecticides leads to accumulation in soil, which concentrates in vegetables, fruits, crops etc and make them unfit for use.

Control of soil pollution:

- Use of pesticides should be minimized.
- Use of fertilizers should be judicious.
- Cropping techniques should be improved to prevent growth of weeds.
- Special pits should be selected for dumping wastes.
- Controlled grazing and forest management.
- Wind breaks and wind shield in areas exposed to wind eosin.
- Planning of soil binding grasses along banks and slopes prone to rapid eosin.
- Forestation and reforestation.

Noise pollution: The term noise may be defined as

- The unwanted unpleasant sound and is also characterized by its undesirability and loudness.
- Noise is the wrong sound at the wrong time in the wrong place.
- Noise in physics, is an acoustic, electrical or electronics signal consisting of a random mixture of wavelength.

A particular sound may be a pleasure to one but may be a noise to another. Whether a given sound is as pleasant as music or a noise depends on its loudness, duration, rhythm and the mood of the person. Loudness is the most significant criterion, which makes sound into noise. Noise is a physical form of pollution and its effects are more on the receiver (human). The noise may be classified by its occurrence in time as, steady state noise (continuous), impact noise (single impulse of short duration at regular or irregular intervals) and intermediate noise.

Sources of noise pollution: The sources noise may be classified into

(a) Natural sources:

- Earthquake.
- Volcano.
- Thunder.
- Fast wind blows.

(b) Artificial sources:

- Industrial noise.
- Transportation noise.
- Construction noise.
- House hold and residential noise.
- Urban or community noise.

Effects of noise pollution:

(a) Effect on hearing ability: The most immediate and acute effect of noise pollution is impairment of hearing:

- Eardrum may be damaged by sudden loud noise or prolonged exposure to noise
- The sensory cells meant for hearing in our ears may be permanently damaged, if they are subjected to repeated sounds of high intensity before their recovery.
- The noise in cities is often enough to deafen people gradually as they grow old.

(b) Effect on general health: Following adverse effects on general health are caused by noise pollution

- Noise cause anxiety and stress and in extreme cases may lead to fright.
- Constant exposure to noise causes hormonal imbalance leading to several disorders such as increased rate of heartbeat, constriction of blood vessels and increase in cholesterol level producing high blood pressure, hypertension and decreased heart output.
- Noise causes digestive spasms and dilation of eye pupil, impairment of night vision and decrease in the rate of colour perception.
- A sudden high intensity noise produces a startle reaction which may affect psychomotor performance of a person and even heart failure in heart patients.
- Noise also detracts attention and causes emotional disturbance.

- Damage to heart, brain and liver has been reported in animals due to prolonged noise pollution.

(c) Other effects: Noise interferes with our conversation, disturb concentration and upsets mood.

Control of noise pollution: Noise pollution can be minimized by the following measures.

- **Reduction at source:** The best method of controlling noise pollution is to reduce the noise at the source itself. Measures should be planned such that it can generate less noise. The measures are installing noisy machines in sound proof chambers, covering the noise producing machines with sound absorbing materials, use of silencer to control noise from ducts, automobiles etc. Providing vibrating machine by vibration damping (rubber, neoprene cock etc), use quieter machines(designing & fabricating) to replace noisy ones, better lubrication methods and maintenance of machines.
- **Reduction at receivers end:** The workers working in the area of noisy machines should be provided with ear protection aids such as ear-muffs, head phones, ear plugs etc. By using these aids noise can be controlled effectively.
- **Acoustic zoning:** A rational town planning can help to reduce outdoor noise pollution. A city or town can be divided into residential area, industrial area, bus terminals area, aerodromes area, railway station area, hospital area etc so that sufficient distance can be maintained between the noisy area and residential areas. A silence zone can be maintained near residential areas, hospital area and educational institution.

Problems on water pollution

$$pH = \log\frac{1}{H^+} \quad \text{or} \quad pH = -\log H^+$$

$$H^+ \times OH^- = 10^{-14}$$

Problem 1: If Hydrogen ion concentration in a sample of water is 0.000001. Calculate its pH value.

Solution:

$$pH = \log\frac{1}{H^+} = \log\frac{1}{0.000001} = 6$$

Problem 2: If the concentration of OH^- in a water solution is 0.008, find the value of pH.

Solution:

We know that

$$H^+ \times OH^- = 10^{-14}$$

$$H^+ = \frac{10^{-14}}{0.008} = 1.25 \times 10^{-12}$$

$$pH = \log\frac{1}{H^+} = \log\frac{1}{1.25 \times 10^{-12}} = 11.9$$

Problem 3: In a water treatment plant, the pH value of entering and leaving water is 6.5 and 8.5 respectively. Assuming linear variation of pH with time, calculate the average pH value of water.

Solution: $pH = \log\frac{1}{H^+}$

For entering water, pH = 6.5

$$6.5 = \log\frac{1}{H^+}$$

$$H^+ = 10^{-6.5}$$

For leaving water, pH = 8.5

$$8.5 = \log\frac{1}{H^+}$$

$$H^+ = 10^{-8.5}$$

Average value of H^+ ion concentration = $\frac{(10^{-6.5} + 10^{-8.5})}{2}$

$= 1.596 \times 10^{-7}$

$$pH = \log\frac{1}{H^+} = \log\frac{1}{1.596 \times 10^{-7}} = 6.796$$

$$\textbf{\textit{Hardness}} = \frac{Concentration\ of\ divalent\ cat-ions\ x\ Eq.wt.of\ CaCO_3}{Eq.wt.of\ divalent\ cat-ions}$$

(Note: Only divalent cat-ion causes hardness).

(Note: Only divalent cat-ion causes hardness).

Problem 4: A River water was proposed as the raw water source for a city. Chemical analysis of the water indicates the constituents given below. Calculate the hardness of water. Assume Eq wt. of $CaCO_3$ as 50, Mg^{2+} as 12.2 and Ca^{2+} as 20

Ions	Zn^-	Na^+	Mg^{2+}	Cl^-	$SO4^{2-}$	Ca^{2+}
Concentration (mg/l)	4	18	16	68	20	50

Solution:

Only divalent cat-ion causes hardness.

Sl.No.	Divalent Cat-ion	Concentration (mg/l)	Eq.wt of Cat-ion	Hardness (mg/l)
1	Ca^{2+}	50	20	(50x 50)/20 = 125.00
2	Mg^{2+}	16	12.2	(16 x 50)/12.2 =65.57
	Total hardness in mg/l			**190.57 Ans**

Problem 5:- An analysis of a sample of water with pH 7.5 has produced the following concentrations(mg/L). Calculate the total hardness of water. Assume Equivalent weight. of $CaCO_3$ as 50, Mg^{2+} as 12.2 and Ca^{2+} as 20

Ions	Ca^{2+}	Mg^{2+}	Na^+	k^+
Concentration (mg/l)	80	30	72	6

Solution:

Only divalent cat-ion causes hardness.

Sl.No.	Divalent Cat-ion	Concentration (mg/l)	Eq.wt of Cat-ion	Hardness (mg/l)
1	Ca^{2+}	80	20	(80x 50)/20 = 200
2	Mg^{2+}	30	12.2	(30 x 50)/12.2 =122.95
	Total hardness in mg/l			**322.95 Ans**

Problem 6:-A River water was proposed as the raw water suitable for a city. Chemical analysis of the water indicated the constituents given below. Calculate the hardness of water. Assume Eq wt. of $CaCO_3$ as 50, Mg^{2+} as 12.2 and Ca^{2+} as 20

Ions	Zn^-	Na^+	Mg^{2+}	Ca^{2+}	Cl^-
Concentration (mg/l)	4	18	16	50	68

Solution:

Only divalent cat-ion causes hardness.

Sl.No.	Divalent Cat-ion	Concentration (mg/l)	Eq.wt of Cat-ion	Hardness (mg/l)
1	Ca^{2+}	50	20	(50x 50)/20 = 125.00
2	Mg^{2+}	16	12.2	(16 x 50)/12.2 =65.57
	Total hardness in mg/l			**190.57Ans**

Problem 7: Calculate the hardness of the water sample with the following analysis.

Assume Eq wt. of $CaCO_3$ as 50, Mg^{++} as 12.2, Ca^{++} as 20 and Sr++ as 43.80.

Ions	Sr++	Na^{+}	Mg^{++}	Cl^{-}	SO_4^{--}	Ca^{++}
Concentration (mg/l)	03	20	12	54	15	15

Solution:

Only divalent cat-ion causes hardness.

Sl.No.	Divalent Cat-ion	Concentration (mg/l)	Eq.wt of Cat-ion	Hardness (mg/l)
1	Ca^{++}	15	20	(15 x 50)/20 = 37.5
2	Mg^{++}	12	12.2	(12 x 50)/12.2 = 49.2
3	Sr++	03	43.8	(3 x 50)/43.8 = 3.4
	Total hardness in mg/l			**90.1 Ans**

Problem 8:-A lake water has been proposed as a raw water source for a town. Chemical analysis of the water indicates the constituents given below. Calculate the total hardness of water. Assume Eq wt. of $CaCO_3$ as 50.

Ions	**Na^{+}**	**Cl^{-}**	**Sr^{2+}**	**Mg^{2+}**	**Ca^{2+}**	**K^{+}**
Eq. Wt.	23	35.5	43.8	12.2	20.0	40.0
Concentration (mg/l)	10	52	14	40	72	40

Solution:

Only divalent cat-ion causes hardness.

Sl.No.	Divalent Cat-ion	Concentration (mg/l)	Eq.wt of Cat-ion	Hardness(mg/l)
1	Ca^{2+}	72	20	(72x 50)/20 = 180
2	Mg^{2+}	40	12.2	(40 x 50)/12.2 =163.9
3	Sr^{2}	14	43.8	(14 x 50)/43.8 =15.98
	Total hardness in mg/l			**359.88 Ans**

Problem on noise pollution : Unit of noise is deci-Bell (dB)

Equivalent noise level (L_{eq}):- Equivalent noise level also called the equivalent continuous equal energy level is the statistical value of sound pressure level that can be equated to any fluctuating noise level.

Eg. A sound of 100 dB lasting for 10 minutes, followed by a sound of 110 dB for the next 80 minutes and then followed by a sound of 120 dB for the next 5 minutes, will compose a fluctuating noise level, which can be represented by a certain dB value which is indicative of producing the same effect over the entire time period of 10+80+5 = 95 minutes, as the original fluctuating noise.

L_{eq} is thus defined as the constant noise level, which over a given time, expands the same amount of energy, as is expanded by the fluctuating levels over the same time. This value is expressed by the equation:

$$L_{eq} = 10 \log_{10} \sum_{i=1}^{i=n} [10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}]$$

Where n = Total number of sound samples

L_i = The noise level of any i^{th} sample

t_i = Time duration of i^{th} sample,

t_t = Total time duration of samples.

Problem 9:- A sound of 80 dB lasted for 10 minutes, followed by a sound of 60 dB lasted for next 80 minute and then followed by a sound of 100 dB lasting for the next 5 minutes will compose a fluctuating noise level. Calculate the equivalent noise level which is indicative of producing the same effect over the entire time period of 95 minutes.

Solution:

We know that Equivalent noise level (L_{eq}) is given by equation

$$L_{eq} = 10 \log_{10} \sum_{i=1}^{i=n} [10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}]$$

$$\sum_{i=1}^{i=3}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}] = [10^{(\frac{80}{10})} \times \frac{10}{95} + 10^{(\frac{60}{10})} \times \frac{80}{95} + 10^{(\frac{100}{10})} \times \frac{5}{95}]$$

$$L_{eq} = 10\log_{10}[10.526 \times 10^6 + 842.105 \times 10^3 + 526.315 \times 10^6]$$

$$L_{eq} = 10\log_{10}[537.683\ 10^6] = 87.305\ \text{dB}$$

Problem 10:- A sound of 90 dB lasted for 10 minutes, followed by a sound of 65 dB lasted for next 70 minute and then followed by a sound of 110 dB lasting for the next 6 minutes will compose a fluctuating noise level. Calculate the equivalent noise level which is indicative of producing the same effect over the entire time period of 86 minutes.

Solution:

We know that Equivalent noise level (L_{eq}) is given by equation

$$L_{eq} = 10\log_{10}\sum_{i=1}^{i=n}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}]$$

$$\sum_{i=1}^{i=3}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}] = [10^{(\frac{90}{10})} \times \frac{10}{86} + 10^{(\frac{65}{10})} \times \frac{70}{86} + 10^{(\frac{110}{10})} \times \frac{6}{86}]$$

$$L_{eq} = 10\log_{10}[116.279 \times 10^6 + 2.573 \times 10^6 + 6.976 \times 10^9]$$

$$L_{eq} = 10\log_{10}[7.0948 \times 10^9] = 98.509\ \text{dB}$$

Problem 11:- A sound of 90 dB lasted for 15 minutes, followed by a sound of 65 dB lasted for next 80 minute and then followed by a sound of 110 dB lasting for the next 12 minutes will compose a fluctuating noise level. Calculate the equivalent noise level which is indicative of producing the same effect over the entire period of time.

Solution:

We know that Equivalent noise level (L_{eq}) is given by equation

$$L_{eq} = 10\log_{10}\sum_{i=1}^{i=n}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}]$$

$$\sum_{i=1}^{i=3}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}] = [10^{(\frac{90}{10})} \times \frac{15}{107} + 10^{(\frac{65}{10})} \times \frac{80}{107} + 10^{(\frac{110}{10})} \times \frac{12}{107}]$$

$$L_{eq} = 10\log_{10}[140.186 \times 10^6 + 2.364 \times 10^6 + 1.12 \times 10^{10}]$$

$$L_{eq} = 10\log_{10}[1.1357 \times 10^{10}] = 100.55 \text{ dB}$$

Problem 12:- A sound of 90 dB lasted for 15 minutes, followed by a sound of 70 dB lasted for next 45 minute and then followed by a sound of 110 dB lasting for the next 16 minutes will compose a fluctuating noise level. Calculate the equivalent noise level which is indicative of producing the same effect over the entire period of time.

Solution:

We know that Equivalent noise level (L_{eq}) is given by equation

$$L_{eq} = 10\log_{10}\sum_{i=1}^{i=n}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}]$$

$$\sum_{i=1}^{i=3}[10^{(\frac{L_i}{10})} \times \frac{t_i}{t_t}] = [10^{(\frac{90}{10})} \times \frac{15}{76} + 10^{(\frac{65}{10})} \times \frac{70}{76} + 10^{(\frac{110}{10})} \times \frac{16}{76}]$$

$$L_{eq} = 10\log_{10}[197.368 \times 10^6 + 5.921 \times 10^6 + 2.105 \times 10^{10}]$$

$$L_{eq} = 10\log_{10}[2.1253 \times 10^{10}] = 103.27 \text{ dB}$$