ENVIRONMENTAL CHEMISTRY

1. INTRODUCTION

(i) Pollution may be defined as any undesirable change in the physical, chemical or biological characteristics of air, water and soil which may cause any harm to man and other living organisms of the environment.

2. TYPES OF POLLUTANTS

The agents causing pollution are termed as **pollutants**.

2.1 On the basis of form of their occurence, pollutants are divided into two categories.

(i) **Primary pollutants** – These are present in the same form in which they are produced. eg. carbon monoxide, DDT

(ii) **Secondary pollutants** – These are formed by reaction between the primary pollutants in the presence of sunlight eg. PAN, Ozone, HNO_3 H_2So_4 etc. Nitrogen oxides and hydrocarbons react photochemically to produce peroxyacetyl nitrates (PAN) and ozone.

The secondary pollutants may be more toxic than the primary once. The phenomenon is called **synergism**.

2.2 On the basis of their degradation, pollutants are divided into two categories.

(i) **Biodegradable Pollutants** – Pollutants which are decomposed or degraded by biological ormicrobial action are called biodegradable pollutants eg. domestic sewage.

(ii) **Non-biodegradable Pollutants** – Pollutants which are not decomposed or degraded by living organisms or micro organisms are are called non-biodegradable pollutants eg. DDT, glass, plastics, aluminium cans, phenolic compounds, pesticides, radioactive substances, heavy metals like mercury, lead, cadmium etc.

2.3 On the basis of their existance in nature, pollutants are divided into two categories.

(i) **Quantitative pollutants** – These are naturally present in nature and are also added by man. These become pollutants only when their concentration reaches beyond a threshold value in the environment. eg. CO_2.

(ii) **Qualitative pollutants** – These are not present in the nature but are added in nature only due to human activities eg. insecticides, fungicides, herbicides etc.

3. KINDS OF POLLUTION

On the basis of environmental study pollution is of following types.

3.1 Air pollution –

(i) It is mainly caused by industries and automobiles. Automobiles are the greatest pollutior of the atmosphere and are responsible for 75% of noise pollution and about 60-80% of air pollution of big cities.

(ii) The combustion of fossil fuels (coal, oil, gas etc.) releases CO, CO_2, nitrogen oxides, fluorides, hydrocarbons etc. into atmosphere usually in the form of smoke causing air pollution.

(iii) Particulate matters released by mills, factories and mines also cause air pollution.

(iv) Some of the natural air pollutants are pollen grains, spores, volcanoes etc.

3.1.1 Major air pollutants –

3.1.1.1 Carbon monoxide –

(i) It is formed by incomplete combustion of fuels in various industries, automobiles etc.

(ii) CO accounts for about 50% of total air pollution. It is largest pollutant in Delhi's air.

(iii) CO combines with haemoglobin, produces **carboxyhaemoglobin** and therefore decreases oxygen carrying capacity leading to hypoxia, headache, decreased vision, muscular weakness, nausea, exhaustion etc.

(iv) When 50% of haemoglobin has been transformed into carboxyhaemoglobin, then death occurs due to CO-poisoning leading to anoxia (oxygen starvation)

3.1.1.2 Carbon dioxide –

(i) It is a **green house gas**. It is produced due to combustion of fuels, volcanic eruptions and during the process of respiration.

(ii) Its average concentration in the atmosphere is 300 ppm (0.03%) .

(iii) It is normally not an atmospheric pollutants, but under very high concentration it may act as a pollutant.

(iv) It causes **Global warming** .

3.1.1.3 Sulphur dioxide (SO_2) –

(i) It is produced during combustion of fossil fuels (mainly coal) and smelting of sulphur containing ores.

(ii) It causes acid rain (gaseous SO_2 oxidises to SO_3, which on combination with water forms H_2SO_4).

(iii) Acid rain is 60-70% due to SO_2 and SO_3, and 30-40% due to NO_2 and NO_3.

(iv) Due to acid rain the leaves develop chlorotic and necrotic spots.

(v) SO_2 corrodes stones, metals, leather, paper and fabrics. There is deterioration of colour and lusture of fabries, stones and painted surfaces.

(vi) **Tajmahal of Agra** is affected by gases (SO_2, H_2S etc.) discharged from oil refinery of Mathura.

(vii) **Lichens** (*e.g.* ***Usnea***) are extremly sensitive to SO_2 and could be regarded as indicators of SO_2 pollution. (indicators of air pollution)

(viii) Garden pea is another SO_2 pollution indicator.

(ix) Lichen vegetation (*parmelia, usnea, cladonia,*) Garden pea and mosses are completely destroyed due to SO_2.

(x) SO_2 causes chlorosis (destruction of chlorophyll) and necrosis of vegetation, membrane damage and yeild reduction.

(xi) In plants and animals, SO_2 destroys all membrane systems.

(xii) In human beings SO_2 increases the chances of occurence of asthma, bronchitis and emphysema. (xv) It produces eye irritation, damage respiratory tract.

3.1.1.4 Hydrocarbons –

(i) They are produced naturally (e.g. marsh gas CH_4) and by burning of petroleum.

(ii) Benzene (C_6H_6) is a major constituent of petrol and automobile exhaust.

(iii) Hydrocarbons are carcinogenic, cause irritation of eyes and mucous membrane.

(iv) Benzene is a known carcinogen causing **leukemia**.

(v) Ethylene (C_2H_4) causes premature senescence and abscission in many plants especially in orchids and cotton,

(vi) Methane (marsh gas) has the potential of destroy ozone.

3.1.1.5 Nitrogen oxides –

(i) There are three oxides of nitrogen which act as air pollutants : Nitric oxide (NO), nitrogen dioxide (NO_2) and nitrogen trioxide.

(ii) Nitrogen and oxygen combine together at high temperature in any combustion process to produce nitrogen oxides.

(iii) These are also released by furnaces, forest fires, industries and denitrifying bacteria.

(iv) NO is less toxic but NO_2 is a poisonous gas.

(v) Nitrogen oxides are responsible for forming photochemical smog.

(vi) They also cause acid rain due to formation of HNO_3.

(vii) They produce lesions, necrosis, defoliation, dieback and death of many plants.

(viii) Like SO_2, they corrode metals and deteriorate paints, textiles as well as various articles.

(ix) They cause eye irritation, dilation of arteries, injury of lungs, liver and kidneys.

3.1.1.6 Fluorides –

(i) Fluorides are emitted during refinement of aluminium and rock phosphates .

(ii) Fluorides cause necrosis and chlorosis of leaf tips and leaf margins.

(iii) In human fluorides cause mottling of teeth, weak bones, boat-shaped posture, knocking knees etc.

(iv) Disease caused by fluoride is known as **fluorosis**.

3.1.1.7 Particulate matter –

(i) It is the non-gaseous matter in the atmosphere.

(ii) It consists of soot, dust, mist, fibres, fly ash, fur, spores, pollen grains etc.

(iii) It is of two types settleable (larger than 10 μm) and suspended (less than 10μm)

(iv) SPM (suspended particulate matter) is classified into 3 categories –
(a) Aerosols (less than 1 μm)
(b) Dust (solid particles with more than 1 μm diameter)
(c) Mist (liquid particles with more than 1 μm diameter)

(v) It is added in the atmosphere by burning of fuels.

(vi) Particulate matter causes about 10-15% of air pollution.

(vii) Under condition of high humidity, the particulate matter causes corrosion and erosion of surfaces.

(viii) In human beings, it may cause respiratory problems.

(ix) Particulate matter from processing industries (eg. cotton dust, iron mill dust, flour mill dust, mine dust) causes **pneumoconiosis**, byssinosis, siderosis, emphysaema and other pulmonary problems.

(x) The asbestos fibers cause asbestosis which is a type of cancer.

(xi) Dust and smoke produce smog.

(xii) The ill effects of different kinds of dusts are listed below –
(a) Coal dust **– Anthracosis**
(b) Silica **– Silicosis**
(c) Asbestos **– Asbestosis**, Lung cancer
(d) Iron – **Siderosis**
(e) Cotton dust – **Byssinosis**
(f) Hay or grain dust – **Farmer's lung**

3.1.1.8 Aerosols –
(i) These are chemicals released in the air with force in the form of mist or vapour by jet planes.

(ii) Aerosols contain **CFC (chlorofluor-ocarbons)** which destroy ozone layer in the stratosphere. This permitting some more harmful

(iii) U.V. radiations to reach the earth surface, U.V. radiations cause skin cancer and increases mutation rates.

(iv) Ozone acts as preventive shield against the U.V. rays.

(v) Freons are several CFMS (chlorofluoromethanes) released into troposphere where they dissociates and release free chlorine that causes depletion of ozone.

(vi) Freon or CFC also used in refrigerator, air conditioners and in making plastic foams.

3.1.2 Effect of air pollutants – Air pollutants are involved in causing four major environmental effects :
(i) Smog (ii) acid rain (iii) global warming and (iv) ozone layer depletion.

3.1.2.1. Smog –
(i) The term smog was coined by Des Voeux.

(ii) It is produced by the combination of smoke and fog.

(iii) It causes silvering/glazing and necrosis in plants, allergies and asthma/bronchitis in human.

(iv) Smog is of two types :
(a) **Classical or London smog or sulphurous smog** – It occurs at low temperature and contains H_2S, SO_2, smoke and dust particles. It was first observed in winter months at London in 1905. It is formed due to domestic and industrial combustion of coal.

(b) **Photochemical smog or Los Angeles smog** –It was first observed in the mid day at Los Angeles in 1943. The cause of this smog was thought to be due to combustion of petroleum in automobiles.
Photo chemical smog occurs at high temperature over cities and towns. It is formed by the reaction of two air pollutants nitrogen oxides (mainly NO_2) and hydrocarbons (HC) that react with one another in the presence of UV radiations of sunlight to produce ozone (O_3) and PAN (peroxy acetyl nitrate) which constitute the photochemical smog.
Nitrogen oxides + Hydrocarbons

$$\xrightarrow[\text{of sunlight}]{\text{U.V. radiation}} \text{PAN} + \text{Ozone}$$

Ozone and PAN are commonly referred to as oxidants.
Breathing ozone affects the respiratory and nervous system, resulting in headache, respiratory distress and exhaustion. It also causes irritation in eyes and asthma. The ozone is known to destroy crops of potato, alfalfa and spinach to the extent of 50%. It also damages leaves of tobacco, tomato and pine as also the grap fruits. Besides, the PAN also blocks Hill reaction of photosynthesis.

3.1.2.2 Acid rain –
(i) The coal and oil burned by power plants release SO_2 into the air.

(ii) Automobile exhaust puts NO_2 in the air.

(iii) Both SO_2 and NO_2 are converted to acids (H_2SO_4 and HNO_3 respectively) when they combine with water vapour in the presence of O_2 in the atmosphere. These acids return to the earth as acid rain.

(I) $NO + O_3 \longrightarrow NO_2 + O_2$
$NO_2 + O_3 \longrightarrow NO_3 + O_2$
$NO_2 + NO_3 \longrightarrow N_2O_5$
$N_2O_5 + H_2O \longrightarrow 2HNO_3$

(II) $2SO_2 + O_2 \xrightarrow{\text{No. Soot or Metal ions}} 2SO_3$

(iv) The pure rain has a pH of about 5.6 while the acid rain has pH below 5.6.

(v) Acid rain is actually a mixture of H_2SO_4 and HNO_3 (usually 60-70% H_2SO_4 and 30-40% HNO_3)
(vi) Acid rain affects the ability of the trees to tolerate cold temperatures and the weakened trees are killed by cold conditions or become more susceptible to diseases.
(vii) Acid rain leaches lead, mercury and calcium, from the soils and rocks and discharges them into rivers and lakes. The metals may become concentrated in fish and then passed on to people through food chain.
(viii) Acid rain also damages building materials, including steel, paint, plastics, cement and marble.

3.1.2.3. Green house effect and Global warming –

(i) The sunlight that reaches to the earth, warms both atmosphere and the earth surface. The earth's atmospheric system then reradiates the heat as infra-red radiations.

(ii) Gases like CO_2 , CH_4, CFCs, NO_2 are strong absorbers of long-wave or infra-red radiations emitted by the surface of the earth, and warm the earth's atmosphere. This is called the **green house effect** because it is like the glass panel of a green house that allows sunlight to pass through and then traps the resulting heat inside the structure.

(iii) CO_2 in the principal green house gas responsible for warming of the earth.

(iv) CO_2 is rising into the atmosphere slowly as a result of large scale burning of fossil fuels (coal, oil etc), volcanic activities and respiration

(v) 50% of the increase in earth's temperature in due to CO_2, 20% is due to CFCs and remaining 30% is due to other gases.

(vi) Some ecologists visualise that the green house effect shall lead to global warming. In the next fifty years time the temperature of earth shall rise by 2° –5°C.

(vii) A rise of global temperature by 2 to 5°C may lead to

(a) Melting of glacies and polar ice caps.

(b) Flooding of low lying coastal plains.

(c) Increase in the flow of rivers and change in rainfall pattern.

(d) Possible submersion of islands.

(viii) The UNEP (United Nations Environment Programme) has appropriately choosen the slogan "Global Warming: Global Warning" and since 1989, 5^{th} june is celebrated as World Environment Day.

3.1.2.4 Ozone layer depletion –

(i) The ozone layer present in the stratosphere acts as an ultraviolet absorbant thus protecting the earth from its harmful effect.

(ii) Depletion/destruction of ozone layer is primarily caused by CFCs (Chlorofluoro carbons) and halons (halocarbons C_xF_x Br_x)

(iii) CFCs are heat transfer agents used in refrigerators, air conditioners, fire extinguishers.

(iv) Halons are antifire agents used in fire extinguishes .

(v) The CFCs react with ozone and thus cause thining of ozone layer which permits more UV radiations to reach the surface of earth.

(vi) UV radiations cause mutations that can develop skin cancer and cause eye cataracts. UV rays also affect our immune system.

(vii) Severe depletions of ozone layer are commonly called ozone holes.

(viii) A hole in the ozone layer has been discovered in the Antarctica region. There was a severe depletion of some 40–50% above the Antarctica region.

(ix) The ozone layer depletion is caused by chlorine atoms. These chlorine atoms comes from the break down of CFCs. These atoms combine with ozone and remove the oxygen atoms one by one.

$Cl + O_3 \rightarrow ClO + O_2$

$ClO + O \rightarrow Cl + O_2$

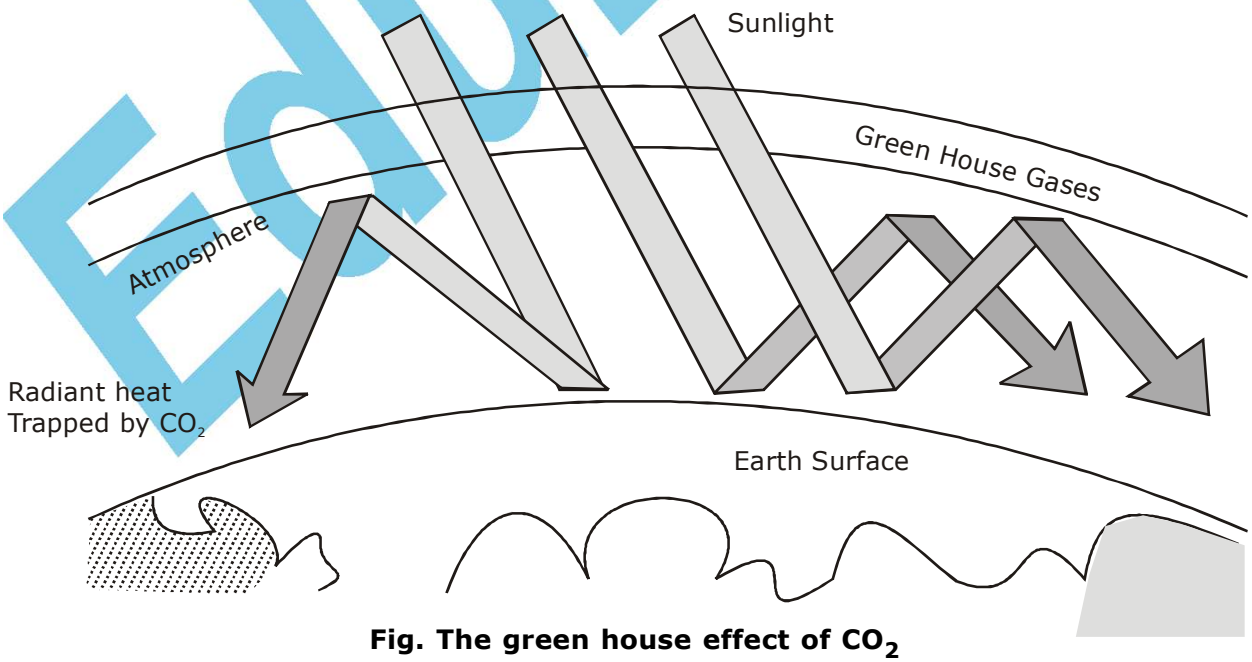

Fig. The green house effect of CO_2

(x) One atom of chlorine can destroy upto 100,000 molecules of ozone.

(xi) Most countries of the world have agreed to stop using CFCs by the year 2000.

Bhopal gas tragedy

Occured on 2nd December 1984, when a poisonous gas **MIC** (**methyl isocynate**) was leaked in the atmosphere from a fertilizer plant of union carbide company. MIC was used to manufacture an insecticide marked in the name of SAVIN. The gas caused death of about 2500 persons. December 2 is recalled as National Pollution Prevention Day.

Important days :

Hiroshima day – 6th August –
World earth day – 22nd April
World environment day – 5th june
International day for preservation of ozone layer [OR] Ozone day – 16th September
Bhopal gas tragedy – 2nd December,1984

Important abbreviations :

N.E.E.R.I. – National Environmental Engineering Research Institute, Nagpur.
I.U.C.N. – International Union for Conservation of Nature and Natural Resources, Switzerland.
C.P.C.B.– Central Pollution Control Board.
U.N.E.P.– United Nations Environment Programme.
O.D.P. – Ozone Deplecting Potential. (It is maximum in CFCs)
I.A.P. –Indices of Atmospheric Pollution. [prepared with the help of lichens (sensitive to SO_2)]
C.N.G. – Compressed Natural Gas
C.T.B.T – Comprehensive Test Ban Treaty
C.S.E. – Centre for Science and Environment.

Important acts to control air pollution :

National Environment Policy Act, 1969
- Air (Prevention and Control of Pollution) Act, 1981 (water act, 1974)
- Environment Protection Act, 1986
- Motor Vehicle Act, 1988

Important points :

(i) Benzpyrene/polycyclic hydrocarbon is a powerful carcinogen (cancer causing agent). It is emitted by cigarette smoking, combustion of petrol, diesel etc.
(ii) Carbon monoxide (CO) accounts for about 50% of total air pollution .
(iii) Sulphur dioxide (SO_2) accounts for 6% of total air pollution.
(iv) Particulate matter accounts for 10 -15% of total air pollution.
(v) First Earth Summit of United Nations Conference on Environment and Development (UNCED) was held at Rio-de-Janerio (Brazil) in 1992.
(vi) First International Conference on "Environment and Development" was held at Stockholm in 1972.
(vii) Second International Conference on " Environment and Development " was held at New Delhi in 1985.
(viii) Cyclon collector is used for minimising air pollution.
(ix) Most polluted city of the world–Tokyo (Japan)
(x) Most polluted city of India – Kolkata.
(xi) In Delhi and Kolkata pollution is mainly due to automobiles and fire.
(xii)In Mumbai pollution is mainly due to industries.
(xiii) Cotton dust is main source of air pollution in Surat and Ahmedabad.
(xiv) Level of suspended particulate matter (SPM) concentration is highest in the atmosphere of Kolkata.
(xv) In Bihar and Andhra Pradesh major source of air pollution is thermal power plants.
(xvi)Pittsburg city (USA) was once named as "Smoke city ".
(xvii)The automobile emission can be reduced by adding barium salts in the petrol.
(xviii)CFCs have maximum Ozone Depleting Potential (ODP)
(xix) Ozone, PAN, HNO_3 and H_2SO_4 are secondary pollutants.
(xx) Green Charter– Drawn by the World Wildlife Fund for Nature for India in December , 1997. It states that "Protection of environment is crucial for human survival and well being now and in future".
(xxi) Excessive inhalation of manganese causes pneumonia.
(xxii) Methane is released by cud–chewing domestic animals.
(xxiii) Excess of pollen causes allergic reactions in several human beings. The common reactions are collectively called hay fever.
(xxiv) The smoke reduces visibility. To visualise the extent of darkness caused due to smoke Ringelmann charts are used.
(xxv) Tocofarol produces resistance against carcinogen.
(xxvi) Formation of ozone hole is maximum over Antarctica.

3.2. Water Pollution

Water pollution is defined as the addition of some substances (organic, inorganic , biological, radio logical) or factor (eg. heat) which degrades the quality of water so that, it either becomes health hazard or unfit for use.

3.2.1. Kinds of water pollution –

The water pollution may be physical, chemical or biological.

(a) **Physical pollution** – It involves the changes in the physical properties of water eg. colour, taste, adour, temperature, turbidity etc.

(b) **Chemical pollution** – It is caused due to change in the chemical properties of water. They mainly include the pH, dissolved O_2, inorganic or organic chemicals, heavy metals etc.

Inorganic chemicals include fluorides, chlorides, phosphates and nitrates. Organic chemicals include phenols, dyes, pesticides and chlorocompounds.

(c) **Biological pollution** – It is caused due to the presence of living organisms in water such as algae, fungi, bacteria, viruses, protozoans, insects etc.

3.2.2. Sources of water pollution and effects of water pollutants –

Water pollution is a serious health hazards in India, especially in villages. It is estimated that 50-60% of Indian population suffers from diseases caused by it. 30-40% of all deaths are believed to be due to it.

The principal sources of water pollution and effects of water pollutants are as follows.

3.2.2.1. Domestic wastes and sewage

(i) Sewage containing human faeces, urine, kitchen and cloth washings, organic waste, industrialwaste etc. is usually poured into water bodies which cause water pollution.

(ii) The villagers often wash their animals, cloths and take bath in the same pond. Such water get contaminated with infectious agents for cholera, typhoid, dysentery, Jaundice and skin diseases.

(iii) Sewage provide food for decomposers, so the population of decomposers increases.

(iv) Decomposers/microorganisms causing decomposition of sewage take up most of the oxygen present dissolved in water. So in this water BOD (Biological oxygen demand or Biochemical oxygen demand) increased very much.

(v) BOD is the amount of oxygen in milligrams required by microorganisms for five days to metabolise waste present in one litre of water at 20°C .

(vi) A weak organic waste will have BOD below 1500 mg/litre, medium organic waste between 1500 – 4000 mg/litre while in strong waste above 4000 mg/litre.

(vii) The degree of pollution is directly proportional to BOD.

(viii) In sewage phosphorous and nitrogen compounds are present which are necessary for the growth of algae. In polluted water these are accumulated which result into excessive growth of algae on water surface. Excessive growth of algae is called **water bloom** .

(ix) The phosphates present in detergents stimulate algal growth in the water bodies and cause eutrophication.

(x) Presence of extra nutrients brings about dense growth of plants and animals life. The phenomenon is called **eutrophica-tion**.

(xi) Eutrophication leads to organic loading, depletion of oxygen,death of animals and fouling of water.

(xii) Sewage produces foul odour and makes the water brownish and oily.

3.2.2.2. Industrial effluents (or industrial discharges)

Industries usually discharge waste water into ponds, lakes and rivers. Industrial waste water contains heavy metals (mercury, lead, copper, arsenic and cadmium), inorganic pollutants (acids, alkalies and bleaching liquors), organic pollutants (phenol, naphtha, proteins, aromatic compounds, cellulose fibres etc.) Industrial effluents are the most hazardous pollutants on land and water.

(a) **Mercury (Hg)** –

(i) It is released during combustion of coal, smelting of metallic ores, paper and paint industries.

(ii) Mercury is highly persistent . In water it gets changed into water soluble dimethyl form $[(CH_3)_2Hg$ and enters the food chain (undergoes biomagnification).

(iii) It kills fish and poisons the remaining fauna. Human beings feeding on such poisoned animals develop a crippling deformity called **minamata disease** which is characterised by impairment of various senses, diarrhoea, haemolysis, meningitis and death.

(iv) The minimata disease was first detected in Japan.

(v) Mercury inhibits chromosomal disjunction during gamete formation. So it brings about genetic changes also.

(b) **Lead (Pb)** –

(i) The sources of lead pollution are smelters, battery industry, paint, chemical and pesticide industry, automobiles exhausts etc.

(ii) Lead is pollutant of air, soil and water.

(iii) It is used as anti-knock reagent in petrol and released by automobile exhausts.
(iv) Lead is a persistant pollutant and may show biological amplification or biomagnification.
(v) It is a mutagenic and causes anemia, headache, vomitting, colic, loss of muscle power, bluish lines around the gums, loss of appetite and damage of liver, kidney and brain.
(c) **Cadmium (Cd)** –
(i) It is added to the environment by metal industries, welding and electroplating, pesticides and phosphate industries.
(ii) Cd shows biological amplification and accumulates inside kidneys, liver, pancreas and spleen.
(iii) It causes hypertension, anemia, diarrhoea and damages liver and kidneys.

3.2..2.3. Oil

(i) During extraction and transportation of oil from the sea to different parts, some of the oil spreads over the surface of water. Refineries also discharge a lot of oil present in their effluents into rivers.
(ii) Oil spreading on the surface of water prevents its oxygenation and inhibits photosynthetic activity of aquatic plants. Animal life is destroyed due to reduced availability of oxygen , food and toxic effects of oil.
(iii) Oil spilled over the surface of water may catch fire and hence kill all organic life.

3.2.2.4. Thermal pollution

(i) Hot water is produced by many industries, power generation plants and thermal power plants.
(ii) Thermal pollution is caused by addition of hot water effluents in water bodies, it bring about rise in water temperature.
(iii) Warmer water contains less oxygen. Therefore, there is decrease in the rate of decomposition of organic matter.
(iv) In hot water green algae are replaced by less desirable blue green algae.
(v) Many organisms fail to reproduce in hot water e.g. Salmon, Trout.

3.2.2.5. Radioactive wastes

(i) The nuclear tests performed into sea pollute the water.
(ii) The animals and plants are affected by the remaining radioactivity of the wastes. Radioactive elements (eg. cesium –137, strontium –90, Iodine – 131) enter the human system.
(iii) Cesium–137 accumulates inside body muscles, strontium–90 in bones while Iodine–131 in thyroid.
(iv) Cesium – 137 brings about functional and genetic changes.
(v) Strontium – 90 causes blood and bone cancer.
(vi) Iodine – 131 affects normal functioning of thyroid.

Important points related to water pollution

(i) Some organism like Daphnia, Trout and fishes are sensitive to water pollution, they are indicator of water pollution.
(ii) I.W.P.– Indices of Water Pollution.
(iii) Drinking water rich in nitrates cause methaemoglobenemia.
(iv) Faecal pollution is indicated by *Escherichia coli*. **MPN** is Most Probable Number of *E-coli*. It is indicator of water pollution.
(v) Algal Genus Index – High organic pollution is indicated by presence of 20 or more genera of algae in a water body. Growth of less than 5 genera of algae is indication of clear water. It is called as **Algal Genus Index** (AGI)
(vi) Water (Prevention and control of pollution) Act, 1974. It has been amended in 1988.
(vii) Putriscibility – Decay and decomposition of organic matter present in water by bacteria and micro - organisms.
(viii) Silent spring– Novel written by Rachel Carson (1962) mentioning the effect of DDT on birds. DDT use has been banned in USA since then.
(ix) In India, DDT banned for agricultural use in 1985. It is a chlorinated hydrocarbon and show biomagnification .
(x) **Fluorosis** –13 states of India possess high fluoride content in drinking water (more than 1.5 mg/l) which causes fluorosis in human.
(xi) ABS (Alkyl Benzene Sulphonate) – It is most harmful component of detergents causing water pollution.
(xii)Maize (*Zea mays*) is sensitive indicator of fluoride pollution.
(xiii)Ganga Action Plan started in 1985 for controlling pollution in Gangas.
(xiv)Reed plants yellow iris are used to purify water. This method of purifying water is called "Green method of water cleaning". Yellow iris plant is less affected by herbicides, so reed beds are highly effective in those areas where pesticides are in use and provides microbiological methods of pesticie detoxification. These plants filter out the particulate matter, while the microbes living in association with the plants, decompose the organic wastes.

(xv) **Endrin** is most toxic amongst chlorinated hydrocarbons.
(xvi) **Aldrin** in most persistant insecticide in the water and soil.
(xvii) Water hyacinth (Eicchornia) popularly known as Jalkumbhi or Kaloi, can purify water polluted by biological or chemical wastes. It can also filter out heavy metals like cadmium , mercury, lead and nickel as well as other toxic substances found in industrial waste waters.
(xviii) **Biotic index** :- It gives an idea of pollution of a particular water body. Any water body with a biotic index of more than 15 is clean, while index lower than 10 is polluted.
(xix) C.O.D. (Chemical Oxygen Demand) – It is amount of oxygen required to oxidise all pollutant materials is one litre of water at 20°C in five days. The value of COD is much higher than BOD.
(xx) B.O.D. of pure drinking water - Less than 1ppm or mg/l
(xxi)Soil salinity can be measured by conductivity meter.

3.3 Soil Pollution

(i) Unfavourable alteration of soil by addition or removal of substances and factors which decrease soil productivity, quality of plant products and ground water is called soil pollution.
(ii) The soil pollutants include pesticides, fertilizers, industrial wastes, salts, radio-nuclids, tin, iron, lead, copper, mercury, aluminium, plastics, paper, glass, broken bottles, discarded food etc.

3.3.1 Types of Soil pollution

Soil pollution is of two main tyes
3.3.1.1 Negative soil pollution
3.3.1.2 Positive soil pollution

3.3.1.1 Negative soil pollution –
(i) It includes over use of soil and erosion .
(ii) Soil erosion is caused by water and wind.
(iii) Water erosion of soil is found near the hills where high speed flooding removes top soil.
(iv) Soil erosion also occurs by high speed winds which bring sand particles from dry desert.

3.3.1.2 Positive soil pollution – It is caused by addition of undesirable substances (eg. pesticides, fertilizers, industrial waste, air pollutant washed down from atmosphere through rain)

(A) Pesticides –
(i) These include insecticides (kill insects), fungicides (kill fungi), algicides (kill algal blooms), weedicides or herbicides (kill weeds), rodenticides (kill rodents).
(ii) Pesticides are generally broad-spectrum and affect other animals, man and even plants. They are hence, also called **biocides**.
(iii) DDT (dichloro diphenyl trichloroethane), BHC (benzene hexachloride or gamaxine), aldrin, dieldrin, endrin, heptachlor etc. are chlorinated hydrocarbons used as pesticides.
(iv) Dieldrin is five times more toxic than DDT when ingested and 40 times more poisonous when absorbed.
(v) Endrin in the most toxic amongst chlorinated hydrocarbons.
(vi) Chlorinated hydrocarbons are persistent, fat soluble and show **biomagnification**.
(vii) DDT and other chlorinated hydrocarbons affect CNS, cause softning of brain, cirrhosis of liver (liver cancer), cerebral haemorrhage, cancer, hypertension, thinning of egg shells in birds, malformation of sex hormones, failure of gonad development.
(viii) The population of certain birds (e.g. Bald **e**agle) has declined due to these biocides.
(ix) DDT also affects the photosynthetic activity of plants, especially phytoplankton.
(x) DDT was banned in 1985 for agricultural purpose in India.
(xi) In India concentration of DDT in fat tissue of people is 18-31 ppm.
(xii) The weedicides (or herbicides) are usually metabolic inhibitors which stop photosynthesis and other metabolic activities and hence kill the plants.
(xiii) 2,4-D, 2,4,5 -T, DCMU and CMU are weedicides.

(B) Fertilizers –
(i) The fertilizers contain plant nutrients particularly N,P and K , but the soil also gets polluted mainly due to organic pollutants present as impurities.
(ii) Excessive use of fertilizers cause soil deterioration through decrease of natural microflora (nitrogen fixing, nitrifying bacteria)
(iii) Fertilizers added to soil enter the crop plants. Nitrogen fertilizers produce toxic concentration of nitrate in the leaves and fruits. When these leaves and fruits are eaten, nitrates changed into nitrites by the activity of bacteria in the alimentary canal. The nitrites enter the blood and combine with haemoglobin to form methaemoglobin. As a result oxygen transport is reduced. It gives rise to disease known as **methaemoglobinaemia**. In infants it produces **cyanosis (blue baby syndrome)**

(C) Industrial wastes –
(i) Wastes of the industries are dumped over the soil. They contain a number of toxic substances including cyanides, acids, chromates, alkalies and metals like mercury, copper, zinc, lead, cadmium etc.
(ii) The industrial pollutants increase the toxicity level of the soil.
(iii) Heavy metals destroy useful micro organisms of the soil.
(iv) In 1970 some 200 people died in Japan by Cd pollution of soil due to itai–itai disease.

3.4 Noise Pollution –

(i) Various kinds of undesirable loud sounds, which disturb our environment are called noise pollutants.
(ii) Noise pollution is produced by loud sounds of various machines, loudly played radio, automobiles, thundering of jet planes, loud speakers etc.
(iii) The intensity of noise is measured in decibels (or dB).
(iv) The sound above 80 dB causes noise pollution.
(v) Moderate conversation produces 60 dB sound, loud conversation 70dB.
(vi) Scooter, buses, trucks etc. create noise of about 90 dB, Jet aeroplanes 150 dB, rocket 180 dB.
(vii) Noise pollution may cause hypertension (high B.P), respiratory and cardiac problems.
(viii) Noise stimulates the secretion of adrenaline which increases irritability, nervousness, neuromuscular tension and feeling of fatigue, so decreasing the working efficiency.
(ix) Noise has an adverse effect on mind health and behaviour of man.
(x) Noise may damage ear drum and eye sight.
(xi) Noise brings about interference in conversation and hearing.
(xii) The first effects of noise are anxiety and stress.
(xiii) Noise can impair the development of nervous system of unborn babies which leads to abnormalbehaviour in later life.
(xiv) Plantation of trees is very essential for reducing the noise pollution.
(xv) Green plants are being planted along the road sides to check the noise pollution. This is called as **Green muffler**.

3.5 Radioactive pollution

(i) It is a special type of physical pollution of air, water and soil with radioactive materials.
(ii) Nuclear explosion results into production of radioactive substances as Sr^{90}, U^{235}. I^{131} and cause pollution of air, water and soil.

3.5.1 Sources of Radioactive pollution

3.5.1.1 Natural (Background) radiations –
(i) These include cosmic rays that reach the earth surface from outer space and terristrial radiations from radioactive elements(radium–224, thorium –232,

3.5.1.1 Natural (Background) radiations –
(i) These include cosmic rays that reach the earth surface from outer space and terristrial radiations from radioactiveelements (radium–224, thorium –232, uranium–235, uranium–238, radon–222, carbon–14, potassium–40 etc.) present in the earth's crust. These radioactive elements are present in rocks, soil and water.
(ii) Maximum back ground radiation is found in Kerala beach where 75% of thorium deposits of the world are found
(iii) Monazite is the source of thorium.

3.5.1.2. Man-made radiations – Man made sources of radiations include mining and refining of plutonium, uranium and thorium, production and explosion of nuclear weapons, nuclear power plants, nuclear fuels and preparation of radioactive isotopes.

4. Green chemistry in day- to day Life

(i) **Dry Cleaning of Clothes**

Tetra chlroroethene ($Cl_2C=CCl_2$) was earlier used as solvent for dry cleaning. The compound contaminates the ground water and is also a suspected carcinogen. The process using this compound is now being replaced by a process, where liquefied carbondioxide, with a suitable detergent is used. Replacement of halogenated solvent by liquid CO_2 will result in less harm to ground water.
These days hydrogen peroxide (H_2O_2) is used for the purpose of bleaching clothes in the process of laundary, which gives better results and makes use of lesser amount of water.

(ii) **Bleaching of paper**

Chloring gas was used earlier for bleaching paper. These days, hydrogen peroxide (H_2O_2) with suitable catalyst, which promotes the bleaching action of hydrogen peroxide, is used.

(iii) **Synthesis of Chemicals**

Ethanal (CH_3CHO) is now commercially prepared by one step oxidation of ethene in the presence of ionic catalyst in aqueous medium with an yield of 90%.

$$CH_2 = CH_2 + O_2 \xrightarrow[Pd(III)/Cu(II)(in\ water)]{Catalyst} CH_3CHO(90\%)$$

Green chemistry, in a nutshell, is a cost effective approach which involves reduction in material, energy consumption and waste generation.