5.1 Pollutants

- All of the organic and inorganic components surrounding us, as well as the events, conditions and processes of their interactions are known as environment.
- Any undesirable change in the environment is known as environmental pollution.
- A pollutant is a containment that adversely alters the physical, chemical or biological properties of the environment.
- Odum(1971) defines, 'pollution is an undesirable change in the physical, chemical or biological characteristics of our land, air, or water what may or will harmfully affect human life or that of desirable species.
- Sources of air pollutants:
- Sources of air pollution refer to the various locations, activities or factors which are responsible for the releasing of pollutants in the atmosphere. These sources can be classified into two major categories which are:

  Anthropogenic sources (human activity) mostly related to burning different kinds of fuel:

  i. "Stationary Sources" include smoke stacks of power plants, manufacturing facilities (factories) and waste incinerators, as well as furnaces and other types of fuel-burning heating devices.

  ii. "Mobile Sources" include motor vehicles, marine vessels, aircraft and the effect of sound etc.

  iii. Chemicals, dust and controlled burn practices in agriculture and forestry management. Controlled or prescribed burning is a technique sometimes used in forest management, farming, prairie restoration or greenhouse gas abatement. Fire is a natural part of both forest and grassland ecology and controlled fire can be a tool for foresters. Controlled burning stimulates the germination of some desirable forest trees, thus renewing the forest.

  iv. Fumes from paint, hair spray, varnish, aerosol sprays and other solvents.

  v. Waste deposition in landfills, which generate methane. Methane is not toxic; however, it is highly flammable and may form explosive mixtures with air. Methane is also an asphyxiate and may displace oxygen in an enclosed space. Asphyxia or suffocation may result if the oxygen concentration is reduced to below 19.5% by displacement.

  v. Military, such as nuclear weapons, toxic gases, germ warfare and rocketry.

  Natural sources:

  i. Dust from natural sources, usually large areas of land with little or no vegetation.

  ii. Methane, emitted by the digestion of food by animals, for example cattle.

iii. Radon gas from radioactive decay within the Earth's crust. Radon is a colourless, odourless, naturally occurring, radioactive noble gas that is formed from the decay of radium. It is considered to be a health hazard. Radon gas from natural sources can accumulate in buildings, especially in confined areas such as the basement and it is the second most frequent cause of lung cancer, after cigarette smoking.

iv. Smoke and carbon monoxide from wildfires.

v. Volcanic activity, which produce sulphur, chlorine, and ash particulates.

- Generally Pollutants are generally grouped under two classes:
  (a) Biodegradable pollutants – Biodegradable pollutants are broken down by the activity of micro-organisms and enter int; o the biogeochemical cycles. Examples of such pollutants are domestic waste products, urine and faucal matter, sewage, agricultural residue, paper, wood and cloth etc.
  (b) Non- Biodegradable pollutants – Non-biodegradable pollutants are stronger chemical bondage, do not break down into simpler and harmless products. These include various insecticides and other pesticides, mercury, lead, arsenic, aluminum, plastics, radioactive waste
  etc.

- There are many methods to classify the pollutants. According to the pollution caused by the pollutants, they are : Air Pollutant, Water pollutant, solid waste pollutant, hazardous waste, trace elements .

- **Air pollutants:**
  The air pollutants are classified in different ways as follows
  (a) According to origin:
  - (i)   Primary pollutants- Directly omitted into the atmosphere and found as e.g. carbon monoxide, nitrogen oxides, sulphur dioxide and hydrocarbons.

(a) Sulfur dioxide: Certain fossil fuels, particularly coal, may contain the element sulfur. When these fuels are burned for power or heat, the sulfur is also burned or oxidized. Sulfur dioxide is a colorless gas with a sharp, choking odour. It is a primary pollutant because it is emitted directly in the form of SO_2. The sulfuric acid (H_2SO_4) mist is a secondary pollutant because it is not emitted directly, but is formed subsequently in the atmosphere. It is a constituent of acid rain, an important regional air pollution problem.

(b) **Nitrogen oxides**: There are many forms of nitrogen oxides (characterized collectively as NOx), but the one that is of greatest importance is nitrogen dioxide (NO_2). Most emissions are initially in the form of nitric oxide (NO), which by itself is not harmful at concentrations usually found in the atmosphere. But NO is readily oxidized to NO_2, which in the presence of sunlight can further react with hydrocarbons to form photochemical smog. Smog is, of course, harmful. NO_2 also reacts with the hydroxyl radical (OH-) to form nitric acid (HNO_3), which contributes to the problem of acid rain. Although NO is colorless, NO_2 is pungent, irritating gas that tends to give smog a reddish brown color.

(c) **Carbon Monoxide:** During complete combustion of fossil fuels, carbon atoms in the fuel combine with oxygen molecules to form carbon dioxide (CO_2). But the process of combustion is rarely complete. Incomplete combustion of the fuel may occur when the oxygen supply is insufficient, when the combustion temperatures are too low, or when

residence time in the combustion chamber is too short. Carbon monoxide (CO), a product of incomplete combustion, is the most abundant of the criteria air pollutants.

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(d) **Solid or liquid particulates:** Extremely small fragments of solids or liquid droplets suspended in air are called particulates. Most particulates range in size from 0.1 to 100 μm (one micrometer, or 1 μm, is one millionth of a meter; it may also be called a micron). The particulate materials of most concern with regard to adverse effects on human health are generally less than 10 μm in size.

Suspended solids roughly 1 to 100 μm in size are called dust particles, while smaller suspended solids (less than 1 μm) may be called either smoke or fumes. Dust is formed from materials handling activities or mechanical operations, including grinding, wood working, and sandblasting. Smoke is a common product of incomplete combustion; smoke particles consist mostly of carbonaceous material. Fumes, usually consisting of very small metallic oxide particles, are typically formed during certain high temperature chemical reactions and vapor condensation.

(e) **Lead particulates:** This toxic metal, in the form of a fume (less than 0.5 μm in size), is one of the criteria pollutants. In the past, major sources of lead (Pb) fumes were motor vehicles that burned gasoline containing a lead based antiknock additive. Young children are particularly at risk from lead poisoning because even slightly elevated levels of lead in the blood cause learning disabilities, seizures, permanent brain damage, and even death.

  (ii)   Secondary pollutants – derived from primary pollutants due to chemical or photochemical reactions in the atmosphere. e.g. ozone, peroxyl acyl nitrate(PAN), photochemical smog etc.

(b) According to chemical composition:
  (i)   Organic pollutants e.g hydrocarbons, aldehydes, ketones, amines and alcohol
  (ii)   Inorganic pollutants:
        Carbon compounds: e.g.CO and carbonates
        Nitrogen compounds: e.g. nitrogen oxides and ammonia
        Sulpur compounds: e.g. hydrogen sulphide, sulphur dioxide, sulphur trioxide and sulphuric acid
        Halogen compounds: e.g. hydrogen fluoride, hydrogen chloride and metallic fluorides
        Oxidizing agents: e.g. ozone
        Inorganic particles e.g. fly ash, silica, asbestos and dusts from transport, mining, metallurgical and industrial activities.

(c) According to states of matter:
  (i)   Gaseous pollutants which get mixed with air and do not normally settle out e.g. CO, NO_x and SO_2
  (ii)   Particulate pollutants which comprises of finely divided solids or liquids and often exist in colloidal states as aerosols e.g. smoke, fog, fumes, mist, smog and sprays.

Note: The **Air Quality Index** (**AQI**) (also known as the **Air Pollution Index** (**API**) or **Pollutant Standard Index** (**PSI**)) is a number used by government agencies to characterize the quality of the air at a given location. As the AQI increases, an increasingly large percentage of the population is likely to experience increasingly severe adverse health effects. To compute the AQI requires an air pollutant concentration from a monitor or model. The function used to convert from air pollutant concentration to AQI varies by pollutant, and is different in different countries. Air quality index values are divided into ranges, and each range is assigned a descriptor and a color code. Standardized public health advisories are associated with each AQI range. An agency might also encourage members of the public to take public transportation or work from home when AQI levels are high.]

Important Air Pollution Episodes
1. London Smog 1952 (4000 deaths)
2. Black Fog 1962 (400 deaths)
3. Killer Smog of Donora 1984 (steel industry, wire plank and H2SO4 plants)
4. The Meuse valley Disaster Belgium 1930 (Sulphate, inorganic acids, Metallic oxidants)
5. The Inter State suit Duck town, Tennesse 1900.
6. Pittsburgh (Alleghency country) Pennsylvania.
7. Before 1948, Pittsburgh was nick named as 'Smoke city'.
8. Bay of smoker, Los Angeles, California 1958.
9. Bhopal Gas Tragedy 1984, December 2, Methyl Iso Cyanate termed as one of the world's ever severe industrial accident.
10. Sri Ram food and Fertilizer Ltd., Delhi 1987, Oleum gas leakage.
11. National fertilizer plant, Paripat (Haryana) Ammonia gas, 1992.
12. The Chernobyl Disaster, USSR 1986, Ukraine 50,000 people had to be evacuated, large tracts of agricultural land in various combine remain inhospitable for many years 1000 of tones of vegetables and milks were destroyed radioactivated cattle's were slaughtered.

- **Water Pollutants:**
  Sources of water pollutants
  First, a pollutant soure can be classified according as **point source** ora **dispersed source pollutant (non point source)**.

  A point source pollutant is one that reaches the water from a pipe, channel or any other confined and localized source. The most common example of a point source of pollutants is a pipe that discharges sewage into a stream or river. Most of these discharges are treatment plant effluents.

  A dispersed or non point source is a broad, unconfined area from which pollutants enter a body of water. Surface runoff from agricultural areas carries silt, fertilizers, pesticides, and animal wastes into streams, but not at only one particular point. These materials can enter the water all along a stream as it flows through the area. Acidic runoff from mining areas is a dispersed pollutant. Storm water drainage systems in towns and cities are also considered to be dispersed sources of many pollutants, because, even though the pollutants are often conveyed into streams or lakes in drainage pipes or storm sewers, there are usually many of these discharges scattered over a large area.

  Classification of w**ater pollutants :**

(a) Oraganic pollutants:

(I)   Oxygen demanding wastes:
* includes domestic and animal wastes, biodegradable organic compounds and industrial wastes from food processing plants, slaushter houses, paper and pulp mills, tanneries etc. as well as agricultural run-off.
* degradation and decomposition of above mentioned undergo degradation and decomposition by bacterial activity in presence of dissolved oxygen**(DO)**
*result in decreased amount of DO and death of aquatic organisms.

(II)   Disease causing wastes:
*includes pathogenic microorganisms which may enter the water along with the sewage and other wastes and may cause tremendous damage to public health.
* mainly viruses and bacteria

(III)   Synthetic organic compounds:
*man-made materials such as synthetic pesticides, synthetic detergents, food additives, pharmaceuticals, insecticides, paints, synthetic fibres, elastomers, solvents, plasticizers, plastics and other industrial chemicals
*enter into the hydrosphere either by spillage during transport and use or by intentional oraccidental release of wastes from their manufacturing establishments.
* potentially toxic to plants,animals and humans
* some biorefractory (i.e. resistant to microbial degradation) organics such as aromatic chlorinated hydrocarbons may cause offensive colour, odours and tastes in water, even when present in traces and make the water (or fish present in it) unacceptable from aesthetic point of view.
* Non degradable chemicals such as alkyl benzene sulphonate from synthetic detergents often lead to persistent foams.
* volatile substances such as alcohols and other organic compounds causes explosion in sewage plants.

(IV)   Sewage and agricultural run-off:
*Sewage and run off of agricultural lands supply plant nutrients which may stimulate the growth of algae and other aquatic weeds in the receiving waterbody.
* the excessive growth of the algae over the surface is called as algal bloom which result in the decrease of DO in water bodies and hence result in death of aquatic organisms.

(V)   Oil:
*caused by the oil spills from cargo oil tankers on the seas, losses during off shore exploration and production of oil, accidental fires in ships and oil tankers, accidental or intentional oil slicks and leakage from oil pipe lines, crossing water ways and reservoirs
* result in reduction of light transmission through surface waters, thereby reducing photosynthesis in marine plants.
* reduces DO of water and endangers water birds , coastal plants and animals.

(b) Inorganic pollutants:

* mineral acids, inorganic salts, finely divided metals or metal compounds, trace elements, cyanides, sulphates, nitrates, organometallic compounds and complexes of metal with organis present in natural waters

* metal organic interactions involve natural organic species such as fulvic acids and synthetic organic species, such as EDTA.

* influenced by or influence redox equillibria, acid base reactions, colloid formation and reactions involving micro organisms in water, algal growth in water and metal toxicity in aquatic ecosystems.

*Most toxic among the trace elements are heavy metals such as Hg, Cd and Pb and metalloids, such as As, SB and Se & they have great affinity for sulphur and attack the –SH bond.

* Protein carboxylic acid and amino groups may also get attacked and heavy metal ions get attached to the cell membrane and interfere with the transport phenomena across the cell wall.

* Heavy metal also precipitates phosphate biocompounds or catalyse their decomposition

* Pollution by heavy metals is due to street dust, industrial effluents and domestic wastes.

(c) Suspended solids and sediments

* silt, sand and minerals eroded from land

* organic matter content in sediments is generally higher than that In soils

* sediments and suspended particles exchange cations with the surrounding aquatic medium and act as repositories for trace metals such as Cu, Co, Ni, Mn, Cr and Mo.

* suspended solids such as silt and coal may injure the gills of the fish and cause asphystation.

(d) Radioactive materials

* mining and processing of ores e.g. uranium

*increasing use of radioactive isotopes In research, agricultural, industrial and medical applications E.g. I^{131}, P^{32}, Co^{60} etc

* radioactive materials from nuclear power plants and nuclear reactors e.g. Sr^{90}, Cs^{137}, $Pu^{248,}$, Am^{241}

* radioactive materials from testing and use of nuclear weaponry,e.g Sr^{90}, Cs^{137}

(e) Heat

* thermal pollution results from thermal power plants, particularly the nuclear power based electricity generation plants, industries in which water is used as coolant, the waste hot water is returned to the original water bodies and temperature of it increases

* increase in temperature decreases dissolved oxygen in waterwhich adversely effect the aquatic life

* any rise in temperature may increase the susceptibility of aquatic biota to the toxic effect of some chemicals such as methyl mercury and some policyclic aromatic hydrocarbons

* suspended solids in water may also cause bad odours and tastes and also may promote conditions fovourable for growth of pathogenic bacteria.

- **Solid waste pollutant:** Any unwanted discarded material from residential, commercial, industrial, mining and agricultural activities that cause environmental problems may be termed as solid waste. Its classification –
  - (a) **Domestic wastes:** includes wastes from household preparation, cooking and serving of food, waste paper and plastics, cloth, rags etc,
  - (b) **Municipal waste**: includes garbage and rubbish from households, offices, hotels, markets etc. and also the street refuse such as street sweepings, dirt, leaves, contents of litter receptacles etc. Here, garbage means biodegradable food wastes and rubbish non biodegradable wastes
  - (c) **Industrial wastes** : These includes
    * non process waste such as office and cafeteria waste, packaging wastes etc.
    * process wastes which depend upon the type of the products being manufactured such as tannery waste, weaving and dying waste, food processing wastes, plastic wastes, rubber wastes, metal scraps etc. from the respective industrial establishment
  - (d) **Agricultural wastes:** comes from farms, feed lots and livestock yards(paddy husks, baggase from sugarcane, tobacco and corn residues, slaughter house wastes, manures etc.)
  - (e) **Special wastes :** these includes wastes from- radioactive wastes from nuclear power plants, laboratories, hospital etc.; toxic substances such as heavy metal sludges, pesticides, pharmaceuticals etc.; biological products such as enzymes, antibiotics, pathogenic and pathological wastes etc; miscellaneous wastes such as inflammable substances, corrosive materials, explosives, security wastes etc.

- **Hazardous wastes:** a waste or combination of wastes which because of the quantity, concentration or physical, chemical or infectious characteristics may cause or significantly contribute to increase in mortality or increase in serious irreversible or incapacitating reversible illness, or pose a substantial present or potential hazard to human health or the environment when improperly treated , stored. transported or disposed off or otherwise managed. These includes –
  (a)radioactive wastes : these wastes are generated by -nuclear fuel cycle, low level dose radiations from nuclear power plants effluents and low & high level dose radiations from radioactive wastes
  * particulate and electromagnetic radiations from radioactive materials effect living cells very badly. These effects are classified as somatic and genetic.
  * somatic effects are caused on the exposed individuals and the cell damage cause may manifest in malignancies such as leukemia or cancer
  * genetic effects are transmitted to the descendants of exposed individuals and thus can affect unexposed generation too. These includes gene mutations and chromosomal aberratios and changes in the number of chromosomes

  (b) biomedical wastes: originate from hospitals, clinics, research and testing laboratories and drug companies

*includes pathological and surgical wastes: experimental animals and cadavers, drugs and chemical residues and their containers; discarded bandages, linens and other infectious wastes: disposal syringes, needles and surgical instruments, contaminated equipments, food and other waste materials.

(c) Chemical Wastes:

*chemical and chemotherapy wastes, organic solvent wastes and radioactive wastes are not included in biomedical wastes

* non radioactive wastes (chemical wastes): These includes hazardous industrial wastes resulted in large scale manufacture of TV sets, aerosol cans, pesticides, plastics, preservatives, automobiles etc.

* proper management of such wastes is mandatory from view point of human health and environmental protection otherwise incidents such as Love Canal Episode will happen any time.

- **Trace elements as pollutants:**

* about 90elements are found in the earth's crust out of which a mere 9 elements (Al, Fe, Ca, Mg, O, Si, Na, K and Ti) only account for over 99% by weight. The remaining 81 elements together which account for hardly 0.14% by weight, constitute as trace elements.

* A trace element is considered to be essential if it satisfies following criteria

present in all healthy tissues in all living things or within a botanical and zoological family

its concentration is fairly constant among various species

its deficiency, depletion or withdrawal from the body induces reproductive structural and physiological anomalies irrespective of the species studied.

deficiency symptoms or abnomalities reduces by the deficiency disappearence or reverse on replenishment of the element under consideration

the abnormalities induced by the deficiency of the elements are always accompanied by pertinent, specific biochemical changes

biochemical changes can be prevented or cured when the deficiency is prevented or cured

* out of about 40 naturally occurring elements detected in living organisms, about 25 of them seem to be highly essential for the higher animals and humans. These includes:

Metals: Na, K, Ca, Mg, V ,Cr, Mn, Fe, Co, Cu, Mo, Zn and Sn
Non metals: H, C, N, O, Si, P, S, Se, F, Cl, Br and I

* Some trace metal such as Pb, Cd and Hg & metalloids like As, Sb and Se are considered to be toxic.