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ENVIRONMENTAL POLLUTION

Introduction:

Pollution is an unfavorable alteration in the physical, chemical or biological characteristics of air, water and land that may or will adversely affect human life, industrial life, industrial progress, living conditions and cultural assets. Thus it is a sort of negative stress exerted on the positive health of the ecosystem.

Pollution is the process of making land, water, air or other parts of the environment dirty and not safe or suitable to use. This can be done through the introduction of a contaminant into a natural environment, but the contaminant doesn't need to be tangible. Things as simple as light, sound and temperature can be considered pollutants when introduced artificially into an environment.

Pollution, also called **environmental pollution**, the addition of any substance (solid, liquid, or gas) or any form of energy (such as heat, sound, or radioactivity) to the environment at a rate faster than it can be dispersed, diluted, decomposed, recycled, or stored in some harmless form.

Pollution may be defined as the excessive discharge or addition of unwanted and undesirable foreign matters into the environment that causes huge damage to the life and properties of human, plants and animal.

Environment includes air, water and land. The harmful substances that cause damage are called **pollutants**. They are discharged from various industries, automobiles, microorganism, volcanic eruptions, forests and strong winds.

Pollutant:

Pollutant is any substance released into the environment as a result of human activity or natural processes that has an adverse impact on living organisms. An

air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as either primary or secondary. Common pollutants are the waste products either of human biology, like domestic sewage, the residues and waste of industrial and agricultural process, automobile exhausts, chemicals from factories, radioactive materials from nuclear plants, etc. Many potentials pollutants, like CO and ozone, are present as normal constituents of various parts of environment, but in most cases, they are kept at harmless levels by natural processes.

Classification of pollutants:

Pollutants are classified as follows

(i) According to the form in which they persist after getting released into the environment, the pollutants may be primary or secondary.

- **a. Primary pollutants:** Those pollutants that are emitted directly from the identifiable sources and are found in the atmosphere in the same from in which they were emitted are called primary pollutants. Example DDT, Plastic.
- **b. Secondary pollutants or derivative pollutants:** These are formed by interaction of the primary pollutants. For example, peroxy-acetyl nitrate (PAN) is formed by the reaction of primary pollutants like nitrogen oxides and hydrocarbon during sunlight.

(ii) According to their existence in nature, the pollutants may be quantitative or qualitative.

- **a. Quantitative pollutants:** These are the materials, which occur in nature but become pollutants when their concentration reaches beyond a threshold value in the environment. Example CO_2, NO_X.
- **b. Qualitative pollutants:** These are the materials that do not occur in the environments but are passed into it through human activities. Example spraying of herbicides, fungicides, DDT etc.

(iii) According to their disposal by natural means, the pollutants may be biodegradable and non-degradable.

a. **Biodegradable pollutants:** These are waste products, which gets slowly degraded by microbes. They cause pollutants, if their production exceeds the capacity to degrade them e.g., sewage.
b. **Non-degradable**: These pollutants could not be decomposed or are decomposed very slowly. They include wastes (plastics, glass, plastic bottles polythene-bag, used soft drink cans etc.) or poisonous materials (e.g., pesticides like DDT, radioactive materials, heavy metal salts etc). The non-biodegradable pollutants are difficult to manage and in there is no treatment process.

(iv) According to their origin, they may be natural and anthropogenic.

a. **Natural**: Natural pollution caused by volcanic eruption emission of natural gases, soil erosion, and cosmic rays etc. Volcanic eruptions add huge masses of toxic gases and particulate matter in the environment.
b. **Anthropogenic:** Pollution is mostly man made; it includes industrial pollution, agriculture pollution etc.

Causes of pollution

The following are the main causes of pollution.

1. Huge increase in population.
2. Rapid industrialization.
3. Rapid urbanization.
4. Uncontrolled exploitation of nature.
5. Radioactive substances.
6. Volcanic eruptions, etc.

Classification of pollution

To understand the magnitude of pollution problems, it may be classified into three types as follows.

1. Air pollution
2. Water pollution
3. Land pollution
4. Noise pollution

AIR POLLUTION :

Introduction:

Air is one of the essential factors making life on the Earth possible. Depending on the body constitution, a human being consumes 6–13 cubic meters of air daily or even more in cases of heavy physical loads.

Air pollution refers to the release of pollutants into the air that are detrimental to human health and the planet as a whole. The Clean Air Act authorizes the U.S. Environmental Protection Agency (EPA) to protect public health by regulating the emissions of these harmful air pollutants .Air pollution is a change in the physical, chemical and biological characteristic of air that causes adverse effects on humans and other organisms. The ultimate result is a change in the natural environment and ecosystem. The substances that are responsible for causing air pollution are called air pollutants. These air pollutants can be either natural (e.g. wildfires) or synthetic (man-made); they may be in the form of gas, liquid or solid**.**

Air pollution kills an estimated seven million people worldwide every year. WHO data shows that 9 out of 10 people breathe air containing high levels of pollutants. WHO is working with countries to monitor air pollution and improve air quality.

Air Pollution may be defined as the excessive discharge or addition of unwanted and undesirable foreign matters into the atmosphere that causes huge damage to the life and properties of human, plants and animal.

According to WHO, air pollution is defined as ".... Phenomenon in which substances put into air by the activity of mankind into concentration sufficient to cause harmful effect to his health, vegetables, property or interfere with the enjoyment of his property.

Composition of the Atmospheric gases

To study air pollution and its control, it is very necessary to study the composition of the atmosphere. The living forms exist in the troposphere layer. Atmosphere is composed of nitrogen and oxygen as major components.CO2 is present in significant proportion in atmosphere. The composition of atmosphere gases n clean dry air, near sea level is given in Table.

Table: Composition of pure atmosphere

Components	Percentage(%)	ppm(dry)
N_2	78.0	780,000
O_2	20.94	209,400
Ar	0.934	9,340
CO_2	0.032	320
He	0.0524	5.24
CH_4	0.01	1.2
N_2O	0.005	0.5
H_2	0.008	0.08

Classification of Air Pollutants:

An air pollutant is known as a substance in the air that can cause harm to humans and the environment. Pollutants can be in the form of solid particles, liquid droplets, or gases. In addition, they may be natural or man-made. Pollutants can be classified as either primary or secondary.

(I) Primary pollutants: Primary pollutants are substances directly emitted from a process, such as ash from a volcanic eruption, the carbon monoxide gas from a motor vehicle exhaust or sulphur dioxide released from factories.

Major primary pollutants produced by human activity:

(i) **Sulphur oxides (SOx):** SO_2 is produced by volcanoes and in various industrial processes. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide. Further oxidation of SO2, usually in the presence of a catalyst such as NO_2, forms H2SO4, and thus acid rain. This is one of the causes for concern over the environmental impact of the use of these fuels as power sources.

(ii) Nitrogen oxides (NOx): Especially nitrogen dioxide is emitted from high temperature combustion. Nitrogen dioxide is the chemical compound with the formula N02. It is responsible for photochemical smog, acid rain etc.

(iii). Carbon monoxide(CO): It is a colourless, odourless, non-irritating but very poisonous gas. It is a product by incomplete combustion of fuel such as natural gas, coal or wood. Vehicular exhaust is a major source of carbon monoxide.

(iv). Carbon dioxide (CO2): A greenhouse gas emitted from combustion but is also a gas vital to living organisms. It is a natural gas in the atmosphere.

(v). Volatile organic compounds: VOCs are an important outdoor air pollutant. In this field they are often divided into the separate categories of methane (CH4) and non-methane (NMVOCs). Methane is an extremely efficient greenhouse gas which contributes to enhanced global warming.

(vi) Particulate matter: Particulates alternatively referred to as particulate matter (PM) or fine particles, are tiny particles of solid or liquid suspended in a gas. In contrast, aerosol refers to particles and the gas together. Sources of particulate matter can be manmade or natural.

(vii)Radioactive pollutants – produced by nuclear explosions, war explosives, and natural processes such as the radioactive decay of radon.

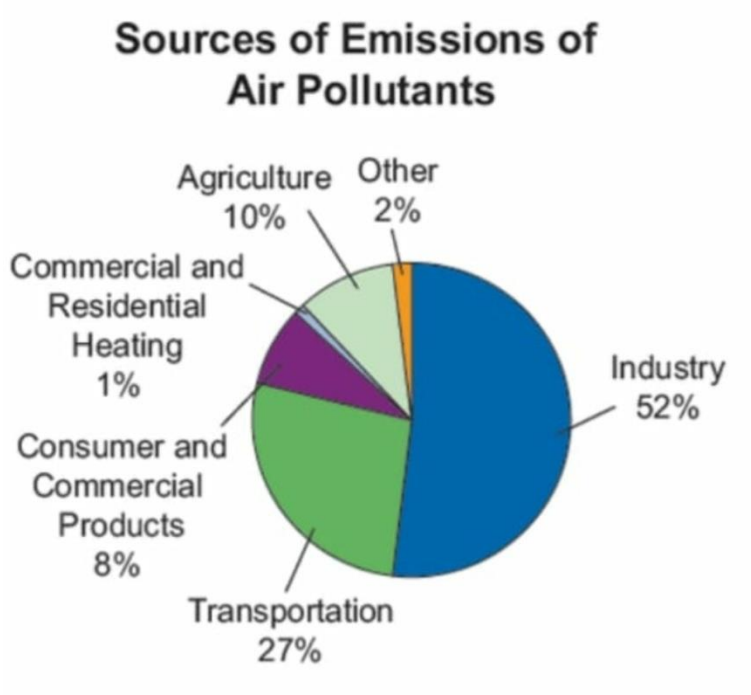


Fig: Sources of Air pollutants

(II) Secondary pollutants: Secondary pollutants are not emitted directly. Rather, they form in the air when primary pollutants react or interact. An important example of a secondary pollutant is ground level ozone is one of the many secondary pollutants that causes photochemical smog.

(i) **Particulate matter** formed from gaseous primary pollutants and compounds in photochemical smog. Smog is a kind of air pollution; the word "smog" is a portmanteau of smoke and fog. Classic smog results from large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide.

(ii) **Ground level ozone (O3)** -formed from NOx and VOCs. Ozone (O3) is a key constituent of the troposphere (it is also an important constituent of certain regions of the stratosphere commonly known as the Ozone layer). Photochemical and chemical reactions involving it drive many of the chemical processes that occur in the atmosphere by day and by night.

(iii) **Peroxyacetyl nitrate (PAN)** – similarly formed from NOx and VOCs and is a dangerous air pollutant mostly affects our respiratory system and nervous system.

Table : Atmospheric pollutants

S.No.	Name of Pollutant	Formula	Important characteristics	impact of pollutant on nature/health
1	Sulphur dioxide	SO_2	Colourless, Soluble gas has choking fumes	Vegetation damaged bad for human health
2	Sulphur trioxide	SO_3	Water soluble gas	Very corrosive in nature
3	Hydrogen sulphide	H_2S	Rotten egg smell, no odour at high concentration	Very much poisonous
4	Nitrous oxide	N_2O	Colourless, carrier gas	Nongeneration in burning inactive
5	Nitric oxide	NO	Colourless gas	Obtained at high temp. and pressure
6	Nitrogen dioxide	NO_2	Brown gas	Part of photochemical smog
7	Carbon monoxide	CO	No odour of color	generated by incomplete combustion
8	Carbon dioxide	CO_2	No odour of color	Antropogenic, part of very poisonous greenhouse gas
9	Ozone	O_3	Reactive, intraction	Photochemical smog component bad for vegetation
10	Hydrocarbons	HO	Several derivatives with varing property	Exist from car, injurious,industrial operations
11	Methane	CH_4	Combustible, it has no odour	Grenhouse gas
12	Chlorofluorocarbon	CFC	good thermal properties unreactive	Dissociate ozone

Sources of Air Pollution:

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:

(1).Anthropogenic sources (human activity)

It 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.

(vi) Military, such as nuclear weapons, toxic gases, germ warfare and rocketry.

2. 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.

Effects of Air Pollutants:

The air pollutants causes adverse effects on human health. A part from human beings vegetation and plants also get severely affected on exposure to polluted atmosphere.

Table : Source of pollutants

S.N.	Source of pollution	Name of element present	Toxic effect on
1	Soil dust	Al, Si, Ti, Sc,Mn.	Silicolysis, Lung Problem
2	Marine environment	Na-Cl.	High blood pressure
3	Lime stone industry	Ca	Cardiac problems
4	Steel industry	Mn, Fe, Cr	Blood anemia
5	Auto exhaust emission	Pb, Br	Levew affected Cirrhosis
6	Combustion-refuse	Zn, K, Pb, Sb	Metal flume fever
7	Combustion-oil	V, S, As	Lung throat affects
8	Combustion-coal	Al, SO_2, S.	Dementia, alzarmine
9	Diesel oil exhaust	C	Throat infection
10	Nonferrous metal factory	Cu, Zn, As, Sb.	Fever, anemia, Vomiting

There are Various Harmful Effects of the air Pollutants:

(i) **Effect on Human health**: The air pollution have deleterious effect not only on human health but also on vegetation and animals, materials and structure of atmosphere, soil and water bodies. The carbon, sulphur and fluoride cycle in nature on large scale affects man. SO_2 is released in troposphere. Fertilizers release fluoride which gets accumulated in vegetation and harms our teeth and bones. The body can discharge these pollutants lead can get ingested in body and cause problems with brain. While CO interact with blood generating carboxy hemoglobin and arrest flow of blood. The human respiratory system is

most sensitive's towards atmosphere pollutants. The nasal, trachea bronchial or pulmonary portion of respiratory system gets affected by air pollutants.

Table : Physiological effects on health

Pollutant	Effects on human health
CO	Circulatory system affected, cardiovascular disease noted.
NO_2	Respiratory pathogens increase, causes eye irrtatuin.
O_3	Coughing, chest problem.
Pb	Neuromotor and neurocongitivits disease, brain is affected.
PAN	Eye irrtation, burning, sneezing, cough and cold.
SO_2	Respiratory disorder, chronic problem, chest disease.

(ii) **Effect on vegetation and animals:** the low concentration of pollutant in air does not affect plant even on long exposure, but they have biochemical chemical changes with some physiological response and symptoms of deterioration and date of epidermal cells. Ozone, sulphurdioxide, NO-NO_X, PAN are deadly harmful to plants. The intake of PAN, O_3 develops immunity in Plants for pest infection. Intake of heavy metals more serious for animal's arsenic lead and mercury intake has caused diarrhea, anemia, and discoloration of hair of the animals.

(iii) **Effect of pollutants on material:** They are corroded if they wet aluminum has no effect by SO_2. Galvaised plates show also depletion of zinc layer on exposure to pollution. Copper and silver form protective coating and prevents corrosion on exposure to pollution. The exposure of Building to SO_2, CO_2, shows the destruction of surface of wall. The dyes and fabric get affected with pollutants with SO_2. The SPM, spoils fabric and textile products. SO_2 affects glass, paper and leather on prolonged exposure.

Table : Effect on materials

Material	Effects on materials	Pollutants for exposure
Metals	Lose of lustre	SO_2, NO-NO_X
Pigment	Bleaching action	SO_2, Cl_2,
Paints	Discolouration	SO_2,H_2S, SPM
Leather	Bad gloss with no shine	SO_2, CO_2
Paper	Increase brittleness	SO_2, CO_2, H_2S
Textile	Decrease in durability	SO_2, CO_2
Dyes	Bleaching action	NO_2, Cl_2 H_2S
Rubber	Cracks, fatigue	O_3, CO_2, CO
Ceramic and glass	Rough surface	Acid vapours

(iv) **Effect of pollutants in space and planets:** The long term affects are global warming depletion of ozone layer in atmosphere and green house effect. CO_2 promotes global warming. The greenhouse gases are those which absorb light and radiate it to the earth. The CFC undergoes degradation on exposure to sunlight

Prevention and Control of air pollution

"Prevention is better than cure". Similarly, it is better to control the air pollutants at its source itself.

The following are the steps to be taken for controlling air pollution.

1. Dust particles can be removed by the use of bag filters and dust separators.
2. *Smoke may be removed by Cottrell's electrostatic precipitator.*
3. Tall chimneys may be used to reduce the concentration of pollutants at the ground level.
4. The exhaust gases from automobiles and vehicles should be minimized by the use of catalyst.
5. The use of coal, wood and traditional fuels should be slowly reduced. Solar energy, tidal power, nuclear power and electricity should be used for domestic and industrial purpose.
6. Acid and chemical fumes are absorbed in water, concentrated and reduced.
7. Growing of trees reduces more pollution as well as the harmful carbon dioxide concentration in the atmosphere. Plants take carbon dioxide during photosynthesis and releases oxygen to environment. Hence, more trees should be planted.

Global Warming and Greenhouse Effect:

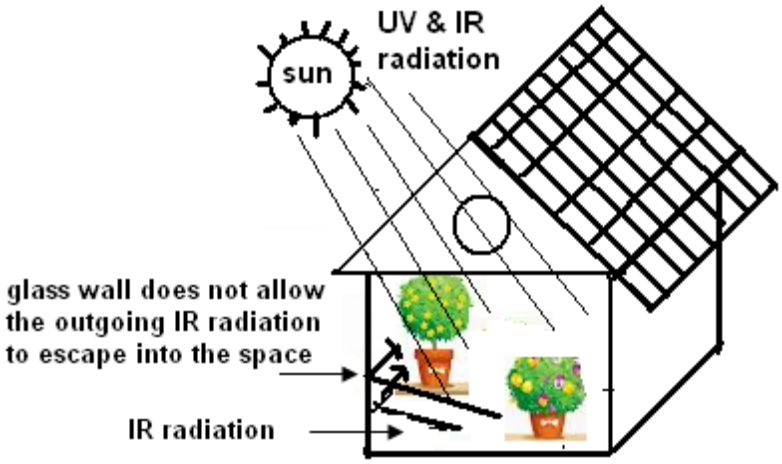
The history of the greenhouse effect and global warming. First of all, predicted by Svante Arrhenius was a Swedish scientist that was the first to claim in 1896 that fossil fuel combustion may eventually result in enhanced global warming. He proposed a relation between atmospheric carbon dioxide concentrations and temperature.

When we burn organic materials (i.e. carbon-containing) fuels, or organic matter decomposes, carbon dioxide is released into the air. It is transparent to incoming solar radiation, but opaque to some wavelengths of heat radiated from the warmed surface of the Earth, and so traps heat, leading eventually to a warming of the lower atmosphere" This is known as the greenhouse effect, as in principle, the atmosphere behaves in a similar manner to a garden greenhouse, it allows sunlight to penetrate, but heat is trapped within the atmosphere in the same way that it is trapped within the glass walls of a greenhouse. This trapped hot air is causing the earth to heat up, resulting in global warming, and ultimately climate change.

The earth surface gets warmed due to the blanketing effect of pollutants like CO2 present in the atmosphere. It is known as green house effect.

Gases that cause green house effect are mainly CO2, methane, water vapour and chloro fluoro carbons (CFC). These gases are called green house gases. However, human activities, such as burning of coal, exhaust fumes from vehicles, and burning of trees during deforestation activities, are contributing huge amounts of additional greenhouse gases into the atmosphere, where they enhance the greenhouse effect further and contribute to global warming.

Global warming: The warming up of the earth's surface due to green house effect is termed as global warming.CO_2 and other green house gases present in the atmosphere trap the infrared radiation from the sun and do not allow the radiations to escape. Hence the earth's surface is warming up more and more.



Green House effect

The Albedo Effect

Snowcapped mountains and ice sheets reflect radiation away from the Earth which is a phenomenon that is known as the albedo effect. This helps reduce the amount of heat absorbed by the Earth, and therefore plays a vital role in keeping the Earth cool. When ice sheets melt, it exposes dark rock or vegetation that doesn't have the same reflective properties as ice, and thus tends to absorb rather than reflect heat. Life sustains on Earth by depending on the energy coming from the sun. About 60 percent of the energy and light reaching the surface of the Earth passes through the air and clouds where the harmful gases

get segregated and absorbed. These gases are radiated upwards in the form of infrared heat. About 89 percent of this heat is then taken by the greenhouse gases and radiated back to the surface. Due to depletion of the ozone layer and global warming, the greenhouse effect has become the primary reason for which the Earth surface now radiates more heat than it usually should

Greenhouse Gases:

Our planets contain many gases which surface a layer and prevent unwanted radiations to reach the surface. These gases are in certain proportions breaking which, the components get disturbed. The greenhouse gas absorbs and emits these radiations within the range which ultimately causes the greenhouse effect. The common greenhouse gases in Earth's atmosphere are:

1. Water vapor (H_2O)

2. Carbon dioxide (CO_2)

3. Methane (CH_4)

4. Nitrous oxide (N_2O)

5. Ozone (O_3)

6. Chlorofluorocarbons (CFCs)

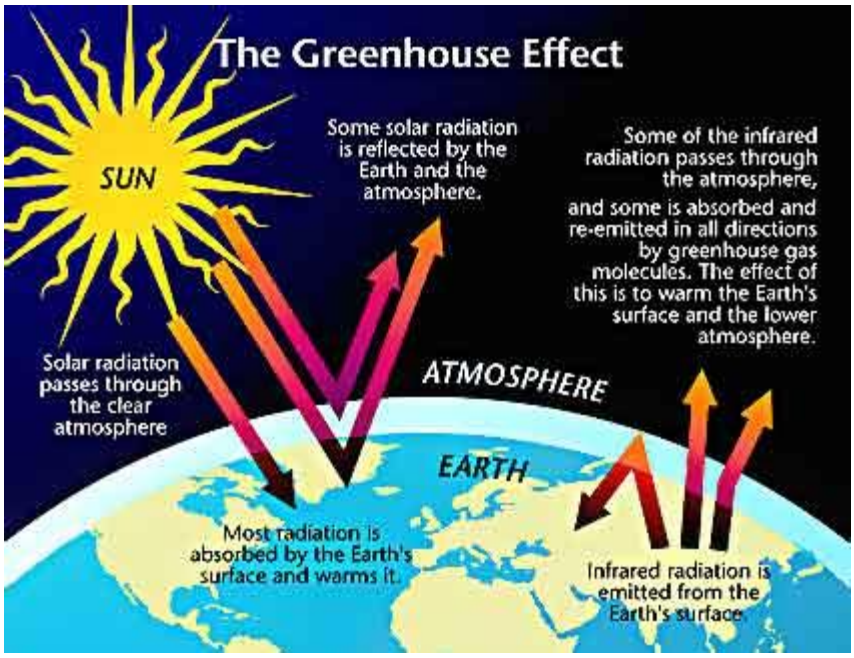


Fig: **The Greenhouse Effect and Global Warming**

Causes of Global warming With the coming of Industrial revolutions, the use of chemicals and fuel in the factories has increased to a dangerous amount. Along with it, deforestation due to industrial or economic purposes and the excess burning of fossil fuels like natural gas, oil, and coal, has increased the concentration of atmospheric carbon dioxide from 315 ppm (part per million by volume) to about 363 ppm since 1958. These are some of the primary reasons for which the heat gets trapped in the atmosphere thus causing global warming. The greenhouse effect is caused by the interaction of the sun's energy with greenhouse gases such as carbon dioxide, methane, nitrous oxide and fluorinated gases in the Earth's atmosphere. The ability of these gases to trap heat is what causes the greenhouse effect

Consequences of Global warming :

1. Warmer climate: On average, the Earth's temperature will become warmer than earlier, while some places will get warm while others may not.

2. The rise of sea level: Due to global warming, the glaciers and ice sheets of Greenland and Atlantic will melt which will add water to the sea level, thus causing many disasters like Tsunami. A rise in sea level will also have an economic impact especially on the low-lying coastal areas and islands causing unavoidable soil erosion.

3. Agricultural impact: According to multiple experiments, with the high concentration of CO_2 in the atmosphere, the growth of crops is twice than the normal growth. At the same time, the shifting of the climatic pattern may change the areas where crops grow faster and better thus affecting the normal amount of agricultural production.

4. Environmental effect: The greenhouse effect is a major factor in keeping the Earth warmer because it keeps some of the planet's heat that would otherwise escape from the atmosphere out to space. In fact, without the greenhouse effect the Earth's average global temperature would be much colder and life on Earth would not be possible.

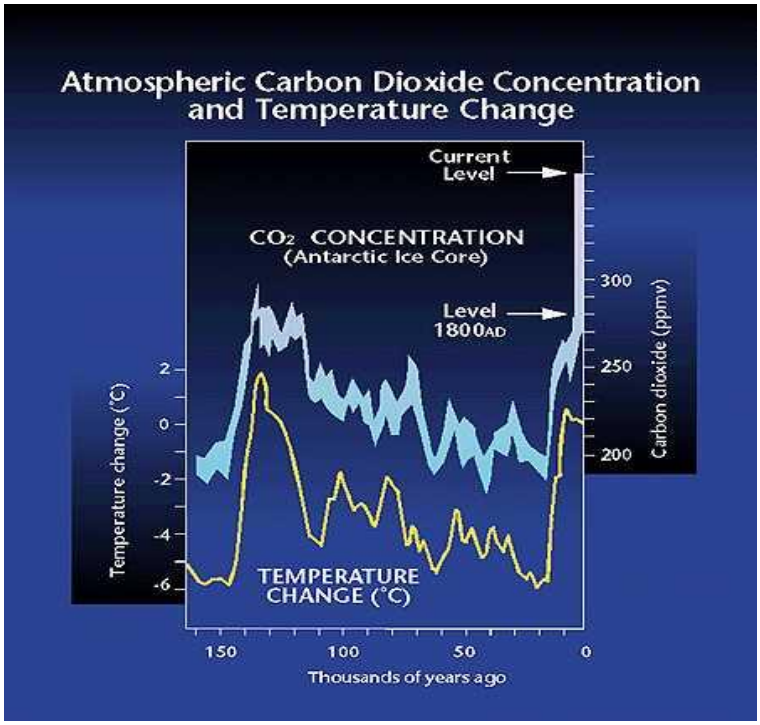


Fig: **Correlation Between CO_2 Levels and Temperature Change**

Harmful effects of global warming caused by Green house effect:

1. Evaporation process of surface water is enhanced very much due the

increase in temperature of earth's surface which leads to drastic seasonal change. Some region of the world would become dry.

2. Sea level is increased due to melting of glaciers. Hence, low lying land

areas will be submerged under sea water.

3. Food production is mainly affected and it leads to draught.

4. The tropical diseases like malarial fever, dengue fever and cholera will spread to the other parts of the world.

5. It causes drastic change in seasons. Hence, human beings and animals are mostly affected by climatic change.
6. Natural calamities like cyclones, hurricane, typhoons and tsunami may occur frequently and strongly.
7. Because of global warming, the normal weather pattern is disrupted.

Some parts of the world will face severe water crisis while the othern parts will suffer from flooding. Spring arrives earlier in many parts of the world. An early spring may disturb animal migration.
8. Biological productivity also decreases due to global warming.

OZONE LAYER AND ITS DEPLETION:

Introduction:

The ozone layer was discovered in 1913 by the French physicists Charles Fabry and Henri Buisson. The ozone layer has the capability to absorb almost 97-99% of the harmful ultraviolet radiations that sun emit and which can produce long term devastating effects on humans beings as well as plants and animals.

One of the gifts given by nature is ozone layer. It is present about 20 km above the earth's surface. It forms a layer of about 3mm thickness called ozone layer. Oxygen is converted into ozone by photochemical change as follows. The region in which O_3 density high is called ozone layer.

$$3\ O_{2\,(g)} \xrightarrow{\text{Radiation}} 2\ O_{3\,(g)}$$

Mechanism of Ozone Layer Depletion

Chlorine plays a vital role in the depletion of ozone layer. Chloro fluoro

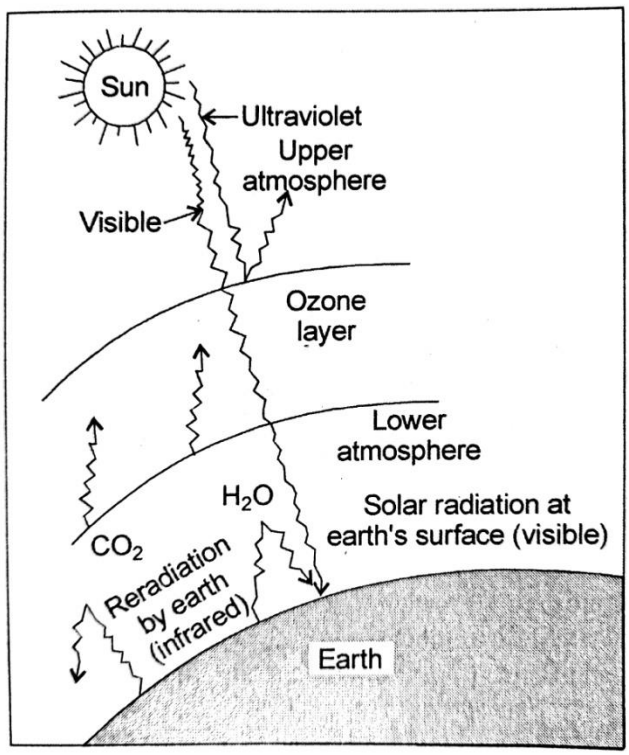
carbons are released from the supersonic jets, air crafts and jet engines. They get accumulated at high altitude and undergo decomposition in the presence of ultraviolet radiations. Chlorine is the main decomposition product. It reacts with the ozone and converts it into oxygen.

Chlorine converts the ozone molecules into oxygen in the presence of UV radiation as follows.

$$2Cl_2 + 2O_3 \rightarrow 2ClO + 2O_2$$

$$2ClO + 2[O] \rightarrow 2Cl + 2O_2$$

$$2Cl + 2O_2 \rightarrow Cl_2 + 2O_2(g)$$



It is noteworthy that one atom of chlorine may convert huge number of molecules of ozone into oxygen. The main source for chlorine is CFC

which is released by aircrafts, jet planes, refrigerators, air-conditioners, etc. *One atom of chlorine can convert about 100,000 molecules of ozone into oxygen.* The other gases which cause ozone layer depletion are NO and NO_2.

Importance of ozone layer

1. Ozone layer covers the earth's surface and prevents the entry of harmful UV radiation. It saves the lives of human beings and animals. If not so, no life is found on earth.
2. If the ozone layer is not present in the atmosphere, the harmful UV radiations will enter the earth. This will destroy human and animal life, change the wind pattern, rain fall, climatic change and global temperature.

Causes of Ozone Layer Depletion:

Scientists in this age are working around the clock to develop Hydro fluorocarbons (HFCs) to take the place of hydro chlorofluorocarbons (HCFCs) and chlorofluorocarbons (CFCs) for use in vehicle air conditioning. Hydro chlorofluorocarbons are powerful greenhouse gases, but they are not able to deplete ozone. Chlorofluorocarbons, on the other hand, significantly contribute to climate change, which means Hydro fluorocarbons continue to be the better alternative until safer alternatives are available.

There are two regions in which the ozone layer has depleted.

(i) In the mid-latitude, for example, over Australia, ozone layer is thinned. This has led toan increase in the UV radiation reaching the earth. It is estimated that about 5-9% thickness of the ozone layer has decreased, increasing the risk of humans to overexposure to UV radiation owing to outdoor lifestyle.

(ii) In atmospheric regions over Antarctica, ozone layer is significantly thinned, especially in spring season. This has led to the formation of what is called 'ozone hole'. Ozone holes refer to the regions of severely reduced ozone layers. Usually ozone holes' form over the Poles during the onset of spring seasons. One of the largest such hole appears annually over Antarctica between September and November.

The Causes of ozone layer depletion is mainly two types are-

(a) Natural causes of depletion of ozone layer: Ozone layer has been found to be affected by certain natural phenomena such as Sunspots and stratospheric winds. But this has been found to cause not more than 1-2% depletion of the ozone layer and the effects are also thought to be only temporary. It is also believed that the major volcanic eruptions.

(b) Man-made causes of depletion of ozone layer: The main cause for the depletion of ozone is determined as excessive release of chlorine and bromine from man-made compounds such as chlorofluorocarbons (CFCs). CFCs (chlorofluorocarbons), halons, CH_3CCl_3 (Methyl chloroform), CCl_4 (Carbon tetrachloride), HCFCs (hydro-chlorofluorocarbons), hydrobromofluorocarbons and methyl bromide are found to have direct impact on the depletion of the ozone layer. These are categorized as ozone-depleting substances (ODS).

The chlorine and bromine free radicals react with ozone molecule and destroy their molecular structure, thus depleting the ozone layer. One chlorine atom can break more than 1, 00,000 molecules of ozone. Bromine atom is believed to be 40 times more destructive than chlorine molecules.

Harmful effects of ozone layer depletion:

1. Due to ozone layer depletion, the harmful UV radiation may enter freely into the earth's surface and affect the lives on earth.
2. They affect human beings and cause skin cancer, skin aging, breast cancer, lungs cancer, eye defects and visual defects.
3. They reduce the population of aquatic species.
4. They affect the growth of plants and vegetables.
5. They affect the eco-system very badly.
6. The sea food production also decreases due to the depletion of ozone layer.
7. Depletion of ozone layer causes the change in earth's climate, wind pattern, rainfall and global warming.

Prevent of ozone layer depletion:

. Desist from using pesticides: Pesticides are great chemicals to rid your farm of pests and weeds, but they contribute enormously to ozone layer depletion. The surefire solution to get rid of pests and weeds is to apply natural methods. Just weed your farm manually and use alternative eco-friendly chemicals to alleviate pests.

2. Discourage driving of private vehicles: The easiest technique to minimize ozone depletion is to limit the number of vehicles on the road. These vehicles emit a lot of greenhouse gases that eventually form smog, a catalyst in the depletion of ozone layer.

3.Utilize environmentally friendly cleaning products: Most household cleaning products are loaded with harsh chemicals that find way to the atmosphere, eventually contributing to degradation of the ozone layer. Use natural and environmentally friendly cleaning products to arrest this situation.

4. Prohibit the use of harmful nitrous oxide: The Montreal Protocol formed in 1989 helped a lot in the limitation of Chlorofluorocarbons (CFCs). However, the protocol never covered nitrous oxide, which is a

known harmful chemical that can destroy the ozone layer. Nitrous oxide is still in use today. Governments must take action now and outlaw nitrous oxide use to reduce the rate of ozone depletion.

Acid rain

The term acid rain was first used by Robert Angus Smith in 1972.Acid rain is infact cocktail of mainly H_2SO_4 (60-70%), HNO_3(30-40%) and HCl where the ratio of these acid may vary depending upon the sulphur, nitrogen and chlorine emission. Acid rain refers to a mixture of deposited material, both wet and dry, coming from the atmosphere containing more than normal amounts of nitric and sulfuric acids.

The gases like SO_2 and NO_2 emitted from various industries react with moisture present in the atmosphere to form corresponding acids. It means that rain water contains more acids. The rain water containing the acid is called acid rain. They slowly fall down on the earth as acid rain during snow fall or normal rainfall. This is called as acid rain. Acidity is determined on the basis of the pH level of the water droplets. Normal rain water is slightly acidic with a pH range of 5.3-6.0, because carbon dioxide and water present in the air react together to form carbonic acid, which is a weak acid. When the pH level of rain water falls below this range, it becomes acid rain. The contributions of acids in the acid rain are :$H_2SO_4 > HNO_3 > HCl$.

$$2SO_2 + O_2 + 2H_2O \rightarrow H_2SO_4$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

$$HCl + H_2O \rightarrow HCl$$

$$CO_2 + H_2O \rightarrow H_2CO_3$$

$$NO + 1/2\ O_2 \rightarrow NO_2$$

$$4\ NO_2 + O_2 + 2H_2O \rightarrow 4HNO_3$$

Combustion of fossil fuels accounts for approximately 80% of the total atmospheric SO_2 in the United States. The effects of burning fossil fuels can be dramatic: in contrast to the unpolluted atmospheric SO_2 concentration of 0 to 0.01 ppm, polluted urban air can contain 0.1 to 2 ppm SO_2, or up to 200 times more SO_2 like the oxides of carbon and nitrogen, reacts with water to form sulfuric acid

Presently, large amounts of acid deposition is witnessed in the southeastern Canada, northeastern United States and most of Europe, including portions of Sweden, Norway, and Germany. In addition, some amount of acid deposition is found in parts of South Asia, South Africa, Sri Lanka, and Southern India.

Measurement of Acid Rain: We use the pH scale to measure acid rain. The pH scale measures how acidic a substance is. It runs from 0 to 14; in which 0 is the most acidic, 7 is neutral, and 14 is the most basic. Although pure water is known to have a pH of 7, normal rainwater has a slightly more acidic pH of around 5.6. This pH level is due to the carbon dioxide oxides of Sulphur and Nitrogen in the atmosphere that dissolves into carbonic acid, sulphuric acid, nitric acid. Acid rain has an average pH of 4.2 to 4.4, which is almost ten times more acidic than normal rain.

Causes /Sources of Acid Rain

Both natural and man-made sources are known to play a role in the formation of acid rain. But, it is mainly caused by combustion of fossil fuels which results in emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx).

1. Natural Sources: The major natural causal agent for acid rain is volcanic emissions. Volcanoes emit acid producing gases to create

higher than normal amounts of acid rain or any other form of precipitation such as fog and snow to an extent of affecting vegetation cover and health of residents within the surrounding. Decaying vegetation, wildfires and biological processes within the environment also generate the acid rain forming gases. Dimethyl sulfide is a typical example of a major biological contributor to sulfur containing elements into the atmosphere. Lightning strikes also naturally produces nitric oxides that react with water molecules via electrical activity to produce nitric acid, thereby forming acid rain.

2. Man-made sources: Human activities leading to chemical gas emissions such as sulfur and nitrogen are the primary contributors to acid rain. The activities include air pollution sources emitting sulfur and nitrogen gases like factories, power generations facilities, and automobiles. In particular, use of coal for electrical power generation is the biggest contributor to gaseous emissions leading to acid rain. Automobiles and factories also release high scores of gaseous emissions on daily basis into the air, especially in highly industrialized areas and urban regions with large numbers of car traffic. These gases react in the atmosphere with water, oxygen, and other chemicals to form various acidic compounds such as sulfuric acid, ammonium nitrate, and nitric acid. As a result, these areas experience exceedingly high amounts of acid rain.

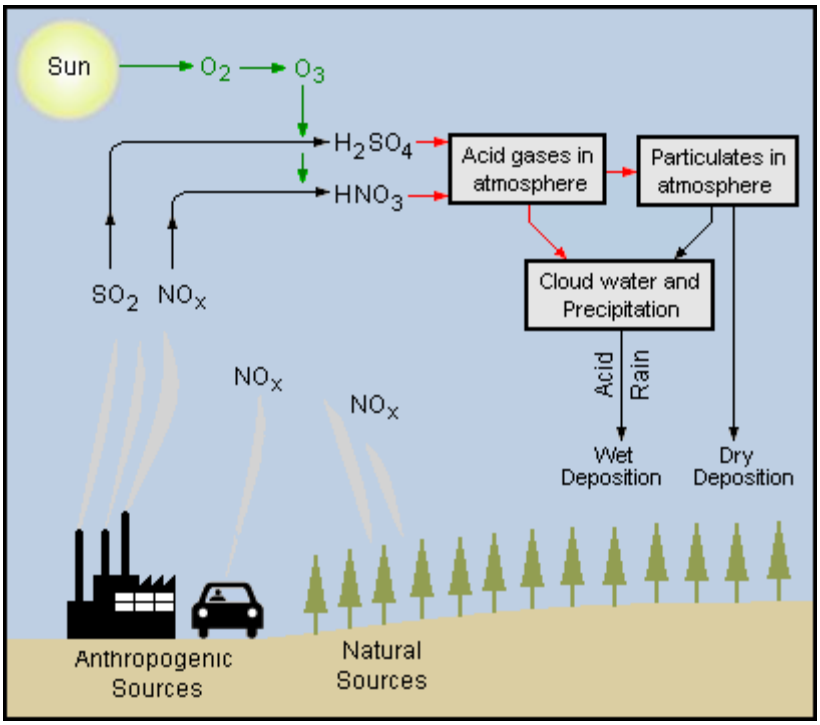


Fig: Depiction of how acid rain is formed

Effects of Acid Rain:

Acid rain has significant effects on the world environment and public health.

1.Effect on Aquatic Environment: Acid rain either falls directly on aquatic bodies or gets run off the forests, roads and fields to flow into streams, rivers and lakes. Over a period of time, acids get accumulated in the water and lower the overall pH of the water body. The aquatic plants and animals need a particular pH level of about 4.8 to survive. If the pH level falls below that the conditions become hostile for the survival of aquatic life. Acid rain tendency of altering pH and aluminum concentrations greatly affects pH concentration levels in surface water,

thereby affecting fish as well as other aquatic life-forms. At pH levels below 5, most fish eggs cannot hatch. Lower pH can also kill adult fishes. Species including fish, plant and insect types in some lakes, rivers and brooks have been reduced and some even completely eliminated owing to excess acid rain flowing into the waters.

2.Effect on Forests: It makes trees vulnerable to disease, extreme weather, and insects by destroying their leaves, damaging the bark and arresting their growth. Forest damage due to acid rain is most evident in Eastern Europe – especially Germany, Poland and Switzerland.

3.Effect on Soil: Acid rain highly impacts on soil chemistry and biology. It means, soil microbes and biological activity as well as soil chemical compositions such as soil pH are damaged or reversed due to the effects of acid rain. The soil needs to maintain an optimum pH level for the continuity of biological activity. When acid rains seep into the soil, it means higher soil pH, which damages or reverses soil biological and chemical activities. Hence, sensitive soil microorganisms that cannot adapt to changes in pH are killed.

4.Vegetation Cover and Plantations: The damaging effects of acid rain on soil and high levels of dry depositions have endlessly damaged high altitude forests and vegetation cover since they are mostly encircled by acidic fogs and clouds. Besides, the widespread effects of acid rain on ecological harmony have led to stunted growth and even death of some forests and vegetation cover

5.Effect on Architecture and Buildings: Acid rain on buildings, especially those constructed with limestone, react with the minerals and corrode them away. This leaves the building weak and susceptible to decay. Modern buildings, cars, airplanes, steel bridges and pipes are

all affected by acid rain. Irreplaceable damage can be caused to the old heritage buildings.

6.Effect on Public Health: When in atmosphere, sulfur dioxide and nitrogen oxide gases and their particulate matter derivatives like sulfates and nitrates, degrades visibility and can cause accidents, leading to injuries and deaths. Human health is not directly affected by acid rain because acid rain water is too dilute to cause serious health problems.

Control of Acid Rain:

The phenomenon of acid rain is highly interactive problem and remedial measures to control it are very expensive. Some of the major procedures that must be followed to control acid rain are as follows:

1. Reduce amount of sulphur dioxide and oxides of nitrogen released into the atmosphere-

(a) Flue gas desulphurization (b) Catalytic Converters

2. Use cleaner fuels

(i) Coal that contains less sulphur.

(ii) “Washing” the coal to reduce sulphur content.

(iii) Natural Gas

3. Flue Gas Desulphurisation (FGD)

(i) Removes sulphur dioxide from flue gas (waste gases).

(ii)Consists of a wet scrubber and a reaction tower equipped with a fan that extracts hot smoky stack gases from a power plant into the tower.

(iii) Lime or limestone (calcium carbonate) in slurry form is injected into the tower to mix with the stack gases and reacts with the sulphur dioxide present.

(iv) Produces pH-neutral calcium sulphate that is physically removed from the scrubber.

(v) Sulphates can be used for industrial purposes.

4. Use other sources of electricity and Energy conservation: (i.e. nuclear power, hydro-electricity, wind energy, geothermal energy, and solar energy)

5. Reducing the effects of Acid Rain by Liming: Powdered limestone/limewater added to water and soil to neutralize acid.

WATER POLLUTION

Introduction

The quality of water is of vital concern for mankind since it is directly linked with human welfare. Three fourth (3/4) of the earth surface is covered by water, 97% in oceans, 2% in glaciers and less than 1% is surface waters available for human.

Water pollution is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). This form of environmental degradation occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds.

Water-Pollution

Water pollution can be defined in many ways. Usually, it means one or more substances are added in water to such an extent that they cause problems for animals or people. Oceans, lakes, rivers, and other inland waters can naturally clean up a certain amount of pollution by dispersing it harmlessly.

The chemicals in the ink could very quickly have an effect on the quality of the water. This, in turn, could affect the health of all the plants, animals, and humans whose lives depend on the river. Thus, water pollution is all about quantities: how much of a polluting substance is released and how big a volume of water it is released into. A small quantity of a toxic chemical may have little impact if it is spilled into the ocean from a ship. But the same amount of t.he same chemical can have a much bigger impact pumped into a lake or river, where there is less clean water to disperse it.

Water pollution almost always means that some damage has been done to an ocean, river, lake, or other water source. A 1969 United Nations report defined ocean pollution as:

"The introduction by man, directly or indirectly of toxic substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities, including fishing, impairment of quality for use of sea water and reduction of amenities."

Major types of water pollution

When we think of Earth's water resources, we think of huge oceans, lakes, and rivers. Water resources like these are called surface waters. The most obvious type of water pollution affects surface waters. For example, a spill from an oil tanker creates an oil slick that can affect a vast area of the ocean .

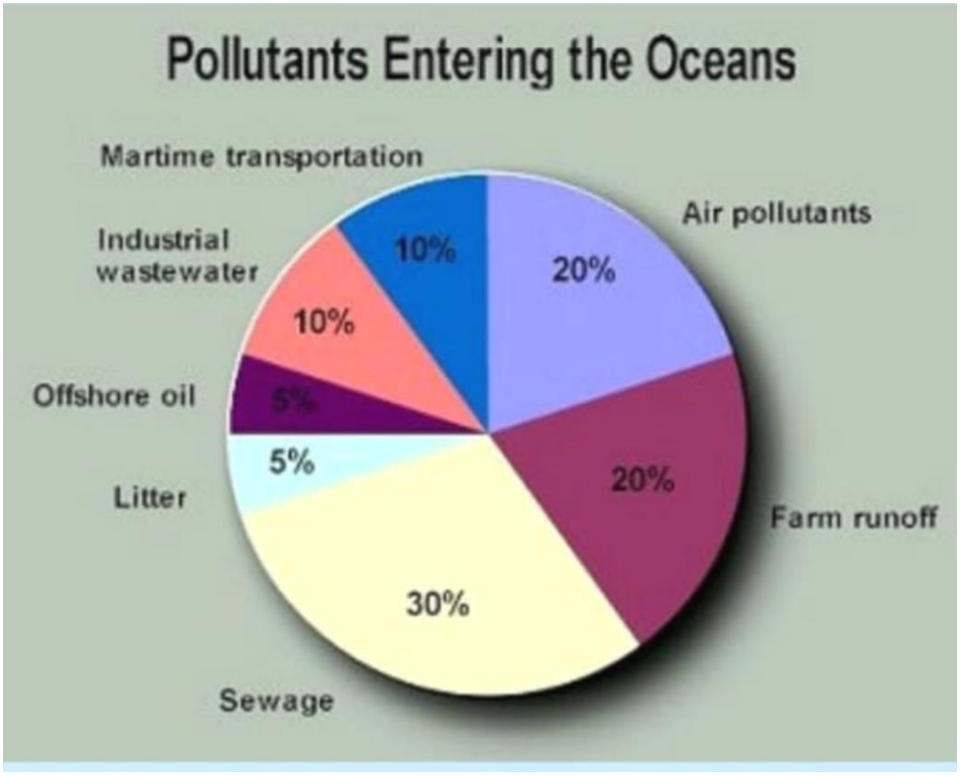


Fig: Pollutants Overview

1. Groundwater

When rain falls and seeps deep into the earth, filling the cracks, crevices, and porous spaces of an aquifer (basically an underground storehouse of water), it becomes groundwater—one of our least visible but most important natural resources. For some folks in rural areas, it's their only freshwater source. Groundwater gets polluted when contaminants—from pesticides and fertilizers to waste leached from landfills and septic systems—make their way into an aquifer, rendering it unsafe for human use. Ridding groundwater of contaminants can be difficult to impossible, as well as costly. Once polluted, an

aquifer may be unusable for decades, or even thousands of years. Groundwater can also spread contamination far from the original polluting source as it seeps into streams, lakes, and oceans.

2. Surface water

Covering about 70 percent of the earth, surface water is what fills our oceans, lakes, rivers, and all those other blue bits on the world map. Surface water from freshwater sources (that is, from sources other than the ocean) accounts for more than 60 percent of the water delivered to American homes. But a significant pool of that water is in peril. According to the most recent surveys on national water quality from the U.S. Environmental Protection Agency, nearly half of our rivers and streams and more than one-third of our lakes are polluted and unfit for swimming, fishing, and drinking. Municipal and industrial waste discharges contribute their fair share of toxins as well. There's also all the random junk that industry and individuals dump directly into waterways.

3. Ocean water

Eighty percent of ocean pollution (also called marine pollution) originates on land—whether along the coast or far inland. Contaminants such as chemicals, nutrients, and heavy metals are carried from farms, factories, and cities by streams and rivers into our bays and estuaries; from there they travel out to sea. Meanwhile, marine debris—particularly plastic—is blown in by the wind or washed in via storm drains and sewers. Our seas are also sometimes spoiled by oil spills and leaks—big and small—and are consistently soaking up carbon pollution from the air. The ocean absorbs as much as a quarter of man-made carbon emissions.

4. Point source

When contamination originates from a single source, it's called point source pollution. Examples include wastewater (also called effluent) discharged legally or illegally by a manufacturer, oil refinery, or wastewater treatment facility, as well as contamination from leaking septic systems, chemical and oil spills, and illegal dumping. The EPA regulates point source pollution by establishing limits on what can be discharged by a facility directly into a body of water. While point source pollution originates from a specific place, it can affect miles of waterways and ocean.

Types of water pollution

There are many types of water pollution because water comes from many sources. Here are a few types of water pollution:

1. Nutrients Pollution
Some wastewater, fertilizers and sewage contain high levels of nutrients. If they end up in water bodies, they encourage algae and weed growth in the water. This will make the water undrinkable, and even clog filters. Too much algae will also use up all the oxygen in the water, and other water organisms in the water will die out of oxygen starvation.

2. Surface water pollution
Surface water includes natural water found on the earth's surface, like rivers, lakes, lagoons and oceans. Hazardous substances coming into contact with this surface water, dissolving or mixing physically with the water can be called surface water pollution.

3. Oxygen Depleting
Water bodies have micro-organisms. These include aerobic and anaerobic organisms. When too much biodegradable matter (things that easily decay) end up in water, it encourages more microorganism growth, and they use up more oxygen in the water. If oxygen is depleted, aerobic organisms die, and anaerobic organisms grow more to produce harmful toxins such as ammonia and sulfides.

4. Ground water pollution
When humans apply pesticides and chemicals to soils, they are washed deep into the ground by rainwater. This gets to underground water, causing pollution underground.

This means when we dig wells and bore holes to get water from underground, it needs to be checked for ground water pollution.

5. Microbiological
In many communities in the world, people drink untreated water (straight from a river or stream). Sometimes there is natural pollution caused by microorganisms like viruses, bacteria and protozoa. This natural pollution can cause fishes and other water life to die. They can also cause serious illness to humans who drink from such waters.

6. Suspended Matter
Some pollutants (substances, particles and chemicals) do not easily dissolve in water. This kind of material is called particulate matter. Some suspended pollutants later settle under the water body. This can harm and even kill aquatic organisms that live at the bottom of water bodies.

7. Chemical Water Pollution
Many industries and farmers work with chemicals that end up in water. This is common with Point-source Pollution. These include chemicals that are used to control weeds, insects and pests. Metals and solvents from industries can pollute water bodies. These are poisonous to many forms of aquatic life and may slow their development, make them infertile and kill them.

8. Oil Spillage
Oil spills usually have only a localized effect on wildlife but can spread for miles. The oil can cause the death to many fish and get stuck to the feathers of seabirds causing them to lose their ability to fly.