General Knowledge Today

Environment-4: Pollution Related Topics

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Air Pollution Topics

Primary & Secondary Air Pollutants

Air borne emissions emitted from various industries are a cause of major concern. These emissions are of two forms, viz. solid particles (SPM) and gaseous emissions. Thus, Air Pollutants can be solid particles, liquid droplets, or gases. They can be natural or manmade. The pollutants have been classified into primary and secondary categories.

- The *primary pollutants are "directly" emitted* from the processes such as fossil fuel consumption, Volcanic eruption and factories. The major *primary pollutants* are Oxides of Sulphur, Oxides of Nitrogen, Oxides of Carbon, Particulate Matter, Methane, Ammonia, Chlorofluorocarbons, Toxic metals etc.
- The *secondary pollutants are not emitted directly*. The secondary pollutants form when the primary pollutants react with themselves or other components of the atmosphere. Most important *secondary level Air Pollutants* are *Ground Level Ozone, Smog and POPs (Persistent Organic Pollutants).*

Primary Air Pollutants

Oxides of Sulphur

Sulphur Oxides are generally a product of the Volcanoes, Industrial processes, Coal and petroleum, because most of them have Sulphur as a component. The Sulphur Dioxide in presence of a catalyst such as NO2 causes Acid Rain, because of the formation of Sulphuric Acid. The *Indian Coal is though low in sulphur content* but still coal consumption is a major danger of acid rain because of the coal based power plants.

Oxides of Nitrogen

Most of the Nitrogen Oxides are produced due to high temperature combustion. In the cities the brown haze dome above the cities is mostly because of the Nitrogen Oxides. The most important toxic gas is Nitrogen dioxide which is brown, with sharp odour.

Oxides of Carbon

Carbon Monoxide, which is colourless, odourless and non irritating but very poisonous gas is the product of incomplete combustion of the natural gas, coal or wood. The vehicle exhaust is the major source of CO.

The Carbon *Dioxide is associated with the Ocean Acidification* and is emitted from combustion, factories and respiration of living organisms.

Then, we have primary pollutants such as *Volatile Organic Compounds or VOCs* which are methane (CH4) and *non-methane (NMVOCs).*

- Methane is a GHG which contributes to Global Warming.

- The NMVOCs include the aromatic compounds such as Benzene, Toluene, Xylene which are proved or suspected carcinogens.
- Another dangerous compound is the 1,3-butadiene, often associated with industrial uses.

Particulate Matter

The particulate matters are the fine particles which may be either solid or liquid, suspended in a gas. They are different from the Aerosols. Aerosols are particle and gas referred together. The aerosols which are created by the Human activities are anthropogenic aerosols. They account for around 10% of the total aerosols in the atmosphere.

Other Primary Pollutants

Another category of the primary air pollutants is toxic metals such as Cadmium, Lead and Copper, which are products of the Industrial processes. The Chlorofluorocarbons (CFCs) are proved to be harmful to the ozone layer emitted from products currently banned from use. In agriculture process, Ammonia is emitted which has characteristic pungent odor. It is a precursor to foodstuffs and fertilizers. Ammonia is also a building block for the synthesis of many pharmaceuticals.

Secondary Air Pollutants

Ground Level Ozone

The most important secondary pollutant is the Ground Level Ozone or Tropospheric Ozone. Emissions from industrial facilities and electric utilities, motor vehicle exhaust, gasoline vapours, and chemical solvents are some of the major sources of Nox and VOC. Ground Level Ozone forms due to reactions of the NOx, Carbon Monoxide and VOCs in presence of sunlight.

Smog

Another most important secondary pollutant is the Smog, which has made up of Smoke and Fog. Traditionally, the smog has resulted from large amounts of coal burning in an area caused by a mixture of smoke and sulphur dioxide. Now-a-days, the Vehicle emissions and Industrial emissions that are acted on in the atmosphere by ultraviolet light from the sun to form secondary pollutants that also combine with the primary emissions to form photochemical smog.

Ground Level Ozone

The most important secondary pollutant is the Ground Level Ozone or Tropospheric Ozone. Ground Level Ozone is formed by the reactions of the oxides of Nitrogen (NOx), Carbon Monoxide (CO) and Volatile Organic Compounds (VOCs) and NMVOCs such as Xylene in the atmosphere in the presence of sunlight. Thus culprits for Ground Level Ozone are NOx, CO, VOCs and NMVOCs.

In the last 100 years, the emission of *Methane* (a Volatile Organic Compound) has increased dramatically and it has contributed to the increased concentration of Ground Level Ozone.

Formation of Ground Level Ozone

The formation of the Ground Level Ozone involves a long complex series of the reactions in which carbon monoxide and VOCs are oxidized to water vapour and carbon dioxide. The series of the reactions begins with the Hydroxyl OH radicals, which is one of the main chemical species controlling the oxidizing capacity of the global Earth atmosphere. They are produced by many pathways but most notably they are formed from the decomposition of hydro peroxides (ROOH) and by reaction of excited atomic oxygen with water. The reaction involves the following steps:

The Carbon Monoxide reacts with the Hydroxyl Radical, producing a Hydrogen atom.

$OH + CO \rightarrow H + CO_2$

The hydrogen atom formed by this reacts rapidly with oxygen to give a peroxy radical HO_2

$H + O2 \rightarrow HO_2$

Peroxyradical then reacts with the NO and gives NO_2 which, in presence of Sunlight is photolysed to give atomic oxygen and through reaction with oxygen a molecule of ozone.

$HO2 + NO \rightarrow OH + NO_2$

$NO2 + h\nu \rightarrow NO + O$

$O + O2 \rightarrow O_3$

In total, the reaction is as follows:

$CO + 2O_2 \rightarrow CO_2 + O_3$

The above reaction is simple demonstration. The Chemical processes that involve the VOCs are the complex ones. But the result of these reactions is the Ozone. From the above, kindly note that *Carbon Dioxide DOES NOT play a role in formation of Ground level Ozone.*

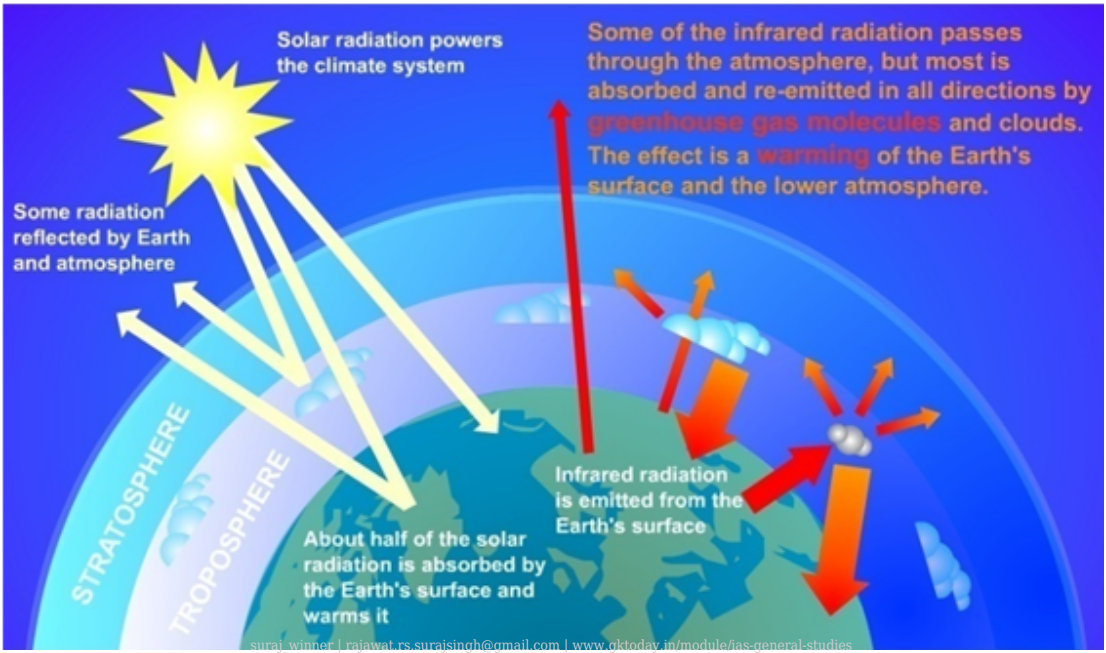
Sources and Health Effects of Ground Level Ozone

Breathing ozone can trigger a variety of health problems, particularly for children, the elderly, and people of all ages who have lung diseases such as asthma. Ground level ozone can also have harmful effects on sensitive vegetation and ecosystems.

Green House Effect

In the Green House Effect, the thermal radiation from a planetary surface is absorbed by atmospheric greenhouse gases, and is re-radiated. Due to this, the temperature of the body is higher than what it would have been if there was no atmosphere.

Process of Green House Gas on Earth



Earth receives the energy from Sun in the form of Ultraviolet, Visible and Near Infra Red radiation. Except most of the UV radiation, almost all of them pass through the atmosphere without being absorbed. Out of this 50% is absorbed by the surface of the Earth. When surface becomes warm, it radiates the far Infrared thermal radiation, which has longer wavelengths than that of the radiation absorbed. This thermal radiation is absorbed by the atmosphere, and the atmosphere reradiates it both upwards and downwards. The radiation that is sent downward again raises the temperature of the Earth.

Thus, the long wave radiation is trapped and the equilibrium temperature of earth is higher than if there was no atmosphere.

The Incoming sun light is mostly in the form of visible light and nearby wavelengths, in the range 0.2–4 μm. The loss of the Radiation is almost nothing at the surface level but maximum at higher in the atmosphere because of the decreasing concentration of water vapor, an important greenhouse gas. While the major atmospheric components (Nitrogen and Oxygen) absorb little or no radiation, some of the minor components are effective absorbers. Particularly effective is water vapor and CO2 which absorb effectively in the IR wavelength range.

These absorbing gases and their surrounding air warm up, emitting radiation downward, towards the Earth's surface, as well as upward, towards space. This effectively traps part of the IR radiation between ground and the lower 10 km of the atmosphere. This reduction in the efficiency of the

Earth to lose heat causes the surface temperature to rise above the effective temperature until finally, enough heat is able to escape to space to balance the incoming solar radiation. The effect is analogous to that of a blanket that traps the body heat preventing it from escaping into the room and thus keeps us warm on cold nights.

Green House Effect versus Planetary Albedo

If Earth was an ideal black body which absorbs all the radiation from the Sun and emit the radiation due to this heating, its temperature would have been approximately 5.3 °C. The Earth and other planets are not perfect black bodies, as they do not absorb all the incoming solar radiation but reflected part of it back to space. The ratio between the reflected and the incoming energies is termed the planetary albedo. Earth reflects 36-37% of this incoming light and it corresponds to the Earth Albedo 0.367. So, Earth's mean temperature is 14 °C. If there were no atmosphere and no radiation was lost due to reflection, its mean temperature would have been −18 or −19 °C. This difference is due to the Green House Effect.

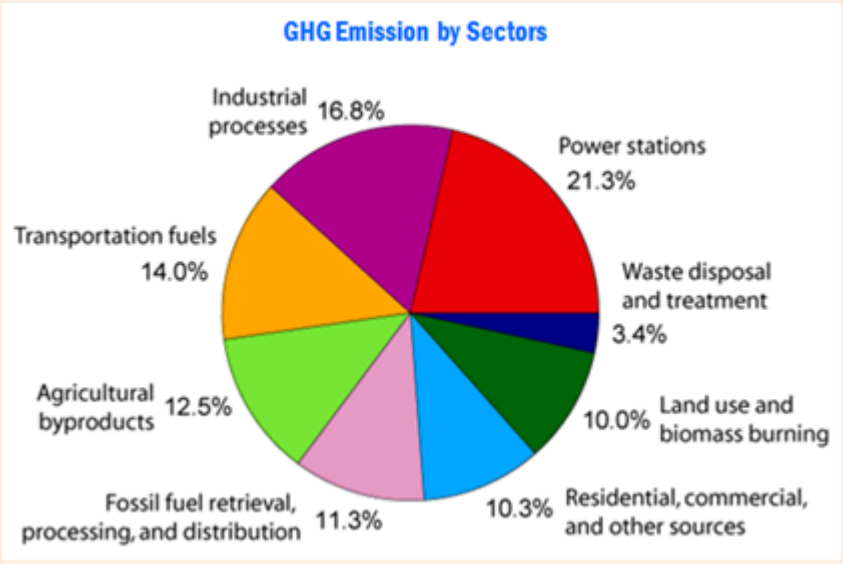
Green House on higher altitudes

At high elevations, air temperatures are generally cooler and have a greater day- to-night range. Since both the thickness and density of the air column decrease with elevation; *the greenhouse effect is weaker at high elevations.*

Green House Gases

The Major Green House Gases are Methane, Water Vapour, Carbon dioxide, Nitrous Oxide (N2O), Ozone, Sulphur Hexafluoride (SF6), Hydrofluorocarbons (HFCs) and Perfluorocarbons (PFCs). Out of them, most potent greenhouse gas is water vapour, which causes about 36-70% of the greenhouse effect. Carbon dioxide (9-26%), methane (4-9%) and Ozone (3-7%) are other major greenhouse gases.

GHG Emission by sectors



Maximum anthropogenic GHG emission is by Power Stations (over 21%) as shown in the following chart. It is followed by the Industrial Processes (around 17%).

Anti-greenhouse effect

In Solar system, Mars and Venus show the Green House Effect, but Titan (the largest planet of Saturn) and Pluto, show Anti-Green House Effect.

Greenhouse effect occurs because the atmosphere transparent to solar radiation, but largely opaque to infrared and far infrared emitted by the planet / body. But in anti-greenhouse effect, the *atmosphere is opaque to solar radiation but lets out infrared.* The effect is that the body is cooler than the actual temperature would have been.

In case of Titan, both Green House Effect and Anti Green House Effect have been proved. Due to Green House Effect, the temperature goes up by 21K while, due to Anti-Green House effect, the temperature goes down by 9K. The result is that surface temperature is 12 K warmer than without atmosphere.

At Pluto, there is different mechanism. Here, the sunlight causes the Nitrogen ice to sublimate which cools the body.

Ozone Depletion

Ozone or Trioxygen is an allotrope of oxygen that is much less stable than the diatomic allotrope (O_2), paramagnetic compared to the diamagnetic O_2; and is present in low concentration in atmosphere.

At ground level, it has harmful effects on the respiratory systems of animals. However, in upper

atmosphere, it creates ozonosphere, which prevents potentially damaging ultraviolet light from reaching the Earth's surface. Ozonosphere is located 10-18 kilometres above Earth's surface.

Factors Affecting Thickness of Ozone Layer

The thickness of the ozone layer-that is, the total amount of ozone in a column overhead-varies greatly worldwide, being thin at equator and thickest at poles. It also varies with season, being in general thicker during the spring and thinner during the autumn in the northern hemisphere. The reasons for this latitude and seasonal dependence are complicated, involving atmospheric circulation patterns as well as solar intensity.

Creation of Ozone Hole

Ozone depletion has been seen everywhere beyond tropics and there is a severe depletion in the Polar Regions due to some reasons. The polar regions get a much larger variation in sunlight than anywhere else and during the 3 months of winter spend most of time in the dark without solar radiation. Due to this, the temperatures in Polar Regions go very much down.

The extremely low temperatures in Polar Regions in winter cause formation of so called Polar Stratospheric Clouds (PSCs) in the otherwise dry stratosphere there. These clouds are made of ice crystals which provide surface of many of chemical reactions. A complex interplay of chemistry, dynamics, and radiation lead to conditions conducive to significant ozone loss in the Polar Regions.

The culprit compounds are Chlorofluorocarbons as we all know. Upon reaching the stratosphere. They CFCs are subject to higher levels of ultraviolet radiation that decompose them and release atomic chlorine. Atomic Chlorine reacts with Ozone and gives out Oxygen as follows:

$Cl+O_3 \rightarrow ClO+O_2$

In the above reaction, atomic Chlorine (Cl) gets removed once it has converted an ozone molecule to Oxygen molecule but then it is regenerated through reaction of Chlorine Monoxide (CIO) with oxygen atom (O) as follows:

$ClO + O \rightarrow Cl + O_2$

The net reaction in above two sets is as follows:

$O_3+O \rightarrow 2O_2$

The net result of the two reactions is the depletion of ozone.

Role of Chlorine Compounds

Atomic Chlorine gets regenerated again and again in the above reaction and thus plays a catalytic role. This role was not discovered until 1973. Once discovered, the efforts to bring down / ban use of Chlorofluoro Carbons was started.

Antarctic Ozone Hole

Antarctic ozone hole is an area of the Antarctic stratosphere in which the recent (since about 1975) ozone levels have dropped to as low as 33% of their pre- 1975 values. This hole occurs during

Antarctic Spring (September to Early December) as the strong westerly winds start to circulate around the continent and create an atmospheric container. In this container over 50% of the lower stratospheric ozone is destroyed.

Arctic Ozone Hole

Every March to April during the Northern Hemisphere springtime similar, but less pronounced ozone hole forms above the Arctic. There are several reasons as to why the arctic ozone hole is less prominent in comparison to the antarctic hole. *Firstly,* Polar Vortex, a natural circulation of wind that isolates Antarctica from rest of the world during winter is less developed over arctic. *Secondly,* stratospheric temperatures at Arctic, are not as low as in the Antarctic. This is a lucky proposition because formation of even a moderate ozone hole above the Arctic region can give cause for considerable concern due to the greater populations in the higher latitudes of the Northern Hemisphere. *Thirdly,* **Earth's magnetic field** directs more positively charged solar wind particles to Earth's south pole. These are largely hydrogen, hydrogen oxidizes to water vapor, and water vapor both destroys ozone, and blocks one path of ozone production (not really important when UV-C is not available to make ozone anyway).

Dobson units in context with Ozone Depletion

OPlease note that ozone in the atmosphere can be measured in the PPT but that is not the units of Ozone Depletion. The Ozone hole is measured in terms of *reduction in the total column ozone*, above a point on the Earth's surface, expressed in "*Dobson units*".

One DU is 2.69×1016 ozone molecules per square centimetre, or 2.69×1020 per square meter or 0.4462 milli moles of ozone per square meter. **The base unit for an ozone hole was fixed 220 DU** because total ozone values of less than 220 Dobson Units were not found in the historic observations over Antarctica prior to 1979.

Vienna Convention

Vienna convention was the first multilateral Environmental Agreement in context with the Ozone depletion. It was agreed upon at the Vienna Conference of 1985 and entered into force in 1988, thus paving the way for a legally binding treaty as its protocol called Montreal protocol. Vienna Convention itself has not placed legally binding reduction goals for the use of CFCs. Its protocol called Montreal Protocol is legally binding to all signatories.

Montreal Protocol 1989

"Montreal Protocol on Substances That Deplete the Ozone Layer" or simply Montreal Protocol is the protocol to the Vienna Convention for the Protection of the Ozone Layer. This international treaty was designed to protect the ozone layer by phasing out the production of substances believed to be responsible for ozone depletion.

- Opened for signature on September 16, 1987

- Ratified by 197 Countries
- Entered into force on January 1, 1989.

The Montreal Protocol opened for signature on September 16, 1987. This date is observed as International Ozone Day every year.

Montreal Protocol stipulates that the production and consumption of compounds that deplete ozone in the stratosphere-chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform-are to be phased out by 2000 (2005 for methyl chloroform). These compounds significantly deplete the stratospheric ozone layer that shields the planet from damaging UV-B radiation. To date, 197 countries have signed the Protocol. As per the latest amendment, the treaty calls for complete phase out of HCFC by 2030.

It is believed that if the international community adheres to this treaty, the ozone layer will be recovered by 2050. Thus, this protocol is hailed as most successful international agreement to date.

HCFC versus HFC

Montreal Protocol currently calls for a complete phase-out of HCFCs (Hydrochlorofluorocarbons) by 2030, but does not place any restriction on HFCs (Hydrofluorocarbons). The difference between these two is of Chlorine. Hydrofluorocarbons contain only one or a few fluorine atoms are the more common type of organofluorine compounds used as refrigerants, their atmospheric concentrations are rapidly increasing, causing international concern about their rising contribution to anthropogenic radiative forcing emissions. All the HCFCs, HFCs & CHCs are now considered to be the Global Warming Potential.

India and Montreal Protocol

India became a party to the Montreal Protocol in 1992 and has been sharing the global concern for phasing out Ozone Depleting Substances. India has emerged as a global leader in promoting smooth transition for phasing out Ozone Depleting Substances (ODS).

Acid Rain

Acid rain refers to the precipitation with elevated levels of hydrogen ions or a low pH. When fossil fuel is burnt, some of the elements within their molecules combine with oxygen and form oxides. The oxide produced in a large quantity is carbon dioxide, followed by smaller quantities of Sulphur Oxides and Nitrogen Oxides. All of these oxides form the acidic solution when they dissolve in water. Out of these oxides, the Nitrogen oxides can also be produced naturally by lightning strikes. Similarly, the Sulfur Dioxide can also be produced by the volcanic eruptions. *But these natural phenomena did not contribute the acidic rains as compared to the anthropogenic activities.* The Acid Rains have been seen in many parts of the world more prominently since 1970s. In some parts of the world the Acid Rains with as low as 1.5pH has been witnessed.

Chemistry of Acid Rains

The three kinds of Oxides matter in the Acid Rains. They are *Oxides of Sulphur*, *Oxides of Nitrogen* and *Oxides of Hydrogen* viz. water and Hydroxyl Radicals.

The sulphur dioxide is oxidized by reaction with the hydroxyl radical via an intermolecular reaction shown below:

$SO_2 + OH \rightarrow HOSO_2$

$HOSO_2$ is unstable and it reacts with atmospheric Oxygen as follows:

$HOSO_2 + O_2 \rightarrow HO_2 + SO_3$

The Sulfur Trioxide SO_3 produced so quickly reacts with the water and forms the Sulphuric acid as follows:

$SO_3 (g) + H_2O (l) \rightarrow H_2SO_4 (l)$

The Nitrogen Dioxide also reacts with the OH to produce the Nitric Acid

$NO_2 + OH \rightarrow HNO_3$

The above reactions may take in the cloud drops as follows:

$SO_2 (g) + H_2O \rightarrow SO_2 \cdot H_2O$

$SO_2 \cdot H_2O \rightarrow H^+ + HSO_3^-$

$HSO_3^- \rightarrow H^+ + SO_3^{--}$

Impacts of Acid Rain

Impact on Biota and Human Life

The Acid Rains show adverse impact on the forests, freshwaters, soil and aquatic life forms. The acid rain eliminates the insect life in the lakes and ponds. It kills the soil organisms and thus changes the soil chemistry.

Impact on Soil Chemistry:

In the soil, there is an adverse impact on the nutrients such as Magnesium. This is because, Calcium and Magnesium are leached away by the Hydronium ion of the acids.

Impact on Buildings

Acid rain is capable of damaging the buildings and historic monuments which are made up of rocks such as limestone and marble. This is because these rocks contain a large amount of Calcium Carbonate, which reacts with the Sulfuric Acid to create Gypsum. Gypsum flakes off easily. This is shown in the following reaction:

$CaCO3 (s) + H2SO4 (aq) \rightarrow CaSO4 (aq) + CO2 (g) + H2O (l)$

How to control Acid Rain?

The best approach to combat acid rain is to reduce the amount of NO_X and SO_2 being released into the atmosphere. Fitting a catalytic converter a catalytic converter to a car can reduce the emission of NOx by up to 90%, but they very expensive, and cause more carbon dioxide to released, which

contributes to the greenhouse effect. SO_2 emissions from power stations can be reduced before, during, or after combustion. In addition there are several methods to controls SO_2 and NO_x in the environment. Acid rain may be controlled by

- When fuel with low sulphur content (such as North Sea gas or oil) is burnt, not much sulphur dioxide will be formed. However, low sulphur fuels are more expensive because they are in greater demand and although high-sulphur fuels can be treated to reduce their sulphur content, it is very expensive
- The SO_2 created during combustion can be absorbed if an appropriate chemical (such as limestone) is present while the fuel burns.
- Once the fuel has been burned, the SO_2 can be removed from the exhaust gases. Most system spray a mixture of limestone and water onto the gases. This mixture reacts with the SO_2 to form gypsum, useful building materials
- Another option is not to burn fossil fuels, but to use alternative energy sources.
- All these methods for reducing acid gases are expensive, and have draw-backs, so have been passed to use them. The best way to reduce them is not to use as much energy in the first place. One can save energy by turning off-lights when you leave a room, avoiding short journeys by car, insulating the house properly and using electric and related appliances which use less energy.

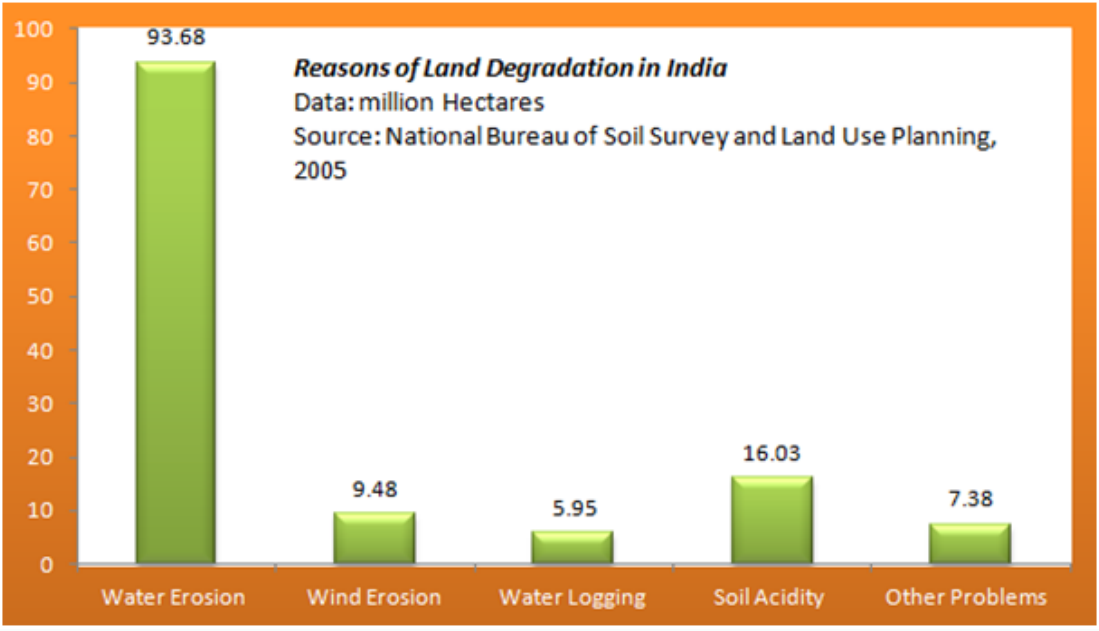
Land, Soil & Water Pollution Topics

Land Degradation

Land degradation is any change or disturbance to the land perceived to be deleterious or undesirable. Land degradation can be caused by both manmade and natural reasons such as floods and forest fires. It is estimated that up to 40% of the world's agricultural land is seriously degraded.

Causes of Land Degradation

The main causes of the land degradation include Climate Change, Land clearance and deforestation, Depletion of soil nutrients through poor farming practices, Overgrazing and over grafting, inappropriate irrigation, Urban sprawl and commercial development and Soil Pollution. In our country, *water erosion is the most prominent reason of land degradation*, followed by Soil acidity; as shown in below graphics:



Consequences of Land Degradation

The major outcomes of land degradations are as follows:

- Decline in the productive capacity of the land (temporary or permanent)
- Decline in the lands "usefulness".
- Loss of biodiversity
- Increased vulnerability of the environment or people to destruction or crisis
- Accelerated soil erosion by wind and water
- *Soil acidification* and the formation of acid sulphate soil resulting in barren soil
- *Soil alkalinisation* owing to irrigation with water containing sodium bicarbonate leading to poor soil structure and reduced crop yields
- *Soil salination* in irrigated land requiring soil salinity control to reclaim the land
- *Soil water logging* in irrigated land which calls for some form of subsurface land drainage to remediate the negative effects.
- Destruction of soil structure including loss of organic matter.

Shifting Cultivation

Under Shifting cultivation, a piece of land is used for quite some years until the fertility is dropped. After that the farmers move to the new plots. It is practiced by tribal and also known as *Burn and Slash cultivation*. It is known as Jhoom in Assam, Onam in Kerala, Podu in Andhra Pradesh and Odisha. The same is known as Bewar in Madhya Pradesh.

Key Features of Shifting Cultivation

Over a large part of North East India, chief characteristics of shifting cultivation, while having different local names are found to be the same. These are

- Rotation of fields
- Use of fire for clearing the land
- Keeping the land fallow for regeneration for a number of years
- Use of human labour as main input
- Non-employment of draught animals
- Non-use of the plough, but instead very crude and simple implements such as dibble sticks and scrapers, are used, and
- All the crops being grown are mixed together.

Furthermore, in most parts of Northeast India it is found that hunting and gathering is an important subsidiary occupation of the shifting cultivators.

Extent of Shifting Cultivation in India

According to recent estimates, India's 0.59 percent of the total geographical area is under shifting cultivation. The effects of shifting cultivation are devastating and far-reaching in degrading the environment and ecology of these regions. *The earlier 15–20 years cycle of shifting cultivation on a particular land has reduced to two or three years now.* This has resulted in large-scale deforestation, soil and nutrient loss, and invasion by weeds and other species. The indigenous biodiversity has been affected to a large extent. The current statistics say that *India's largest area under shifting cultivation is in the state of Odisha*.

Impacts on Hilly Terrains

Most states of north east India are covered by dense forests. The topography of the region apart from fertility of the soil can be attributed as one of the factors for widespread practice of Jhum cultivation. The sloppy hills, fertile soil and accessibility to the forests are an ideal site for jhuming. The hilly areas of north East are becoming more and more barren due to jhuming.

Other Names of Shifting Cultivation

Shifting Cultivation is known as Ladang in Indonesia, Caingin in Philippines, Milpa in central America & Mexico, Ray in Vietnam, Taungya In Myanmar , Tamrai in Thailand, Chena in Sri Lanka, Conuco in Venezuela, Roca in Brazil, Masole in central Africa. Chinook is a local wind.

Soil Pollution

Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents and other xenobiotic (man-made) chemicals or other alteration in the natural soil environment. Pollution in soil is mainly associated with__:

- Indiscriminate use of fertilizers

- Indiscriminate use of pesticides, insecticides and herbicides
- Dumping of large quantities of solid waste
- Deforestation and soil erosion

The most common chemicals involved in soil pollution are petroleum hydrocarbons, solvents, pesticides, lead, and other heavy metals. A soil pollutant is any factor which deteriorates the quality, texture and mineral content of the soil or which disturbs the biological balance of the organisms in the soil. Pollution in soil has adverse effect on plant growth.

Effect of Soil Pollution

- Pollutants runs off into rivers and kills the fish, plants and other aquatic life
- Crops and fodder grown on polluted soil may pass the pollutants on to the consumers
- Polluted soil may no longer grow crops and fodder
- Soil structure is damaged (clay ionic structure impaired)
- Corrosion of foundations and pipelines
- Impairs soil stability
- May release vapours and hydrocarbon into buildings and cellars
- May create toxic dusts
- May poison children playing in the area

Land Rehabilitation

Land rehabilitation is the process of returning the land to some degree of its former state, after some process (industry, natural disasters, etc.) has resulted in its damage.

Land rehabilitation has been a major priority since Independence, and several policies and government agencies address desertification and degradation.

These include various programmes such as Desert Development Programme; Integrated Wasteland Development; National Watershed Development Project for Rainfed Areas; Soil Conservation in the Catchment of River Valley Projects; National Afforestation Programme; Arid Zone Research; Mahatma Gandhi National Rural Employment Guarantee Scheme; National Rural Drinking Water Programme etc.

Indiscriminate Use of Fertilizers

Fertilizers contaminate the soil with impurities, which come from the raw materials used for their manufacture. Mixed fertilizers often contain ammonium nitrate (NH4NO3), phosphorus as P2O5, and potassium as K2O. Further, over use of NPK fertilizers reduce quantity of vegetables and crops grown on soil over the years.

Pollution by Indiscriminate use of Urea

Since Urea is more subsidized in comparison to the P and K fertilizers, there is much more use of

Urea and this brings in nitrogenous pollution. The nitrogen from fertilizers and manures are eventually converted by bacteria in the soil to nitrates. These nitrates can be leached into the groundwater or be washed out of the soil surface into streams and rivers. High nitrate levels in drinking water are considered to be dangerous to human health.

Pollution by indiscriminate use of Phosphorus

Phosphorus cannot be readily washed out of the soil, but is bound to soil particles and moves together with them. Phosphorus can therefore be washed into surface waters together with the soil that is being eroded. The phosphorus is not considered to be dangerous, but *it stimulates the excessive growth of plants and this process is called eutrophication.* These algae eventually die and decompose, removing the oxygen from the water which in turn kill the fish. Further, the *The Arsenic, Lead and Cadmium present in traces in rock phosphate mineral get transferred to super phosphate fertilizer.*

Since the metals are not degradable, their accumulation in the soil above their toxic levels due to excessive use of phosphate fertilizers, becomes an indestructible poison for crops.

Indiscriminate use of Potassium

Potassium, the third major nutrient in fertilizers, *does not cause water quality problems because it is not hazardous in drinking water and is not a limiting nutrient for growth of aquatic plants.* It is tightly held by soil particles and so can be removed from fields by erosion, but generally not by leaching. However, too much use of Potassium inhibits the absorption of other nutrients, which leads to the symptoms caused by the deficiency of these nutrients.

It also **reduces the protein content of wheat, maize, grams**, etc., grown on that soil. The carbohydrate quality of such crops also gets degraded. Excess potassium content in soil decreases Vitamin C and carotene content in vegetables and fruits. The vegetables and fruits grown on overfertilized soil are more prone to attacks by insects and disease.

Vermicompost

Vermicompost is the product or process of composting utilizing various species of worms, usually red wigglers, white worms, and earthworms to create a heterogeneous mixture of decomposing vegetable or food waste, bedding materials, and vermicast.

Benefits of Vermicompost for Soil

- Vermicast, similarly known as worm castings, worm humus or worm manure, is the end-product of the breakdown of organic matter by a species of earthworm.
- Vermicompost is an excellent, nutrient-rich organic fertilizer and soil conditioner.
- Vermicompost improved the physical make up of upper layers of soil, enriches soil with micro-organisms (adding enzymes which help to use complex matters such as phosphate and cellulose).

- The microbial activity in worm castings is 10 to 20 times higher than in the soil and organic matter that the worm ingests, it also attracts deep-burrowing earthworms already present in the soil and the mucus present in vermicast improves water holding capacity

Benefits of Vermicompost for Plant growth

- Vermicompost enhances germination, plant growth, and crop yield and improves root growth and structure.
- It enriches soil with micro-organisms (adding plant hormones such as auxins and gibberellic acid)

Economic Benefits of Vermicompost:

- Biowastes conversion reduces waste flow to landfills. Elimination of biowastes from the waste stream reduces contamination of other recyclables collected in a single bin (a common problem in communities practicing single-stream recycling.
- The production also creates low-skill jobs at local level. Vermicompost has low capital investment and relatively simple technologies make vermicomposting practical for less-developed agricultural regions

Environmental Benefits of Vermicompost:

- Vermicompost helps to close the "metabolic gap" through recycling waste on-site. large systems often use temperature control and mechanized harvesting, however other equipment is relatively simple and does not wear out quickly. Production reduces greenhouse gas emissions such as methane and nitric oxide (produced in landfills or incinerators when not composted or through methane harvest)

Disadvantages / Issues of Vermicompost:

- Moisture, air circulation and compost quantity need regular monitoring otherwise the Vermicompost will smell like an old garbage. The quality of Vermicompost deteriorates in anaerobic environment.
- Vermicompost can be carried out at relatively low temperatures (under 25 °C) only. It is vitally important to keep the temperature below 35 °C, otherwise the earthworms will be killed.
- Vermicompost is time consuming. It can take many months, or even years, to build up a large working population of earthworms capable of vermicomposting significant quantities of waste. As well as this, earthworms (sometimes in large numbers) tend to escape during damp weather conditions or when food is in short supply.

Biofertilizers

There are five biofertilizers viz. Rhizobium, Azotobacter, Azospirillum, Phosphate Solubilizing Bacteria and mycorrhiza, which have been incorporated in India's Fertilizer Control Order (FCO),

1985.

- Rhizobium, Azotobacter, Azospirillum and blue green algae (BGA) have been traditionally used as Biofertilizers. Rhizobium inoculant is used for leguminouscrops such as pulses.
- Azotobacter can be used with crops like wheat, maize, mustard, cotton, potato and other vegetable crops.
- Blue green algae such as Nostoc, Anabaena, Tolypothrix and Aulosira fix atmospheric nitrogen and are used as inoculants for paddycrop.
- Phosphate solubilizing bacteria like *Pantoea agglomerans* strain P5, and Pseudomonas putida strain P13 are able to make the phosphate usable by solubilize it from inorganic sources.

Pesticides and Insecticides

Man is using the pesticides since the evolution and development of agriculture and civilization began. The word pesticide comes from Latin *pestis,* which means the destructive agent or plague. Pesticides are generally oily or waxy substances in the form of dust, granules, pallets, emulsified concentrates, aerosols, soluble powders, wettable powders etc.

Types of Chemical Pesticides

According to their chemical nature, pesticides can be classified in below categories:

Organochlorines

Organochlorines are very slowly decomposing chlorinated organic compounds, which are *lipophilic* (show much affinity for the fatty tissue of animals). Examples of Organochlorines are DDT, BHC, Aldrin, Endosulphan etc.

- DDT is the most famous chemical in the world and is oldest synthetic pesticide.
- Benzene hexachloride (BHC) also known as Lindane or Gammexane was used in agriculture and Pharma until its farm use was banned under the Stockholm convention on Persistent Organic Pollutants. However, it is still used in second-line pharmaceutical treatment for lice and scabies.
- Aldrin is applied to foundations of buildings to prevent termite. D

Organophosphates

Organophosphates are organic esters of phosphoric, thiophosphoric and other phosphoric, thiophosphoric and other phosphoric acids. Common examples are Malathion, Parathion, Fenitrothion etc.

Malathion is widely used in agriculture, residential landscaping, public recreation areas, and in public health pest control programs such as mosquito eradication. In some countries, it is the most commonly used organophosphate insecticide. Malathion / Organophosphates are harmful and of concern to both scientists and regulators because they work by irreversibly blocking an enzyme that's critical to nerve function in both insects and humans. Thus, their effect is mostly visible on nervous

system.

Carbamates

Carbamates are organic compounds derived from carbamic acid (NH2COOH). They are having structural resemblance with acetylcholine. Examples of Carbamates are Aldicarb (Temik), Carbofuran (Furadan), Carbaryl (Sevin), Ethienocarb, Fenobucarb, Oxamyl And Methomyl. These insecticides kill insects by reversibly inactivating the enzyme acetylcholinesterase.

Pyrethoids

Pyrethroids are synthetic derivatives of pyrethrin. Pyrethrin is obtained from a plant botanically called *chrysanthemum cineraifolium.* These compounds are the fastest growing groups of chemicals today. They are highly toxic and quite expensive.

Common example is Pyrethrin, which is a natural insecticide and least harmful of all. It is one of the insecticides based on learning how wild plants, especially tropical species produce chemical compounds that repel insects or inhibit their feeding. There are two major types of these compounds pyrethrins from wild chrysanthemum type plants and rotenoids produced by the roots of rain-forest legumes. Both types of compounds are *biodegradable, effective in low doses, and cause little harm to higher animals such as birds and mammals, including humans.*

Triazines

Triazines are a group of herbicides derived from urea. They are used for controlling weeds in tea, tobacco and cotton. Examples are simazine, atrazine etc.

Environmental Hazards of Pesticides

Pesticides increase the crop yield manifold because the insects which destroy crops in bulk are killed. Further, insecticides have helped to counter the various insects that function as dreadful diseases such as Malaria.

However, pesticides / insecticides are poisons which kill all biota irrespective of their benefits or harms to the crops or animals or humans. Since these pests also make food chain in the ecosystem, their elimination disturbs the entire ecosystem. Further, many of the pesticides are persistent organic pollutants, which enter into the food chain and keep bioaccumulating. If they are soluble in water, they cause water pollution.

Labelling of Pesticides

The pesticide packet are labelled using square divided into two triangles with color in lower triangle and word poison in upper triangle. This categorization is as follows:

Classification of pesticides	Colour of the lower triangle	Symbol and signal word* on upper triangle
Extremely toxic	Bright Red	Skull and cross bones 'POISON' in red
Highly toxic	Bright Yellow	'POISON' in red
Moderately toxic	Bright Blue	DANGER
Slightly toxic	Bright Green	CAUTION

* Signal words in Indian languages may also be given in addition to those in English

Examples

Biopesticides

Animals or plants used wilfully to destroy pests are called Biopesticides. For common knowledge, we can divide them into *bioherbicides* and *bioinsecticide.*

Bioherbicides

Pesticides destroying herbs are called bioherbicides. One example is insect *Cactoblastis cactorum*, which eats only cactus of Opuntia variety. The first bioherbicides, developed in 1981 was a mycoherbicide based on the fungus P*hytophthora palmivora.* It controls the growth of milk weed vines in citrus orchards.

Bioinsecticide

Bioinsecitides are animals (including insects) that kill other insects. For example, the *praying mantis eats aphids. Similarly, Gambusia fish is used to feed on larvae of mosquitoes.*

Examples of Biopesticides

- Daisy plants (Chrysanthemum cinerariaefolium) were first used centuries ago as a lice remedy in the Middle East, and this led to the discovery of pyrethrum insecticides. The seeds contain a natural insecticide called pyrethrin, a generic name for six related active compounds. It is one of the safer insecticides for several reasons: it decomposes rapidly in sunlight; it has few known effects on mammals; and insects do not develop resistance to it, the safer insecticides for several reasons: it decomposes rapidly in sunlight; it has few known effects on mammals; and insects do not develop resistance to it. It is used on foodstuffs, in head lice shampoos, and

in many indoor insect sprays. Lakhs of tonnes of mosquito coils made from pyrethrum are sold each year. Scientists have synthesized similar compounds called pyrethroids, but the chemical synthesis produces all geometric isomers of the compounds, many of which are ineffective and are difficult to separate from the active forms. The plant material contains only the active isomers.

- In South America, the natives use an extract of a forest vine to stun fish; this led to the discovery of rotenone, a biodegradable insecticide.
- The bacterium *Bacillus thuringiensis* produces toxic proteins that kill certain insects but are apparently harmless to humans. These are being produced and marketed as biopesticides.
- The Neem tree, in India, has been found to be a source of the insecticide azadirachtin, as well as fungicides, spermicide, and agents potentially valuable in birth control such as materials that prevent implantation or cause abortion. The tree has been used in traditional agriculture, medicine and cosmetics for centuries.

Drivers of Water Pollution

Almost 70 per cent of India's surface water resources and a growing percentage of its groundwater reserves are contaminated by biological, toxic organic and inorganic pollutants. In many cases, these sources have been rendered unsafe for human consumption as well as for other activities such as irrigation and industrial needs. The high incidence of severe contamination near urban areas indicates that the industrial and domestic sector's contribution to water pollution is much higher. Besides rapidly depleting groundwater table, the country faces another major problem on the water front – groundwater contamination – a problem which has affected as many as 19 states, including Delhi. The geogenic contaminants, including salinity, iron, fluoride and arsenic have affected groundwater in over 200 districts spread across 19 states.

Driver of water pollution

Fertilizers

Rapid increase in agro-chemical use in the past five decades, has contributed significantly to the pollution of both surface and groundwater resources. Fertilizers and pesticides enter the water supply through run-offs and leaching into the groundwater table and pose a hazard.

- Some of these substances have been known to *bio-accumulate* in certain organisms, leading to an increased risk of contamination when used for human consumption and a persistence of the chemicals in the environment over long periods of time.
- Water enriched with nutrients leads to *eutrophication*. Decaying organic matter releases odourous gases and partially decomposed matter accumulates on the river or lakebed, thereby limiting water's suitability for human consumption and other uses.

- *High levels of fertilizer use has been associated with increased incidence of eutrophication in rivers* and lakes in several of India's most important water bodies.

Industrial Sector

Though Industrial sector only accounts for three per cent of the annual water withdrawals in India, yet its contribution to water pollution, particularly in urban areas, is considerable. Wastewater generation from this sector has been estimated to be 55,000 million m^3 per day, of which 68.5 million m^3 are dumped directly into local rivers and streams without prior treatment. The government has called for the establishment of Common Effluent Treatment Plants (CETP) in industrial areas but their implementation has been slow, and most industries either are not connected to CETPs or only partially treat their wastewater before disposal.

Domestic Sector

The domestic sector is responsible for the majority of wastewater generation in India. Combined, the 22 largest cities in the country produce over 7,267 million litres of domestic wastewater per day, of which slightly over 80 per cent is collected for treatment. Inadequate treatment of human and animal wastes also contributes to high incidence of water-related diseases in the country. Till date, only 19.2 per cent of the rural and 70 per cent of the urban inhabitants have access to adequate sanitation facilities.

Persistent Organic Pollutants (POPs)

Persistence is an important characteristic of the environmental pollutants in an environmental medium (air/ water/ soil) or in a living tissue, in which the pollutants remain active for a longer time in a toxic form through chemical, biological, and photolytic processes.

Persistent organic pollutants (POPs) are organic compounds that, to a varying degree, resist photolytic, biological and chemical degradation.

Due to persistence, the pollutants are capable of long-range transport, **bioaccumulation** and **biomagnification**. Most of the POPs include pesticides, Industrial solvents, polyvinyl chloride, and pharmaceuticals. The Other words used are PBTs (Persistent, Bioaccumulative and Toxic) or TOMPs (Toxic Organic Micro Pollutants.)

Common Characters of the POPs

The persistent Organic Pollutants generally have __:

- Low Water solubility
- High lipid solubility: *This property leads them to bioaccumulation in animal tissues.*
- Semi volatile: The property of their physico-chemical characteristics that permit these compounds to occur either in the vapour phase or adsorbed on atmospheric particles, thereby facilitating their long range transport through the atmosphere
    - The POPs with higher Molecular weights are more toxic and more persistent

generally.

- Most of the POPs are halogenated and many have Chlorine as a component.

Bio-accumulation, Bio-concentration and Bio-magnification

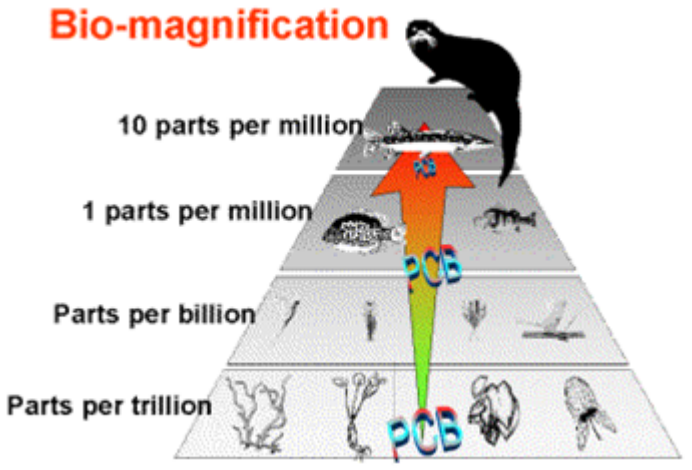
The above three terms are different with each other.

- *Bio-accumulation* refers to increase in concentration of a substance in certain tissues of organisms body.
- While Bioaccumulation occurs when an organism absorbs a toxic substance from all sources at a rate greater than that at which the substance is lost. *Bioconcentration* occurs when an organism absorbs a toxic substance from ONLY Water at a rate greater than that at which the substance is lost.
- Please note that *Bioaccumulation* and *Bioconcentration* are synonymous except the difference of the source. *Both Bioaccumulation and Bioconcentration occur in the same organism. But Biomagnification occurs across various trophic levels in a food chain.*

Biomagnification

Biomagnification refers to the is the INCREASE in concentration of the POPs such as DDT, that occurs in a food chain as a consequence of persistence, high lipid solubility and low water solubility.

The substances become more and more concentrated in tissues or internal organs as they move up the chain. This is shown in the following picture:



Dirty Dozen

In May 1995, the United Nations Environment Programme Governing Council (GC) started investigations on the POPs. The process began with 12 POPs which were most common at that time. They were called "Dirty Dozen".

The Dirty Dozen are: *Aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex,*

polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene.
The list enlarged later with inclusion of some more chemicals.

Stockholm Convention on Persistent Organic Pollutants

Stockholm Convention is first ever-concerted global effort on Persistent Organic Pollutants (POP). It was called in 1995 by UNEP. The convention calls to outlaw nine of the dirty dozen chemicals, *limit the use of DDT to malaria control,* and curtail inadvertent production of dioxins and furans. The convention listed twelve distinct chemicals in three categories in the beginning.

These includes

- Eight pesticides (aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, mirex and toxaphene)
- Two industrial chemicals (poly chlorinated biphenyls and hexachlorobenzene)
- Two unintended byproducts (poly chlorinated dibenzo-p-dioxins and dibenzo furans, commonly referred to as dioxins and furans).

Countries are required to make efforts to identify, label and remove PCB-containing equipment by the year 2025, and manage the wastes in an environmentally sound manner, not later than 2028.

The Convention also seeks to continue minimization and, where feasible, ultimate elimination of the releases of unintentionally produced POPs, such as dioxins and furans. Stockpiles and wastes containing POPs must be managed and disposed off in a safe, efficient and environmentally sound manner, taking into account international rules, standards and guidelines. Each Party is required to develop a plan for implementing its obligations under the Convention.

India and Stockholm Convention

India is a party to the Stockholm convention since 2005. The Convention will enable India to participate in the It will also enable India to avail technical and financial assistance for implementing measures to meet the obligations of the Convention.

Stockholm Convention and Endusulphan

Endosulphan belongs to the **organochlorine group of pesticides** such as DDT. In pure form it exists as colourless crystals, slightly soluble in water, dissolves readily in xylene, chloroform, kerosene and most organic solvents and is a non-combustible solid. It is mixable with most fungicides and compatible with most pesticides

It is used as an organochlorine insecticide and **acaricide (killing tickes and mites).** It causes endocrine disruption and neurotoxic impacts. It is also supposed to be a genotoxic and may lead to genetic mutation, however, it has not been found to be a carcinogenic. Because of its threats to environment as a POP, it is banned in more than 63 countries but still is widely used.

Currently, a global ban on the use and manufacture of Endosulphan is being considered under the Stockholm Convention. India is the largest user of Endosulphan, and had sought a 10 year remission from ban. However, in 2011, the Supreme Court banned the use of Endosulphan due to some

peculiar health impacts seen after aerial spray of in **Cashew Plantations in Kerala**. The court ordered a complete ban on the manufacture, sale and use of Endosulphan after a PIL had brought to the court's notice the hazardous effects of the pesticide on human life as well as biodiversity in Kerala, Karnataka and other states.

Hazardous substances

The Hazardous material or Hazmats are the solids, liquids and gases which can harm people, organisms, property and environment. The Hazardous Materials are often subject to various legislations. The Hazmats may be radioactive, flammable, explosive, corrosive, oxidizing, asphyxiating, biohazardous, toxic, pathogenic, or allergenic.

International Programme on Chemical Safety

This programme was launched in 1980 by **three UN bodies viz**. WHO, ILO and UNEP. The idea was to establish the basis of safe use of the chemicals and strengthen the national capabilities for chemical safety. WHO publishes some awareness documents on toxicological properties of the chemical substances under this programme.

Rotterdam Convention on Hazardous Substances

The most important international convention in context with the Hazmats is "Rotterdam Convention" on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade". This is a non-legally binding convention that promotes *shared responsibilities* in relation to importation of hazardous chemicals. It promotes open exchange of information, proper labelling, include directions on safe handling, and inform purchasers of any known restrictions or bans.

Various Treaties on Marine Pollution

Spread of chemicals, particles, industrial, agricultural and residential waste, noise or the invasive organisms in the marine is the Marine Pollution. Toxins bioaccumulate in Zooplankton and phytoplankton and then get biomagnified in the ocean food chains. They cause Eutrophication, ocean acidification etc. leading to problems such as algal bloom, hypoxia and anoxia. There are four main types of inputs of pollution into the ocean:

- Direct discharge of waste into the oceans such as rivers
- Runoff into the waters due to rain
- Pollutants that are released from the atmosphere
- Ship Pollution which includes many ways including the oil spills.

London Convention on Marine Pollution

The London Convention or LC-72 is a non-binding treaty which seeks address the problem of deliberate disposal at sea of wastes or other matter from vessels, aircraft, and platforms. But it does

not cover discharges from land-based sources such as pipes and outfalls, wastes generated incidental to normal operation of vessels, or placement of materials for purposes other than mere disposal, providing such disposal is not contrary to aims of the Convention.

One regional type of convention is Barcelona Convention, which covers the same problems in the Mediterranean sea.

International Convention for the Regulation of Whaling

International Convention for the Regulation of Whaling is an international environmental agreement which governs the commercial, scientific, and aboriginal subsistence whaling practices of fifty-nine member nations. It was signed in 1946. By this convention, International Whaling Commission (IWC) was set up to "provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry".

This organization has been active against the commercial whaling. In 1986, it adopted a moratorium on commercial whaling . This ban still continues. In 1994, it created the *Southern Ocean Whale Sanctuary* surrounding the continent of Antarctica. Here, the IWC has banned all types of commercial whaling. Only two such sanctuaries have been designated by IWC till date. Another is Indian Ocean Whale Sanctuary by the tiny island nation of the Seychelles.

Wadden Sea Agreement

Wadden Sea is located between the coast of northwestern continental Europe and the range of Frisian Islands. It is a World Heritage site (Dutch and German part) which forms a shallow body of water with tidal flats and wetlands, thus very rich in biodiversity. Wadden Sea is famous for its rich flora and fauna, especially birds such as waders (shorebirds), ducks, and geese. Wadden Sea is protected in cooperation of all three national parks, and cooperation between three countries as follows:

- Schleswig-Holstein Wadden Sea National Park
- Hamburg Wadden Sea National Park
- Lower Saxony Wadden Sea National Park

The three countries viz. **Netherlands, Germany and Denmark** concluded the Wadden Sea Agreement for protection of the Wadden Sea in 1990.

ACCOBAMS

ACCOBAMS refers to "Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area". So, it is a cooperation for the protection of Cetaceans in the Black Sea and Mediterranean Sea. It was concluded on the sidelines of Convention on the Conservation of Migratory Species of Wild Animals, in 1996 and came into force in 2001. Currently 21 countries in the Black Sea, Mediterranean Sea and contiguous Atlantic area are parties

to this convention.

MARPOL 73/78

MARPOL refers to Marine Pollution. MARPOL 73/78 is the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. It entered into force on 2 October 1983 and it has 169 parties. It is one of the most important environment conventions on marine pollution and prevents the pollution from Oil Spill, Noxious Liquid Substances carried in Bulk, Harmful Substances carried in Packaged Form, Sewage , Garbage and Air Pollution.

It centers around minimizing the pollution of the seas, including dumping, oil and exhaust pollution. There are 150 countries party to this agreement.

India is a party to MARPOL 73/78. India's enshrined the obligation to inform contravention of provision of MARPOL 73/78 in the Sec 356 (H) of Merchant Shipping Act 1948.

Mercury Poisoning in Fishes

Fishes concentrate mercury in their bodies, often in the form of methyl mercury, a highly toxic organic compound of mercury. The mercury is absorbed, usually as methylmercury, by algae at the start of the food chain. It gets magnified to about 0.01 ppm in the herring, tuna etc. The same fishes when consumed by the human get more concentration of mercury. In Sharks, the mercury gets accumulated to the extent of 1 ppm.

Minimata Disease

The disease was searched in the seaside town of Minimata, in Japan in late 1950s when a strange behaviour in animals was seen. The abnormal behaviour was seen in the Cats, Birds and also in Humans. Investigations found that a petrochemical company had been discharging mercury waste into the sea. Around 5,000 people were killed and perhaps 50,000 have been to some extent poisoned by mercury. Thus, this disease got famous as Minimata disease.

Oil Spills

In Oil Spills, the oil is released into the ocean or coastal waters. The Oil may be crude oil from the tankers, offshore platforms, drilling rigs, Oil wells, ships or in any other form.

Impacts on Marine Life

- **Plumage:** The most important impact of the oil spills on the sea organisms is on the plumage of the birds. The seabirds, when their plumage gets penetrated by the soil, the insulating ability is reduced drastically and the birds became vulnerable to minor change in temperature. The oil penetration also makes them less buoyant in water.
- **Ingestion:** The ingestion of the oil by the seabirds and sea mammals causes Kidney Failure, dehydration and other metabolic disorders.
- **Furs:** The furs of the sea otters and other marine animals are affected in several ways.

- **Photosynthesis:** The oil floats on the top of the water and this reduces the penetration of sunlight in the sea water.

Recovery

The Recovery from the oil spill is difficult and depends upon many factors. The clearing and recovery depends upon the following factors:

- Type of the oil spilled
- Temperature of the water which may affect the evaporation and biodegradation.
- Type of shore line involved.

Largest Oil Spills

As per records, Kuwaiti oil fires of 1991 is the largest Oil spill of the world till date. It included 14-20 crore tons of crude oil. The top largest oil spills are as follows:

- Kuwaiti oil fires 1991
- Lakeview Gusher 1910-1911
- Gulf War oil spill 1991
- Deepwater Horizon 2010
- Ixtoc I , Mexico Oil Spill of 1979

Bioremediation of Oil Spills

Bioremediation uses the microorganisms or biological agents such as oil eating bacteria. There are three kinds of oil-consuming bacteria viz. Sulfate-reducing bacteria (SRB), Acid-producing bacteria are anaerobic and General aerobic bacteria (GAB). Out of them, Sulfate-reducing bacteria (SRB) and acid-producing bacteria are anaerobic, while general aerobic bacteria (GAB) are aerobic.

Oil Zapper

In 2010, a new technique of using the bacteria to get rid of oil spill became popular called Oil Zapper. Oil Zapping is a bio-remediation technique involving the use of 'oil zapping' bacteria.

United Nations Convention on the Law of the Sea (UNCLOS)

United Nations Convention on the Law of the Sea (UNCLOS) is also known as **Law of the Sea treaty**. The latest UNCLOS is UNCLOS III which covers all the vital issues regarding the maritime boundaries. This convention introduced a number of provisions and covered the most significant issues such as setting limits, navigation, archipelagic status and transit regimes, exclusive economic zones (EEZs), continental shelf jurisdiction, deep seabed mining, the exploitation regime, protection of the marine environment, scientific research, and settlement of disputes. This treaty defines the following terms:

Internal waters

Internal Waters refers to the all water and waterways on the landward side of the baseline of a country. In the internal waters a country is free to set laws, regulate its use and use of its resources.

There is *no interference of the foreign countries.*

Territorial waters

Territorial waters refer to *12 Nautical Miles from the baseline*. In this area the countries are free to set laws, regulate use and also use its resources. However, the foreign vessels are NOT given all rights to passage through except "Innocent Passage".

The innocent passage refers to the passing through the waters which is not prejudicial to peace and security. However, the nations have right to suspend the innocent passage. The submarine while passing through other country's territorial waters has to navigate on the surface and show their flags.

Archipelagic waters

If the country is an archipelago or has an archipelago under it, a baseline is drawn between the outermost points of the islands, provided that these islands are close to each other. All water inside this is called *Archipelagic Waters*. The state has full sovereignty over these waters very much similar to the internal waters and the foreign vessels are allowed for innocent passage through archipelagic waters.

Contiguous Zone

The contiguous zone refers to the area 12 Nautical Miles beyond the Territorial waters. This means that it is 24 Nautical Miles from the baseline limit. In this zone the country can enforce laws only in 4 areas viz. pollution, taxation, customs, and immigration.

Exclusive Economic Zones (EEZs)

Exclusive Economic Zones refers to the area from the edge of the territorial sea out to *200 nautical miles* from the baseline. In this area, the country has sole exploitation rights over all natural resources. The most important reason to introduce EEZ was to halt the clashes over the Fishing Rights and Oil Rights. In the EEZ, the foreign vessels have freedom of navigation and over flight, subject to the regulation of the coastal states. Foreign states are allowed to lay submarine pipes and cables.

UNCLOS and problem of Arctic

As per the current international law, no country owns the North Pole or the region of the Arctic Ocean surrounding it.

- There are five countries that surround the Arctic viz. Russia, United States (Via Alaska), Canada, Norway & Denmark (Via Green Land).
- However they are limited to an Exclusive Economic Zone (EEZ) which refers to an area of 200 Nautical Miles (370 kilometers) adjacent to their coasts.

The dispute in Arctic Seas is between these 5 countries viz. Russia, United States, Canada, Norway & Denmark. The UNCLOS had given every country a ten year period to make claims to an extended continental shelf which, if approved, gives it exclusive rights to resources on or below the seabed in

the vast circumpolar territories. In this context, on October 15, 2010, the Russian scientists have opened a floating polar research station in the Chuckchi Sea at the margin of the Arctic Ocean. The name of the station is Severny Polyus-38 and will be home to 15 researchers for a year. They will conduct polar studies and gather scientific evidence 'to reinforce Russia's claims to the Arctic'.

Thermal Pollution of Water

Thermal pollution is the degradation of water quality by any process that changes ambient water temperature. A common cause of thermal pollution is the use of water as a coolant by power plants and industrial manufacturers. When water used as a coolant is re turned to the natural environment at a higher temperature, the change in temperature decreases oxygen supply and affects ecosystem composition. Urban runoff-storm water discharged to surface waters from roads and parking lots-can also be a source of elevated water temperatures.

Ecological Impacts of Thermal Pollution of Water

Thermal pollution, the release of liquid or gas that increases heat in a surrounding area, has far-reaching and damaging ecological effects by impacting aquatic organisms and animal populations.

When a power plant first opens or shuts down for repair or other causes, fish and other organisms adapted to particular temperature range can be killed by the abrupt change in water temperature known as "thermal shock." This problem is particular for marine / cold blooded organisms because they are adapted to specific temperature ranges. *If water temperatures change too much, metabolic processes break down.* Unlike humans, who can adapt to wide temperature ranges, most organisms live in narrow temperature niches.

Eutrophication

Eutrophication derives from the Greek word eutrophos, meaning nourished or enriched. Eutrophication refers to the addition of artificial or non-artificial substances, such as nitrates and phosphates, through fertilizers or sewage, to a fresh water system. It can be anthropogenic or natural. It leads *increase in the primary productivity of the water body or "bloom" of phytoplankton*. The overgrowth causes the loss of oxygen in the water leading to severe reductions in fish and other animal populations.

- Please note that some animals such as **Nomurai Jellyfish** show an increase in population that negatively affects other species in the local ecosystem.

Important Notes on Eutrophication

- Eutrophication escalates rapidly when high nutrients from fertilizers, domestic and industrial wastes, urban drainage, detergents and animal, sediments enter water streams.
- Eutrophication is mainly divided into natural and cultural Eutrophication.
    - In natural Eutrophication, a lake is characterized by nutrient enrichment. During this

process an oligotrophic lake is converted into an eutrophic lake. It permits the production of phytoplankton, algal blooms and aquatic vegetation that in turn provide ample food for herbivorous zooplankton and fish.

- *When the process of Eutrophication is increased by the human activities, it is called cultural Eutrophication*. This is because the human activities (mainly development in nature) increase the surface run off and the nutrients such as Phosphates, Nitrates are supplied to the Ocean water. They may be supplied by Constriction works, treatment plants, golf courses, fertilizers, and farms. Human activities are responsible for addition of 80% nitrogen and 75% phosphorus to lake and streams.

- Eutrophication causes several physical, chemical and biological changes, which considerably deteriorate the water quality.
- It creates algal bloom, releases toxic chemicals that kill fish, birds and other aquatic animals.
- Decomposition of algal bloom leads to the depletion of oxygen in water. Thus with a high CO_2 level and poor oxygen through reduction of nitrates.
- On complete exhaustion of nitrate, oxygen may as last resort be obtained by reduction of sulphate yielding hydrogen sulphide causing foul smell and putrefied taste of water. Many pathogenic microbes, viruses, protozoa and bacteria and grow on sewage products under anaerobic conditions. It results into the spread of fatal water-borne disease such as polio, dysentery, diarrhoea, typhoid and viral hepatitis.

Control of Eutrophication

- Several prevention and technical devices have been used to control Eutrophication. The wastewater must be treated before its discharge into water streams.
- Recycling of nutrients can be checked through harvest. Removing nitrogen and phosphorous at the source, division of nutrient-rich waters from the receiving bodies and dilution of these elements can minimize Eutrophication.
- Algal blood should be removed upon their death and decomposition. Limiting the dissolve nutrients can control algal growth. The most suitable, feasible and effective method involves the use of chemicals to precipitate additional phosphorus.
- Precipitants like alum, lime, iron and sodium aluminate may be used. Physicochemical methods can be adopted to remove nutrients. for example phosphorous can be removed by precipitation and nitrogen by nitrification or denitrification.
- Electrodialysis, reverse osmosis and ion exchange methods. Cooper-sulphate and sodium arsenite are employed for killing algae and rooted planet respectively.