IMS Engineering College

NH-09, Adhyatmik Nagar, Near Dasna, Distt. Ghaziabad, U.P.

Tel: (0120) 4940000

Department of Applied Sciences and Humanities

ENVIRONMENT AND ECOLOGY:BAS104 / BAS204

Unit-3

[Pollution and their Effects; Public Health Aspects of Environmental; Water Pollution, Air Pollution, Soil Pollution, Noise Pollution, Solid waste management.]

Pollution introduces us to the world of hazardous products. These hazardous materials are called Pollutants. Pollutants, such as volcanic ash, may be normal. Human activity such as garbage or runoff created by factories may also generate them. The quality of air, water and land are impaired by contaminants.

Environmental Pollution

Environmental pollution occurs when in due course of time, the environment is unable to absorb and neutralize toxic byproducts of human activities (poisonous gas emissions).

Types of Environmental Pollution

There are different kinds of environmental pollution. The most important environmental pollution is described below:

Air Pollution

Air pollution is a blend of airborne solid particles and gases. Car pollutants, factory chemicals, dust, pollen and mold spores may be suspended in the form of particles. In cities, ozone, a gas, is a big part of air pollution. It's also called smog as ozone creates air pollution. Sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, volatile organic compounds and airborne particles are some of the most notable air pollutants. Radioactive emissions are among the most harmful air pollutants, specifically when produced by nuclear explosions.

Effects of Air Pollution

Breathing in harmful gases is bad for our health. Every year, more than a billion tons of these pollutants are released into the air because of human activities. These pollutants can lead to health problems like bronchitis, chest congestion, and wheezing. To minimize these effects, it's essential to reduce exposure to these pollutants.

Let's talk about specific gases. **Sulphur dioxide** is a major cause of lung diseases, causing irritation in the nose and mucus lining, shortness of breath, fluid accumulation in tissues, and bronchospasm. **Nitrogen oxides**, released from vehicles like buses and trucks, irritate eyes and lungs and can even lead to serious issues like gum inflammation, internal bleeding, pneumonia, and cancer. **Carbon**

monoxide, a highly toxic gas, hinders the blood's ability to carry oxygen, posing risks like heart disease, respiratory problems, and skin irritation.

High levels of air pollution can result in various health issues, including heart attacks, asthma, and respiratory complications. Animals are also affected, experiencing health problems like birth defects and reproductive failure. Air pollution doesn't just harm living things; it also has environmental consequences. Acid rain, formed by burning fossil fuels, kills trees and affects water bodies, making it tough for marine life. Nitrogen oxides contribute to toxic algae blooms, and man-made chemicals like hydrochlorofluorocarbons deplete the ozone layer, affecting our planet's health.

Effects of Radioactive Pollution

Radiation can affect your health in different ways, and the impact depends on factors like the type, amount, and energy of the radiation, as well as the age of the person and the body part exposed. Ionizing radiation, in particular, can lead to various biological effects in humans.

One significant effect is an increased risk of cancer which is known as **Carcinogenic effects**. Here Ionizing radiation raises the likelihood of developing different types of cancer.

Another impact is on the genetic material, causing changes that can be passed on to offspring. This is known as **Mutagenic effects**.

In addition, radiation can affect the development of embryos, leading to birth defects. It's important to note that cells undergoing rapid division, like those in a fetus, are more sensitive to radiation. This sensitivity is also higher in children. This is known as **Teratogenic effects**.

While studies on radiation have mostly been conducted on animals, the findings provide some insights into the potential damage caused. However, it's crucial to recognize that these results cannot be directly applied to humans.

Effects: Respiratory diseases like asthma, lung cancer, and cardiovascular issues. It can also lead to smog, acid rain, and depletion of the ozone layer, resulting in climate change and global warming.

Water Pollution

Water pollution includes insecticides and herbicides, waste from food production, animal wastes, organic volatile compounds, heavy metals, chemical waste, etc. Water contamination happens when a stream, river, lake, ocean, aquifer, etc. is polluted by harmful substances, often chemicals or microorganisms, degrading the quality of water and making it poisonous to humans or the ecosystem.

Effects of Water Pollution

The consequences of water pollution depend on where contaminants are dumped. Water pollution is a significant danger to humans, animals and marine life. Water sources near urbanized areas tend to be highly contaminated by the legal and illegal dumping of waste and chemicals by industrial facilities, health centres and individuals.

The death of marine animals, which can destroy the whole food chain, is by far the greatest consequence of water contamination. In drinking water supplies, fertilizer contamination can cause toxic algae blooms that destroy fish and other aquatic animals. Direct exposure to these poisonous algae causes significant human health issues, including neurological symptoms, breathing problems and stomach and liver diseases.

When disinfectants used to treat drinking water enter water contaminated with toxic algae and respond to the production of dioxins, a consequential problem is developed.

Effects: Contaminated water sources can lead to various health problems such as gastrointestinal illnesses, reproductive problems, and neurological disorders. It also harms aquatic life, disrupts ecosystems, and affects drinking water supplies.

Land and Soil Pollution

Fossil fuels (oil, gas, coal) have transcended virtually all conceivable barriers in modern industrialized societies and established themselves in our daily lives. We use fossil fuels for our obvious daily needs (such as fueling a vehicle). These are also used in the power generation industry (specifical oil) in goods such as all kinds of plastics, solvents, detergents, asphalt, lubricating oils and a wide range of industrial chemicals.

Effects of Land and Soil Pollution

For humans, plants, microorganisms and marine life, land and soil contamination have significant implications. Different skin problems, respiratory problems and even various types of cancers may result from polluted land and soil.

These poisonous substances come into direct contact with the human body by eating fruits and vegetables grown in polluted soils, direct contact with the skin and breathing in air polluted by particles and dust.

When it comes to land loss and soil erosion, deforestation is the greatest problem. Cutting of trees and tree cover produces harsh conditions that destroy forests and ecosystems. In atmospheric situations, deforestation often produces an imbalance, decreasing the amount of pollution is naturally taken out of the atmosphere. This is a significant problem given that the majority of people's emissions are focused on biomass.

Effects: Reduced soil fertility, contamination of crops, and food chain disruption. Soil pollution can also lead to health problems if contaminated food is consumed by humans or animals.

Noise Pollution:

Effects: Hearing loss, stress, sleep disturbances, and interference with communication. Prolonged exposure to high levels of noise pollution can also lead to cardiovascular issues and other health problems.

Light Pollution:

Effects: Disruption of ecosystems and wildlife behavior, interference with astronomical observations, and adverse impacts on human health, including sleep disturbances and disruptions to circadian rhythms.

Thermal Pollution:

Effects: Disruption of aquatic ecosystems by raising water temperatures, which can reduce oxygen levels and harm aquatic life. Thermal pollution also affects the climate by altering weather patterns and exacerbating global warming.

Public Health Aspects

Environmental pollution has significant public health implications across various dimensions:

Respiratory Health: Air pollution, including particulate matter (PM), nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), and carbon monoxide (CO), is linked to respiratory diseases such as asthma, chronic obstructive pulmonary disease (COPD), and lung cancer. Poor air quality exacerbates respiratory symptoms and increases the risk of respiratory infections.

Cardiovascular Health: Air pollution is associated with an increased risk of cardiovascular diseases such as heart attacks, strokes, hypertension, and arrhythmias. Fine particulate matter and pollutants like nitrogen oxides can enter the bloodstream and cause inflammation, oxidative stress, and endothelial dysfunction, contributing to cardiovascular problems.

Neurological Health: Exposure to environmental pollutants such as lead, mercury, and polychlorinated biphenyls (PCBs) can impair neurological development in children and adults. These pollutants are neurotoxic and may lead to cognitive deficits, behavioral disorders, learning disabilities, and developmental delays.

Cancer: Several environmental pollutants, including air pollutants, water contaminants, and carcinogenic chemicals, are linked to an increased risk of cancer. Long-term exposure to pollutants such as benzene, formaldehyde, arsenic, and asbestos can lead to various types of cancer, including lung cancer, bladder cancer, and leukemia.

Reproductive Health: Environmental pollution can affect reproductive health by disrupting hormone regulation, impairing fertility, and increasing the risk of pregnancy complications. Exposure to pollutants like endocrine-disrupting chemicals (EDCs), pesticides, and heavy metals can lead to infertility, miscarriages, birth defects, and developmental abnormalities in offspring.

Child Health: Children are particularly vulnerable to the health effects of environmental pollution due to their developing organ systems, higher respiratory rates, and increased exposure to pollutants in indoor and outdoor environments. Pollution-related health problems in children include respiratory infections, asthma exacerbations, lead poisoning, neurodevelopmental disorders, and impaired growth and development.

Mental Health: Environmental pollution can have indirect effects on mental health by contributing to stress, anxiety, depression, and psychological distress. Poor air quality, noise pollution, and degraded natural environments can negatively impact overall well-being and quality of life, particularly in urban areas with high levels of pollution.

Infectious Diseases: Environmental pollution can facilitate the transmission of infectious diseases by compromising immune function, damaging respiratory epithelium, and altering microbial communities. Poor sanitation, contaminated water sources, and pollution-related factors contribute to the spread of waterborne and vector-borne diseases such as diarrhea, cholera, malaria, and dengue fever.

Addressing public health aspects of environmental pollution requires multidisciplinary approaches that integrate environmental management, public health policies, urban planning, health education, and community engagement. Strategies to reduce pollution and protect public health include promoting clean energy sources, improving air and water quality standards, enhancing waste management practices, implementing pollution control technologies, and fostering sustainable development initiatives.

Water Pollution

About three fourths of our planet earth's surface is covered by water. However, very little of it is available for consumption. Most (about 97%) of the water on earth is present in the seas and oceans. It is too salty to be of any use for drinking, agriculture and industrial purposes. The remaining 3% is fresh water; 75% of which is locked up in the polar ice caps and in glaciers and quite deep under the earth's surface as underground water. The fresh water, which we can use, comes to us from two sources:

i) Surface water

ii) Ground water

(i) Surface Water: Rain and snow are good natural resources of fresh water. It is estimated that of all the precipitation (rain water and snow) that falls on the earth, about one-third is absorbed by the plants and another one-third seeps down into the soil and the remaining one third runs off the surface into streams and rivers. This part of precipitation, which runs off to form streams, rivers and lakes, is called the **surface** water.

Precipitation (rain or snow) that runs-off into stream, rivers and lakes is called surface water.

The small fraction of usable surface water is continuously replenished by means of the hydrological cycle. The hydrological cycle involves evaporation of water from oceans, rivers and other sources to form clouds. The clouds on saturation with water vapours cause precipitation falling back on earth's surface. On surface, the water runs off to rivers and finally to oceans. The water again evaporates and the cycle continues.

Surface water has a natural tendency to clean itself as it contains certain organisms that break down pollutants into harmless substances.

Ground Water: The part of precipitation that seeps into the ground as a result of gravity and fills the pores between soil particles and rocks under it is called **ground water**. The water bearing layers of soil and rocks are called **aquifers**. Ground water is very important for agricultural and industrial purposes. Ground water in the form of wells and springs is often the only source of water supply especially in villages and small towns.

<u>Water Pollution – Parameters</u>

A large amount of water is discharged back after domestic and industrial usage. This is contaminated with domestic waste and industrial effluents. When this contamination reaches beyond certain allowed concentrations, it is called **pollution** and the contaminants are called the **pollutants**.

Water pollution may be defined as the contamination of streams, lakes, seas, underground water or oceans by substances, which are harmful for living beings. Industrialisation and population explosion are two important factors for water pollution.

Water may be called polluted when the following parameters stated below reach beyond a specified concentration in water.

(i) Physical parameters. Colour, odour, turbidity, taste, temperature and electrical conductivity constitute the physical parameters and are good indicators of contamination. For instance, colour and turbidity are visible evidences of polluted water while an offensive odour or a bitter and difference than normal taste also makes water unfit for drinking.

(ii) **Chemical parameters**: These include the amount of carbonates, sulphates, chlorides, fluorides, nitrates, and metal ions. These chemicals form the total dissolved solids, present in water.

(iii) **Biological parameters**: The biological parameters include matter like algae, fungi, viruses, protozoa and bacteria. The life forms present in water are affected to a good extent by the presence of pollutants. The pollutants in water may cause a reduction in the population of both lower and higher plant and animal lives. Thus, the biological parameters give an indirect indication of the amount of pollution in water.

Water Pollution – Sources

Water pollutants refer to the substances which are capable of making any physical, chemical or biological change in the water body. These have undesirable effect on living organisms. As mentioned earlier, the water used for domestic, agricultural and industrial purposes is discharged with some undesirable impurities in it. This contamination leads to the pollution of water, which is generally called the **fresh water pollution**.

Fresh water pollution may be classified into two types: **surface water pollution** and **ground water pollution**.

a) Surface Water Pollution

When pollutants enter a stream, river or lake these gives rise to surface water pollution. The surface water pollution has a number of sources. These can categorised as:

- Point and Non-point Sources
- Natural and Anthropogenic Sources

(i) Point and Non-point Sources

The well-defined sources that emit pollutants or effluents directly into different water bodies of fresh water are called **point sources** e.g., domestic and industrial waste. The point sources of pollution can be effectively checked. On the other hand, the **non-point sources** of water pollution are scattered or spread over large areas. This type of source delivers pollutants indirectly through environmental changes and account for majority of the contaminants in streams and lakes. For example, the contaminated water that runs off from agriculture farms, construction sites, abandoned mines, enters streams and lakes. It is quite difficult to control non-point sources.

(ii) Natural and Anthropogenic Sources

An increase in the concentration of naturally occurring substances is also termed pollution. The sources of such an increase are called **natural sources**. S**iltation** (which includes soil, sand and mineral particles) is one such natural source. It is a common natural phenomenon, which occurs in most water bodies. Indiscriminate deforestation makes soil loose and flood waters bring silt from mountains into streams, rivers and lakes.

On the other hand, the human activities that result into the pollution of water are called **anthropogenic** or man made sources of water pollution**.** For example, domestic (sewage and waste water), industrial and agricultural wastes that goes into the rivers, lakes, streams and seas are anthropogenic sources. Certain materials that are leached from the land by run-off water and enter the various water bodies also belong to this category.

b) Ground Water Pollution

When the polluted water seeps into the ground and enters an aquifer it results into **ground water**

pollution. The most of our villages and many townships, ground water is the only source of drinking water. Therefore, pollution of groundwater is a matter of serious concern. Groundwater gets polluted in a number of ways. The dumping of raw sewage on soil, seepage pits and septic tanks cause pollution of groundwater. The porous layersof soil hold back solid particles while the liquid is allowed to pass through. The soluble pollutants are able to mix with the groundwater. In addition to these, the excessive use of nitrogenous fertilizers and unchecked release of toxic wastes and even carcionogenic substances by industrial units many result in slow trickling down through the earth's surface and mixing with the groundwater. This problem is very serious especially in areaswhere water table is high (i.e., where water is available near surface of earth).

The ground water can move over large distances by virtue of the large empty space available below the earth's surface. This way if some impurities seep into the ground water at one point, they may be observed at a different point far removed from the pointof source. In such a case it is difficult to estimate the source of water pollution. However, suspended impurities and bacterial contaminants are removed in the process of seepage by the soil acting as an absorbent and filter, and water acting as a solvent.

Since the movement of groundwater through the porous rock is very slow, pollutants which get mixed with the groundwater are not readily diluted. Furthermore, groundwaterdoes not have access to air (in contrast to surface water) therefore, oxidation of pollutants into harmless products in groundwater does not occur.

Water Pollutants

Water pollutants can be broadly put under the following types.

(i) Sewage Pollutants (Domestic and Municipal Waste)

(ii) Industrial Pollutants

(iii) Agricultural Pollutants

(iv) Radioactive and Thermal Pollutants

(i) Domestic and Municipal Pollutants: The sewage contains garbage, soaps, detergents, waste food and human excreta and is the single largest sources of water pollution. Pathogenic (disease causing) microogranisms (bacteria, fungi, protozoa, algae) enter the water system through sewage making it infected. Typhoid, chloera, gastroenteritis and dysentery are commonly caused by drinking infected water.

Other ingedients which enter the various water bodies are the plant nutrients, i.e., nitrates and phosphates. They support growth of algae, commonly called **algal bloom** (blue-green species). This process is called **eutrophication**.

(ii) Industrial Pollutants: Many industries are located near rivers or fresh water streams. These are responsible for discharging their untreated effluents into rivers like highly toxic heavy metals such as chromium, arsenic, lead, mercury, etc. alongwith hazardous organic and inorganic wastes (e.g., acids, alkalies, cyanides, chlorides, etc.). River Ganges receives wastes from textile, sugar, paper and pulp mills, tanneries, rubber and pesticide industries. Most of these pollutants are resistant to breakdown by microorganisms (called non-biodegradable), therefore damage the growth of cropsand the polluted water is unsafe for drinking purposes.

Factories manufacturing plastic, caustic soda and some fungicides and pesticides release mercury (a heavy metal) along with other effluents in nearby water body. Mercury enters the food chain through bacteria, algae, fish and finally into the human body. The toxicity of mercury became

evident by the Minamata Bay tragedy in Japan during the period 1953-60. Fish died due to mercury consumption and thosewho ate fish were affected by mercury poisoning and quite a few died. The milder symptoms of mercury poisoning are depression and irritability but acute toxic effects can cause paralysis, blindness, insanity, birth defects and even death. The high concentration of mercury in water and in fish tissues results from formation of soluble monomethylmercury ion, (CH_3Hg^+) and volatile dimethylmercury [$(CH_3)_2Hg$] by anaerobic bacteria in sediments.

(iii) Agricultural Waste: Manure, fertilizers, pesticides, wastes from farms, slaughterhouse, poultry farms, salts and silt are drained as run-off from agricultural lands. The water body receiving large quantities of fertilizers (phosphates and nitratesor manures becomes rich in nutrients which leads to eutrophication and consequent depletion of dissolved oxygen. Consumption of water rich in nitrates is bad for humanhealth especially for small children.

Pesticides (DDT, dieldrin, aldrin, malathion, carbaryl etc.) are used to kill insect and rodent pests. Toxic pesticide residues enter the human body through drinking water or through food chain (**biomagnification**). These compounds have low solubility inwater but are highly soluble in fats. For example, the concentration of DDT in river water may be very low but some fish over a period of time accumulate so much ofDDT that they become unfit for human consumption. The use of pesticides in our country is increasing very rapidly.

Some of these chemicals which are highly toxic become metabolised by animals that graze on fields. Therefore, these poisonous chemicals have been often observed inthe human food chain. The presence of these chemicals in humans even in minute amounts can cause hormonal imbalance and may lead to cancer.

(iv) Physical Pollutants: Physical pollutants can be of different types. Some of them are discussed below :

(a) Radioactive Wastes: Radionucleides found in water are radium and potassium-40. These isotopes originate from natural sources due to leaching from minerals. Waterbodies are also polluted by accidental leakage of waste material from uranium and thorium mines, nuclear power plants and industries, research laboratories and hospitals which use radioisotopes. Radioactive materials enter human body through water and food, and may be accumulated in blood and certain vital organs. They cause tumours and cancer.

(b) Thermal Pollutants/Sources: Various industries, nuclear power plants and thermal plants require water for cooling and the resultant hot water is often discharged into rivers or lakes. This results in thermal pollution that leads to the imbalance in the ecology of the water body. Higher temperature lowers the dissolved oxygen level (which is very essential for marine life) by decreasing the solubility of oxygen in water. Fish and other aquatic organism can get affected by a sudden change in water temperatures.

(c) Sediments: Soil particles carried to streams, lakes or oceans form the sediments. The sediment become polluting due to their large amount. Soil erosion defined as the soil carried by flood water from crop land, is responsible for sedimentation. The sediments may damage the water body by introducing a large amount of nutrient matter.

(v) Petroleum Products: Petroleum products are widely used for fuel, lubrication, plastics manufacturing, etc. and happen to be poisonous in nature. Crude oil and other related products generally get into water by accidental spillage from ships, tankers, pipelines etc. Besides these accidental spills, oil refineries, oil exploration sites and automobile service centres pollute different water bodies. Oil slick whichfloats on the water surface causes death of marine life and

severely affects the ecosystem of the ocean.

A list of various types of water pollutants, their sources and effects have been summarised in Table below:

Table: Types of water pollutants, their sources and effects

	Pollutant	Sources of Pollutants	Effects and Significance
1	Pathogens	Sewage, human and animal wastes, natural and urban runoff from land, industrial waste	Depletion of dissolved oxygen in water (foul odour) health effects (outbreaks of water borne diseases)
2	Organic pollutants • Oil and grease • Pesticides and weedicides • Plastics • Detergents	Automobile and machine waste, tanker spills, offshore oil leakage Chemicals used for better yield from agriculture Industrial and household waste Industrial and household waste	Disruption of marine life, aesthetic damage Toxic effects (harmful for aquatic life), possible genetic defects and cancer; kills fish Eutrophication, aesthetics
3	Inorganic pollutants Fertilizers (phosphates and nitrates)	Agricultural runoff	Algal bloom and eutrophication, nitrates cause methemoglobenemia
	Acids and alkalies	Mine drainage, industrial wastes, natural and urban runoff	Kill fresh water organisms, unfit for drinking, irrigation and industrial use.
4	Radioactive materials	Natural sources, uranium mining and processing, hospitals and research laboratories using radioisotopes	Cancer and genetic defects
5	Heat	Cooling water for industrial, nuclear and thermal plants	Decreases solubility of oxygen in water, disrupts aquatic ecosystems
6	Sediments	Natural erosion, runoff from agricultural land and construction sites	Affects water quality, reduces fish population

Water Pollution Treatment

Waste water generated by household activity, industries or garbage landfills is called **sewage** which is classified as the municipal water pollution. Sewage contains solid matters in the form of suspended colloidal and dissolved organic matter, detergent, mineral matter, nutrients and gases. Sewage is one of the major causes of water borne diseases and therefore the treatment of sewage is one of the important tasks. For a long time treatment of municipal waste in the form of sewage involved mainly of the removal of suspended solids, oxygen demanding materials and harmful bacteria. Now the disposal of the solid residue from sewage has been improved by applying municipal treatment processes.

The treatment of this waste water is carried out in the following three stages:

(i) Primary treatment

(ii) Secondary treatment, and

(iii) Tertiary treatment

Primary Treatment: When the waste water is to be dumped off into a river or flowing steam, the treatment is carried out by sedimentation, coagulation and filtration. This is known as primary treatment. If the water is required for drinking purposes, it has to undergo further treatment called secondary and tertiary treatments. The following steps are performed to do primary treatment of water:

(i) Sedimentation: This step is carried out in large tanks specially built for this purpose in sewage treatment plant. The polluted water is allowed to settle so that silt, clay and other matter settle to be bottom and water is slowly allowed to move out. Fine particles do not settle and are thus required to be removed in the next step.

(ii) Coagulation: Fine particles and colloidal suspension are combined into large particles by a process called coagulation. This step is carried out by the addition of special chemicals called coagulants (flocculants) such as potash alum. The large particles either settle to the bottom or are moved in the next step.

(iii) Filtration: Suspended particles, flocculants, bacteria and other organisms are filtered by passing the water through a bed of sand or finely divided coal or through some fibrous materials. The total impurities collected in these steps are called **sludge**. It is used as a valuable fertilizer. On composting (i.e. the action of anaerobic bacteria), it releases sludge gas. It consists mainly of methane gas which is used for cooking purposes.

Secondary or Biological Treatment: The water after primary treatment is not fit for drinking purposes and has to undergo further treatment. This is done through secondary or biological treatment. A commonly used method is to allow polluted water to spread over a large bed of stones and gravel so that the growth of different microorganisms needing nutrients and oxygen is encouraged. Over a period of time a fast moving food chain is set up. For example, bacteria consume organic matter from the polluted water; protozoa live on bacteria. Every form of life including algae and fungi help in the cleaning up process.

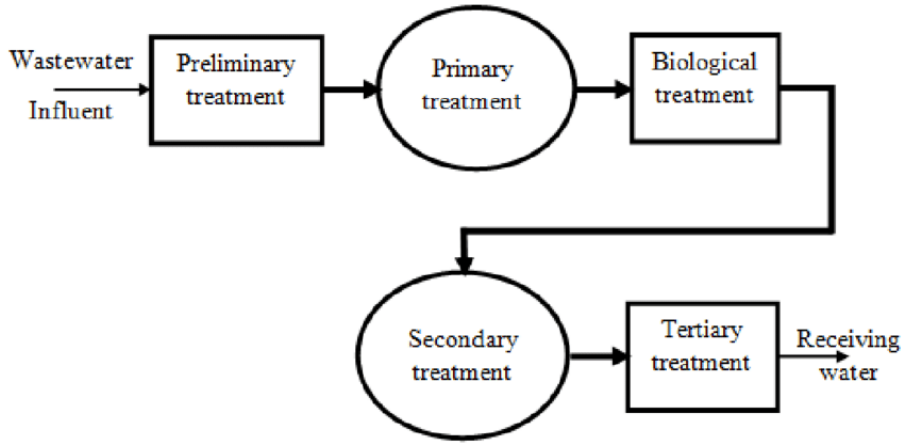
This is called secondary treatment of water. It involves the following processes

(i) Softening : By this treatment undesirable cations of calcium and magnesium are removed from hard waters. Either water is treated with lime and soda ash to precipitate Ca^{2+} ions as carbonates or it is passed through cation exchangers. This makes water soft.

(ii) Aeration: In this process, soft water is exposed to air by forcing air through it to add oxygen to water. This encourages bacterial decomposition of organic matter into harmless products such as carbon dioxide and water. The addition of oxygen reduces carbon dioxide. sulphide etc.. The water is as yet not fit for drinking purposes. The pathogenic and other microorganisms need to be killed. This is done in the next treatment.

Tertiary Treatment : The tertiary treatment is actually disinfecting water. Chlorine is the most commonly used disinfectant used for killing bacteria. However, chlorine also reacts with traces of organic matter present in water and forms undesirable chlorinated hydrocarbons (toxic and potentially carcinogenic). It is therefore desirable to reduce the organic matter in water before passing chlorine gas. Other methods of disinfection such as ultraviolet radiation, ozone gas treatment or reverse osmosis are preferred over chlorine treatment. But these methods are more

expensive.



In a treatment plant, the waste is passed through a series of screens, chambers and chemical processes to reduce its bulk and toxicity. During primary treatment a large percentage of suspended solids and inorganic material is removed from sewage. The secondary stage reduces organic material by accelerating natural biological processes. Tertiary treatment is done when water is to be reused. Here 99% of solids are removedand various chemical processes are used to ensure that water is free from infecting materials.

Water Pollution Control Measures

- **Avoiding the usage of Chemical Fertilizers**
  Chemical fertilizers and pesticides must be banned and instead organic or eco-friendly fertilizers should be used. The better option is to switch to organic farming methods and use animal-based manure. These will keep the harmful chemicals away from water bodies.
- **Utilization of Less Water**
  We must save water as much as possible as only about 1% of the earth's total water is available for the use of most aquatic and terrestrial organisms. It can be easily achieved by installing water-saving equipment like sinks, toilets, and showers. In our daily lives, we can help save water by taking short baths, and not keeping the tap running during brushing, shaving, etc.
- **Keeping water checks for Lead Contamination**
  When water pipelines made of lead or containing lead bring water into homes can cause lead poisoning resulting in severe health problems. So, it is required to do regular checks to determine if any lead is present in the water, and if found then either the pipeline can be changed or a lead filter should be installed.
- **Avoid Polluting Open-Air Water Sources**
  Littering of water bodies and their surroundings, oil spills, chemical disposal, dumping in drains, dumping of fertilizers, pesticides, etc. that occurs due to open-air pollution causes harm to both humans and other organisms directly and indirectly connected to contaminated water bodies. So, it is required to stop littering and dumping wastes near the water sources or around them to avoid seeping the wastes into the water sources.
- **Use Environmentally Friendly Products**
  Water contamination can be reduced by using more and more organic, natural, and environmentally friendly products domestically as well as commercially. The fundamentals of reduction, reuse, and recycling will also go a long way to overcoming the impacts of water pollution.

Air Pollution

Air pollution refers to the introduction into the atmosphere of substances that have harmful effects on humans, other living organisms, and the environment. These substances can occur as solid particles, liquid droplets or gases. Air pollution can result from natural processes such as dust storms, forest fires, and volcanic eruptions, or from human activities such as biomass burning, vehicular emissions, mining, agriculture, and industrial processes

Causes of Air Pollution:

To prevent the pollution of air around, you have to understand the causes of air pollution at first. The main causes are –

- **Burning of Fossil Fuels:**

  Fossil fuel emits harmful gases such as sulfur dioxide and carbon monoxide into the air. One of the biggest causes of air pollution is sulfur dioxide, which is emitted through the combustion of fossil fuels such as coal, petroleum for energy in power plants, and other industry combustibles.

- **Automobiles:**

  The emission of harmful gases is caused by the excessive use of automobiles.

- **Agricultural Activities:**

  Various processes take place during agricultural activities such as the emission of ammonia, overuse of insecticides, pesticides, and fertilizers. Ammonia is a typical byproduct of agriculture and one of the most dangerous gases in the atmosphere. Insecticides, pesticides, and fertilizers have all become increasingly common in agricultural practices. They release hazardous chemicals into the atmosphere and can pollute water.

  Farmers also set fire to the fields and old crops to clear them up for the new cycle of sowing. According to reports, burning to clean up fields pollutes the air by emitting toxic pollutants.

- **Factories and Industries:**

  Emission of harmful gases and chemicals into the air by the increasing industrial activities. Manufacturing companies emit a significant amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air, lowering air quality.

  Manufacturing industries may be found in every corner of the globe, and no region has escaped their influence. Petroleum refineries also emit hydrocarbons and a variety of other pollutants, which damage the air and soil.

- **Mining Activities:**

  Increasing emission of harmful substances through mining activities. Mining is the extraction of minerals from under the earth's surface utilizing heavy machinery. Dust and chemicals are released into the air throughout the process, resulting in significant air pollution.

  This is one of the factors contributing to the deteriorating health of workers and inhabitants in the area.

- **Domestic Resources:**

  Effects of domestic sources such as the use of chemical paints and overuse of air conditioners. Household cleaning products and painting supplies release hazardous chemicals into the air,

polluting the environment. Have you ever observed that when you paint your house's walls, it emits a noxious odor that makes it nearly impossible to breathe?

Another source of pollution is suspended particle matter, sometimes known as SPM. SPM refers to the particles that float in the air and is typically caused by dust, combustion, and other factors.

Classification of Sources of Air Pollution

Mobile sources/transportation : include motor vehicle, rail, ship, aircraft

Stationary sources: include utility, industrial, institutional and commercial facilities. Examples are power plant, heating plant, paper-pulp industry, petroleum refineries, municipal waste combusters

Area sources: include many individually small activities, e.g. gasoline service stations, small paint shops, open burning associated with solid waste, agriculture and forest management, cooking in slum areas.

Classification of Pollutants

•According to Origin:

1) Primary Pollutants: Emitted directly into the atmosphere and are found in form in which they were emitted, e.g. Sox , NOx , HC •

2) Secondary Pollutants: Derived from the primary pollutants by chemical or photo-chemical reactions in the atmosphere, e.g. ozone, peroxyacetyl nitrate

•According to Chemical Composition:

1) Organic: e.g. Hydrocarbons (HC), Aldehydes and ketones (HCO), VOCs, PCBs, PAHs

2) Inorganic: NOx , SOx , CO, HCl, H2SO4 , H2S, NH3

•According to State of Matter

1) Gaseous: CO, NOx , Sox (Inorganic), Benzene, Methane (Organic)

2) Particulates/Aerosols: Dust, smoke, fume, fly ash (solid), mist, spray (liquid), pollen, bacteria, virus (natural)

Criteria pollutants

Under the US Clean Air Act, the Environmental Protection Agency (EPA) establishes air quality standards to protect public health and the environment. The EPA has set national air quality standards for six common air pollutants: carbon monoxide, ground-level ozone, nitrogen dioxide, sulfur dioxide, lead, and particulate matter (also known as particle pollution). The EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. The set of limits based on human health is called **primary standards**. Another set of limits intended to prevent environmental and property damage is called **secondary standards**. Of the six pollutants, particle pollution and ground-level ozone are the most widespread health threats.

Health and environmental effects of criteria pollutants		
Pollutant	**Health Effects**	**Environmental Effects**
Carbon Monoxide	Breathing elevated levels of CO reduces the amount of oxygen reaching the body's organs	Contributes to the formation of CO_2 and ozone, greenhouse gases

(CO)	and tissues. For those with heart disease, this can result in chest pain and other symptoms leading to hospital admissions and emergency room (ER) visits. At very high levels, CO can cause dizziness, confusion, unconsciousness, and death.	that warm the atmosphere.
Ground-level Ozone (O_3)	Reduces lung function and causes respiratory symptoms, such as coughing and shortness of breath. Aggravates asthma and other lung diseases leading to increased medication use, hospital admissions, and ER visits. May also increase premature mortality from respiratory causes.	Damages vegetation by injuring leaves, reducing photosynthesis, impairing reproduction and growth and decreasing crop yields. Damage may alter ecosystem structure, reduce biodiversity, and decrease plant uptake of CO_2. Is a greenhouse gas and main ingredient of smog.
Oxides of Nitrogen (NO_x)	Aggravates respiratory diseases, particularly asthma, leading to respiratory symptoms, hospital admissions, and ER visits. Long-term exposure may contribute to asthma development and increased susceptibility to respiratory infection.	React with VOCs to form ozone. React with ammonia and other compounds to form particle pollution. Contributes to acidification and nutrient enrichment of soils and surface waters.
Sulfur Dioxide (SO_2)	Aggravates asthma and increases respiratory symptoms. Contributes to particle formation with associated health risks.	Reacts with ammonia and other compounds to form particle pollution. Contributes to acidification of soils and surface waters. Can also cause injury to vegetation and species loss in aquatic and terrestrial systems.
Lead	Damages the developing nervous system of children, resulting in lower IQs, learning deficits and behavioral problems. Contributes to cardiovascular effects such as high blood pressure and heart disease in adults.	Decreases growth and reproductive rates in plants and animals.
Particulate Matter (PM)	Causes harmful effects on the cardiovascular system, including heart attacks and strokes. Linked to harmful respiratory effects, including asthma attacks.	Causes reduced visibility (haze) in parts of US, including parks and wilderness areas. May make lakes and streams acidic, change nutrient balance in coastal waters and large river basins, damage sensitive forests and farm crops, and affect diversity of ecosystems. Stains and damages stone and other materials.

Effects of Air Pollution:

The air pollution information shows that increasing air pollution can have an adverse effect on plants, animals, and humans.

- **Global warming**

  Air Pollution can increase the amount of global warming as the temperature of the earth will keep rising with the emission of harmful gases. With rising global temperatures, rising sea levels, melting ice from colder places and icebergs, relocation, and habitat loss, an imminent crisis has already been signaled if preservation and normalization measures are not done soon.

- **Acid rain**

  When water droplets combine with harmful chemicals and pollutants, it will lead to acid rain. When fossil fuels are burned, harmful chemicals such as nitrogen oxides and sulfur oxides are emitted into the environment. When it rains, the water droplets interact with the contaminants in the air, becoming acidic and falling to the earth as acid rain. Acid rain has the potential to harm humans, animals, and agriculture.

- **Ozone layer Depletion**

  All this will eventually lead to depletion of the ozone layer that protects us from harmful UV sun rays. The presence of chlorofluorocarbons and hydrochlorofluorocarbons in the atmosphere is degrading the ozone layer on Earth. As the ozone layer thins, damaging rays are emitted back to Earth, potentially causing skin and eye problems. UV rays have the power to harm crops as well.

- **Effects on general atmospheric properties**

  Air pollutants affect atmospheric properties in the following ways:

  1) Visibility reduction

  2) Fog formation and precipitation

  3) Solar radiation reduction

  4) Temperature and wind direction alteration

- **Effects on Human Health**

  Air Pollution can lead to increasing diseases like throat infections and lung cancer in humans. Every year, diseases related to air pollution kill and hospitalize millions of people. According to World Health Organization estimates, one out of every eight fatalities worldwide is caused by conditions related to air pollution. New research has found significant correlations between the development of respiratory and cardiovascular disorders and both outdoor and indoor air pollution. Ischemic heart disease, stroke, chronic obstructive pulmonary disease (COPD), lung cancer, and acute lower respiratory infections in children are among the most prevalent diseases induced by air pollution.

- **Effects on Animals**

  Increasing air pollution affects animals and aquatic life, leading them to stray and wander for food. Many of the animals are on the verge of extinction because of this. Animals, sometimes known as wildlife, are particularly vulnerable to the effects of air pollution. Acid rain, heavy metals, persistent organic pollutants (POPs), and other harmful compounds are all pollution concerns.

  Insects, worms, clams, fish, birds, and mammals all have diverse ways of interacting with their surroundings. As a result, each animal's exposure to and vulnerability to the effects of air pollution is unique.

Air pollution has two major effects on wildlife. It has an impact on the area or habitat in which they reside, as well as the food supply's availability and quality.

- **Effects on Vegetation**

  Pollutants that are known phytotoxins (substances harmful to vegetation) are SO_2, peroxyacetyl nitrate, ethane, ozone. Of somewhat lesser severity are chlorine, hydrogen chloride, ammonia and mercury. • Gaseous pollutants enter plant through stomata in the course of normal respiration of plant. Once in the leaf, pollutants destroy chlorophyll and disrupt photosynthesis. • Damage can range from a reduction in growth rate to complete death of plant. • Symptoms of damage are usually manifested in the leaf.

- **Effects on Materials**

  Air pollutants can affect materials by soiling or chemical deterioration. High smoke and particulate levels associated with soiling of clothing and structures. Acid or alkaline particles, especially those containing sulfur, corrode materials such as paint, masonry, electrical contacts and textiles

Air Pollution Control

It is not easy to control air pollution, but it will require some simple steps like:

PREVENTIVE MEASURES

- **Automobile Related**
  - Avoid Using Vehicles : Prefer using public transport as it will reduce the emission of CO into the air. The availability of carpools can help in the reduction of vehicles which in turn reduces pollution. Prefer walking or cycling to nearby places and many such.
  - Use of Alternate fuels in Vehicles : Another method of reducing pollution is to use different fuels. CNG – Compressed Natural Gas–powered and electric vehicles are replacing petrol and diesel vehicles in many parts of India.
  - Keep your car in good repair: Fix exhaust and oxygen sensor problems ASAP. Check your tire pressure monthly; under-inflated tires have been shown to lower gas mileage, particularly at lower speed.
  - Turn off your engine. An idling engine creates a hot spot of pollution. Buses and big trucks produce particularly unhealthy exhaust.
- **Energy Conservation**

  Use energy-efficient electrical devices at the workplace and home place. You can keep your lights switched off when not in use. The electrical appliances should be checked on a regular notice period so that it won't affect the conservation.

- **Use of Clean Energy Resources**

  It will help to reduce the pollution level. Instead of using fossil fuels, we can use natural resources to produce energy like Solar Energy, Wind Energy, etc.

- **Decrease or eliminate the usage of fire and fire-related items**.
  - Limit backyards fire in the city. Smoke from backyard fires can cause unhealthy conditions for hundreds of people, especially during stagnant weather conditions. Since cities have elevated

levels of pollution compared to rural areas, urban fires are more of a nuisance to people with asthma and other lung conditions. If you do have a campfire:

- Keep fires brief and small — 3 feet across or less.
- Burn only dry fire wood. In the Twin Cities it is illegal to burn any waste in a fire, even yard waste.
- Never start campfires during an air quality alert.

➢ Don't burn your garbage. Burning your household garbage is dangerous to your health and our environment

- **Source treatment of Pollutants**

  Because industrial emissions are one of the leading causes of air pollution, the pollutants can be reduced by controlling or treating them at the source. If a given raw material's reactions produce a pollutant, for example, the raw materials can be replaced with less harmful materials.

- **Plant and care for trees.**

  Trees filter pollutants and absorb carbon dioxide. Trees also release oxygen into the atmosphere and help cool our homes.

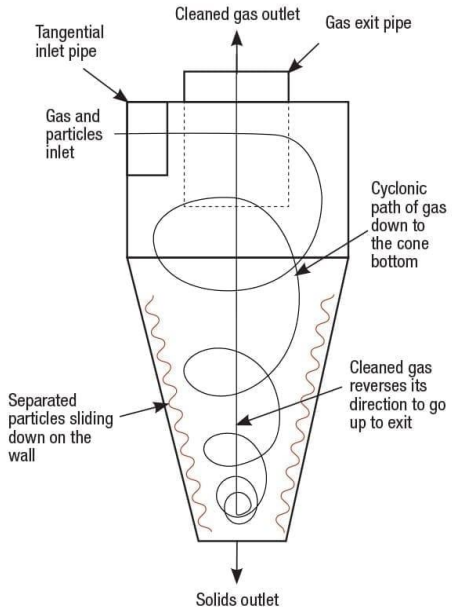
CONTROL MEASURES

Control of particulate matter

Airborne particles can be removed from a polluted airstream by a variety of physical processes. Common types of equipment for collecting fine particulates include cyclones, scrubbers, electrostatic precipitators, and baghouse filters.

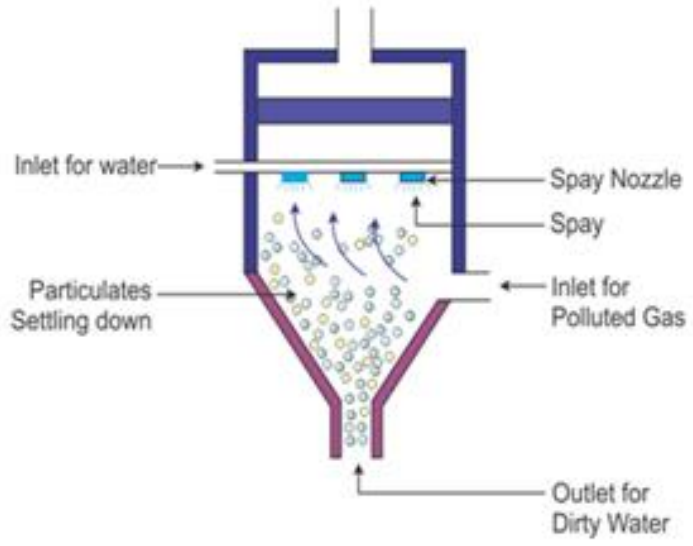
Cyclones

A cyclone removes particulates by causing the dirty airstream to flow in a spiral path inside a cylindrical chamber. Dirty air enters the chamber from a tangential direction at the outer wall of the device, forming a vortex as it swirls within the chamber.



The larger particulates, because of their greater inertia, move outward and are forced against the chamber wall. Slowed by friction with the wall surface, they then slide down the wall into a conical dust hopper at the bottom of the cyclone. The cleaned air swirls upward in a narrower spiral through an inner cylinder and emerges from an outlet at the top. Accumulated particulate dust is periodically removed from the hopper for disposal. Cyclones are best at removing relatively coarse particulates.

Devices called **wet scrubbers** trap suspended particles by direct contact with a spray of water or other liquid. In effect, a scrubber washes the particulates out of the dirty airstream as they collide with and are entrained by the countless tiny droplets in the spray.

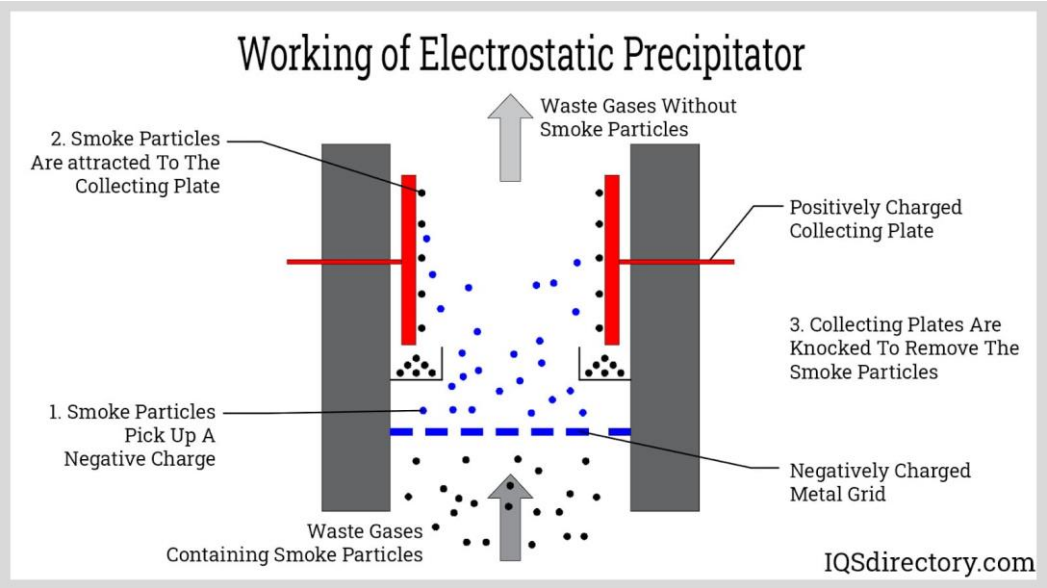


Several configurations of wet scrubbers are in use. In a spray-tower scrubber, an upward-flowing airstream is washed by water sprayed downward from a series of nozzles. The water is recirculated after it is sufficiently cleaned to prevent clogging of the nozzles. Spray-tower scrubbers can remove 90 percent of particulates larger than about 8 μm.

In orifice scrubbers and wet-impingement scrubbers, the air-and-droplet mixture collides with a solid surface. Collision with a surface atomizes the droplets, reducing droplet size and thereby increasing total surface contact area. These devices have the advantage of lower water-recirculation rates, and they offer removal efficiencies of about 90 percent for particles larger than 2 μm.

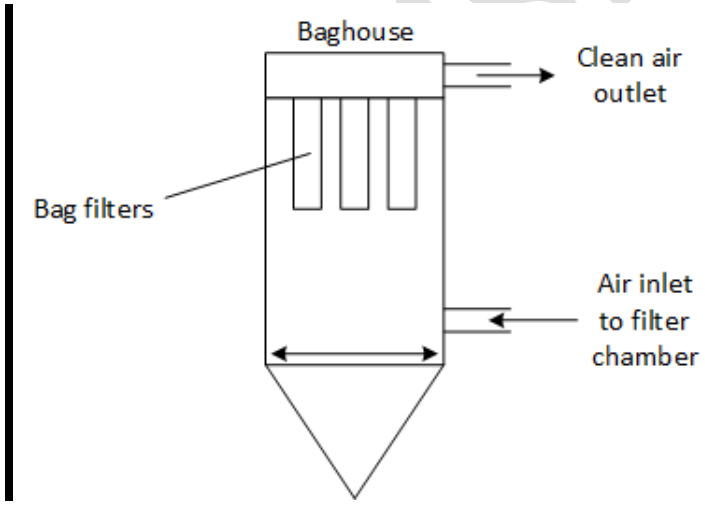
Venturi scrubbers are the most efficient of the wet collectors, achieving efficiencies of more than 98 percent for particles larger than 0.5 μm in diameter. Scrubber efficiency depends on the relative velocity between the droplets and the particulates. Venturi scrubbers achieve high relative velocities by injecting water into the throat of a venturi channel—a constriction in the flow path—through which particulate-laden air is passing at high speed.

Electrostatic precipitation is a commonly used method for removing fine particulates from airstreams. In an electrostatic precipitator, particles suspended in the airstream are given an electric charge as they enter the unit and are then removed by the influence of an electric field.



Baghouse Filters

One of the most efficient devices for removing suspended particulates is an assembly of fabric-filter bags, commonly called a baghouse. A typical baghouse comprises an array of long, narrow bags—each about 25 cm (10 inches) in diameter—that are suspended upside down in a large enclosure. Dust-laden air is blown upward through the bottom of the enclosure by fans. Particulates are trapped inside the filter bags, while the clean air passes through the fabric and exits at the top of the baghouse.



Control of gaseous matter

In automobiles: To restrict the amount of pollutants that are emitted from vehicles into the atmosphere, we can use a device called a catalytic converter. A catalytic converter is a device used to reduce the emissions from an internal combustion engine (used in most modern day automobiles and vehicles). Not enough oxygen is available to oxidize the carbon fuel in these engines completely into carbon dioxide and water; thus toxic by-products are produced. Catalytic converters are used in exhaust systems to provide a site for the oxidation and reduction of toxic by-products (like nitrogen oxides, carbon monoxide, and hydrocarbons) of fuel into less hazardous substances such as carbon dioxide, water vapor, and nitrogen gas.

Gaseous criteria pollutants, as well as volatile organic compounds (VOCs) and other gaseous air toxics, are controlled by means of three basic techniques: absorption, adsorption, and incineration (or combustion). These techniques can be employed singly or in combination. They are effective against the major greenhouse gases as well.

Absorption

In the context of air pollution control, absorption involves the transfer of a gaseous pollutant from the air into a contacting liquid, such as water. The liquid must be able either to serve as a solvent for the pollutant or to capture it by means of a chemical reaction.

Adsorption

Gas adsorption, as contrasted with absorption, is a surface phenomenon. The gas molecules are sorbed—attracted to and held—on the surface of a solid. Gas adsorption methods are used for odour control at various types of chemical-manufacturing and food-processing facilities, in the recovery of a number of volatile solvents (e.g., benzene), and in the control of VOCs at industrial facilities.

Activated carbon (heated charcoal) is one of the most common adsorbent materials. It is very porous and has an extremely high ratio of surface area to volume. Activated carbon is particularly useful as an adsorbent for cleaning airstreams that contain VOCs and for solvent recovery and odour control. A properly designed carbon adsorption unit can remove gas with an efficiency exceeding 95 percent.

Incineration

The process called incineration or combustion—chemically, rapid oxidation—can be used to convert VOCs and other gaseous hydrocarbon pollutants to carbon dioxide and water.

Soil Pollution

Soil pollution refers to the contamination of soil with anomalous concentrations of toxic substances.

It is a serious environmental concern since it harbours many health hazards. For example, exposure to soil containing high concentrations of benzene increases the risk of contracting leukaemia. An image detailing the discolouration of soil due to soil pollution is provided below. It is important to understand that all soils contain compounds that are harmful/toxic to human beings and other living organisms. However, the concentration of such substances in unpolluted soil is low enough that they do not pose any threat to the surrounding ecosystem. When the concentration of one or more such toxic substances is high enough to cause damage to living organisms, the soil is said to be contaminated.

The root cause of soil pollution is often one of the following:

- Agriculture (excessive/improper use of pesticides)
- Excessive industrial activity
- Poor management or inefficient disposal of waste

The challenges faced in soil remediation (decontamination of soil) are closely related to the extent of soil pollution. The greater the contamination, the greater the requirement for resources for remediation.

Pollutants Contaminating Soil

Some of the most hazardous soil pollutants are xenobiotics – substances that are not naturally found in nature and are synthesized by human beings. The term 'xenobiotic' has Greek roots – 'Xenos' (foreigner), and 'Bios' (life). Several xenobiotics are known to be carcinogens. An illustration detailing major soil pollutants is provided below.

The different types of pollutants that are found in contaminated soil are listed in this subsection.

Heavy Metals

The presence of heavy metals (such as lead and mercury, in abnormally high concentrations) in soils can cause it to become highly toxic to human beings. Some metals that can be classified as soil pollutants e.g., Arsenic, Antimony, Mercury, Zinc, Nickel, Lead etc.

These metals can originate from several sources such as mining activities, agricultural activities, and electronic waste (e-waste), and medical waste.

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (often abbreviated to PAHs) are organic compounds that

1. Contain only carbon and hydrogen atoms.
2. Contain more than one aromatic ring in their chemical structures.

Common examples of PAHs include naphthalene, anthracene, and phenalene. Exposure to polycyclic aromatic hydrocarbons has been linked to several forms of cancer. These organic compounds can also cause cardiovascular diseases in humans.

Soil pollution due to PAHs can be sourced to coke (coal) processing, vehicle emissions, cigarette smoke, and the extraction of shale oil.

Industrial Waste

The discharge of industrial waste into soils can result in soil pollution. Some common soil pollutants that can be sourced from industrial waste are listed below.

- Chlorinated industrial solvents
- Dioxins are produced from the manufacture of pesticides and the incineration of waste.
- Plasticizers/dispersants
- Polychlorinated biphenyls (PCBs)

The petroleum industry creates many petroleum hydrocarbon waste products. Some of these wastes, such as benzene and methylbenzene, are known to be carcinogenic in nature.

Pesticides

Pesticides are substances (or mixtures of substances) that are used to kill or inhibit the growth of pests. Common types of pesticides used in agriculture include

- Herbicides – used to kill/control weeds and other unwanted plants.
- Insecticides – used to kill insects.
- Fungicides – used to kill parasitic fungi or inhibit their growth.

However, the unintentional diffusion of pesticides into the environment (commonly known as 'pesticide drift') poses a variety of environmental concerns such as water pollution and soil pollution. Some important soil contaminants found in pesticides are listed below.

Herbicides

- Triazines
- Carbamates
- Amides
- Phenoxyalkyl acids
- Aliphatic acids

Insecticides

- Organophosphates
- Chlorinated hydrocarbons
- Arsenic-containing compounds
- Pyrethrum

Fungicides

- Mercury-containing compounds
- Thiocarbamates
- Copper sulfate

These chemicals pose several health risks to humans. Examples of health hazards related to pesticides include diseases of the central nervous system, immune system diseases, cancer, and birth defects.

Processes that Cause Soil Pollution

Soil pollution can be broadly classified into two categories –

- Naturally caused soil pollution
- Anthropogenic soil pollution (caused by human activity)

Natural Pollution of Soil

In some extremely rare processes, some pollutants are naturally accumulated in soils. This can occur due to the differential deposition of soil by the atmosphere. Another manner in which this type of soil pollution can occur is via the transportation of soil pollutants with precipitation water.

An example of natural soil pollution is the accumulation of compounds containing the perchlorate anion (ClO_4^-) in some dry, arid ecosystems. It is important to note that some contaminants can be naturally produced in the soil under the effect of certain environmental conditions. For example, perchlorates can be formed in soils containing chlorine and certain metals during a thunderstorm.

Anthropogenic Soil Pollution

Almost all cases of soil pollution are anthropogenic in nature. A variety of human activities can lead to the contamination of soil. Some such processes are listed below.

- The demolition of old buildings can involve the contamination of nearby soil with asbestos.
- Usage of lead-based paint during construction activities can also pollute the soil with hazardous concentrations of lead.
- Spillage of petrol and diesel during transportation can contaminate soils with the hydrocarbons found in petroleum.
- Activities associated with metal casting factories (foundries) often cause the dispersion of metallic contaminants into the nearby soils.
- Underground mining activities can cause the contamination of land with heavy metals.
- Improper disposal of highly toxic industrial/chemical waste can severely pollute the soil. For example, the storage of toxic wastes in landfills can result in the seepage of the waste into the soil. This waste can go on to pollute groundwater as well.
- Chemical pesticides contain several hazardous substances. Excessive and inefficient use of chemical pesticides can result in severe soil pollution.
- Sewage produced in urbanized areas can also contaminate soil (if not disposed of correctly). These wastes may also contain several carcinogenic substances.

Other forms of waste that can pollute soil include nuclear waste, e-waste, and coal ash.

Negative Consequences of Soil Pollution

Soil pollution harbours a broad spectrum of negative consequences that affect plants, animals, humans, and the ecosystem as a whole. Since children are more susceptible to diseases, polluted soil poses a greater threat to them. Some important effects of soil pollution are detailed in this subsection.

Effects on Human Beings

Soil contaminants can exist in all three phases (solid, liquid, and gaseous). Therefore, these contaminants can find their way into the human body via several channels such as direct contact with the skin or through the inhalation of contaminated soil dust.

The short term effects of human exposure to polluted soil include

- Headaches, nausea, and vomiting.
- Coughing, pain in the chest, and wheezing.
- Irritation of the skin and the eyes.
- Fatigue and weakness.

A variety of long-term ailments have been linked to soil pollution. Some such diseases are listed below.

- Exposure to high levels of lead can result in permanent damage to the nervous system. Children are particularly vulnerable to lead.
- Depression of the CNS (Central Nervous System).
- Damage to vital organs such as the kidney and the liver.
- Higher risk of developing cancer.

It can be noted that many soil pollutants such as petroleum hydrocarbons and industrial solvents have been linked to congenital disorders in humans. Thus, soil pollution can have several negative effects on human health.

Effects on Plants and Animals

Since soil pollution is often accompanied by a decrease in the availability of nutrients, plant life ceases to thrive in such soils. Soils contaminated with inorganic aluminium can prove toxic to plants. Also, this type of pollution often increases the salinity of the soil, making it inhospitable for the growth of plant life.

Plants that are grown in polluted soil may accumulate high concentrations of soil pollutants through a process known as bioaccumulation. When these plants are consumed by herbivores, all the accumulated pollutants are passed up the food chain. This can result in the loss/extinction of many desirable animal species. Also, these pollutants can eventually make their way to the top of the food chain and manifest as diseases in human beings.

Effects on the Ecosystem

- Since the volatile contaminants in the soil can be carried away into the atmosphere by winds or can seep into underground water reserves, soil pollution can be a direct contributor to air and water pollution.
- It can also contribute to acid rain (by releasing huge quantities of ammonia into the atmosphere).
- Acidic soils are inhospitable to several microorganisms that improve soil texture and help in the decomposition of organic matter. Thus, the negative effects of soil pollution also impact soil quality and texture.

- Crop yield is greatly affected by this form of pollution. In China, over 12 million tons of grain (worth approximately 2.6 billion USD) is found to be unfit for human consumption due to contamination with heavy metals (as per studies conducted by the China Dialogue).

Control Measures

Several technologies have been developed to tackle soil remediation. Some important strategies followed for the decontamination of polluted soil are listed below.

- Excavation and subsequent transportation of polluted soils to remote, uninhabited locations.
- Extraction of pollutants via thermal remediation – the temperature is raised in order to force the contaminants into the vapour phase, after which they can be collected through vapour extraction.
- Bioremediation or phytoremediation involves the use of microorganisms and plants for the decontamination of soil.
- Mycoremediation involves the use of fungi for the accumulation of heavy metal contaminants.

Solid Waste Management

Solid waste is a non-liquid, non-soluble material ranging from municipal garbage to industrial waste that sometimes contains complex and hazardous substances. It includes domestic waste, sanitary waste, commercial waste, institutional waste, catering and market waste, bio-medical waste, and e-waste.

Category	*Sources of generation*	*Types of solid wastes*
Municipal Solid Wastes	*Residential –* family dwellings, low, medium & high-rise buildings/apartments, etc.	Food wastes, rubbish, ashes, special wastes
	Commercial – stores, restaurants, markets, hotels, shopping complexes, repair workshop shops, etc.	Food wastes, rubbish, ashes, construction. Wastes, special wastes, Occasionally hazardous Wastes .
	Open areas – Streets, alleys, parks, vacant plots, play-grounds, beaches, highways, recreational areas, etc.	Special wastes, rubbish
	Treatment plant sites- Water, wastewater & industrial treatment processes, etc.	Treated wastes /residual sludges.
Industrial Wastes	Textiles, paper & allied products, chemicals & related products, rubber, food & kindred products, furniture, printing, leather & leather products, glass, Petroleum & refineries, etc.	Chemicals, metals, scrap products, gypsum, asbestos resins, glass, organic dyes, glues, ect.
Hazardous Wastes	*Industries –* Chemical & oil refineries, ordinance factories, fire works, etc.	Volatile organic chemicals, inflammable substances, toxic gases & liquids, etc.
	Hospitals : Bio-medical wastes	Chemicals, pathological wastes, infectious wastes, sharp objects, pharmaceutical wastes, Laboratory wastes, pressurized cans, etc.

Harmful Effects of Solid Waste

- Bad odour of waste
- Production of toxic gases
- Degradation of natural beauty
- Air pollution
- Water pollution
- Soil pollution
- Spread of diseases
- Effect on biodiversity

An effective waste management system includes one or more of the following options:

(a) Waste collection and transportation.

(b) Resource recovery through sorting and recycling i.e. recovery of materials (such as paper, glass, metals) etc. through separation.

(c) Resource recovery through waste processing i.e. recovery of materials (such as compost) or recovery of energy through biological, thermal or other processes.

(d) Waste transformation (without recovery of resources) i.e. reduction of volume, toxicity or other physical/chemical properties of waste to make it suitable for final disposal.

(e) Disposal on land i.e. environmentally safe and sustainable disposal in landfills.

Functional Elements of Municipal Solid Waste Management

The activities associated with the management of municipal solid wastes from the point of generation to final disposal can be grouped into the six functional elements:

(a) waste generation;

(b) waste handling and sorting, storage, and processing at the source;

(c) collection;

(d) sorting, processing and transformation;

(e) transfer and transport; and

(f) disposal.

Waste Generation:

Waste generation encompasses activities in which materials are identified as no longer being of value (in their present form) and are either thrown away or gathered together for disposal. Waste generation is, at present, an activity that is not very controllable. In the future, however, more control is likely to be exercised over the generation of wastes. Reduction of waste at source, although not controlled by solid waste managers, is now included in system evaluations as a method of limiting the quantity of waste generated.

Waste Handling, Sorting, Storage, and Processing at the Source:

The second of the six functional elements in the solid waste management system is waste handling, sorting, storage, and processing at the source. Waste handling and sorting involves the activities associated with management of wastes until they are placed in storage containers for collection. Handling also encompasses the movement of loaded containers to the point of collection. Sorting of waste components is an important step in the handling and storage of solid waste at the source. For example, the best place to separate waste materials for reuse and recycling is at the source of generation. Households are becoming more aware of the importance of separating newspaper and cardboard, bottles/glass, kitchen wastes and ferrous and non-ferrous materials. On-site storage is of primary importance because of public health concerns and aesthetic consideration. Unsightly makeshift containers and even open ground storage, both of which are undesirable, are often seen at many residential and commercial sites. The cost of providing storage for solid wastes at the source is normally borne by the household in the case of individuals, or by the management of commercial and industrial properties. Processing at the source involves activities such as backyard waste composting

Collection:

The functional element of collection, includes not only the gathering of solid wastes and recyclable materials, but also the transport of these materials, after collection, to the location where the collection vehicle is emptied. This location may be a materials processing facility, a transfer station, or a landfill disposal site.

Sorting, Processing and Transformation of Solid Waste:

The sorting, processing and transformation of solid waste materials is the fourth of the functional elements. The recovery of sorted materials, processing of solid waste and transformation of solid waste that occurs primarily in locations away from the source of waste generation are encompassed by this functional element. Sorting of commingled (mixed) wastes usually occurs at a materials recovery facility, transfer stations, combustion facilities, and disposal sites. Sorting often includes the separation of bulky items, separation of waste components by size using screens, manual separation of waste components, and separation of ferrous and non-ferrous metals. Waste processing is undertaken to recover conversion products and energy. The organic fraction of Municipal Solid Waste (MSW) can be transformed by a variety of biological and thermal processes. The most commonly used biological transformation process is aerobic composting. The most commonly used thermal transformation process is incineration. Waste transformation is undertaken to reduce the volume, weight, size or toxicity of waste without resource recovery. Transformation may be done by a variety of mechanical (eg shredding), thermal (e.g. incineration without energy recovery) or chemical (e.g. encapsulation) techniques.

Transfer and Transport:

The functional element of transfer and transport involves two steps:

(i) the transfer of wastes from the smaller collection vehicle to the larger transport equipment and

(ii) the subsequent transport of the wastes, usually over long distances, to a processing or disposal site. The transfer usually takes place at a transfer station.

Disposal:

The final functional element in the solid waste management system is disposal. Today the disposal of wastes by landfilling or uncontrolled dumping is the ultimate fate of all solid wastes, whether they are residential wastes collected and transported directly to a landfill site, residual materials from Materials Recovery Facilities (MRFs), residue from the combustion of solid waste, rejects of composting, or other substances from various solid waste-processing facilities. A municipal solid waste landfill plant is an engineered facility used for disposing of solid wastes on land or within the earth's mantle without creating nuisance or hazard to public health or safety, such as breeding of rodents and insects and contamination of groundwater.

Types of Solid Waste Disposal

- **Landfill:** It involves burying the waste in vacant locations around the city. The dumping site should be covered with soil to prevent contamination.

  Benefits: A sanitary disposal method if managed effectively.

  Limitations: A reasonably large area is required.

- **Incineration:** It is the controlled oxidation (burning/thermal treatment) of mostly organic compounds at high temperatures to produce thermal energy, CO_2, and water.

  Benefits: Burning significantly reduces the volume of combustible waste.

  Limitations: Smoke and fire hazards may exist.

- **Composting:** It is a natural process of recycling organic matter like leaves and food scraps into beneficial fertilizers that can benefit both soil and plants.

Benefits: It is beneficial for crops and is an environment-friendly method.

Limitations: Requires high-skilled labour for large-scale operation.

- **Recycling:** It is a process of converting waste material into new material. Examples: wood recycling, paper recycling, and glass recycling.

  Benefits: It is environment-friendly.

  Limitations: It is expensive to set up and not reliable in case of an emergency.

- **Vermicomposting:** Vermicomposting is a bio-conversion technique that is commonly used to handle solid waste. Earthworms feed on organic waste to reproduce and multiply in number, vermicompost, and vermiwash as products in this bio-conversion process.

  Benefits: It reduces the need for chemical fertilizers and enhances plant growth.

  Limitations: It is time-consuming, cost-ineffective, and requires extra care.

Noise Pollution

The word noise is derived from the Latin word 'Nausea', which means sickness in which one feels the need to vomit. Noise is the unpleasant and undesirable sound which leads to discomfort in human beings. **The intensity of sound is measured in decibels (dB)**. The faintest sound that the human ear can hear is 1 Db. Due to increasing noise around the civilizations, noise pollution has become a matter of concern. Some of its major causes are vehicles, aircraft, industrial machines, loudspeakers, crackers, etc. When used at high volume, some other appliances also contribute to noise pollution, like television, transistor, radio, etc.

Types of Noise Pollution

Following are the three types of pollution:

- Transport Noise
- Neighbourhood Noise
- Industrial Noise

Transport Noise

It mainly consists of traffic noise which has increased in recent years with the increase in the number of vehicles. The increase in noise pollution leads to deafening of older people, headache, hypertension, etc.

Neighbourhood Noise

The noise from gadgets, household utensils etc. Some of the main sources are musical instruments, transistors, loudspeakers, etc.

Industrial Noise

It is the high-intensity sound which is caused by heavy industrial machines. According to many researches, industrial noise pollution damages the hearing ability to around 20%.

Causes and Sources of Noise Pollution

Following are the causes and sources of noise pollution:

- **Industrialisation:** Industrialisation has led to an increase in noise pollution as the use of heavy machinery such as generators, mills, huge exhaust fans are used, resulting in the production of unwanted noise.
- **Vehicles:** Increased number of vehicles on the roads is the second reason for noise pollution.
- **Events:** Weddings, public gatherings involve loudspeakers to play music resulting in the production of unwanted noise in the neighbourhood.
- **Construction sites:** Mining, construction of buildings, etc add to the noise pollution.

Noise Level	Effect
150 dB	cause instant loss of hearing.
120 dB	is physically painful and should be avoided.
100 dB	short periods of exposure cause a temporary loss of acuity (threshold shift) with prolonged exposure likely to cause irreparable damage to auditory organs.
90 dB	long term exposure at this level normally causes permanent hearing loss.
65 dB	long periods of exposure cause both mental and bodily fatigue.

Noise Pollution Examples

Following are the examples of noise pollution:

- Unnecessary usage of horns
- Using loudspeakers either for religious functions or for political purposes
- Unnecessary usage of fireworks
- Industrial noise
- Construction noise
- Noise from transportation such as railway and aircraft

Impacts of Noise Pollution

Physical Impacts:

- **Hearing Loss**: Prolonged exposure to high levels of noise can lead to permanent hearing damage or loss.
- **Tinnitus**: Constant exposure to loud noise can cause ringing, buzzing, or other phantom sounds in the ears, known as tinnitus.
- **Ear Pain**: Intense noise levels can cause physical discomfort and pain in the ears.
- **Increased Blood Pressure**: Loud noise can trigger the body's stress response, leading to an increase in blood pressure and cardiovascular strain.
- **Muscle Tension**: Continual exposure to noise can result in muscle tension, particularly in the neck and shoulders, due to heightened stress levels.

Physiological Impacts:

- **Stress**: Noise pollution is a significant stressor, triggering the release of stress hormones like cortisol, which can have long-term physiological effects on the body.
- **Anxiety and Agitation**: Loud noise can induce feelings of anxiety, agitation, and irritability, affecting overall mental well-being.

- **Sleep Disturbances**: Noise pollution disrupts sleep patterns, leading to insomnia, fragmented sleep, and decreased sleep quality.
- **Impaired Cognitive Function**: Excessive noise can impair concentration, memory, and cognitive performance, particularly in learning environments.
- **Cardiovascular Effects**: Chronic exposure to noise pollution is associated with an increased risk of cardiovascular diseases such as hypertension, heart attacks, and strokes.

Social and Behavioral Impacts:

- **Communication Interference**: High levels of noise can hinder effective communication, leading to misunderstandings and social isolation.
- **Reduced Productivity**: Noise pollution in workplaces can decrease productivity levels due to distraction, impaired concentration, and increased error rates.
- **Behavioral Changes**: Noise pollution can alter behavior patterns in both humans and animals, leading to aggression, avoidance behaviors, and changes in social interactions.
- **Negative Impact on Quality of Life**: Persistent exposure to noise pollution can diminish overall quality of life, affecting mood, relationships, and general well-being.

Environmental Impacts:

- **Disturbance of Wildlife**: Noise pollution disrupts natural habitats, affecting wildlife behavior, reproduction, and survival.
- **Ecosystem Disruption**: Loud anthropogenic noise can disrupt ecosystems, altering predator-prey dynamics, species distribution, and biodiversity.
- **Underwater Noise Pollution**: Noise from maritime activities such as shipping and sonar can interfere with marine life, causing stress, habitat displacement, and communication disruption.
- **Air and Water Pollution**: Some sources of noise pollution, such as industrial machinery and transportation vehicles, also emit pollutants that can further degrade air and water quality.

<u>Prevention of Noise Pollution</u>

Some noise pollution preventive measures are provided in the points below.

Control at Receiver's End:

- Use of earplugs or earmuffs to reduce the impact of noise on individuals.
- Designing buildings with soundproof windows and doors to minimize external noise infiltration.
- Educating people about the importance of noise reduction and encouraging them to adopt noise-reducing behaviors, such as keeping volume levels low on personal electronic devices.

Suppression of Noise at Source:

- Implementing engineering controls to reduce noise emissions at the source, such as using quieter machinery and equipment.
- Regular maintenance and lubrication of machinery to minimize noise generated by moving parts.

- Installing noise barriers or enclosures around noisy equipment or processes to contain and reduce noise levels.

***Acoustic Zoning**:*

- Establishing zoning regulations that separate noise-sensitive areas (e.g., residential areas, schools, hospitals) from noisy sources (e.g., industrial zones, transportation corridors).
- Setting noise level limits for different zones and enforcing these limits through regulations and monitoring.
- Planning urban development in a way that minimizes exposure of noise-sensitive areas to high levels of noise.

***Sound Insulation at Construction Stages**:*

- Incorporating sound-absorbing materials into the design and construction of buildings to minimize transmission of noise from outside sources.
- Ensuring proper insulation of walls, floors, and ceilings to reduce sound transmission between rooms and from adjacent buildings.
- Installing double-glazed windows or using laminated glass to provide better sound insulation.

These measures, when implemented effectively, can help mitigate noise pollution and create quieter, more comfortable environments for people to live, work, and relax in.