NETAJI SUBHAS OPEN UNIVERSITY

মানুষের জ্ঞান ও ভাবকে বইয়ের মধ্যে সঞ্চিত করিবার যে একটা প্রচুর সুবিধা আছে, সে কথা কেহই অস্বীকার করিতে পারে না। কিন্তু সেই সুবিধার দ্বারা মনের স্বাভাবিক শক্তিকে একেবারে আচ্ছন্ন করিয়া ফেলিলে বুদ্ধিকে বাবু করিয়া তোলা হয়।

—রবীন্দ্রনাথ ঠাকুর

ভারতের একটা mission আছে, একটা গৌরবময় ভবিষ্যৎ আছে, সেই ভবিষ্যৎ ভারতের উত্তরাধিকারী আমরাই। নূতন ভারতের মুক্তির ইতিহাস আমরাই রচনা করছি এবং করব। এই বিশ্বাস আছে বলেই আমরা সব দুঃখ কষ্ট সহ্য করতে পারি, অন্ধকারময় বর্তমানকে অগ্রাহ্য করতে পারি, বাস্তবের নিষ্ঠুর সত্যগুলি আদর্শের কঠিন আঘাতে ধূলিস্যাৎ করতে পারি।

—সুভাষচন্দ্র বসু

Any system of education which ignores Indian conditions, requirements, history and sociology is too unscientific to commend itself to any rational support.

—Subhas Chandra Bose

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NSOU • SLM • PGES • CC • 201

NETAJI SUBHAS OPEN UNIVERSITY

Post Graduate Degree Programme

PGES

PGES CC 201

SELF LEARNING MATERIAL

ENVIRONMENTAL POLLUTION, DEGRADATION AND CONTROL

PREFACE

In the curricular structure introduced by this University for students of Post-Graduate degree programme, the opportunity to pursue Post-Graduate course in subject introduced by this University is equally available to all learners. Instead of being guided by any presumption about ability level, it would perhaps stand to reason if receptivity of a learner is judged in the course of the learning process. That would be entirely in keeping with the objectives of open education which does not believe in artificial differentiation. I am happy to note that the university has been recently accredited by National Assessment and Accreditation Council of India (NAAC) with grade 'A'.

Keeping this in view, study materials of the Post-Graduate level in different subjects are being prepared on the basis of a well laid-out syllabus. The course structure combines the best elements in the approved syllabi of Central and State Universities in respective subjects. It has been so designed as to be upgradable with the addition of new information as well as results of fresh thinking and analyses.

The accepted methodology of distance education has been followed in the preparation of these study materials. Co-operation in every form of experienced scholars is indispensable for a work of this kind. We, therefore, owe an enormous debt of gratitude to everyone whose tireless efforts went into the writing, editing and devising of proper lay-out of the materials. Practically speaking, their role amounts to an involvement in 'invisible teaching'. For, whoever makes use of these study materials would virtually derive the benefit of learning under their collective care without each being seen by the other.

The more a learner would seriously pursue these study materials the easier it will be for him or her to reach out to larger horizons of a subject. Care has also been taken to make the language lucid and presentation attractive so that they may be rated as quality self-learning materials. If anything remains still obscure or difficult to follow, arrangements are there to come to terms with them through the counselling sessions regularly available at the network of study centres set up by the University.

Needless to add, a great part of these efforts is still experimental–in fact, pioneering in certain areas. Naturally, there is every possibility of some lapse or deficiency here and there. However, these to admit of rectification and further improvement in due course. On the whole, therefore, these study materials are expected to evoke wider appreciation the more they receive serious attention of all concerned.

Professor Indrajit Lahiri
Authorised Vice-Chancellor
Netaji Subhas Open University (NSOU)

Netaji Subhas open University
Post Graduate Degree Programme
Choice Based Credit System (CBCS)
Subject: P.G. Environmental Science (PGES)
Course: Environmental Pollution, Degradation and Control
Course Code: PGES-CC-201

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P.G. Environmental Science
PGES-CC-201

Course: Environmental Pollution, Degradation and Control

UNIT 1 ❑ Air Pollution

Structure

1.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different air pollution sources,
- understand different types of pollutants and their transmission,
- outline different inorganic, particulate, organic and bio-pollutants
- know the atmospheric stability and pollutant dispersion mechanism,
- learn about acid rain phenomenon and its associated problems,

- understand the different adverse effects of air pollution,
- comprehend the control mechanism of air pollution,
- understand the ambient air quality standards and legislation.

1.2 Introduction

The biosphere's main component, the atmosphere, is a dynamic system that continuously ingests a variety of particles from both natural and artificial sources, including solids, liquids, and gases. These substances scatter through the air, interact chemically and physically with one another, and move around. The majority of these components eventually end up in a repository like the ocean or a receptor like a person. Yet, some chemicals, like helium, escape the biosphere. Others, like carbon dioxide, may enter the atmosphere more quickly than they could enter a reservoir, slowly accumulating in the air.

78.09% nitrogen and 20.94% oxygen make up the volume of pure, dry air. The remaining 0.97% of the atmosphere is made up of a gaseous combination of carbon dioxide, helium, argon, krypton, nitrous oxide, and xenon, as well as very minute amounts of a few additional organic and inorganic gases whose concentrations in the atmosphere change with time and location. Through both natural and artificial activities that take place on earth, different quantities of pollutants are constantly released into the atmosphere. Man has dubbed these compounds "pollutants" for the fraction of them that interacts with the environment to cause toxicity, sickness, aesthetic distress, physiological impacts, or environmental destruction.

Generally speaking, human activity is the main contributor to pollution, and as the population grows, so do the associated pollution issues. With the discovery of fire, man's impact on nature saw its first major alteration. In his cave, prehistoric man lit a fire for lighting, cooking, and heating. At this period, the issue of air pollution first emerged.

"Air pollution means the presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odor, smoke, or vapour, in quantities, with characteristics, and of durations such as to be injurious to human, plant, or animal life or to property, or which unreasonably interferes with the comfortable enjoyment of life and property." - Engineers Joint Council (U.S.A.)

"Air pollution is the presence in ambient atmosphere of substances, generally resulting from the activity of man, in sufficient concentration, present for a sufficient time and under circumstances which interfere significantly with the comfort, health or welfare of persons or with the full use or enjoyment of property." -Indian Standards Institution IS-4167 (1966).

"Air pollution is the excessive concentration of foreign matter in the air which adversely affects the well-being of the individual or causes damage to property." - American Medical Association Since

1.3 Types of Air Pollutants

Air pollution may come from numerous human activities like industrial processes or it may come from the natural world. The by-products of internal combustion, such as the reactions in gasoline and diesel engines, or by-products of external combustion, such as smoke, dust, and sulphur oxides, can also be considered industrial pollutants. Moreover, the emissions may be main pollutants or secondary pollutants. The numerous pollution sources can also be roughly divided into fixed sources and mobile ones. In the pages that follow, each of these is explained in further depth.

Air pollutants can be classified as follows

a. Based on where the pollutants came from. They are divided into two categories: primary pollutants and secondary pollutants.

i. Principal air pollutants are those released from known sources directly. Primary air contaminants include:

1. Less than 100 μm diameter particles, 2. Large particles (diameter higher than 100 μm), 3. Sulfur compounds, 4. Nitrogen oxides 5. Carbon monoxide, 6. Halogen substances 7. Organic substances 8. Radioactive substances, 9. Finer aerosols contain metal, charcoal, tar, glue, pollen, microorganisms, and other particles.

ii. Secondary air pollutants are those that are released into the atmosphere as a result of interactions between two or more main pollutants or as a result of chemical reactions with regular atmospheric elements, either with or without photoactivation. Secondary air pollution examples include:

1. Ozone, 2. Formaldehyde, 3. PAN (Peroxy Acetyl Nitrate), 4. Smog that is photochemical, 5. When water droplets are present in the atmosphere, sulphur dioxide and dissolved oxygen combine to form acid mists (H_2SO_4).

b. On the basis of physical state, air pollutants are categorized into three types:

i. Solid air pollutants: Carbon particles, etc.

ii. Liquid air pollutants: H_2SO_4, HNO_3, etc.

iii. Gaseous air pollutants: CO, NOx, SOx

c. Based on how contaminants enter the atmosphere and their form, the sources are divided into three categories: point, line, and area/volume sources. They come in both instantaneous and continuous varieties.

i. Point Source – It is the continuous emission of pollutants into the atmosphere from a single spot, such as the stack of a power station. The point at which pollution is not continuously emitted is known as an instantaneous source. Examples include volcanic eruptions.

ii. Line Source –This type of emission is described as the entry of pollutants into the atmosphere through a source that has a line shape, such as automobile exhaust pollution, which emits pollutants continuously. An instantaneous line source of pollution is a line-shaped source, such as an aeroplane spraying pesticides, through which the emission of pollutants is not continuous.

iii. Area/Volume Source – It is the continual release of pollutants into the atmosphere from an area or volume source, such as the industrial city core. An instance of an instantaneous area/volume source is the blasting of a poison gas tank, where the discharge of contaminants is not continuous.

d. Depending on the chemistry of the contaminants. They are divided into two categories: i) organic pollutants and ii) inorganic pollutants.

(i) Organic Pollutants – PAN (Peroxy Acetyl Nitrate) and hydrocarbons are examples of pollutants that are made up of organic elements and exhibit features of organic molecules.

(ii) Inorganic Pollutants – The pollutants that are made of substances that resemble inorganic substances, such as CO, SO_2, and NO_2, are referred to as inorganic pollutants.

e. Based on the state of matter in which they are found in the atmosphere they are divided into two categories: i) gaseous pollutants and (ii) particulate pollutants.

(i) Particulate pollutant : These are the tiny, finely divided solid and liquid particles that are produced during combustion and found in the atmosphere. Their sizes range from 500 nm to 0.0002 nm. They are primarily transported through smoke, dust, etc. because of their extremely reactive chemical characteristics.

(ii) Gaseous Pollutants - Gaseous pollutants are pollutants that exist in the form of gases, such as Carbon-di-Oxide, Sulfur-di-Oxide, etc.

f. Based on the origin, air contaminants are classified into two types :

i. Natural contaminants: e.g., natural fog, pollen grains, bacteria, and products of volcanic eruption.

ii. Aerosols (particulates): e.g., dust, smoke, mists, fog and fumes.

iii. Gases and vapors

1.3.1 Natural Contaminants

Pollen is a significant natural contaminant because some people find its distinctive qualities annoying. Gymnosperm and angiosperm male gametophytes called pollen grains are released into the atmosphere by weeds, grasses, and trees. Many pollen grains are released due to wind pollination. While the majority of pollen grains carried by air are between 10 and 50 (microns) in size, some have been discovered to range in size from 5 to 100 um. Because they trigger allergic reactions in sensitive people, airborne contaminants are important from a pollution perspective. Many people experience hay fever or asthma. While the majority of patients have a straightforward form of hay fever, where symptoms go away at the pollen season.

1.3.2 Aerosols/Particulate Pollutants

The dispersion of microscopic-sized solid or liquid particles in gaseous medium, such as dust, smoke, or mist, is referred to as an aerosol. A colloidal system with a gas as the dispersion medium and a solid or liquid as the dispersed phase is known as an aerosol.

When anything is suspended in the air, the term "aerosol" is employed. The word no longer applies once it has settled, whether due to its weight, agglomeration, or impact on a surface made of solid or liquid. Hence, particulate matter only constitutes an air pollution when it takes the form of an aerosol. Nonetheless, both as an aerosol (which reduces visibility) and as settled or deposited waste, it is an annoyance (soiling of surfaces, corrosions).

In terms of particle size, particle density, and their significance as pollutants, aerosols vary greatly. They typically have dimensions between 0.01 o and 100 μm, or less. The different aerosols are listed below.

a. Dust: Solid particles that are primarily larger than those present in colloids and capable of momentarily suspending in air or other gases make up dust. They don't typically flocculate until there are electrostatic forces at play, and when gravity is at play, they don't diffuse but instead settle.

Dust is created when organic and inorganic materials are crushed, ground, etc. They typically have a diameter of over 20, however some are smaller. Fly ash from chimneys ranges from 80 to 3; cement is between 150 and 10; and foundry

dust is between 200 and 1. The majority of dust particles fall to the ground as they are, but those that are five microns or smaller usually form stable suspensions.

b. Smoke : Finely fragmented particles created by imperfect mixing make up smoke. It primarily comprises of carbon particles and other flammable substances. The particles are often smaller than 1 in size. Oil smoke particles range in size from 1.0-0.03 p, while coal smoke particles range in size from 0.2-0.01 μm.

c. Mists : This phrase describes a low concentration dispersion of sizable liquid particles. It refers to a light dispersion of tiny water droplets hanging in the atmosphere in meteorology. The size of naturally occurring mist particles, which ranges from 500 to 40, is relatively enormous. The fragments might combine. Mist is a suspension of liquid droplets that is created when vapour condenses. They range from 40 to 500 microns in size.

d. Fog : Visible aerosols with a liquid-like dispersion phase are referred to as fog. Condensation-based formation is typically suggested. It is the dispersion of water or ice in the atmosphere close to the earth's surface that causes visibility to drop to less than km in meteorology. The size of the particles in natural fog ranges from 40 to 1.0.

e. Fumes : These are solid particles **with a size range of 0.03 to 1 microns** that are produced by condensation from the gaseous state, usually after volatilization from melted materials, and frequently in conjunction with a chemical process like oxidation. Fumes sometimes agglomerate and flocculate.

f. Smog : The photochemical reaction between particulate matter and water molecules creates smog, which is a suspension of smoke particles and condensed liquid droplets.

g. Haze : It is a type of air pollution brought on by the presence of very small particles of dust in the atmosphere. In terms of Coefficient of Haze (COH), it is as follows: COH = 100 (log), or transmittance at 100%.

1.4 Important Gaseous Pollutants

The gases in air pollution are as follows:

1.4.1 Oxides of sulphur

One of the main components of air pollution is this. Often abbreviated as SOx, this combination. The components of SOx are SO_2, (97 to 99%), and SO_3, (1 to 3%). It is a heavy, water-soluble gas that is colourless and has an offensive smell. Quickly dispersing oxidising agent that produces acid. React with minerals, metals, and organic substances. Reacts with water to generate H_2SO_4.

Volcanic activity and other natural sources, over which humans have no influence, are responsible for over 67% of the SOx pollution in the world. The remaining 33% of SO_2 emissions are caused by human activity, including fuel combustion, coal-fired power plants, transportation, refineries, metallurgical processes like the smelting of sulphide ores, and chemical plants like those that produce sulfuric acid. Urban and industrial regions are where the majority of man-made SOx pollution is found.

The burning of fuels, particularly coal, is the principal source of sulphur dioxide. As a result, the sulphur content of the fuel used to generate electricity and heat buildings determines how much of it is present in the atmosphere. Fuels range in sulphur content from under 1% for high-quality anthracite to over 4% for bituminous coal.

Most crude petroleum products have sulphur content of less than 1%; a handful have up to 5%. Sulfur compounds are frequently concentrated in the heavier fractions throughout the refining process. Sulfur is also present in fuel gases, but only in trace amounts.

Flue gases contain sulphur dioxide, which accounts for virtually all of the sulphur in liquid and gaseous fuels and around 80% of the sulphur in coal. The inorganic sulphur that is still present in coal and so persists in the ash. Sulfur dioxide levels in flue gases typically vary from 0.05 to 0.25 percent, but they can occasionally reach 0.4%.

Metallurgical processes are another frequent source of sulphur dioxide in the environment. The main component of several ores, including zinc, copper, and lead, is sulphur. Sulfur dioxide is released from these ores during smelting in stack concentrations of 5-10%. (SO_2). Nonetheless, this can be recovered as sulfuric acid.

Sulfuric acid facilities and paper mills are two examples of the several industries that release sulphur dioxide into the atmosphere. The amounts are typically small, making control measures simple to implement.

Municipal incinerators and open burning of waste both release some sulphur dioxide into the sky.

Photochemical smog is created when photolytic and catalytic processes involving ozone, NOx, and hydrocarbons convert SO_2 to SO_3 in atmospheric air. SO_2 can be oxidised in the presence of catalysts like NOx, metal oxides, soot, and dust. When the atmosphere is normally humid, SO_3 combines with water vapour to form H_2SO_4, aerosol particles, which result in the so-called "acid rain" that will be covered later.

$$SO_2 + O_3 \rightarrow SO_3 + O_2$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \rightarrow (H_2SO_4)n$$

$SO_2 + ½ O_2 + H_2O \rightarrow$ (Catalyst such as metal oxide, soot etc.) $H_2SO_4 \rightarrow$ aerosol $(H_2SO_4)n$

Controlling SOx emissions caused by human activity is envisioned along these lines:

(1) Taking away SOx from polluted gases into the atmosphere can be achieved by using chemical scrubbers like (a) lime stone or (b) citric acid are advised.

$2\ CaCO, + 2SO_2 + O_2 \rightarrow 2\ CaSO_4, + CO_2$

(2) Sulfur removal from fuels for combustion: Coal washeries can grind and wash coal to remove pyrite sulphur. Unfortunately, it is difficult to extract sulphur from charcoal that has been biologically bonded. A specific class of microorganisms that can transform organically bound sulphur into soluble form is being created through biotechnology research.

(3) Using fuels with little sulphur.

(4) generating power from alternative energy sources and preventing the construction of thermal power facilities that rely on fossil fuels.

Effects: Quick absorption and irritation of the upper respiratory tract are the biochemical consequences. reacts with the molecules that make up cells, like enzymes. The H^+ that is produced lowers pH, hinders enzyme activity, and obliterates several useful molecules. causes bronchial spasms, shortness of breath, decreased lung clearance, reduced pulmonary function, and increased susceptibility to infection.

1.4.2 Nitrogen oxides

Next to sulphur dioxide, nitrogen oxides are perhaps the second most prevalent atmospheric pollutants in many cities. Only nitric oxide and nitrogen dioxide, which are produced by a variety of human activities and are categorised as pollutants, are two of the seven nitrogen oxides (N_2O, NO, NO_2, NO_3, N_2O_3, N_2O_4, N_2O_5). They are typically listed as "total oxides of nitrogen," or "NO," in atmospheric analyses. Out of the seven potential nitrogen oxides, only N_2O, NO, and NO_2 are significant atmospheric components. NO, NO_2, and N_2O make up the majority of NOx. NO is a colourless gas that has a negligible water solubility. NO_2 is a reddish-brown gas that is an oxidising agent and relatively water soluble. It may combine with water to generate HNO_3, a strong oxidising agent that can react with practically all metals and many organic compounds. Inhalation of NO_2 can enter the respiratory system. Moreover, it contributes to ozone synthesis in the atmosphere. N_2O, NO, and NO_2 have background atmospheric values of 0.25 ppm, 0.1 to 2 ppm, and 0.5 to 4 ppm, respectively. Although N_2O concentrations are higher in the atmosphere, NO and NO_2 are more important from the perspective of air pollution, and they are typically referred to as NO. High temperatures (between 1210 and 1765°C), which are typically reached in the combustion processes involving air, are favourable for the production of NO from N_2 and O_2. NO does not dissociate

when the combustion products are quickly cooled (quenched). High temperatures (1100°C) also encourage the oxidation of NO to NO_2, but the amount of NO_2 produced is typically less than 0.5% of the total NOx present. The effluents from companies where nitric acid is produced or employed in chemical reactions often have the highest concentration of nitrogen oxides in gaseous emissions. In automotive exhaust, the concentration is the second highest. Then follow the effluents from big power plants and, to a lesser extent, those from furnaces and burners with low heat. As was previously mentioned, photolytic reactions in the environment also produce NO_2. Here are a few of the possible reactions:

$N_2 + O_2 \rightarrow$ [1210-1765 °C) 2NO

$2NO + O_2 \rightarrow 2NO_2$

$NO_2 + hv \rightarrow NO+O$

$O_2 + hv \rightarrow 398$ nm $2O + O^*$

$O+O_2 + M \rightarrow 242$ nm $O_3 + M$

$O_3+NO \rightarrow$ (third body) $NO_2 + O_2$

$O_3 + NO \rightarrow N_2\ 0, +0_2$

$4NO_2 + 2H_2O + O_2^- \rightarrow 4HNO,$

Alternative Mechanism for Nitric Acid formation

(a) $O_3 + NO_2 \rightarrow NO_3 + O_2$

(b) $NO + NO_2 \rightarrow N_2O_5$

(c) $N_2O_5 + H_2O \rightarrow 2HNO_3$

Both spontaneous and artificial nitrogen fixation from the environment as well as nitrogen molecules found in organic matter can result in the formation of nitrates of nitrogen. About 5 x 10' tonnes of NOx are released globally each year from artificial sources, which is only marginally less than the amount released by bacterial activity in the environment. Nitrogen oxides are created through the burning of organic materials including coal, oil, and natural gas. Hence, NOx is released into the atmosphere through sources like as coal-fired power stations, incinerators, furnace stacks, and other similar sources. Some of the N in the air is converted to NO when fuels are burned in the presence of air. The temperature of the flame and the rate at which the combustion products cool or are quenched affect how much NO is produced. The generation of NO is aided by higher flame temperatures and quick cooling of the combustion products.

NO and NO_2, respectively, spend an average of 4 days and 3 days in the atmosphere. In the atmosphere, they go through a variety of photochemical and chemical processes that result in the creation of HNO, which precipitates as nitrates during rain or as dust.

In comparison to rural locations, urban areas may have 10 to 100 times more NOx from man-made sources. Even in metropolitan regions, the ambient NOx levels change according on the time of day and the amount of traffic.

Photochemical smog is created as a result of chemical and photochemical processes involving NO_2, hydrocarbons, and sunlight.

Using two stage catalytic converters can reduce the NOx from vehicle emissions, as was covered in the prior section. Similar to this, a two-stage combustion method can cut NOx emissions from power plants by 90%. It is possible to ignite the fuel at a reasonably high temperature using just approximately 90% of the necessary stoichiometric air, resulting in the formation of a negligible amount of NO in these circumstances. The fuel can then burn completely in the extra air at a relatively low temperature. NO does not form in these circumstances.

Biochemical effects : oxidises lipids within cells, combines with haemoglobin to form connections that decrease the effectiveness of oxygen delivery. some cellular enzyme systems are disrupted. Greater concentrations and extended exposures could result in pulmonary fibrosis, an inflammation of the lung tissues that could ultimately result in death. causes some actions of nitric acid that are comparable to those of H_2SO_4 that were previously described. If NO_2 enters the bloodstream, it can combine with haemoglobin to generate other compounds.

1.4.3 Hydrogen Sulphide

The gas hydrogen sulphide has a bad odour. Anaerobic biological degradation processes on land, in marshes, and in the water are some of the origins of its natural emission. Natural water springs and volcanoes both release some hydrogen sulphide.

The Kraft pulp sector, which uses a sulphide method to make paper, is one of the main emitters of hydrogen sulphide. Other industrial sources of hydrogen sulphide include chemical factories, coke ovens, viscose rayon facilities, and petroleum refineries. The strong scents of methyl mercaptan (CH_3 SH), dimethyl sulphide (CH_3-S-CH_3), dimethyl disulphide (CH_3 SS CH_3), and their higher molecular homologs make these sulphur compounds and others of interest in the study of air pollution. Certain pulp mills, oil refineries, and chemical industrial facilities release combinations of pollutants, including mercaptans.

1.4.4 Hydrogen Fluoride

The production of phosphate fertilisers, the aluminium sector, brick manufacturing, pottery

production, and ferro-enamel works are the main producers of fluorides. Other metallurgical processes, such zinc foundries and open-hearth steel furnaces, also release small amounts. The burning of coal, which typically contains 0.01% fluorine, also releases small amounts.

Even at extremely low quantities of 0.001-0.10 ppm by volume, hydrogen fluoride is a significant air pollutant. When present at these concentrations, hydrogen fluoride causes more harm to plants and animals than it does to people. For enterprises producing aluminium and phosphate fertilisers, the regulation of such emissions is essential due to the high level of toxicity of fluorine compounds.

1.4.5 Hydrogen chloride with chlorine

The element chlorine itself, hydrogen chloride, chlorine-containing organic molecules like perchlorethylene, and inorganic chlorides are all present in contaminated atmospheres. The last compound is a solid and is therefore found in particulate form, whereas the previous compounds are gases.

The production of chlorine or its usage in the synthesis of other chemicals are the most frequent sources of chlorine in the atmosphere. Equipment malfunction can occasionally cause chlorine to escape into the atmosphere since chlorine is utilized in swimming pools, sewage treatment facilities, and water purification facilities.

Several industrial chemical processes produce hydrogen chloride, but because it is so easily recovered, very little of it ends up in the environment. The principal impacts of chlorine and its derivatives include irritation of the respiratory system, corrosion caused by hydrogen chloride, and harm to vegetation.

1.4.6 Combustible Oxide

The primary source of carbon monoxide, an odourless and colourless gas, is the incomplete combustion of carbonaceous materials. It is a very dangerous gas that is typically categorised as an asphyxiant.

Combustion, mainly from car exhausts, is the main cause of carbon monoxide in the environment. Yet, relatively little carbon monoxide is present in the gaseous emissions from well adjusted, correctly functioning equipment, with the exception of motor cars and other internal combustion engines. Automobile exhausts are by far the most significant generator of carbon monoxide in the atmosphere, even if other industrial processes such as electric and blast furnaces, some petroleum refining operations, gas producing plants, and coal mines are also potential contributors.

1.4.7 Ozone

Ozone is a light blue gas with some water solubility, instability, and a sweetish odour. a very reactive oxidising chemical that can combine with rubber and other materials as well as numerous organic molecules found in organisms and tissues. Plants, animals, and people can all be harmed by O and PAN. Although the source of the ozone that is found in the air is unknown, it is most likely a combination of sunlight and combustion. Ozone is toxic and odorous. Under natural circumstances, it is very prevalent in the high atmosphere.

Biochemical effects: Oxidize the components of cells. The creation of free radicals results in the toxicity of PAN and ozone. The generated free radicals may harm DNA, changing cellular genetic integrity as a result. After inhalation and absorption in the lungs, the harmful effects of ozone become apparent and result in fluid buildup in the lungs (pulmonary edoema), damage to the capillaries in the lungs, and, in the case of prolonged or high exposure levels, fatality. The eyes and respiratory system become irritated by both 0 and photochemical smog. The sulphydryl groups on enzymes are attacked by free radicals produced by oxygen and other photochemical oxidants, which also renders enzymes like isoctric dehydrogenase, malic dehydrogenase, and glucose-6-phosphate dehydrogenase inactive. These enzymes are heavily involved in the citric acid cycle and the production of cellular energy. Several enzymes involved in the synthesis of cellulose and lipids in plants may similarly be inhibited by O_3. Cysteine is one of the sulfur-containing amino acids that PAN attacks most vigorously.

1.4.8 Aldehydes

They are created from the burning of fuels like gasoline, diesel, fuel oil, and natural gas. Aldehydes are created when motor fuel and lubricant oils undergo incomplete oxidation. There is a possibility that lower aldehydes exist in the environment at levels comparable to sulphur dioxide. They might also develop in the atmosphere as a result of photochemical reactions. The eyes are irritated by formaldehyde.

1.4.9 Chemical Vapors

Many chemical substances, such as paraffins, olefins, acetylenes, aromatic hydrocarbons, chlorinated hydrocarbons, etc. are among these pollutants. They are created through petroleum operations, home incinerators, and combustion processes, particularly in autos. Also, it's likely that they cause changes in the atmosphere that lead to the development of smog.

1.4.10 Radioactive Gases

The nuclear power plant and associated fuel management facilities are a significant producer of radioactive gases and particulates. Other sources include experimental accelerators, atmospheric nuclear bomb tests, and the use of radioactive isotopes in industry, agriculture,

and medicine. Nuclear fuel reprocessing facilities are a further source of radioactive particles and gases that are becoming more significant.

1.4.11 Smog

Smoke and fog are two adjectives that are synonymous with smog. Smog can be either coal or photochemical induced. Only heavily populated sections of metropolitan cities, like Los Angeles, have photochemical haze. It happens when the air movement is constrained and there are poor meteorological conditions. When certain hydrocarbons and oxidants interact, hazardous peroxy acetyl nitrate is produced under the effect of sunlight, which is the source of smog (PAN). Nitrogen oxides, PAN, hydrocarbons, carbon monoxide, and ozone make up the majority of its components. It impairs visibility, irritates the eyes, harms plants, and causes rubber to fracture.

When the temperature is below 10°C and the weather is calm, coal-fired power plants produce fog that blankets urban areas at night or on chilly days (December 1952). Fly ash, sulphur compounds, and smoke make up this fog. Long-term smog exposure may increase the risk of death, especially in the elderly and those with a history of chronic bronchitis, asthma, bronchopneumonia, or other lung or heart disorders.

1.5 Sources of Air Pollution

Natural and human-made pollution make it impossible to find clean air in the natural world. Natural processes, such as volcanic activity, vegetation decomposition, and forest fires, continuously emit gases into the atmosphere, including CO, SO_2, and H_2S. In addition, winds, volcanic eruptions, and other similar natural disturbances disperse minute particles of solids or liquids throughout the air. Man-made pollutants, such as gases, mists, and particulates that emerge from the chemical and biological processes that humans use, are in addition to these "natural pollutants." When compared to background air concentrations, the latter are found in quite high concentrations. At altitudes more than 2000 feet, these contaminants hardly ever exist. Concentrations of air pollutants in the atmosphere disrupt the dynamic equilibrium in the atmosphere and thereby affect man and his environment.

Air pollution sources are generally classified into two categories namely anthropogenic and natural sources.

Many significant natural sources that contribute to air pollution include the following :

1 . Large amounts of toxic gases, such as SO_2, H_2S, CO, and others, will be released during volcanic eruptions, producing air pollution.

2 . Air pollution from CO and CO_2 emissions is a result of natural forest fires.

3 . Vast volumes of CO_2 are released into the atmosphere by green plants through evapo-transpiration.

4 . Other sources of air pollution include forest fires and interactions between natural gas emissions.

5 . Winds and storms will release solid particles into the air, generating air pollution.

6 . Hydrocarbons, CO, and CO_2 produce air pollution when natural gas is forced out of borewells.

7. CO and CH_4 gases are produced during seed germination, marsh gas production, organic matter breakdown, and bio-degradation. These gases persist in the atmosphere and contribute to air pollution.

8 . Pollen grains from flowers, dust, and natural organic and inorganic decomposition are formed and discharged into the air, making it unclean and harmful to human health.

Anthropogenic sources mean man-made sources. The following man-made sources cause air pollution:

a. Combustion of fossil fuels : The organic materials that produce energy during combustion include coal, natural gas, petroleum, wood, and oil, among others. These substances are also known as "fossil fuels." Air pollution results from burning fossil fuels like coal, wood, and oil. when black smoke is created during the burning of coal, wood, and oil. Unburned black carbon particles as well as toxic chemicals like CO and SO_2 are present in this smoke. Oils and coal both have sulphate as an impurity. Hence, SO_2 and CO_2 gases will be released during the burning of coal and oil. As a result of the atmospheric persistence of CO, CO_2, SO_2, and unburned carbon particles from the burning of fossil fuels, the air becomes contaminated.

b. Population explosion : The most major source of air pollution is the increasing expansion of the population day by day. Population growth causes greenhouse gas emissions and global warming. As a result, sou level will result. As a result, the ice caps and glaciers will be visible in low-lying places of the globe. Food grain production will decline as a result of global warming. According to estimates, due to an increase in CO_2 concentration that melts ice caps, the sea level may rise by 200 feet by the year 2050, flooding major towns and low-lying areas.

c. Transportation : Vehicles are regarded as the principal mode of transportation, including cars, trucks, motorcycles, taxis, buses, lorries, aeroplanes, and scooters. Air pollution is

brought on by the CO, NO_2, and NO gases emitted by internal combustion engines in vehicles including cars, buses, trucks, and aeroplanes. The internal combustion engine that burns gasoline as a fuel can emit pollutants as seen in the diagram below. Let's assume that the fuel utilised in car engines is gasoline. Hydrocarbons are one of the key components of gasoline. These hydrocarbons are known as octanes because their general chemical formula is C_8H_8. In an automobile engine, gasoline burns quickly. Due to the limited burning duration, incomplete combustion of gasoline results in CO_2, CO, H_2O vapour, alcohol, acid, and unburned carbon.

d. Deforestation : Deforestation is the term used to describe the indiscriminate removal of plants, trees, and debris from jungles and forests. In nature, forests have a specific place. Forests are seen as a gift from nature to all living things. The equilibrium of CO_2 and O_2 concentrations in the environment is mostly maintained by plants.

e. Industrialization : Due to the current population explosion, the need for rapid industrialization has become imperative. Basically, the living community's support system is its industry. Sources of various industries, such as chemical industries, paper mills, cotton mills, metal extraction plants, petroleum refineries, oil refining factories, plastic, rubber, mica industries, nuclear reactors, soap industries, drug industries, etc., to be started become a necessary activity based on regional needs. These industries release a variety of harmful substances into the atmosphere. These gases contaminate the air. Around 20% of air pollution is attributable to the aforementioned businesses.

f. Agricultural Activities : Due to the rapid population growth, more agricultural land needs to be planted in order to provide for the minimum level of living standards. Fertilizers must be used in order to produce a large yield. The crop may experience several diseases during the ripening stage, which are brought on by various pests. Several kinds of "biocides" such pesticides, insecticides, herbicides, and rodenticides must be used to eradicate these pests. This utility for biocides pollutes the air. This is due to the fact that when these harmful compounds are sprayed on crops, some of them are transported by the wind to various locations. As a result, the air that contains "biocides" is dangerous for both humans and other animals.

Here are a few examples of specific things that contribute to air pollution :

1 . Chlorine (Cl_2) gas is released into the air from a bleaching powder manufacturing facility.

2 . Businesses that extract metals from sulphide ores, such as Fe, Cu, and Zn, create SO_2 gas, which pollutes the air.

3 . The smoke that is emitted into the atmosphere by factories contains gases that pollute the air, such as CO_2, CO, SO_2, H_2S, NO_2, and NO.

4 . Different industries' dust pollutes the air.

5 . In 1952, London's haze claimed the lives of nearly 3000 individuals as a result of the buildup of 1.3 ppm SO_2 pollutants in the atmosphere.

6 . Methyl iso cyanate (MIC) vapour released into the cool winter atmosphere due to explosion from MIC tanks of Union carbide pesticide factory during the preparation of carbaryl or sevin, turned the city into a poisonous gas chamber. The Bhopal gas tragedy, which occurred on 3-12-1984, was regarded as the worst disaster in history and occurred in Bhopal, India. 18000 people died as a result, while 100,000 more were hurt. For numerous generations, the surviving will continue to experience genetic harm.

7 . Ozone deflection is brought on by nitrogen oxides (NOx), pollutants released from numerous plants.

8 . Air pollution is brought on by the radioactive waste that nuclear reactors release. High intensity gamma radiations are created during the enrichment of radioactive materials used in laboratories and hospitals.

9 . More than 2100 million tonnes of particulate matter are thought to reach the atmosphere each year.

10 . By 2047, there would be 30 crore tonnes of solid trash, 45 crore tonnes of ash waste, and other waste that contributes to air pollution.

Additionally, anthropogenic sources are two types i.e., stationary sources and non-stationary sources. Stationary sources include fossil fuel smoke stacks and biomass power plants, manufacturing facilities (factories), furnaces and other methods of waste incineration (incinerators as well as open and uncontrolled fires of unmanaged trash). Stationary sources again divided into two categories that is area sources and point sources. Examples of area sources includes residential heating, on site incineration, open burning, evaporative losses, institutional & commercial heating coal oil and gas. Examples of point sources include power plants, industrial processing, etc. On the other hand, non-stationary sources, also called mobile sources, includes facilities like motor vehicles, trains (especially diesel locomotives and DMUs), marine boats, and aircraft are. Non-stationary sources again divided into two categories that is area sources and line sources. Examples of area sources includes port vessels, railyard locomotives, etc. Examples of line sources include highway vehicles, channel vessels, etc.

1.6 Pollutants Transportation and Dispersion

Mean wind flow and atmospheric turbulence both affect how chemical contaminants are dispersed in the atmosphere. The friction of the ground surface, actual obstructions to

wind flow, and the vertical temperature profile of the lower atmosphere are a few examples of the elements that cause turbulence.

The level of turbulence in the atmosphere is described by the stability class. Stability typically refers to the lower portions of the atmosphere, where contaminants are released, when discussing air quality. Although the concept of discrete stability classes simplifies the complexity of the atmosphere, it has proven effective in research that aim to forecast future events.

A stable atmosphere is characterised by air that is colder on the ground than it is in the atmosphere, by slow-moving winds, and as a result, by little turbulence. Long distances can be travelled in a largely undamaged state by a pollution plume that has been released into a stable lower layer of the atmosphere.

On the other side, a high level of turbulence indicates an unstable atmosphere. An unstable environment may cause a visible plume to take on the recognisable looping pattern that turbulent eddies produce. The "neutral" stability class is a middle turbulence class between stable and unstable circumstances. The edges of a visible plume released into a neutral stability situation may stretch out in a V-shape, giving the plume the appearance of a cone. A layer of the atmosphere is referred to as an inversion when temperature rises with height as opposed to falling, as is typically the case. This inversion layer acts as a cap, stopping any further upward dispersion of chemical contaminants. As a result, pollutant levels will increase below the cap and a protracted period of such a pollutant buildup is commonly referred to as a stagnation event during which smog might form.

It has been common practise to erect taller stacks in order to lower emissions at a particular location. When pollutants are released from a source with a tall stack, the concentrations at ground level are typically lower than when the same quantity of pollutants are released from a source with a short stack. The ability of pollutants discharged from tall stacks, above the inversion layer, to travel great distances has been a problem despite the fact that a traditional method to air pollution prevention has been to build a taller stack. However, sources with the same stack height might have various effects based on the plume rise above the stack, which is influenced by the exit velocity of the emissions, the temperature of the emissions, and other factors. The term "effective stack height" refers to the sum of the physical stack height and plume rise over the stack.

Pollutants produced in the atmosphere or released into it eventually run out. Two other typical depletion mechanisms are dry deposition and washout, in addition to chemical transformation, which depletes precursors.

Dry deposition is the term used to describe the removal of both particles and gases from the ground surface. When rain or snow falls on the ground, water droplets and snow

pick up particles and gases in the atmosphere and remove them from the environment through washouts.

Precipitation must form within the clouds in order for wet deposition to really remove contaminants from the atmosphere. The pollutant mass remains in the atmosphere until there are no cloud components larger than around 100 microns in diameter, primarily due to the very small cloud drops' insignificant rates of fall.

Pollutant separation between water phases prevents the transmission of cloud water acidity to big particles, which do precipitate quickly. The majority of precipitation in mid-latitude storms is begun by the production of ice particles in the cold, upper reaches of the clouds. The acidity of precipitation typically tends to be significantly lower than that of the cloud water that remains aloft, in part due to such microphysical phenomena and in part due to non-uniform distributions of contaminants within the clouds.

The result of all of these consequences is that the air can become highly polluted, as evidenced by the quality of life in some inner-city neighbourhoods. Identification of the contaminants in the atmosphere, through precise sample techniques, is a critical issue where precision and dependability are a need.

1.7 Atmospheric Stability and Temperature Inversions

In well-mixed, dry air, the temperature drops by roughly 3.3°F (about 1.8°C) for every 1000 feet (300 m) of elevation gain. The value given is the typical lapse rate, which is the term for this vertical temperature gradient. A dense cold stratum of air at ground level is covered by lighter, warmer air at higher altitudes when the reverse or negative lapse rate occurs. The term "inversion" refers to this process. Inversions limit vertical air circulation, which causes pollutants to accumulate in the thicker air at ground level and below the inversion layer. As a result, the atmosphere remains stable and there is very little turbulence or mixing during temperature inversion. In these circumstances, air pollutants do not disperse.

Autumn and winter are when inversions are most common, and the buildup of smoke and other pollutants makes pollution much worse by keeping the sun's rays from warming the ground and the air around it. Because the temperature at ground level is below the dew point of the air's water vapour, fog is frequently linked to inversions. When horizontal air flow is constrained, inversions are more likely to occur in narrow valleys. Visibility is significantly decreased and pollutants are at their highest during inversions.

1.7.1 Types of Inversions

a. Radiation inversion: This phenomenon typically happens at night when the earth radiates heat away, cooling the air that comes into touch with it. Fog will form in wet air when the

temperature is below the dew point. Once warmer air has covered the cool air stratum, upward movement is halted until the following morning, the sun heats the lower air. Because to the longer nights, this kind of inversion occurs more frequently in the winter than in the summer. Such inversions may regularly occur in valley locations due to the surrounding high ground's restriction of horizontal air flow. In India, inversions end shortly after daybreak due to the tremendous sunlight heating of the ground. Yet, the presence of fog or mist at the same time as an inversion lengthens its duration by preventing sunlight from reaching the ground.

b. Inversion of subsidence It appears at low elevations and frequently lasts for several days. It is brought on by the air in anticyclones sinking or subsiding (high pressure areas surrounded by low pressure areas). Around the location, the air progressively lowers at a rate of around 1000 m each day. The air is heated and compressed as it sinks, creating a warm, dense layer. This serves as a cover to stop pollutants from rising. The inversion height can range from the level of the ground to 1600 metres. Extreme pollution happens when the distance is smaller than 200 m. Subsidence inversion and radiation inversion can sometimes happen at the same time. This occurrence is referred to as "double inversion."

1.7.2 Adiabatic Lapse Rate

The upward lift of air pollutants released into the atmosphere, and consequently their ultimate dispersion and dilution, are significantly influenced by the change in air temperature with height. The term "adiabatic lapse rate" refers to the pace at which a parcel of dry air rises in a hydrostatically stable atmosphere and gently expands to lower the atmospheric pressure without exchanging heat. 0.98°C/100 m is the dry adiabatic lapse rate. A smoke plume will rise into the atmosphere under adiabatic lapse rate circumstances due to its low density due to the greater temperature until it meets air of a similar density. The lapse rate, however, may frequently be more or lower than the adiabatic rate due to external heating or cooling factors. The super adiabatic lapse rate (rate greater than adiabatic) and the negative lapse rate are the two circumstances that are most crucial from the point of air pollution (inversion). During a sunny summer day, the sun's rapid heating of the earth warms the air close to the surface, causing the lapse rate to become super-adiabatic. The atmosphere is believed to be in an unstable equilibrium at this point, and there is a noticeable vertical mixing of the air as a result. This is a situation where contaminants spread out quickly.

1.7.3 Mixing Height

The mixing height is the fourth and key meteorological characteristic. It can be described as the height above the surface of the planet where relevant contaminants will travel mostly due to atmospheric turbulence. It usually has something to do with one or more of the three

wind-related variables: wind speed, wind turbulence, and wind direction. In other cases, it might be connected to all three.

After air pollutants are released into the sky, the weather has complete control over how they will behave going forward, or how they will disperse. The vertical extent of the mixing varies throughout the day, seasonally, and is also influenced by topographical characteristics. The amount of atmosphere that can be used to reduce the pollution concentration increases with vertical extent. The Maximum mixing depth (MMD), or convective mixing layer depth, is determined by thermal buoyancy effects. Mean maximum mixing depths (MMMD) are the average MMD values that are available for a month.

The temperature of an air parcel increases when it is heated by solar radiation at the surface of the earth. The air packet will climb inside the local atmosphere after heating until its temperature reaches the ambient temperature there. The height at which the air parcel and its surroundings reach equilibrium determines the maximum mixing depth or the top of the convective mixing layer.

When solar energy at the earth's surface warms an air parcel. In reality, the MMD is calculated using the actual temperature profile of the atmosphere many kilometres above the surface of the globe. Temperature readings are communicated back from various altitudes using a balloon that is launched into the air. They are plotted against height and are referred to as radiosonde measurements. On this plot, a dry adiabatic temperature line is also drawn, beginning at the highest surface temperature recorded for that particular month. The MMD is the height at which this dry adiabatic line crosses the radiosonde readings. Although morning measurements are also commonly performed, temperature sounding data are typically taken at night.

The MMD readings are typically lower at night and higher during the day. The value may be practically nil during a severe inversion at night, whereas values between 2000 and 5000 metres are typical during the day. The mean MMD varies seasonally, reaching its lowest point in the winter (December and January) and its highest point in the summer (May and June). When the MMD value is below 1500 metres, it has been observed that large urban air pollution episodes regularly happen. Although readings below threshold are very typical in many metropolitan areas, there is frequently a high risk for air pollution episodes. It is important to check that the MMD values are at least 2000 metres before situating an industry. Similar to the minimum surface, the minimum mixing depth, which typically occurs before sun rise, is calculated by adding 5°C.

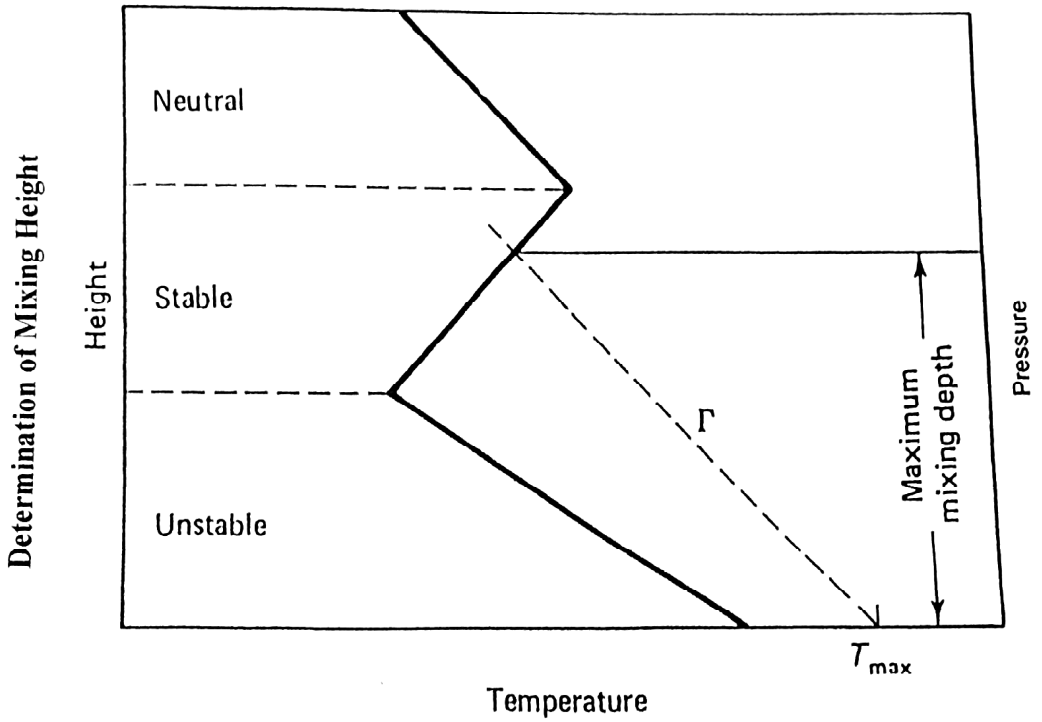


Figure 1.1 : *Mixing Hight : Adiabatic compared to ambient*
[Source : https://www.euromotor.org/mod/resource/view.php?id=14599]

1.8 Plume Behavior

The term "plume" describes the direction and size of the gaseous effluents that are emitted from a source, typically a stack, into the sky. Localized air stability determines how a plume released from any stack behaves. Because of the combined effects of buoyancy and velocity on plume rise, effluents from tall stacks are frequently injected to an effective height of several hundred metres above ground. The daily differences in air stability and the long-term alterations brought on by seasonal changes are further factors influencing plume behavior.

The vertical temperature and wind profiles affect the geometric shapes of stack plumes, and vice versa. By observing the plume, one may determine the stability condition and the atmosphere's ability to disperse particles. The environmental lapse rate determines a plume's behavior and dispersion throughout its entirety (ELR). According to Fig. 1.2, a portion of air expelled from a stack into the environment follows the Dry Adiabatic Lapse Rate (DALR) and reaches a temperature of about 16°C (depending on surface temperature and altitude). Nonetheless, the ambient temperature will be around 25°C. As a result, in the warmer and lighter environment, the denser parcel of air cannot rise upward.

Consequently, the most unfavorable circumstance for the dispersion of contaminants in the atmosphere is inversion. The temperature in the environment would drop at a quicker pace in a super-adiabatic atmosphere (n> 1.4), say 1.5°C/100 m, compared to the plume temperature, which would drop at the typical rate of 1°C/100 m. As a result, the temperature of a plume or parcel of air expelled from a stack is higher than the ambient temperature. Due to its reduced density, the air parcel is therefore continuously lifted aloft. Such an atmosphere is referred to be an unstable atmosphere since it has good pollution dispersion and low ground level concentrations.

The impact of temperature profile (also known as environmental lapse rate) and wind speed on the dispersion of pollutants released from a stationary source of smoke stack is depicted in Figure 1.2. It should be noted that the environmental lapse rate (ELR), which is typically positive at roughly 6.6°C/km, turns negative under exceptional circumstances, such as when an inversion occurs. Adiabatic lapse rate (ALR) is a term used to describe the rate at which the temperature falls in an ascending parcel of air as it slowly expands in a decreasing ambient pressure. The stability of the atmosphere is determined by the ratio of ELR to ALR in magnitude.

The spread of the plume is closely tied to the vertical temperature gradient, as illustrated on the left side of the picture, and several patterns of plume behaviour under various meteorological conditions are shown in Table 1.1.

a. ***Looping :*** This kind of plume has a wavy appearance. Rapid mixing results in a highly unstable atmosphere where it happens. High concentrations may develop close to the stack if the plume reaches the ground, however the high degree of turbulence aids in the plume's quick dispersion. Highly unstable (ELR > ALR)

During warm seasons with bright skies, it is related to turbulent air. Despite the fact that looping happens in unstable environments that are conducive to complete mixing, taller stacks might be required to avoid making contact with the ground too soon.

b. ***Coning :*** This kind of plume has a cone-like shape. When the wind speed is more than 32 km/h, this occurs in an atmospheric environment that is almost neutral (adiabatic condition). Yet, the plume travels farther to the ground than looping. Neutral or near neutral (wind > 32 kmph. Weakly stable, ELR < ALR)

The environment is neutral or only marginally stable when the ambient lapse rate is sub-adiabatic. As a result of the limited vertical mixing, there is a higher chance that the area will experience air pollution issues. Coning is the term for the typical plume in such circumstances. The visible plume has a horizontal axis and a cone shape of about 10 degrees. Compared to a looping plume, it disappears longer downwind. Coning happens when there are strong to moderate winds with gloomy skies, either during the day or at

night. Unlike to looping, the majority of the pollutant concentration in coning is carried quite far downwind before substantially reaching ground level.

c. ***Fanning :*** It is a specific kind of plume that is released when there is a severe inversion. In these circumstances, the plume will primarily extend horizontally and very little to none vertically. As a result, it is challenging to forecast ground level concentrations in this area. Strongly stable (ELR negative)

Large negative lapse rates (inversion and isothermal lapse rate) cause a "fanning plume," which causes a severe surface inversion to occur far above the stack height. There is very little turbulence and the winds are light, and the atmosphere is remarkably stable. The plume typically appears at night and in the early hours of the morning when the earth is being cooled by emitted radiation. For several kilometres downwind, a fanning plume may appear as a small horizontal fan with no vertical spreading. Warm wastewater causes the plume to climb gradually before drifting horizontally. The plume disperses very slowly and concentrates in a high altitude at a comparatively far distance downwind. Despite the possibility of turbulence, there is a limited likelihood of ground impact.

d. ***Lofting :*** When there is a significant lapse rate above a surface inversion, lofting takes place. The inversion layer is not penetrated by downward diffusion under these circumstances, despite rapid upward diffusion. These circumstances prevent emissions from rising to the surface. Stable, but inversion above plume source.

In the late afternoon and early evening, when the sky is clear, "lofting" rules. When the sun has set, radiation from the surface causes an inversion layer to form close to the ground. A lofting plume will become a fanning plume as the inversion layer deepens. The plume has a well-defined bottom and diffuses to the top in the shape of loops or cones. The winds in the upper layer are moderately turbulent and significant, but they have minimal effect on the winds in the layer below. The likelihood of ground contact during lofting is limited unless the inversion layer is shallow. Since there is little chance of contaminants coming into contact with the ground, it is regarded as the ideal setting for dispersion.

e. ***Fumigation :*** When the air becomes unstable, pollutants that are high in the air are quickly transported to the ground level. Stable, inversion aloft, but inversion layer above plume source.

Fumigation plumes develop when a stable air layer is located just above the plume's discharge point and an unstable air layer is located directly beneath the plume. It happens when an inversion transitions to a normal state and when there is a sea wind in the late morning or early afternoon. Except when there is a sea breeze, it stays for a maximum of 30 minutes. In that case, it stays for several hours. A negative temperature gradient from the base upward forms as a result of the morning sun heating the ground. Large amounts

of stack gas will be carried downwind to the surface once the newly developed unstable layer reaches the height of the stack. Although there is simply thermal turbulence in the bottom layer, the winds are light to moderate both above and below. Concentrations at ground level are high, particularly when the plume has stagnated above. Fumigation typically forms in the summer and is more common when there are no clouds and little breeze. The typical beginning is when a fanning plume fragments into a looping plume.

f. ***Trapping :*** The term is used to describe circumstances in which a plume is stuck between two inversions and can only spread to a certain vertical height. The lofting plume is the preferred method for reducing air pollution. From the perspective of ground level pollution concentrations, the fumigating and trapping plumes are extremely important. Stable, inversion both above and below the source.

With an unstable atmosphere sandwiched between the two inversion layers and occurring in a stable atmosphere, it can only spread up to a certain vertical height. Any season, any time of day, may see it happen. When linked to subsidence inversions, it can endure for several weeks, as it did in Los Angeles, whereas when linked to warm frontal inversions, it only lasts a few hours. One of the worst pollution crises exists right now.

g. ***Neutral Plume :*** Until it hits air with a density akin to the plume itself, it has a tendency to rise straight into the atmosphere. If the wind speed is greater than 10 m/sec and the cloud cover blocks both the solar radiation during the day and the terrestrial radiation at night, it frequently converts to coning. Neutral or near neutral (ELR~ALR)

When choosing where to take air samples, it can be helpful to observe these apparent smoke plumes. Understanding plume characteristics is also useful for addressing invisible pollution. Nonetheless, caution should be exercised to prevent optical illusions when witnessing a plume (for example, a plume may be visible for several kilometres yet not extend upward for a small fraction of a kilometre). This may be accomplished by simultaneously or consecutively viewing the plume from two sites that are at right angles to one another.

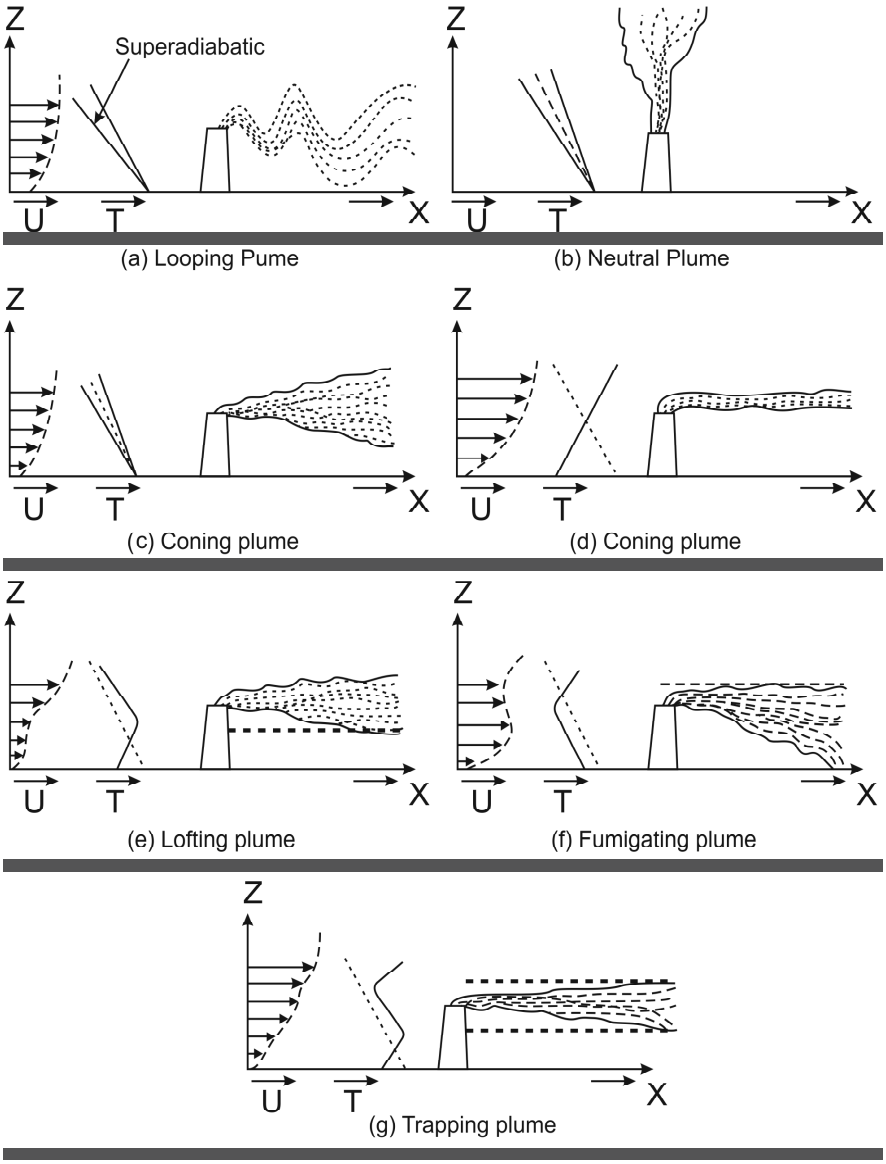


Figure 1.2 : *Different types of Plume Behavior*

Table 1.1 : ***Demonstrates the diverse characteristics of plumes***

Type	Description of visible plume	Despersion and ground contact	Associated wind and turbulence	Temperature profile and stability	Typical Occurrence
Looping	Irregular loops dissipate in relatively rapidly with distance.	Disperses rapidly with distance large high concentrations sporadically at ground relatively close to the stack.	Light winds with intense thermal	Adiabatic or super adiabatic Unstable. Inverted and isothermal lapse rate. Very stable.	During day time with clear or cloudy skies and intense solar heating.
Coning	Cone shaped with horizontal axix, dissipates further down-wind than looping plume.	Disperses less rapidly with distance than looping plume, large probability of ground contact some distance down-wind. Concentration less but persists longer than looping plumes.	Moderate to strong winds. Turbulence largely mechanical rather than thermal.	Lapse rate between dry adiabatic and isothermal. Neutral or stable	During windy conditions, day or night. Layer type cloudiness favoured in day.
Fanning	Narrow horizontal fan. No vertical spread for kms down-wiind. If effluent is warm, plume	Disperses slowly, con-centration aloft high at relatively great distance downwind, small pro-bability of	Light winds. Very little turbulence.	Adiabatic lapse rate at stack top and above. Inverted below stack. Lower layer stable, upper layer neutral	At night and in the early morning, any season usually favorite- ed by light winds.

	rises slowly, then drifts horizontally.	ground contact, thoght increase in turbulence can result in ground contact,		or unstable.	
Lofting	Loops cones with well defined bottom.. Diffuses to top.	Probability of ground contact is small unless inversion layer is shal-low, considered to be the best condition for dispersion since pollutants are dispersed in upper air with small probability of ground contact.	Moderate winds and considerable turbilence aloft, very light winds, and little turbulence in layer below.	Adiabatic or supper adiabatic lapse rate at stack top and below.	During change from lapse to inversion condition. usually near sunset on fair days.
Fumigation	Fan or cone with well defined cone and dragged or diffused bottom.	Large probability of ground contact in relatively high concentration. especially after plume has stagnated aloft.	Winds light to moderate aloft and light be low. Thermal turbulence in lower layer, little turbulence in upper layer.	Isothermal or inverted lapse rate above. Lower layer. unstable or neutral upper layer stable.	During change from inversion to lapse condition, may Occur with sea breeze in late morning or early after-noon.

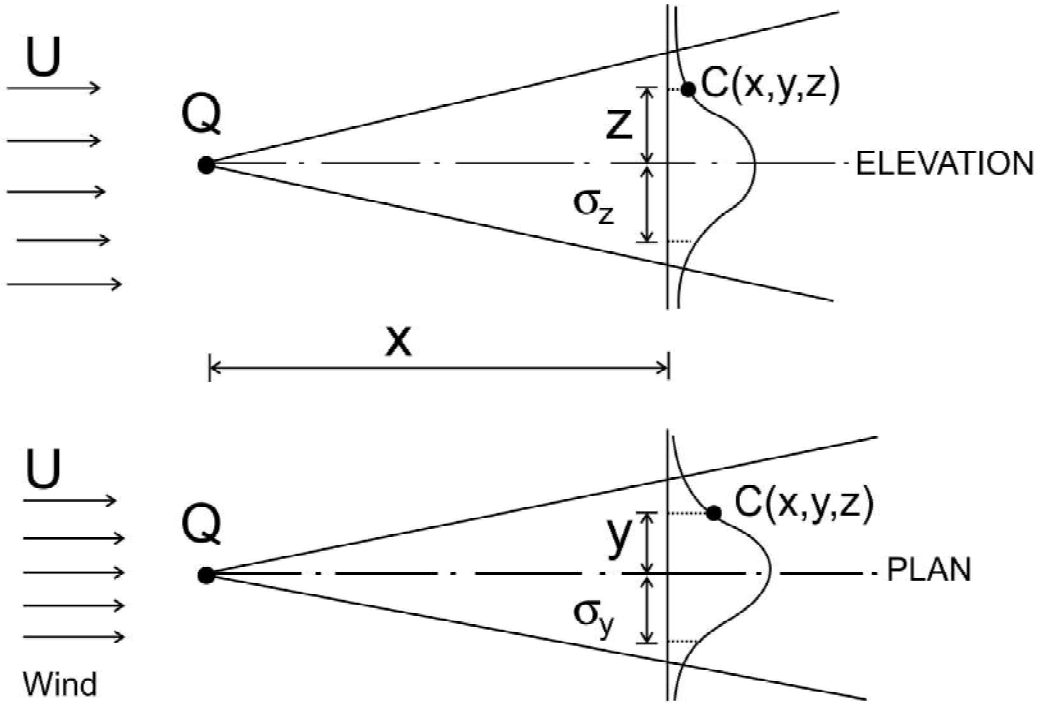
1.9 Gaussian Plume Model

A mathematical simulation of the physics and chemistry driving the transport, dispersion, and transformation of pollutants in the atmosphere is known as an atmospheric dispersion model. In addition, it entails estimating downwind air pollution concentrations using data on pollutant emissions and atmospheric composition.

The most popular methods for determining the effects of nonreactive contaminants are gaussian models. The most of the people utilize it. In the Gaussian Dispersion Model, it is assumed that molecular diffusion accounts for the majority of the plume dispersion, pollutant concentrations in the plume are regularly distributed (double Gaussian distribution), both horizontally and vertically, and the spread and shape of the plume change depending on the weather.

1.9.1 Development of Gaussian Dispersion Model

Imagine a point source in the air that continuously releases a pollutant at a rate Q (kg/s). The wind is blowing continually at a speed of U (m/s) and in the direction x (measured in metres from the source). The plume expands as it moves in the x direction, resulting in local concentrations C(x,y,z) (kg/m^3) that form distributions with "Gaussian" or "normal" forms in planes parallel to the x direction at every point in space.



The profile shape in the lateral, or y, direction is determined by

$$\frac{1}{\sigma_y \sqrt{2\pi}} e^{\left(\frac{-y^2}{2\sigma_y 2}\right)}$$

While moving vertically, or in the z direction, it is indicated by

$$\frac{1}{\sigma_z \sqrt{2\pi}} e^{\left(\frac{-z^2}{2\sigma_z 2}\right)}$$

The Gaussian distributions' parameters y and z (m), which represent the spread of the plume in the y and z directions, respectively, are standard deviations. They grow as you move away from the source by x. The area under the distribution, determined by integration of the functions given above between plus and minus infinity, is equal to unity.

The function describing the form of the distribution in three dimensions a sort of pollutant "hill"-is obtained by multiplying these two-dimensional shape distributions together.

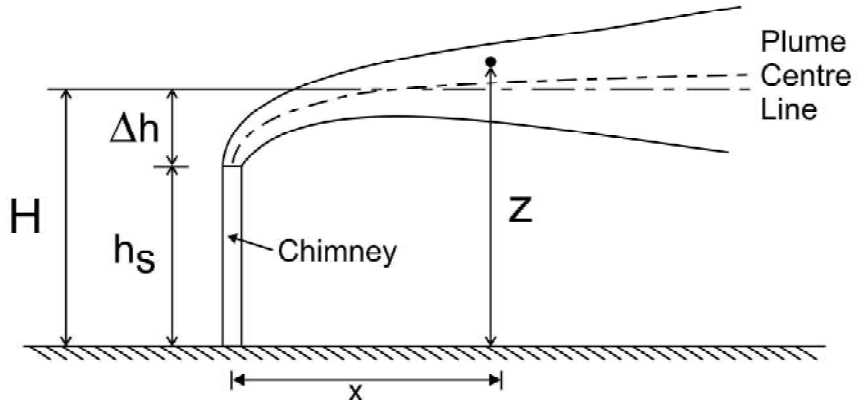
$$\frac{1}{2\pi\sigma_y \sigma_z} e^{\left(\frac{-y^2}{2\sigma_z 2}\right)} e^{\left(\frac{-z^2}{2\sigma_z 2}\right)}$$

Every point's concentration is provided by

$$C(x, y, z) = \frac{Q}{U} \frac{1}{2\pi\sigma_y \sigma_z} e^{\left(\frac{-y^2}{2\sigma_y 2}\right)} e^{\left(\frac{-z^2}{2\sigma_z 2}\right)}$$

As a result, the concentration is determined by multiplying the shaping function by the rate of emission from the source, which is then divided by the wind speed.

This distribution measures y and z typically from the x-axis, which is also sometimes referred to as the plume's centre line. The source will typically be elevated above the ground in practise (for example the exit of a chimney). Hence, in order to measure the z coordinate from the ground, we must change it.



Where, H is the center-line effective height of the plume (m)

hs stands for height above ground (m)

Δh (m) is initial plume rising,

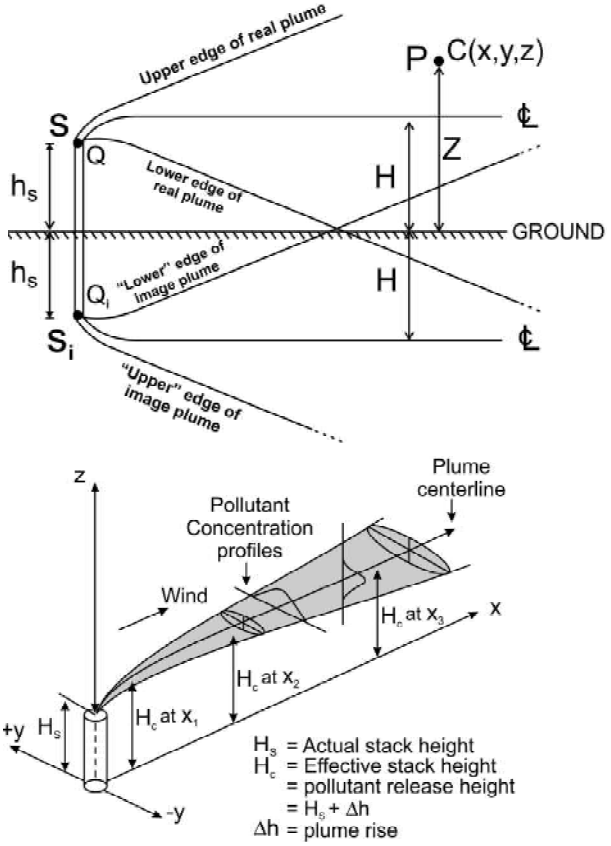
Z is a coordinate that represents a position in the plume as measured vertically from the ground (m)

Hence, the new vertical coordinate is (Z-H) with respect to the plume axis.

$$C(x,y,z) = \frac{Q}{U}\frac{1}{2\pi\sigma_y\sigma_z} e^{\left(\frac{-y^2}{2\sigma_y{}^2}\right)} e^{\left(\frac{-(z-H)^2}{2\sigma_z{}^2}\right)}$$

This equation still has to be changed in one more way. Contrary to a plume that spreads in free air, most plumes are released near to the ground, as in the case of the chimney in the image above. So, when the plume goes downwind from the source, it will eventually "strike" the earth as it spreads downward (as well as above). There is no way the plume can keep extending into the ground. As opposed to that, it is "reflected" back into the air above the ground. Through the use of a fake "mirror-image" source (Si = S) with the same strength (Qi

= Q) and location at the same height from the ground (λs), the influence of the ground boundary is quantitatively accounted for in the concentration equation.



As a result, at every position P, both the genuine source (S) and the hypothetical source (S) contribute to the concentration C(x, y, z) (Si). The vertical distance between P and the true plume's centre is (z-H). P is located (z+H) vertical distance from the imagined source's centre. For both sources, the lateral distance (y) into the page is the same.

As a result, P's overall concentration is

$$C(x,y,z) = \frac{Q}{U}\frac{1}{2\pi\sigma_y\sigma_z} e^{\left(\frac{-y^2}{2\sigma_y^2}\right)}\left[e^{\left(\frac{-(z-H)^2}{2\sigma_z^2}\right)} + e^{\left(\frac{-(z+H)^2}{2\sigma_z^2}\right)}\right]$$

We can simplify the equation by putting z=0 if just ground-level concentrations are needed, such as when determining how much exposure crops or people have to the contaminant. These results

$$C(x,y,0) = \frac{Q}{U}\frac{1}{\pi\sigma_y\sigma_z} e^{\left(\frac{-y^2}{2\sigma_y^2}\right)} e^{\left(\frac{-H^2}{2\sigma_z^2}\right)}$$

The highest level of concentration is reached when

$$\sigma_z = \frac{H}{\sqrt{2}}$$

The concentration fluctuates in proportion to $1/(\sigma y \,.\, \sigma z)$ at far-off locations when z is significantly bigger than H.

Since both z=0 and y=0, the equation is further simplified if just concentrations at ground level on the center-line of the plume (in the x-axis direction) are required. As a result,

$$C(x,0,0) = \frac{Q}{U}\frac{1}{x\sigma_y\sigma_z} e^{\left(\frac{-H^2}{2\sigma_z^2}\right)}$$

Using the fundamental equation, we can calculate the concentration (C) at any location if we know the rate of emission from the source (Q), the predominant wind speed and direction (x), and the height of the centre of the plume above ground (H) (x,y,z). To accomplish this, though, we must first learn about the plume spread by getting values for σy and σz.

There are numerous formulae and semi-empirical expressions that can be used to calculate σy and σz under various atmospheric stability scenarios. When the source is high above the ground (as at the top of a chimney), a good approximation in areas close to the source is

$$\sigma y = Iy \,.\, x \text{ and } \sigma z = Iz \,.\, x$$

where Iy and Iz are, respectively, the turbulence intensities (turbulence speed fluctuations) in the y and z directions.

It has been discovered that, under neutral air conditions, Iy and Iz may be calculated as spanning a range of heights corresponding to the vertical plume dispersion, centred at about hs.

$$I_y = \frac{0.88}{In\left(\frac{h_s}{z_o}\right) - 1}$$

$$I_z = \frac{0.50}{In\left(\frac{h_s}{z_o}\right) - 1}$$

where "ln" stands for the natural log, "hs" for release height, and "zo" for aerodynamic roughness, all of which indicate various topographic ground conditions (see notes on atmospheric boundary layers). Both this straightforward model for turbulence intensities and the estimates we used previously in the course for Ix, Iy, and Iz may be applied in practise. The following typical values apply to broad cases of various atmospheric conditions:

Thermal stratification	**Lateral intensity (Iy)**	**Vertical intensity (Iz)**
Extremely unstable	0.40 - 0.55	0.15 - 0.55
Moderately unstable	0.25 - 0.40	0.10 - 0.15
Near neutral	0.10 - 0.25	0.05 - 0.08
Moderately stable	0.08 - 0.25	0.03 - 0.07
Extremely stable	0.03 - 0.25	0 - 0.03

As atmospheric conditions become increasingly unstable, it may be observed that the turbulence intensities, particularly the vertical wind speed fluctuations, rise.

The plume rise (h) is an additional aspect that must be taken into account in practise. This is the center-line plume's course or trajectory from the time it leaves the source. The quantity of buoyancy and vertical momentum in the first plume at the source, as well as the atmospheric conditions, all affect the course of the plume.

The variation in plume rise due to buoyancy forces is $x^{2/3}$.

The plume rise varies with $x^{1/3}$ due to momentum forces.

So, the forces that control the plume will determine the trajectory's shape. According to atmospheric conditions, the chimney plume can ascend to a maximum level between h = 0.2 hs and h = 0.6 hs above the source, depending on the turbulence intensities, especially if they

are buoyant. An approximate expression for the end plume increase, if the initial plume momentum dominates, is

$$\Delta h = \frac{3\,D\,W}{U}$$

where D is the source's diameter, such as the diameter of a chimney's exit (m)

W is the plume's initial vertical velocity (in m/s).

In reality, the initial vertical velocity frequently resembles the current wind speed. Hence, the final plume rise is in the range of 9m for a standard chimney diameter of, let's say, 3m. Many times, the value of the plume rise is so negligible in comparison to the size of the plume and the magnitude of the release height that the plume centre line may be assumed to be horizontal for convenience.

1.10 Acid Rain

Mankind has long treasured rain since only adequate and timely rainfall makes healthy crops and copious water sources feasible. Summer downpours renew people. The aquifers are refilled and the groundwater is purified during spring rains. The air is purified by winter snow and autumn rain. In general, rain evokes feelings of optimism, vigour, and promise for the future.

In some places of the world, however, simple rainfall has acquired a dangerous complexity over the past several decades. In these areas, where the atmosphere is contaminated with nitrogen and sulphur oxides (SOx), rain must travel through it (NOx). Sulfuric acid, nitric acid, and water are frequently produced as a result of the pouring rain and snow reacting with these oxide pollutants. This is referred to as acid rain or acid precipitation.

Due to the reaction of atmospheric CO_2 with water to form carbonic acid, rain typically has a pH of 5.6 to 5.7. Nonetheless, although not being extremely acidic, this modest quantity of acidity is sufficient to dissolve minerals in the earth's crust and make them accessible to plant and animal life. The natural sources of acidity in rain also include various air components from volcanic eruptions, forest fires, and other similar natural events. Even so, typical rainfall is able to digest the massive amounts of acids that nature produces each year to the point that they do little to no known harm.

However, the contributions of SOx, NOx, etc. from anthropogenic activities upset this acid equilibrium and turn naturally occurring, moderately acidic rain into precipitation, having

significant negative effects on the environment. Hence, any sort of precipitation with a pH below 5.6 is considered acid rain. The pH of typical rain is little around 6, which makes it mildly acidic. The mild carbonic acid that results from the dissociation of dissolved carbon dioxide is what causes this natural acidity. Sulfur from volcanic eruptions, impurities in fossil fuels, and nitrogen from the air combine with oxygen to generate sulphur dioxide and nitrogen oxides, which are what is known as "acid rain." They dissipate into the atmosphere, where they combine with water to generate soluble sulfuric and nitric acids, which then fall as rain. In addition, some hydrochloric acid is created.

Gas phase chemistry of acid rain

By a tri-molecular interaction with the hydroxyl radical, sulphur dioxide is oxidised in the gas phase:

$$SO_2+OH+M \rightarrow HOSO_2+M$$

$$HOSO_2+O_2 \rightarrow HO_2 + SO_3$$

In the presence of water sulfur trioxide is converted rapidly to sulfuric acid:

$$SO_3 + H_2O+M \rightarrow H_2SO_4 + M$$

Nitric acid is formed by the reaction of OH with nitrogen dioxide:

$$NO_2+OH+M \rightarrow HNO_3 +M$$

Sulfur dioxide dissolves in water, then, like CO_2, hydrolysis in a series of equilibrium reactions:

$$SO_2 (g) + H_2O \leftrightarrow SO_2 H_2O$$

$$SO_2 H_2O \leftrightarrow H^+ + HSO_3^-$$

$$HSO_3 \leftrightarrow H^+ + SO_3^{2-}$$

1.10.1 Sources of Acid Rain

As mentioned in the earlier sections, a sequence of photochemical reactions and chemical reactions catalysed by other species in the environment cause SOx and NOx emissions into the atmosphere to finally be transformed into H_2SO_4 and HNO_3 droplets. With bases such particulate lime, NH, etc., these acid droplets are partially neutralised. Acidic precipitation, often known as "Acid Rain," is created by these salts, the residual H_2SO_4 and HNO_3 droplets, HCI, and HCl emissions from both natural and man-made sources. Following species were discovered through analysis of acid rain samples: H, NH, Na, K, Ca, Mg, SO, NO and Cl.

The three acids all contribute to acid rain in roughly the same proportions. H_2SO_4>HNO_3>HCl Acid rain may occur far from the sources of the pollution, perhaps even 500 to 1000 kilometres away.

1.10.2 Effects of Acid Rain

Because of the significant SOx and NOx emissions into the atmosphere from large industrial locations, acid rain is one of the main effects of air pollution. The more time SO and NO spend in the atmosphere, the more likely it is that one of the many photochemical and catalytic chemical reactions will result in their oxidation to H_2SO_4 and HNO_3. Acid showers have the potential to seriously harm a variety of materials and terrestrial ecosystems, including water, fish, plants, stone, steel, paint, soil, and people.

Effects on materials and terrestrial ecosystems

1. Pitting and mechanical weakening caused by the acidic components' attack on architectural and structural materials, as well as priceless ancient statues carved from marble, limestone, sandstone, etc. According to reports, acid rain damage caused stone statue deformation and deterioration in nations like Greece and Italy. If appropriate steps are not taken, architectural landmarks like the Taj Mahal in our nation will be threatened in a similar way.

2. Soil acidification and its consequences on soil fauna, microbial life, and nitrogen fixing. Moreover, there are indirect repercussions from changes in soil chemistry brought on by soil acidification, which lowers forest production.

3. Damage to crops and forests from foliar growth, nutrition loss from leaves, and modifications to seed germination traits. Injury to tissues of young, growing plants and the photosynthesis process, which impedes plant growth and jeopardises their survival.

4. Acidification, a decline in alkalinity, and the mobilisation of metals like aluminium are potential repercussions on aquatic systems.

5. There are also other biological consequences on aquatic life, such as altered species compositions in plankton, flora, and invertebrates, a drop in fish and amphibian productivity, skeletal abnormalities, and higher fish mortality rates.

6. Corrosion of steel, zinc, paints made of oil, and automotive coatings.

7. Potential impacts on people. Skin, hair, and lungs could be impacted. Acid rain's heavy metal emissions could also pose a harm to human health. Increases in heavy metal concentrations and acidification of drinking water reservoirs may go beyond acceptable levels for public health and have harmful impacts.

Acid rain's effects on aquatic systems

The loss in fish population, which is particularly detrimental to recreational fishing, is the most significant impact of acid rain on aquatic systems. Economic impact is the indirect result on tourism. The decline of specific zooplankton, algae, and aquatic plant species, which upsets the lake's overall food chain and could lead to ecological imbalances, are other aquatic impacts of acid rain. These include effects on humans who consume fish that have higher metal concentrations in their flesh. Trout and Atlantic salmon are particularly sensitive to low pH levels, which interfere with their reproductive activities and frequently result in skeletal malformations, as studies have amply shown.

Fish and maybe other delicate biota, such planktonic crustaceans, are frequently killed by high aluminium concentrations in acidifying water. Aluminum concentrations are quite low in lakes that are alkaline or nearly neutral. But, as the pH falls, the previously insoluble aluminium that is present in very high amounts in rocks, soils, and sediments from rivers and lakes starts to dissolve. At low concentrations (between 0.1 and 1 mg/l), aluminium is remarkably toxic to a variety of aquatic life once it is in solution. Although the content of aluminium rises exponentially below a pH of 4.5 to 4.7, fish poisoning starts to occur at this pH. Aluminum that is free and ionic occurs primarily below 4.2 and is exceedingly hazardous. The hydroxyl forms prevail at a pH of about 5.0, and the toxicity decreases above and below this pH. At pH 5.0, aluminium concentrations of 0.2 mg/l or above harm fish gills and cause brown trout and whitesucker gills to secrete mucus. The gills appear to be plugged by the slimy mucus, leading to breathing issues. Moreover, the semipermeable gill membranes, which allow for the exchange of gases and salts, lose some of their fundamental integrity. In light of this, it appears that aluminium may also be a significant hazardous component in water with a pH of 5.0 and for sure at 4.0, in addition to an increase in H^+ ions as a cause of fish deaths and population decreases. For the protection of their external skeletons, some groups of biota, such as the molluscs (animals with shells, such as snails, limpets, mussels, and oysters), heavily rely on calcium. They cannot thrive in such water because acidic water easily dissolves calcium carbonate and prevents these organisms from absorbing calcium.

Effects on forests

Our woodlands are under a sneaky, perhaps fatal threat from acid rain. It has been demonstrated that somewhat acidic rain can harm seedlings (pH 4.6). Researchers are starting to examine how acid rain affects a tree's susceptibility to disease and insects. Although there is no direct evidence of acid rain harming foliage directly, the abrupt and spectacular loss and dieback of trees in Central Europe is a driving force behind such worries.

Effects on trees : Depending on the country's geography and the acidity of the rain, acid rain's effects on trees can range from mild to severe. Acidic precipitation, acidic fog, and acidic mist harm leaves and needles' surfaces, lessen a tree's resistance to cold, and prevent plant germination and reproduction. As a result, the tree's vitality and capacity for regeneration are diminished.

Effects on crops : There is no conclusive proof that acid rain has yet injured agricultural leaves in the field, despite the fact that many crop species appear to be far more sensitive to direct foliar damage than many tree species.

Groundwater and drinking water quality

Surface water percolates through the soil and bedrock to the water table, where it slowly builds up as groundwater.

According to scientific data, some locations are experiencing groundwater acidification and the subsequent metal contamination that results from this. Lead, copper, and zinc are the main metals of concern because they may seep from water pipelines and containers, and aluminium because it comes from the bedrock itself.

Corrosion of water pipes

Water pipes deteriorate from acidic water. Naturally, this increases the need for pipe repair, but it also increases the danger that individuals could directly consume metals that have leached from pipe walls. Older homes continue to have lead pipes, which are also typical in older homes in Britain and Ireland. Another common use is for high-zinc galvanised pipes. Below pH 5.0, as well as with rising temperature, copper solubility increases significantly. Acidic water inside hot water pipes makes them particularly prone to dissolving.

Effects on buildings, materials and paint

Many airborne contaminants, such as acid rain, damage stone structures, statues, and monuments. Steel, paint, plastics, cement, masonry, galvanised steel, limestone, sandstone, and marble are among the building materials that are susceptible to harm. Sulfur dioxide and its byproducts are widely acknowledged to be the primary single corrosive agent of construction materials. Sandstones and limestones are frequently used as building materials for statues and monuments. Both corrode more quickly in city air that is high in sulphur than in rural air that is low in sulphur. The calcium carbonate in sandstone or limestone reacts with sulphur pollutants when they are dumped on the surface, turning it into the easily soluble calcium sulphate (gypsum), which is washed away in the rain.

1.10.3 Remedial and Control Measures of Acid rain

Reducing SOx and NOx emissions is the only workable solution to the acid rain issue. For this, the following three standard alternatives are taken into account:

1. Energy conservation results in less fuel consumption and hence fewer SOx and NOx emissions. It is also being researched how to conserve through increased thermal insulation and more effective fuel use.

2. The desulfurization and denitrification of fuels used in stack gases, increasing usage of fuels with low sulphur content naturally occurring, or application of technologies that lower SOx and NOx emissions Currently, and possibly for some time to come, the only effective management methods are desulfurization and the deployment of low NO-producing technology.

3. Future remedies to this issue might include substituting other alternative energy sources for fossil fuels.

By using methods like coal cleaning, coal gasification, and desulfurization of liquid fuels, as well as by removing the sulphur content during combustion as in fluidized-bed combustion, as well as by removing the sulphur emissions after combustion as in stack or flue gas desulfurization systems of scrubbers, it is possible to reduce SOx emissions. The development of these strategies will determine SOx, control from conventional fuel sources in the future.

The design of the furnace and burners can be changed, as well as the operating conditions, to reduce NOx emissions from stationary combustion sources. Currently, it is possible to modify combustion by employing two-stage combustion, carefully regulating airflow, injecting water during burning, recirculating flue gases, and/or changing the architecture of firing chambers. With equipment like a 3-way system that simultaneously decreases carbon monoxide, hydrocarbons, and NOx, as well as lowering engine combustion temperatures, it is possible to reduce NOx emissions from mobile combustion sources.

1.11 Bio-Pollutants

Bacteria, viruses, cat saliva, home dust, mites, cockroaches, and pollen are examples of biological pollutants. Living beings produce or cause biological pollutants. Some kinds of asthma, allergic rhinitis, and hypersensitivity pneumonitis are brought on by certain biological pollutants. The air is a common way for infectious diseases like the flu, measles, and chicken pox to spread. Toxins that cause illness are released by moulds and mildew. Sneezing, wet eyes, coughing, shortness of breath, dizziness, tiredness, fever, and stomach issues are examples of biological pollution' health effects.

1.11.1 Sources

1. Pollens, which come from plants,
2. Pollens, which come from plants,
3. viruses, which are spread by people and animals,
4. mould
5. bacteria, which is spread by people, animals, soil, and plant debris,
6. household pets, which are sources of saliva and animal dander (skin flakes), cockroach, rodent, and other pest or insect droppings,
7. viruses, and bacteria
8. Rat and mouse urine contains a protein that is a strong allergen. It has the potential to fly when it dries.
9. Contaminated central air handling systems can grow mould, mildew, and other biological contaminants, which can subsequently spread throughout the house.

1.11.2 Effects of Bio-pollutants

Only after repeated exposure to a particular biological allergen do allergic responses develop. Yet, that response could happen right away after a subsequent exposure or after several exposures spread out over time. As a result, individuals who previously experienced relatively minor allergic reactions or none at all may find that they are suddenly extremely sensitive to certain allergens. Certain illnesses, such as humidifier fever, are linked to toxins produced by bacteria that can flourish in sophisticated building ventilation systems. These illnesses are also linked to microorganisms that thrive in humidifiers and residential HVAC systems. Disease-causing biological agents in the indoor air are especially dangerous to children, the elderly, those with breathing issues, allergies, and lung conditions. Asthma can be brought on by mould, dust mites, pet dander, and bug droppings or dead bodies. A sizeable fraction of the population can develop allergic reactions to biological pollutants like mould and pollen. It is recognised that certain diseases can be spread through the air, including influenza, measles, staphylococcus infections, and Legionella.

1.11.3 Control of Bio-pollutants

Maintenance of the heating and cooling systems as well as general excellent housekeeping are crucial. Good air circulation and enough ventilation are also beneficial. Moisture management is essential for controlling mould. If there is mould, remove the mould and any extra water or moisture. Mold, dust mites, and cockroaches can all be managed by keeping the relative humidity between 30% and 60%. Control insect and animal allergens by using

integrated pest management. There are methods for treating cooling towers that can lower Legionella and other microbial levels. Install and operate outdoor-ventilated exhaust fans in bathrooms and kitchens, and vent clothes dryers outside.

The moisture that accumulates from daily activities can be greatly reduced by these procedures. There are quiet exhaust fans available on the market, which is a crucial factor for some people. Using exhaust fans in the kitchen and bathroom also has the advantage of lowering the amount of organic pollutants that are vaporised from hot water used in showers and dishwashers.

Ventilate the crawl space and attic to keep moisture from accumulating.

Water condensation on building materials can be avoided by keeping humidity levels in these regions below 50%.

Whether utilising cool mist or ultrasonic humidifiers, clean equipment as directed by the manufacturer and top it with fresh water every day. These humidifiers have the potential to spread biological pollutants and result in illnesses including humidifier fever and hypersensitivity pneumonitis. Moreover, evaporation trays in refrigerators, dehumidifiers, and air conditioners should be cleaned frequently.

Water-damaged carpets and building materials must be thoroughly cleaned and dried (within 24 hours, if possible), or removal and replacement may be an option. Mold and bacteria can grow on carpets and in construction materials that have been flooded. Complete biological contamination removal from such materials is quite challenging.

Keep your home tidy. Although they cannot be completely removed, household dust mites, pollens, animal dander, and other allergens can be decreased with routine cleaning.

Allergy sufferers should wear allergen-proof mattress covers, wash bedding in hot (130° F) water, and stay away from dust-collecting room furniture, especially if they can't be washed in hot water. Also, allergic people should leave the house while it is being vacuumed because this might actually raise the amount of mite allergens and other biological contaminants in the air. It might also be beneficial to use central vacuum systems that are vented to the outside or vacuums with high-efficiency filters.

Reduce biological contaminants in basements by taking appropriate action. The basement floor drain should be cleaned and sanitised frequently. Finishing a basement below ground level is not advised unless all water leaks are repaired, external ventilation is installed, and sufficient heat is provided to prevent condensation.

Keep animals that cause allergies away from your home: Avoid owning some animals as pets if you have an allergy to them, such as cats. Many allergies are brought on by animal dander (dead skin cells) and other shed animal particles. Animals with short hair or those that don't shed (like hamsters) may make better pets.

Utilize mattress and pillow covers that are "mite-proof" Special covers for the bedding can be helpful for those who are allergic to dust mites. To kill mites, wash pillowcases, mattress covers, and sheets in hot (not warm) water.

1.12 Air Pollution Impacts

There are three areas of study on the impact of air pollution:

i. Human health effects of air pollution
ii. Effect of air pollution on Materials
iii. Effect of air pollution on some particular Materials

1.12.1 Effects on Human

The health of both adults and children is significantly impacted by air pollution. Particles are a diverse group of pollutants, including nitrates, sulphates, carbon and acid aerosols. Depending on the time and place, airborne particles have different sizes and compositions. Adults who are exposed to low concentrations of the pollutant will have symptoms like coughing, chest pain, sore throats, and occasionally headaches. The impact of air pollution immediately affects the lung, an extraordinarily complex organ. More than 40 different types of cells can be found in the lung. Each of these cells is crucial to sustaining the body's health and fitness. By harming the lung cells that are most vulnerable to damage, air pollution can alter lung tissue. The lungs may not develop to their full potential if the cells necessary for the creation of new functioning regions of the lung suffer injury. Although the prevalence of other disorders like allergic responses, bronchitis, and respiratory infections has also been rising, asthma may be the most common condition with a growing frequency. Gaseous pollutants like ozone, sulphur dioxide, nitro-gen dioxide, and carbon monoxide are frequently present in the environment, which exacerbates the issue. Recent studies have shown that babies exposed to air pollution during the development of their organs may experience long-term alterations to those organs. Research on newborn rats demonstrated that exposure to carbon monoxide could alter the cardiac muscle tissue. The Table 1.2 below shows various health effects due to different air pollutants :

Table 1.2 : ***Human health effects of major air pollutants***

Pollutant	Health effects
Carbon monoxide	Reduction in oxygen-carrying capacity of blood
Sulfur dioxide	Irritation of eyes, and respiratory system, increased mucus production, cough and shortness of breath
Oxides of nitrogen	Irritation of pulmonary tract affecting functioning of lungs
Hydrogen sulphide	Excessive inhalation leads to death
Hydrocarbons Chlorine	Lung cancer irritation of mucous membrane
Suspended particulate matter	Respiratory diseases
Dust	Silicosis
Asbestos	Asbestosis
Acids and aldehydes	Eyes, nose and throat irritation
Ammonia	Irritation of mucous membrane
Pesticides	Depression; leads to death if inhaled in excess
Beryllium	Fatal to heart and manufacture of house- lungs
Lead	Cumulative poison, impairment of central nervous system
Arsenic	Toxic
Manganese	Damages nerves and reproductive systems
Benzene	Leukemia, chromosomal damage

a. **Domestic Pollution** : The worst form of air pollution could be the wood smoke inhaled by women while cooking.

b. **Vehicle Pollution :** There are three main categories of vehicles: passenger cars and jeeps with four-stroke engines, two- and three-wheelers with tiny two-stroke gasoline engines, and buses, lorries, and light commercial vehicles with four-stroke diesel engines. Carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NOx), and other chemicals like formaldehyde, acetaldehyde, acrolein, and benzaldehyde are the principal emissions from a gasoline-powered engine. The most hazardous substance among the particles is lead. Lead is present in high concentrations in Indian gasoline, and its emissions can cause cancer and lung illnesses.

c. **Thermal stations :** Coal is the only fuel source for all thermal power plants. These plants mostly emit fly ash, soot, and sulphur dioxide as effluents. Less than 1% of the coal from India contains sulphur. Nonetheless, the coal has a significant ash percentage, ranging from 25% to 40%. Fly ash from power plants impairs visibility and may contain amounts of heavy metals like lead, manganese, cadmium, mercury, and chromium. Again, these have an impact on human health.

d. **Acid rain :** Acid rain is the result of industrial emissions that release sulphur and nitrogen oxides. These oxides produce acids when they come into contact with water vapour, which has severe results. The soil is becoming more acidic, crops and forests are suffering, and fish in lakes and rivers are commonly observed to be dying. Heavy metals like cadmium and mercury are indirectly mobilised by acid rain, where they are then taken by plants and move up the food chain.

e. **Ozone layer :** A layer of ozone located high in the stratosphere shields the planet from the sun's UV rays. The existence of life would not have been conceivable without this ozone layer. But once more, ozone layer disruption brought on by human activity is linked to several forms of skin cancer. Increased nitrogen oxide emissions into the atmosphere, an increase in supersonic aircraft (SSTs), and the presence of chlorofluorocarbons (CFCs), which are used as refrigerants, in fire extinguishers, and as propellants in aerosol spray cans, are some of the factors that cause the ozone layer to be disrupted.

f. **Greenhouse Effect :** The "Greenhouse Effect" is the phrase used to describe how carbon dioxide affects the earth's temperature. The planet acts like greenhouse glass, allowing solar heat to pass through while keeping some of it from radiating back through the atmosphere. The more heat that carbon dioxide retains, the hotter the world becomes. Experts worry that polar ice caps would melt if temperatures rise merely a few degrees, submerging enormous tracts of land in the process.

1.12.2 Effects on Vegetation

Air pollution has a high potential for harming crops, and this risk relies on the type, concentration, and timing of the pollution as well as the habitat's characteristics and current conditions. Ecosystems are considered to be most vulnerable if they are on substrates with a low capacity for buffering, occasionally experience high levels of pollution, or have sensitive important species. According to research, rather than leading to a species' extinction, air pollution has contributed to its decline and attenuation. Yet if the pattern holds, it's likely that vulnerable populations in temperate areas will continue to disappear until they are extinct. Since biodiversity and ecosystems are more fragile in the tropics than in temperate regions, pollution effects there, which are now growing more widespread, can also cause the extinction of species.

There are several subheadings that can be used to discuss how pollution affects vegetation :

Sulfur dioxide, HF, particle fluorides, smog, oxidants like ozone, ethylene (from automobiles), NO, chlorine, and pesticide and weedicide sprays are only a few of the air pollutants that have hazardous effects on plants. The damage typically appears as visual impairment, such as chlorotic marking, banding, silvering, or bronzing of the leaf's underside. In some circumstances, plant development can be slowed down. The kind and quantity of the pollutant, the length of exposure, the state of the soil and plant, the stage of growth, the relative humidity, and the amount of sunlight all affect how much harm a plant sustains.

Plant Diseases - A number of plant diseases are also brought on by air pollutants that are released as a result of human activity. These conditions include :

a. Necrosis: Also known as tissue death, leaf tissue destruction, or extreme drying, is one example.

b. Chlorosis: This condition causes the green colour of the leaf to disappear by reducing the amount of chlorophyll in the leaf.

c. Epinasty - Epinasty is the downward curling of the leaf's upper surface.

d. Acute Damage - This type of damage is brought on when a plant is exposed to contaminants at a high concentration.

Effects on Freshwater Systems - In places where the bedrock does not weather quickly, the surface waters are vulnerable to acid deposition. Many areas of the world have seen an increase in their acidity. With increasing acidity, consequences on freshwater life become more pronounced. In the beginning of acidification, some species and groups soon vanish, while others are impervious to harm and, in the absence of competition, may even thrive. According to estimates, between 15,000 and 25,000 European lakes where anthropogenic acid deposition has caused the pH to drop by more than 0.5 units have lost at least 20% of their plant and animal species.

Impacts on Heath Lands - Acidic or base-poor heath lands can experience significant alterations as a result of air pollution. For example, excessive nitrogen inputs to unmanaged heath land have caused nitrophilus grasses to take the place of slower-growing heath plants.

Effects on Mountain Sites - Environments at high altitudes will be among the first to experience the effects of acidification. Although pollution often declines with elevation, deposition can still be considerable because of the rise in precipitation. In addition, harsh weather conditions prevent plants from absorbing extra atmospheric nitrogen, which instead seeps into steams.

1.12.3 Damage to farm animals

The primary contaminants that harm livestock include arsenic, lead, and fluorides. When animals eat the polluted flora, which has accumulated with these airborne toxins, it poisons the animals.

In many ores including coal, arsenic can be found as an impurity. Insecticides also make use of it. Arsenic poisoning affects livestock in the vicinity of smelting and other industrial processes, with symptoms including salivation, thirst, liver necrosis, inflammation, and central nervous system depression.

Coke ovens and coal combustion in metallurgical smelters, lead arsenate sprays, and vehicle exhausts all produce lead. Horses and other animals can become lead poisoned and exhibit signs like sadness, lethargy, gastritis, paralysis, and breathing difficulties. Particularly vulnerable to flourine poisoning, which can result in fluorosis of the teeth and bones, are cattle and sheep.

1.12.4 Effects on Materials

The ubiquitous process of atmospheric corrosion transcends all geopolitical boundaries. Several developing nations are situated in warm climates with high relative humidity and frequent precipitation, which raises the possibility of contaminants that might cause acidification. Buildings and historical sites are potentially under greater risk when SO_2 and other pollutant emissions rise in emerging nations. Reducing SO_2 may help emerging nations avoid expensive corrosion damage. Sandstone and limestone historical and cultural sites have also suffered extensive damage. Measurements of the impacts of sulphur dioxide (SO_2), oxides of nitrogen (NO_2), and ozone concentrations are used to describe atmospheric pollution. Throughout the last century, anthropogenic sulphur and nitrogen pollution have severely harmed technical constructions and cultural legacy in industrialised nations. Buildings, infrastructure, and cultural heritage are at risk due to the extremely high concentrations of SOx, which is the most harmful pollutant in this regard, as well as the rising car traffic in major Indian cities. The following are the main impacts that are related to how pollutants affect materials:

1. A reduction in mechanical strength;
2. Leaks;
3. Deteriorating protective coatings
4. Loss of carvings' fine detailing;
5. Corrosion in pipes.

Several Pollutants' Acidic Deposition Processes for Corrosion :

(a) Atmospheric corrosion - Direct effect frequently occurring close to the emission source. Climate factors including temperature, precipitation, and relative humidity influence it. Sulfur dioxide significantly speeds up the deterioration of several materials. The synergistic effect of many pollutants, such as sulfur-dioxide, SO_2, plus NO_2, or O_2, is a growing source of worry.

(b) Water and soil corrosion - Long-distance transboundary air pollution transport makes the indirect effects of soil and water acidity mostly a regional issue.

Impacts of Particular Materials

(a) Zinc and Copper - Increasing deterioration rates are caused by protective corrosion products dissolving.

(b) Rock - The textures, structures, and compositions of rock-stone employed in construction vary. Due to the original calcium carbonate's transition into gypsum and calcium sulphate and subsequent deposition by sulphur dioxide, calcareous stone, such as limestone or marble, is extremely vulnerable to this process.

(d) Cultural Heritage - The term "cultural heritage" refers to both prized indoor items housed in museums and archives as well as outdoor structures and sculptures. Cultural heritage has value that cannot always be quantified in monetary terms.

(e) Sculptures - Sculptures are different from regular stone constructions in that architects choose the stones for their aesthetic appeal and practical value rather than only their physical and chemical characteristics.

(c) Organic Material: Paints and rubber tyres. Ozone degradation is typically linked to temperature, solar radiation, and ozone. Moreover, indoor effects on specific paint pigments might harm priceless and significant pieces of architecture, sculpture, and art.

(f) Stained Glass-Church windows made of mediaeval stained glass are susceptible to the damaging corrosion attack of air pollutants. Rock carvings, textiles, artwork, and archaeological monuments are some more objects. Corrosion rates are significantly higher than the worst values in Europe in South-Western China, test sites in towns where sulfur-containing coal is the main energy source. Thus, it is advised that developing countries reduce SO to prevent expensive corrosion damage.

Darkening of sky and reduction in visibility

Sky becoming darker and visibility becoming worse. Sky darkening may be brought on by dust storms, intense smoke and fog, or both. Smoke, fog, and industrial odours, which contain

particles with a size range of 0.4 to 0.9 μm and scatter light, may be the cause of the decreased visibility. Particle size, sun angle, aerosol density, air mass thickness, and meteorological elements like inversion height, wind speed, and humidity all determine how strong these effects are.

1.13 Prevention and Control of Air Pollution

Air pollution prevention is not an easy task. It is impossible to offer at a fair price. Modern life's expanding needs and conveniences are contributing to some air pollution. For instance, it can be challenging to operate a scooter or car powered by gasoline without contributing to some air pollution. Similar to this, it is challenging to operate an industry without contributing to air pollution. A thermal plant cannot be operated without polluting the atmosphere.

The two fundamental methods for reducing air pollution are as follows:

i. Limiting or controlling the pollution at its source. You can accomplish this by

   a. Changing the process such that pollutants do not form above allowed amounts at all.

   b. Using the appropriate tools to destroy, alter, or trap the pollutants created to lower the pollutant concentrations to acceptable levels before they are discharged into the environment.

ii. Reducing air pollution levels to acceptable levels before it reaches the receptor. To prevent the build-up of hazardous ground level concentrations inside the defined zones, this can be accomplished by employing towering stacks, managing the process parameters, with due attention for the local meteorological circumstances, and effective community planning.

1.13.1 Methods and equipment used to control gaseous pollutants

The following are various methods for reducing these pollutants:

1. ***Combustion :*** This method is employed when the contaminant has organic-based gases or vapours. These pollutants are converted into comparatively harmless compounds, like CO, and water vapour by catalytic or flame combustion. Fume incinerators, steam injection or venturi flares, and after-burners are examples of the machinery used for flame combustion. Catalytic combustion is used when lower operating temperatures are preferred, for as when burning waste cracking gases, paint or enamel baking oven fumes, or when roasting coffee.

2. ***Absorption :*** This method involves passing the gaseous effluents through scrubbers or absorbers with a suitable liquid absorbent to either remove or modify one or more contaminants from the gas stream. The degree of surface contact between the liquid and the gas, the duration of the contact, the concentration of the absorbing media, and the chemical reactivity of the

gaseous pollutant in the liquid phase all affect how well gas is absorbed. The tools employed include liquid jet scrubber towers, plate towers, spray towers, packed towers, and bubble-cap plate towers. The removal of contaminants like NOx, H_2S, SO_2, SO_3, and fluorides from gaseous effluents is commonly done using the gas absorption approach. Table 1.3 lists the various absorbing liquids that are frequently used.

Table 1.3 : ***Absorbents for some gaseous pollutants.***

Pollutants	Absorbents
NOx	H_2O, aq. HNO_3
SO_2	Alkaline water, water, suspension of Ca(OH), sulphites of Ba or Ca or Na, ethanolamine, dimethyl aniline, 1:1 mixture of water and xylidine, aluminum sulphate, etc.
H_2S	Ethanol amines, $NaOH^+$ Phenol (in mole ratio of 3:2), sodium alamine, soda ash, tripotassium phosphate, ammonia liquor from coke ovens, sodium thioarsenate, etc.
HF	H_2O, NaOH

3. ***Adsorption :*** This method involves passing gaseous effluents via porous solid adsorbents placed in the appropriate containers. Physical adsorption or chemisorption holds the organic and/or inorganic components of the effluent gases at the interface of the solid adsorbent. Adsorption efficiency is influenced by the adsorbent's surface area per unit weight, various physical and chemical properties, the kind and concentration of the gas being adsorbed, and other factors.

Table 1.4 : ***Lists the typical adsorbents utilised for different gaseous contaminants.***

Pollutants	Adsorbents
NOx	Silica gel, commercial zeolites
SO_2	Pulverized lime stone or dolomite, alkalized alumina ($Al_2O_3 + Na_2O$)
H_2S	Iron oxide
HF	Lump lime stone, porous pellets of NaF.

Petroleum fractions	Bauxite
Organic solvent vapors	Activated carbon
Vapours associated with gases	Alumina, Silica gel, Bauxite

Certain adsorbents are selective for particular uses due to their preferential adsorption properties. For instance, synthetic zeolite or silicate molecular sieves, activated alumina, and Silica gel-6 all favourably adsorb water vapour from a mixture of water vapour and organic contaminants. Increasing the temperature or decreasing the pressure is typically used to desorb the sorbed gases.

Higher concentrations of the gases, such as NO_2, SO_2, etc., in waste gas streams allow for their economically viable recovery and use in the production of HNO_3, H_2SO_4, etc. Pulverized limestone can be injected into the boiler furnace to remove SO from power plants. As the SOx and CaO combine, calcium sulphite and calcium sulphate are produced. Thus, there is no SO emission into the atmosphere. Masking, counter-action, sorption in a suitable solvent, or adsorption on activated carbon can all be used to regulate odorous gases.

Methods and equipment used for controlling particulate emissions

Both fixed and mobile sources can contribute to the ambient air's particle content. The size, shape, electrical characteristics, and hygroscopic characteristics of the particulates in question are used to determine the particulate collection devices. The numerous gadgets can be grouped under the following categories:

1) Mechanical gadgets : The following two mechanisms serve as the foundation for most of these devices' operations:

(a) Gravity settling, in which the horizontal carrier gas's velocity is sufficiently lowered to cause the particles to settle through gravity force. (b) The particles separate out as a result of the gas flow's abrupt change in direction because they have more momentum.

The most widely used mechanical devices for separating particles from gases include settling chambers, buffer chambers, and cyclone separators. Particulate matter is gathered in settling chambers either by centrifugal force or gravity. They are employed in enterprises producing rock products and power plants.

Settling Chambers : These are sealed tanks with an inlet and output configuration. The dirty gas is permitted to enter chambers with reduced gas velocity that are closer to laminar flow conditions, which may allow the particles to separate from the gas stream via gravity. Baffle or

mesh screens may be suspended in the chamber to guarantee uniform velocity. At the bottom of the settling zone, a hopper bottom with a 1:1 slope is supplied to collect the settled particles. Typically, the flow velocity falls between 0.5 and 3 m/sec. 10 microns is the smallest particle size that can be eliminated. For the removal of particles larger than or equal to 50 microns, efficiency is high.

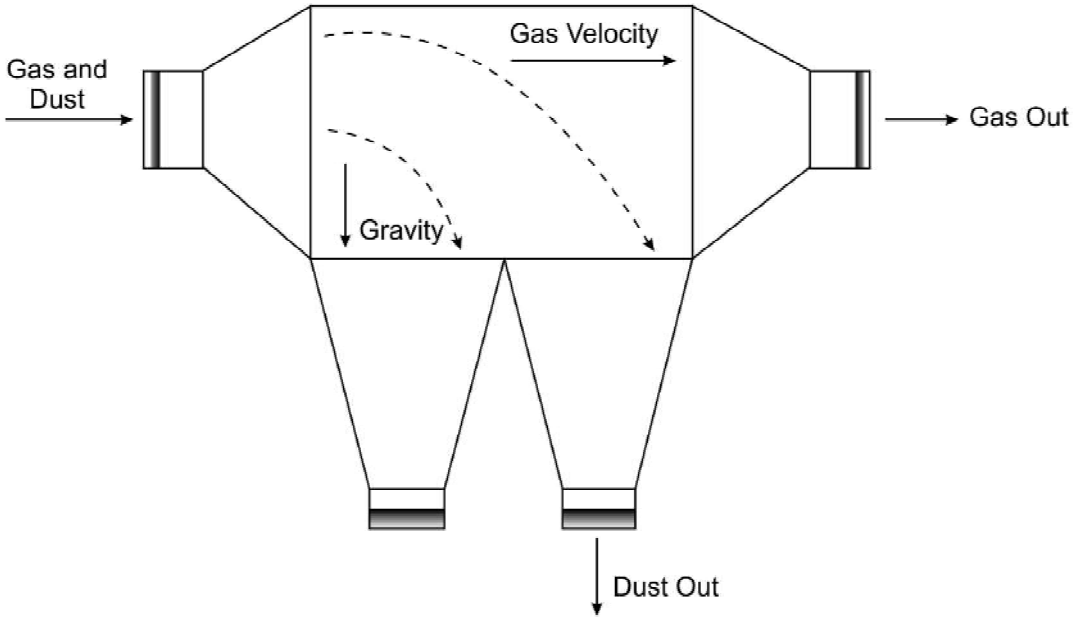


Figure 1.3. *Schematic diagram of Settling Chambers*
[Source : ebrary. net/210130/environment/setting-chambers]

In cyclone collectors, the gas stream's velocity is reduced to create a small, constrained vortex, from which the centrifugal forces pull the suspended particles into the collection structure's sides. Cyclone collectors are used in the mining, metallurgical, iron and steel, and rock product industries to remove particle contaminants.

Cyclone Separators : An enclosed, vertically positioned cylinder with an inverted cone at the base is a cyclone separator. The inlet is set up at the top of the cylinder with a tangential entrance and an outlet design. By the tangential intake, which provides a swirl option, the calate-containing gas enters the cylinder. The contaminated gas pushes against the cylinder's edge. The heavy particles travel towards the cyclone's edge as a result of centrifugal force. The particles then descend into a conical collector at that location. The gas continues to descend until it reaches the conical section's base. A small inner spiral that is concentrically positioned with the first spiral is how the gas there rises. The clean gas exits the cylinder through an outlet pipe once it reaches the top.

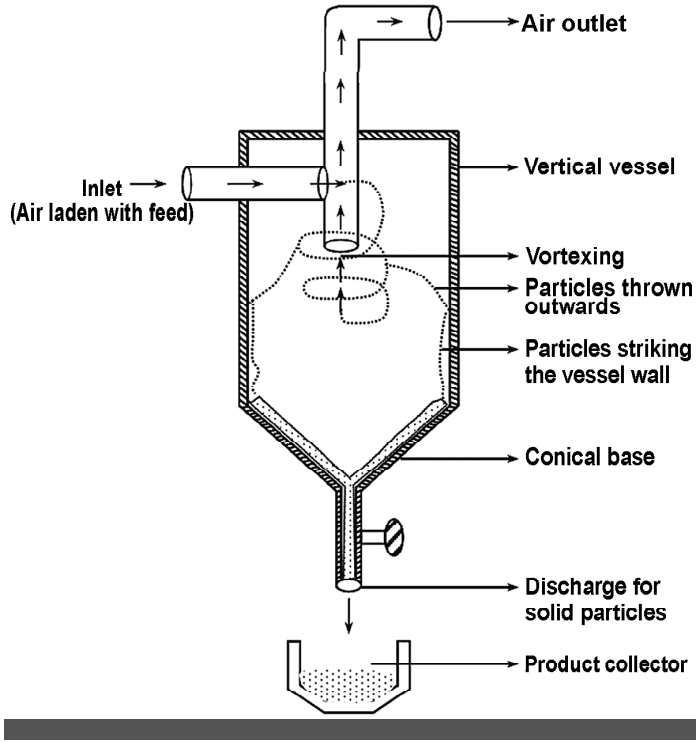


Figure 1.4. *Schematic diagram of Cyclone Separator [Source : marinerspointpro. com/cyclone-separator]*

2) **Filtration Systems :** A porous material, such as woven or filled cloth, is used to force dust-laden gases through it. The particles are then caught and collected in the filters, and the dust-free gases are released. Filters made of fibre or deep beds and fabric bags are frequently utilised. The materials used to make fabric filter media include cotton, wool, nylon, dacron, asbestos, silicone-coated glass cloth, etc. Nylon and cloth filters are utilised up to 80-90°C, while glass cloth filters wrapped in asbestos and silicone may withstand temperatures of 250-350°C. For alkaline media, cloth, nylon, and asbestos filters are better than wool, Orlon, and Vinylon filters for acidic gases. Glass fibre filters are better at withstanding chemicals. Industries that deal with rock materials, pigments, etc. use fabric filters.

Bag Filters : Particles less than 10 microns in size are removed using bag filters. These particulate removal technologies are dependable and effective. They are set up in a structure known as the "Bag House". Each of the dangling bags has a diameter of 120 to 400 m and a length of 2 to 10 m. The bag's outlet ends open alternately and are joined to a manifold. The intake pipe is where the contaminated gas enters. Gravity will cause the big particles to fall into the hopper. Through the outlet pipe, the gas flows into the bags before exiting. The filter cake will become loose as the cake is cleaned using a shaking mechanism. This cake will fall into the hopper that is placed at the base of the bag house as it becomes looser.

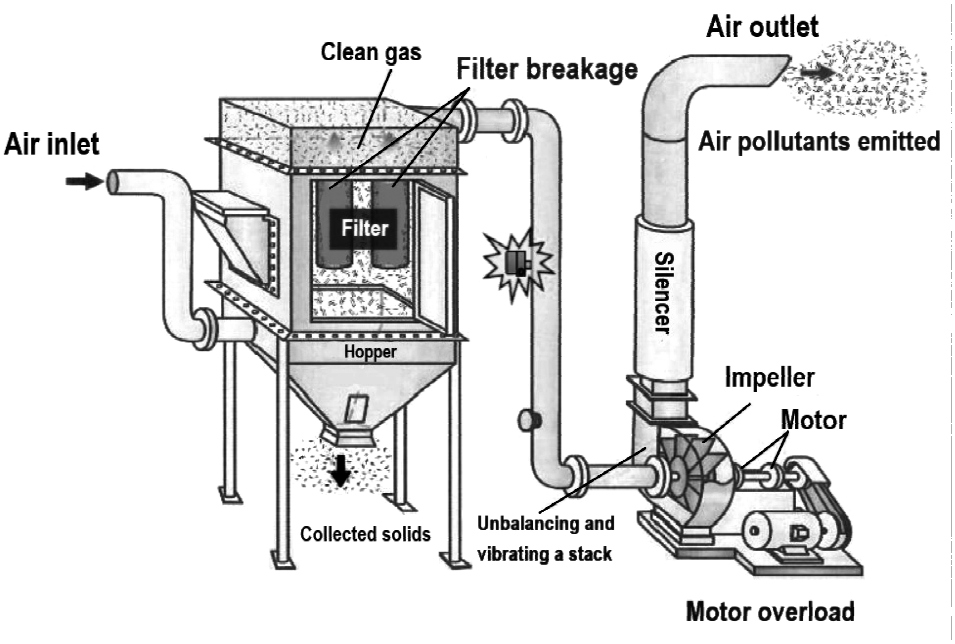


Figure 1.5. *Schematic diagram of Bag Filters*

3) **Wet Scrubbers :** Wet scrubbers are used when it is necessary to efficiently remove fine particles, remove particulates and gaseous contaminants, treat combustible gases, treat large variations in process flow rates, and treat gases that are 300 °C or higher in temperature. To capture SO_2, NH_3, metal vapours, etc., wet scrubbers are utilised in the chemical, mining, and metallurgical industries.

It is crucially important to effectively remove particles and gaseous contaminants from anthropogenic gaseous effluents. If air pollutants are released into the atmosphere randomly, the dynamic balance already present in the atmosphere will be upset, having a negative impact on both man and his surroundings.

The enclosed tanks known as wet collectors have separate inlet and output configurations for contaminated gas and a cleaning liquid. With a liquid, the particles are cleaned from the gas (scrubbing). Typically, water is utilised as the cleaning agent. When the particulates are made to strike a liquid surface inside the wet collector, the particulates are separated from the gas. These are pre-cleaners that can be used. Wet collectors are typically divided into four basic categories based on the extent of contact made between the material and the liquid.

- Spray Tower
- Cyclone Scrubbers
- Venturi Scrubbers, and
- Packed Bed or floating Bed Tower.

In addition to these, to reduce air pollution, a wide range of wet scrubbers are used, including ventilation scrubbers, gravity spray scrubbers, wet impinger scrubbers, wet centrifugal scrubbers, etc.

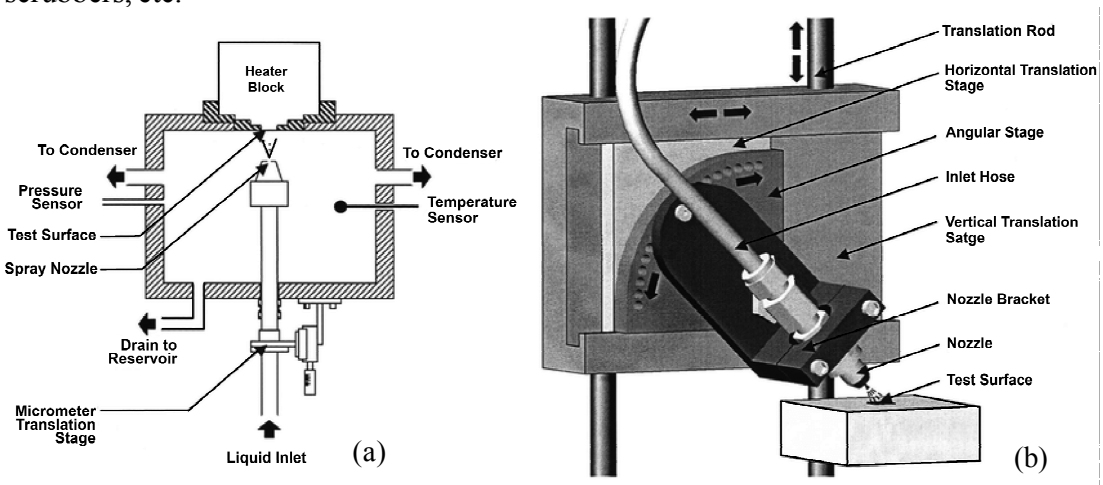


Figure 1.6 : *Spray chambers (a) upward and (b) downward [Source : DOI : 10.1109/TC APT.2008.2010405]*

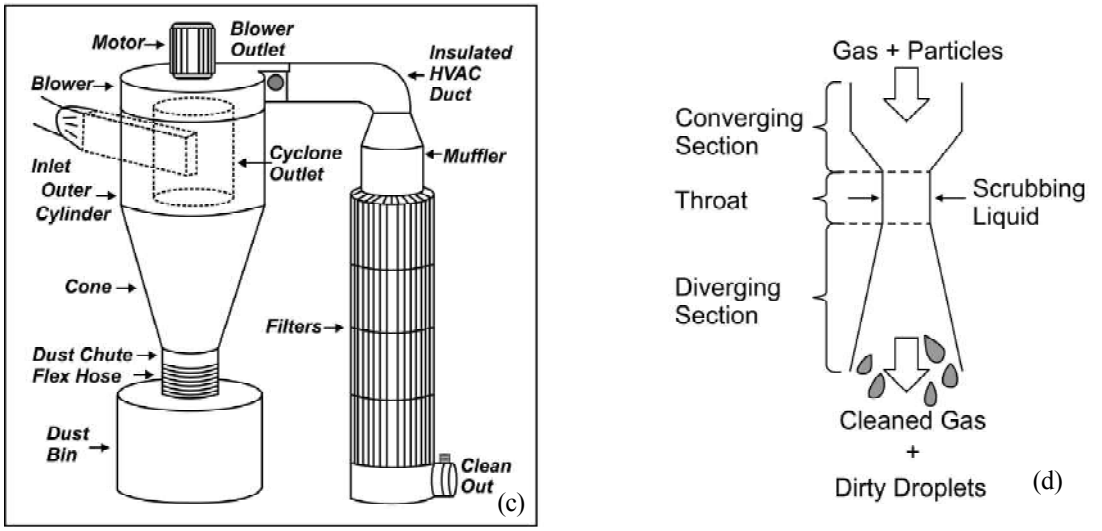


Figure 1.7 : *Cyclone scrubber (c)Ventury scrubber (d) (Source : teral.acrotech. Con / cyclone-scrubber-manufacturer/]*

According on the mechanism of particle collection, wet scrubbers can be categorised as follows:

(a) Liquid carrier type, in which the liquid carrying the trapped gas particles goes to a point outside the collection for final disposal after the gas stream containing the particles is allowed to impact a liquid surface inside the collector.

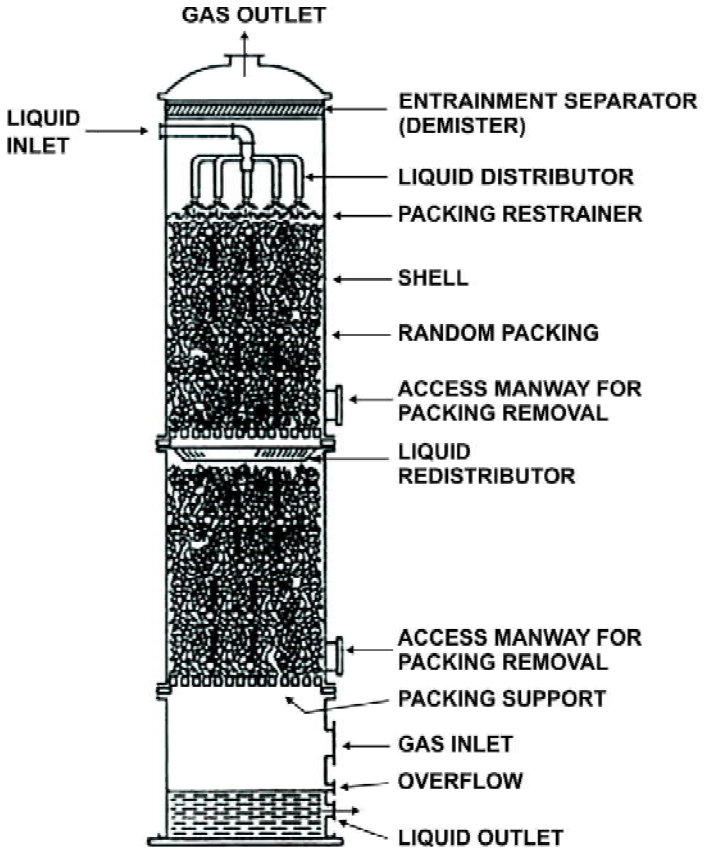


Figure 1.8 : *Schematic diagram of Packed Bed*

(b) The particle conditioning type involves bringing the gas stream's dust particles into close contact with water, increasing the particles' effective size as a result of the creation of heavier water-particulate agglomerates. Any of the collection systems can more easily separate them from the gas stream.

4) **Electrostatic precipitators :** For the removal of very minute size pollutants (Aerosols, such as dust, fumes, or mist), electrostatic precipitators are particularly common. It is possible for the contaminated gas to travel between two electrodes. One is a high voltage, negatively charged electrode, while the other is a plate or cylinder that is positively charged. They continue to have a potential difference. High potential difference causes a strong ionising field to emerge. This produces "CORONA," also known as an active glow zone, extremely close to the negative electrode. The passing particles pick up a charge as the negative ions go in the direction of the collecting electrode (low potential electrode). The particles are drawn to and deposited on the collecting electrode by the electric field. The following components make up an electrostatic precipitator: (a) A high-voltage source (b) A large surface area collecting

electrode (often positive and at ground potential) and a high voltage discharge electrode (typically negative) with small cross-sectional area, such as a wire. (c) A means of discarding the material gathered; (d) a housing covering the electrode. Operation of an electrostatic precipitator involves the following four fundamental steps: (1) Ionizing the particles to electrically charge them (2) Moving the charged particles to the collecting surface by applying force to them in the electric field (3) Neutralizing the electrically charged particles that precipitated on the collecting surface (4) Removing the precipitated particles from the collecting surface by rapping or washing.

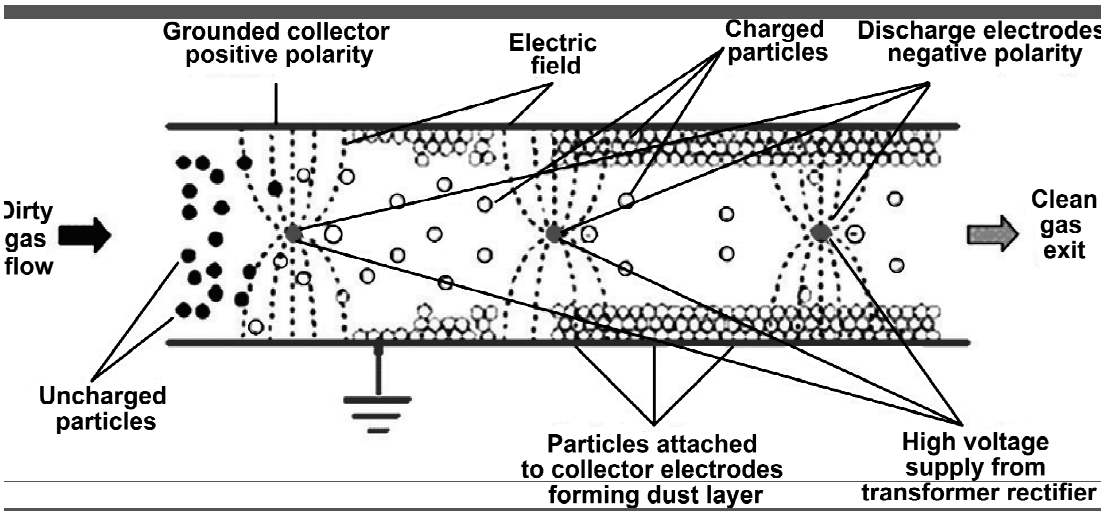


Figure 1.9. *Schematic diagram of Electrostatic Precipitator*

Ionization and collection are done in one step in one-stage electrostatic precipitators. In two-stage precipitators, collection comes after the pre-ionizing stage. The latter cannot be used in environments with high levels of dust. Usually, air-conditioning plants employ them.

When handling (1) extremely large volumes of gases, (2) recovering valuable dry material, (3) needing a very high collection efficiency to remove fine particulates, and (4) needing very high gas temperatures, electrostatic precipitators are the preferred device. Power companies, paper and pulp businesses, chemical businesses like sulfuric acid plants, iron and steel businesses, mining and metallurgical businesses, rock product businesses, refineries, carbon black manufacturing businesses, etc. all employ electrostatic precipitators extensively.

1.14 Ambient Air Quality Standards in India

Ambient air quality refers to the state or quality of air surrounding us in the outdoors. The Central Pollution Control Board (CPCB) has established ambient air quality guidelines known as National Ambient Air Quality Standards that are applicable across the country. The 1981 Air (Prevention and Control of Pollution) Act grants the CPCB this authority.

Previous to the criteria in November 2009, India had established air quality guidelines on April 11, 1994, which were then updated on October 14, 1998. The 2009 standards uniformized the national standards and considerably reduced the maximum allowed values for contaminants. Industrial zones used to be subject to less strict regulations than residential areas.

Also, a brand-new National Air Quality Index (AQI) (http://www.arthapedia.in/index.php?title=National_Air_Quality_Index) was introduced in October 2014 to provide the general public with information on air quality in a format that is simple to grasp. The National Ambient Air Quality Standards for short-term (up to 24-hourly averaging period) are based on eight pollutants: PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb. The worst reading in these pollutants reflects the AQI for that city.

NATIONAL AMBIENT AIR QUALITY STANDARDS
CENTRAL POLLUTION CONTROL BOARD
NOTIFICATION
New Delhi, the 18th November, 2009

No.B-29016/20/90/PCI-L-In exercise of the powers conferred by Sub-section (2) (h) of section 16 of the Air (Prevention and Control of Pollution) Act, 1981 (Act No. 14 of 1981), and in super session of the Notification No(s). S.O. 384(E), dated 11th April, 1994 and S.O. 935(E), dated 14th October, 1998, the Central Pollution Control Board hereby notify the National Ambient Air Quality Standards with immediate effect, namely :-

NATIONAL AMBIENT AIR QUALITY STANDARDS

S. No.	**Pollutant**	**Time Weighted average**	**Concentration in Ambient Air**		**Methods of Measurement**
			Industrial, Residential, Rural and Other Area	Ecologically sensitive area (Notified by Central Govt.)	
1	Sulphur Dioxide (SO_2), $\mu g/m^3$	Annual*	50	20	• Improved West and Geake • Ultraviolet fluorescence
		24 hours**	80	80	
2	Nitrogen Dioxide (NO_2), $\mu g/m^3$	Annual*	40	30	• Modified Jacob & Hochheiser
		24 hours**	80	80	

					(NaArsenite) • Chemiluminescence
3	Particulate Matter (size less than 10 µm) or PM_{10} µg/m^3	Annual*	60	60	• Gravimetric • TOEM • Beta attenuation
		24 hours**	100	100	
4	Particulate Matter (size less than 2.5 microns) or $PM_{2.5}$ µg/m^3	Annual*	40	40	• Gravimetric • TOEM • Beta attenuation
		24 hours**	60	60	
5	Ozone (O_3) µg/m	8 hours*	100	100	• UV photometric • Chemiluminescence • Chemical method
		1 hour**	180	180	
6	Lead (Pb) µg/m^3	Annual*	0.5	0.5	• ASS / ICP method after sampling on EPM 2000 or equivalent filter paper • ED - XRF using Teflon filter
		24 hours**	1	1	
7	Carbon Monoxide (CO) mg/m^3	8 hours*	2	2	Non Dispersive Infra RED (NDIR) Spectroscopy
		1 hour**	4	4	
8	Ammonia (NH_3) µg/m^3	Annual*	100	100	• Chemiluminescence • Indophenol blue method
		24 hours**	400	400	
9	Benzene (C_6H_6) µg/m^3	Annual*	5	5	• Gas chromatography based continuous analyser • Adsorption and desorption followed by GC analysis
10	Benzo (a) Pyrene (BaP) - particulate phase only µg/m^3	Annual*	1	1	Solvent extraction followed by HPLC / GC analysis
11	Arsenic (As) ng/m^3	Annual*	6	6	AAS / ICP method after

					sampling on EPM 2000 or equivalent filter paper
12	Nickel (Ni) ng/m^3	Annual*	20	20	AAS / ICP method after sampling on EPM 2000 or equivalent filter paper

* Annual arithmetic mean of minimum 104 measurements in a year at a particular site taken twice a week 24 hourly at uniform intervals.

** 24 hourly or 8 hourly or 1 hourly monitored values, as applicable, shall be complied with 98% of the time in a year. 2% of the time, they may exceed the limits but not on two consecutive days of monitoring.

Note: Whenever and wherever monitoring results on two consecutive days of monitoring exceed the limits specified above for the respective category, it shall be considered adequate reason to institute regular or continuous monitoring and further investigation.

1.15 Summary

The existence of mankind in the planet is now directly impacted by air quality. The magnitude of the issue can indeed be managed unless the general public is aware of it. To achieve this, people must comprehend the meanings of the many terms used by environmentalists, such as the greenhouse effect, climate change, acid rain, and photochemical smog. The atmosphere resembles a bizarre, large kitchen where numerous recipes are being prepared continuously. Although while pollutants are produced naturally, if humans did not increase their levels through anthropogenic activity, nature would be able to handle them. Human civilization and the accumulated contaminants from pollution both pose a hazard today. With a focus on their production and clean-up, the principles of air pollution and different aspects of air pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit. Additionally, this unit describe air quality standards in Indian perspectives.

1.16 Self-Assessment questions

1. How are air-pollutants classified? State five common air-pollutants, their sources and effects on the man and his environment.
2. What are the sources of NOx and SOx, in the atmosphere? What are the undesirable effects manifested by them? How can they be controlled?

3. What is acid rain? How is it caused? What are its bad effects on the man and his environment? What steps are needed to control acid rain?
4. What is photochemical smog? How is it formed in the atmosphere? What are its consequences?
5. Discuss the sources and effects of particulates in the atmosphere.
6. Explain the terms "Lapse rate" and "temperature inversion". What are their consequences in the atmosphere?
7. Discuss with the help of diagram the plume characteristics under different lapse conditions.
8. Discuss the various techniques available for air-pollution control.
9. Discuss the sources of Pb in the particulate matter in the atmosphere. How can it be controlled?
10. State the characteristics and biochemical effects of the following air pollutants: (a) SOx (b) NOx
11. What is air-pollution? What are its different sources?
12. Distinguish between primary and secondary air-pollutants.
13. What is acid-rain? What are its effects?
14. How does air-pollution affect human health? How does carbon monoxide affect the human body?
15. What is fumigation? What do you understand by mixing height?

1.17 Suggested Readings

1. R. K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi.
2. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998
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6. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi.
7. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

UNIT 2 ❑ Water Pollution

Structure

2.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different water pollution sources,
- understand different types of water pollution and water pollutants,
- outline different inorganic, organic and biological pollutants
- know sources, effects and control measures of ground water pollution,
- learn about eutrophication phenomenon and its remedial measures,
- understand the different adverse effects of water pollution,
- comprehend the control mechanism of water pollution,
- understand the water legislation.

2.2 Introduction

Every form of life requires water to survive. The average person drinks roughly 2 litres of water every day. account for water for roughly 70% of a person's overall weight. The earth's surface, which covers a total of 50,000 million hectares, is covered by water to an extent of about 80%. Just 33,400 m^3 of the estimated 1,011 million km^3 of total water on Earth are usable for drinking, farming, home use, and industrial use. The remaining water is trapped underground, in polar ice caps and glaciers, and in oceans as salt water. The need for water supply has been rising dramatically as a result of rising industrialization on the one hand and a population that is booming on the other. In addition, a sizeable portion of this scarce resource for water is contaminated by sewage, industrial waste, and a variety of synthetic chemicals. The population's health is still under danger from water-borne diseases and epidemics, especially in developing and underdeveloped nations. As a result, both the quality and the availability of clean water are crucial to human welfare.

India experiences annual rainfall of between 1400 and 1800 mm. 96% of this water is thought to be used for agricultural, 3% for domestic usage, and 1% for industry. According to a 1982 investigation, nearly 70% of the water that is available in our country is tainted. Many actions are being conducted to control water contamination in light of this circumstance.

The phenomena of "water pollution" is defined as the decline in the quality of freshwater (rivers, lakes, marshes, and groundwater) or saltwater as a result of numerous human activities. When compared to now, human waste disposal did not cause issues in the past as long as human contamination was little and communication was dispersed throughout large expanses of land. Yet, as populations increased and towns and villages expanded, organized waste disposal began to take its place, though once more through the assistance of natural land and soil columns. Many communities that implemented the basket privy system resorted to collecting human waste and disposing of it in mud pits.

Any physical or chemical alteration to the water that could harm organisms is referred to as water pollution. It is a global issue that affects both developed and developing countries. The streams of affluent countries are polluted by heat, harmful metals, acids, sediment, animal and human waste, and synthetic organic compounds.

In the industrialized countries, human and animal wastes, silt, and harmful organisms are at the top of the list. Malnutrition and unclean water are the main causes of illness and mortality in these nations. Water pollution originates from a variety of anthropogenic and natural sources,

just as air pollution. Similar to air pollution, water pollution from one country may spread to another, leading to complicated global control issues that could take decades to resolve.

2.3 Various Types of Water Pollution

Four criteria can be used to classify water pollution. They include:

i. Physical water pollution
ii. Chemical Water Pollution
iii. Biological Water Pollution
iv. Water Physiological Pollution

2.3.1 Physical Water Pollution

Water varies in terms of its colour, flavour, density, taste, turbidity, thermal properties, and other characteristics due to physical pollution.

a. ***Turbidity:*** Water turbidity is mostly caused by soil erosion, colloidal debris, and fine suspended particles. The concentrations of sewage and industrial effluent are often higher and the impacts are generally worse the higher the turbidity. The most serious turbidity is that caused by bacterial sewage contamination.

b. ***Colour:*** Changes in colour are not hazardous unless they are brought on by a tonic substance, but they may modify the type of sunlight that reaches a certain depth and slow down plant and animal metabolism.

c. ***Odour:*** Water odour pollution is brought on by both chemical (such as H_2S, CI_2, and NH_3) and biological factors (such as algae, fungi, microorganisms etc.) The amount of HS produced will increase with a lower pH, as will the odour annoyance.

d. ***Foam:*** Soaps, detergents, and untreated organic waste from the paper and pulp industries all produce foam.

e. ***Thermal pollution of water:*** It is mostly caused by the release of heat that was produced inefficiently by different thermal power plants. Since there is less dissolved oxygen (DO) in the warmer waters, organic stuff breaks down more quickly.

2.3.2 Chemical Water Pollution

Acids, alkalies, poisonous inorganic compounds, dissolved inorganic compounds, and dissolved organic compounds are only a few examples of the inorganic and organic chemicals that contribute to the chemical pollution of water. Acidity, alkalinity or pH, dissolved oxygen

(DO), and other gases in water alter as a result of chemical contamination. Organic contaminants, inorganic pollutants, or a combination of both may be to blame. Both biodegradable and non-biodegradable organic contaminants are possible.

Organic pollutants that don't degrade: These contaminants are those that linger for a long time in the aquatic system. Pesticides, fungicides, bactericides, etc. are a few examples. Inorganic pollutants include a number of gases, poisonous metals, and chemicals since they also significantly lower water quality.

2.3.3 Biological Water Pollution

The presence of harmful bacteria, specific fungi, pathogenic protozoa, viruses, parasitic worms, etc. causes bacterial pollution of water. Domestic sewage and industrial waste are the main causes of bacterial pollution. The ideal environment for bacterial growth in water is solid human waste and sewage's decomposing organic content. The excretory by-products of warm-blooded mammals, such as humans, wild animals, and domestic animals, contribute to bacterial pollution of water. The coliform group, certain subgroups, streptococci, and other organisms are the primary contaminants.

2.3.4 Water Physiological Pollution

Many chemical substances, including chlorine, sulphur dioxide, hydrogen sulphide, mercaptans, phenols, and hydroxy benzene, contribute to the physiological pollution of water. Depending on the origins and locations of the water, there are five different types of water pollution.

i. Ground water pollution
ii. Surface water pollution
iii. Lake water pollution
iv. River water pollution
v. Sea water pollution

Ground Water Pollution

The amount of groundwater, including recharge from infiltration and seepage, is roughly 210 billion m^3. Almost one-third of this is taken out for industrial, commercial, and don use, while the majority of the water is recycled into rivers.

Sources of Ground Water Contamination: Drinking water supplies underneath are extremely polluted, particularly in smaller towns and cities' outskirts. The following is a list of the most common questions we get from our customers.

1. Domestic wastes
2. Industrial wastes
3. Agricultural wastes
4. Runoff from Urban Areas
5. Soluble Effluents

Surface Water Pollution

The following factors affect the type and extent of surface water pollution:

a. Diluting biocides' hydrological properties and their level of self-purification

b. The amount of rock weathering, the kind of soil, and vegetation.

c. The physical, chemical, and biological properties of wastewater that enters surface waters.

d. Systems and methods for treating residential and sewage waste water disposal.

Sources of contamination in surface waters: Lakes, streams, and surface chains all have direct contact with surface water and the atmosphere. As a result, while the waste is being introduced via water conveyances, dissolved and atmospheric gases are continuously exchanging.

Lake Water Pollution

These enormously diverse water resources are seriously threatened by the speedy industrialization and urbanization processes.

Polluting sources in lakes

i. the release of hazardous effluents from cities and organic waste from hills.

ii. factory waste sludges, as well as washings and tailings dumping.

iii. Toxic organic materials in lake water are also a result of sewage treatment plants.

iv. Industrial effluents that are toxic and dangerous seriously contaminate lake water.

River Water Pollution

Due to rising population, industrialization, urbanisation, and a wide range of human activities, pollution of water resources has been most exploited.

The river water pollution leads to the following significant conclusions:

i. Everywhere, the quality of the water is declining.
ii. River pollution is worse during the monsoon season and least during the winter.
iii. Depending on the distance and kind, effluents and discharge have different effects.

Sea Water Pollution

More than two thirds of the surface of the earth is covered by oceans, which are essential to maintaining the chemical and biological balance necessary for life.

Marine pollution is the dumping of waste materials into the ocean that harms aquatic life, poses health risks to humans, hinders fisheries, and degrades seawater quality. Changes in the physical, chemical, and biological properties of the saltwater are related to marine pollution. Because of its high salt concentration, this water is likewise unsuited for consumption by humans and for use in industry.

Oil Pollution of Water: The most harm is done to water by petroleum and its by-products. The aquatic life in the surface layers as well as the flora and animals along the coast are put in risk by oil and its by-products. To keep the water from coming into touch with ambient oxygen, a single drop of petroleum covers a large area.

2.4 Major Water Pollutants

The following five major categories can be used to categorize different forms of water pollutants:

Organic Pollutants:

The organic pollutants may be further categorized as follows:

(a) Oxygen-demanding wastes : They include sewage from people and animals, biodegradable organic compounds, industrial waste from meatpacking facilities, slaughterhouses, paper and pulp mills, tanneries, etc., as well as runoff from agricultural operations. All of these pollutants are neither degraded or decomposed by bacterial action when dissolved oxygen is present (D.O.) As a result, the amount of D.O. in the water quickly decreases, which is bad

for aquatic life. For the sustaining of aquatic life, the ideal D.O. in natural waters is 4-6 ppm. Any drop in this D.O. value serves as a measure of pollution caused by the wastes that are oxygen-demanding stated above. At lower levels of D.O. in water, many aquatic creatures cannot thrive.

(b) Disease-causing wastes : They include pathogenic microbes, which can seriously harm the public's health when they enter the water together with sewage and other contaminants. These severe water-borne diseases, which include cholera, typhoid, dysentery, polio, and infectious hepatitis in humans, can be brought on by these germs, which are primarily viruses and bacteria. As a result, the first step in reducing water contamination is disinfection.

(c) Synthetic Organic Compounds : These include artificial substances including synthetic pesticides, synthetic detergents (syndets), food additives, medicines, insecticides, paints, synthetic fibres, elastomers, solvents, plasticizers, plastics, and other industrial chemicals. It's a good idea to have a backup plan in case something goes wrong. Most of these substances have the potential to be harmful to humans, animals, and plants. Even in tiny amounts, some bio-refractory (i.e., resistant to microbial degradation) organics, such as aromatic chlorinated hydrocarbons, can produce objectionable tastes, aromas, and colours in water, rendering the water (or fish living in it) unattractive. Persistent foams are frequently caused by non-biodegradable compounds such alkyl benzene sulphonates found in synthetic detergents. Alcohols, aldehydes, ethers, and gasoline are examples of volatile compounds that might explode in sewers.

(d) Sewage and agricultural run-off : Plant nutrients are supplied by sewage and runoff from agricultural fields, which may encourage the growth of algae and other aquatic weeds in the receiving water body. The water body's worth is diminished as a result of this ungainly plant growth, which is intended for recreational and other uses. Furthermore, the water body eventually turns into a dead pool of water due to the natural biological process of eutrophication, which causes it to lose all of its D.O.

(e) Oil : Oil spills from cargo oil tankers on the seas, losses during offshore oil exploration and production, unintentional fires in ships and oil tankers, accidental or deliberate oil slicks (as in the Gulf War between Iraq and U.S.-led allied forces in the year 1991), and leaks from oil pipe-lines, crossing waterways, and reservoirs are all potential causes of oil pollution. Reduced light penetration through surface waters as a result of oil pollution lowers the amount of photosynthesis by marine plants. Moreover, it lowers the D.O. in the water and puts waterfowl, animals, and plants around the coast in danger. As a result, oil contamination

causes ugly and dangerous circumstances that are bad for marine life and seafood. Due to the rise in oil-based technologies, huge oil shipments, accidental oil spills, and purposeful oil slicks during international confrontations, oil pollution in the oceans has been rising in recent years.

Inorganic Pollutants

Mineral acids, inorganic salts, finely divided metals or metal compounds, trace elements, cyanides, sulphates, and nitrates, as well as complexes of metals with organics found in natural waterways are examples of inorganic pollutants. Natural organic species like fulvic acids and manufactured organic species like EDTA are both involved in the metal-organic interactions. Redox equilibria, acid-base reactions, colloid formation, and reactions involving microorganisms in water all affect or are affected by these interactions. These interactions also have an impact on aquatic habitats' metal toxicity and algal growths.

The amount of different metals and metallic compounds in water that are released due to human activity equals their background levels in nature. While some of these trace elements are vital to biological functions, others may be hazardous to biota at larger concentrations:

The heavy metals, such as Hg, Cd, and Pb, and metalloids, such as As, Sb, and Se, are the most poisonous of the trace elements. The -SH bonds in enzymes are attacked by the heavy metals, which have a strong affinity for sulphur, immobilising the enzymes as a result. The heavy metal ions may also damage amino-groups (-NH) and carboxylic acid groups (-COOH) in proteins. The transport phenomena through the cell wall are hampered by the heavy metals that may be attached to the cell membranes. Moreover, heavy metals often precipitate phosphate bio-compounds or catalyse their breakdown. Most commonly, street dust, home sewage, and industrial effluents cause heavy metal water pollution.

Suspended solids and sediments

The main causes of sediments include soil erosion brought on by natural processes, agricultural expansion, strip mining, and construction activities. Silt, sand, and minerals that have eroded from the earth make up the majority of the suspended particles in water. For tropical nations like India, soil erosion caused by water, wind, and other natural factors is particularly important. 175 million hectares of the 328 million hectares of land that make up the entire planet are thought to be vulnerable to soil erosion. The continents are thought to lose 5.8 cm of surface soil every 1000 years. Every year, roughly 6000 metric tonnes of soil are washed into the ocean, which translates to approximately 5.37 million tonnes of NPK (nitrogen, phosphorous, and potassium) fertilisers. The soil in the land region degrades both qualitatively

and quantitatively as a result of this erosion. As a result, soil from agricultural land may be relocated to places where it is not at all necessary, such water reservoirs. The process of sedimentation occurs when soil particles eroded by flowing water eventually end up in water reservoirs. Due to siltation, soil fragments and other solid materials are deposited inside reservoirs and dams. This shortens the lifespan of the dams and reservoirs by reducing their ability to store water. Similar issues are present with our reservoirs, including Ram Ganga, Hirakud, Nizamsagar, Bhakra, and Maithan, and the consequent decrease in live storage capacity of the reservoirs may result in a significant loss of our country's irrigation potential. The suspended particles found in water bodies may also obscure the sunlight needed for photosynthesis by the bottom plants, in addition to filling up reservoirs and harbours. This might also suffocate corals, shellfish, and other bottom-dwelling organisms. The typical aquatic life in streams is harmed by the deposition of sediments in still sections. Moreover, organic solid-containing sludge blankets break down, creating anaerobic conditions and unpleasant gas production. By using effective soil and forest management techniques and good farming practises, the enormous problem of oil erosion can be reduced.

In general, sediments have a larger organic matter content than do soils. To store trace metals like Cu, Co, Ni, Mn, Cr, and Mo, sediments and suspended particles exchange cations with the surrounding aquatic medium. Silt and coal are examples of suspended particles that can damage fish gills and result in asphyxiation.

Radioactive Materials

The following anthropogenic activities may be the source of the radioactive water pollutants:

a. Ore extraction and processing, such as with uranium tailings.
b. Growing usage of radioactive isotopes for research, industrial, agricultural, and medical (diagnostic and therapeutic) purposes, such as I^{131}, P^{32}, Co^{60}, Ca^{45}, S^{35}, C^{14}, Rb^{86}, Ir^{132}, and Cs^{137}.
c. Radioactive substances from nuclear reactors and power plants, such as Sr^{90}, Cs^{137}, Pu^{248}, and Am^{241}.
d. Radioactive materials from nuclear weapon testing and usage, such as Sr^{90} and Cs^{137}

Water contains the radioactive isotopes Sr^{90}, I^{131}, Cs^{137}, Cs^{141}, Co^{60}, Mn^{54}, Fe^{55}, Pu^{239}, Ba^{l40}, K^{40}, and Ra^{226}. These radioactive isotopes are poisonous to all living things. For instance, Sr^{90}, which is produced during nuclear bomb testing and accumulates in bones and teeth, can

lead to major health issues in people. Sr^{90} can be present in water at a maximum concentration of 10 pico curies per litre (10^{-12} curies = 1 pico curie).

Heat

In any process where heat is transformed into mechanical work, waste heat is produced. Hence, thermal power plants—especially those that produce electricity using nuclear fuel—significantly contribute to thermal pollution. Waste hot water from these industries, where water is utilised as a coolant, is returned to the original water bodies. As a result, the water body's temperature rises. Due to the drop in water's DO level brought on by this temperature increase, aquatic life is negatively impacted. Moreover, any increase in temperature may make aquatic life more vulnerable to the harmful effects of particular substances, including aromatic methyl mercury and several polycyclic hydrocarbons. The range of organisms that can adapt to live at that temperature and DO level may change if there is a reduction in DO in the water. In addition to producing unpleasant tastes and odours, suspended particles in water may also foster conditions that are conducive to the growth of harmful germs.

2.5 Water Pollution Sources

All living things require water, the most plentiful and lovely natural resource, to survive. Yet, today's clean water is a valuable resource, and its quality is challenged by a variety of pollution sources, including:

1. Domestic waste and sewage, 2. Industrial waste products, 3. Agricultural effluent, 4. Plant Foods, 5. Detergents, 6. Harmful metals, 7. Siltation, 8. Thermal pollutants, 9. Radioactive substances

Domestic Wastes and Sewage

Sewage is often a mineral- and organic-rich diluted aqueous solution. Sewage, household trash, and food processing facilities account for around 75% of all water pollution. Moreover, it contains sewage sludge, soap, detergents, metals, glass, garbage, and human excrement. Household sewage and other wastes are frequently thrown into bodies of water like ponds, lakes, streams, and rivers either untreated or only partially treated. As the dumping is unregulated, particularly close to large cities, the water bodies are unable to recycle them and lose their ability to self-regulate.

There is a danger that the water will become contaminated if domestic sewage is not correctly managed when it is produced or if the sewage collected at the end of the sewage

treatment plant does not meet the required criteria. Domestic sewage handling without consideration may also contaminate wells and other subterranean water sources. The water of such rivers is tainted or polluted if sewage or poorly treated sewage is released directly into them.

Industrial Effluents

Industrial waste, hazardous chemicals, phenols, aldehydes, ketones, amines, cyanides, metallic waste, plasticizers, toxic acids, corrosive alkalies, oils, greases, dyes, biocides, suspended particles, and thermal pollutants are all found in industrial effluents that are discharged into water bodies. Some of the most significant causes of water pollution are effluents, or discharges from various industries, including those in the pharmaceutical, brewing, tannery, dyeing, textile, paper, plastic, chemical, metallurgical, fertiliser, etc. When these effluents are released into the sewage system, they contaminate the biological purification process used in sewage treatment and cause a number of pollution issues.

Agricultural Discharges

Water supplies are said to be heavily contaminated by plant nutrients, pesticides, fertilisers, farm wastes, manure slurry, sediments, drainage from silage, plant and animal detritus, and soil erosion, which is largely made up of inorganic components. In current agricultural pesticides, soil is amended using NPK fertilisers, which contain nitrates and phosphates. Some of these are irrigated and drained into water bodies by rainfall, where they seriously disrupt the aquatic ecology. When plant nutrients are used in excess, the nitrogen and phosphorus balance in the water is disturbed, which has an impact on plant growth. The BOD of receiving water rises as a result of organic waste.

Fertilizers

Artificial fertilisers, such as various biocides, are widely used in modern agriculture. Despite the fact that these chemicals improve vegetation, they destroy the entire aquatic ecology. They seriously contaminate the water. Because some fertilisers get washed off the land into rivers and lakes by irrigation, rain, seepage, and drainage, excessive and indiscriminate use of fertilisers on land has also had a negative ecological impact on aquatic ecosystems. The main component of fertilisers that causes an algal bloom is phosphate salts.

Detergents

Surfactants (10–30%), builders (15%), and other components are used to make detergents, which are modern cleaning agents. Several contaminants included in household

detergents have a negative impact on water bodies. They contain surface-active compounds that contribute to sodium (Na) phosphates, sodium silicates, sodium sulphates, and other salts. The environmental degradation brought on by industry waste being dumped into surrounding water sources is detergents' main drawback.

Toxic Metals

The mining sector is one of those with the highest heavy metal emission rates. industries like metallurgy, leather, distilleries, battery manufacturing, and thermal power plants. Industrial processes and home sewage disposal add toxic metals to the water system. It has been determined that traces of heavy metals like Hg, Cd, Pb, As, Co, Mn, Fe, and Cr are harmful to the aquatic ecology and human health. Trash containing dangerous metals in large concentrations, either singly or in combination, is exceedingly toxic to all living things.

Siltation

Silt is made up of dust and dirt that travel from the land to the river. The most pervasive and harmful contaminant, particularly in hill streams, is siltation. High turbidity levels in the water are caused by these soil particles, which may impede fish growth and productivity as well as the ability of aquatic organisms to move freely.

Thermal Pollutants

That leads to two significant issues:

(a) Since biological life is more active at high temperatures, there is a greater need for dissolved oxygen as water temperature rises.

(b) The amount of dissolved oxygen in water decreases as temperature increases. So, at higher temperatures, there will be less dissolved oxygen in the water. Thermal power plants are where the most unused heat is released, which is bad for the aquatic environment.

Radioactive Materials in Water

In water bodies where live species are acclimated to radioactive materials, man-made sources have started to introduce high doses of radio nucleoid with a variety of negative effects. Nuclear power facilities, reactors, fusion products, and other sources all release radioactive pollutants into the water streams.

1.6 Impacts of Water Pollution

2.6.1 Negative Impacts of Household Garbage and Sewage

(a) Sewage is a great environment for pathogenic bacteria, viruses, and protozoa to develop.

(b) Household sewage renders water absolutely unfit for drinking and domestic use. Domestic sewage is primarily constituted of spent water that contains wine, soapy water, and food particles.

(c) Many pathogenic bacteria that are introduced into the water have negative effects on humans and animals and cause chronic illnesses.

2.6.2 Harmful Effects of Industrial Pollutants

(a) It has harmful effects on living things and may result in death in sub-lethal kidney, liver, brain, and lung pathologies.

(a) Disinfectants, which are added to water to reduce bacterial and algal growth, may linger in bodies of water and endanger fish.

(c) Acidic and alkaline effluents render the water corrosive.

2.6.3 Effects of Fertilizers

a) Impacts on People and Animals : When nitrogen fertilisers are applied excessively to the soil, nitrates typically build up in the water, where they are then transformed by gut bacteria into harmful nitrates when consumed by humans and animals. Methanoglobin is created when nitrates enter the bloodstream and interact with haemoglobin, which has a greater affinity for nitrates than for oxygen. This harms the vascular and respiratory systems, which increases the risk of suffocation and death.

b) Effects on plant : Agricultural fertilisers drive out vital nutrients that are found in the upper soil layers, which has negative effects on plants. Humus that has been microbe-enriched promotes plant development. Nevertheless, soil that has been fertilised cannot sustain microbial life for very long. Fertilizers that are used to boost crop growth also boost algal growth in the surface water that crops are washed into. Eutrophication is the term used to describe the enhanced water fertility that accelerates the growth of water plants and algae.

1.6.4 Thermal pollution's effects on water

The quality of the water and organisms are both significantly impacted by the increase in temperature in aquatic systems. Some negative impacts include the following:

(a) Decreasing dissolved oxygen levels, b) Rise in BOD, c) Overuse of eutrophication, d) Lessening of gases' solubility in water; e) The aquatic food supply is impacted by the water's silt load setting up quickly.

1.6.5 Effects of Radioactive Pollutants in Water

(a) Radiation sickness is a group of symptoms caused by contaminated water that contains radioisotopes and is characterised by nausea, vomiting, diarrhoea, epilation, and overall weakness.

(b) It destroys the body's biological immune system, making it less resistant to certain illnesses.

(c) It results in blood abnormalities, gene mutations, and somatic and genetic problems in higher animals, including man.

(d) Water-borne radioactive elements build up in soil sediments, the atmosphere, and aquatic ecosystems.

(e) Plant mutation rates may rise if radioactive traces are present. (f) According to a recent study, phosphatic fertilisers also include fluorine and trace amounts of uranium, which are harmful to plants' metabolism and reach the water supply through rainfall.

2.7 Some Important Water Pollutants and Their Sources

Causative agents are as follows:

1. BOD Content (Organic Matter): Brewery, sugar production, wool processing (wool washing), pulp and paper industry, leather industry, municipal sewage, and night soil treatment plant are some of the industries that deal with processing food (canned goods and dairy products processing, marine product processing, starch processing, etc.).
2. Suspended Solids (SS): (Organic SS) Municipal sewage, coal washing, paper and leather industries, food processing. graveyard, mining industry, quarrying industry, and ceramic industry (inorganic SS).

3. Fats and oils: industries involved in food processing, petrochemicals, the production of iron and steel, mild finishing, and wool processing (wool washing).
4. Acids or alkalies: Mining, papermaking, pulp, electroplating, and metal all need acids or alkalies. chemical, textile, leather, and surgical industries.
5. Ammonia: Gas and coke plants
6. Phenols: Coke and gas production facilities, synthetic resin production, and other organic chemical businesses.
7. Sulfides: Wastewater treatment facilities, the dyeing and leather industries, the pulp and gas sectors.
8. Color: The production of dyes, dyeing, paint, leather, chemical industries, and nocturnal soil treatment facilities.
9. Odour: Industries that produce odours include those that process chemicals, pulp, marine products, pork, sugar, or leather, as well as sewage and night soil treatment facilities.
10. Detergents: Active agents for laundry, textile industry, and municipal sewage surfaces.

2.8 Strategies for Water Pollution Control

We are currently in a situation where water pollution has emerged as a major global issue, in part owing to the amazing growth of industrialization and in part due to the population boom. Man's activities have negatively impacted the neutral aquatic environment, either by overcrowding and insufficient or non-existent sanitation or through the uncontrolled huge discharge of trade waters into water systems.

Using pollution control techniques is an investment that will yield long-term returns. It is a reality that the costs associated with implementing effective and long-lasting pollution control measures are far more than the harm caused by pollution. Pollution is a sign of an ineffective procedure. It signifies the waste of global resources, a financial burden on a country, and a loss of revenue for an organisation. Reducing inefficiencies will help to minimise and reduce pollution. The majority of industrialized or developed nations use energy with an overall efficiency of 40%. Almost 50% of the energy consumed is lost and manifests as waste heat, which affects both the climate and aquatic ecosystems. As a result, the civic society is increasingly opposing industries.

Building wastewater treatment systems and plants wastes a lot of time and money. In many instances, altering the technique or the raw materials would guarantee that the issue is resolved for the least amount of money and without degrading the product's quality. Yet, the problem cannot be solved by the conventional pollution control method. Yet that might make it more difficult. For instance, whereas the combustion of chemical wastes produces harmful gases as well as particulate matter, the purification of wastewater produces sludge. Thus, an environmental dilemma result. It costs money to clean up pollution. Remaining after pollution has been removed. The removal of this residue requires additional resources, and doing so also results in an increase in pollution. Thus, the following measures need to be modified in order to control and avoid water pollution:

a. In order to increase non-waste technology's structural dimensions, various industrial, agricultural, and urban activities should be linked together. In this way, one industry's trash can be used as the raw material for another. Such a technology would depend on the efficient use of resources as well as the internal transfer of wastes from one area to another where they would serve as the raw materials. The goals ought to be: a) Waste prevention, b) Reducing wastes that cannot be avoided; and c) making waste that is eventually released into the environment harmless.

b. Cleaner manufacturing methods should be used to prevent pollution since they are safer because polluting waste is eliminated at the source.

c. Stabilizing the aquatic ecosystem by regulating the intake and outflow of energy and nutrients is unquestionably the most effective strategy to prevent and control water pollution. Reducing waste inputs, managing hazardous industrial effluents and municipal sewage, harvesting biomass, storing nutrients, aerating the air, and managing fish populations to safeguard aquatic flora and fauna are all practical ways to promote ecological stability.

d. Wastes can be treated using affordable and effective techniques. For instance, oxidation or stabilisation ponds can also be employed where there is enough land, by utilising the abundant sunshine and hot heat that occurs in most places of India. Domestic or industrial waste is held in big, clearly defined shallow ponds for a few days in oxidation ponds. A healthy bloom of algae and bacterial colonies develop in the presence of enough sunlight and organic nutrients in waste. The bacteria quickly break down the organic waste and make it safe through this reciprocal process. There is no risk of pollution when using these effluents again for irrigation of land. If the procedure is run correctly, there is no offensive odour released.

2.9 Groundwater Pollution

The earth's surface is covered by more than 98% of its fresh water supply. We observe the remaining 2% in lakes, rivers, streams, and reservoirs. Around 90% of the fresh water below the water table is ground water, which is water that exists in saturated materials below the water table. The unsaturated zone above the water table contains around 2% water as soil moisture, which is necessary for plant growth.

Due to the large pore space in earth materials, ground water serves as a reservoir, a conduit for long-distance water transportation, and a mechanical filter that enhances water quality by eliminating bacteria and suspended particulates. The source of water for wells and springs is the important factor.

The suggested source for rural home usage is the water that comes from springs and wells. It is new precipitation that falls as rain, snow, sleet, or hail. Industrial, household, and agricultural waste are now being continuously and alarmingly added to ground water reservoirs by human activities. Ground water contamination is typically irreversible, meaning that it is challenging to return the aquifer's original water quality once it has been poisoned. The water quality is reduced by excessive groundwater mineralization, which results in an unpleasant taste, odour, and excessive hardness. Although the soil mantle acting as an adsorbent and holding a significant amount of colloidal and soluble ions due to its capacity for cation exchange, ground water is not entirely immune from the threat of chronic pollution.

India's key industries like metals, chemicals, pharmaceuticals, and petroleum have adequate industrial infrastructure. But, other sectors for instance plastics, pesticides, fuels, solvents, paints, and food additives release effluents and pollutants that harm the soil, water, and plant ecology. Heavy metal pollution of the soil and plant-animal ecosystems results from the discharge of solid and liquid wastes containing heavy metals as lead, mokel, chromium, molybdenum, and mercury in land or water bodies.

2.9.1 Factors Affecting Ground Water Pollution

1. Pattern of Rainfall
2. Water table depth
3. The separation from the contaminating source
4. The texture, structure, and titration of the soil

2.9.2 Ground Water Contamination Sources

1. Household waste 2. Wastes from industry 3. Animal manures 4. Runoff from cities. 5. Saturable wastes

Household waste

In metropolitan locations, household garbage and disposal techniques are of the utmost importance. Pathogenic organisms, oxygen demand, nutrients, and sediments from household wastes are some of the elements causing the water quality to deteriorate. Solid wastes represent a severe threat to the quality of the groundwater since they are partially burned and partially assimilated into the soil.

Wastes from industry

The majority of businesses often generate large amounts of organic and inorganic effluents, as well as wastes containing harmful heavy metals. These substances seriously harm the groundwater by contaminating it. In North Delhi, more than 500 companies are seriously contaminating the groundwater, which is used for domestic purposes. Heavy metal acids are being dumped into open cesspools and drains by steel re-rolling mills and pickling companies, and these pollutants then seep into the water. Those who live close to or work in these companies are most severely impacted since they frequently rely on hand pumps to provide them with drinkable water.

Agricultural wastes

The water is continually being supplemented with fertilisers, pesticides, insecticides, herbicides, processing wastes, and animal faeces. Nitrate, phosphate, and potash-containing leachates from agricultural land flow downward with percolating water and join the aquifers below, posing a threat to ground water. Hence, a seemingly benign activity like farming could result in undetectable nitrate contamination. Although in India phosphate is more to blame for this as it produces phyxiation of water bodies, nitrate also contributes to the eutrophication of rivers.

Subsequent studies revealed that all pesticides were present in groundwater at higher levels than in surface water. The paper explains that the high pesticide residue concentration in ground water may be caused by the fact that ground water flows more steadily and experiences smaller dilutions than surface water, as well as by the concentration of organochlorine pesticide residues in ground water's higher stability. These pests accumulate in the soil, where they are

gradually moved into the groundwater. Because people, especially in rural areas, rely more on groundwater than other sources because they think it is safer than surface water, this dangerous situation must be corrected.

Runoff from Urban Areas

1. A lot of oils, greases, nutrients, metals, and detergents are concentrated in urban wastewater. Because they are soluble, detergents can penetrate the soil and reach groundwater.
2. Water pollution also results from raw sewage discharged in shallow soak pits and seepage from contaminated lakes, ponds, and streams.
3. Rainfall may carry significant impurities from air and dust into the aquifer below. Sand-filled soils and well waters may become polluted as a result of the intrusion of harmful liquid contaminants.
4. The problem has gotten worse as a result of forest clearing, which raises surface runoff and lowers groundwater levels.

Soluble effluents

1. The ground water is severely polluted by several soluble effluents. In areas with sandy soils and in humid climates with high water tables, the extent of pollution is greater.
2. In dry tropics, agriculture frequently uses 90% of the water withdrawals. Crop kinds with high yields need a lot of water. Water bodies like rivers and lakes have become smaller as a result of the current high water withdrawal rates.
3. The levels of ground water have been directly impacted by this. Lowering groundwater levels are a result of increased groundwater consumption.
4. Saline wake has entered ground water as a result of rising ground water withdrawal prices.
5. Pollution is a significant role in the decline of water quality and, consequently, clean water availability.
6. Nature's capacity to degrade pollutants into less dangerous substances has been surpassed by the quantities and varieties of trash that are released.

Other possible groundwater contamination sources

1. Lagunas for the treatment of sewage, 2. Mine Spills, 3. Seep holes, 4. Municipal and rural waste, 5. Composting septic systems 6. Rubbish Dumping, 7. Pollutant Leaching and Downward Movement

2.9.3 Harmful Effects of Ground Water Pollution

Ground water pollution causes irreparable damage to soil, plants and animals including

1. Harmful Effects on Man

a. The main factor contributing to the spread of epidemics and chronic diseases in humans is contaminated ground water. It results in typhoid, hepatitis, jaundice, dysentery, diarrhoea, and tuberculosis.

b. Lung cancer and asbestosis are lethal diseases brought on by water contaminated with asbestos fibres.

i. Groundwaters in locations with high rainfall levels have dangerous levels of iron as high as 20 ppm. In deep tube wells, iron is present as the ferrous ion, which when removed quickly undergoes oxidation and precipitation as ferric hydroxide, changing its hue to a bright yellow orange. Given that the acceptable limit for iron in drinking water is only 0.3 ppm, such waters are exceedingly dangerous.

ii. The woollen industries in Punjab-Ludhiana, Amritsar, Haryana-Sonepat, and Ambala contribute significant amounts of hazardous metals to groundwater, including Hg, Ni, Cu, Cr, Fe, and cyanides, which cause skin and stomach illnesses in humans.

iii. High fluoride level (greater than 0.5–1.5 ppm) results in mottled teeth, bone deformation, and joint pain that renders people incapable of doing nearly all productive activities.

iv. Both people and animals are negatively impacted by rising nitrate levels in groundwater. "Methaemoglobinaemia" or "Blue baby disease" is brought on by nitrate's combination with haemoglobin, the blood's oxygen transporter, to create methaemoglobin, which reduces the tissue's ability to carry oxygen.

2. Harmful Effects on Soil

i. When used to irrigate agricultural fields, dirty groundwater causes significant crop damage and lowers grain yields.

ii. Dead bacteria and other soil microorganisms severely reduce soil fertility. I Contaminated groundwater makes soils more alkaline.

iii. Groundwater pollution disrupts the entire ecosystem and has a negative impact on plant metabolism.

1.9.4 Control of Groundwater Pollution

i. Carefully examine the sources of the contaminants

ii. The location of municipal and industrial disposal sites should be chosen while taking the local groundwater levels and flow patterns into consideration.

iii. The industry itself needs to take action to effectively remediate harmful industrial effluents.

iv. Extreme caution should be exercised while choosing the location of wells for drinking water supply.

v. The origins and directions of any nearby contaminants should be considered.

vi. In the case of drinking water wells, it is not advisable to draw water from the topmost aquifer.

2.10 Eutrophication

The word "eutrophos," which means well-nourished or enriched in Greek, is the source of the term "eutrophication," a natural process. Due to anthropogenic or natural factors, the lake water is enhanced in nutrients, nitrates, and sulphates during this process. This causes aquatic plants of all sizes, whether micro or macro, to grow excessively, which causes the phenomena of natural plant ageing. Nitrates and sulphates are the main nutrients, although other substances like phosphates and calcium levels can also contribute to eutrophication.

2.10.1 Nutrients' Sources

When fertiliser nutrients are applied in unnaturally large concentrations, eutrophication quickly worsens. Urban drainage, detergents, animal waste, domestic and industrial waste, and sediments all enter water streams.

2.10.2 Eutrophication Types

1. Natural Eutrophication
2. Man-made eutrophication

1. Natural Eutrophication

Natural eutrophication is the term used to describe the process of lake ageing marked by nutrient enrichment resulting from environmental factors. The micro-plants, such as algae, that helped the lake grow originally contribute additional nutrients to the lake waters when they are

dying. The nutrients help in the formation of more and more aquatic planktons and plants, which causes the lakes to age. This promotes the growth of micro plants like water hyacinth, which further raise the concentration of the nutrients in their death phase. Consequently, oligotrophic (a lake without plants at first) lakes become eutrophic lakes throughout the process of natural eutrophication. In the beginning, it allows for the growth of phytoplankton, algal blooms, and aquatic vegetation like water hyacinth, aquatic weeds, water fern, and water lettuce, which in turn supplies plenty of food for fish and herbivorous zooplanktons, but in the later stages, it may cause aquatic animals to perish from DO depletion.

2. Man-made eutrophication

Human activities, which provide 80% of the nitrogen and 75% of the phosphorus to lakes and streams, typically speed up this process.

2.10.3 Eutrophication's Impacts

a. When there is eutrophication, harmful compounds are released by algal blooms, killing fish, birds, and other aquatic species and causing the water to sink.

b. Algal bloom decomposition causes water to lose oxygen. Aquatic species start to perish as a result of the low oxygen levels and high CO levels, and the clean water degrades into a foul outflow.

c. The same microorganisms produce oxygen by reducing nitrates when the oxygen level is zero (anaerobic zone). When nitrate is completely depleted, oxygen can only be recovered as a last option by reducing sulphate, which results in hydrogen sulphide and gives water a putrid flavour and odour.

d. Sewage products support the growth of numerous harmful bacteria, viruses, protozoa, and other organisms under anaerobic conditions. It causes the spread of water-borne illnesses that can be lethal, including typhoid, polio, dysentery, diarrhoea, and viral hepatitis.

e. Overfertilization causes algae to become highly dominant. Algae and rooted weeds impair water quality and waterworks, block filters, and interfere with hydroelectric power generation.

2.10.4 Control of Eutrophication

1. To reduce the nutritional value, the wastewater must be treated before being released into water streams.

2. By eliminating nitrogen and phosphorus from the source, dividing nutrient-rich waters from the receiving bodies, and diluting these substances, eutrophication can be reduced.
3. Once an algae bloom has died and begun to decompose, it should be removed.
4. Dissolved nutrients can be removed using physicochemical techniques. For instance, nitrogen can be removed using nitrification, denim base, reverse osmosis, and ion exchange techniques. Phosphorus can be eliminated using precipitation.
5. Although the eutrophication process, which involves a natural series of events, is challenging to manipulate, it can be temporarily controlled by eliminating aquatic vegetation. To kill algae and rooted plants, respectively, $CuSO_4$ and sodium arsenate are used.

2.11 Summary

Protecting the environment and living things is one of the main goals of pursuing environmental science. For our quality-of-life water is a crucial resource. Therefore, the availability to safe water for consumption and hygienic reasons is a requirement for human health and well-being. Water bodies (such as lakes, oceans, rivers, aquifers, seas, and groundwater) can get contaminated through human activity. Any modification to the physical, chemical, or biological characteristics of water that will have a negative impact on any living thing is referred to as water pollution. Chemical fertilisers and pesticides, sediment from soil degradation, discharge from sewer systems, effluent from cattle feedlots, toxic waste (some poisonous) from companies, plastics, and wastewater and other urban wastes from cities and towns are among the factors that contribute to water pollution. It has diverse range of adverse impacts on different components of the environment. Accordingly, the control of noise pollution is crucial. With a focus on their production and clean-up, the principles of water pollution and different aspects of air pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit.

2.12 Self-Assessment questions

1. How are water pollutants classified? Give suitable examples.
2. Discuss the important characteristics of waste waters.
3. Define water pollution. Describe different types of water pollution.
4. Explain different Sources of water pollution.
5. What are biodegradable pollutants?
6. Explain the fallowing a) Industrial pollutants b) Agricultural pollutants c) Domestic pollutants.

7. Describe briefly the causes of eutrophication and their control measures.
8. Describe briefly ground water contamination causes, effects and their control measures.
9. Briefly describe control strategies of water pollution.
10. Write a short note on water pollution effects.

2.13 Suggested Readings

1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi.
2. P.K. Goel, "Water Pollution Effects and Control" New Age International (P) Limited; Publishers, New Delhi, 1997.
3. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998
4. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001.
5. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi.
6. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

UNIT 3 ❑ Noise pollution

Structure

3.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different noise pollution sources,
- understand sound wave characteristics,
- outline noise measurement units and different noise indices,
- understand the different adverse effects of noise pollution,
- comprehend the control mechanism of noise pollution,
- understand the noise legislation.

3.2 Introduction

One of the many pollutants and polluting agents is noise, which has the ability to cause a wide range of illnesses, from a simple headache to heart attack and irreversible hearing loss. It is imperative that the authorities put a stop to the noise pollution sources since the amount of noise pollution is rising to frightening heights in every megacity. But, before dealing with noise pollution, we must be clear about the difference between noise and pollution in our minds.

Although man has been plagued by the threat of loud noise and echophony since the dawn of time, Robert Alex Baron (1964) was the first to demonstrate that noise, which is an unavoidable component of daily life for many individuals, has negative physiological and psychological impacts. Too much loud noise, which is pervasive, especially in the nation's crowded cities where there is no moral or legal restriction on the use of blasting horns and high-pitched talk, has become a severe hazard to the environment for people. While, most people are unlikely to experience excessive noise level, it may be annoying or disturbing to them. So, one definition of noise pollution is "unwanted sound that is released into the environment to annoy its recipients."

Definition of Noise

The latin word for "nausea" is where the word noise comes from. When all of the definitions of noise are taken into account, it becomes evident what noise actually is. Despite having a variety of deliberate interpretations, the subject is still up for debate. For example, at a political event, the attendees are ecstatic to hear their scary intrusion into their tranquilly. Similar to how young people may find beautiful music, the elderly and ill may find it to be hell. Hence, in essence, music is a sound that pleases the ear, whereas noise is a sound that irritates and annoys. These definitions will provide some insight. "Bad sound at any time," "Sound without value," "Sound that the recipient does not want"

"Noise" as defined by the World Health Organization (WHO), is undesirable and unwanted sound."

"Noise is generally defined as the sound that is disturbing to the normal level of human perception of sound". The degree of disturbance, however, varies widely with the sensitivity of the person vis-a-vis factors such as age, health of the hearing mechanism and the nature of the stress and strains undergone by the individual. Webster defines noise as "a sound that lacks agreeable musical quality or is noticeably loud, harsh or discordant".

3.3 Characteristics of Sound and Its Measurement

The motion of waves in an elastic material that result from molecular vibrations makes up sound. Periodic mechanical disruption of solids and fluids. Both vibrating surfaces and vibrating gases emit sound. Also, as exhaust gas speed increases, noise also increases quickly.

The vibrations of solid objects or the separation of fluids as they move over or through holes in solid objects are what enable sound to be produced in the surroundings by alternating pressure changes in the air. These vibrations create compression, then rarefaction, and so forth in the surrounding air. Sound waves are created by the alternating compression and rarefaction of the surrounding air, and they travel in a sinusoidal pattern.

Period: The interval between successive oscillation peaks or troughs is referred to as the period (P). The frequency is the number of times a peak appears within a second (D). Hence,

$$P = \frac{1}{f}$$

Wave Length: Wave length (λ) is the separation between two succeeding peaks or troughs, when C is the sound wave's velocity.

$$\lambda = c \times \frac{1}{f}$$

Amplitude: The height of the peak sound pressure, measured above or below the zero-pressure line, is known as the amplitude (A) of the wave. Thus, a sine wave's equivalent pressure is denoted by the root mean square pressure (Prms), which is denoted as

$$\text{Prms} = \sqrt{P^2 \times (t)} = \sqrt{\frac{1}{T}\int_0^T P^2 \times (t) \times dt}$$

Where P(t)= Pressure at any time t.

Hence, to calculate the r.m.s. sound pressure, add the squares of the amplitude values at short time intervals, divide the sum by the averaging period, and then take the square root of the total.

Sound Pressure = Total Atmospheric Pressure - Barometric Pressure

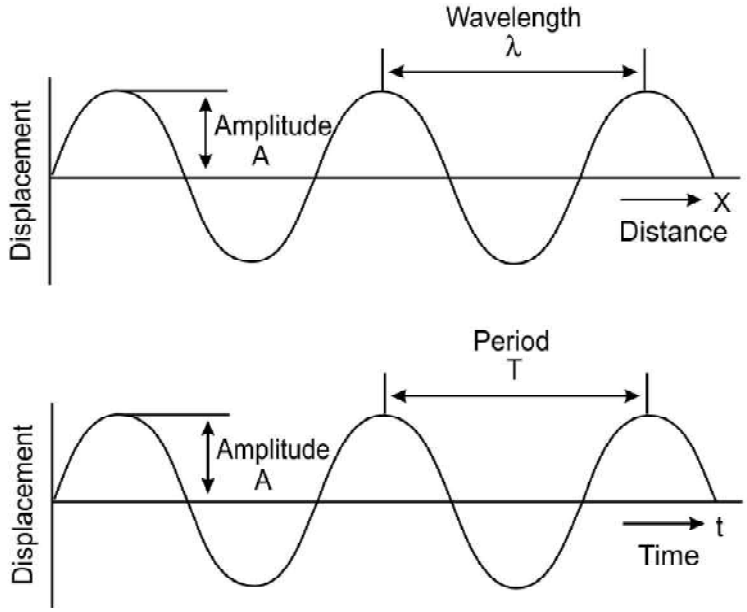


Figure 3.1. ***Sound wave and their characteristics***

Power of sound (W): The pace at which a sound wave is producing work while travelling in its path of propagation is known as the power of sound (W). Hence, the power of a sound wave is defined as the amount of energy it transmits in the direction of propagation and is measured in watts in S.I. units.

Sound Intensity: The sound intensity (I) is the sum of the sound power per unit area normal to the direction of the sound wave, averaged over time. The equation relates a sound wave's intensity and power.

$I = W/a$

Where I = Intensity in watt/m^2

W = Power of sound wave in watts

a = A unit area $\perp$ to the direction of wave motion

$I = P^2$r.m.s/ρ.C, where P^2rms = r.m.s. sound pressure in pascal (P)

ρ = density of air or medium in kg/m^3

C = velocity of sound in m/s

(ρ,c) can be known if temperature of air is known

c=20.05 √T, T= absolute temperature in Kelvin(k)

c is in m/sec

3.4 Measurement of Noise

3.4.1 Decibels and Levels

The decibel was developed to fulfil the scientific requirement of providing information about the physical amplitude of sound. It is the fundamental unit of sound. Although there are several sophisticated systems for measuring noise, the decibel is arguably the most often used one (dB). A sound's strength, or how loud it is to the ear, is measured in decibels. The decibel (dB) is a relative measurement of gradation; if a sound is 60 dB, it is 60 dB louder than a sound standard at, let's say, zero.

The decibel scale is logarithmic, meaning that 60 dB is ten times as severe as 50 dB, one hundred times as intense as 40 dB, and one thousand times as intense as 30 dB. A jet taking off in close proximity produces noise levels of 140–150 dB, which are 10,000,000 times louder than the 50 dB of typical neighbourhood background noise. When compared to air pressure, the sound pressure variations that we are capable of hearing are extremely modest. As the pressure of typical speaking is on the order of one millionth that of atmospheric pressure. Yet, there is a very wide range of pressures between the quietest noises humans can hear and the loudest. The sound pressure that will induce pain is about 200 Pa, while the lowest audible pressure for a 1000 Hz pure tone is 2×10^{-5} Pa. This is equivalent to a variation in pressure by a factor of 10 (ten million) or a variation in sound intensity by a factor of 10^{14}. A quantity Q is related to a reference quantity Q_o in decibels by the equation

$$\text{Decibel } (Q) = 10 \log (Q/Q_o) \text{ d Bre.} Q_o$$

The notation dB re Q_o means that Q is expressed in terms of decibels relative (re) to the reference quantity Q_o.

3.4.2 Other Units for Measuring Noise

The "bels" unit, which bears Graham Bell's name, can also be used to quantify noise intensity. Tenth of a bel is a dB. Although it has been demonstrated in experimental settings, the threshold of hearing is a hypothetical phenomenon. What is referred to as silence, in general terms, it is normally around 25 dB. Noise inflicts pain at about 120 dB but severe

pain and temporary loss of hearing are inflicted after only a few minutes at 140 or few seconds at 150 dB or more.

Sons can also express how loud a sound is. A sone is defined as 40 dB of noise at 1000 hertz. For the ordinary person, the range of sound vibrations below 16 Hz and above 20,000 Hz are referred to as infrasonic and ultrasonic, respectively. Yet, some people are able to hear frequencies that others are unable to.

Occasionally, the phon, a psychoacoustic language, is used to describe sound. Both frequency and intensity are considered. The loudness of 92 dB at 20 Hz is equal to 40 phons.

Human Hearing Intensity

The range of human hearing is between 0 and 120 dB in intensity. At 50 dB, we can hear normal conversation or speech, while 75 dB and 95 dB are regarded fairly loud and extremely loud, respectively. A jet's noise registers at 11 0 dB, which is regarded as being too loud. The noise is agonisingly loud at 140–150 dB. Hence, major cities like Delhi, Bombay, Kolkata, and Chennai are too noisy. A recent study done by the institute of Road Traffic Education, suggests that Delhi is the noisiest city in India with 83 dB during day and 77 dB at night, followed by Kolkata (82 and 75 dB), Bomaby (80 and 74 dB) and Chennai (77 and 73 dB).

Sound Levels

Sound Level: If the amplitude of pressure fluctuations has been P then the sound level in decibels has been given by

$$L = 10 \log_{10} [P/P_0]^2 dB$$

Where $Po = 2x\ 10^{-5}\ N/m^2$ (a reference pressure)

Sound Power Level: It is given by the equation

$$L_w = 10 \log_{10} W/W \text{ dB re Wo}$$

Where W = the sound power emitted by the source and

$W_o = 10^{-12}$ = reference sound power

Sound Intensity Level:

$$L_I = 10 \log_{10} [I/I_o] \text{ dB re } I_o$$

Where I = the sound intensity and the reference intensity is

$L_o = 10^{-12}$ W/m²

Sound Pressure Level: The word "decibel" typically refers to sound pressure level, and the majority of sound measuring devices detect sound pressure. Decibel scales are frequently used to measure power-like ratios. As sound pressure squared is proportional to sound intensity, the sound pressure level is then stated in terms of sound pressure squared (power). The unit of sound pressure level is defined as Lp.

$Lp = 10 \log (p^2/p_o^2)$ dB re p_o

$= 20 \log (p/p_o)$ dB re p_o

where the reference pressure is, $P_o = 2 \times 10^{-3}$ N/m²

Both P and P_o are expressed as rms values.

Relationship Between Sound Power Level, Sound Intensity level, and Sound Pressure Level

$L_I = 10 \text{ Log}(I/I_o) = 10 \text{ Log}(p^2/p_c I_o)$

$= 10 \text{ Log } (p^2/P_o^2) + 10 \text{ Log } (p_o^2/p_c I_o)$

For standard atmospheric conditions in air, the quantity $(P_o^2/P_c I_o)$ is almost equal to unity and, hence its logarithm is approximately zero. For most practical conditions, we may assume

LI = LP

3.5 Sources of Noise Pollution

Industrial and non-industrial sources are the two main types of noise pollution, and they are described here in more detail:

1. Noise pollution from industry

Noise is a by-product of the conversion of energy from large machines employed in a variety of mills, foundries, and other enterprises. Hence, industrial complexes with heavy machinery operating at high speeds make a lot of noise and have loud noise levels that cannot be tolerated without causing damage.

Industrial workers are the ones that are most affected by noise in the workplace. Because of prior failures, industrial estates are built far from habitations. Yet, unauthorised cottage industries in residential areas might disturb nearby neighbours with loud noise. Actually, industry faces two challenges from noise.

Diesel engines are used in open coal mines in the coal-bearing regions of Raniganj, Asansol, and Durgapur, which adds to the noise pollution. Similar circumstances exist in the Jammu and Kashmir regions of Handwara and Kalakote.

2. Non-industrial Noise Pollution

Transportation noise from cars, trains, and planes is a major contributor to non-industrial noise pollution, as are noises from machinery and appliances like those found in cement plants, concrete mixers, crushers, and many others. Other non-industrial sources of noise pollution include the use of musical instruments, fireworks, radios, transistors, televisions, cables, and electric generators. Below is a discussion of each of these in turn:

Transportation Noise: Vehicle noise is one type of transportation noise that has the biggest impact on urban residents. Broadly, it originated from three sources namely road traffic noise, rail traffic noise and air traffic noise. This consists of engine and exhaust noise, indiscriminate use of horns, usage of pressure horns, and vehicle repair workshop. According to a survey by the State Pollution Control Board, noise levels in major cities like Kolkata and Bombay can reach 95 decibels, with cars accounting for 70 to 85 decibels of that noise.

In large cities, noise from aeroplanes and trains is a huge worry. The sound is louder and more intense close to train stations, becoming a physical irritant that, with prolonged exposure, has a variety of negative effects. In fact, the sound waves travel into the atmosphere and pollute the entire environment, and everyone feels uncomfortable in this environment. The train's noise intensity exceeds 150 dB.

Table 3.1: Noise level from various sources

Source	Noise level (dB)
Diesel truck (200 m)	85-110
Jet take off (100 m)	130-140
Jet take off (300 m)	100-110
Propeller Jet take off (300 m)	90-100

Rail traffic (30 m)	90-100
Medium road traffic (main stream)	70-80
Heavy road traffic (highway)	80-90
Light road traffic (side streets)	60-70
Bulldozer (10m)	90-105
Kitchen blender	90-95
Electric shaver	70-90
Normal conversion	60
Passenger car (25 m)	70-80
Large cooling tower (600 m)	120-130
Barking dog (250 m) high	65
Subway platform (as high)	110
Rock drill	120

Noise from Machinery and Gadgets: This includes the noise made by equipment used in construction, such as cement plants, concrete mixers, and crushers.

Noise pollution always affects the urban man as a result of demolition and building for urban regeneration and expansions. In the newly constructed colonies in large cities, large, heavy machinery are used during the demolition of existing sites and construction of new structures, which makes a lot of noise. The obvious examples that have become familiar sights not only in cities and large towns but also in the villages where building is taking place include stone crushers, cement, and sand stone mixers.

Pyrotechnics: During holidays like Diwali, Id, Baisakhi, etc. as well as other celebrations like weddings, marriages, religious gatherings, and social events, pyrotechnics like crackers and bombs are sources of intolerable noise generation. The use of blasting material in construction of roads, civil works and quarries also causes lot of noise.

Use of Radios/Transistors and Loud Speakers: The clamour produced by tape recorders and stereos that are carelessly used in marketplaces, matadors, and buses while disregarding the needs of the public.

The other sources of noise in the morning include bhajans played through loudspeakers from adjacent temples or shabad kirtans from Gurudwaras. Nothing is audible clearly since

the sounds coming from both sources continuously crisscrossing one's ears. One simply has to put up with a loud noise that is uncomfortable in the morning. The difficulty is much the more serious for the pupils who get up in the morning to memorise their courses.

Usage of Cable and TV: Due to their loud intensities, TVs contribute significantly to noise pollution. As major cities and megacities have become increasingly controlled by cable TV. The following TV sound intensity table from Doordarshan's network and cables may be useful to them. It is:

i. 70 dB for TV sound at medium volume.
ii. 80 dB for impulse noise of advertisements at the same. volume.
iii. 86 dB for the film songs at same volume.
iv. 82 dB for fighting scene sounds.
v. 54 dB for minimum TV volume.
vi. 94 dB for maximum TV volume.

Use of Electric Generators: Electric generators are now frequently used during social gatherings, weddings, and other ceremonies as a result of the patchy availability of electricity in towns and cities, as well as in shopping centres and other businesses. The business owners utilise electric generators as backups if the power goes out, which makes a terrible amount of noise and endangers the pedestrians.

Use of Musical Instruments in Festivals: Many sound-producing instruments are employed throughout religious, cultural, and social events as well as festival celebrations throughout India. Drums are constantly beat during the Losar dance of Ladakh, the Kud dance of Bhaderwah (Jammu), and the Bhangra of Jammu during the Baisakhi fair. The traditional dances of Nagaland, Kulu and Chamba (Himachal Pradesh), and the Gidda dance of Punjab are not only performed to the beat of drums, but also to the blowing of conch shells and "brass surma" at these events. The amount of noise that is created in this way pollutes the entire environment.

3.6 Effects of Noise Pollution

Recent research has revealed that between 90 and 110 million individuals in India experience daily annoyance from environmental noise pollution, with about 50 million suffering negative health effects. Noise pollution affects large cities far more than it does smaller ones.

In contrast, the distant regions of the Himalayas are the ideal hubs of solitude and quiet. Compared to rural residents in the furthest reaches of the country, more than 20% of people in larger cities find it difficult to get a good night's sleep. Noise pollution has some odd and unpleasant impacts on both people and animals. These are a few of them:

3.6.1 Effects on Human Beings

There are five ways that noise might hinder our activities: (i) At the audiological level by impairing the hearing mechanism's ability to work properly, (ii) On a biological level by obstructing the body's biological processes. (iii) On a psychological level by interfering with the body's ability to fall asleep and move, (iv) By influencing the respondents' social conduct on a behavioural level and (v) By affecting the personality on a personological level.

Consequently, noise pollution affects how well humans perform in the areas of acoustics, biology, psychology, behaviour, and personology.

Audiological Effects: According to studies, brief exposure to loud noise can cause temporary deafness that can last anywhere from a few seconds to a few hours. By the auditory reflex, a noise of 90 dB for more than 10 seconds contracts the tympanic membrane. Long-term exposure during the course of the workday can result in chronic, irreversible deafness. When the noise level exceeds 120 dB, permanent deafness results, while noise levels between 90- and 120 dB result in less damage. Yet, the following factors determine how severely hearing power is damaged:

(a) The type of noise,

(b) The level of intensity of the noise,

(c) The noisy area;

(d) The type of the noise-generating device, and

(e) Exposure time.

Common sources of noise that might permanently harm the hearing mechanism include explosions, jet aircraft, and several industrial processes where the noise is amplified by the diaphragm. A 150 dB explosion can rupture the eardrum, permanently damaging the cochlea's nerve endings and other structures. Noise levels of 130 dB might produce ear ache or a tickling sensation.

The auditory system is destroyed by noise exposure for 8 hours a day at a noise intensity of 79 to 90 dB. Also, this causes serious disruptions that even damage memory, retention, and

expressive abilities. Additionally, it has been found that long-term exposure to noise levels exceeding 50 dB not only permanently impairs a person's ability to hear clearly, but also reduces their productivity at work.

Another condition of its kind caused by loud noise is auditory fatigue. It may cause whistling and buzzing noises in the ear, which suggests that one can find it difficult to discern between different sounds while others are present.

Biological Effects

The harmful effects of noise pollution on people can also be shown biologically in a variety of ways. It interferes with metabolism, disrupts the nervous system, makes it difficult to concentrate, causes tension and weariness, and contributes to a number of other ailments.

Unchecked exposure to noise can result in a variety of illnesses, including headaches, a loss of mental and physical equilibrium, insomnia, mental strain, and short-temperedness in men. Noise levels between 60 and 120 dB reduce productivity and induce mental stress.

According to medical research, loud noise can cause heart attacks in people who have already suffered cardiac damage, and long-term exposure can result in chronic problems like hypertension or ulcers. In fact, prolonged exposure to loud noises causes blood arteries that carry and take in blood to constrict, blood pressure to rise, and faster heartbeats, all of which lead to heart conditions. Dr. D.P. Agarwal (All India Institute of Medical Sciences 2000) mentioned a Japanese experiment in which 300 workers were subjected to sound levels of 85 to 120 dB while at work to discuss the impact of noise on the cardiovascular system. Their heart rates were seen to decelerate down. Moreover, blood vessels tighten, pupils enlarge, and voluntary and involuntary muscles tense up at high noise levels.

Table 3.2: Effect of different levels of noise on human ear

Noise level	Type of effects
Zero dB	Threshold of hearing
25 dB	General silence
30-55 dB	Ordinary conversation
60 dB	Normal conversation.
65 dB	Does not pollute the environment

75 dB	Moderately loud and not so uncomfortable.
85 dB	Uncomfortable
85 dB (8 hours exposure)	Impairs hearing ability of the worker.
95 dB	Very loud and more uncomfortable.
110 dB (constant exposure everyday)	Develops hearing problems
120 dB	Severe pain and temporary loss of hearing.
130 dB	Tickling sensation or pain in car.
150 dB or more (Few seconds)	Severe pain and temporary loss of hearing.
150 dB (constant exposure)	Deafness
150 dB (Explosive sound)	Rupture the ear drum

The acceleration of the heartbeat and breathing rate by noise pollution might alter a person's physiological state. The effects of excessive noise on women, especially those who are pregnant, are addressed in the report. Noise pollution often prolongs and extends the duration of menstrual bleeding. The growing foetus is subject to noise pollution's harshest effects, which might result in preterm birth. Moreover, it is thought that noise pollution hinders sexual sensations. High intensity noise can cause psychological indisposition and pose a serious threat to young children in areas where it continues to be a problem. Very unpleasant noises seriously disrupt the female reproductive system, producing vomiting, pain, and restlessness in addition to heavy monthly bleeding. Loud noise causes urban girls' first periods to appear sooner than those of their rural sisters.

It has been discovered in Japan that loud noises (between 85 and 120 dB) cause the stomach's gastric juice and salivary secretions to decrease, disturbing the digestive system. A sudden injection of adrenaline causes an increase in anxiety, agitation, irritability, and neuromuscular tension. Noise triggers convulsions in people with epilepsy.

Psychological Effects

Unwanted noise disrupts communication, causes annoyance and insomnia, as well as lack of cooperation and social disputes, all of which are psychologically and physiologically caused.

Paranoia, homicidal and suicidal impulses are some detrimental mental effects. When noise levels hit 90 dB, a man's visual response decreases by 25%. After impairing night vision

and impairing colour perception, noise is also reported to produce a constriction of the pupils. Some of the symptoms of disruptive sound intensities include psychotic symptoms and terrified and furious inner and exterior dispositions.

When the noise's origin is unknown, intolerable suffering could occur. Speech communication interruptions can hinder performance, increase error risk, and reduce production and efficiency. Muscle tightness, nervous irritation, and strain can all be brought on by noise.

Behavioral Effects

As a result of exposure to excessive levels of noise, numerous behavioural charts in people are reported. Certain symptoms are immediately observable. The unwanted sound could irritate others. Noise reduces a person's aural sensitivity, which has a negative impact on concentration and attention. It has been noted that students whose schools are located in crowded urban areas and subject to noise pollution do poorly in comprehension tests. Learning problems are the outcome of annoyance brought on by noise. A person can become uneasy and distracted by sudden noise. Housewives using various kitchen appliances cause headaches and giddiness owing to the noise and vibrations they produce.

Some of the symptoms caused by specific anomalies in behaviour, which get built up slowly but surely during noise pollution, include the inability to think, analyse, and solve problems, amass stress, an inability to relax, and indifference to surroundings.

Long-term exposure to sounds with very high intensities has an impact on how systems function, which can hinder growth, cause the thinking faculties to deteriorate, cause failure to respond to such things in the system that are necessary for integrating various functional processes, and interfere with coordination between various systems in the body.

Effects on Personality

The damaging effects of noise can disrupt a person's entire personality when they last for a long time and generate consistent maladaptive reactions. The optimal personological development of children may be compromised by feelings of inadequacy, lack of confidence, and poor self-perception that may develop in children. When a youngster experiences these emotions in their formative years, it is difficult to get rid of them without leaving permanent scars.

Other Effects

The following is a list of other effects of noise pollution :

i. Noise also has additional physical impacts. Medical researchers claim that loud noise can occasionally induce abrupt blindness, stuttering, and even epileptic fits—especially in young children.

ii. According to some evidence gathered by a British research team, noise from aircraft engines causes people who live close to airports to experience mental health problems. They experienced neurotic disease suffering.

iii. Extreme noise levels adversely alter hormonal blood levels and cause miscarriage in females. Other effects of loudness include cyanosis and buzzing feelings.

iv. Loudness and extreme unpleasantness can easily bother older individuals. Older folks seek more sleep, which is interfered with. Excessive amounts of environmental noise might impair the sleep of the babies also.

v. The unwelcome sound may contribute to foetal nervous system malformations that may impact behaviour in later life.

vi. Noise may be a factor in the development of gastrointestinal conditions such peptic ulcers.

vii. The loudness disturbs the tranquilly of the mind and causes discomfort.

viii. Loud noise has a long list of chronic health impacts, including emotional outbursts and various physical diseases.

ix. The noise made by car horns close to hospitals or schools is a major annoyance. In hospitals, the blowing of horns disturbs the patients and makes them feel uneasy, while in classrooms, it interferes with students' ability to pursue their academic goals.

x. A chain reaction can be started by an abrupt loud noise. The body tenses up. Several systems act unevenly, the veins constrict, the heart beats more quickly, and the blood rises. pressure

xi. Industrial noise is substantially more harmful to workers than background city noise. The numbness around the ears that the mill workers experience is reported to be continuous. Child laborers suffer from permanent hearing losses due to their exposure of debilitating noise level at tender age.

xii. Noise increases the likelihood of mistakes in manual and skilled work as well as in mental activity; as a result, there is a significant risk to both the operators' and others' safety.

3.6.2 Effects on Animals/Birds

Noise pollution affects many animals and birds in addition to people. For the purpose of examining the impacts of noise, animals such as guinea pigs, rats, dogs, and cats are exposed to high levels of noise for relatively brief periods of time. Blood chemical changes, brain, heart, and liver damage, as well as hearing mechanism impairment, are some of these harms. The majority of agricultural animals exhibit decent adjustment.

Animals suffering from noise pollution also experience mental fatigue. Noise pollution can also cause edoema, stiffness, and damage to the bones and joints. Although there is no proof that people are as sensitive to noise as animals are, abrupt loud noises can cause animals to convulse. Rats were shown to lose their reactions and behave erratically in trials where they were subjected to noise levels above 500 dB.

High intensity sounds have been shown to cause a percentage of birds to cease producing eggs. Moreover, many birds relocate from noisy environments. When a location is exposed to noise pollution, migratory birds begin to leave that area in lower numbers.

The majority of poultry birds cannot become used to loud noises, especially sudden loud noise. In fact, a farmer who complained that flying aircraft were interfering with egg production in a letter to the Postmaster General in 1923 represents one of the earliest instances of an official complaint about aviation noise being made.

3.6.3 Buildings' Impacts

High-intensity sounds have been said to have a serious negative impact on the building. Buildings and other structures acquire cracks and fissures when they are stressed by unpleasant and loud noises. Also, there are loud sounds of glass panels breaking.

3.7 Control of Noise Pollution

The following actions can reduce noise levels to within tolerance levels or even completely eliminate them based on three fundamental concepts of noise control: control at noise sources, control at the transmission path, and control at the receiver end.

3.7.1 Noise Pollution Control at Source

Limitations on the Usage of Old Vehicles and Horn Ban

The Pollution Control Board must identify the sources of noise pollution and action should be done to reduce them. Old automobiles should not be permitted to ply as they

produce maximum noise. Similar to this, traffic police should enforce strict measures to make motor vehicle users reduce the amount of noise coming from their vehicles. Because of this silencer, it should be in good shape. Ear piercing horns ought to be prohibited, as they are in western nations. Legislative restrictions can actually be used to limit noise pollution.

Engineering Techniques

Using engineering control techniques or regulating exposed employees are two ways to reduce noise exposure. Engineering control strategies include design modifications, adjustments to the way a noise source operates, and the building of soundproofing materials such soundproofing walls and sound absorbers. Air protecting devices must be provided or the exposure period must be reduced in order to regulate exposed personnel.

Replacement with Quieter Equipment

By using quieter equipment or quieter process activities, noise from equipment can be decreased. Examples are the use of centrifugal fan in place of axial flow fan, the use of welding to replace a nosier riveting process.

Better Designs

In case of machinery, automobiles, motor cycles and aircrafts, noise control can be achieved through superior design and effective silencing and sound proofing devices and procedures during the manufacturing stage.

Sealed Outlets

The best way to stop noise from entering the building is to shut all of the outlets that lead outside. Double structures may be used in circumstances of high noise pollution. For high frequency sounds, they can lower the noise intensity by 5 to 10 dB.

3.7.2 Examining the Noise Source

Checking various noise sources, such as radios, televisions, tape recorders, and stereos, can help minimise excessive noise. But, when turning these audio-visuals up, one must keep others in mind.

Using Scrubbing Cloths

The reflected sound can be dampened and absorbed by covering the walls, floors, and ceilings with a soft, pliable material.

Availability of Gaskets

Household door gaskets can also lessen noise transfer from one area to another.

1.7.3 Noise Pollution Control at the Transmission Path

Zones of Vegetation Buffer

Many evergreen trees and shrubs that make up vegetation buffer zones are great sources of sound absorption. So, these must be built in the heavily inhabited parts of cities and large towns, close to the workplaces, hospitals, and schools. It has been discovered that a dense evergreen hedge might minimise the noise by 10 dB during rubbish collection in the towns.

Plantation Strip

The house is successfully shielded from the noise pollution caused by traffic by a 6 m wide plantation of trees inside the compound wall.

Rows of tall tree planting

Tall trees planted in rows and densely covered bushes and shrubs placed on either side of busy roadways act as noise filters and noise absorbers. To reduce noise, it is helpful to plant trees, especially *Polyalthia longifolia* and *Azadirachta indica*, whose leaves work as noise absorbers.

Srivastava (2001) recently identified a number of plant species that are effective in absorbing noise and maintaining a tolerably quiet environment. Table 3.3 has a list of them.

Table 3.3 : Noise Absorbent Plant Species

Local name	Scientific name
Neem	*Azadirachta indica*
Jangal Jalebi	*Inga duleis*
Semal	*Bombax ceiba*
Bargad/Borh	*Ficus bengalensis*
Peepal	*Ficus religiosa*
Katrer or Kachnar	*Bauhinia variegata*

Pink mohar	*Cassia nodosa*
Sal	*Shorea robusta*
Amaltas or Karangal	*Cassia fistula*
Pangara tree	*Erythrina variegata Var Orientalis*
Rumbal	*Ficus racemosa or Ficus glomerata*
Mahua	*Madhuca latifolia*
Ashoka	*Saraca indica*
Nili Gulmohar	*Jacaranda mimosaefolia*
Panjtara or Jerul	*Lagstromia flosregia*
Gulmohar	*Delonix regia*
Palah or Dhak	*Butea monosperma*
Not known	*Cassia racemosa*

Usage of Rugs and Drapery

Spreading carpets or drapes and using acoustical materials inside of buildings can lower noise levels, but they have no impact on noise that enters from outside.

3.7.4 Noise Pollution Control at the Receiver End

Technique for Lowering Noise

Some of the newest aircrafts such as the 747 have included noise reducing technology developed in previous few years. Anything that can absorb and exchange sound can minimise noise, but of course at the cost of extra weight and space.

Use of Mufflers

Due to turbulence created by the surrounding atmosphere, a stream of air and some moving fluids can generate high sound levels. The installation of a muffler is frequently the most practical way to reduce noise, especially for vehicles and motorcycles. A dissipative muffler installed in a gas flow pipe makes use of absorbing materials to reduce sound for horn or fibers may be used as sound absorbing material.

Usage of Earplugs or Ear Muffs

Workers in factories that produce loud noise should be given wool earplugs or muffs to block out dangerous sounds and protect their ears. In actuality, these ought to be given to passengers going by train and bus together with their tickets as well (upon request). Noise pollution can be reduced most effectively and affordably by wrapping cotton wool with vaseline.

Public Awareness

Using electronic media can significantly help to lessen noise pollution and improve the environment. The World Health Organization has also stated that noise pollution is the most easily remedied of all environmental issues, including air and water pollution. The dangers of noise pollution need to be brought to the attention of the general public.

Strict standards

The strictest noise control regulations must be applied to car horns. Its indiscriminate usage should be avoided and silence zones designated in cities near educational institutions, hospitals and offices.

Setting up Noise Limits

By carefully implementing the Air Pollution Act and establishing noise limitations in metropolitan areas, noise pollution can be reduced. Criminal sanctions should be applied to lawbreakers.

Guidelines and Limitations

At festivals, other festivities, rallies, and ceremonies, control over fireworks must be exercised. The agencies in charge of enforcing the legislation ought to be severe in their implementation of anti-pollution measures. It is true that permanent outside loud speakers should never be used in a place of worship or another sensitive environment. They should only be allowed to install them inside of buildings for the use of worshippers or followers.

Robert Koch, a Nobel Laureate and bacteriologist, made the following forecast 90 years ago: "A Day will come when man will have to fight ruthless noise as the biggest enemy of health." If the government and the individual do nothing to reduce noise, Koch's prediction may soon come true.

3.8 Noise Pollution - Legal Perspectives in India

In 1970, the Indian government created highly thorough and earnest plans and strategies to create a clean environment through environmental management. The National Fourth Five Year Plan (1969–1974), which highlighted the following environmental challenges, makes this very evident.

i. Each generation has a responsibility to preserve the ability of the land, water, and animals to support life in a way that gives the next generation the option of maintaining a healthy environment.

ii. The physical environment, which includes the land, the air, and the sea, is a dynamic, intricate system. Each of these components is impacted by actions in the others. The independence of living things (plants and animals) and their interactions with the ground, air, and water are also important.

iii. Planting for harmonious development acknowledges the interdependence of man and nature. Only after a thorough analysis of environmental factors, particularly economic and ecological ones, is such planning conceivable.

iv. There are situations where prompt, specialist advise on environmental issues might have aided in project design and prevented ensuing negative environmental effects that would have resulted in the loss of invested resources. Therefore, it is crucial to incorporate environmental considerations into our planning and development along with effective conservation and rational use of natural resources. These aspects, as well as their protection and improvement, are crucial for the well-being of the country.

With the goal of preserving the environment and maintaining its management, the Sixth Five Year (1980–1985) Plan gave environmental issues a specific relevance. Environmental management has taken on a higher priority in the eyes of the government as a result of its awareness of environmental issues and their effects on the growth of the country. In order to address the ecological catastrophe and environmental issues, a separate Department of Environment (DOE) has now been established in every State of India as well.

3.8.1 Legal Control of Noise

Because most people are still unaware of the dangers associated with various types of pollution, including air, water, noise, and soil pollution, they are attaining frightening proportions. They are eating the environmental qualities and harming the eco-system. So, in order to protect the environment from additional pollution and serve the interests of humanity, it is essential to regulate the various forms of pollution through specific laws.

Many nations, like England and America, have passed special legislation to limit noise pollution. The Noise Abatement Act of 1960 in England states in Section 2 that loud speakers may not be used for any reason between the hours of 9:00 p.m. and 8:00 a.m., nor may they be used at any other time for the purposes of advertising, entertainment, trade, or business. Of course, the Act specifies a few exceptions. But India does not have a similar Legislation that focuses solely on noise control issues. Because of this, vehicles continue to honk their horns whether they need to or not. What good does blowing horns loudly serve if their cars are stuck in a major traffic jam?

A significant piece of legislation for regulating noise is the US Noise Pollution and Abatement Act, passed in 1970. To gather data on noise pollution, the Environmental Protection Agency, working through the office of Noise Abatement and Control, arranges public meetings in a few selected cities. Although there is no specific law governing noise pollution in India, Articles 39(e), 47, 48-A, and 51-A of the Indian Constitution do have provisions (6). The health and strength of employees, both men and women, and young children are not abused, according to article (e). The State is required under Article 47 to raise the standard of living, the level of nutrition, and public health. As of 1976, Article 48-A stipulates:

"The State will endeavour to protect and improve the environment and to safeguard the forest and wild life of the country. In certain States viz. M.P., Rajasthan and Bihar, there are Acts which provide restrictions against the use and play of loud speakers".

The Environmental Protection Act of 1986 was passed on November 19, 1986, to honour Mrs. Indira Gandhi, a passionate environmentalist who was well-known throughout the world. This law aims to instill environmental ethics in all citizens and to take the necessary actions to conserve and better the environment. According to Section 2 of the Act, "environment" includes "air, water, and land, as well as the interactions with living things (animals and plants)". The Noise Pollution (Regulation and Control) Rules, 2000 in India was implemented to control noise pollution.

Table 3.4 : Ambient noise standards in India

Area Code	Category of Area / Zone	Limits in dB(A) Leq*	
		Day Time	Night Time
A	Industrial area	75	70
B	Commercial area	65	55
C	Residential area	55	45
D	Silence Zone	50	40

Note :

1. Day time shall mean from 6.00 a.m. to 10.00 p.m.

2. Night time shall mean from 10.00 p.m. to 6.00 a.m.

3. Silence zone is an area comprising not less than 100 metres around hospitals, educational institutions, courts, religious places or any other area which is declared as such by the competent authority

4. Mixed categories of areas may be declared as one of the four above mentioned categories by the competent authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

A "decibel" is a unit in which noise is measured.

"A", in dB(A) Leq, denotes the frequency weighting in the measurement of noise and corresponds to frequency response characteristics of the human ear.

Leq: It is an energy mean of the noise level over a specified period.

3.8.2 Difference between Air/Water and Noise Pollution

In contrast to other types of pollution, noise pollution is unique. It kills us mentally by causing a variety of mental disorders, including deafness and dumbness, restlessness, and abnormal behavior.

The negative effects of noise pollution take time to manifest, much like those of breathing contaminated air or drinking polluted water. At the turn of the century, the majority of Indians will have substantially diminished hearing abilities if this threat is not stopped soon. According to current research, three out of five Indians (particularly those living in large cities and towns) have already lost some of their hearing ability and will never regain it.

3.9 Summary

Today, noise pollution is a major issue. Noise is the name for the undesirable sound. The two qualities of noise—intensity and frequency—are typically used to describe it. Sound pressure level is another name for noise intensity (SPL). Its decibel value expresses it (dB). Noise is measured with a sound level metre or decibel metre, which expresses the frequency of the noise in cycles per second (cps) or hertz (Hz). In the environment, noise comes from a

variety of sources. Industry, transportation, building sites and building services, domestic and recreational activities, *etc.* are the main noise sources. It has diverse range of adverse impacts on different ingredients. Accordingly, the control of noise pollution is crucial. Several noise mitigation strategies should then be implemented. The best option to reduce the noise pollution is to make an effort to quiet the source of the noise. Additionally, by altering the path between the source and the hearers, it can be decreased. The installation of noise barriers, Usage of personal protection gadgets might be successful to prevent noise impacts at the receiver end. Cities and industry should both be properly planned. For the purpose of reducing noise, legislation and the application of current law are crucial, all are described in this unit. Further, for noise pollution to be managed effectively, awareness and education are required.

3.10 Self-Assessment questions

1. Define noise and noise pollution. How is decibel defined ?
2. What are the different sources of noise pollution ?
3. What are (a) Industrial noise (b) Transport noise (c) Neighbourhood noise ?
4. What is the unit of noise pollution measurement ?
5. What are the adverse effects of noise pollution ?
6. What is the difference between noise pollution and air pollution ?
7. What are the physiological and psychological effects of noise?
8. Discuss the different indices used for the measurement of noise levels.
9. Write informative notes on any two of the following: decibel scale, approaches for noise control
10. What are the various methods available for the protection of the personnel exposed to high noise levels?
11. Describe the various acoustical absorptive materials used for noise control.

3.11 Suggested Readings

1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi.
2. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998

3. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001.

4. S.C. Bhatia, "Textbook of Noise Pollution and its Control" Atlantic, New Delhi, 2007

5. S.C. Bhatia, "Textbook of Air Pollution and its Control" Atlantic, New Delhi, 2007

6. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi.

7. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

UNIT 4 ❑ Soil Pollution

Structure

4.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different soil pollution sources,
- understand different types of soil contaminants,
- outline different pesticides and heavy metals contaminating soil,
- know about the synthetic fertilizer contaminating soil,
- understand the different adverse effects of soil pollution,
- comprehend the control mechanism of soil pollution,

4.2 Introduction

Many minerals as well as countless plants, animals, and bacteria are supported by soil. A geologist uses the soil to determine the age of the earth by analysing the several isotopes it contains, whereas chemists view the soil as a repository for plant nutrients. According to physicists, soil is made up of solid, liquid, and gaseous components. For limnologists, the soil is a reliable supply of food for the biota, and for agriculturists, it is the upper crust of the earth that can support plant life and other life forms. Above all, the soil is a living thing that has been the source of all significant ecological occurrences in the past. Yet, incorrect drainage and the

unscientific, chemical utilization of organic wastes are the main causes of soil and land pollution. Due to the importance of these natural resources, erosion and pollution must be avoided in order to preserve them.

4.3 Causes of Soil Pollution

Several factors contribute to soil pollution, including man-made chemicals, waste products from mining and quarrying operations, improper disposal of solid waste, etc. The following are the major sources:

4.3.1 Use of Chemical Fertilizers

There is no question that the use of diverse fertilizers, such as nitrogenous, phosphatic, and potassic fertilizers, has enhanced the yield of numerous crops, particularly high yielding types of wheat, rice, and maize. However, its continued usage has contaminated the groundwater, making it unsafe for consumption by humans and all other species.

Since almost all nitrogenous fertilizers are water soluble, nitrates are easily transported into the water. The applied fertilizers are washed away after heavy rains or irrigation, transporting nitrates into the streams or rivers as well as into drainage water. Due to their high percolation capability, sandy soils are far more dangerous for nitrate pollution.

Methaemoglobinamia, often known as "blue blood baby illness," is brought on by a high nitrate concentration in drinking water and can be fatal to infants. Infants' high consumption has been linked to their vulnerability to nitrate. Nonetheless, adults are not seriously affected by this issue. Nitrate levels as low as 65 ppm in water are dangerous. The acceptable limit of this pollutant, 45 ppm, has not been detected in drinking water in any places where this disease has been recorded. When produced on soils with extensive applications of chemical fertilizers, fodders like oat and maize stalks may result in health difficulties such the deterioration of the vascular tissues in the lungs, heart, and liver in animals. According to reports, 100-150 ppm of nitrate is the essential level in this situation.

Considering that phosphorus is an inert nutrient, little soil may be leached of it. But it becomes mobile and can be leached out into groundwater as soluble organic phosphorus in inorganic soils with lower levels of iron and aluminium. In addition, it is also transported by sediments into lakes and ponds. Increased eutrophication, which is damaging to fish and other aquatic life, will result from the addition of phosphorus together with excessive amounts of nitrate that have been applied to the soil.

The soil pH is lowered and plants have less access to phosphorus when nitrogenous fertilizer is applied improperly. This may be seen in some of the Kandi belt soils in Jammu, where urea, a nitrogenous fertilizer, has been used continuously to cause soil acidity (pH 5.2–6.5). Moreover, nitrogenous fertilizer is now being used alone, which is having detrimental impacts on many crops and is devastating in soils with low pH levels.

Synthetic Fertilizers:

To improve soil fertility and crop yield, synthetic fertilizers are used. The vital nutrients are concentrated in the top soil layer by these fertilizers. Synthetic fertilisers are produced in factories. Yet, when used improperly and in excess, as well as when they contain hazardous substances, fertilisers and manures will damage the soil and significantly alter its character and composition. Chemical fertilisers include urea, ammonium sulphate, ammonium phosphate, ammonium nitrate, and ammonium chloride. Unfortunately, the microbial flora necessary to enrich the humus that supports plant growth cannot survive in soil that has been fertilized chemically. Soil pollution may occur if chemical fertilizers are used excessively and without consideration.

More specifically, chemicals called fertilisers are administered to crops in order to increase production. They are regularly used by farmers to increase agricultural output. The fertilisers contain the minerals that plants require, such as nitrogen, potassium, and phosphorus. They increase the soil's fertility while simultaneously enhancing its ability to retain water.

Inorganic fertilisers are generally made of chemicals and contain nutrients for crop growth that are produced by chemical processes. Examples of inorganic fertilisers include the following:

Nitrogen Fertilizers

- Nitrogen, which is necessary for crop development, is present in nitrogen fertilisers.
- Nitrogen is a crucial part of chlorophyll that maintains the equilibrium of the photosynthesis process.
- Furthermore, it is one of the amino acids that build up protein in plants.
- Fertilizers containing nitrogen increase crop output and quality.

Phosphorus Fertilizers

- The most crucial nutrient in phosphorus fertilisers is phosphorus.
- Effective phosphorus concentration, fertilisation techniques, soil characteristics, and crop strains all affect how successful a fertiliser is.

- The protoplasm of the cell, which contains phosphorus, is essential for cell growth and proliferation.
- The growth of plants roots benefits from the application of phosphorus-based fertilisers.

Potassium Fertilizers

- Another most crucial nutrient in potassium fertilisers is phosphorus.
- Enhances drought resistance and root development, helps in photosynthesis and food production, enhances protein content of crops.
- Keeps turgor up, cuts down on water losses and wilting, produces grains high in starch.
- Helps delay the development of plant disease and worms.

4.3.2 Use of Pesticides

Pesticides are a significant soil-based agricultural input. Weedicides, insecticides, nematicides, fungicides, antibiotics, and hormones are among the agricultural compounds classified as pesticides. Several pesticide chemicals have a mobility class rating of 1, which indicates a significant degree of immobility. A few examples of the substances in this group are phorate, parathion, ethion, zineb, benomyl, paraquat, heptachlor, endrin, aldrin, chlordane, toxaphene, and DDT. For use in agriculture, several of these are already prohibited.

Pesticides are compounds (or combinations of substances) used to eradicate or stop the spread of pests. Pesticides that are frequently applied in agriculture include

- Herbicides are used to eradicate or manage weeds and other undesirable plants.
- To kill insects, we employ insecticides.
- Fungicides are substances that either kill or stop the growth of parasitic fungi.

However, unintended pesticide diffusion into the environment, or "pesticide drift," raises a number of environmental issues such soil and water pollution. The following is a list of some significant soil pollutants discovered in pesticides.

Herbicides: Triazines, Carbamates, Amides, Phenoxyalkyl acids, Aliphatic acids

Insecticides: Organophosphates, Chlorinated hydrocarbons, Arsenic-containing compounds, Pyrethrum

Fungicides: Mercury-containing compounds, Thiocarbamates, Copper sulfate

In addition to this, pesticides like the ones listed below are frequently employed:

i. Hydrocarbons with chlorine (*e.g.,* DDT, Aldrin, Dieldrin, Lindane, BHC, *etc*.)
ii. Compounds with carbamate (*e.g.,* Carboryl or Sevin, Zectrion, *etc.)*
iii. Compounds with organophosphorus (*e.g.,* Methyl or ethyl parathion, melathion, guthion, *etc*.)
iv. Organic substances (*e.g.,* As_2O_3, PbO_2, $NiCl_2$, $CuSO_4$, *etc*.)
v. Other substances, such as organic mercurials (2,4D, 2,4,5T, *etc.*).
vi. Herbicides containing sulfonylureas: Commercial sulfonylurea herbicides for controlling weeds include pyrithiobac-sodium, cyclosulfamuron, bispyribac-sodium, terbacil, and sulfometuron-methyl.
vii. Biopesticides: Biopesticides are insecticides made from natural resources like plants, animals, microorganisms, and minerals.
viii. Baking soda and canola oil are two examples of biopesticides.

Atrazine, alachlor, propachlor, simazine, propanil, and diuron are common herbicides with moderate to high immobility, indicating greater persistence in soil. Using pesticides frequently throughout each crop season and applying them to soils with low levels of organic matter and microbial diversity will cause the chemicals to build up over time, creating significant soil and environmental contamination. Under temperate temperatures, some herbicides, such as atrazine, benulide, and chloroxuron, remain persistent in soil for intervals of 300 to 700 days. It is possible for 2,4-D, picloram, and dalapon to leak out into the water because of their increased mobility in soil. Much soil pollution will be caused by this. Following is a list of the relative soil mobility of pesticides:

Decreasing trend →

Immobile ↓

Dalapon Chloramben
Picloram, 2, 4-D
Propachlor, Atrazine, Simazine, Lapazine, Alachlor, Ametryne, Prapazine
Propanil, Diuron, Azinphosmethyl, Diazinon
Lindane, Phorate, Parathion, Disulfolton, Ethion, Zineb, Isodrin, Benomyl, Dieldrin Paraquat, Endrin, Aldrin, Chlordane, Toxaphene, DDT (Relative Mobility of pesticides in soils)

4.3.3 Unscientific Disposal of Organic Wastes

The improper disposal of organic wastes of all kinds is one of the main causes of soil contamination in emerging nations like India. Animal organic waste is turned into manure and applied to fields in rural areas to boost their fertility. Nonetheless, these wastes are stored or deposited in open areas, and nature is left to finish the process of turning them into manures. In addition to polluting the land, this practice also significantly contributes to air pollution. Many gases, including ammonia and nitrogen oxides, escape from these wastes during bacterial degradation and enter the atmosphere. When it rains, there is a significant loss of nutrients. So, this practice, which is widespread in rural Jammu and Kashmir as well, has to be outright prohibited. Farmers should be encouraged to prepare manures out of their readily available organic wastes in pits that have had enough time to decay before being applied to the fields.

Along with creating ammonia, nitrate, and methane, direct contact between waste and soil also serves as a breeding ground for soil pathogens, disease-carrying flies, ant and rodent attacks, and soil pathogens. Crows, vultures, and dogs are encouraged to distribute the trash at the dump sites. Soil pollution is caused by the improper usage of sewage sludges. In addition to dangerous bacteria, actinomycetes, fungi, and other species, they may have an adequate number of active viruses and viable worm eggs. These are harmful to human health and the environment when used to raise crops, including those that may be consumed fresh by both humans and animals. Comparable heavy metals like cadmium, chromium, nickel, and others build up to dangerous levels in soils over time. Due to agricultural goods produced on such soils, these components accumulated in people and animals, leading to a variety of complications.

1. Rate of Salts

Similar to this, inorganic agriculture products contribute to ozone pollution. The practice of enhancing the stumbling at content in the animal fodder fields has been pushed in order to boost animal weight and milk production. When these dungs are employed as manures, they will have a greater salt concentration due to the lack of content in the animal's dungs. Due to the soluble salts leaching from the soils, the long continual application of such manures to soils may eventually cause an increase in the soluble salt content in the soils and in the ground water.

Salinity, sodicity, and acidity increases the degradation of the land is caused by the rise in sodium and soluble salt content (sodicity) brought on by water logging. The productivity of the soil and the condition of the land are both negatively impacted by an increase in the

concentration of soluble sats. In intrigue water, dis salts build up on the soil's surface. Inadequate drainage, especially in food-prone locations and canal well-limited places, exacerbates this. Also, during summertime seas, the salts from the lower levels migrate up by capillary action and are deposited as white crusts on the surface.

2. Land Erosion

Through water, wind, ocean, waves, and glaciers, soil is eroded. People's actions, such as tree-felling, overgrazing, over-cropping, and inappropriate tilling, hasten soil erosion. Whether a place is dry or wet, modern or traditional agriculture has little effect on erosion.

Deforestation is a factor in flooding and soil erosion. The soil is kept intact by the roots of grasses, which are a good binding material. The soil is made more brittle and susceptible to being washed away by the force of heavy rains or high winds when the grass cover is disturbed by the flow. The pace of soil erosion is accelerated by tilling or grazing on slopes or semi-arid soils. The biggest contributors to soil erosion in India have been overgrazing and deforestation. In India, 80 million hectares of fertile land are thought to wash away more than 6,000 million tonnes of top soil each year. When the overall amount of arable and unarable land is taken into account, this number nearly doubles. The majority of this material is washed into the ocean, but some also accumulates behind dams, shortening their lifespan, or is dumped in river beds. This soil's 6,000 million tons of valuable plant nutrients (N, P, and K) are worth more than 700 crores of rupees. The degradation of land and loss of soil reduces the ability of the world to produce food, fuel, and fiber on an annual basis. The soil itself can become a destructive force by silting fertile fields below due to excessive crop production on hill slopes and denuded in forest region. Less sunlight penetration into water due to suspended soils in runoff can have an impact on the aquatic life forms that make up the food chain.

3. Land Degradation

Besides pollution, there are additional issues that affect land and soil. They include soil erosion, overgrazing of pastures, frequent floods, water logging, and deforestation. By the end of this century, it is predicted that nearly one-third of all arable land would have been destroyed due to soil depletion and land degradation.

4. Acid Rains

Acid showers are caused by an excess of sulfur dioxide and nitrogen oxides in the atmosphere as a result of industrialization, as was already explained in the chapter on "Air Pollution."

5. Agricultural Lands

Increasing soil acidity can result in a variety of chemical alterations. Iron, aluminum, manganese, some heavy metals including cadmium and mercury, as well as other trace elements, can be released by acidic soils. These elements are transformed into more accessible forms in acidic soils, where they have a detrimental effect on plant growth. Moreover, plants suffer greatly because of the limited availability of phosphorus, calcium, magnesium, boron, and molybdenum to them.

6. Developmental Activities

Numerous development activities, such as rapid urbanization and human settlements, mining and quarrying, building of factories, industries, dams, canals, roads, railways, airports, etc., are encroaching upon large areas of fertile and productive crop lands, forest areas, grasslands, and horticulture. Our government's careless approach is endangering the ability to produce food for future generations.

4.4 Effects of Soil Pollution

1 . Effects on Water Resources

The impact of acid precipitation depends on the kind of soil. Acid deposition is neutralized by alkaline soils. In contrast, sandy soils and granite topography have a lower capability for neutralizing the effects of deposition and allow more acid to remain in the runoff into rivers and lakes. Large volumes of acidic water being abruptly released into rivers can be extremely harmful, especially for fish. All of the original aquatic life, including snails, crustaceans, and numerous insects, will be wiped out if the water is acidic. This will create a completely new environment.

Acidic discharge will contaminate both the surface and subterranean waters with toxic substances. Aluminium, arsenic, mercury, and lead are extremely poisonous to fish. As soon as the fish hatches, aluminium poisoning could cause it to go extinct. Fish eggs can potentially be killed by acid in water. Fish species like salmon and trout are extremely susceptible to acidity.

The majority of aquatic life requires a pH of 6.0 or higher. A number of algae, bug, insect larvae, and fish species suffer when the pH drops below this value. Snails and species

of microscopic plants are less abundant below pH 5.5. Snails vanish at pH values below 5.2, and the acidification impacts the production and growth of aquatic plants, which in turn limits the availability of food for birds and other animals.

2. Effects on Forest Resources

There is ample evidence of the strong connection between acid pollution and tree die-back. Acid degradation alone or in conjunction with other pollutants has significantly impacted more than 5 million hectares of forests in West Germany, Poland, Yugoslavia, and Czechoslovakia. Acid rains also have an impact on the conifers that thrive in Germany. The signs of severe acid damage include root damage, drying out of tree tops, soft rot, yellowing and loss of unnecessary growth, and stunted development.

3. Damage to Animals and Wildlife

A very steady and intricate food chain is necessary for the survival of both wild animals and tamed livestock. The base of their food chain, which takes the form of a herbaceous component, is formed by the forest floor and plants. The entire food chain is disrupted once the forest floor and its flora are harmed, which ultimately has an impact on the stability of the animal and wildlife population at different trophic levels of the ecosystem.

4. Damage to Human Health

Asthma, bronchitis, lung cancer, and harm to the central nervous system are among the diseases linked to acid rain. The excessive consumption of fluoride through water is the cause of fluorosis in livestock. When humans drink contaminated milk from sick animals, fluorosis also results. The high mercury concentration in water is to blame for thyroid issues, liver issues, paralysis, pulmonary edema, and corneal issues.

4.5 Control Measures

Application of fertilizers, the use of pesticides, and the removal of solid waste are key components in the control of soil pollution. Among the controls to stop soil pollution are:

i. The production and use of chemical fertilisers should be reduced, and their place should be taken by biofertilizers and thoroughly decomposed organic materials.

ii. In order to lessen the usage of pesticides, biological and ecological techniques of pest management should be promoted.

iii. It is important to reduce salinity/sodicity by providing the irrigated and flood-prone fields with adequate drainage. Barley and oats are examples of crops that can be grown in salt-affected soils, along with other tree species like *Acacia nilotica* and *Acacia modesta*, and by implementing better water management techniques. For the restoration of such soils, it has been discovered that the application of organic manures, particularly green manuring, is very beneficial.

iv. Restoring grass and trees can help control erosion and floods while also slowing down land degradation. The simplest and most effective technique to stop soil erosion is by reforestation, which involves planting suitable tree species to provide adequate cover in the eroded regions. It is helpful to stop erosion by planting plants like *Carissa spinarum*, *Adhatoda vasica*, *Desmodium* spp., and *Mimosa himalayana* in eroded areas and public waste lands. These bushes fulfil the requirement for firewood in the community while also promoting soil and water conservation. Grasses such as Cenchrus and a legume Stylosanthes should be allowed due place to grow in the degraded areas for augmenting the feed and erosion management.

v. Organic manures can be made from the solid and liquid excretions of livestock. Nonetheless, it is a flawed practise to store manure on a cultivator's field. Dung and garbage are routinely collected each morning and deposited in heaps in open sections of the fields. As long as the dung heap is left exposed to rain and sunlight, there will be significant nutrient loss. The value of the manual is reduced by about 50 percent. Ammonia is lost during decomposition through volatilization. The scientific strategy outlined below is advised for creating high-quality farmyard management and preventing significant nutrient loss.

a. Trenches measuring 6 to 7.5 metres long, 1.5 to 2 metres wide, and 1 metre deep should be used for the manure preparation. Keep all appropriate dry litter and agricultural waste close to the cattle shed, and place 2 kg (earth-mixed) beneath each animal's feet each evening to help absorb urine. The spots where pee often drips and soaks into the ground should be the only locations where litter is present. The dung and urine-soaked litter should be thoroughly mixed and carried to the manure trench every morning. A section of 1m length of the trench is taken up from one end for filling with daily collection of refuse. The next 1 m of the trench is filled after the section is filed 45–60 cm above ground level and the top surface is coated with cow dung earth slurry.

b. A second trench is dug and entirely filled in the same way as the first one. The manure is prepared for use in three to four months. Usually, the first trench's manure would be ready for use by the time the second trench is full. Yet, the quantity of animals would determine how many ditches were required. Typically, two of these ditches are needed to 3 to 4 catle.

vi. Recycling and material recovery is another practical way to lessen soil pollution. By doing so, the amount of waste would be reduced and natural resources would be preserved. Paper, grass, and various types of plastic, for instance, can all be recycled. Although though recycling glass and paper is expensive, it is beneficial for preserving resources. According to research, recovering one tonne of paper using this method would prevent the need to cut down at least 17 trees in order to obtain this quantity of paper.

4.6 Summary

The existence of mankind in the planet is also directly related with land. The magnitude of the issue can indeed be managed unless the general public is aware of it. When waste, compost, and other poisons are deposited on the ground, they contaminate or pollute the environment. Soil pollution originates from a variety of sources. Human activities including littering and waste from ships, rigs, transportation, building sites and building services, domestic and recreational activities and sewage treatment facilities that wash ashore contribute to land contamination. With a focus on their production and clean-up, the principles of soil pollution and different aspects of soil pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit. Further, for soil pollution to be managed effectively, awareness and education are required.

4.7 Self-Assessment questions

1. What are the sources of soil pollution? What are the detrimental effects of soil pollutants?
2. What are the major contributing factors of soil pollution?
3. Comment on the heavy-metal toxicity of soil.
4. What are the pesticide problems related to soil pollution?
5. What are the naturally occurring toxic elements in soil?
6. What are the naturally occurring pesticides in soil?
7. How acid rain can affect soil?
8. Comments on the remedial measures to soil pollution.

9. Discuss the role of urban waste and modern agro-technology in soil pollution.

10. How do industrial wastes contribute to soil pollution? What measures are to be taken to minimize soil pollution from this source?

4.8 Suggested Readings

1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi.

2. H. S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998

3. S. C. Santra, "Environmental Science" New Central Book Agency (P) Ltd., London 2001.

4. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi.

5. R.D. Gupta, "Environmental Pollution - Hazard and Control" Concept Publishing Company Ltd., Pvt, Ltd, 2006, New Delhi.

UNIT 5 ❑ Thermal Pollution

Structure

5.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different thermal pollution sources,
- understand different types of thermal pollution and thermal pollutants,
- learn about heat island concept and its characteristics,
- understand the different adverse effects of thermal pollution,
- comprehend the control mechanism of thermal pollution.

5.2 Introduction

The harmful consequences of heated effluents discharged by various power stations have been referred to as thermal pollution. It refers to the degradation of the quality of the aquatic and terrestrial environments. Water is used as a cooling agent in many industrial operations, including mills and thermal, atomic, nuclear, and coal-fired plants.

The temperature difference between the heated effluents and the intake waters is 8 to 10 °C, which lowers the content of D.O. (Dissolved Oxygen).

Thermal pollution can be defined as:

1. An aquatic system being too warm to the point where desirable creatures are negatively impacted.
2. The addition of too much unwelcome heat to water, which renders it dangerous for people, animals, plants, and aquatic life, or poses other serious risks to the regular operations of aquatic organisms in water.
3. Heated effluents from both natural and artificial sources that are tainted with water supplies pose a risk to human health due to their toxicity, decreased levels of dissolved oxygen (D.O.), unattractive appearance, and potential for the spread of illnesses.
4. According to biological indices of community and variety, it depletes aquatic species and upsets the delicate balance of life in streams.
5. It is a by-product of unplanned, rapid industrial development and population growth.

5.3 Sources of Thermal Pollution

The demand for thermal power plants has increased due to the fast industrialization, accelerated pace of growth, and dense population. Today, pollution from human activities is being continuously and alarmingly added to the air and water. Thermal pollution comes from the sources listed below:

1. Nuclear Power Plants

Nuclear power plants release a significant amount of trapped radionuclides and wasted heat into neighbouring water streams, along with drainage from hospitals, research facilities, nuclear tests, and explosions. The temperature of aquatic bodies is also raised by emissions from processing equipment and nuclear reactors. Power plant discharges of heated effluents, which are released at temperatures 10 degrees higher than the coolant receptor, have a negative impact on aquatic life.

2. Industrial Effluents

To remove heat, thermal energy-producing industries like coal-fired power plants need enormous quantities of cooling water. But to a far lower level, other industries including textiles, paper and pulp, as well as sugar, also release heat in water. The heat from the turbo-generators placed in industrial settings raises the temperature of the effluent by 5 to 9 degrees Celsius above the standard stream temperature. In order to meet the rising

demand for energy and the fast industrialization, more installations are being built, which leads to the discharge of more water and heated effluent that is hotter than the receptor water body temperature.

3. Coal-fired Power Plants

A few thermal power plants discharge effluent that is 15 °C warmer than the water body it is released into. The primary source of thermal pollution is coal-fired power stations, which are used in thermal energy production. The temperature of the neighbouring water is raised when the heated coils are cooled with water from a nearby lake or river and then discharge the hot water back into the receptor water body. The amount of dissolved oxygen in the heated effluent is reduced. It causes the death of fish and other marine life.

4. Hydro-electric Power

Occasionally, the process of producing hydroelectric power has a negative impact on water infrastructure. Many enterprises with cooling contribute to thermal loading besides the electric power sector. According to reports, nuclear power plants provide cooling ponds with around 18% more heat than any other plant of comparable scale.

5. Household Sewage

Whether or not it has been treated, domestic sewage is frequently dumped into rivers, lakes, and canals. The temperature of the municipal sewage is often higher than that of the receiving water. In addition to significantly increasing stream temperature, the released water has several negative consequences on aquatic life. The dissolved oxygen in the surface water is used by the organic materials in the sewage to oxidise it. The D.O. content falls and the need for oxygen increases as the water's temperature rises. As a result, the anaerobic environment will cause the emission of unpleasant and irritating gases. The marine species that depends on the D.O. will disappear, and the water's quality will also suffer.

5.4 Effects of Thermal Pollution

The different effects of thermal pollution include :

1. Change in Water Properties

As the temperature rises, water's chemical and physical characteristics change. Although water's viscosity is sharply decreasing, the vapour pressure is rapidly rising. The settling

speed of suspended particles accelerates due to the decrease in gas density, viscosity, and solubility, which has a significant impact on aquatic species' ability to feed.

2. Decrease in Dissolved Oxygen Concentration

As water temperature rises, dissolved oxygen concentration drops. For instance, the D.O. level in water is 14.6 ppm at 32 °F and 6.6 ppm at 64 °F. As a result, the high-water temperatures would be intolerable to cold-water fish, which need roughly 6 ppm to thrive. They would run out of oxygen if they stayed in the vicinity. A suitable amount of dissolved oxygen should be present in a healthy stream because aquatic biota are aerobic organisms.

3. Increased Toxicity

The toxin found in water becomes more toxic as the temperature rises. A temperature increases of 10 °C doubles the toxicity of potassium cyanide, whereas an increase of 80 °C triples the toxicity of o-xylene, which causes high rates of fish mortality.

4. Interference with Reproduction

Fishes depend on a certain ideal temperature for several functions, including nest construction, spawning, hatching, migration, and reproduction. For instance, lake trout may effectively spawn at a temperature of 8.9 °C. Warm water disrupts spawning and kills the eggs that have already been placed.

5. Changes in Reproduction Rate

The female begins depositing eggs when the temperature rises. When the water temperature reaches a crucial level, estuarine fish spawn four hours later, which makes the triggering more spectacular.

6. Interference with biological processes

It is thought that temperature has a crucial role in the physiology, metabolism, and biochemical processes that regulate respiration rates, digestion, excretion, and the overall growth of aquatic species. The ecosystem as a whole is completely disrupted by temperature variations. Temperature fluctuations are frequently damaging due to the fact that aquatic organisms' lives include a number of chemical processes, the rates of which are affected by temperature fluctuations.

7. Increased Disease Vulnerability

Higher temperatures speed up the activities of certain harmful bacteria. A bacterial infection brought on by hot water prevents some fish from developing eggs when the temperature is elevated.

8. Variations in Metabolic Rate

Fishes' breathing rate, oxygen consumption, food consumption, and swimming speed all rise. Fish exhibit a noticeable increase in basal metabolic rate when temperature approaches the fatal level.

9. Invasion of harmful creatures

Thermal pollution may allow the entry of organisms that are tolerant of warm waters and are extremely harmful, such as the invasion of ship worms into Oyster Creek in New Jersey.

10. Unwanted Changes in Algal Population

Algal expansion has a significant impact on ecosystem life. The washout waters from thermal plants and farmlands contain too many nutrients, which promote excessive algal growth and speed up eutrophication and other unwanted effects.

11. Biochemical Oxygen Demand

B.O.D. is achieved at a lower temperature when the temperature of a stream carrying biodegradable organic matter rises due to the enhanced action of aquatic organisms. Fish death may occur owing to synergistic action, which is caused by rapid chemical or biochemical action, when the temperature of a stream carrying biodegradable organic waste rises.

12. Destruction of Organisms in Cold Water

It takes a tremendous amount of water to cool a stream. Unfortunately, the heat shock, increased pressure, and water viscosity kill a lot of the plankton, small fish, and insect larvae that are drawn into the condenser along with cooling water.

13. Impact on Marine Life

The physiology, metabolism, growth, and development of marine species are all significantly influenced by temperature. Because they are poilkilothermic, marine species experience temperature changes in response to the water they are in. Certain aquatic organisms can't handle drastic temperature fluctuations; therefore, they perish at higher temperatures.

14. Impact on Bacteria

The industrial facilities' and industries' hot emissions severely harm the bacteria. The result includes harmful action of metabolic products, melting of cell fats, coagulation of body protein, *etc*.

1.5 Heat Islands

The heat from the sun is absorbed and emitted from structures more than it is from natural landscapes like woods and water bodies. These structures include buildings, roads, and other infrastructure. Urban areas become "islands" of greater temperatures compared to outlying areas because of the concentration of these structures there and the lack of greenery. "Heat islands" are the term used to describe these hot spots. Heat islands can develop in a variety of settings, including during the day or at night, in small or large cities, in suburbs, in climates in the north or south, and during any season.

5.5.1 Causes of Heat Islands

Several things can cause heat islands to arise, including:

Reduced Natural Landscapes in Urbanized Regions: By producing shade, transpiring water from plant leaves, and evaporating surface water, respectively, trees, vegetation, and water bodies tend to chill the air. Urban settings' hard, dry surfaces, such sidewalks, roads, buildings, and parking lots, offer less shade and moisture than the surrounding natural environment, which raises the temperature.

City Size and Shape: The size and shape of cities differ significantly from rural areas in terms of aerodynamics. Tall structures serve as barriers and slow down winds.

Urban canyons: The tall canyons created by city structures that absorb radiant energy. According to "canyon effect" comparisons between North American and European cities, heat islands will form more quickly in locations with taller and denser structures.

Properties of urban materials: Compared to trees, vegetation, and other naturally occurring surfaces, conventional human-made materials used in urban contexts, such as pavements or roofing, tend to reflect less solar radiation and absorb and emit more of the sun's heat. The sluggish release of heat from urban materials is a common cause of heat islands, which frequently develop throughout the day and become more noticeable after nightfall.

Urban haze: The air pollution haze that hovers over many cities can function as a tiny greenhouse layer, keeping heat from escaping from urban regions.

Effects of humidity: Although the amount of water that is retained in the atmosphere by cities and rural areas (absolute humidity) is similar, the greater urban temperatures actually cause the relative humidity to decrease (since warm air can hold more water than cold air).

Anthropogenic heat: The heat that is released when fossil fuels are burned can also increase the temperature in cities. The amount of energy released by burning fossil fuels in Manhattan on an average winter day is four times greater than the energy that the Sun provides for the city.

5.5.2 Characteristics of Heat Islands

The variance in temperatures between cities in relation to their surroundings is typically used to calculate heat islands. A city's internal temperature can also change. The uneven distribution of heat-absorbing pavements and buildings makes some locations hotter than others, while trees and other vegetation keep other areas cool. Intra-urban heat islands are created by these temperature disparities. Residential areas, urban ponds, and parks are cooler than downtown regions according to the heat island effect diagram. There are two different kinds of heat islands: surface heat islands and atmospheric heat islands.

Surface Heat Islands: Roadways and rooftops, which absorb and emit heat more than most natural surfaces, are examples of urban surfaces that contribute to the formation of these heat islands. On a hot day with a 91°F temperature, typical roofing materials may get up to 60°F warmer than the surrounding air. The peak of surface heat islands usually occurs when the sun is shining during the day.

Climatic heat islands: Warmer air in cities than in rural areas leads to the formation of these heat islands. Compared to surface heat islands, atmospheric heat islands have substantially smaller intensity variations.

5.5.3 Effects of Heat Islands

Effects on animals

Urban heat islands will lengthen the growing season in temperate regions, which will disrupt the breeding plans of the species that live there. The impact of urban heat islands on water temperature is the best example of this. As a result of precipitation warming up quickly and neighbouring buildings occasionally reaching temperatures of over 50 °C and higher, there will be an excessive amount of thermal pollution from runoff into the streams, lakes, and rivers (or other bodies of water) in the area. The rise in thermal pollution has the potential to raise the temperature of the water by 20 to 30 °C.

Cities' urban heat islands have changed the course of natural selection. A new set of selected forces emerge as a result of the relaxation of selective pressures such as the temporal fluctuation in food and water.

Further, see the air pollution effects on plants, animals, and people.

Weather and climate effects

In addition to their impact on temperature, UHIs can change local wind patterns, cause clouds and fog to form, increase humidity, and vary precipitation rates, among other secondary effects on local meteorology. The additional heat from the UHI causes higher upward motion, which can increase the activity of showers and thunderstorms. Also, during the day, the UHI develops a small low-pressure area where relatively moist air from its rural surrounds converges, potentially resulting in more favorable conditions for cloud formation. Cities' downwind rainfall rates have increased by 48% to 116%. Monthly rainfall is roughly 28% higher between 20 and 40 miles (32 and 64 km) downwind of cities than it is upwind, in part due to this warming. Some cities experience a 51% increase in overall precipitation.

5.5.4 Control Measures of Heat Islands

- Tree planting: Planting and efforts to increase the area covered by vegetation are the main requirements for reducing the amount of heat that metropolitan areas generate.
- Passive Cooling: For both residential and commercial buildings, passive cooling technology, a popular method for creating naturally ventilated structures, can be a critical alternative to deal with the urban heat island.
- Ancient Indian architectural designs that made use of this technology are mentioned in the IPCC report and could be applied to contemporary buildings in the context of global warming.
- Using the right building materials is one of the other ways to reduce heat.
- To reflect heat and lessen absorption, roofs and terraces should be painted in white or light hues.
- Gardening in the kitchen and on terraces should be encouraged.

5.6 Thermal Pollution Control

The condenser cooling waters must be cooled before being dumped into bodies of water. The following are the key tenets of the heat loss process:

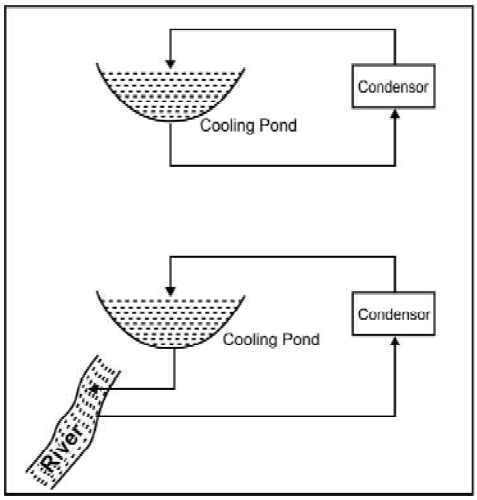
1. Conduction
2. Convection

3. Radiation
4. Evaporation

To reduce high temperatures brought on by thermal discharges, utilize the following techniques:

1. Cooling Ponds:

As may be seen in Fig. 5.1a, cooling towers are useful for dissipating heat.



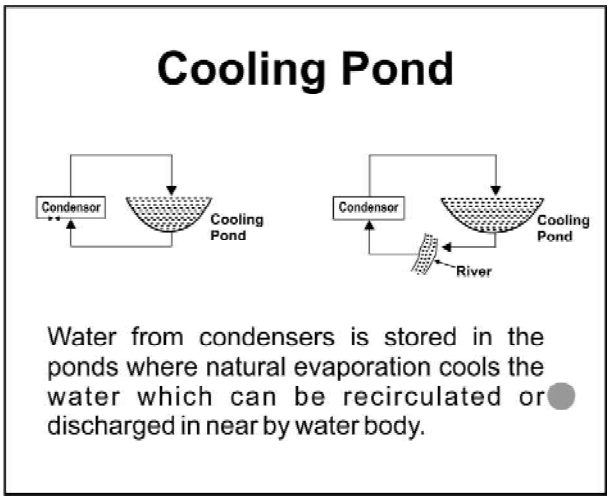


Figure 5.1a ***Figure 5.1b***

The earth dike ponds where the condenser water is held allow for natural evaporation to lower the temperature. Once more, the water is circulated. A different approach to installing cooling ponds is depicted in Fig. 5.1b.

2. Spray Ponds:

In spray ponds, water is sprayed into cooling ponds using spray nozzles to create tiny droplets that have larger surface area and can transmit heat to the atmosphere more effectively.

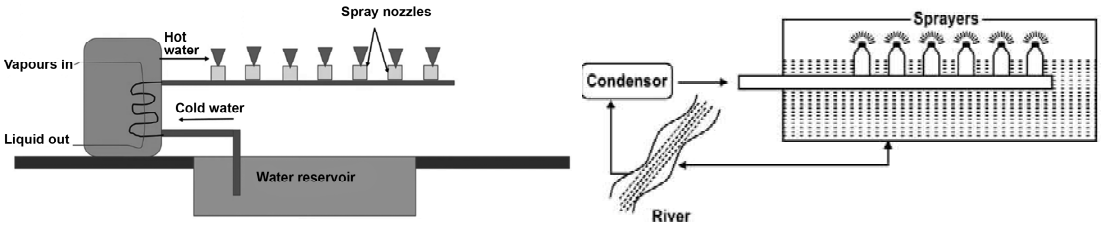


Figure 5.2 ***Schematic diagram of spray ponds***

1. Cooling Towers

Wet Cooling Towers: In a wet cooling tower, warm water comes into touch with air that is constantly flowing. The temperature decreases as a result of evaporation. The water is broken down into droplets by the use of spray nozzles or by splashing it on the packing or baffles in the cooling towers, increasing the surface area of contact.

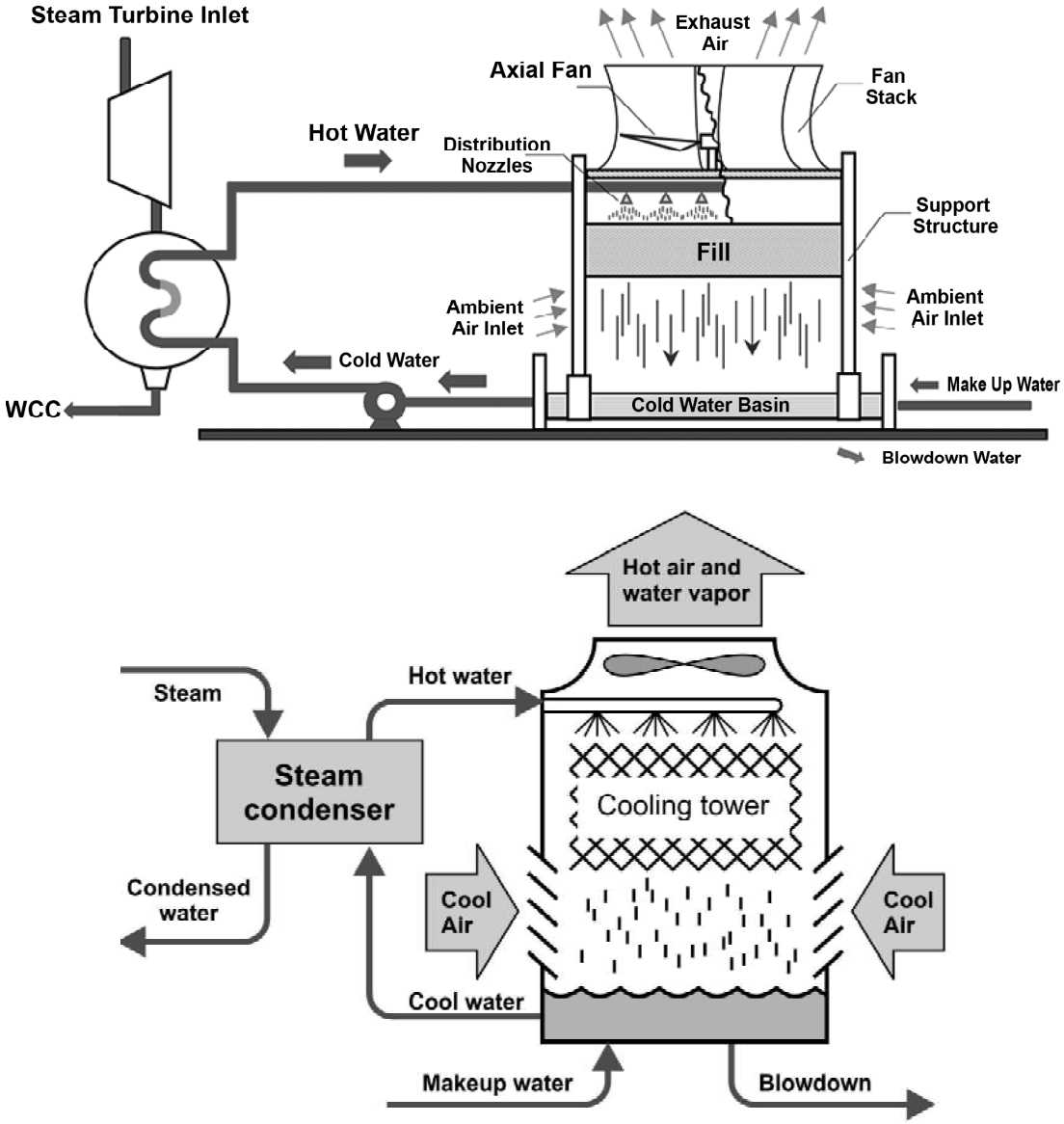


Figure 5.3 *Schematic diagram of wet and dry cooling tower*

Atmospheric Cooling Towers: In atmospheric cooling tower, warm water falls and air enters sideways to comes into touch with falling water. Finally, the air come out by absorbing the heat from water.

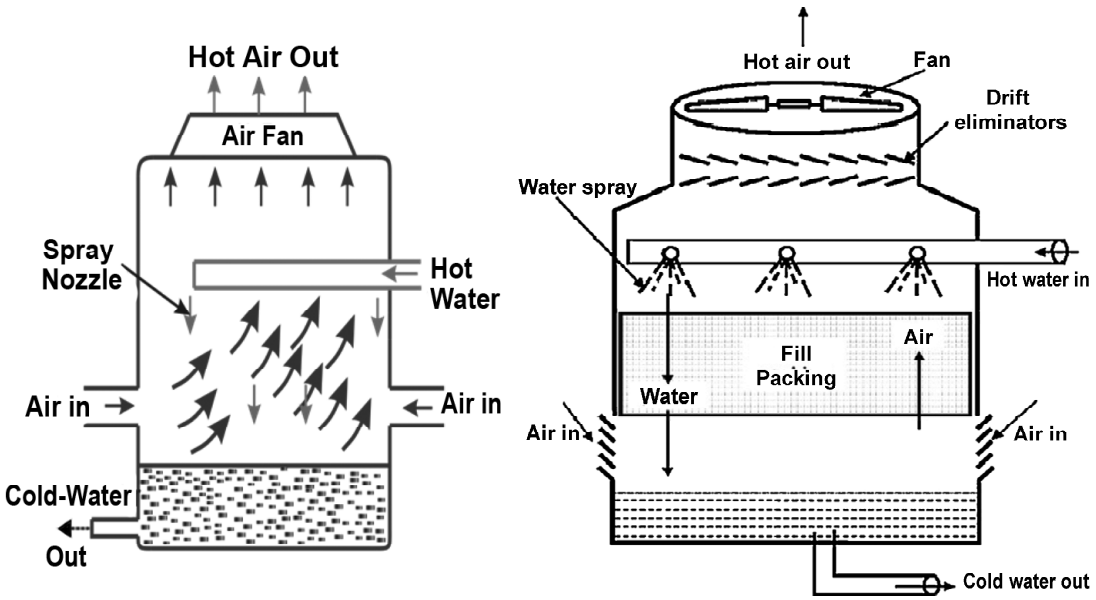


Figure 5.4 ***Schematic diagram of atmospheric cooling tower***

5.7 Summary

The release of warm water into water bodies is known as thermal pollution. Thermal or nuclear power plants, effluents from places like oil refining, paper mills, chemical industries, steel plants, and smelters, wastewater effluents, and biochemical activities are the main sources of thermal heat pollution. The enormous heat output to the environment has posed a significant impact. As a result, action must be taken in advance to use this thermal energy or treat it before discharging it to the environment. With a focus on remedial measure, the principles of thermal pollution and different aspects of thermal pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed in this unit.

5.8 Self-Assessment questions

1. What is thermal pollution? What are the different types of thermal pollution?
2. Discuss in brief the different effects of thermal pollution.

3. Briefly state different factors contributing to thermal pollution.
4. Discuss the steps taken towards solving the problem of thermal pollution.
5. Briefly describe urban heat island concepts.

5.9 Suggested Readings

1. BHATIA, H.S. "Environmental Pollution and Control", 1998. Galgotia Publishers, New Delhi.
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4. Goel, P.K. "Water Pollution- Causes, Effects and Control". 1997, New Age International pub lishers. New Delhi.
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6. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi.
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UNIT 6 ❑ Marine Pollution

Structure

6.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different marine pollution sources,
- understand different types of marine pollution and marine pollutants,
- know the different adverse effects of marine pollution,
- comprehend the control mechanism of marine pollution and associated regulations,
- understand the coastal zone concept and its management perspective,
- know the coastal economic zone management rules.

6.2 Introduction

Marine pollution is the term used to describe waste and pollutants that enter the ocean from land-based sources. Both the marine species and the economic systems that rely on marine infrastructure are severely harmed by this pollution.

The phenomena of human-spread materials including industrial waste, agricultural waste, household rubbish, etc. being dispersed across sea bodies is referred to as marine pollution.

All manmade items that wind up in the water, the majority of which are made of plastic, are considered marine garbage. This debris, which comes from sources on land in 80 percent of cases, accumulates as a result of littering, storm gusts, and poor waste management. Many plastic goods, such as shopping bags and beverage bottles, together with cigarette butts, bottle caps, food wrappers, and fishing equipment are examples of common maritime garbage. As such a persistent contaminant, plastic waste is particularly harmful. Decomposition of plastic products might take hundreds of years.

6.3 Types of Marine Pollution

Ocean pollution, also known as marine pollution, is one of the major dangers today because of industrialisation and agricultural practises. It poses a threat not only to the aquatic ecosystem but also, perhaps unintentionally, to people. There are various forms of marine pollution, including:

Toxin marine Pollution

One of the most hazardous forms of marine pollution, poisons are brought on by several toxins that build up in the oceans. DDT, Furan, radioactive waste, pesticides, PCB, TBT, phenol, and other toxins don't dissolve or break down; hence they endanger marine life.

Marine Plastic Pollution

Plastic pollution in the world's oceans is a result of its continued expansion in use. At the same time that the human population is growing, more plastic is being dumped into the oceans. The marine ecology is in danger as a result of how profoundly the plastic dumps are impacting marine life.

Eutrophication Marine Pollution

It has an impact on how animals breed. Nutrient pollution, also known as eutrophication, is what happens when water contains excessive amounts of chemical nutrients, particularly nitrates and phosphates. It degrades water quality and lowers oxygen levels in the ocean, making the environment uninhabitable for marine life.

Acidification Coastal Pollution

By absorbing carbon dioxide from the atmosphere, oceans also benefit the ecosystem. Regrettably, the overabundance carbon dioxide in the atmosphere is causing the oceans' water to become acidic. Marine life is also being impacted by ocean acidification.

6.4 Source of Marine Pollution

There are several causes of marine pollution, the most of which are produced by humans. Sometimes it results from dumping waste, and other times it results from ocean mining. Land-based sources account for 80% of the pollution that affects the marine ecosystem. Nonpoint source pollution, which results from runoff, is one of the main sources. Many minor sources, such septic tanks, automobiles, trucks, and boats, as well as larger ones, like farms, ranches, and forested regions, make up nonpoint source pollution. Every day, little volumes of oil are discharged into highways and parking lots by millions of motor vehicle engines. A large portion of this also ends up in the ocean. These are some of the sources of marine contamination that are discussed:

1. Sewage pollution contaminates ocean

Sewage is one way that pollution gets into the ocean directly. Rivers carry sewage into the ocean, which contaminates the marine life. Because of the decreased oxygen content of the water, oceanic creatures and plants have a harder time surviving.

2. Oily-water discharge from ship

Lubricating oil, fuel oil, grease, and water frequently leak into ship bilges as a result of the functioning of the power plants. When the oily-water separator is either not installed or is installed but is inoperable, the resulting emulsified water and oil constitute a source of maritime pollution from ships. Ballast water poured into oil cargo tanks is another form of oily water pollution. Before fresh crude oil is added, this water must typically be pumped overboard because it contains some oil residue and exotic species. Moreover, cleaning the crude oil tanks on these ships adds to marine pollution because the oily water used in cleaning contains detergent, solids, and rusty scales from corrosion that are dumped overboard.

3. Industrial waste

As a result of industrial waste, the ocean is exposed to thousands of other pollutants. Every day, about 2.8 billion gallons of industrial wastewater are dumped directly into ocean seas, including wastewater from electric utilities and offshore oil and gas operations. Several marine species, including those that are eaten by humans, frequently include heavy metals generated by industry, such as mercury and lead. Longer-lived, larger fish, like king mackerel, tilefish, swordfish, and shark, usually have unhealthy levels of the pollutant mercury, which can disrupt children's developing brains and neurological systems and harm fetuses. Pesticides

and pharmaceutical substances, together with biological contaminants like bacteria, viruses, and protozoa, made their way into the ocean.

4. Plastic Pollution

Global plastic pollution is a serious issue. Many people are unaware of how toxic and dangerous plastic is to the environment and to marine life. The main drawback of plastics is that they cannot decompose. They are employed in the creation of containers, bottles, bags, and food product wrapping. When these things are eventually dumped into the ocean, they pollute it, endangering marine life and even humans who eat seafood that contains plastic debris.

5. Accidental Spillage during Terminal Loading

During the loading and disposal of crude oil at offshore oil terminals, operational errors, pipe ruptures, and pump and valve malfunctions can result in oil spills. Ships may also spill while loading bunker oil or lubrication oil for their engines. Oil can spill if a hose ruptures. Tanks aboard a ship could overflow if someone is not keeping an eye on the amount of oil being pumped into them.

6. Industrial chemicals contribute to marine contamination

Toxins and chemicals introduced into seawater through agricultural and industrial wastes are another factor in ocean pollution. These chemicals contribute to thermal pollution as heavy pollutants. Thermal pollution causes an increase in ocean temperature. In oceans, there are some creatures that cannot endure high temperatures and perish.

7. Tanker Accidents

Oil spills are most frequently connected with ship pollution. Gas, chemical, and oil transports are vulnerable to common maritime risks such collision, grounding, explosion, and fire. Catastrophic accidents have been caused by the exploration, exploitation, and transportation of oil, gas, and their derivatives. Oil spills have disastrous effects, albeit being less common than the pollution that results from normal activities. When this leakage happens, effective efforts are typically taken to stop it.

8. Garbage and Other Solid waste

When there is no enforcement, non-oil pollutants from ships, such as trash and other solid waste, are frequently dumped into the ocean or a river. Glass, paper, cardboard, aluminum

and steel cans, plastic bottles, and solid debris from ships all fall under this category. It might have a dangerous or non-hazardous nature. Solid trash that enters the ocean has the potential to turn into marine debris, which then poses a risk to persons, coastal communities, and businesses that depend on marine waters.

9. Wastewater discharged from ships

Black water and grey water are the two types of wastewaters produced on board ships. Sewage, often known as blackwater, is the waste water from bathrooms and hospitals that may include dangerous infections, viruses, parasites, and minerals. Grey water is used water from the laundry, kitchen, showers, and sinks. This includes water that has byproducts such as fat and oil, food scraps, household chemicals, soap and detergent that is high in phosphate, nitrate, and microbiological pathogens dissolved in it or that have not been declared (e.g., bacteria and viruses). Both types of wastewaters offer serious health concerns to humans when released into aquatic habitats because they can harm ecosystems, cause algal blooms, and harm human health.

10. Ballast-water discharged from ships at ports:

Since about 120 years ago, when steel-hulled ships first appeared, water has been utilized as ballast to stabilize ships at sea. While ballast water is crucial for the safe and effective functioning of contemporary ships, the abundance of marine species that are transported in it raises severe ethical, financial, and health concerns. These consist of various species of bacteria, microbes, tiny invertebrates, eggs, cysts, and larvae. The transplanted species may endure to form a regenerative population in the host habitat, where it will become invasive, outcompete native species, and proliferate to pest levels. The consequences for direct and indirect health are getting worse, and environmental harm is frequently irreparable.

11. Marine Degradation via Land Runoff

Land runoff also contaminates marine water. It happens when too much water from rain, flooding, etc. seeps into the sea water. This water pollutes the oceans when it enters them with toxins like pesticides, oil, fertilizers, and animal faeces. These contaminants have detrimental impacts on marine life and cause the demise of aquatic animals and vegetation.

12. Mining-related marine pollution

Deep sea mining is a new method of resource recovery in which minerals are extracted from the ocean floor. Mining is done for precious metals like silver, gold, copper, cobalt, zinc, etc. Deep sea mining, like its land-based counterpart, immediately discharges large amounts

of contaminants onto the ocean floor. Since it's a novel type of mining, its environmental implications haven't been properly investigated. Deep sea mining is undoubtedly damaging, just like its land-based equivalent. Corrosion, spills, and leaks will change the ecology of the mining region.

In addition to contributing to marine pollution, ocean mining also makes noise. The ocean's bottom level is impacted by deep-sea mining. The marine ecology is impacted by the contaminants released into the ocean as a result of the mining of metals like silver, gold, copper, *etc*.

13. Atmospheric pollution

Marine pollution also contributes to atmospheric pollution. In the vicinity of bodies of water, winds sweep dust and trash like plastic bags from landfills. For instance, during the warm season, when the ridge builds and advances northward through the subtropical Atlantic, dust from the Sahara passes over the subtropical ridge's southern periphery and moves into the Caribbean and Florida.

As a result of increased carbon dioxide levels, altered marine ecosystems, and altered fish distributions, climate change is raising ocean temperatures over time. Fishing-dependent communities have been impacted as a result of this.

14. Underwater noise

Sea life may be sensitive to noise or sound pollution from things like passing ships, seismic surveys for oil prospecting, and low-frequency active sonar used by the navy. In comparison to the atmosphere, sound travels faster and farther in the sea. Sea creatures, like cetaceans, frequently have poor eyesight and navigate their environment mostly by sound. This holds true for many fish living in the deeper waters, who dwell in a world of darkness. In one site in the Pacific Ocean, background noise increased by roughly ten decibels between 1950 and 1975.

The Lombard vocal response, which occurs when there is noise, also causes species to communicate loudly. When submarine detectors are active, whale songs are longer. If species don't "talk" loud enough, human sounds may cover up their voice. These silent cries could be warnings, prey being found, or net-bubbling preparations. The entire ecosystem will eventually speak louder as a result of one species' voice masking the sounds of other species.

The oceanographer Sylvia Earle has said that underwater noise pollution is similar to dying from a thousand cuts. Each sound may not be of immediate concern on its own, but when combined, the noise from seismic surveys, military activity, and shipping is transforming the environment in ways that were unimaginable even fifty years ago.

Cnidarians and ctenophora, which are crucial components of the marine ecology, can be harmed by noise from ships and human activity. Because of their straightforward designs, they encourage a high degree of variation and serve as models for biology and ecology. The vibrations in the water caused by underwater noise harm the cilia hairs on the Coelenterates. In a study, the creatures were subjected to sound waves for varying lengths of time, and the findings revealed that damaged hair cells had extruded or been absent, or had kinocilia and stereocilia that were twisted, flaccid, or missing altogether. Ships may be certified as meeting specific noise standards.

Other sources of marine contamination -

- Fossil fuel emissions that contribute to climate change are a major factor in marine pollution and water acidification.
- Marine contamination is also influenced by atmospheric pollution. For instance, the acidity of ocean water is increased by atmospheric carbon dioxide.
- The marine ecosystem is contaminated by nuclear waste from numerous sectors, which has an impact on the marine ecosystem's food chain.
- Oceans are exposed to thermal pollution from industrial, power plants, and other sources, which raises the water's temperature.
- Marine pollution is also a result of acid rain.
- When acid showers, the sulphuric acid and nitric acid interact with marine water, increasing the acidity of the water.

Simply, "marine pollution" is the word used to describe seawater contamination. Marine ecosystem is contaminated by a variety of factors, including soil erosion and mining.

- One of the main components of marine pollution is plastic. Thrown into the sea are bottles, polythene, plastic bags, etc.
- Sewage dumped into the ocean creates marine contamination.
- The rivers and oceans are filled with industrial pollution. It has a terrible adverse effect on the water.

- Many sources of toxins, including phenol, pesticides, and fertilisers.
- Seawater is also contaminated by oil spills.
- Another source of marine pollution is thermal pollution. The causes and effects of each type are all covered in full below.

6.5 Effects of Marine Pollution

The impacts of marine contamination are as numerous and diverse as the impacts. Marine pollution has a significant impact on marine life. Some of the dangerous causes of marine pollution include poisons, chemicals, polluted wastes, etc. These contaminants have a variety of effects on the oceanic Eco-system, including:

Particularly at risk are aquaculture installations, designated breeding grounds, fishponds, and cages. Garbage and toxins reduce the oxygen level in the ocean, making it impossible for many species to live, particularly larger ones like whales, dolphins, penguins, sharks, iguanas, and seals. A lack of oxygen and the development of a dead zone can result from an overabundance of oxygen-depleting compounds in the water. Also, precipitation that moves across paved surfaces is known as storm water runoff. It may gather deposits of sediments, car fluids, and air pollutants, among other things. In actuality, ship storm water runoff from marine ports contributes to impairment in Nigeria's estuaries and coastal waters.

Plastic trash, abandoned fishing nets, and other items of a similar nature that are present solely as a result of human irresponsibility act as serious marine pollution agents and have an effect that cannot be imagined unless observed. A significant number of animals die as a result of consuming plastic; one example is sea turtles, which mistake it for jellyfish and eat it. The main cause of (eutrophication), a rise in chemical nutrients in surface waters, usually compounds containing nitrogen or phosphorus, is excessive nutrient inputs into water bodies. Other repercussions include a shortage of oxygen and drastic reductions in water quality, fish numbers, and other animal populations, as well as an increase in the ecosystem's primary productivity (excessive plant growth and degradation). Nutrient surplus promotes the growth of algae.

These marine poisons can spread to terrestrial animals because many animal feeds contain a lot of fish meal or fish hydrolysate, which eventually appears in meat and dairy products and poses a threat to human health when consumed. The most frequent ocean pollution is oil. Each year, the sea is contaminated by more than 3 million metric tonnes of oil. Oil contamination in the waters is primarily caused by land. Oil is carried into the ocean

through runoff and garbage from towns, businesses, and rivers. Ships wash out their tanks or discharge their bilge water into the ocean, which contributes to nearly a third of the oil pollution in the ocean. Broadly the marine pollution effects are described below:

Impact of pollution on marine bio-system

Spilled oil poses major risks to freshwater and marine habitats, affecting surface resources as well as a wide range of subterranean creatures that are linked in a complicated food chain that includes human food resources. In addition to the physical harm that affects wildlife and their habitats (such as coating birds or mammals with an oily film), this can also poison exposed species due to the oil's toxicity.

Oil that is drifting pollutes seals' fur and seabirds' feathers. In birds, it clogs and ruins the feathers' insulating and waterproofing abilities. The bird will deplete its fat reserves while attempting to maintain its body temperature, weakening it. It is almost impossible to rebuild these reserves since, in its debilitated condition, whenever it flies the bird has to carry as much as 20% extra body-weight in sodden feathers. Moreover, during incubation, oil is transferred to the surface of its eggs, which decreases the hatchability. Oil pollution also disrupts the life cycle of coral reefs, clogs fish gills and kills them, and hinders marine plants' ability to synthesize oxygen, which eventually kills them.

Impact of pollution on Local industries

Fishing Industry

When an oil disaster happens, the fishing business suffers greatly. The fish are dangerous for several reasons, chief among them that they are frequently doused with oil or have ingested oil. Moreover, a great deal of fish perish, reducing the potential catch of fish. Since this pollution has an effect on the seafood population, it has significant economic repercussions. Large-scale catastrophes, like an oil leak, have the potential to completely damage the local economies of coastal towns that depend on these businesses.

Tourist Industry

In seaside towns where the ocean is overrun with contaminants, tourism suffers. For instance, if oil is spilled and it gets close to the shore, it contaminates the beaches and the intertidal zone. As a result of the oil slick destroying the aesthetic splendor of the seashore, the local tourism business suffers. Operations must be suspended while the water is cleaned, which can have a

negative impact on industries that depend on clean seawater for normal functions. The community's economy is then impacted by this.

Impact of Marine Pollution on Public health

Ocean pollutants find their way back to people. Larger predators, many of which are seafood that we eventually consume, eat little organisms that have ingested toxins. Toxins from contaminated animals can enter human tissue and cause cancer, birth abnormalities, and other long-term health problems.

The most acute health issues when oil is spilled into a residential area, for instance, are those brought on by volatile compounds, which are airborne poisons that lead individuals to complain of symptoms like headaches and nausea while also worrying about long-term issues like cancer.

However, a trace amount of heavy metals are also present in crude oil, though they rarely vaporise into the atmosphere. As the oil leaks onto the rivers, they remain with it instead. Several of these substances, like arsenic and lead, can harm the nervous system even at very low concentrations. These substances include mercury, manganese, nickel, chromium, and others that are poisonous at high quantities.

Reduction in oxygen content

The majority of the rubbish deposited in oceans throughout the world is unable to degrade for many years, dramatically lowering the oxygen content of the water. The amount of oxygen in the ocean is being alarmingly depleted by excessive trash. The health of marine plants and animals, including sharks, penguins, whales, dolphins, turtles, and seals, is directly impacted by the low oxygen levels.

Impact on oceanic food chain

Industrial and agricultural garbage are dumped into the sea via the river that eventually empties into the ocean. Pesticides, chemicals, radioactive waste, and other industrial and agricultural waste settle to the ocean's bottom and remain there for a long time. The ocean's surface and bottom are both affected by this accumulated garbage. Little marine creatures that consume these substances are later consumed by larger marine creatures. The entire food chain is impacted in this way.

Disruption of the coral reef cycle

Oceanic plants cannot grow when sunlight cannot penetrate an oil spill that covers the seawater's surface. Hence, it has an impact on photosynthesis. As a result, the coral reef cycle adversely affected.

Impact on aquatic species' reproductive systems

Chemicals that are detrimental to marine life make up the trash from industries and agriculture. Some substances are sufficiently harmful that they can harm aquatic creatures' internal organs, including their reproductive systems. The inability of the reproductive system to function has an impact on how water animal species reproduce.

Toxins' detrimental consequences on marine life

As the chemicals in the oceans continue to build up, they are beginning to have serious effects on aquatic life, including cancer, tissue and cell damage, organ failure, behavioural disorders, and reproductive system failure. These creatures are directly or indirectly exposed to hazardous chemicals, pesticides, and oil spills, which can cause a variety of health problems and even death.

Common victims of ocean pollution include sea life. For instance, oil spills can trap and drown marine life by seeping through their gills. Seabirds that have oil in their feathers may be unable to fly or feed their young. Animals not killed by crude oil may get cancer, have behavioural abnormalities, or lose the ability to reproduce.

As well as becoming entangled in or strangled by plastic bags and abandoned fishing nets, marine creatures also mistake small pieces of plastic garbage for food. Dolphins, fish, sharks, turtles, seagulls, and crabs are among the animals most at risk from marine plastic trash impact.

Other implications of marine contamination include:

- Unconditional death of helpless aquatic life results from a disruption in the natural water equations caused by an increase in oceanic temperature brought on by pollution.
- Sea pollution also affects human health indirectly.
- The pollutants from the harmed ocean animal are passed into people' bodies when they consume affected species.

- The ocean's acidity is increased by the dissolved poisons, putting marine life at serious risk.
- The sun and the ocean floor are separated by pollutants like oil spills. The photosynthetic mechanism of plants is hampered by these pollutants because they prevent sunlight from reaching the bottom.

6.6 Monitoring and Control Measures of Marine Pollution

It is necessary to take action to stop waste chemicals and oil from being dumped into the ocean. For the management and prevention of maritime environmental contamination, there are national and international legislation, recommendations, and codes. Everyone has a responsibility to protect marine life because it is an essential component of our eco-system. Working together to stop marine pollution will have an impact. The following is a summary of some of the crucial preventative methods for marine pollution:

We must all work together to prevent marine pollution since, as we are all aware, prevention is always preferable to treatment. Everyone has a responsibility to protect marine life because it is an essential component of our eco-system. Working together to stop marine pollution will have an impact. The following is a summary of some of the crucial preventative methods for marine pollution:

- Use less chemical fertilizer: Eventually, extra chemical fertilizer finds its way into the oceans. Choose organic fertilizers, which typically contain less nutrients, and apply them half as often or at half the recommended dosage.
- Choose reusable containers and cutlery: Straws and other disposable plastic utensils contribute significantly to ocean pollution. Use reusable containers and utensils to avoid adding to the threat to marine life.
- Create a cleanup strategy: Plan a cleanup event to promote social distance at the beach or a neighboring park. Less garbage enters our waters as a result of more trash being picked up and properly disposed of.
- Dispose of trash and plastics properly: One of the main causes of marine pollution is now plastic bottles, bags, and other products. To avoid plastics and other recyclable items from ending up in the ocean, properly dispose of them is one of the simplest strategies to decrease ocean pollution. Take your rubbish home with you while you're

in an outside area, such as a park or the beach. To protect marine life and the ecosystem, we must cease consuming products manufactured of plastic.

- Studies show that trash from land-based sources is responsible for about 80% of marine contamination. By reducing the waste produced, we can lower this.
- Cleaning up the seashores requires effort from all of us. Cleaning up beaches will help minimize marine pollution to some extent.
- In place of employing chemical pesticides and fertilizers, the farmers should practice organic agricultural methods. The plants and animals of the sea suffer a variety of health problems when these fertilizers and pesticides are introduced into ocean water.
- Since the majority of drain water ends up in the oceans, we must all take care that only rainwater enters the drainage system. The marine life will eventually suffer if sewage and other waste are allowed to enter the drainage system.
- The majority of rivers empty into the sea, where waste also mixes with the water. As a result, we also need to maintain the rivers' purity to prevent marine life from becoming contaminated.
- To safeguard the marine ecosystem, we ought to stop using single-use plastic.
- Say "NO" to disposable items like straws, mugs, and plastic shopping bags. These things only contribute to an increase in the amount of trash that ends up in the oceans.
- Ocean environment is greatly protected through recycling.
- To lower the ocean's temperature, we should make an effort to utilize as little energy as possible.
- Buy eco-friendly goods and materials whenever possible.
- Raise people's awareness of the need to protect and value the maritime environment.
- You can become a member of any group that strives to protect marine life from pollution.

6.6.1 Laws and Regulations

Since there are numerous ways for the ocean to become polluted, numerous laws, rules, and treaties have been established throughout history. Policies have been created globally to protect the ocean from marine pollution.

- The Federal Water Pollution Control Act which Harry Truman signed into law in 1948, gave the federal government authority to manage marine pollution in the United States of America.
- The US Congress passed the Marine Protection, Research, and Sanctuaries Act of 1972 (MPRSA) in 1972, which governs the ocean dumping of waste into US waterways.
- Due to flag states' disregard for the law, both the 1973 International Convention for the Prevention of Pollution by Ships and the 1954 Convention for the Prevention of Pollution of the Sea by Oil were only loosely implemented.
- MARPOL 73/78 was a convention created in 1973 and 1978 to limit pollution from ships, particularly with reference to oil. The MARPOL 73/78 pact was internationally enforced in 1983 by the International Convention for the Prevention of Pollution from Ships.
- By requiring states to limit their ocean pollution, the 1982 United Nations Convention on the Law of the Sea (UNCLOS) was developed to safeguard the marine ecosystem. It set limits on the quantity of poisons and pollutants that are released from all ships that travel abroad.
- The Marine Debris Research, Prevention and Reduction Advisory Council (MDRPRAC).
- The National Oceanic and Atmospheric Administration (NOAA) created it to aid in the identification, attribution of origin, mitigation, and prevention of marine debris.
- The Ad Hoc Open-Ended Expert Group on Marine Litter and Microplastics was established by the UN Environmental Agency (UNEA) in December 2017 with the aim of researching marine plastic pollution and determining solutions.

6.7 Coastal Zone Management

The area where land and sea meet are known as a coastal zone. The territorial waters up to the high-water mark serve as the boundary for the coastal zones. These are long, narrow characteristics of the continent, islands, and seas that typically define the outer limit of the coastal domain. These areas are crucial since they are home to the vast majority of the world's inhabitants. The Coastal Zone Management (CZM) process of governance comprises

of the institutional and legislative structure required to guarantee that management and development plans for coastal zones are integrated with environmental and social goals and are established with the participation of people impacted.

6.7.1 Coastal Zone Management's Objectives

The objectives of CRZ are to "preserve, protect, develop, enhance, and restore the coastal resources where practicable." These are the goals of coastal zone management:

1. The main goal of CZM is to strike a balance between the need for development and the protection of natural resources, so if coastal ecosystems are managed according to the principles of sustainability, millions of people's livelihoods will be safeguarded, and their survival will be ensured.
2. To make the most of the advantages offered by the coastal zone
3. To reduce disputes and negative repercussions of actions on one another, resources, and the environment
4. Encourage connections between various sectoral operations
5. To direct the ecologically appropriate development of coastal areas
6. To maintain and safeguard the coastal zone from actions that can result in quality degradation or loss of coastal land.

6.7.2 Necessity of Regulating Coastal Zones

- Preservation of ecologically sensitive areas, such as mangrove swamps and coral reefs that serve as a barrier against cyclones and tsunamis
- enhancing coastal populations' quality of life, particularly fishing communities
- Resilient strategies for reducing the effects of climate change and strong cyclones
- To strike a balance between growth and coastal environment preservation

6.7.3 Difficulties of Management of Coastal Zone

The definition of problems and their remedies in the coastal zone are handled through the interdisciplinary and cross-sectoral practise of coastal zone management. It faces a variety of difficulties, some of which are listed below:

1. Failing to recognise how connected coastal systems are
2. Insufficient regulation and non-enforcement
3. Insufficient knowledge of and expertise with ICZM
4. Inadequate comprehension of marine and coastal processes
5. A lack of knowledgeable staff, appropriate technologies, and apparatus

6.7.4 Coastal Zone Management Strategies

The Rio Declaration on Environment and Development, which outlines accepted worldwide principles, serves as the foundation for the Coastal Zone Management (CZM), which is also based on the bio-physical characteristics of the coastal zone. The changes brought about by the Coastal Regulation Zone (CRZ) Notification make it relevant to Government Policies/Indian Polity.

To safeguard and preserve the ecology and ecosystem along the nation's coastline, the Government of India issued a notification in 1991 under the Environment Protection Act, 1986, which is overseen by the Ministry of Environment and Forests (MoEF).

The Coastal Regulatory Zone is defined by the notification as the coastal area up to 500 metres from the High Tide Line (HTL) and a stage of 100 metres along the banks of creeks, estuaries, backwaters, and rivers vulnerable to tidal fluctuations (CRZ).

6.7.5 Tide Lines and Tides

In order to understand the Coastal Regulatory Zone, it is crucial to comprehend Tide Lines.

Spring Tide: This extraordinarily high tide is caused by the complimentary role that the Sun and Moon play. It should be noted that a Syzygy occurs when the Sun, Moon, and Earth are all in the same line. These take place twice a month, once during the full moon and once during the new moon.

High Tide Lines (HTL): It is the area of land that the highest water line during the spring tides extends to.

Low Tide Lines (LTL): It is the area of land up to which the lowest water line during spring tides extends.

6.7.6 Coastal Regulation Zone Classification

The Ministry of Environment and Forest and Climate Change published the Coastal Regulation Zone Notification in 1991 with the intention of conserving and protecting the coastal environment. According to the CRZ Notification from 1991 through 2003, there are four different classifications for the coastal regulation zones across the nation.

For regulation of developing activities, the coastal sections within 500 m of HTL on the landward side are categorised into four groups, viz.

Category I (CRZ-I)

Areas that are ecologically sensitive and significant, such as national parks, marine parks, sanctuaries, reserve forests, wild habitats, mangroves, corals/coral reefs, areas near fish breeding and spawning grounds, historical and heritage areas, areas rich in genetic biodiversity, areas likely to be inundated due to sea level rise brought on by global warming, and such areas as may be declared by the authorities.

The region including the Low Tide Line and high tide line

Regulations:

Rules prohibit new development within 500 metres of the HTL.

Category II (CRZ-II)

The region that has previously been developed up to or around the shoreline is classified as Category II (CRZ-II). For this purpose, "Developed Area" refers to any area that is considerably developed, inside municipal borders or in other legally recognised urban regions, and that has access to drainage and approach roads as well as other infrastructure like water supply and sewage mains.

Regulations:

a) Structures are not authorised on the seaward side of either the current road (or any roads proposed in the area's approved Coastal Zone Plan) or the projected road. Existing approved structures must adhere to current Town and Country Planning laws, including FIS/FAR standards.

b) The authorised building may be rebuilt as long as it complies with current FSI/FAR standards and its intended purpose is not altered.

c) Building designs and construction must complement the architecture and natural surroundings.

Category III (CRZ-III)

Places that are neither in Category I nor II but are nonetheless relatively undeveloped are classified as Category III (CRZ-III). Coastal zones in both developed and undeveloped areas, as well as places inside municipal boundaries or in other officially recognised urban areas that are not extensively built up, will be included in this.

Regulations :

a) A "No Development Zone" is designated for the region up to 200 metres from the HTL. Except for repairs to already-authorized structures that don't go above existing FSI, existing plinth area, and existing density limits, no construction is allowed in this zone. Nonetheless, the following uses—agriculture, horticulture, gardens, pastures, parks, play fields, forestry, and the production of salt from sea water—might be allowed in this zone.

b) Construction of hotels or beach resorts for short-term occupancy by tourists or visitors is permitted on unoccupied lots between 200 and 500 metres of the High Tide Line in designated CRZ-III zones with the previous clearance of the Ministry of Environment and Forests.

c) Building or reconstructing residential structures within 200 to 500 metres of the High Tidal Line is permissible as long as it respects traditional rights and customary usage, such as those of existing fishing villages and gothans. Construction approval for such Construction and reconstruction will be subject to the limitations that the number of housing units combined cannot reach twice the number of existing units, that the total area covered on all floors cannot exceed 9 metres, and that the number of floors of building cannot exceed two (ground floor plus one floor).

d) Reconstruction or alteration of an authorised existing building is allowed under the conditions of (1) to (3) above.

Category IV (CRZ-IV)

Coastal lengths of the Andaman and Nicobar Islands, Lakhadweep, and small islands that are not part of the CRZ I, CRZ II, or CRZ III are classified as Category IV (CRZ-IV).

Regulations

a) On the Andaman and Nicobar Islands, no new building construction is allowed within 200 metres of the HTL.

b) Buildings between 200 and 500 metres from the HTL must have no more than two floors, a total area on all floors no larger than 50% of the plot's size, and a maximum height of 9 metres.

c) Buildings must be built in a manner that complements the local architectural style and surrounding surroundings.

d) Sand and coral from beaches and coastal waters are not to be exploited for building or other purposes.

e) Underwater blasting and dredging are not allowed near or within coral formations.

f) However, with the prior consent of the MoEF and in such designated structures, coastline portions in some of the islands may also be categorised into categories of CRZ-I, II, or III.

6.7.7 Things That Are Prohibited Inside the CRZ

Inside the CRZ, the following activities have been declared illegal.

1. Establishing new industries and growing existing ones, with the exception of those with a direct connection to the waterfront or that genuinely require seafront infrastructure.
2. The production, handling, or disposal of hazardous materials.
3. Establishing and growing fish processing facilities, including warehousing (excluding hatchery and natural fish drying in permitted areas)
4. Installing and expanding equipment for dumping garbage and effluents into waterways.
5. Discharging of untreated wastewater and city waters from businesses, towns, and other populated areas.
6. The practise, if any, of dumping municipal garbage for land filling or other purposes shall be phased out within a reasonable period of time not to exceed three years from the date of notification.
7. Ash or other trash disposal after the notice date.
8. Land reclamation, construction, or other activities that alter the normal flow of seawater with similar observations, excluding those necessary for maintaining or controlling coastal erosion, sandbar construction, or storm water recharge.

9. Mining of non-existent substrata resources outside CRZ regions, such as sand, rocks, and other minerals.
10. Groundwater harvesting or drawing is allowed within 200 metres of the HTL, but within 500 metres of the HTL, it must only be done manually through regular wells for drinking, horticulture, agriculture, and fishing.
11. Building projects in ecologically delicate locations
12. Any construction between LTL and HTL, with the exception of facilities for treating effluents and waste discharges, pipelines for oil, gas, and similar substances, and dressing or altering of sand dunes, hills, and other natural features, including landscape changes for aesthetic, recreational, and other similar purposes.

Table 6.1 : CRZ at a glance

Category	Description
CRZ1	Regions that are environmentally sensitive and necessary for preserving the ecology along the shore are known as high tide lines (HTL) and low tide lines (LTL). Permissions : • Natural gas exploration • Salt extraction
CRZ2	Areas that have been developed right up to the coast's edge.Permissions : • Some construction that only complies with the rules. • Rebuilding the permitted structure while maintaining the current use.
CRZ3	Locations in both urban and rural settings that are not included in CRZ-1 and CRZ-2 fall under CRZ-3. Although they have been given to the municipality, they are not heavily developed.Permission : • Only specific activities associated with forests, salt production from seawater, horticulture, gardens, pastures, parks, and play areas. • In this area, only repairs to already-authorized structures are allowed for construction. • Only public facilities to be built.

CRZ4	Lakshadweep, small islands, and coastal sections in the Andaman and Nicobar Islands, excluding those designated as CRZ I, CRZ II, and CRZ III. In this area, solid garbage should be disposed of.Permissions • Sand and coral from beaches and coastal waterways are not permitted to be used for building or other purposes. • In and near coral formations, dredging and underwater blasting are prohibited.

Coastal Regulation Zones Announcement 2011

The 2011 Coastal Regulation Zone Notification took into account the problems of the 1991 notification and made appropriate adjustment recommendations. The 2011 Coastal Regulation Zone Notice made the following changes:

Category	**Description**
CRZ1	Exemption for brand-new building • Building highways and trans-harbour sea links between HTL and LTL, etc., without affecting the tidal flow. • Initiatives involving the Department of Atomic Energy.Additional authorizations given for interactions between HTL and LTL include • Exploration and extraction of natural gas Salt production Desalination facilities
CRZ2	• Facilities for non-hazardous cargo storage in the notified ports. • Permits for construction of buildings on the dangerous line's landward portion. • Among other things, are among the licences given for activities between HTL and LTL. o Desalination plans o Only in accordance with the notification's rules are certain types of building allowed.

CRZ3	• New construction exceptions. o Building highways and trans-harbour sea links between HTL and LTL, etc., without affecting the tidal flow. Projects for public facilities, petroleum products, salt production, and the Department of Atomic Energy • Building homes for nearby communities in some places.
CRZ4	• The traditional fishing practiced by nearby communities is unrestricted. • These places may not be used for the discharge or dumping of solid waste or untreated sewage.

Under the leadership of Dr. Shailesh Nayak, the Ministry of Environment, Forest, and Climate Change established a Committee in June 2014 to investigate the different challenges and worries of Coastal States/UTs and other stakeholders in order to recommend necessary adjustments to the CRZ Notification, 2011.

In 2015, the Shailesh Nayak Committee delivered its recommendations following extensive talks with state governments and other stakeholders.

The Union Cabinet gave its approval to that draught notification in December 2018. New CRZ requirements were then announced by the MoEFCC in January 2019.

Coastal Regulation Zone Notification 2018 and 2019

In accordance with Section 3 of the Environment Protection Act of 1986, the revised CRZ Notice aims to:

- *"to advance sustainable development based on scientific principles, taking into account the risks associated with natural calamities, sea-level rise as a result of global warming," and*
- *"to conserve and safeguard the unique ecosystem of coastal stretches and marine areas, besides livelihood security to the fisher people and other local groups in the coastal area".*

The following new changes are included in the Coastal Regulation Zone Notice for 2018 and 2019:

- Development projects
  - Reduction of No Development Zones (NDZ)
- New Categories in CRZ

  Two distinct classifications have now been established for CRZ-III(Rural) areas, and they are as follows :

CRZ-III A	**CRZ-III B**
Highly inhabited rural areas with a 2161/km^2 population density. They will have a 50-meter NDZ from the horizontal. According to the 2011 CRZ Notice, it was previously 200 metres from the HTL.	Highly inhabited rural areas with a 2161/km^2 population density. NDZ will be 200 metres from HTL for them.

- Tourism Infrastructure
- FSI Norms for Relaxed
  - According to the CRZ, 2011 Announcement, the Floor Space Index (FSI) or Floor Area Ratio (FAR) for CRZ-II (Urban) regions had been frozen at 1991 Development Control Regulation (DCR) levels.
  - It has been agreed to de-freeze the same and allow FSI for construction projects, as they were on the date of the new Notification, in the CRZ, 2019 Notification.
- Pollution Abatement
- Critically Vulnerable Coastal Areas (CVCA)
  - Sundarban region of West Bengal and other ecologically vulnerable places recognised as such under the Environment (Protection) Act, 1986.
  - Coastal communities, notably fishermen who rely on coastal resources for a sustainable living, are involved in their management.

6.8 Summary

Aquatic environments with elevated amounts of dissolved salt make up marine ecosystems. They encompass the open ocean, the deep-sea ocean, and coastal maritime ecosystems, each of which has diverse physical and biological properties. An international

issue is ocean pollution. It crosses international borders and has many sources. It results from irresponsible, opportunistic, and untenable resource extraction. It puts marine ecosystems in danger. Marine air pollution is a mixture of chemicals and debris, which mostly comes from terrestrial sources and is washed or blown into the ocean. This contamination leads in environmental damage, to the welfare of all species, and to economic systems globally. With a focus on remedial measure, the principles of marine pollution and different aspects of marine pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed thoroughly in this unit.

6.9 Self-Assessment questions

1. What is marine pollution? What are the different types of marine pollution?
2. Discuss in brief the different effects of marine pollution.
3. Briefly stale different factors contributing to marine pollution.
4. Discuss the steps taken towards solving the problem of marine pollution.
5. What do you mean by coastal zone? Write down different types of coastal regulation zone with characteristics.
6. Differentiate between low and high tide.
7. Briefly describe coastal zone regulation notification.

6.10 Suggested Readings

1. R.K. Khitoliya, "Environmental Pollution-Management & Control for Sustainable Development" S. Chand & Company Ltd., Pvt, Ltd, 2007, New Delhi.
2. P.K. Goel, "Water Pollution Effects and Control" New Age International (P) Limited; Publishers, New Delhi, 1997.
3. H.S. Bhatia, "A Text book on Environmental Pollution & Control" Galgotia Publications (P) Ltd., New Delhi, 1998
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5. S. S. Dara, "A Textbook of Environmental Chemistry and Pollution Control" S. Chand & Company Ltd., Pvt, Ltd, 2004, New Delhi.
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UNIT 7 ❑ Radioactive Pollution

Structure

7.1 Objectives

After successfully completing this unit, you will be able to:

- learn about the different radiation pollution sources,
- understand different types of radiation and their characteristics,
- understand the different adverse effects of radiation pollution,
- comprehend the control approaches of radiation pollution.

7.2 Introduction

A physical kind of environmental contamination is radioactive pollution. It differs from other forms of pollution in that it not only has a negative impact on the individual but also causes physiological alterations in future generations. Radionuclides damage man's essential life support system by contaminating the air, water, and soil. Any radioisotope that is introduced to the environment and has a long enough half-life is said to enter a person's body. There are dangers associated with even the slightest increase in radiation over the background radiation

from the environment. Radiation contamination is now being brought to unprecedented levels by the expansion of nuclear testing, X-ray fluoroscopy, radars, and light materials like colour televisions.

Radiation is the energy that is emitted from a source. Ionizing radiation is any electromagnetic or particle radiation that can produce ions by interacting with matter, either directly or indirectly. Many medicinal, nuclear, and industrial uses produce ionizing radiation. On the basis of wavelength, different types of radiation are categorized. A radiation type's associated energy is determined by its wavelength. The frequency and energy increase with decreasing wavelength.

The three main systems that support life, air, water, and soil are all affected by radioactive pollution, which is a unique type of physical pollution. Because radioactive contamination has a very different nature from other types of contamination, it must be explained separately. Also, its impacts are unique in sort. Radioactivity is a phenomenon that results from the spontaneous breakdown of the atomic nuclei of specific elements, which causes the emission of protons (alpha particles), electrons (beta particles), and gamma rays (short wavelength electromagnetic waves).

Wavelength = Velocity/ Frequency

The medium that radiation passes through affects its speed.

7.3 Fundamental Radiation Types

7.3.1 Alpha Particles

i. Only marginally penetrating, and halted by 80 mm of air or by thin materials.
ii. Repelled by magnetic and electric fields.
iii. Moves fairly slowly
iv. Very high ionisation
v. Have two helium ions in their nucleus.

7.3.2 Beta Particles

i. Has the ability to pierce aluminium sheeting. The energy of the particles affects the penetration strength.
ii. In magnetic and electric fields, strongly deflected.

iii. Are electrons with great velocities.

7.3.3 γ-rays

i. Depending on the radiation's energy, it can penetrate several centimetres of lead.
ii. In magnetic fields, undeflected
iii. Are protons with a very high frequency.

7.4 Radioactive Decay

This is a natural process that resulted from some kind of nuclear instability. It is a random process, meaning that the likelihood that a given nucleus would decay over a unit of time depends on both the timing of the time interval and any chemical or physical variables. Equation for decay

$$N = N_o\, e^{-\lambda t}$$

Where

N = number of nuclei present at time, t

N_o = Original number of nuclei

λ = decay constant

Activity, A = n/t

where n is the number of transformations in time, t.

The AN, decaying per unit time, is subject to statistical fluctuations that follow a Poisson distribution.

Half Life (T/2): It is the amount of time needed for half of the nuclei to decay.

7.5 Sources of Radio Active Pollution

Natural and man-made processes are the two main sources of radioactive pollution.

7.5.1 Natural Sources

The primary natural sources of radioactivity are thought to include cosmic radiation from space, naturally occurring radioisotopes found in the environment, and those found inside

the bodies of living things. The solar system's cosmic radiations are alien in origin and likely come from beyond the sun. They are made up largely of protons and a few heavy nuclei, which are incredibly energetic particles. When these cosmic particles strike the upper atmosphere's gas molecules, they intensely ionise the gases and create secondary cosmic rays, which are mostly made up of neutrons, mesons, and gamma rays. The earth eventually receives cosmic rays, which are a complicated collection of particles. Moreover, significant amounts of 3H and 14C are produced by these particles in the air.

The existence of radionuclides in the lithosphere, hydrosphere, and atmosphere is another source of natural radiation. Every element with an atomic number higher than 82 (Lead) is radioactive by nature and emits varying amounts of radiation. Uranium, Thorium, and Potassium-40 are the three radionuclides that are found in nature in the greatest abundance. Little amounts of 40K, as well as uranium and its daughters, are present in soils, minerals, and even building materials.

7.5.2 Artificial Sources

Nuclear weapon testing, the construction of nuclear power plants, the mining and processing of plutonium and thorium, and the production of radioactive isotopes are all examples of human activity that results in radioactive contamination.

1. ***Nuclear weapons***

Testing nuclear weapons includes:

a. Fissioning of uranium 235 and plutonium 239.

b. Lithium or hydrogen as fusion fuel.

Chain reactions beyond our control cause atomic explosions. These result in situations with very big neutrons that make other materials in the immediate area radioactive. Enormous clouds of tiny radioactive gases and particles are released into the atmosphere and carried by the wind to far-off locations. They gradually descend to the ground as they fall or are carried there by rain.

2. Atomic Reactors and Nuclear Fuel

Uranium, thorium, and plutonium are the most frequently employed fuel types for fission in nuclear power reactors. Before entering reactors, as well as during the mining process, uranium travels through a number of steps. When the energy has been used, the spent reactor materials

are reprocessed to recover unburned uranium, plutonium, and some other significant isotopes that can be employed in medicine or for other beneficial reasons. The term "nuclear fuel cycle" refers to the entire process, including the mining of the fuel and its ultimate disposal. Since liquid, gaseous, and solid radioactive wastes are emitted at practically every stage of the nuclear fuel cycle and have a high potential to contaminate the environment, extreme care must be taken to ensure environmental safety at the time of nuclear operations.

3. Radioactive Isotopes

Different levels of radioactive materials are present in radioactive isotopes including 125I, 14C, and 32P as well as their compounds, which are widely used in scientific research organisations. This effluent causes water pollution when it enters various water sources like rivers, streams, lakes, etc. through sewers. Radioactive phosphorus and iodine also enter the food chain through water, where they may eventually make their way to man through fish, etc.

4. Radioactive Fallout

Radioactive fallout is the term for the radioactive dust that results from atomic explosions. Depending on the type of bomb that detonated, different radioactive fallout exists. Iodine 131 and phosphorous 32 are two radioactive elements with extremely limited half-life. As a result, they decompose quickly and are blocked from entering plant metabolic pathways. However, some radioactive elements have extraordinarily long half-lives, or very slow rates of disintegration. Strontium-90 and Cesium-137, for instance, have even longer half-life than calcium-45, which has a half-life of 160 days. Likewise, the most harmful isotopes for humans and other vertebrates are those with longer half-lives.

5. Other Sources

Many medical procedures involve the introduction of differing levels of radiation into the body. For example, X-rays are frequently used to diagnose skeletal problems, and radiation therapy for cancer patients frequently involves radium and other isotope radiations.

Dental X-rays, which can run at a voltage of roughly 10 KV, emit more penetrating radiation and may be more dangerous if not adequately insulated. X-rays are a common type of ionising radiation and are produced by radiography equipment, X-ray therapy equipment, and other devices.

Over 240 million dental and medical X-rays are taken each year, and 15 million tests employing radioactive materials as tracers in the human body are also conducted, according to reports.

7.5.3 Man's Exposure to Radiations

Ionizing radiation exposure to humans comes from the following sources:

Industrial Applications: Some examples of this source include the luminous dials found on watches and other instruments, the sterilisation of food and medications, radiography of metallic objects, X-ray fluoroscopy, X-ray crystallography, and spectroscopic examinations.

Medical Applications: This source of radiation consists of tracers, internal therapeutic agents, and external therapeutic techniques that are used in the body to study the behaviour of particular elements, determine the selective absorption of particular elements by specific tissues, and find the location of tumours and other diseases, respectively.

Civil Exposure: Man is slightly exposed to radiation through cosmic rays, nuclear reactor accidents, X-rays produced by televisions, and fallout from nuclear weapon testing, all of which have been previously covered.

Mode of Action of Radiations

The primary result of radiations entering the body is the formation of ions, which is followed by changes to the chemical makeup of enzyme systems. Damage is more noticeable in cells that are going through mitosis. Moreover, chromosome damage can lead to genetic disorders and cancer. Radiation can seriously harm the developing foetus. As previously indicated, the risk is larger for radioactive elements with lengthy half-life, and it is lower for those with short half-life that are removed more quickly.

7.6 Radioactive Pollution's Effects

The impacts of radioactive pollutants depend on i) the ability to release energy, (ii) the radioactive elements' half-lives, (iii) the rate of diffusion, and (iv) the rate of contamination deposition. Atmospheric and climatic conditions, such as temperature, rainfall, and wind, also have an impact on their impacts.

7.6.1 Damages to a Biological System

The majority of the harm done by radioactive contaminants is due to their ability to emit extremely destructive high-energy radiations to living systems. A biological system may be endangered by radioactive pollution in one of two ways.

i. Radiation damage from an external source.
ii. Radiation damage brought on by internal body sources.

Damages brought on by radiation at various levels

1. Molecular level damage: Ionization cross-linkages within and between two impacted molecules cause harm to macromolecules like enzymes, DNA, RNA, and other types of molecules.
2. Damages at the subcellular level: mitochondrial dysfunction, chromosomal fragmentation, cell membrane damage, etc.
3. Damages at the cellular level: It include the prevention of cell division, as well as cell death, ageing, and malignancy.
4. Tissue and Organ Injury: disruption of various systems, including the central nervous system, blindness, inactivation of bone marrow function leading to blood cancer and intestinal ulcers.
5. Damages to the individual and population as a whole: Radiation-induced death or life-shortening mutations might alter a person's features. Radiation exposure in humans initially has little consequences that are observable. However, damage symptoms only become apparent after 12 to 24 hours. This includes skin reddening, anaemia, anorexia, vomiting, and diarrhoea, as well as blister formation, skin pigmentation, burning sensations throughout the body, loss of vision, etc. with excessive doses. It should be mentioned that there is no known remedy for any of these. A person must deal with the effects of radiation exposure once it has occurred. Ineffective medical assistance.

Moreover, delayed effects have been noted. Some results don't manifest for many months or even years. Which are:

(i) Leukemia and malignant tumours. (ii) Skin infections, dermatitis, ulcers, and burns, (iii) Gangrene sickness, (iv) Leucopaenia in the lymphatic system, (v) Depressed bone marrow, causing granulocytosis, aplastic anaemia, and thromocytopaenia. (vi) Blood vessels: Oedema of the vessel wall and surrounding tissues, increased permeability, and haemorrhages, (vii) cataract in the eyes, (viii) Gonads-Sterility in both sexes, (ix) Osteosarcoma and bone necrosis, (x) Genetic effects: Inability to conceive, stillbirths, congenital malformations, epilepsy, mental problems, neuromuscular, haematological, and endocrine system disorders.

Though innocuous, therapeutic radiation exposure to humans can occasionally cause radiation sickness, which is characterised by nausea, loss of appetite, a moderate temperature, and a general feeling of malaise. There is practically any safe dose, and even a small increase

in background radiation can lead to leukaemia and cancer. Moreover, it causes mutations. The harmful genes can survive in humans, animals, and plants and eventually impact their offspring. The protoplasm is damaged by ionising radiations including alpha, beta, neutron, and gamma rays, which also replace some elements like calcium, carbon, and zinc when their quantity in the protoplasm rises.

7.6.2 Radiation effects and their key characteristics

As ionising radiation penetrates living tissues, wreak havoc on the atoms and molecules in its route, making man the final victim of radiation attempts and the end of all reactions and interactions.

(1) Man's exposure to ionising radiation, (ii) Microwave radiation effects, iii) Consequences of radioactive fallout, (iv) X-ray effects, (v) Non-ionizing radiation effects, (vi) Radiofrequency radiation effects, (vii) Radiation's biological effects, (viii) Plant effects of radiation, ix) Effects of plutonium as a carcinogen, item, x) Nuclear radiation's effects on polymers, (xi) Nuclear threat, power plant danger, and reactor danger

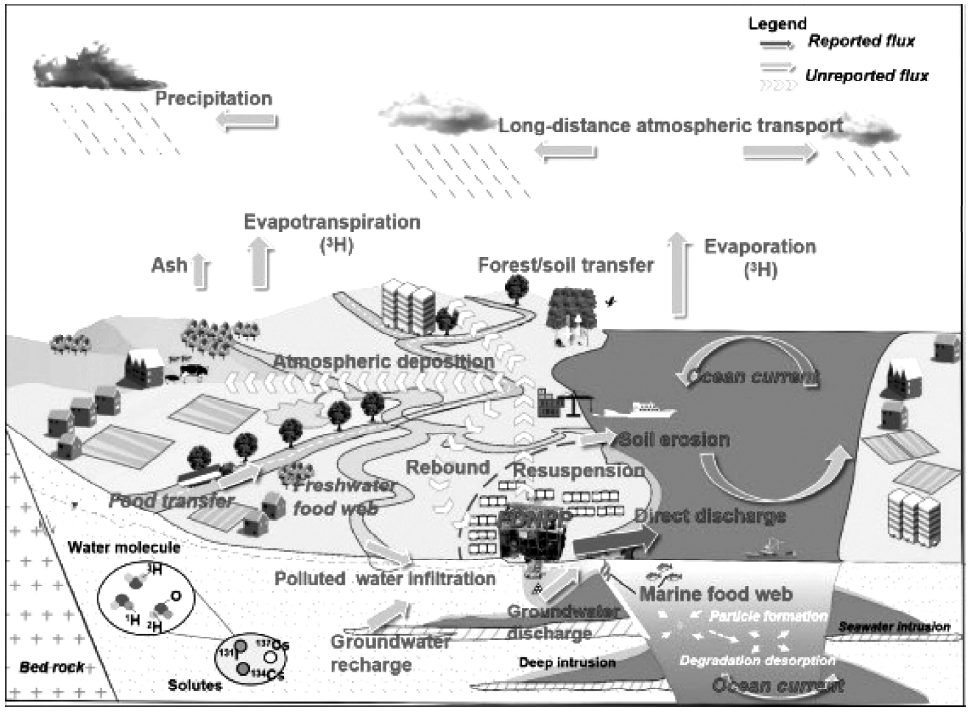

Figure 7.1 : Impacts of radiation pollution
[Source : doi.org/10.1016/j.geosus.2021.04.002]

7.7 Control of Radioactive Pollution

It might not be able to control natural radioactive pollution. Only artificial radioactivity-out of all the sources—is subject to intervention, whenever controls are imaginable. The following safety precautions can be strictly enforced to reduce radioactive pollution.

All wastes, whether they are low level or high level, have a great potential to harm the ecosystem. Low level wastes cannot be contained since they are frequently created in significant amounts. They go through a visual process to remove the radioactive, and then they are released normally in water or on land. High level wastes, on the other hand, must be concentrated, contained, and kept away from the area where people live. They cannot be dumped into the environment at will.

Typically, the radioactive wastes that cause water pollution are in a liquid or solid state. These varied waste types provide a variety of issues since disposal methods safe for one type of waste may be harmful for another. All methods, however, are aimed at preventing radioactive waste components from harming living things, particularly humans.

Treatment of Solid Radioactive Wastes

Reducing their volume is the goal of the treatment of radioactive solid waste. Incineration, compacting, and fragmentation are the three basic techniques for treating radioactive solid waste. Before burning, materials should be properly sorted to remove anything that could produce explosive or hazardous fumes, as well as non-combustible things. A press can be used to compress some types of solid waste. The garbage is placed into single-use containers for disposal after compaction.

Radioactive waste disposal alternatives

The disposal of this garbage in space, ice sheets, a very deep hole of three to five kilometres where the rock is still heated, and a deep ocean floor beneath the sediments are the significant choices. Some technologies are, however, no longer used or put on hold for potential future use, either because they are very expensive, provide a larger risk to the environment, or need more technical expertise than is currently available.

In summary, following measure can be adopted to stop radioactive pollution, including:

i. Atomic reactor leakages need to be monitored and regulated on a regular basis.
ii. Radioactive fuels, fission products, and radioactive isotopes shall never again be handled, transported, or used in any way without proper safety precautions.

iii. The safety precautions must to be strictly and completely implemented. For instance, no safety measures are required if the radiation level is less than 5 millicuries. Therefore, in order to prevent contamination, doctors must wear strong rubber gloves, plastic aprons, plastic shoe covers, and spectacles if the body contains radioactive material between 5 and 30 millicuries.

iv. Before sending contaminated clothing to the laundromat, it should be carefully cleaned with soap and water and stored for proper radioactive material decay.

v. The radioactive waste must be disposed of in a secure manner. In dangerous situations, regular monitoring must be provided through frequent sample and quantity analysis.

vi. Preventative measures must be used to ensure that background radiation levels do not exceed allowable levels.

vii. Safety precautions should be put in place and reinforced to prevent accidents. Moreover, measures against occupational exposure must be adopted that are appropriate.

viii. Very low radiation radioactive wastes should be disposed of in sewage systems.

7.8 Summary

The introduction or build-up of radioactive materials into an area when its presence is unintentional or the quantities of radiation are unwanted is known as radioactive contamination. Radionuclides are the principal sources of pollution; they release beta particles and gamma rays, radioactive compounds. Radioactive pollution of water, water supplies, and air space is the outcome of radioactive fallout from the clouds of a nuclear explosion. Due to the ionising radiation, it emits, this kind of pollution is dangerous to human health. Accordingly, with a focus on remedial measure, the principles of radioactive pollution and different aspects of radiation pollution namely sources, diversity of pollutants and their adverse impacts as well as control measures have been discussed thoroughly in this unit.

7.9 Self-Assessment questions

1. What is Radiation Pollution? What are its effects on biological system?
2. What are the types of radiation?
3. Write a note on sources of radiation pollution.
3. Describe the control measures of radiation pollution.

7.10 Suggested Readings

1. G. N. Pandey, "Environmental Management" Vikas Publishing House, Pvt, Ltd, 1997, New Delhi.
2. P.K. Goel, "Water Pollution Effects and Control" New Age International (P) Limited; Publishers, New Delhi, 1997.
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