Air Pollution and Prevention

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AIR POLLUTION

AND PREVENTION

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1. A Descriptive Study of Air Pollution in India

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Abstract:

India is the world's second most polluted country. Air pollution shortens the average life expectancy of Indian by 5 years. Air pollution in India is a major environmental issue. The fast growth in motor vehicle and industrialization have contributed to the high levels of air pollution in urban areas. The present chapter aims to discuss different aspects of air pollution and its control measures in India. Air pollution has become a serious problem that threat in the recent years posing serious risks to environment and social wellbeing. In India, the policy action to address air pollution is urgently needed. Due to the presence of different sources of pollutants, the problems of air pollution as well as solutions become complex.

Keywords: *Air pollution, Life expectancy, Environmental issue, Industrialization, Pollutants.*

1.1 Introduction:

Air pollution has become a serious problem in many parts of the world. India is no exception and dealing with the critical issue of air pollution, particularly in its urban areas. Rising urbanization, growing industrialization and anthropogenic activities are the main reasons that lead to air pollution. It is expected that by 2030, almost 50% of the global population will be inhabiting in urban areas and more than 80% of the urban population is exposed to emissions which exceeds the standards set by World Health Organisation. At present, air pollution is widely known and affects over human health, ecology, agriculture, and climate. In case of health, common issues are related to respiratory, cardiopulmonary, cardiovascular and reproductive systems. In India, air pollution became the second leading risk factor in health after child and maternal malnutrition. This risk factor encircles the both outdoor and indoor air pollution. The common sources for outdoor air pollution are emissions caused by combustion from fuel burnings, motor vehicles and industry. The indoor air pollution caused due to household products, smoke, pesticides, molds, pet dander etc.

1.1.1 Objectives:

- To study the causes of air pollution in India.
- To analyse the scenario of air quality during lockdown in COVID-19 pandemic.
- To study the various preventive measures of air pollution.

1.2 Methodology:

The information presented in this chapter are collected from secondary sources such as books, research papers, jounals and websites.

1.2.1 Current Scenario of Air Pollution in India:

The State of Global Air Report 2022, shows that India is mostly affected by air pollution among other countries in the world. The report estimates that Delhi as the most polluted city, Kalkata taking the next position after Delhi and Mumbai stands 14th on levels of particulate matter, which is the important measure of air pollution. Again the World Air Quality Index 2022 has included the three cities and number of smaller cities namely Kanpur and Rohtak, among the most polluted places in the world. In case of India, air pollution hardly receive attention. People are not completely aware about the dangers of inhaling polluted air and the governments are lax in order to take measure to prevent air pollution. The sources of air pollution are used to fossil fuels, vehicular emissions, industries, factories, dust from construction etc. The National Cleans Air Program aimed to reduce the levels of particulate matter by 20-30% in

132 cities by 2024 was launched in 2019.Air pollution creates serious health and economic consequences. According to WHO, air pollution as the world's largest health risks and accounts for one in eight deaths worldwide. And the economic costs are also high, particularly in developing countries. In this respect, India is the worst place. India's Air Quality Index (AQI) and Real-time levels are shown in the below figure.

Table 1.1: India-States Air Pollution Level

States	Status	Aqi(Us)	Pm 2.5	Pm 10	Temp	Humid
Andhra Pradesh	POOR	110	39	80	27	70
Arunachal Pradesh	MODERATE	59	16	30	23	56
Assam	POOR	131	59	94	24	70
Bihar	UNHEALTHY	286	223	320	22	48
Chandigarh	POOR	150	69	125	18	46
Chattisgarh	POOR	114	38	127	23	43
Dadra And Nagar Haveli	UNHEALTHY	310	260	283	25	38
Daman And Diu	POOR	226	176	203	25	36
Delhi	UNHEALTHY	248	197	295	17	68
Goa	POOR	166	84	125	28	56
Gujarat	POOR	155	87	125	22	49
Haryana	UNHEALTHY	228	169	219	18	56
Himachal Pradesh	MODERATE	105	43	67	15	31
Jammu And Kashmir	MODERATE	69	22	34	11	36

States	Status	Aqi(Us)	Pm 2.5	Pm 10	Temp	Humid
Jharkhand	POOR	155	45	225	20	58
Karnataka	POOR	102	36	41	23	81
Kerala	POOR	138	58	137	28	73
Madhya Pradesh	POOR	154	78	149	20	45
Maharashtra	POOR	153	75	147	24	50
Manipur	MODERATE	64	19	33	24	65
Meghalaya	MODERATE	63	18	24	20	36
Mizoram	GOOD	19	03	16	28	60
Nagaland	MODERATE	40	10	23	22	45
Odisha	POOR	143	55	131	24	64
Puducherry	POOR	126	46	78	28	76
Punjab	POOR	152	69	142	19	35
Rajasthan	POOR	154	77	143	21	33
Sikkim	MODERATE	98	34	41	13	46
Tamil Nadu	POOR	91	31	59	27	79
Telangana	POOR	133	60	89	25	72
Tripura	POOR	170	92	125	25	71
Uttar Pradesh	POOR	179	104	186	20	36
Uttarakhand	POOR	140	61	104	19	39
West Bengal	POOR	179	114	205	24	52

1.2.2 Sources of Air Pollution:

Air pollutants arise from both natural process (volcanic activities, forests, oceans etc.) and human activities (transportation, fossil fuel combustion etc.). The sources of air pollution are –

a. Transport emissions: The vehicle pollution is the major contributor to air pollution in every city, but this is worse in urban areas, where car ownership rates are more than compared to rural areas. When car burns gasoline, then it emits pollutants in the air which is harmful for the environment, vehicle emits carbon monoxide, nitrogen oxide, hydrocarbons and particular matter (PM 2.5 and PM 10). In urban areas, road traffic emissions are the prime contributions to the air pollution.

b. Industrial Emission: India has witnessed large-scale industrialization from the last few decades. Industrialization has deteriorated the air quality in urban cities. These activities emit several pollutants which affect the air quality. Particulate matter 2.5 and 10, Sulphur dioxide, Nitrogen dioxide, carbon monoxide are the main pollutants emitted from the industries that use coal and wood as the energy sources for production process. The Central Pollution Control Board categorized the polluting industries into 17 types and these are fall under the small and medium scale.

Seven industries are categorized as "critical" industries which include iron and steel, paper, sugar, fertilizer, cement, aluminium and copper.

c. **Agriculture:** Agricultural activities produce emissions which create a serious impact on decreasing air quality. To begin with, ammonia and nitrous oxide are the main pollutants that are released from agricultural activities. Now a days, fertilizers and pesticides are mixed with new invasive species for the purpose of quick growth of vegetation, but these species are not found in nature. Other sources are methane emissions from the enteric fermentation process, nitrogen emissions from agricultural soils and emissions of methane from wetlands. Agricultural procedures such as 'slash and burn' are the prime reasons for photochemical smog.
d. **Domestic sector:** Domestic sector is also responsible to pollute air. When family's burn fuels such as wood, dung, kerosene, agricultural waste in their homes then various types of pollutants are generated. Household air pollution was considered as a responsible factor for an estimated 3.2, million deaths per year in 2020.The combined effects of household and ambient air pollution is related with 6.7 million premature deaths annually. In poorly ventilated households, Indoor smoke have fine particles 100 times higher than acceptable.
e. **Construction and Demolition Waste:** Another key source of air pollution is waste which is the outcome of construction and demolition. Construction and demolition wasted is created from construction, repair, renovation and demolition of houses, building structures, bridges, roads and dams. Construction and Demolition waste is serious because it contains hazardous materials namely asbestos and lead. Now a days, application of green technologies and green infrastructure during construction could tackle the issue of waste and maintain clean air quality.

1.2.3 Impacts of Air Pollution from Various Perspectives:

a. On the ecosystem: The terrestrial ecosystem is extensively affected by ground air pollution. The bad effects include respiratory and pulmonary disorders for animals and humans. The effects on the marine ecosystem include eutrophication, acidification of lakes and mercury accumulation in aquatic food.

These processes indirectly affect the living organism. And due to soil acidification, long term pollutant accumulation exists in the environment. Soil pollution affects the ecosystem of plants and animals which are susceptible on soil for nutritional absorption. Air pollution can create damages to crops and trees in various ways. Ground level ozone can reduce agricultural crop and forest yields, reduce growth and survivability of trees. Air pollutants reduce the ability of ecosystem to perform functions in a well manner.

b. On biodiversity: The ill-effects of air pollution could impact on the biological diversity. Acid rain, which is caused by oxidation and deposition of NO_2 and SO_2 emissions in the atmosphere. Therefore, acid rain as a result of air pollution can create harmful effects on the biodiversity. Another pollutant is ozone which can be considered as toxic for the both plants and animals. Due to ozone, the growth of plants become slower and reduced photosynthesis. In case of humans and animals, ozone can affects lung tissues causing respiratory diseases, such as asthma. Moreover, the reproductive process of animals also affected due to increasing oxidative stress.

c. On Human Health: People inhabiting areas exposed to high pollution level and poor air quality prone to dangerous health risks. Such deleterious implications lead to both the respiratory diseases and fatal diseases. Various studies showed that emissions namely particulate matter, ozone, NO_2 and SO_2 have the potential to damage of the cardiovascular and respiratory disorders of humans.

In urban areas, health risk arises in terms of mortality and morbidity due to poor air quality. Exposure to severe of air pollution can causes heart disease and lung cancer. The particulate matter can cause nasal irritation and other disturbances. The risk of death increases with the long term exposure to polluted air.

d. On Materials and Buildings: SO_2 and NO_2 emissions harm the material surfaces and buildings. The negative effects are in the form of loss of material, discoloration, structural failing and soiling. Air pollution can decrease the services of buildings and severely damage the historical monuments. For instance, India's white marble Taj Mahal, which become yellow as a result of exposed to SO_2 emission from factories and acid rain. Another example is Hyderabad's Charminar, is turning black because of highly polluted air.

1.2.4 A Review of COVID-19: Impact of Lockdown on Air Pollution in India:

The COVID-19 pandemic has created an innumerable crisis in the whole world socially, economically as well as environmentally. This crisis causes a huge loss to human life, but made significant improvements in environment as Air Quality Index has reduced to 49% in India. To curtail the virus transmissions, lockdowns have been implemented. These lockdowns had positive impact on the air quality due to reduction in vehicle movement. The key factors contributing to air pollution are transport, industries, constructions, power plants, road dust, restaurants, landfills fires etc. As a result of travel restrictions and prohibition of non-essential activities which are the causes of air pollution, the quality of air has been improved. On 24th March, 2020 India has declared lockdown 1 i.e. 21 days amid the COVID-19 pandemic, it is the largest lockdown in world. During that lockdown, people were at their houses, constructions and factories were stopped, traffic has decreed drastically and all these factors lead to significant reduction in air pollution

a. **Prevention of Air Pollution:** We have seen that the adverse effects of air pollution on environment and its causes. Now, it is time to discuss the preventive measures of air pollution. Air pollution can be decreased only if there is a collective support from everyone's side. The different ways which are helpful to air pollution are discussed below.
b. **Use of Public Transport:** The burning of fossil fuel is the major cause of air pollution. If most people use the public transport, then the number of vehicles decrease and thereby reduce the burning of fossil fuels. The less burning of fossil fuels leads to lessee's amount of greenhouse gases
c. **Recycling and Reuse of Products:** Some of the products that are thrown away after use could be recycled and reused for clean environment.
d. **Reduce The Consumption of Electricity:** We can reduce the consumption of electricity in homes by switching off the lights and other appliances when not in use. Here, reduce electricity leads to enhance air quality.

e. Avoid Plastic bags: Plastic bags are become a curse to the environment. Because, plastic bags are not recyclable and reused and it takes a longtime to decompose. Also the burning of plastic bags releases poisonous gases to the air. There by, plastic bags should be replaced by paper bag which are decompose easily.

f. Avoid Use of Air Conditioners and Fans: The heat released by the air conditioner causes global warming. The Freon gas i.e. used as a refrigerant cause's degradation of ozone layers.

g. Planting More Trees: Trees absorb toxic chemicals through their stomata and filtering these chemicals from air. Plants also mitigate the greenhouse gas by trapping heat and it reduces the ground-level ozone.

1.3 Conclusion:

Air pollution is a severe problem that affects the lives of billions people every year. According to World Health Organization report, more that 26% of deaths in the world directly link to the pollution. Air pollution is considered as a health threat particularly in developing countries. The type and level of pollutants vary in different urban and rural areas. Rapid and unplanned urbanization and industrialization has resulted degradation of India's air quality. With technological advantages people are enjoying the comfort and luxury appliances but overlooking the necessary evil i.e. air pollution. As India has the second largest manufacturing industry, cement industry which is one of the main contributions of particulate matter. Long-term health effects related to air pollution are health disease, respiratory disease, lung cancer etc. Air pollution also causes damages to people's nerves, kidney, liver, brain and other organs. Therefore, necessary steps should be taken in order to prevent air pollution such as save energy, minimize air pollution from cars, maintain wood stove, recycle and reuse the products, plant trees etc.

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2. Air Pollution in Guwahati City- An Analytical Study

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Abstract:

Environmental Pollution is a curse towards the existence and survival of human beings. The present century has seen the emergence of various types of environmental pollution. Out of which Air Pollution is regarded as one of the major pollutions. It is necessary to invoke into the sources, effects and remedial measures to curb the air pollutions in cities and towns. The present topic delves into the searching of the root causes, effects of air pollution in Guwahati city. The applicable initiatives to minimize the air pollution in the city of Guwahati has been also suggested. From an environmentalist point of view, study on the air pollution is significant for the people of twenty first century.

Keywords: *Pollution, Man-made source, radioactive substance, Global warming, Sustainable environment.*

2.1 Introduction:

Rapid population growth, advancement in Science and Technology giving birth to various commodities, growing industrialization have created an unhygienic and unscientific situations all over the world.

Environmental Pollution is the term arising out along with the advancement and progress of human society in the pathway of civilization. Out of the various types of pollution, Air Pollution has identified itself as a remarkable havoc in cities, towns and also in some rural areas. The air we breathe is not pure at present.

This has augmented towards the human diseases and also affected the flora and fauna surrounding us. The 21st century has seen the massive aggravation of the quality of atmosphere because of the degrading nature of emitted pollutants in air.

Air pollution, by nature is an atmospheric condition in which certain substances, elements, components cause undesirable effects on man and environment. Such substances include toxic gases, particulate matter, heavy metals, radioactive substances etc. The city of Guwahati is also suffering from air pollution problem along with the progress and way of growth and development. This Book Chapter focuses and reflects the sources, effects of air pollution and the recommendable mitigation measures of air pollution in Guwahati city.

2.1.1 Study Area:

Guwahati city is the capital city of the state of Assam, India. Guwahati is the Gateway of North-Eastern India and also the commercial, business hub of this territory. Various environmental pollutions have crippled the life-style of the citizens of the city many a times. Out of that, air pollution is also one of the notable type of pollutions affecting the city. The emitted gases, particulate matters etc. are elevating the nuisance of air pollution in many parts of this metropolitan region of India.

2.2 Sources of Air Pollution:

The sources of air pollution in Guwahati city are both natural and man-made (anthropogenic). Man-made air pollution is found to be severe in comparison to the natural sources in this region. The natural sources of air pollution in Guwahati city are- Sand, Dust, biological decay, forest fire, pollen grains of flowers, spores, radio-active materials etc. The Man-made air pollution sources count within it the industrial units, vehicular or automobile exhausts, fossil fuel burning, construction activities, power plants, indoor activities including household emissions etc.

The metallurgical plants, fertilizer plants, textile mills, oil refinery, chemical industries in this sector are found to be emitting polluted gases in the environment. Vehicular emissions is another major source of air pollution in Guwahati. Automobiles release gases such as carbon monoxide, carbon dioxide, lead, oxides of nitrogen, hydrocarbon, Sulphur dioxide, suspended particulate matter (SPM). Burning of fossil fuels emits smokes, carbon particles, aerosol, dust, sulphate, nitrogenous oxides, halogens, radioactive materials etc. Construction activities using the bricks, sand, and cement emit polluted radon gas. The disposed solid wastes and effluents in the drains of the city are arising the hydrogen sulphide (H_2S) gas during the decomposition process. On mixing with water vapour and atmospheric oxygen, this has also forwarded an alarming invitation to the probable acid rain. The emission of radioactive materials from industries, laboratories, medical diagnostic centers have created a threat to the public. The agricultural activities in some parts/land area (basically hilly region) of the city are emitting organic phosphate, chlorinated hydrocarbon, arsenic, lead in the atmosphere. Burning of coal, extensive use of gas cylinders, kerosene etc. are identified as indoor air pollutants in Guwahati city. On occasional case, during the time of Diwali and other festivals, the air pollution is found to be more due to the bursting of crackers. Smoking Cigarettes, Bidis etc. on the public places by the people are also causing air pollution trespassing into the city life.

2.3 Effects of Air Pollution:

The various dimensions that come into account with respect to exerted and possible air pollution in Guwahati city are as follows:

(A) Effects on human health:

- Years of exposure to air pollutants affect natural defenses and can result in lung cancer, asthma, chronic bronchitis, emphysema.

- Sulphur dioxide causes constriction of respiratory passage and can arise bronchitis like conditions.
- Suspended particulate matters and fly ash present in the Guwahati city can lead to the damage of the lung tissues and cancer causing toxic pollutant can enter into the human body.
- Carbon monoxide can result in fatigue, reduction in oxygen transportation in blood. Carbon dioxide and hydrocarbons can inhibit heart functioning.
- Exposure to lead can hamper the formation of hemoglobin, brain functioning whereas aldehydes emitted from various air pollution sources can affect the intestine and respiratory tract.
- Radioactive substances can create body deformation in the newly born child and can infuse carcinogenic materials in adults.

(B) Effects on other animals: The polluted gases on mixing with the water sources of the city can enhance the acidity of water. As a result, the aquatic flora and fauna are being affected. Fluorosis can result on inhalation of fluorine gas emitted from factories, industries.

(C) Plant life is also being adversely affected due to exposure of various air pollutants.

(D) Industrial activities emitting carbon monoxide, carbon dioxide, ozone, hydrocarbon, nitrous oxide etc. acting as greenhouse gases have erected the effect of climate change and global warming influence. The city of Guwahati is also suffering from unusual warm like atmospheric trend from the last 10 years.

(E) The walls, metallic surfaces, statues, monuments of Guwahati city are also found to be dusty because of the exposure to air pollutants like fly ash, dust, particulate matter which is declining the aesthetic beauty and hidden values.

2.4 Control of Air Pollution:

The remedial measures that can be adopted for mitigating the air pollution problem in Guwahati city are suggested below:

a. The lead free petrol and use of catalytic converter in vehicles can reduce the accumulation of pollutant gases.
b. Suspended particulate matter acting as air pollutant can be removed by electrostatic precipitator, cyclone separators, bag-house filters, scrubbers etc.
c. Encouragement for adoption of non-conventional and renewable energy sources for human activities.
d. Using low Sulphur coal in industries.
e. Smoke emitting chimneys in brick manufacturing industries must be taller so that smokes can't enter easily to human body.
f. Technology promoting less emission of air pollutants must be promoted.
g. Plantation of trees must be intensified.
h. Proper Environmental Impact Assessment studies for the industries of the city by Pollution Control Board and environmental agencies must be highly executed.
i. Smoking in public places in Guwahati must be banned effectively.

j. Public awareness regarding air pollution through mass communication media must be conducted regularly.

Although the air pollution has emerged out as a havoc even in New Delhi, the capital city of India, the problem can be diminished up to appreciable extent through suitable steps. In Guwahati city, air pollution causing disruptive effect has also become a matter of significance for survival and sustainable development of the city life. Appropriate planning and implementation of Air Pollution Control rules and regulations can play the role of catalyst for tackling the air pollution menace in the city of Guwahati.

2.5 Conclusion:

Air pollution is one of the major environmental pollutions in the present period of time especially in cities and towns. In order to maintain a sustainable environment with an objective of protecting our mother earth, air pollution must be prevented. Otherwise, human ailments, global warming, climate change, destruction of sculptures, buildings, monuments will always remain accompanied along with the pace of human civilization. Air pollution and Prevention must be checked, monitored, diagnosed and must be a matter of constant discussion amongst academicians, environmentalists, nature conservation agencies and the Government authorities.

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3. Stratospheric Ozone- Reasons for Depletion and Remedies

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Ozone is an inorganic molecule having one more oxygen than O_2 (dioxygen) and having chemical formula O_3. The name ozone is given to this by scientist as its smell, in Greek 'ozein' means smell. We know our breathing oxygen (O_2 Dioxygen) is without smell, but as it converted to trioxygen (O_3) the nature changes and it acquire a pungent smell. In such a way nomenclature for this gas was reported. Ozone is a pale blue coloured gas and has a typical pungent smell. Our nostril easily captures when concentration of ozone increases above 0.1 ppm in surrounding. Ozone a word now a day very commonly linked with our nature. As tracing back in history no one exactly knowing how it was first coming in existence on earth, because as we know ozone formed when heat and solar radiations induce chemical reaction in between oxides of nitrogen and volatile organic compounds i.e., hydrocarbons. These activities are seeming to be human impact. But in past there may be natural factors which are responsible for ozone layer existence.

3.1 Discovery of Ozone:

In 1776, the elementary nature and nomenclature of oxygen was done by Lavoisier, in 1785 Van Marum when in his experiment passed electric current through oxygen gas noted a peculiar smell and they assumed it, may be due to electrode and named as "electrical odour". The German scientist Cristian Friedrich Schonbein made this gas in his laboratory in 1839.[1] the molecular formula was determined by Soret in 1865.[2]

The UV radiation absorption property of ozone was suggested by W.N. Hartley[3] in 1880.It is natural substance and present in our atmosphere as the earth atmosphere developed.

3.1.1 Location of Ozone:

Ozone gas found in atmosphere, but stratospheric ozone is beneficial to earth and its ecosystem. This stratosphere is the second layer of earth's atmosphere and located above the troposphere. Troposphere is located up to 10 km (6.2 miles or 33,000 ft.) above the earth crust. Stratospheres locate in between 10 km to 50 km (around 35 miles or 185000 ft.). The height of stratosphere is minimum i.e., 7 km at the polar region of earth and maximum at 20km at equator.[10] In 1930 British scientist, Chapman proposed a theory and predict that ozone layer is maximum at equator and decreases toward the poles[4].

3.1.2 How Ozone Form in Stratosphere:

The interesting thing about stratosphere is that when we go upward (altitude) then the temperature rises this is exactly opposite to the troposphere where temperature declines when we move to upward. The stratospheric ozone band is a natural chemical process. The two things are most important for this conversion, O_2 and Ultraviolet radiations. In the presence of solar UV radiation, the O_2 molecule get converted to two O atoms (2O), this single oxygen reacts with normal dioxygen(O_2) and #form trioxygen molecule i.e., Ozone(O_3) Figure 3.1.

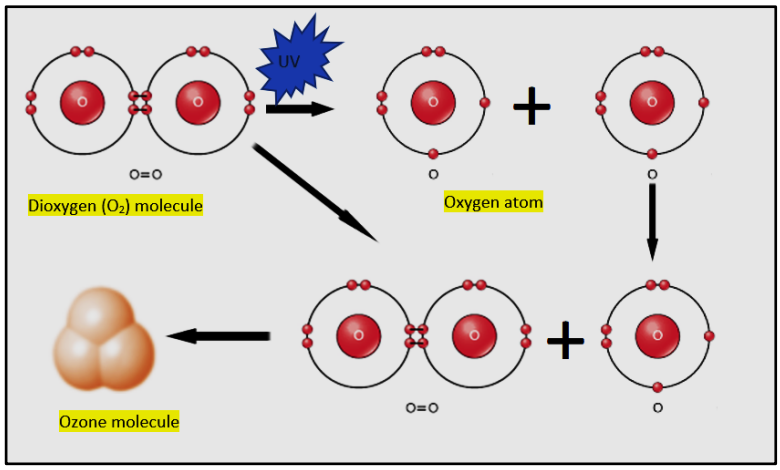

Figure 3.1: In stratosphere Dihydrogen in presence of UV radiation converted to atomic Oxygen (Highly reactive), combine with normal Dioxygen molecule form Ozone (Trioxygen).

3.1.3 How Ozone Destroyed in Stratosphere:

There are two main ways of destruction of ozone

1. Natural process of ozone destruction and
2. Pollution (Human activities)

Ozone is unstable molecule; solar UV radiations not only support the formation of ozone but it also destroys ozone and convert it back to Dioxygen (O_2).

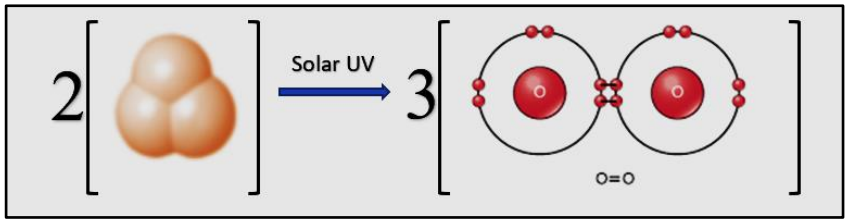

Figure 3.2: Effect of solar UV radiation in destruction of Ozone

3.1.4 Ozone Depletion:

Ozone depletion means decrease the layer of ozone surrounding earth atmosphere specifically in the stratosphere. Before 1979 scientist did not aware about depletion of atmospheric ozone concentration, but later. According to NASA.gov ozone depletion means decrease in concentration of ozone below 220 Dobson unit, this is also known as ozone hole[11].

The reason behind depletion is, the rate of formation of ozone is less than ozone destruction. Human knowingly or unknowingly uses chemicals in which halogens are single or in combine state, these halogens when move upward to the stratosphere where they react with ozone and destruct it. Two main gases chlorine and bromine are more reactive to ozone than other. These two gases are present in Chlorofluorocarbons (CFC), a gas present in refrigerator and air conditioner. Bromine is rank second and found in fire extinguishers. Other human sources from where bromine released in atmosphere are water disinfectant in swimming pool, wastewater treatment plant, industrial processes and burning of fossil fuel. According to many researchers the life span of CFC's and other Chlorine and bromine containing compounds are very short and when they release mostly destroyed in troposphere and hence play negligible role in ozone depletion.

Fluorine and iodine are again two halogens which are heavier than chlorine and bromine and very short life span hence not involved in ozone depletion in stratosphere. Other substances like methane, nitrous oxide, and water vapours together involved in ozone in stratosphere.

3.1.5 Ozone Rising is Always Useful???

No! As per definition of pollution any substance when decrease or rise from normal level then they cause adverse effect on human and its environment. Likewise, when ozone level rise above 5 ppm or higher, condition is most dangerous for survival of living organisms.

Direct contact with ozone shows a variety of health issue in human being and responsible for breathing related problems like asthma. But stratospheric ozone is good for human because it protects carcinogenic UV radiations from direct contact.

3.1.6 How to Protect Stratospheric Ozone??

By changing our lifestyle and following some strict laws helps to protect ozone layer in stratosphere.

- Avoid using HCFCs dependent cooling instruments.
- Avoid HCFCs as insulating agents
- Use aerosol propellant which do not contain HCFCs.
- Use other alternatives in ACs and Refrigerators gas.
- Follow proper maintenance and services for instruments.
- If possible, replace Bromine or chlorine with iodine or fluorine

3.1.7 CFC Alternative:

CFCs were first synthesized in 1928 by Thomas Midgley[7], Jr. of General Motors, as safer chemicals for refrigerators used in large commercial applications. Of the chemical classes for replacement of CFCs are two, Hydro chlorofluorocarbon (HCFC) and Hydro fluorocarbons (HFC). HCFC contributes to the destruction of stratospheric ozone, but much less than CFC. The use of HCFC as an infectious refrigerator will allow industries to stop the production of CFC and the continuous use of CFC will provide environmental benefits. Because of its hydrogen, HCFCS is more easily decomposed than CFC in the environment. Therefore, in addition to low global warming capacity in HCFC, ozone has a low capacity to decrease.

3.1.8 Laws to Reduce Ozone Depletion:

The United Nations Environment Protection Committee signed an international agreement in September 1979 to protect ozone depletion, September 16, 'International Ozone Day' [5, 9].

The Montreal Agreement[6] of 1959 have noticed the seriousness of the ozone depletion. As a result, the creation of CFC has decreased by 5 percent. United States “Clean air act” was enforced in 1963, 1965, 1970, 1977, 1990 rspectively.[8]

India is a responsible and conscious nation regarding the Ozone problem. India has signed a Montreal Agreement in 1992, knowing that ozone exploitation is a global problem. India has banned the production and trade of liquids that destroy ozone.

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4. The Sources, Effects and Prevention of Air-Pollution

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Abstract:

Nature is mankind's best friend, and it is interlinked with the environment. One of the chief components of the environment is air. When unwanted harmful solids, liquid particles and gases enters into the environment, and create a destructive effect on living and nonliving particles by reducing the air quality then it is called as air pollution. The substances which cause air pollution are termed as air pollutants. These can be categorized as primary and secondary pollutants. Primary pollutants are the pollutants which are emitted from a source and come in contact with the air directly.

Emissions from industries, vehicles, volcanic eruption, sand storm, dust are the primary pollutants. Carbon monoxide, nitrogen oxides, hydrocarbons, Sulphur oxides are also the examples of primary pollutants. When the primary pollutants come in to the atmosphere, physical or chemical interactions between the atmospheric components and primary pollutants takes place and produce Photochemical smog, ozone, formaldehyde like secondary pollutants, which are dangerous and injurious to the atmosphere.

Keywords: *Interlinked, environment, emissions, pollutants, destructive, atmosphere.*

4.1 Introduction:

Air pollution has been an environmental issue since the time of industrial revolution. Air pollution come to the atmosphere and makes it unsafe for all living creatures and is a threat to the natural ecosystem. Vehicles, industries, wild fires, dust are the common examples of air pollutants. According to NEERI (National Environmental Engineering and Research Institute) in India 30% of dust particles are generated from construction activities.

- **History:**

History reminds us that air pollution tragedies happened in DONORA SMOG of United States in October 1948, the GREAT SMOG OF LONDON in December 1952, and the BHOPAL GAS TRAGEDY OF INDIA in 2nd December 1984. Nuclear explosions of HIROSHIMA, NAGASAKI were the examples of radio-active air pollutions. These show that air pollution was a world-wide serious problem since early days. Technically, the World develops every day but because of pollution it is also deteriorating day by day. The WHO (World Health Organization) declared Karachi of Pakistan, New Delhi of India, China's Beijing, Lima of Peru, Cairo of Egypt as some of the most air polluted cities of the World.(1).

- **Sources of air pollution**:

World's fourth largest threatening cause for early death is air pollution. (2). During the LOCK DOWN period of COVID -19 pandemic the improvement of air quality was seen as the whole World stopped in transportations, construction activities, economic and industrial field. It became very easy to find out the sources of air pollution at that time. Sources of air pollution are sometimes natural and sometimes artificial or carelessness of human beings. Air pollution is not always seen physically.

Sometimes a pungent smell detected in the air will be an evidence of air pollution. Various industries like brick plant, oil refinery, paper industry, domestic sewage are the odour emitting major industries. Newly painted houses deliver an unpleasant odour, inhalation of this odour is not good for our health.

Odour as well as the smog of smoking cigarettes is very dangerous for the health. Planes, trains, trucks, buses, cars, motorbikes, etc. can be categorized as mobile sources of air pollutions. Automobiles or fossil fuel vehicles are the great sources of carbon-monoxide, nitrogen oxides, and among them Trucks, and Jeeps are the main polluters (Figure 4.1) Soot comes to the atmosphere as a result of burning fuel from the industries and from the automobiles. (Figure 4.2)

Another air pollutant that comes in contact to the atmosphere is through smelter and coke oven industries. Different types of insecticides, pesticides, fertilizers used in agricultural field are also the causes of air pollution. Factories and industries are the stationary sources of air pollution, have great contribution towards the air pollution by emitting carbon monoxide, smog and hydrocarbons.

Emission of smog and ash from wild fires, Sulphur and chlorine gas of volcanic eruption, dust storm can also be considered as the natural sources of air pollution. Area sources of air pollution include agricultural land, cities, etc. Nuclear tests, nuclear explosions, medical equipment's for examples CT scan machine, X-ray machine, Gamma ray producing machines have been developing modern technologies, but also have harmful effects on the environment as radioactive pollutants.

Figure 4.1 Pollution from Automobiles

Figure 4.2: Pollution from Industries and Factories

Effects: Air pollution is directly proportional to climatic change i.e. when air pollution increases climatic changes also increases, and consequently global warming arises. By increasing the temperature of the Earth, global warming melts the mountain glaciers, increases the sea and ocean level, because of which flood rate of the World shoots up every year.

The Environment Protection Act or EPA has shown in 1986, that every 1% depletion of the ozone layer would lead to a 2% rise of skin cancer. Health risk of air pollution is much more higher among the living organisms. Discomfort to the nose, eyes, throat, skin and nausea,

headache, asthma among kids are the examples of short term effects of air pollutions on human beings. Excessive amount of lead can cause brain and kidney problems among children. Air pollutant mercury has the ability to damage the nervous system. Long term diseases generated by the polluted air on human health are- heart disease, lung cancer, damages to the liver, kidney, brain, nervous system. The protective shield against injurious ultra violet radiation (or ozone layer) has been depleting due to the air pollution caused by CHLOROFLUOROCARBONS. As a result of which immune systems of human beings are decreasing gradually. Diseases like non-melanoma skin cancer (NMSC) are increasing at a rapid rate, eye related problems mainly corneal infection, issues on eye lens, breathing problems, headaches, and cardio-vascular diseases are rising.

In the plant kingdom, Ultra-violet (UV) radiation causes physical changes like undersized leaf, reduced growth, deficient seed and diseases, harming in the harvesting process. Ozone layer depletion affects the phytoplankton and krill in the Antarctic Ocean, as a result of which marine animals like fish, birds including gulls, penguins, albatross, seals, and whales also suffer by the air pollution. Bacteria, fungi like microorganisms are affected by the methane gas released from the chemical and textile industries. (3). In case of Plants, Sulphur dioxide, hydrogen chloride, ammonia, nitrogen oxide, nitrogen oxide, mercury hamper the growth of the plant and the photosynthesis phenomenon. Plastic bags are one of the most dangerous elements for the environment. They are non-biodegradable, therefore animals like cows, buffalos and sheep can easily consume this material at the time of grazing, as a result of which the internal organs of these animals get harmed by the plastic, and slowly milk production rate decreases.

Damages to the digestive systems, suffocation, and finally death have happened among the marine animals because of various types of harmful plastic materials in the oceans. (4). When Sulphur dioxide reacts with the air it initiates acid rain- the poisonous rain of the environment. The acid rain have damaged various historical monuments like the **Taj Mahal** of Agra, causing its white marble structure to turn yellow in colour. Delhi is one of the most rapidly growing cities of India and can be considered as one of the most polluted city. Here, increasing number of automobiles are the main source of air pollution. Due to the poor visibility in the air the Delhi International airport often have to cancel their domestic and international flights. (5) Recently primary schools of Delhi were closed for a few days due to the increasing quantity of air pollution. A study done by the PUNJAB POLLUTION CONTROL BOARD and INDIAN INSTITUTE OF TECHNOLOGY, Delhi (2013) proved that vehicles, industries, *tandoor* (a kind of clay oven) of nearby restaurants have led to adverse effect on the famous GOLDEN TEMPLE of Amritsar. (6). Artistic monuments for example the COLOSSEUM OF ROME, SAN MARCO BASSILLICA in Vanice, Italy are some examples of decaying due to air pollution. Air pollutants have also damaged various ancient buildings in Japan, France, Egypt, and London and in New York City.

Causes of air pollution: Deforestation is one of the primary sources for the generation of the air pollution, due to which carbon dioxide gas increases in the atmosphere. Over population directly or indirectly affects the deforestation to fulfill their needs. Building construction, government projects such as construction of roads, highways, bridges upset the ecosystem by developing lot of dust particles in the air. During the weddings and festivals like Diwali, the bursting of crackers can also lead to air pollution.

Prevention: Prevention of air pollution is a great challenge for the society. To generate the awareness amongst people against pollution issues and to create protection the 2nd December of every year is celebrated as **National Pollution Control Day,** and the **5**th June of each year is noted as **World Environment Day.** One of the most effective methods to combat the air pollution is to adopt afforestation in an aggressive manner. The 'Forest Man of India' Jadav Payeng, has been a role model in afforestation, since 1979. He has single handedly turned a barren land into a lush green forest, and his remarkable contribution to the environment should be followed by all. The satellites of NASA (National Aeronautics and Space Administration) are orbiting the Earth and monitoring the air pollution vividly. (7).

In 1987, an International treaty MONTREAL PROTOCOL was signed to restrict the ozone depletion. Combustion, absorption, adsorption, controlling particulate emissions are the latest methods of air pollution control. (8) The CLEAN AIR ACT (1970) of United States permits the U.S. Environmental Protection Agency (EPA) to safe-guard human beings by monitoring the emission of air pollutants.(9). In 1981, Air (Prevention and Control of Pollution) Act was introduced in India to control the Air pollution in the country. Air Pollution Act of 1987 was put forward for the prevention and control of air pollution.

4.2 How to Reduced Air Pollution:

From the above studies, it has been seen that plantation of trees is very necessary to decrease air pollution. It is a basic and easy step to control air pollution. In urban areas indoor plantation, rooftop gardening (Figure 4.3) are suitable. Instead of using a vehicle, riding a bicycle (Figure 4.4) is more preferable because it does not release any harmful gases. Less driving of private cars, uses of public transport, or carpooling system and battery operated vehicles can reduce the air pollution to a great extent.

Turning off the engine of cars and bikes during the traffic jam and at traffic signals should be done. In case of industry, by using low Sulphur fuel, release of Sulphur dioxide into the atmosphere can be reduced. Eco-friendly fuel like CNG (Compressed Natural Gas), bio gas etc. are preferable in industry and vehicles. Building construction, government projects should be done in a systematic and non-polluting way so that there is no air pollution. Odors in an enclosed area can be minimized by proper ventilation. In future the use of paper, jute and cloth bags will become more applicable instead of plastic bags. Green Diwali i.e. Diwali with Rangoli and lighting of lamps will become more popular in the coming days.

By following the 3 Rs- Recycle, Reduce, Reuse, the amount of air pollution can be reduced, as well as energy sources can be saved with these 3Rs. Firm rules and regulations should be followed by the industries and factories so that minimum amount of gases and chemicals are released .When low volatile coal is used in many industries in place of high volatile coal, it helps in eliminating smoke and soot in lesser amount. Development of solar energy, wind energy, geothermal energy and uses of it in the place of fossil fuel is a suggestion for the reduction of air pollution. To reduce the air pollution painting of houses, offices and buildings should be done with brush not with the spray. Power consumption of AC (Air-conditioner) is very high and it produces lot of heat and harms the environment. This can be decreased by substituting the AC with fan for cooling purpose.

Figure 4.3: Rooftop Gardening in Urban Areas

Figure 4.4: Air Pollution can be Reduced by the Above Ways

4.3 Conclusion:

When human beings become aware about the causes and sources of air pollution, a beautiful and green World will become a reality. Awareness programs are the stepping stones for it. Workshops, seminars, rally like programs, different types of write-ups, posters making, and various types of essay competitions among the students will be helpful in this regard. Proper use of sunscreen lotion is a good protector against the harmful ultra violet radiation. By increasing the physical fitness, immune system human beings are able to overcome the various diseases caused by air pollution. To protect ourselves from radio-active pollution, measures such as keeping distance from the sources of radiation, monitoring of that particular area regularly, and proper protective equipment kits are necessary. By investigating the sources of air pollution researcher and scientist can improve the air quality easily.

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5. Modernization of Rice Cultivation in Assam and Its Impact on Air Pollution

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Abstract:

Rice cultivation is an integral part of the life of every Assamese farming family .Since ancient times, a major portion of rural Assamese people has been relying on rice cultivation for their economic status. Traditional hand tools like Nangol, Juoli, Moi, Lahoni, Ukhon, Mukhora etc. are easily available in every Assamese house. But the picture is not remaining the same. Rapid modernization of agriculture is putting an impact on these things. All these traditional hand tools are being replaced by tractors; threshing machines etc. The modernization of rice cultivation has also had an impact on pollution. The present study aims to evaluate the effect of the modern agricultural practices on air pollution in rural areas of Assam. For this purpose, several secondary data available on internet, news articles were analysed.

Keywords: *Rice cultivation, Modernization of Agriculture, Air pollution, Air quality index, Assam.*

5.1 Introduction:

Assam is traditionally a rice growing area. Rice plays a pivotal role in the socio-cultural life of the people of the state [1]. While most other states in India are gradually moving away from their traditional agriculture-based economy toward industry or service oriented economy, Assam is a state in Northeast India, still heavily dependent on the agricultural sector. The agriculture sector in India specifically Assam utilizes manual power. In traditional. Agriculture, hand tools play an important role. Farm workers in Assam utilized hand and animal-drawn equipment's to carry out their agricultural practises [2]. Modernisation of agriculture is a process of transforming agriculture from traditional labour-based agriculture to technology-based agriculture [3]. During last decade, the agricultural practices are gradually modernizing in Assamese rural areas. Ploughing paddy field with nangol, threshing crops using bare feet or animal etc. are being replaced by the use of tractors, threshing machine etc. The modernisation process and technological change are regarded as the driving force behind economic growth [4]. But we can't ignore the fact that these machine operated agriculture tools are becoming the sources of increasing air pollution. Therefore, this present study will analyse the present air pollution scenario of Assam, the modernization of agriculture sector specifically rice cultivation and its impacts on Air pollution.

5.1.1 Objectives:

The objectives of this study are:

a. To investigate the current scenario of air pollution in Assam.
b. Impact of modern agriculture practice on Air pollution.

5.1.2 Methodology:

Secondary data was gathered from different published research papers, government websites, published article in newspapers etc.

5.2 Current Scenario of Air Pollution in Assam:

Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere. Household combustion devices, motor vehicles, industrial facilities and forest fires are common sources of air pollution. Pollutants of major public health concern include particulate matter, carbon monoxide, ozone, nitrogen dioxide and sulphur dioxide. Sources of air pollution are multiple and context specific. The major outdoor pollution sources include residential energy for cooking and heating, vehicles, power generation, agriculture/waste incineration, and industry Policies and investments that support sustainable land use, cleaner household energy and transport, energy-efficient housing, power generation, industry, and better municipal waste management can effectively reduce key sources of ambient air pollution [5]. Assam is the one of the States of seven sisters including Sikkim of north eastern India, which was almost an environmental friendly region with large number of green trees. But, at present with the growth of industry, number of vehicles, population of human, and the concentration of various pollutants in the atmosphere has increased [6]. A Delhi –based Centre of Science and Environment (CSE) recently warned that the problem of air pollution is growing steadily in Assam and also in other northern eastern states, posing a threat to the concept of pristine blue skies and clean air in this region .The high level of air pollution resulting from massive motorization, traffic congestion, and use of solid fuel is causing a public health crisis in the hilly terrains and valleys of the northeaster states. But, at present with the growth of industry, number of vehicles, population of human, the concentration of various pollutants in the atmosphere has increased[7].The air quality index (AQI) is one of the significant paraphernalia accessible for investigating and representing air quality status consistently [8]. According to a data retrieved on 12.12.2022 at 8.00 pm, Air quality index in Assam was 178. Concentration of PM2.5, PM10, So_2, CO, Ozone and No_2 were 108 $\mu g/m^3$, 201 $\mu g/m^3$, 9 $\mu g/m^3$, 1014 $\mu g/m^3$, 4 $\mu g/m^3$ and 4 $\mu g/m^3$ respectively. Guwahati, Assam ranked 92 among the world's most polluted hundred countries [9].

5.3 Impact of Modern Agriculture Practice on Air Pollution in Assam:

Over the last decade the scenario of Assam's rice cultivation is completely changed. Like Punjab and Haryana, farmers of Assam have also started to use modern machines for rice cultivation instead of traditional hand tools.

Government has launched several schemes for the benefit of farmers. Utilization of these modern tools has definitely increased production volumes in agriculture however the negative aspects of utilising these tools cannot be ignored. Agricultural machinery is an important non-road vehicle source that can emit multiple pollutants and make a primary and secondary contribution to air pollution. These types of agricultural machineries use a large quantity of fuel and their emissions cause significant air pollution [10]. These types of vehicles mostly use diesel fuel, which has proven to be a major source of nitrogen compounds (NOx) and particulate matter (PM). Air pollutants, such as PM, NOx, CO, volatile organic compounds (VOCs), etc., emitted by agricultural machinery and diesel internal combustion engines have a great impact on the surrounding environment [11].

In 2017, a study from Korea recorded yearly amounts of CO, NOx, SOx, TSP (PM10), PM2.5, VOCs, and NH3 emitted from agricultural tractors were calculated as 3300 Mg, 9110 Mg, 4 Mg, 567 Mg, 522 Mg, 759 Mg, and 33 Mg, respectively. The yearly amounts of total air pollutants emitted from one unit of walking tractors and small, medium, and large riding tractors were estimated to be 7.0 kg, 20.5 kg, 34.6 kg, and 46.3 kg, respectively [12]**.** Similarly, the tremendous use of these non-road agricultural vehicles in Assam is contributing air pollutants to the atmosphere along with other on road vehicles.

5.4 Conclusion:

In this 21st century, use of modern machinery for paddy cultivation by Assamese farmers is a welcoming step. One can't deny the economic benefits got by the farmers by using these tools. But we should also consider the environmental aspects. Like the cities of Assam; air pollution is also increasing in rural areas. Limiting the negative effects on atmosphere is possible if modern agriculture practises are applied in accordance with the principles of pollution act. The farmers should be trained about the preventive measures of air pollution. The educated youth from rural areas can play an important role in this regard.

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6. Air Pollution and Environmental Ethics

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Abstract:

Human behavior towards the environment has been very brutal since many years. The constant harm caused to nature has resulted in many environmental problems like global warming, ozone layer depletion, etc. The most common and widespread problem is pollution. There are many types of pollution all over the world which has not only degraded the environment, but has also caused severe health issues in human beings. Hence, it is of utmost importance to make the environment and its safety our priority.

Keywords: *Environment, pollution, human beings, nature.*

6.1 Introduction:

Over the years, our environment has undergone major changes, most of which are negative. Human activities can be considered as the main reason behind such changes. Deforestation in the name of urbanization, wastage of natural resources, use of excessive chemicals during agriculture, disregard for animals etc. are few of the negligence's of human beings due to which the environment is severely suffering.

Also, domestic sewage and animal waste are the leading sources of organic pollution in our environment. The changes in the environment can be witnessed in the form of various types of pollution, rise in temperature, global warming etc. These changes are detrimental not only for the environment, but for all the living organisms including human beings. In this chapter we shall be discussing one of the concerns that our environment has been facing- "pollution" with special emphasis on air pollution.

6.2 Fundamentals of Pollution:

Pollution can be defined as the presence of unwanted substances in the environment which are harmful for human beings as well as other living organisms. Pollution can be both man-made as well as natural.

This environmental problem has created a havoc not only on the planet but on our health too. The major types of pollution occurring in our environment are given below-

- Air pollution
- Water pollution
- Soil pollution
- Noise pollution
- Plastic pollution
- Thermal pollution
- Radioactive pollution
- Light pollution etc.

The introduction of harmful substances has degraded the quality of air, water, soil. These substances have been named as "pollutants". Pollutants can be both natural as well as man-made.

6.2.1 Pollutants Generated Due to Natural Causes:

- *Volcanic eruption*: Volcanoes are one of the main sources of pollutants as harmful gases are released into the atmosphere in large quantities. The excessive release of carbon dioxide during volcanic eruption leads to rise in temperature which ultimately leads to climate change and global warming. Volcanic eruptions also release toxic substances like arsenic, lead, mercury which are extremely detrimental for the environment.
- *Forest fire*: Forest fire, also known as wildfire, bushfire is an uncontrolled fire that occurs in forests mostly due to natural causes such as lightning. Like volcanic eruption, forest fires also release harmful gases like carbon dioxide and carbon monoxide which are the leading causes behind global warming, air pollution and ozone layer depletion.

6.2.2 Pollutants generated due to man-made causes:

- ***Motor vehicles***: The gases emitted from the motor vehicles are one of the principal causes behind air pollution. Harmful gases like carbon monoxide, hydrocarbons, nitrogen oxide, sulphur dioxide, etc are released from these vehicles leading to degradation of the air quality as well as rise in temperature.
- ***Excessive use of plastic***: The excessive use and manufacture of plastic by human beings has led to pressing environmental issues. Due to the use of single use plastic, there has been a massive hike in the amount of non-degradable waste in the environment. This in turn has given rise to "plastic pollution".
- ***Burning of fossil fuels***: Burning of fossil fuels like coal, gasoline, etc. for various purposes like transportation, generation of energy has led to emission of toxic gases like carbon monoxide, nitrogen dioxide leading to air pollution.
- ***Industrial emission***: With industries set up in every corner of the world, there is uncontrolled emission of air pollutants such as sulphur dioxide, nitrogen dioxide, etc. which has caused numerous health issues in human beings like bronchitis, asthma, eye problems etc.

6.3 Types of Pollution:

Pollution can be defined as undesirable change in physical, chemical, and biological characteristics of land, air or water that occurs due to accumulation of pollutants. It is of five major types namely air pollution, water pollution, land pollution, radioactive pollution, and noise pollution. In terms of origin also it may be categorized as natural or anthropogenic.

- **Air pollution** can be defined as qualitative and quantitative changes in the constituents of the atmosphere due to addition or contamination of some substances that are harmful to man and ecosystem. Over population, increasing urbanization, industrialization, energy consumption etc. are the major causes of air pollution.
- **Water pollution** is defined as the addition of unwanted substances or the change of physical and chemical characteristics of water which makes it unsuitable for human consumption. It is mainly caused by waste products of industries, domestic sewage, oil spillage agricultural and industrial run off etc.
- **Soil or land pollution** results due to addition or removal of substances that decreases soil productivity and the quality of ground water. Modern agronomic practices, artificial fertilizers, farm chemicals etc. can lead to decrease in soil quality.
- **Radioactive pollution** is the result of emission of protons, electrons and electromagnetic radiations that are released by the disintegration of various radioactive substances like radium, thorium, uranium etc. Such pollution can ultimately lead to air, water, and land pollution.
- **Noise pollution** can be defined as any unwanted and unpleasant sound that affects animals and humans badly. Noise level above 120 db. is considered harmful to human beings. High pitch sound produced by automobiles, machines, power plants, trains, helicopters, airplanes, rockets, public broadcasting systems, T.V, explosion of bombs, sound of crackers etc. are the potent source of air pollution.

6.4 Causes of Air Pollution:

Air pollution is mainly caused by various pollutants that includes harmful gases like nitrogen oxide and sulphur dioxide, CFCs, toxic metals such as lead and mercury, radioactive pollutants obtained from nuclear explosions and many other matters. Both human activities as well as some natural actions are responsible for causing air pollution. Various human activities like burning of the fossil fuels, vehicle exhaust fumes, Emissions generated in industries and agriculture leads to the release of air pollutants. Combustion of fossil fuels like coal, petroleum and other products that are extensively used in power plants, manufacturing factories, in vehicles, incinerators and other fuel burning heating devices is a major cause of air pollution. Emission of greenhouse gases from agricultural fields during crop cultivation and by livestock (e.g.: production of methane by cattle) as well as deforestation is also responsible for causing air pollution.

Natural events that pollute the air include forest fires, volcanic eruptions, wind erosion, pollen dispersal, evaporation of organic compounds and natural radioactivity. At the time of volcanic eruptions, a series of toxic gases and particulate matters are released which have negative impact on the environment.

Carbon monoxide, methane etc. that are obtained from wildfires could affect air significantly. Winds and air currents also plays an important role in the spreading of air pollution by mobilizing the pollutants from ground and distribute them over large areas.

6.4.1 Types of Air pollutants:

The pollutants are emitted to the surrounding atmosphere and can be transported from the place of their origin to other nearby regions. We can categorize the pollutants into two kinds: primary and secondary pollutants. The Primary air pollutants are harmful chemicals that are released directly from a source into the atmosphere. The secondary air pollutants are released as a result of complex chemical reactions involving the primary pollutants. There are six primary air pollutants, such as carbon monoxide, nitrogen oxides, sulphur dioxide, Volatile Organic Compounds (VOCs), ammonia and other particulate matters. On the other hand, secondary air pollutants are formed as a result of chemical reactions that occurs in between primary pollutants and other elements. Some important secondary pollutants include ground level ozone, peroxyacyl nitrates, sulphur trioxide etc.

All the pollutants discussed above can be grouped broadly under the following heads-

- Gaseous pollutants (e.g. SO2, NOx, CO, ozone, Volatile Organic Compounds).
- Persistent organic pollutants (e.g. dioxins).
- Heavy metals (e.g. lead, mercury).
- Particulate Matter.

Gaseous pollutants are mainly emitted as a result of combustion of fossil fuels. E.g. CO is produced as a result of incomplete combustion and are produced from the transport. Again, Nitrogen oxides reacts with ozone or radicals in the atmosphere and forms NO2.

Persistent organic pollutants form a toxic group of chemicals that includes pesticides, as well as dioxins, furans and PCBs etc. Dioxin is produced from burning of chlorine containing compounds as well as due to incomplete combustion.

Heavy metals are mainly found on earth's crust. They include lead, mercury, cadmium silver nickel, vanadium, chromium, manganese etc. Human bodies require such elements in a small amount to maintain the normal metabolic reactions. However, at higher concentrations they can become toxic to human health.

Particulate matter is the mixture of complex and other particles of varying shape and sizes that are produced by a wide variety of natural and anthropogenic activities. Major sources of particulate pollutants are factories, power plants, refuse incinerators, motor vehicles, construction activity, fires, and natural windblown dust etc.

6.4.2 Impact of Air Pollution on Human Health:

The air pollutants can affect the human health to a very great extent. A low level of air pollutants irritates the eyes and cause inflammation of respiratory tract.

Air pollution can affect a person having respiratory illness badly and his/her condition may become chronic during later stages. It may lower the immunity system of a person and the body becomes more prone to diseases. The effects of air pollution on human health are discussed below-

1. From various studies it has been found that, a higher concentration of air pollutants as well as long term exposure to lower concentration of pollutants have similar effect on human body. Such pollutants result various health issues like nose and throat irritation, bronchoconstriction, asthma, lung diseases etc.
2. Carbon monoxide, a strong pollutant can cause conformational change in haemoglobin and reduces its capacity to transport oxygen. As a result of this, the functions of various organs also get affected.
3. Some heavy metals like lead, mercury, arsenic etc. can affect the nervous system and may lead to some serious health issues such as memory disturbances, sleep disorders, anger, fatigue, hand tremors, blurred vision, and slurred speech etc.
4. Heavy metals are also responsible for damage of kidney resulting tubular dysfunction.
5. Another important air pollutant named dioxin induces the damage of liver cells as well as other gastrointestinal problems.

6.5 Ethics of the Environment:

Ethics of the environment or "environmental ethics" is a branch of philosophy that examines the conceptual underpinnings of environmental values and the more specific issues of social attitudes, behaviour, and policies for protecting and conserving biodiversity and ecosystems. This field first came into being in the 1970s. This branch studies the relationship between human beings and the environment and the role of ethics in it. According to environmental ethics, every human being is a part of this environment and is associated with the other living organisms in one way or the other. Hence, every human being should follow a code of conduct when it comes to dealing with other beings or this environment as a whole. With the growing human population and excessive use of resources, it has become an absolute necessity for us to follow environmental ethics and treat the planet in a respectable manner. Few of the questions that need to be asked in order to keep the environment healthy are-

- What obligations do all human beings have towards nature?
- How to apportion the benefits and costs of complying with this obligation?
- What strategies and institutional structures should be in place to implement them?
- Is it absolutely necessary to cut down forests for urbanization?

If such above mentioned questions are taken into consideration by human beings before taking any rash decision, the environment will be much healthier.

6.6 Conclusion:

Air pollution occurs due to introduction of various gases, dust particles, fumes (or smoke) or odor into the atmosphere which ultimately threatens the health of humans and other living beings in our planet.

It is responsible for production of smog and acid rain, causes cancer and other various respiratory diseases, reduces the ozone layer atmosphere, and also pays contribution to global warming. It is our responsibility to save our mother nature from deterioration. Although different policies have been introduced as a preventive measure against pollution, but controlling of environmental pollution also requires people who can effectively execute them. People should understand the pollution issues deeply and take the necessary actions for the same. Local governments are also required to provide pollution enquiry centers as well as aware the common people about the control of pollution.

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7. New Trends in Environmental Biotechnology for Air Pollution Control

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7.1 Introduction:

Industrialization and increased human activity have led to environmental degradation due to soil, water, and air pollution. Although there are set regulations each industry should follow to conserve the environment, it remains a daunting task. Scientists have realized that if you can't control the waste being released, you can manage it.

Initially, chemicals were used to treat waste and other pollutants. However, chemicals turned out to be costly and inefficient. With technological advancement and enhancement in knowledge, scientists now develop sustainable waste treatment and pollutant removal strategies. This branch of biotechnology relies on beneficial microorganisms to create a safe, greener environment.

Technology is a great industry as it has improved the human lifestyle and the world at large. However, it has also had detrimental environmental effects due to high pollution and increased human activity. As a solution to pollution, scientists developed environmental biotechnology.

Biotechnology provides a plethora of opportunities for effectively addressing issues pertaining to the monitoring, assessment, modeling, and treatment of contaminated water, air, and solid waste streams.

Also offers the most economical and environmentally benign method for air pollution control when dealing with the removal of odorous and toxic contaminants from industrial and municipal airstreams.

Environmental biotechnology is a branch of science that uses living organisms and innovation to solve environmental problems effectively. This is one industry that has experienced positive results following tech advancement and discoveries. Environmental Biotechnology manipulates microbial organisms while exploiting their beneficial properties to serve the human community. This has paved the way for efficient environmental conservation strategies against global warming and climate change.

With the promising advancements in environmental biotechnology, there's no telling what to expect in the future. Today, you can control pollution better and exercise environmental remediation thanks to advancements in environmental biotechnology.

But here are the environmental biotechnology trends shaping the industry in 2023! The rapidly increasing industrialization has adversely affected the environment due to deterioration of water and air quality. The continuous addition of hazardous chemicals, gaseous contaminants, and particulate materials to our environment imposed the life-threatening challenges for flora and fauna. There is an urgent need to adopt the sustainable technologies to reduce the contamination occurring in air and water resources.

In this context, source tracking of environmental pollutants and process modeling using biological based methods are becoming increasingly important, mainly owing to the accuracy and robustness of such techniques. ***Environmental Monitoring and Modeling*.**

In developing countries, water, air, and soil pollution has become a persisting environmental problem due to rapid industrialization and urbanization. Using environmental Kuznets curve (EKC) it was observed that, during early stages of economic development in a particular region, the environment paid a high price for economic growth as the human race used technology to exploit all possible valuable resources.

Nevertheless, in agricultural areas, N, P, and K compounds are easily transported by farmland drainage and surface water to valuable water resources resulting in the deterioration of water quality that warrants the use of novel biosensors to monitor water quality.

Recently, it has been proposed that cellular-based biosensor technologies, that is, the bioelectric recognition assay (BERA), utilize live, functional cells in a gel matrix coupled with a sensor system that is able to measure changes in the cellular electric properties. Cells that are able to specifically interact with a target analyte produce a unique pattern of electrical potential as a result of their interaction with this analyte.

Concerning modeling, traditionally, the performance of many bioprocesses [1] has been modeled/predicted using process-based models that are based on mass balance principles, simple reaction kinetics, and a plug flow of water/air stream.

An alternate modeling procedure consists of a data driven approach wherein the principles of artificial intelligence (AI) are applied with the help of neural networks [2, 3]. The concept of neural network modeling has widespread applications in the fields of applied biosciences and bioengineering.

7.1.1 Pollutant Removal and Toxicity:

Environmental pollutants such as heavy metals and pesticides are commonly present in water emanating from acid mine drainage or other industries and from agricultural runoffs. These toxic pollutants can accumulate in living organisms and produce adverse effect such as carcinogenicity and acute toxicity.

Complete mineralization and/or removal of these pollutants and their toxic byproducts can be achieved using biological process that uses active bacterial/fungal/mixed microbial cultures.

7.1.2 Biofuels Production:

Biohydrogen production through anaerobic fermentation is a sustainable alternative for managing the recent (dogging) energy crisis and creating a sustainable green environment. Fermentative hydrogen production processes are technically feasible and economically cost-competitive and have large-scale commercialization implications [6, 7].

Besides some of the pure microbial species, that can be used to produce biofuels, as of late, it was shown that microbes present in the sediments of mangroves have the capability to yield biohydrogen.

Mangrove sediments are inherently rich in organic content and offer the following advantages: flexible substrate utilization and the simplicity of handling, no major storage problems, minimal pre-culturing requirements, and sediments being available at low cost.

7.2 Microbial Products for the Environment:

With increasing concern for the natural environment, biosynthetic and biodegradable biopolymers such as poly-β-hydroxybutyrate (PHB) have attracted great interest because of their excellent biodegradability and being environmentally benign and sustainable.

The high production cost of PHB can be curtailed by strain development, improving fermentation and separation processes, and using inexpensive carbon source. Due to recent advancements in fermentation technology and allied sciences, alternative purification solutions are under investigation, among which microbiological ways of utilization of byproducts are very interesting and promising. Such a solution could result in better overall process productivity and facilitate the downstream processing.

Concerning the use of enzymes, owing to its lignolytic enzyme system, the white-rot fungus *Phanerochaete chrysosporium* has been applied in many bioremediation studies

7.3 Microbial Enhanced Oil Recovery (MEOR):

Technological advancement has allowed scientists to apply different molecular approaches to encourage hydrocarbon utilization in oil wells. This purifies the oil, therefore, reducing processing costs for increased profitability.

Genomic and proteomic isolations allow for profiling through technologies like fingerprinting and sequencing. This enables scientists to better understand each community and species for creative exploitation.

In MEOR, scientists cultivate hydrocarbon-consuming bacteria that remove pollutants from wells underground, therefore, cleaning the soil. This promotes environmental bioremediation. MEOR also enables investors to identify new oil wells even with the depleting oilfields.

7.4 Types of EOR Methods:

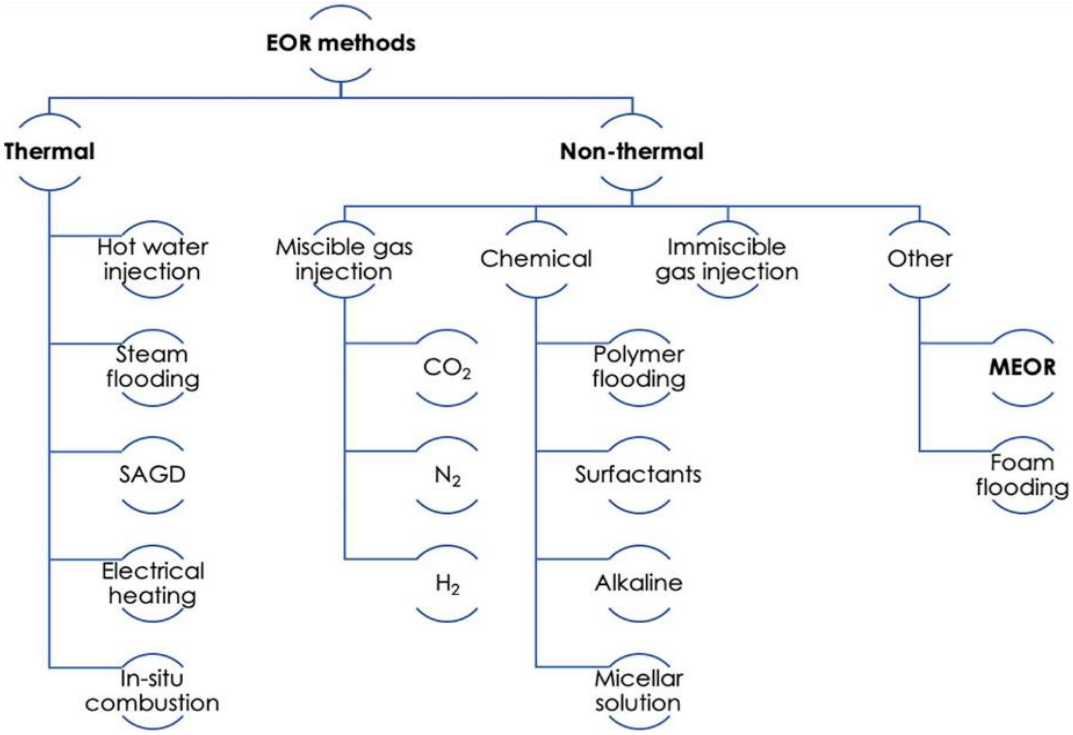

Figure 7.1: Types of EOR Methods

7.4.1 Bio-Electrochemical Systems:

Bio-electrochemical systems like microbial electrolysis cells or microbial fuel cells are the innovation behind fuel production from biodegradable organic matter. The systems use a biofilm catalyst to create electrical energy or hydrogen. Besides reducing energy consumption during waste treatment, bio-electrochemical systems will generate adequate electrical energy for industrial or domestic use.

7.4.2 Microbial Electro-Remediation:

Environmental biotechnologists recognize the important role that bio-electrochemical systems in waste remediation. To exploit the capabilities of this technology, these scientists turn to microbial electro-remediation. This innovative waste management strategy aims to generate sustainable energy through electro-genesis while recovering the resources.

7.4.3 Industrial Waste Treatment:

Industrial waste is the leading cause of environmental pollution, hence blamed for the climate change effects being experienced on earth.

However, advancements in environmental biotechnology have given the world a second chance at saving this planet. Using microorganisms, biotechnologists can technically and economically treat waste. This process relies on controlled biodegradation and detoxification for a quality environment.

Companies are now using bio-augmentation to accelerate the degradation process to treat large volumes of waste. This innovation comes in handy when you have a low volume of microorganisms for successful bioremediation. Bio-augmentation allows the waste treatment system to achieve its goal regardless of the underlying extraneous factors.

7.4.4 Biofuels for Microbial and Process Engineering:

Innovative approaches in environmental biotechnology have paved the way for the sustainable development of biofuels to use in engineering. Environmental biotechnologists use innovative approaches to convert plants into biofuels.

Microalgae such as hyacinth undergo bio-refining to reduce water pollution that has endangered the lives of biotic animals and plants. This will meet the need for alternative energy sources that promote environmental conservation for a quality, greener planet.

7.4.5 Creative Management of Chromium Phytotoxicity:

Chromium is a toxic chemical that will affect the growth of flora and the development of fauna. Because of the danger chromium poses to human life and the environment, environmental biotechnology has created strategies to prevent these phytotoxic effects. The ameliorative approach is the main process of reducing the chromium released in industrial waste and to the environment. Amelioration has limited after-use risks as compared to the traditional metal chelation process.

7.4.6 Enhanced Biological Phosphorous Removal (EBPR):

EBPR is a technologically advanced process of treating sewage in small-scale or domestic wastewater. This system needs an activated sludge that is configured to remove phosphate, which is a toxic pollutant. EBPR is preferable since it’s cost-effective and highly sustainable since you only need to obtain the phosphorous-accumulating organisms (PAO).

7.4.7 Biosensors:

Environmental biotechnology has seen the development of biosensors that improve bio-monitoring of environmental changes and treatment processes. Biosensors come with physiochemical detectors that will sense the presence of certain chemicals in wastewater for remediation.

Microarrays can complement the biosensors to determine how toxic or concentrated a certain pollutant is. This is one of the latest environmental biotechnology technologies, aiming to improve waste treatment efficiency.

7.5 Conclusion:

There are various techniques discovered by the scientists recently to rejuvenate the environment naturally. With the help of Biotechnological approach we can solve the environmental issues by optimized and cost effective way, but further research and development study needs to control the air pollution within less time.

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