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CONTAMINATION OF THE ENVIRONMENT: CAUSES AND EFFECTS OF AIR POLLUTION – A REVIEW

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Abstract

A significant problem of our time is air pollution, which has negative effects on both climate change and public and individual health by causing an increase in illness and death rates. Several contaminants significantly contribute to human disease. Particulate Matter (PM), which consists of tiny particles with varying diameters, enters the respiratory system by inhalation. This can lead to respiratory and cardiovascular disorders, reproductive and central nervous system dysfunctions, as well as cancer. While ozone in the stratosphere provides protection against ultraviolet radiation, it becomes toxic when present in large concentrations at ground level, negatively impacting the respiratory and cardiovascular systems. In addition, nitrogen oxide, sulphur dioxide, Volatile Organic Compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs) are classified as air pollutants that pose a threat to human health. Inhaling excessive volumes of carbon monoxide can lead to immediate poisoning. Lead and other heavy metals, when taken into the human body, can cause direct poisoning or chronic intoxication, depending on the level of exposure. The compounds indicated above can cause several ailments, primarily affecting the respiratory system. These include Chronic Obstructive Pulmonary Disease (COPD), asthma, bronchiolitis, as well as lung cancer, cardiovascular issues, problems with the central nervous system, and skin diseases. Lastly, environmental pollution-induced climate change impacts the geographic spread of numerous infectious diseases, as do occurrences of natural catastrophes. The most effective approach to addressing this problem is to raise public awareness and employ a multidisciplinary strategy guided by scientific professionals. Both national and international organisations should prioritise tackling this emerging threat and develop long-term solutions.

INTRODUCTION

Given that many human activities have an impact on the environment, the relationship between humans and their physical surrounds has been the subject of much research. The environment consists of both the biotic components, which include living organisms and microorganisms, and the abiotic components, which encompass the hydrosphere, lithosphere, and atmosphere. Pollution is the act of introducing dangerous substances into the environment, which can negatively impact humans and other living organisms. Pollutants refer to detrimental substances in the form of solids, liquids, or gases that are present in larger concentrations than normal, leading to a decline in the overall quality of the environment.

Human activities have a detrimental impact on the ecosystem through the contamination of the water we consume, the air we inhale, and the soil in which plants thrive. The industrial revolution was highly successful in terms of technological advancements, societal progress, and the expansion of many services. However, it also brought about the generation of significant amounts of air pollutants that pose a threat to human health. Undoubtedly, global environmental pollution is recognised as an international public health concern with various aspects. This important problem is interconnected with social, economic, and legislative concerns as well as lifestyle behaviours. Undoubtedly, urbanisation and industrialization are currently reaching

unprecedented and concerning levels globally in our day. Anthropogenic air pollution is a significant global public health risk, since it is responsible for around 9 million fatalities annually.

Undoubtedly, all of the aforementioned factors are strongly linked to climate change, and if there is a threat, the repercussions can be devastating for humanity. Climate change and global warming have significant impacts on various ecosystems, resulting in challenges such as food insecurity, melting of ice and icebergs, extinction of animal species, and damage to plant life. Air pollution has diverse health impacts. Even on days with moderate levels of air pollution, the well-being of vulnerable and reactive persons can still be affected. There is a strong correlation between brief exposure to air pollutants and many health issues such as COPD, coughing, difficulty breathing, wheezing, asthma, respiratory disease, and a higher likelihood of being hospitalised (a measure of illness). Chronic asthma, pulmonary insufficiency, cardiovascular illnesses, and cardiovascular mortality are among the enduring consequences linked to air pollution. A Swedish cohort study suggests that prolonged exposure to air pollution may lead to the development of diabetes. Furthermore, air pollution has been found to have numerous adverse health impacts during the early stages of human life, including respiratory, cardiovascular, mental, and perinatal abnormalities. These effects can result in infant mortality or the development of chronic diseases in adulthood.

Various national assessments have highlighted the heightened susceptibility to illness and death. These studies were done in several global locations and demonstrate a correlation between the daily fluctuations in particulate matter (PM) concentration and daily death rates. The predicament could be exacerbated by climate fluctuations and worldwide planetary warming. In addition, there has been a documented rise in hospital admissions (a measure of illness) among older adults and persons who are particularly vulnerable due to certain factors. There is a correlation between fine and ultrafine particulate matter and more severe illnesses, as these particles have the ability to penetrate the deepest regions of the respiratory system and enter the circulation more readily.

The primary impact of air pollution is on individuals residing in densely populated urban regions, where the emissions from vehicles are the primary cause of the deterioration in air quality. Industrial accidents pose a risk of releasing a toxic cloud that can be lethal to the nearby communities. The dispersal of contaminants is influenced by various factors, particularly atmospheric stability and wind.

In emerging nations, the issue is exacerbated by the combination of overpopulation, unregulated urbanisation, and the advancement of industrialization. This results in inadequate air quality, particularly in nations with social inequalities and a dearth of knowledge regarding sustainable environmental management. Low-income individuals are exposed to poor-quality, polluted indoor air while using fuels like wood or solid fuel for household purposes. It is worth mentioning that around three billion individuals worldwide rely on the aforementioned energy sources for their everyday heating and cooking requirements. Women in impoverished nations are particularly susceptible to developing diseases because they are exposed to indoor air pollution for extended periods of time. China, with its rapid industrialization and high population density, is among the Asian nations facing severe air pollution issues. The mortality rate of lung cancer in China is linked to the presence of tiny particles. As previously

mentioned, prolonged exposure is linked to harmful impacts on the cardiovascular system. Notably, cardiovascular diseases are more prevalent in industrialised and high-income countries rather than in low-income developing countries with considerable exposure to air pollution. India experiences severe air pollution, with the air quality reaching dangerous levels. New Delhi is one of the most polluted cities in India. Frequent flight cancellations occur at New Delhi International Airport due to the diminished visibility caused by air pollution. Pollution is prevalent in both urban and rural areas of India as a result of rapid industrialization, urbanisation, and increased reliance on motorbike transportation. However, the burning of biomass for heating and culinary purposes is a significant contributor to indoor air pollution in both India and Nepal. India exhibits regional variability, with variations in climatological circumstances, population, and education levels leading to disparities in indoor air quality. Notably, North Indian states have higher levels of PM2.5 (ranging from 557 to 601 µg/m3) compared to the Southern States (ranging from 183 to 214 µg/m3). The frigid climate in the northern regions of India may be the primary factor contributing to this phenomenon, as it necessitates longer periods spent indoors and increased heating requirements, in contrast to the tropical environment prevalent in southern India. Household air pollution in India is linked to significant health consequences, particularly in women and small children, who spend extended periods of time indoors. Chronic obstructive respiratory disease (CORD) and lung cancer predominantly affect women, whereas acute lower respiratory disease primarily affects children under the age of 5. The presence of high levels of air pollution, including sulphur dioxide and smoke, at a concentration of 1,500 mg/m3, led to a significant rise in mortality rates. In December 1952, London experienced 4,000 deaths, while in 1963, New York City saw 400 deaths. A correlation between pollution and mortality was observed through the monitoring of outdoor pollution in six major US cities. Mortality was consistently found to be strongly associated with the concentrations of fine, inhalable, and sulphate particles, rather than with the levels of overall particulate pollution, aerosol acidity, sulphur dioxide, or nitrogen dioxide. Moreover, Mexico City and Rio de Janeiro exhibit alarmingly elevated levels of pollution, with Milan, Ankara, Melbourne, Tokyo, and Moscow following suit.

Source of Exposure

The emission of the majority of environmental contaminants is attributed to extensive human activities, including the utilisation of industrial machinery, power-generating stations, combustion engines, and automobiles. Due to their extensive magnitude, these activities are the primary sources of air pollution, with cars estimated to account for almost 80% of current pollution levels. Additional human activities, albeit to a lesser degree, are also impacting our environment. These include field cultivation techniques, petrol stations, fuel tank heaters, and cleaning procedures. Furthermore, there are various natural sources, such as volcanic and soil eruptions, and forest fires.The categorization of air pollutants mostly relies on the origins responsible for generating pollution. Hence, it is noteworthy to specify the four primary sources, in accordance with the classification system: The sources of emissions can be classified into four categories: **Major sources, Area sources, Mobile sources, and Natural sources.**

Primary sources encompass the release of contaminants from power plants, refineries, petrochemical facilities, chemical and fertiliser industries, metallurgical plants, and other industrial establishments, as well as municipal incineration. Indoor causes of air pollution encompass activities such as domestic cleaning, dry cleaning,

printing shops, and petrol stations. Mobile sources encompass a variety of vehicles such as autos, cars, railways, airlines, and other similar modes of transportation. Lastly, natural sources encompass physical calamities such as forest fires, volcanic erosion, dust storms, and agricultural burning, as mentioned earlier.

Nevertheless, other classification schemes have been suggested. Another classification method involves categorising pollutants based on the recipient, which can be done as follows: Air pollution is defined as the substantial and prolonged presence of contaminants in the atmosphere. Air pollutants consist of scattered particles, hydrocarbons, carbon monoxide (CO), carbon dioxide (CO2), nitrogen monoxide (NO), nitrogen dioxide (NO2), sulphur trioxide (SO3), and other substances. Water pollution refers to the presence of elevated levels of organic and inorganic substances, as well as biological agents, which negatively impact the quality of water. Soil pollution arises from the emission of chemicals or the improper disposal of substances, including heavy metals, hydrocarbons, and pesticides.

Air pollution can impact the quality of soil and water bodies through the contamination of precipitation, which subsequently infiltrates into water and soil ecosystems. The chemistry of the soil can be altered by acid precipitation, which can have an impact on plants, crops, and water quality. In addition, the mobility of heavy metals is enhanced by soil acidity, facilitating their transfer into the aquatic environment. It is widely recognised that heavy metals, such as aluminium, are harmful to wildlife and fish. The importance of soil quality is evident, as soils with low amounts of calcium carbonate are more vulnerable to the harmful effects of acid rain. In addition to rainfall, snow and particles seep into bodies of water.

Radioactive and nuclear pollution occurs when radioactive and nuclear pollutants are released into water, air, and soil as a result of nuclear explosions and accidents, the use of nuclear weapons, and the handling or disposal of radioactive sewage. Radioactive substances have the potential to pollute surface water bodies and pose a threat to the environment, as well as to plants, animals, and humans. It is widely recognised that certain radioactive chemicals, such as radium and uranium, have a tendency to accumulate in the bones and can lead to the development of cancer.

Machine-generated, vehicular, traffic, and musical noises contribute to noise pollution, which poses a threat to our auditory health. The term DALYs was adopted by the World Health Organisation. The Disability-Adjusted Life Years (DALYs) for an illness or health condition are calculated by adding the Years of Life Lost (YLL) owing to premature mortality in the population and the Years Lost due to Disability (YLD) for individuals living with the health condition or its effects. Air pollution is the primary contributor to the loss of disability-adjusted life years (DALYs) in Europe, with noise pollution being the second leading factor. Researchers have conducted studies on the potential associations between noise and air pollution and their impact on health (40). The study revealed that the impact of environmental noise on cardiovascular illness, measured in DALYs (Disability-Adjusted Life Years), was more significant than the impact of air pollution. Notably, the effects of environmental noise on cardiovascular disease were found to be unrelated to air pollution. Environmental noise should be recognised as a distinct public health hazard.

Environmental pollution occurs when there are alterations in the physical, chemical, or biological components of the environment, such as air masses, temperature, and climate. Pollutants have detrimental effects on our ecosystem, either by causing an

increase in levels beyond what is considered normal or by introducing poisonous compounds that are dangerous. Primary pollutants are directly generated from the aforementioned sources, while secondary pollutants are released as by-products of the primary ones. Pollutants can be classified as either biodegradable or non-biodegradable, and can originate from either natural sources or human activities, as mentioned above. Furthermore, their origin might either be a singular source (point-source) or multiple distributed ones.

Pollutants have variations in their physical and chemical characteristics, which account for the disparity in their ability to generate hazardous consequences. For instance, we may assert that aerosol chemicals possess higher toxicity compared to gaseous compounds because of their minuscule size (whether in solid or liquid form) in the atmosphere, which grants them a better ability to penetrate. Our respiratory system efficiently eliminates gaseous compounds. These particles have the capacity to harm the lungs and can even penetrate the bloodstream, resulting in the untimely deaths of millions of individuals annually. In addition, the acidity of aerosols, as measured by the concentration of hydrogen ions ([H+]), appears to significantly increase the formation of secondary organic aerosols (SOA). However, this finding is not corroborated by other scientific groups.

Clımate and Pollutıon

There is a strong correlation between air pollution and climate change. Climate change is a detrimental factor that diminishes the overall condition of our planet. Pollutants such as black carbon, methane, tropospheric ozone, and aerosols have an impact on the quantity of incoming sunlight. Consequently, the Earth's temperature is rising, leading to the thawing of ice, icebergs, and glaciers. Thus, changes in climate will impact the frequency and occurrence of both persistent and imported illnesses. The duration, timing, and intensity of outbreaks are greatly influenced by climate and weather, which also alter the distribution of infectious diseases worldwide. Parasitic or viral infections carried by mosquitoes are highly influenced by temperature, as warming causes two main effects: it reduces the time it takes for the pathogen to develop, and it changes the areas where the mosquitoes can be found. Likewise, the increase in water temperature caused by climate changes results in a significant rise in waterborne diseases. Migration of populations in many countries has led to the reemergence of eradicated diseases such as cholera, poliomyelitis, tick-borne encephalitis, and malaria. The proliferation of epidemics is linked to natural climate catastrophes and tempests, which appear to be increasingly prevalent in contemporary times. Emerging illnesses that impact public health are also linked to malnutrition and immune system imbalances.

The Chikungunya virus spread from the Indian Ocean to Europe through air travel, resulting in epidemics of the disease in Italy and indigenous instances in France. There has been a rise in cases of cryptosporidiosis in the United Kingdom and the Czech Republic after flooding events. As said before, aerosol compounds are small in size and have a significant impact on the climate. They have the capacity to reflect sunlight (known as the albedo effect) by redirecting 25% of the sun's rays back into space, resulting in a decrease in global temperature over the past three decades.

Aır Pollutıon

The World Health Organisation (WHO) identifies six primary air pollutants: particle pollution, ground-level ozone, carbon monoxide, sulphur oxides, nitrogen oxides, and

lead. Air pollution has detrimental effects on the environment, including groundwater, soil, and air. It also poses a significant threat to living organisms. Our focus is primarily on these pollutants, as they are associated with more widespread and severe health issues and environmental consequences. Acid rain, global warming, the greenhouse effect, and climate change have significant ecological implications for air pollution.

Effects of Partıculate Matter on Health:

Research has demonstrated a correlation between particulate matter (PM) and negative health consequences, specifically in regard to either immediate (acute) or prolonged (chronic) exposure to PM. Particulate matter (PM) often originates in the atmosphere through chemical interactions among various contaminants. The ability of particles to penetrate is strongly influenced by their size. The United States Environmental Protection Agency (EPA) defines Particulate Matter (PM) as a word used to refer to particles. Particulate matter (PM) pollution consists of particles that have sizes of 10 micrometres (µm) or less, known as PM10, as well as very small particles with diameters often measuring 2.5 micrometres (µm) or less. Particulate matter consists of little liquid or solid droplets that can be breathed in and result in severe health consequences. Particles with a diameter of less than 10 µm (PM10) can enter the lungs through inhalation and potentially enter the circulation. PM2.5, which refers to fine particles, presents a higher health hazard.

Several epidemiological studies have investigated the health impacts of PM. There was a demonstrated positive correlation between both brief and extended exposures to PM2.5 and the occurrence of acute nasopharyngitis. Furthermore, it has been discovered that prolonged exposure to particulate matter (PM) over an extended period of time is associated with the development of cardiovascular disorders and increased newborn mortality rates.

These studies rely on PM2.5 monitors and are limited in scope to a specific research area or city due to a lack of detailed daily data on PM2.5 concentrations. As a result, they do not accurately reflect the total population. A recent epidemiological study conducted by the Department of Environmental Health at Harvard School of Public Health in Boston, MA, found that variations in PM2.5 concentrations result in an exposure error known as Berkson error. The study also revealed that the specific magnitudes of the short-term and long-term effects are still not fully understood. The team created a PM2.5 exposure model using remote sensing data to evaluate human exposures over both short and extended periods of time. This model allows for the analysis of short-term effects with high geographical resolution, as well as the evaluation of long-term effects on the entire population.

Furthermore, lung problems and immune system disorders are documented as enduring chronic consequences. Individuals with asthma, pneumonia, diabetes, and respiratory and cardiovascular conditions are particularly prone and susceptible to the impacts of PM. PM2.5 and PM10 are closely linked to many respiratory ailments due to their small size, which allows them to penetrate indoor areas. The particles elicit harmful effects based on their chemical and physical characteristics. PM10 and PM2.5 consist of both organic and inorganic components. The organic components include polycyclic aromatic hydrocarbons, dioxins, benzene, and 1-3 butadiene. The inorganic components include carbon, chlorides, nitrates, sulphates, and metals.

Table 1: Penetrability according to particle size

Particle Size	Penetration Degree
>11 µm	Passage into nostril and upper respiratory tract
7-11 µm	Passage into nasal cavity
4.7 - 7 µm	Passage into larynx
3.3-4.7 µm	Passage into trachea – bronchial area
2.1-3.3 µm	Secondary bronchial area passage
1.1-2.1 µm	Terminal Bronchial area passage
0.43 – 0.65 µm	Alveolar penetrability
0.65 – 1.1 µm	Bronchioles penetrability

Table 2: Types and size of Particulate matter

Type		Diameter
Particulate contaminants	Smoke Soot Tobacco smoke Fly ash Cement dust	0.01–1 0.01–0.8 0.01–1 1–100 8–100
Biological Contaminants	Bacteria and bacterial spores Viruses Fungi and molds Allergens	0.7 – 10 0.01 – 1 2-12 0.1-100
Types of dust	Atmospheric dust Heavy dust Settling dust	0.01-1 100-1000 1-100
Gases	Different gaseous contaminants	0.0001 – 0.01

Particulate Matter (PM) is categorised into four primary classifications based on type and size. Gas contaminants consist of particulate matter (PM) present in the atmosphere. Particulate pollutants encompass smog, soot, tobacco smoke, oil smoke, fly ash, and cement dust. Biological contaminants encompass microorganisms such as bacteria, viruses, fungi, mould, and bacterial spores, as well as cat allergens, house dust and allergens, and pollen. The many types of dust include suspended air dust, settling dust, and heavy dust. Additionally, the small size of PM10 and PM2.5 particles allows them to have an extended half-life in the atmosphere, enabling them to remain suspended for a long time and be transported to faraway locations. This poses a risk of exposing both people and the environment to the same level of pollution. They have the capacity to alter the nutritional equilibrium in aquatic ecosystems, impair forests and crops, and acidify bodies of water.

Degradıng of The Ozone Layer

Ozone (O3) is a gaseous compound that is produced when oxygen is subjected to a high voltage electric discharge. It possesses potent oxidising properties, surpassing chlorine by 52% in strength. It originates in the stratosphere, but it can also occur as a result of chain reactions of photochemical smog in the troposphere. Ozone can be transported across long distances from its point of origin, carried by air masses. It is remarkable that ozone levels in cities are quite low compared to the higher levels seen in metropolitan areas, which could pose a threat to cultures, forests, and plants by inhibiting carbon assimilation. Ozone inhibits plant development and diminishes crop

yield by exerting its antibacterial properties on the plant microbiota. Ozone affects various natural habitats by altering the species composition of bacteria and animal species. Ozone exposure enhances DNA damage in epidermal keratinocytes and results in compromised cellular activity.

Ground-level ozone (GLO) is formed by the chemical reaction of nitrogen oxides and volatile organic compounds (VOCs) released from natural sources or as a result of human activity. Ozone is often absorbed through inhalation. Ozone impacts the epidermis and the lacrimal glands in the upper layers of the skin. An investigation into the effects of brief exposure of mice to elevated levels of ozone revealed the occurrence of malondialdehyde production in the outer layer of the skin (epidermis), as well as a reduction in the amounts of vitamins C and E. There is a high probability that ozone levels do not disrupt the function and integrity of the skin barrier, which could make individuals more susceptible to skin diseases. Because ozone has little water solubility, it can easily enter the lungs when inhaled. Ozone-induced toxic consequences are observed in metropolitan areas worldwide, resulting in biochemical, morphological, functional, and immunological abnormalities.

The APHEA2 project is dedicated to studying the immediate impacts of ozone levels in the environment on death rates. Ozone concentrations and daily fatality rates were studied across various European cities over a span of three years. During the summer months, there was a noticeable rise in ozone levels, which corresponded to an increase in the daily mortality rate by 0.33%, respiratory deaths by 1.13%, and cardiovascular fatalities by 0.45%. There was no discernible impact noticed over the winter season.

Harmful Agents	Causes
CARBON MONOXIDE	Uncompleted fossil fuel combustion produces CO. Carbon monoxide poisoning causes headache, dizziness, weakness, nausea, vomiting, and loss of consciousness. Carbon monoxide binds haemoglobin better than oxygen. Long-term carbon monoxide exposure can cause serious poisoning. Carbon monoxide binding competes with oxygen, causing hypoxia, ischemia, and cardiovascular disease. Carbon monoxide influences greenhouse gases that affect climate and global warming. This may boost soil and water temperatures and cause intense weather or storms.
NITROGEN OXIDE	Automobile engines generate nitrogen oxide, a traffic contaminant. The deep lung penetration of this irritant causes respiratory illnesses, coughing, wheezing, dyspnea, bronchospasm, and even pulmonary edoema when inhaled at high levels. Concentrations over 0.2 ppm cause deleterious effects in humans, whereas those above 2.0 ppm impact T-lymphocytes, including CD8+ and NK cells that produce our immunological response .Research suggests that prolonged exposure to high nitrogen dioxide levels can cause chronic lung illness. NO2 can impair smell over time.

SULPHUR DIOXIDE	The burning of fossil fuels and industrial processes release sulphur dioxide, a toxic gas. The annual SO2 standard is 0.03 ppm. It impacts humans, animals, and plants. People with lung problems, the elderly, and children are at higher risk. Industrial sulphur dioxide emissions cause respiratory irritation, bronchitis, mucus production, and bronchospasm because it penetrates deep into the lung and converts into bisulfite, interacting with sensory receptors and causing bronchoconstriction. Additionally, skin redness, eye damage, mucous membrane damage, and worsened cardiovascular illness have been documented. Acid rain and soil acidification may be linked to sulphur dioxide emissions.
POLYCYCLIC AROMATIC HYDROCARBONS(PAHS)	The atmosphere is the main way PAHs spread, thus they're everywhere. Coal and tar sediments contain them. Additionally, they result from incomplete combustion of organic matter, such as in forest fires, incineration, and engines. PAH chemicals including benzopyrene, acenaphthylene, anthracene, and fluoranthene are poisonous, mutagenic, and carcinogenic. These are major lung cancer risk factors.
VOLATILE ORGANIC COMPOUNDS(VOCS)	Human cancer has been linked to VOCs such toluene, benzene, ethylbenzene, and xylene (90). VOCs have increased due to new goods and materials. VOCs pollute indoor air (90) and may harm health. There are short- and long-term health risks. Indoor air smells from VOCs. Short-term exposure causes eye, nose, throat, and mucosal membrane irritation, whereas long-term exposure causes hazardous effects. Complex VOC combinations can exhibit synergic, antagonistic, or indifferent harmful effects, making toxicological assessment difficult.
DIOXINS	Industrial activities and natural events like forest fires and volcano eruptions produce dioxins. They accumulate in meat, dairy, fish, shellfish, and animal fatty tissue. Short-term dioxin exposure can cause skin darkening and sores. Long-term dioxin exposure can cause developmental issues, immunological, endocrine, and neurological system damage, reproductive infertility, and cancer. Air pollution is largely caused by fossil fuel use. Anthropogenic contamination from agricultural and industrial operations or transportation is possible, as is natural contamination. The European Air Quality Directive sets weaker air quality criteria than the WHO, which is harsher.
	Industrial plants employ lead, which is emitted by petrol engines, batteries, radiators, waste incinerators, and waste waters. Also, metals, mining, and piston-engine aircraft are major contributors of lead contamination. In poor countries, lead poisoning harms humans,

LEAD	animals, and the environment, posing a public health risk. Lead is inhaled, ingested, and absorbed dermally. Lead can also cross the placenta unimpeded. More damaging effects occur in younger foetuses. Brain edoema results from lead toxicity in the foetal nervous system. Inhaled lead accumulates in blood, soft tissue, liver, lung, bones, cardiovascular, neurological, and reproductive systems. Adults reported memory loss, muscular and joint pain, and attention issues. Lead is a neurotoxicant that causes learning impairments, memory loss, hyperactivity, and mental retardation in children and neonates at low levels. High environmental lead levels impair plants and crop growth. High lead levels affect vertebrates and animals neurologically.

Effects of Air Pollution on Health

The predominant air contaminants are ground-level ozone and Particulate Matter (PM). Air pollution can be classified into two primary categories: Ambient air pollution refers to outdoor pollution. Indoor pollution refers to the pollution that arises from the combustion of fuels within households. Individuals who are exposed to elevated levels of air pollution may suffer from various disease signs and conditions of varying severity. These consequences can be categorised into short-term and long-term effects that impact health. Vulnerable populations who should be mindful of health protection measures encompass the elderly, children, individuals with diabetes, and those with preexisting heart or lung conditions, particularly asthma.

As previously said, a recent epidemiological study conducted by Harvard School of Public Health has found that the exact impact of short-term and long-term effects has not been fully understood due to variations in epidemiological methodology and exposure errors. Novel models are suggested to better effectively evaluate short- and long-term human exposure data. In this part, we provide an account of the prevalent short- and long-term health consequences, as well as general concerns, associated with both types of effects. It is important to note that these effects are frequently influenced by ambient factors, dosage, and individual sensitivity. Transient consequences of exposure include transient discomfort, such as irritation of the eyes, nose, skin, throat, wheezing, coughing, chest tightness, and breathing difficulties, as well as more severe conditions, such as asthma, pneumonia, bronchitis, and respiratory and cardiovascular disorders. Brief exposure to air pollution can also result in headaches, nausea, and dizziness.

Prolonged and chronic exposure to pollutants can exacerbate these issues, posing harm to the neurological, reproductive, and respiratory systems, and leading to the development of cancer and, in rare cases, fatalities. The long-term consequences are chronic, enduring for an extended period of time, perhaps spanning years or even an individual's whole lifespan, and in severe cases, may result in mortality. Moreover, the long-term exposure to various air contaminants can potentially lead to the development of different types of cancer.

Respiratory problems are strongly linked to the inhalation of air contaminants, as previously mentioned. These pollutants will enter the airways and build up in the cells. The extent of harm to the cells being targeted should be directly linked to the specific pollutant component, its origin, and the amount of exposure. The health impacts are significantly influenced by the country, region, season, and time. Prolonged exposure to the pollutant is likely to lead to long-term health impacts, considering the variables mentioned above. Particulate Matter (PMs), dust, benzene, and O3 have detrimental effects on the respiratory system. Furthermore, there is an additional danger in the event of a pre-existing respiratory condition such as asthma (98). Individuals with a preexisting medical condition are more likely to experience long-term consequences. Acute exposure to contaminants can lead to voice abnormalities when the trachea becomes polluted. COPD can be triggered by air pollution, leading to higher rates of illness and death (99). The primary contributors to the risk of developing COPD are the enduring consequences of traffic, industrial air pollution, and the combustion of fuels.

Various cardiovascular consequences have been noted following exposure to air pollution. Prolonged exposure can lead to alterations in blood cells that can impact the functioning of the heart. Long-term exposure to traffic emissions has been associated with the development of coronary arteriosclerosis, whereas short-term exposure is linked to hypertension, stroke, myocardial infarctions, and cardiac insufficiency. Long-term exposure to nitrogen oxide (NO2) has been found to cause ventricle enlargement in humans. Extended-term exposure to air pollution has been found to have neurological damage in both adults and children.

Long-term air pollution appears to be associated with psychological difficulties, autism, retinopathy, foetal growth issues, and low birth weight. The causative agent responsible for neurodegenerative disorders such as Alzheimer's and Parkinson's is currently unknown, although there is a belief that prolonged exposure to air pollution may play a role. Pesticides and metals, together with nutrition, are specifically identified as causative causes. The pathogenesis of neurodegenerative diseases involves several processes such as oxidative stress, protein aggregation, inflammation, and mitochondrial dysfunction in neurons. Chronic encephalitis was detected in canines residing in a very contaminated region in Mexico for an extended duration. Markers of systemic inflammation, specifically IL-6 and fibrinogen, were observed to increase in human adults as an early reaction to PNC, potentially resulting in the creation of acute-phase proteins. The development of atherosclerosis and the presence of oxidative stress appear to be the underlying processes responsible for the neurological impairments induced by prolonged exposure to air pollution. Inflammation is a result of oxidative stress and appears to play a role in hindering the maturation of development, impacting several organs. Additionally, there are other elements that contribute to the process of embryonic maturity and determine the susceptibility to long-term air pollution. The factors that influence this include birthweight, mother smoking, genetic background, socioeconomic milieu, and education level.

Nevertheless, the food, beginning with breast-feeding, is an additional influential component. The primary source of antioxidants, which have a crucial function in safeguarding us against air pollution, is our diet. Antioxidants function as scavengers of free radicals, thereby restricting the interaction of free radicals in the brain. Genetic background can lead to varying levels of vulnerability to the oxidative stress pathway. For instance, providing asthmatic children who have the GSTM1 null allele

with antioxidant supplements containing vitamins C and E seems to regulate the impact of ozone. Inflammatory cytokines are generated in the periphery, specifically in the respiratory epithelia, which leads to an increase in the activity of the innate immunological Toll-like receptor 2. Activation and the ensuing events leading to neurodegeneration have recently been identified in lung lavage in mice exposed to ambient particulate matter in Los Angeles, California, USA. Lead exposure in youngsters resulted in the observation of neurodevelopmental morbidities. These children exhibited aggressive and delinquent behaviour, experienced a decrease in IQ, encountered learning difficulties, and displayed hyperactivity. There is no threshold of lead exposure that is considered safe, and the scientific community has requested the Centres for Disease Control and Prevention (CDC) to lower the existing screening standard of 10 µg/dl.

Poor air quality is directly linked to malfunction and neuroinflammation in the immune system. However, there is a noticeable rise in the levels of immunoglobulins (namely IgA and IgM) and the complement component C3 in the serum (106). Another problem arises when air pollutants impact antigen presentation, leading to an increase in the expression of costimulatory molecules like CD80 and CD86 on macrophages. It is widely recognised that the skin serves as a protective barrier against ultraviolet radiation (UVR) and other contaminants, as it is the outermost layer of our body. Exposure to traffic-related pollutants, such as polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), oxides, and particulate matter (PM), can lead to the development of coloured patches on our skin. When pollutants enter the body through the skin or are breathed in, they can cause harm to the organs. Some of these pollutants are capable of causing genetic mutations and cancer, particularly affecting the liver and lungs. Conversely, air pollutants present in the troposphere mitigate the harmful impacts of ultraviolet radiation (UVR) in polluted metropolitan regions. The absorption of air pollutants by the human skin can potentially lead to skin ageing, psoriasis, acne, urticaria, eczema, and atopic dermatitis. These conditions are typically caused by exposure to oxides and photochemical smoke. Exposure to particulate matter (PM) and cigarette smoking are factors that accelerate the ageing process of the skin, resulting in the formation of spots, dyschromia (abnormal pigmentation), and wrinkles. Furthermore, there is a correlation between pollution and the development of skin cancer.

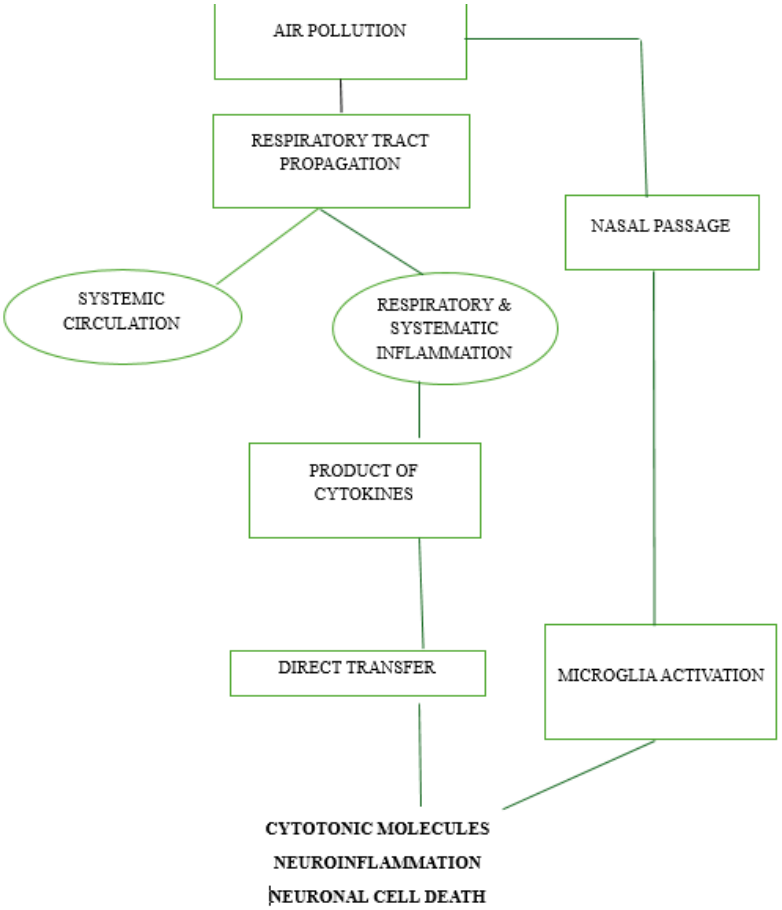
Foetuses and children are more likely to experience increased morbidity when exposed to the aforementioned hazards. Reports have indicated that there is a correlation between impaired foetal growth, low birth weight, and autism. The eye is another external organ that may be impacted. Contamination typically arises from suspended contaminants and can lead to asymptomatic eye conditions, irritation, retinopathy, or dry eye syndrome.

Environmental Impact of Air Pollution:

Air pollution harms humans and the environment. The main environmental consequences are these. Acid rain contains hazardous nitric and sulfuric acids in rain, fog, snow, or particles and gas. They destroy trees, plantations, buildings, outdoor sculptures, constructions, and statues, and acidify water and soil. Fine particles in the air create haze, reducing atmospheric transparency. Gas emissions from factories, power plants, cars, and trucks cause it. Ozone exists at ground level and in the stratosphere of Earth's atmosphere. Stratospheric ozone shields humans from the

Sun's UV radiation. Ground-level ozone is toxic and polluting. Unfortunately, chemicals, insecticides, and aerosols deplete stratospheric ozone. If the stratospheric ozone layer thins, UV radiation can reach Earth, causing skin cancer and crop damage. Ozone closes plant stomata, blocking CO2 transport and reducing photosynthesis. World climate change is a major issue. The “greenhouse effect” maintains Earth's temperature. Unfortunately, greenhouse gas emissions have disrupted this protective temperature effect, causing global warming, which harms humans, animals, forests, wildlife, agriculture, and the aquatic environment. A report says global warming increases impoverished people's health risks.

As temperatures rise, poorly built buildings in warm-climate countries put residents at risk for heat-related illnesses. When exposed to high quantities of air, soil, or water contaminants, wildlife might experience health issues. Failure to reproduce and birth defects have occurred. Eutrophication occurs when elevated nutrient concentrations (particularly nitrogen) induce aquatic algae blooms, which causes fish diversity imbalance and death. A critical pollution concentration that an ecosystem may sustain without being destroyed is related to its acidity neutralisation capability. The Canada Acid Rain Programme set this load at 20 kg/ha/yr. Air pollution harms soil and water. As an air contaminant, PM affects agricultural output and food productivity. Its effects on waterways affect fish and animal survival and productivity. Ozone-exposed plants have impaired photosynthetic rhythm and metabolism. Acid rain is caused by sulphur and nitrogen oxides, which affect plants and marine life.Finally, lead and other metals' toxicity is the biggest threat to our ecosystems (air, water, and soil) and living things.



CONCLUSION

During the inaugural WHO Global Conference on Air Pollution and Health in 2018, Dr. Tedros Adhanom Ghebreyesus, the Director-General of the WHO, characterised air pollution as a "silent public health emergency" and likened it to the harmful effects of tobacco. Without a question, children are more susceptible to the harmful effects of air pollution, particularly throughout their developmental stages. Air pollution has detrimental impacts on various aspects of our lives.

Air pollution-related diseases have significant economic and societal consequences, as they result in missed days of work and school attendance. Although it is challenging to completely eliminate the issue of human-caused environmental pollution, a viable solution could involve a close partnership between government authorities, organisations, and medical professionals to establish regulations and address the problem. Governments should provide ample information and provide education to the public, while also engaging specialists, in order to effectively manage the growth of the problem.

It is imperative to establish and implement technologies that can effectively mitigate air pollution at its origin, and these technologies should be universally adopted across all businesses and power plants. The primary objective of the Kyoto Protocol, established in 1997, was to achieve a significant decrease in greenhouse gas (GHG) emissions, aiming for a reduction of less than 5% by the year 2012. Subsequently, the Copenhagen summit in 2009 was succeeded by the Durban summit in 2011, at which it was determined to maintain the same course of action. Numerous countries ratified the Kyoto accord and its following iterations. China was one of the early adopters of this crucial protocol for global environmental and climate well-being. China is well recognised as a rapidly growing economy, and it is projected to have a significantly high GDP (Gross Domestic Product) by 2050, coinciding with the dissolution of the convention aimed at reducing petrol emissions.

The Paris Agreement of 2015, established by the United Nations Framework Convention on Climate Change (UNFCCC), is a significant and recent international accord that holds great relevance in addressing climate change. This recent agreement was approved by numerous countries belonging to the United Nations, as well as the member countries of the European Union. Parties should actively encourage efforts and steps to improve various elements related to the subject. Implementing measures such as enhancing education, providing training, increasing public awareness, and promoting public engagement are important steps to maximise the chances of achieving the targets and goals related to the urgent issue of climate change and environmental pollution. Undoubtedly, technology advancements simplify our world, but it is challenging to mitigate the detrimental effects of gas emissions. However, we may minimise their use by using dependable strategies. To effectively address the negative health impacts of air pollution caused by human activities, it is crucial to develop a comprehensive global preventative strategy. Effective management of the problem requires the application of sustainable development practices, along with information derived from research.

Currently, it is crucial to have global collaboration in research, development, policy administration, monitoring, and politics to ensure efficient pollution management. Legislation pertaining to air pollution must be synchronised and revised, while policymakers should propose the development of a robust instrument for safeguarding

the environment and public health. The major argument of this article is that we should prioritise the development of local structures to encourage experience and practice. This may then be expanded to the worldwide level by implementing appropriate regulations for the sustainable management of ecosystems.

Recommendations

Considering the significant public health impact, it is imperative to consider various remedies. Reports have indicated success and efficacy in the management of air pollution, particularly at the municipal level. Appropriate technological methods are utilised, taking into account the origin and characteristics of the emission, as well as its effects on human health and the environment. Schwela and Köth-Jahr have reported on the significance of controlling both point sources and non-point sources of air pollution. Undoubtedly, a comprehensive emission inventory must document all sources within a specified region. In addition to the aforementioned sources and their characteristics, it is important to take into account the terrain and meteorology, as previously mentioned. Evaluation of the control policies and procedures is frequently extended from the local level to the regional level and subsequently to the global level. Air pollution can be diffused and transmitted across long distances to distant regions. Air pollution management refers to the process of decreasing air pollutants to levels that are considered acceptable or even eliminating them altogether. These pollutants have a detrimental impact on both human health and the whole environmental ecology. Both private and public companies and authorities take measures to ensure air quality. The World Health Organisation (WHO) and the Environmental Protection Agency (EPA) have established air quality standards and guidelines to effectively regulate air quality. These standards and guidelines address various pollutants. In order to identify areas of concern, it is necessary to compare these criteria with the emissions inventory standards through causal analysis and dispersion modelling. Inventories often rely on a blend of actual measurements and emissions modelling.

For instance, we will discuss the control mechanisms implemented at the origin by utilising catalytic converters in automobiles. These devices utilise catalysis through redox processes to convert the pollutants and hazardous gases emitted from combustion engines into less harmful pollutants. In Greece, the utilisation of private automobiles was limited by monitoring their licence plates with the aim of mitigating traffic congestion during peak hours. Regarding industrial emissions, the use of collectors and closed systems can effectively reduce air pollution to meet the minimum levels mandated by regulation. Estimating the economic worth of the benefits obtained from suggested programmes is necessary in current efforts to enhance air quality. The public authorities have put forth these planned programmes and directives, which come with guidelines that must be followed.

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