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Review Article

Air pollution: health and environmental impacts

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ABSTRACT
Air pollution is one of the biggest problems of our day, not only because it contributes to climate change but also because it has a negative effect on public and individual health due to rising morbidity and mortality. There are several contaminants that play a significant role in human illness. Particulate Matter (PM), which has a varied but extremely small diameter, is one of them. By inhaling it, it damages the respiratory and cardiovascular systems, the reproductive and central neurological systems, and even causes cancer. Ozone, which protects against UV light in the stratosphere, is detrimental when it is present in large quantities below ground level because it also affects the cardiovascular and respiratory systems. In addition, air pollutants that are detrimental to people include nitrogen oxide, sulphur dioxide, volatile organic compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs). High concentrations of carbon monoxide can even result in immediate toxicity when inhaled. Depending on the exposure, heavy metals like lead can either cause acute poisoning or chronic intoxication when absorbed into the human body. Chronic obstructive pulmonary disease (COPD), asthma, bronchiolitis, lung cancer, cardiovascular events, central nervous system dysfunctions, and skin illnesses are the primary diseases brought on by the aforementioned drugs. Last but not least, environmental pollution-induced climate change has an impact on both natural catastrophes and the geographic spread of numerous infectious illnesses. The public must be made aware of the issue, and scientific professionals must attack the issue from a variety of angles. National and international organisations must confront the rise of this threat and offer viable answers.

1. Introduction

Numerous human activities have an impact on the environment, which has led to substantial study of how people and their physical surrounds interact. The biotic (living things and microbes) and abiotic (non-living things) are coupled in the environment. (hydrosphere, lithosphere, and atmosphere). According to the definition of pollution, it occurs when elements that are hazardous to people and other living things are released into the environment. Pollutants are toxic solids, liquids, or gases that affect our environment and are created in greater quantities than usual.

The air we breathe, the water we drink, and the soil where plants grow are all contaminated by human activity, which has a negative impact on the environment. The industrial revolution was very successful in terms of technology, society, and the delivery of many services, but it also brought about the generation of large amounts of air pollutants that are dangerous to human health. Environmental contamination on a worldwide scale is without a doubt seen as a complex international public health concern. This significant issue is connected to social, economic, legal, and lifestyle choices. Clearly, in our day, urbanisation and industrialisation are escalating to unprecedented and alarming levels around the world. Given that anthropogenic air pollution causes over 9 million deaths annually [1], it is one of the greatest global public health risks.

All of the aforementioned are unquestionably directly related to climate change, and if a threat arises, the implications might be disastrous for humanity [2]. Multiple ecosystems are negatively impacted by climate change and the consequences of global warming, leading to challenges with food safety, ice and iceberg melting, animal extinction, and plant damage [3, 4]. Various health implications of air pollution exist. Even on days with little air pollution, vulnerable and sensitive people's health might be negatively impacted. Chronic obstructive pulmonary disease (COPD), coughing, shortness of breath, wheezing, asthma, respiratory diseases, and high hospitalisation rates are all strongly correlated with short-term exposure to air pollution. (a measurement of morbidity).

Chronic asthma, pulmonary insufficiency, cardiovascular illnesses, and cardiovascular mortality are the long-term impacts of air pollution. Diabetes appears to be brought on by prolonged exposure to air pollution, claims a Swedish cohort research [5]. Additionally, it appears that air pollution has a number of detrimental health consequences on developing humans, including respiratory, cardiovascular, mental, and perinatal abnormalities [3], which can result in newborn death or chronic disease later in life [6].

The higher risk of morbidity and death has been recognised in national reports [1]. Studies showing a connection between daily ranges of particulate matter (PM) concentration and daily mortality were carried out all over the world. Climate changes and planetary warming [3] may make things worse. Additionally, a rise in hospitalisation (a measure of morbidity) has been noted among vulnerable seniors and

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older people. Due to their ability to enter the most confined airways and more readily enter the circulation, fine and ultrafine particulate matter appears to be linked to more severe diseases [6].

People who live in major metropolitan areas are most affected by air pollution, which is mostly caused by vehicle emissions. Industrial accidents also pose a risk since they might disseminate poisonous fog that is lethal to the local people. Numerous factors, most notably atmospheric stability and wind, affect how pollutants spread [6].

Due to overpopulation, unchecked urbanization, and the growth of industrialisation, the issue is worse in emerging nations [7]. Poor air quality results from this, especially in nations with socioeconomic inequalities and a lack of knowledge about environmentally sound management practises. People are exposed to poor-quality, filthy air at home when they utilise fuels like wood fuel or solid fuel for household requirements owing to low wages. It is noteworthy that three billion people use the aforementioned energy sources for cooking and heating on a daily basis [8]. Due to their prolonged exposure to indoor air pollution in developing nations, the women of the home appear to be at the greatest risk for illness development [8, 9]. China is one of the Asian nations with the worst air pollution concerns as a result of its rapid industrial expansion and overcrowding [10, 11]. Fine particles are linked to the lung cancer mortality seen in China [12]. As previously mentioned, prolonged exposure has negative effects on the cardiovascular system [3, 5].It's noteworthy to note that cardiovascular disease has been seen more frequently in developed, high-income nations than in low-income, emerging nations that are heavily exposed to air pollution [13]. In India, when the air quality reaches dangerous levels, extreme air pollution has been documented. One of the most polluted cities in India is New Delhi. Due to the limited visibility brought on by air pollution, flights into and out of New Delhi International Airport are frequently cancelled. India's rapid industrialisation, urbanization, and surge in motorbike use have resulted in pollution in both urban and rural regions. Nevertheless, a significant contributor to home air pollution in India and Nepal is biomass combustion related to demands and practises for cooking and heating [14, 15]. In India, there is geographic heterogeneity because various climatological regions, populations, and levels of education produce varying indoor air quality. For example, north Indian states have higher PM 2.5 levels than southern ones (183-214 $\mu g/m^3$) [16, 17]. This may be due mostly to the frigid environment of North Indian regions, where longer stretches at home require more heating than they would in the warm climate of Southern India.In India, household air pollution is linked to serious health impacts, especially in women and small children who spend more time indoors. Lung cancer and chronic obstructive pulmonary disease (CORD) affect predominantly women, whereas acute lower respiratory illness affects children under the age of five [18].

In December 1952 in London and in 1963 in New York City, the number of deaths increased as a result of an accumulation of air pollution, particularly sulphur dioxide and smoke, reaching 1,500 mg/m^3 [19]. Based on the monitoring of outdoor pollution in six US metropolitan centers, a correlation between pollution and mortality has been documented [20]. In every instance, it appears that the levels of fine, inhalable, and sulphate particles were more closely correlated with mortality than the levels of total particulate pollution, aerosol acidity, sulphur dioxide, or nitrogen dioxide [20].

Additionally, Mexico City and Rio de Janeiro have been reported to have exceptionally high pollution levels, followed by Milan, Ankara, Melbourne, Tokyo, and Moscow [19]. Different types of treatments should definitely be considered, depending on the severity of the public health effect. There have been reports of success and efficacy in reducing air pollution, particularly at the local level. The application of adequate technological tools takes into account the emission's type, source, and effects on human health and the environment. According to Schwela and Köth-Jahr [21], controlling point and non-point sources of air pollution is crucial. Unquestionably, a thorough emission inventory must list each source in a certain location. Topography and meteorology should also be taken into account, in addition to the sources mentioned above and their nature, as was previously indicated. Extrapolation of the evaluation of the control policies and procedures from the local to the regional to the global scale is common. It is possible for air pollution to spread and move from one location to another that is far away. The management of air pollutants that have a negative impact on human health or the environment's ecology entails bringing them down to acceptable levels or perhaps getting rid of them altogether. Actions are taken by private and public bodies to ensure the quality of the air [22]. The WHO and EPA adopted air quality standards and recommendations for the various contaminants as a management tool [1, 23]. To identify the problematic locations, these criteria must be matched to the emissions inventory standards using causal analysis and dispersion modelling [24]. Typically, actual measurements and emissions modelling are used to create inventories [24].

We use the usage of catalytic converters in automobiles as an illustration of the source-level control measures here. These tools catalyse redox processes to transform the pollutants and hazardous gases produced by combustion engines into less dangerous pollutants [25]. To lessen traffic congestion during rush hour, the usage of private vehicles was restricted in Greece by monitoring their licence plates [25]. Collectors and closed systems can reduce industrial emissions' air pollution to levels below the legal minimums [26]. The economic worth of the advantages achieved from suggested programmes must be estimated in order to implement current air quality improvement techniques. These suggested governmental policies, directives, and programmes come with expectations that must be upheld.

For the purpose of setting off planning claims, air quality limit values, or AQLVs, are established throughout Europe [27]. The national air quality limit values in the USA are established by the NAAQS (National Ambient Air Quality Standards) [27]. Despite the fact that regulations and directives are based on various methods, great progress has been made in reducing total emissions and the resulting consequences on human health and the environment [27]. The USA establishes global geographical air quality criteria according to the severity of their air quality problem and records all sources of pollutants and their precursors, whereas the European Directive identifies geographical areas of risk exposure as monitoring/assessment zones to record the emission sources and levels of air pollution [27]. In a similar spirit, monies have been used to directly or indirectly finance initiatives relating to air quality as well as the necessary technological infrastructure. These plans concentrate on a list of datasets from environmental planning and air quality awareness programmes. In metropolitan locations, it is also possible to apply pollution control measures for air emissions from machineries, machines, and factories.

The only way for technological innovation to succeed is if it can satisfy societal requirements. In order to facilitate the provision of information and assessments and help decision-makers reach the best judgements possible, technology must mirror the practises and processes used by persons involved in risk assessment and evaluation. In conclusion, the following factors must be taken into account when developing an effective air quality control strategy: environmental factors, ambient air quality conditions, engineering factors, air pollutant characteristics, and finally, financial operating costs for technological advancement as well as administrative and legal costs. Competitiveness via neoliberal ideals is providing an answer to environmental problems when the economic aspect is taken into account [22].

The deployment of a conversation has been sparked by the growth of environmental regulation and technology advancement. Different political parties, scientists, the media, and governmental and non-governmental organisations now have disagreements and grounds of conflict due to environmental politics [22]. Actions and movements for radical environmental activism have been developed [22]. It is frequently investigated if and how the development of new information and communication technologies (ICTs) has affected social movements including activism and communication methods [28]. The phrase "digital activism" has been used more often and across a wide range of fields since the 1990s [29]. Modern digital technology allow for the creation of digital activism on environmental concerns. In order to seek change in political and social events, gadgets with online capabilities, such as laptops or mobile phones, are being employed [30].

In the current study, we concentrate on the causes of environmental pollution in connection to public health and offer some suggestions and interventions that can be of interest to lawmakers and decision-makers in the field of environmental protection.

2. Sources of exposure

The usage of large-scale human activities including autos, power plants, combustion engines, and industrial machines is recognised to release the bulk of environmental contaminants. These activities are carried out on such a vast scale that they are by far the biggest sources of air pollution, with vehicles thought to be responsible for almost 80% of it today [31]. Other human activities, such field cultivation methods, petrol stations, fuel tank heaters, and cleaning practices, as well as a number of natural sources, like volcanic and soil eruptions, and forest fires, are all having a little impact on our environment [32].

The primary factor used to categorise air pollutants is the sources of the pollution. Because of this, it is important to note the four primary sources, which are as follows: Major sources, Area sources, Mobile sources, and Natural sources.

The chemical and fertiliser industries, metallurgical and other industrial plants, power plants, refineries, and petrochemicals, as well as municipal incineration, are major sources of pollution.

Domestic cleaning tasks, dry cleaning, print businesses, and gas stations are a few indoor area sources.

Automobiles, cars, trains, planes, and other sorts of transportation are examples of mobile sources.

As previously mentioned, physical catastrophes [33] including forest fires, volcanic erosion, dust storms, and agricultural burning are included in the category of natural causes.

Nevertheless, several categorization schemes have been put forward. Groupings based on the source of the pollution are another sort of categorization, as seen in the following examples:

When there are significant amounts of contaminants present in the air over extended periods of time, it is considered to be polluted. Dispersed particles, hydrocarbons, CO, CO_2, NO, NO_2, SO_3, etc. are examples of air pollutants.

High levels of biological, inorganic, and organic charges in water pollution [10] have an impact on the water's quality [34, 35].

Chemical spills or waste disposal including pesticides, heavy metals, or hydrocarbons can lead to soil contamination.

By contaminating precipitation that falls into water and soil settings, air pollution can affect the quality of soil and water bodies [34, 36]. Notably, acid precipitation can change the chemistry of the soil by impacting plants, cultures, and water quality [37]. Additionally, soil acidity favours the migration of heavy metals, and as a result, metals are flowing into the aquatic ecosystem. It is well known that fish and animals are poisoned by heavy metals like aluminium. Since soils with low calcium carbonate levels are more vulnerable to acid rain, soil quality appears to be significant. Snow and particle debris also fall into aquatic bodies in addition to rain [36, 38].

Finally, pollution is categorised according to the kind of origin:

Nuclear and radioactive pollution is caused by the management or disposal of radioactive sewage as well as nuclear explosions and accidents that release radioactive and nuclear pollutants into the water, air, and land.

Because they are harmful to the environment, plants, animals, and people, radioactive materials have the potential to pollute bodies of surface water. Numerous radioactive chemicals, including radium and uranium, are known to accumulate in the bones and to be carcinogenic [38, 39].

Machines, trucks, traffic noises, and musical installations all contribute to noise pollution, which is damaging to our hearing.

The term "DALYs" was first used by the World Health Organization. The DALYs for an illness or health condition are calculated as the product of Years of Life Lost (YLL) from population premature mortality and Years Lost due to Disability (YLD) from those who have the disease or its effects [39]. In Europe, noise pollution and air pollution are the two primary contributors to disability adjusted life years lost

(DALYs). Studies have been done on the potential connections between air pollution and noise and health [40]. The effects of ambient noise on cardiovascular disease were shown to be independent of air pollution, leading the study to conclude that DALYs due to noise were more significant than those associated to air pollution [40]. Environmental noise need to be considered a separate concern to the public's health [40].

Changes in the physical, chemical, or biological components of the environment (air masses, temperature, climate, etc.) result in environmental pollution.

By introducing hazardous poisonous compounds or raising levels above the usual, pollutants damage our ecosystem. The aforementioned sources directly create primary pollutants, whereas secondary pollutants are released as byproducts of primary pollutants. As previously mentioned, pollutants can be both natural and manmade, biodegradable or non-biodegradable. Additionally, they may have a single source (a point source) or several sources that are distributed.

Different pollutants have different physical and chemical characteristics, which explain why they might have different levels of toxicity. As an illustration, we argue that because of their microscopic size (solid or liquid) in the atmosphere and their larger penetration capability, aerosol chemicals [41–43] are more dangerous than gaseous compounds. Our respiratory system can more easily get rid of gases [41]. Millions of people die prematurely each year as a result of these particles, which can harm the lungs and even enter the bloodstream [41]. Additionally, the generation of secondary organic aerosols (SOA) appears to be significantly increased by aerosol acidity, while other scientific teams disagree [38].

3. Climate and pollution

Air pollution and climate change are closely related. The climate is another element that lowers the standard of our planet [44]. Aerosols, methane, black carbon, and tropospheric ozone are a few contaminants that have an effect on how much sunlight gets into the atmosphere. As a result, the temperature of the Earth is increasing, which leads to the melting of glaciers, icebergs, and ice.

Similar to this, climate change will affect the frequency and prevalence of both imported and recurrent diseases in Europe. The length, timing, and intensity of outbreaks as well as the global dispersion of infectious diseases are all significantly influenced by climate and weather [45]. Mosquito-borne parasitic or viral illnesses are extremely climate-sensitive because warming both shortens the pathogen's incubation time and changes the vector's geographic range. This results in a high frequency of waterborne infections, just like how climate change warms water. Malaria, cholera, poliomyelitis, and tick-borne encephalitis all seem to be making a comeback in Europe as a result of recent population movement [46].

The spread of infections is connected to natural weather disasters like storms, which seem to happen more frequently these days [47]. Undernutrition and immune system dysregulation are also associated with the emerging diseases that are endangering public health [48].

As outbreaks of the disease were reported in Italy [49] and France [50], the Chikungunya virus "took the aeroplane" from the Indian Ocean to Europe.

Following floods, there appears to have been an upsurge in cryptosporidiosis in the Czech Republic and the United Kingdom [36, 51].

As previously mentioned, aerosol compounds, despite their small size, have a significant impact on the climate. Over the past 30 years, they have lowered the global temperature by scattering a quarter of the sun's rays back into space (the albedo phenomenon).

4. Air pollutants

The World Health Organization (WHO) provides information on six main air pollutants: lead, nitrogen oxides, sulphur oxides, ground-level ozone, and particle pollution. Groundwater, soil, and air are just a few of the elements of the ecosystem that can be severely harmed by air pollution. Furthermore, it seriously endangers all living things. In this sense, these pollutants are the major subject of our interest since they are linked to more serious and broad issues with both human health and the environment. A significant ecological influence on air pollution is caused by factors such as acid rain, global warming, the greenhouse effect, and climatic changes [53].

4.1 Particulate Matter (PM) and health

Studies that concentrated on either short-term (acute) or long-term (chronic) PM exposure have demonstrated a link between particulate matter (PM) and unfavourable health outcomes.

Typically, chemical interactions between the various pollutants result in the formation of particulate matter (PM) in the atmosphere. The size of the particle has a significant impact on its penetration [53]. The United States Environmental Protection Agency used the term "particulate matter" (PM) to refer to these tiny objects [54]. Particulate matter (PM) pollution consists of extremely tiny particles with dimensions typically 2.5 micrometres and smaller, as well as particles with a diameter of 10 micrometres or less, known as PM_{10}.

Tiny liquid or solid droplets included in particulate matter can be ingested and have detrimental effects on one's health [55]. After inhalation, PM_{10} particles (<10μm) can penetrate the lungs and even enter the bloodstream. Health risks are greatest from fine particles, or $PM_{2.5}$ [6, 56].

The consequences of PM on health have been the subject of several epidemiological research. Both short-term and long-term exposures to $PM_{2.5}$ were found to be positively correlated with acute nasopharyngitis [56]. Long-term exposure to PM has also been linked to newborn mortality and cardiovascular disorders, according to research.

Due to a lack of spatially resolved daily $PM_{2.5}$ concentration data, those studies, which rely on $PM_{2.5}$ monitors, are constrained in terms of study region or city area and, as a result, are not representative of the full population. According to a recent epidemiological study by the Department of Environmental Health at the Harvard School of Public Health (Boston, MA) [57], an exposure error (Berkson error) seems to be produced as PM2.5 concentrations vary spatially, and the relative magnitudes of the short- and long-term effects are still not fully understood. Based on remote sensing data, the researchers created a $PM_{2.5}$ exposure model to evaluate both short- and long-term human exposures [57]. This model enables the assessment of long-term impacts throughout the whole population as well as geographic resolution in short-term effects.

Additionally, immune system dysfunction and respiratory conditions are listed as long-term chronic consequences [58]. It is important to note that patients with respiratory and cardiovascular problems, diabetes, asthma, pneumonia, and other illnesses are more prone to the effects of PM. Since $PM_{2.5}$ and PM_{10} are able to pierce interior spaces, they are closely linked to a variety of respiratory system disorders [59, 60]. The chemical and physical characteristics of the particles cause harmful consequences. Both organic (polycyclic aromatic hydrocarbons, dioxins, benzene, and 1-3 butadiene) and inorganic (carbon, chlorides, nitrates, sulfates, and metals) substances may be found in PM_{10} and $PM_{2.5}$ components [55].

According to kind and size, PM is separated into four major types [61].

PM in aerial masses is one type of gas pollutant.

pollutants such as smog, soot, cigarette smoke, oil smoke, fly ash, and cement dust are examples of particulate pollutants.

Microorganisms (bacteria, viruses, fungus, mold, and bacterial spores), cat allergies, household dust and allergens, and pollen are all examples of biological contaminants.

There are several types of dust, such as heavy dust, settling dust, and suspended air dust.

Another fact is that because PM_{10} and $PM_{2.5}$ particles are so small, their half-lives in the atmosphere are prolonged. This allows for their prolonged suspension in the air as well as their transfer and spread to far-off locations where people and the environment may be exposed to the same level of pollution [53]. They have the power to harm forests and crops, alter the nitrogen balance in aquatic ecosystems, and acidify bodies of water.

As previously said, $PM_{2.5}$ are having more severe health consequences because to their minute size. The production of "haze" in various urban locations is mostly caused by the aforementioned tiny particles [12, 13, 61].

4.2 Ozone impact in the atmosphere

When oxygen is subjected to a high voltage electric discharge, ozone (O_3) is created as a gas [62]. It is a powerful oxidant that is 52% more potent than chlorine. It develops in the stratosphere but might potentially develop as a result of photochemical smog chain reactions in the troposphere [63].

Ozone may move with air masses and reach locations far from its original source [64]. Ozone levels over cities are surprisingly low compared to the elevated levels found there, which might be damaging for cultures, forests, and plants [65] as well as limiting carbon absorption [66]. Ozone's antibacterial ability impacts the plant microflora and lowers development and yield [47, 48] as well as [67, 68]. In this sense, ozone affects other natural ecosystems, affecting the species makeup of both microflora [69, 70] and animal species [71]. Ozone worsens cellular function and promotes DNA damage in epidermal keratinocytes [72].

Nitrogen oxides and volatile organic compounds (VOCs) released from natural sources and/or as a result of human activity combine chemically to form ground-level ozone (GLO).

Inhalation is the typical method of ozone absorption. The tear ducts and higher layers of the skin are also impacted by ozone [73]. Malondialdehyde production in the upper skin layer (epidermis) and vitamin C and E depletion were both seen in a research where mice were exposed to high amounts of ozone for a brief period of time. Ozone levels are probably not affecting the function and integrity of the skin barrier to make people more susceptible to skin diseases [74].

Inhaled ozone has the ability to reach deep into the lungs due to its poor water solubility [75].

Ozone's toxic effects have been linked to biochemical, morphologic, functional, and immunological diseases in metropolitan areas across the world [76].

The acute effects of ambient ozone concentrations on mortality are the main focus of the European project (APHEA2) [77]. Over a three-year period, data on daily ozone concentrations and fatality rates were reported from several European cities. The number of fatalities per day (0.33%), respiratory deaths (1.13%), and cardiovascular deaths (0.45%) all increased during the warm season of the year when there was a rise in ozone concentration. Wintertime saw no change in the situation.

4.3 Carbon monoxide (CO)

When fossil fuels burn incompletely, carbon monoxide is created. An inhalation of carbon monoxide can cause poisoning, which manifests as headaches, dizziness, weakness, nausea, vomiting, and, in the end, unconsciousness.

Compared to oxygen, carbon monoxide has a far stronger affinity for haemoglobin. In a similar vein, those who are exposed to high quantities of carbon monoxide over an extended length of time may suffer from severe poisoning. Hypoxia, ischemia, and cardiovascular illness are seen as a result of the loss of oxygen caused by the competitive binding of carbon monoxide.

The greenhouse gases that are closely linked to climate change and global warming are impacted by carbon monoxide. The temperature of the soil and water should rise as a result, and severe weather or storms may develop [68].

However, it has been seen to induce greater plant growth in laboratory and field trials [78].

4.4 Nitrogen oxide (NO_2)

Because it is released by car engines, nitrogen oxide is a contaminant associated with traffic [79, 80]. It irritates the respiratory system and, when breathed at high concentrations, causes respiratory illnesses, coughing, wheezing, dyspnea, bronchospasm, and possibly pulmonary edoema. Humans appear to experience these negative effects at doses over 0.2 ppm, whereas T-lymphocytes, namely the CD8+ cells and NK cells that form our immunological response, are affected at quantities above 2.0 ppm [81].According to reports, chronic lung illness may be caused by prolonged exposure to high concentrations of nitrogen dioxide. The sense of smell may become impaired after prolonged NO_2 exposure [81].

However, other systems outside the respiratory system may be affected, as seen by symptoms including eye, throat, and nose discomfort [81].

Because high amounts of nitrogen dioxide have been shown to lower agricultural production and plant development efficiency, they are harmful to vegetation and crops. Additionally, NO_2 can deteriorate materials' colours and diminish visibility [81].

4.5 Sulfur dioxide (SO_2)

Sulfur dioxide is a dangerous gas that is mostly released after the use of fossil fuels or during industrial processes. 0.03 ppm is the yearly standard for SO2 [82]. Humans, animals, and plants are all impacted. People at risk for harm include individuals with lung conditions, the elderly, and young children. Respiratory irritation, bronchitis, mucus production, and bronchospasm are the main health issues linked to sulphur dioxide emissions in industrialised areas because it is a sensory irritant and penetrates deep into the lung where it is converted to bisulfite and interacts with sensory receptors to cause constriction. Additionally, skin redness, eye and mucous membrane damage (lacrimation and corneal opacity), and aggravation of pre-existing cardiovascular disease have also been reported [81].

Sulfur dioxide emissions appear to be linked to negative environmental impacts such soil acidification and acid rain [83].

4.6 Lead

Lead is a heavy metal that is employed in a variety of industrial settings and released into the environment by some petrol motors, batteries, radiators, waste incinerators, and waste waters [84].

Metals, mining, and piston-engine aircraft are other significant contributors of lead pollution in the atmosphere. Due to its harmful effects on people, animals, and the environment, lead poisoning poses a risk to public health, particularly in developing nations.

Lead exposure can happen by eating, inhalation, or skin absorption. Lead has also been observed to be transported through the placenta because it may pass through unhindered [85]. The toxic effects become more damaging the younger the foetus is. The foetal nervous system is impacted by lead poisoning, and edoema or brain swelling is seen. When lead is breathed, the blood, soft tissue, liver, lungs, bones, cardiovascular, neurological, and reproductive systems all acquire lead. Adults were also noted to experience muscular and joint discomfort, memory loss, and lack of attention [85].

Because lead is a neurotoxicant that may cause learning impairments, memory loss, hyperactivity, and even mental retardation, children and infants are highly vulnerable to it, even at very low levels.

Increased lead levels in the environment are detrimental to the development of plants and crops. Animals and vertebrates with high lead concentrations have neurological consequences.

4.7 Polycyclic aromatic hydrocarbons (PAHs)

Since the atmosphere is the primary mechanism of their dispersion, PAHs are found everywhere in the environment. They are found in sediments of tar and coal. Furthermore, they come from the incomplete combustion of organic waste that occurs in motor exhaust, incineration, and forest fires. Benzopyrene, acenaphthylene, anthracene, and fluoranthene are examples of PAH chemicals that are known to be poisonous, mutagenic, and carcinogenic. They are a significant lung cancer risk factor.

4.8 Volatile organic compounds (VOCs)

Human cancer has been linked to volatile organic chemicals (VOCs) such toluene, benzene, ethylbenzene, and xylene. Actually, the usage of new goods and materials has led to higher VOC concentrations. VOCs contaminate the air within buildings and may be harmful to human health. There are both immediate and long-term negative impacts on human health. Indoor air odours are caused by VOCs. Long-term exposure can result in hazardous effects, while short-term exposure has been shown to irritate the eyes, nose, throat, and mucous membranes. Complex VOC combinations can have effects that are synergistic, antagonistic, or neutral, making it difficult to predict how harmful they will be.

4.9 Dioxins

Dioxins occur from both industrial and natural activities, including volcanic eruptions and forest fires. They gather in meals like meat, dairy products, fish, and shellfish, but they concentrate in particular in the fatty tissue of animals.

Lesions and black patches on the skin may appear as a result of brief exposure to high dioxin concentrations. Long-term exposure to dioxins can result in cancer, immunological, endocrine, and neurological system dysfunction, as well as issues with development.

There is no question that using fossil fuels contributes significantly to air pollution. This contamination may be caused by humans, such as during transportation or agricultural and industrial activities. However, contamination from natural sources is also conceivable. It is interesting to note that the European Air Quality Directive's criteria for air quality are a little less stringent than the harsher WHO recommendations.

5. Health impacts of air pollution

Particulates Matter and ground-level ozone are the most prevalent air contaminants. (PM). Air pollution may be divided into two categories:

Ambient air pollution is the kind that occurs outside.

The pollution produced by fuel combustion in homes is known as indoor pollution.

People who are exposed to excessive levels of air pollution have illness symptoms and states that range in severity. These consequences are divided into those that affect health in the short- and long-term.

Older persons, children, people with diabetes, and those who have a history of heart disease or lung illness, particularly asthma, are among the vulnerable groups that need to be aware of health protective measures.

The relative magnitudes of the short- and long-term impacts have not been fully defined [57] due to the various epidemiological techniques and exposure mistakes, as it has been widely mentioned earlier, according to a recent epidemiological research from the Harvard School of Public Health. For more effective evaluation of short- and long-term human exposure data, new models are proposed [57]. As a result, we include both broad concerns for both types of impacts in this section as well as the more frequent short- and long-term health consequences, which are frequently influenced by the environment, dosage, and individual sensitivity.

The short-term symptoms are transient and can range from minor discomfort, such as irritation of the eyes, nose, skin, and throat, to more serious conditions, such as asthma, pneumonia, bronchitis, and lung and heart issues. Headaches, nausea, and lightheadedness can also result from brief exposure to air pollution.

Extended long-term exposure to the pollutants, which is damaging to the neurological, reproductive, and respiratory systems and causes cancer and, in rare cases, death, can exacerbate these issues.

The chronic long-term consequences can be fatal, lasting for years or your whole life. A variety of malignancies may also develop over time due to the toxicity of several air contaminants.

As was already mentioned, breathing in air contaminants is strongly linked to respiratory illnesses. Through the airways, these contaminants will enter the body and gather in the cells. The component of the pollutant involved, as well as its source and dose, should be matched to the damage to the target cells. The country, region, season, and time all have a significant impact on health. In connection to the aforementioned criteria as well, prolonged exposure to the pollutant should be associated with long-term health impacts.

Dust, benzene, O_3, and particulate matter (PMs) all seriously harm the respiratory system. Additionally, there is an added danger if a respiratory condition like asthma is already present. People with a predisposed illness condition are more likely to have long-term repercussions. After an acute exposure to contaminants, vocal changes may be seen if the trachea is affected. Air pollution may cause chronic obstructive pulmonary disease (COPD), which raises morbidity and death. The primary causes of COPD risk include the long-term impacts of air pollution from industry, transportation, and fuel burning.

After exposure to air pollution, several cardiovascular consequences have been seen. Long-term exposure-induced changes in blood cells may have an impact on how well the heart functions. Long-term exposure to traffic emissions has been linked to coronary arteriosclerosis, but short-term exposure has been linked to hypertension, stroke, myocardial infarctions, and heart failure. According to reports, prolonged exposure to nitrogen oxide in humans results in ventricular hypertrophy. (NO_2).

After prolonged exposure to air pollution, both adults and children have experienced neurological impairments.

Long-term air pollution appears to be linked to psychological issues, autism, retinopathy, foetal development, and low birth weight [83]. Although the cause of the neurodegenerative illnesses (Parkinson's and Alzheimer's) is unknown, prolonged exposure to air pollution is thought to be a contributing factor. In particular, food and metals are mentioned as etiological variables, along with pesticides. Among the factors contributing to the onset of neurodegenerative illness include oxidative stress, protein aggregation, inflammation, and neuronal mitochondrial dysfunction.

Dogs that had long-term exposure to a severely polluted location in Mexico showed signs of brain inflammation. In adults, it was discovered that PNC immediately elevated the levels of the systemic inflammatory markers IL-6 and fibrinogen, which may have caused the creation of acute-phase proteins. The neurological abnormalities brought on by long-term air pollution appear to be a result of oxidative stress and atherosclerosis development. Inflammation follows oxidative stress and appears to be responsible for numerous organs' impaired embryonic maturation. Similar to how other elements may have a role in developmental maturity, which determines a person's susceptibility to long-term air pollution. These include factors including birthweight, mother smoking, genetic make-up, socioeconomic status, and degree of education.

Diet, beginning with breastfeeding, is another determining element, though. Antioxidants, which are an important component of our defence against air pollution, are mostly obtained from diet. As free radical scavengers, antioxidants prevent free radicals from interacting with one another in the brain. Similar to this, a person's genetic background may affect how susceptible they are to the oxidative stress pathway [60]. For instance, in asthmatic infants homozygous for the GSTM1 null mutation, antioxidant treatment with vitamins C and E appears to modify the impact of ozone [61]. Toll-like receptor 2 of the innate immune system is stimulated by inflammatory cytokines secreted in the periphery, such as respiratory epithelia. Mice exposed to ambient Los Angeles (CA, USA) particulate matter showed such activation in lung lavage, as well as the following events resulting in neurodegeneration [61]. After lead exposure in children, neurodevelopmental morbidities were seen. These kids exhibited aggressive and delinquent conduct, had lower IQs, had trouble in school, and were hyperactive. The scientific community has petitioned the Centers for Disease Control and Prevention (CDC) to lower the existing screening standard of 10 µg/dl because there does not appear to be a "safe" level of lead exposure.

It is crucial to note that poor air quality has an effect on the immune system, leading to malfunction and neuroinflammation. Nevertheless, elevations in blood levels of immunoglobulins (IgA, IgM), as well as C3, are seen. Air pollution also affects antigen presentation because it causes macrophages to overexpress costimulatory molecules including CD80 and CD86.

As the outermost layer of our bodies, skin serves as a protective barrier against ultraviolet radiation (UVR) and other contaminants. The contaminants that are associated with traffic, such as PAHs, VOCs, oxides, and PM, can lead to pigmented lesions on our skin. On the one hand, as was already said, when pollutants enter the body through the skin or are breathed, organ damage is seen since some of these pollutants are mutagenic and carcinogenic, notably affecting the liver and lung. On the other hand, in heavily polluted metropolitan areas, air pollutants (including those in the troposphere) lessen the harmful effects of ultraviolet radiation (UVR). Skin aging, psoriasis, acne, urticaria, eczema, and atopic dermatitis may all be brought on by air pollutants that are absorbed by human skin and are typically brought on by exposure to oxides and photochemical smoke. Smoking and PM exposure speed up the ageing process of the skin by creating wrinkles, dyschromia, and spots. Lastly, skin cancer has been linked to pollution.

When exposed to the aforementioned risks, foetuses and children are found to have higher morbidity rates. There have been reports of autism, low birth weight, and impaired foetal development.

The eye is another external organ that could be impacted. Contamination often results from suspended contaminants and can cause dry eye syndrome, inflammation, retinopathy, or asymptomatic eye damage.

6. Environmental impacts of air pollution

Both the environment in which we live and our health are being harmed by air pollution. The following are the key environmental consequences.

Acid rain is any precipitation, whether wet (rain, fog, snow), dry (particles and gas), or a mixture of both, that contains deadly levels of nitric and sulfuric acids. They have the power to harm plants and trees, damage plantations and structures, and even corrode outdoor statues, constructions, and sculptures.

When tiny particles spread out in the air and lessen the atmosphere's transparency, haze is created. Gases released into the atmosphere by factories, power plants, cars, and vehicles are to blame.

As was previously mentioned, ozone may be found both at ground level and in the upper atmosphere (stratosphere). We are shielded from the Sun's dangerous ultraviolet (UV) radiation by the ozone in the stratosphere. In contrast, ground-level ozone is a pollutant and is bad for human health. Unfortunately, ozone-depleting compounds slowly harm stratospheric ozone. (i.e., chemicals, pesticides, and aerosols). When the ozone layer in our stratosphere thins, UV radiation can enter our atmosphere and harm crops and human life (for example, by causing skin cancer). Ozone enters plants through their stomata and causes them to shut, which prevents CO_2 transport and lowers photosynthesis.

Humanity is concerned about the significant issue of global climate change. The "greenhouse effect," as is well known, maintains the Earth's temperature. Unfortunately, our activities have eliminated this protective temperature impact by releasing significant volumes of greenhouse gases, and as a result, global warming is intensifying and having negative consequences on human health, animal welfare, forests, wildlife, agriculture, and the aquatic environment. According to a research, global warming is raising the health risks for the poor.

As temperatures rise, people who live in shoddy structures in nations with warm climates have a significant risk of developing health issues connected to the heat.

Animals might have health issues when exposed to excessive amounts of pollution because wildlife is burdened by hazardous chemicals from the ecosystem's air, soil, or water. Birth complications and reproductive failure have been documented.

When excessive levels of nutrients, particularly nitrogen, encourage the blossoming of aquatic algae, which can disrupt the variety of fish and result in their demise, eutrophication is taking place.

An ecosystem can only withstand a certain amount of pollution before it is destroyed, and this amount is directly related to the ecosystem's ability to neutralise acidity. This load was set at 20 kg per hectare per year by the Canada Acid Rain Program.

As a result, both soil and water are negatively impacted by air pollution. There have been reports on the effects of PM as an air contaminant on agricultural output and food productivity. Its effects on bodies of water have an effect on how long living things like fish survive as well as how productive they may be.

Rhythm and metabolism of the photosynthetic process are shown to be impaired in plants that have been exposed to ozone's impacts.

Acid rain is created by sulphur and nitrogen oxides, both of which are bad for plants and marine life.

Last but not least, as was already indicated, the major danger to our ecosystems (air, water, and soil) and living things is the toxicity linked with lead and other metals.

7. Conclusions

Dr. Tedros AdhanomGhebreyesus, the general director of WHO, referred to air pollution as "the new tobacco" and a "silent public health emergency" during the inaugural WHO Global Conference on Air Pollution and Health in 2018.

Children are undoubtedly especially susceptible to air pollution, especially while they are developing. Our lives are negatively impacted by air pollution in a variety of ways. Due to absences from productive work and education, illnesses linked to air pollution not only have a significant economic cost, but also have a negative societal impact.

Although eliminating the issue of anthropogenic environmental contamination is challenging, a successful solution might be envisioned as a close partnership between authorities, bodies, and doctors to normalise the condition. To properly stop the problem from emerging, governments must provide enough information, educate the populace, and involve specialists in these matters.

All industry and power plants need to implement technologies to limit air pollution at the source. The reduction of GHG emissions to less than 5% by 2012 was one of the primary goals of the 1997 Kyoto Protocol. The Copenhagen summit in 2009 and the Durban summit in 2011 came after this, at which it was resolved to stick with the same course of action. Many nations approved the Kyoto protocol and the ones that followed. China was one of the forerunners that embraced this crucial protocol for the "health" of the planet's ecology and climate [3]. As is well known, China's economy is rapidly growing, and by 2050—the year the Protocol for Reducing Greenhouse Gas Emissions dissolves—its GDP (Gross Domestic Product) is predicted to be quite high.

The Paris accord of 2015, published by the UNFCCC, is a more recent international accord that is extremely significant for combating climate change. (United Nations Climate Change Committee). Numerous UN (United Nations) nations as well as the EU member states approved this most recent accord. Parties should advocate for actions and initiatives to improve several elements of the topic in this way. In order to maximise the chances of achieving the aims and goals on the essential issue of climate change and environmental pollution, it is important to increase education, training, public awareness, and involvement. Without a doubt, technology advancements make our world simpler, and although it may be challenging to lessen the negative effects of gas emissions, we might restrict their usage by looking for effective solutions.

In conclusion, in addition to properly managing the negative health impacts connected with air pollution, a global preventative programme should be developed to fight anthropogenic pollution. To successfully address the issue, sustainable development practises should be used in conjunction with research-based knowledge.

At this stage, successful pollution management depends on international collaboration in terms of research, development, administration policy, monitoring, and politics. A potent instrument for protecting the environment and public health has to be designed, and air pollution legislation needs to be updated and matched. The major recommendation of this article is that, in order to effectively extrapolate experience and practise to the worldwide level, we should concentrate on establishing local organisations that will support sustainable management of ecosystems.

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