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Review Article

Health and environmental impacts of air pollution: A review

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ABSTRACT
High amounts of air pollution can have a number of negative health effects. Lung cancer, heart disease, and respiratory infections are all at increased risk because of it. Air pollution exposure, both short-term and long-term, has been linked to negative health effects. People who are already unwell are subject to more severe effects. The elderly, children, and those in poverty are more vulnerable. The small PM 2.5 particles that enter deeply into the pulmonary airways are the most dangerous pollutants for human health and are closely linked to excessively early mortality. Inefficient transportation (polluting fuels and cars), inefficient domestic fuel combustion for cooking, lighting, and heating, coal-fired power plants, agriculture, and garbage burning are some of the main contributors of ambient air pollution. This paper examines the effects of air pollution on human health and the environment.

1. Introduction

99% of the world's population is breathing polluted air. This means that more than 782 crore people around the world are forced to breathe in such air, in which the level of air pollution is higher than the standards set by World Health Organization (WHO) [1]. If seen, this poison dissolved in the air can be fatal for their health. This information has come out in the latest data released by the World Health Organization (WHO) on air pollution today. This database has been released in the context of World Health Day (WHD). This is the first time that nitrogen dioxide has also been included in this database.

How serious is the problem of air pollution in the world, one can guess from this that this poison dissolved in the air is killing more than 7 million people every year. However, the WHO has also informed that now more cities are monitoring air quality than before. Significantly, the number of cities monitoring air quality has increased by 2,000 cities compared to earlier [2]. Since the database's debut in 2011, the number of cities exchanging air quality data has multiplied by six. According to the data, air quality is being monitored in more than 6,000 cities in 117 countries.

But despite this, there has been no significant improvement in the air quality there. People living in these cities are still breathing in harmful levels of particulate matter (PM) and nitrogen dioxide. In low- and middle-income nations, this danger is significantly larger if it is observed. Significantly, whereas PM 10 and PM 2.5 levels were under the WHO-set limits in 17% of the monitored cities in high-income nations, this number was less than 1% in low- and middle-income countries [3–9]. According to statistics, data on nitrogen dioxide is being collected in 4000 cities in 74 countries of the world, which showed that about 23% of the population of these places is breathing air that does not meet the air quality guidelines of WHO [10]. Air pollution is actually a mixture of small particles, including the below.

1. Particulate matter (PM_{10}, $PM_{2.5}$): It is composed of tiny liquid drops, soot, and other airborne particles like dust [11]. The majority of particulate matter (PM) in metropolitan areas is produced by the direct combustion of fossil fuels by industrial facilities, vehicles, non-road equipment, and power plants. Dust, diesel emissions, and secondary particle production from gases and vapours are additional sources. It is well known that coarse particulate matter (PM_{10}, particles with a diameter of fewer than 10 microns) can harm the upper respiratory system and the nose. Acute heart attacks, strokes, bronchitis, asthma, and lung disease are all brought on by fine particles ($PM_{2.5}$; particles less than 2.5 microns in diameter), which also has been linked to cancer and lung disease. According to studies, youngsters who are exposed to more $PM_{2.5}$ may not grow their brains as well.

2. Black carbon (BC): It is a part of particulate matter and results from the burning of fuel (especially diesel, wood, and coal). The majority of air pollution restrictions concentrate on PM2.5, but black carbon exposure poses a substantial health risk as well. Heart attacks and strokes are more likely to occur in populations that have had prolonged exposure to black carbon at greater levels. In addition, black carbon has been linked to a number of cancer types, bronchitis, asthma, hypertension, and chronic obstructive pulmonary disease.

3. Nitrogen oxides (NO and NO_2): The transportation industry is primarily responsible for producing nitrogen oxide (NO) and nitrogen dioxide (NO_2). In sunshine, NO is quickly transformed to NO_2. Around roads, NO_x (a mixture of NO and NO_2) is generated in high concentrations, which can cause the

onset and worsening of asthma and bronchitis as well as increase the risk of heart disease [12].

4. Ozone (O_3): High in the atmosphere, ozone can shield us from ultraviolet rays. However, ozone is a known respiratory irritant when it is present at ground level (where it is a component of what is often referred to as smog). Volatile organic molecules and nitrogen oxides, both of which are produced as a result of the combustion of fossil fuels, react to form ozone in the atmosphere. Long-term exposure to ozone can result in impaired lung function and chronic obstructive pulmonary disease, whereas short-term exposure can cause chest pain, coughing, and throat irritation [13]. Ozone exposure can also make pre-existing lung conditions worse.

5. Sulfur dioxide (SO_2): It is released into the atmosphere when sulfur-containing fossil fuels are burned. Fuels containing sulphur are burned in the production of coal, metal mining and smelting, ship engines, and heavy diesel equipment. Sulfur dioxide affects the cardiovascular system, aggravates asthma, worsens eye irritation, and increases susceptibility to respiratory infections [14]. Acid rain, which is known to contribute to deforestation, is primarily composed of sulfuric acid, which is created when SO_2 reacts with water.

3 Overall health effects

Polluted air can have negative health effects on even healthy persons, including respiratory discomfort or breathing issues while exercising or engaging in outdoor activities. Depending on your present state of health, the type and concentration of the pollutants in the air, and how long you were exposed to them, you are actually more likely to have negative consequences.

Increased stress on the heart and lungs, which must work harder to supply the body with oxygen, as well as damaged respiratory system cells are just a few of the immediate health issues that high air pollution levels can result in. Long-term exposure to polluted air can have detrimental impacts on one's health, including faster lung ageing, decreased lung function and capacity, the onset of conditions like asthma, bronchitis, emphysema, and possibly even cancer, as well as a shortened life expectancy. People with heart disease, coronary artery disease, congestive heart failure, lung diseases like asthma, emphysema, or chronic obstructive pulmonary disease (COPD), pregnant women, outdoor workers, older adults, the elderly, kids under the age of 14, and athletes who engage in strenuous outdoor exercise are the ones most at risk for severe health issues from air pollution.

The outdoor air pollution can cause serious harm to health. It has been found that, particulate matter, especially PM 2.5, can enter the lungs and even the bloodstream, causing heart attack, stroke and respiratory disorders. There is also evidence that particulate matter can affect many other parts of the body. It can also increase the risk of many diseases. At the same time, due to nitrogen dioxide, the risk of asthma and other respiratory diseases increases, due to which there may be a need to go to the hospital. Not only this, in many cases it can even kill the patient. Similarly, a research conducted in India has shown that exposure to these microscopic particulates of pollution during pregnancy can lead to low birth weight of newborns, due to which they die soon after birth [15]. At the same time, a research article published in the journal PLOS Medicine has revealed that due to air pollution, about 59 lakh newborns are born prematurely every year around the world, while due to this, about 28 lakh babies are born less than normal at birth.

The pollution caused by cooking remains in the air for a long time. Atmospheric aerosol droplets affect the climate. Harmful pollutants can travel long distances in the air. Therefore the persistence of such aerosols may determine their environmental impact. The organic part of atmospheric aerosols includes a variety of molecules with different functions, which vary with season and environment. Cooking-related pollutants, such as organic aerosols, can linger in the atmosphere for several days. The fatty acids ejected during cooking create nanostructures that are discharged into the atmosphere. figuring out the mechanisms that direct the aerosols' ascent into the atmosphere. The impact they have on the ecology and climate can now be better understood and estimated by scientists. The Central Laser Facility and Diamond Light Source at Oxford's Harwell campus were utilised by specialists from the Universities of Birmingham and Bath to conduct experiments on the behaviour of oleic acid thin films [16]. Cooking typically causes the release of fatty acids. The study examined particular chemical characteristics that control how quickly aerosol emissions can degrade into the atmosphere. The team was therefore able to calculate the potential environmental persistence times for cooking-related aerosols using theoretical models and experimental data.

These aerosols have a long history of being linked to bad air quality in cities, but it can be challenging to determine how they are affecting global warming. This is a result of the wide variety of chemicals present in aerosols and their different environmental consequences. It is now possible to describe how organic aerosols are transported and disseminated in the atmosphere by detecting the nanostructures of molecules generated during cooking, which slow down the breakdown of organic aerosols.

Cooking aerosols may account for up to 10% of particulate matter (PM) emissions in the UK, according to Dr. Christian Pfrang of the University of Birmingham's School of Geography, Earth and Environmental Sciences. We will be able to measure aerosols' role in climate change more accurately by developing precise methods for estimating their behaviour, he said. “We are increasingly finding that cooking allows molecules such as these fatty acids to organize themselves into double layers and other regular shapes and stacks within droplets of aerosols floating in the air,” said co-study Dr. Adam Squires from the University of Bath. How drastically it alters how quickly they break down, how long they remain in the sky, and how they impact air pollution and the weather. The University of Birmingham's Blue Bear high performance and high throughput computer service was used to create and analyse the data. By adopting direct, on-chip water cooling, Blue Bear uses some of the most recent technology to give researchers quick and effective processing efficiencies.

The haze and fog spread in the atmosphere is due to sulfate made from sulfur dioxide and nitrogen oxide. The formation of sulphate in the air as a result of the oxidation of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) is what causes haze and air pollution in the atmosphere. The normal process is the formation of sulfur dioxide and airborne

(airborne) sulfate. Specifically, the role of nitrogen oxides in sulfate production in this process is unclear. Sulfate pollution is not directly caused, whereas nitrogen oxides are when fossil fuels like coal, diesel, and natural gas are burned in automobiles. It was found through research. A team from the Hong Kong University of Science and Technology and the California Institute of Technology collaborated to undertake the investigation. Professor YU Jianzhen served as the team's leader. The study found that under nitrogen oxide (NOx) reduction conditions, NOx catalyzes the cycling of hydroxyl radicals, which is an effective oxidant of SO_2, and thus form sulfate. NOx is very high in foggy conditions. NOx acts as the major oxidant of SO_2 and thus enhances the formation of sulfate.

It is clear from these findings that control of both sulfur dioxide (SO_2) and NOx emissions is necessary to reduce sulfate levels in highly polluted haze conditions. Prof Yu said that "policy makers should focus on controlling the emissions of NOx." Because sulphate plays an important role in thick haze, it is formed by the emission of SO_2 and NOx. Since sulfate is one of the major components that promote haze and this can lead to acid rain. This study has laid the basis for more effective measures to control pollution, the major pollutant that causes fog. This will lead to improved air quality and overall better protection of public health and ecosystems.

Even safe levels of carbon monoxide can harm the human health. A small increase in the level of carbon monoxide in the atmosphere can increase the number of deaths due to it. This information has come out in the analysis of data collected by Yale University from 337 cities of the world. Not only this, what we consider to be a safe level for health, the same amount of carbon monoxide can also harm health. This research has been done under the leadership of Kai Chen of Yale School of Public Health. In which researchers have analyzed the data of 40 million deaths from 1979 to 2016 with the help of a statistical model. According to research, even a small increase in the level of carbon monoxide in the atmosphere can prove to be fatal. Not only this, staying in that level for even a short time can increase the chances of death, according to the air quality guidelines issued for it.

If there is an increase in the amount of carbon monoxide by 1 mg per cubic meter compared to the average of the previous day, then it can increase the total death rate by 0.91 percent [17]. In such a situation, reducing the amount of carbon monoxide being emitted due to traffic and other reasons can be beneficial for health. If we look at the air quality standards issued for carbon monoxide in the US, then its daily average is about 7 milligrams per cubic square meter which was established in 1971. In which no changes have been made since then. This standard also applies to Europe and other countries. Whereas in China, the daily standard for carbon monoxide is 4 mg per cubic square meter [18]. It has shown that even if its daily average amount in the air is less than 0.6 mg per cubic square meter, there is no evidence that it can be considered safe. According to Chen, millions of people live in environments where carbon monoxide levels exceed standards, while even where carbon monoxide levels in the atmosphere are considered to be within safe limits, it can cause health damage. In such a situation, it is necessary to consider the air quality guidelines issued for carbon monoxide at the global level and make necessary changes in them. Along with this, there is a need to rethink the policies related to transport.

Even a small increase in nitrogen dioxide (NO_2) levels can increase the risk of cardiovascular and respiratory deaths. It has been shown that if there is an increase of 10 micrograms of NO_2 per cubic meter compared to the previous day, it can increase the total number of deaths by 0.46%, while it can lead to about 0.37% more heart-related deaths. Respiratory deaths may increase by 0.47%. Nitrogen dioxide is very common air pollutant which is usually formed by burning fuel for electricity, transportation and industries etc. Its amount in air is measured in micrograms per cubic meter. A microgram is one tenth of a gram. In this regard, if we look at the air quality guidelines issued by the WHO, the annual average level of nitrogen dioxide in the air should not exceed 40 micrograms per cubic meter.

Even before this, many researches have given information about the effect of nitrogen dioxide on health, but those studies were done at very short intervals, as well as they were done in a particular area, due to which they give a comprehensive picture of this was not presented and there was uncertainty in the results. To address this uncertainty, a team of international researchers has attempted to understand the relationship between nitrogen dioxide concentrations and their cardiovascular and respiratory deaths in several countries around the world. The research was conducted on 398 cities in 22 countries. These cities belonged to Europe, North America and Asia, where the daily amount of nitrogen dioxide was measured over a period of 45 years (1973 to 2018). Daily weather data including average temperature and humidity were also recorded in these cities. Along with this, death records were also obtained from the officials of these countries. Where a total of 6.28 crore deaths were recorded over a period of 45 years. Out of which 1.97 crore or 31.5% were related to heart related and 55 lakh about 8.7% were related to respiratory diseases.

Research has shown that if there is an increase of 10 micrograms of NO_2 per cubic meter compared to the previous day, it can increase the total number of deaths by 0.46%, while it can lead to about 0.37% in cardiovascular deaths and respiratory deaths may increase by 0.47% [19]. Not only this, despite the difference in the amount of other air pollutants such as sulfur dioxide, carbon monoxide, ozone and other fine particulates, the findings were similar.

Every year 135 million kilograms of polluted particles are found in the atmosphere due to smoking. A study has been done by Dr. Noel Aquilina and Professor Emmanuel Sinagra from the Department of Chemistry, University of Malta. This study confirms that apart from many toxic components, airborne particulate matter (PM) or particulate pollution is also polluted by tobacco smoke. The study ended the researchers' 30-year wait. Around 6 trillion cigarettes were used worldwide in 2016. Worldwide, known or unintentional secondhand smoke (SHS) from cigarette smoking alone, approximately 22 million kilograms of nicotine and about 135 million kilograms of particulate matter (PM) are released into the atmosphere each year.

The use of second hand smoke (SHS) particulate matter (PM) can be detected under environmental conditions and in low concentrations. For this purpose, historically many studies have tried to find a marker to show the exposure of ambient secondhand smoke to the air, which from 1991 had nicotine as the main evidence. Subsequent studies have confirmed that nicotine is also found exclusively in the gaseous state, whereas exposure to this state of particulates of secondhand smoke was thus far underestimated. Combines with other secondhand smoke components at different times from other substances; it has a high adsorption rate on different surfaces and is easily reduced from surfaces when the smoke is not high. This meant that nicotine particulate matter (PM) was not high enough as evidence for secondhand smoke (SHS). Over the past 3 decades, 16 different marks/markers have been tried and tested but all failed to meet the required marker characteristics.

In 2013, the Division of Cardiology, Clinical Pharmacology Program found that the tripyridine alkaloid is found in tobacco leaves and tobacco smoke. Due to its low stability, it is mainly detectable in particulate matter which is in secondhand smoke (SHS) and tobacco smoke [20]. It was assumed that nicotine is expected to be more stable in the atmosphere than previously tested for SHS. The test samples highlight the most important fact that these particles remain stable in the atmosphere, so they can be counted. It has been collected by the Faculty of Science in 2018 using Mobile Air Quality Laboratory equipment at the University of Malta. This was combined with local meteorological data to verify atmospheric conditions. A group monitored in real time was used, during which sampling it may have affected the stability of nicotine on the filter. The study revealed that nicotine in second hand smoke (SHS) has been found to be a particulate matter produced by tobacco smoke. It shows its presence in low concentrations and according to population density and tobacco use. The average weight of tobacco smoke particles in airborne particulate matter is 0.06%.

In 2010, exposure to secondhand smoke (SHS) was attributed to about 1% of global mortality. Respiratory infections in children under 5 years of age, ischemic heart disease in adults, and asthma in adults and children indicate that exposure to SHS may present a variety of risks. Although airborne PM is typically loaded with many pollutants that can be mutagenic, genotoxic and carcinogenic (cancer-causing) due to various sources, it is now confirmed that a small proportion of PM is derived exclusively from tobacco smoke. Therefore, the air is also contaminated by tobacco smoke. Although its burden appears to be very low as an immediate danger, it set a new benchmark on the potential chronic risk of secondhand smoke/thirdhand smoke (THS) from breathing particulate matter even in a currently non-smoker environment.

The significance of this study is that it has opened a gateway to research into the potent tobacco-filled specific carcinogens present in particulate matter (PM). It shows an important path towards lung cancer. Thirdhand smoke (THS) is the component that brings to the fore the cases associated with tobacco smoke and its health effects [21]. Tobacco smoke exposure requires attention, which includes breathing through the skin, hand-to-mouth, and ingesting particulate matter that forms after re-emission from surfaces.

Fossil fuel pollution is responsible for 8.7 million deaths worldwide. In India also, about 24.6 lakh people died in 2012 due to emissions from fossil fuels. On the other hand, if we look at China, 39.1 lakh people had to lose their lives due to this. Significantly, this research is based on data from 2012 to 2021. The figures of people who died from fossil fuels in this research are much higher than the previous research. Earlier, research published in the journal Lancet on Global Burden of Disease had estimated the death toll due to fossil fuels at 42 lakh every year. People from China, India, Europe and North-East America are becoming the most victims of air pollution caused by the use of fossil fuels worldwide.

Earlier research relied on satellite data and surface observations to estimate the global average amount of PM 2.5. But the problem is that satellite and surface observations do not reveal which pollutants are mainly responsible for air pollution. They cannot differentiate between particulate matter emitted from fossil fuels and emissions from dust, forest fires, smoke and other sources. According to research researcher Loretta J. Mickle, "In the data obtained from the satellite, you can only see one part of the puzzle. These data do not tell what kind of particles are there. Due to which there is a gap in the data." To avoid this problem, researchers have used Geos-Cam model. With the help of this, it can be found out what kind of pollutants people living in a particular area are breathing. If China halved its fossil fuel emissions, it could save about 2.4 million lives worldwide, of which 1.5 million would be Chinese citizens themselves.

A recent report released by the international voluntary organization Open AQ has shown that Lahore, Delhi and Dhaka have the highest air pollution. According to the data released by him, the annual average of PM 2.5 in Lahore was 123.9, while Delhi recorded 102 and Dhaka recorded 86.5. 90% of the world's population is already breathing toxic air, while only half of them know how toxic the air they are breathing is. One can guess how big the danger of air pollution is from the fact that 90% of the people around the world are breathing such air which according to the WHO is harmful to humans. It is taking three years out of every person's age on average. Air pollution is affecting children and elderly people the most [22].

Due to the lack of health facilities, people from poor countries are becoming the most victims of this. According to the State of Global Air 2020, more than 116,000 newborns in India died in 2019 due to air pollution, while 16.7 lakh people lost their lives due to this. According to researcher Joel Schwartz associated with this research, people often talk about the dangers of fossil fuels in the context of carbon dioxide and climate change. In such a situation, we ignore its effect on health. In such a situation, when we know that reducing emissions from fossil fuels can save millions of lives, it will motivate policymakers to cut greenhouse gas emissions. In such a situation, the use of renewable energy will be strengthened.

4 Deep learning in predicting air quality

Deep learning is a branch of artificial intelligence (AI) and machine learning (ML) techniques that work to shape datasets by following or, say, the human brain. This technology is also being used in many places today, such as virtual assistants, driverless cars and facial recognition through your mobile, all are examples of this. This technology works very much like the human brain. And with the help of many layers of artificial neurons, processes the data and makes a pattern from it. It learns and builds on its own based on the connections existing in very large datasets.

Scientists have tested two deep learning algorithms in this research. In which, with the help of the first algorithm, a comparative study of nitrogen dioxide information received from the ground and satellites has been done, which has helped in finding its level with accuracy. Whereas with the help of the second algorithm, the help of meteorological data, altitude and information about the locations of ground-based stations and major roads and power plants has been taken to help make the forecast more accurate.

With the help of deep learning technology, air quality forecast can be made more accurate and better. This information has come out in a research published in the journal Science of the Total Environment. The use of fossil fuels is dangerous not only for the environment but also for our health. Despite this, even today its forecast at the right time and place is a difficult task. But the scientists associated with this research are of the opinion that deep learning can help us in this work [23]. According to him, the findings of this research could be helpful in examining how increasing pollution as well as economic factors such as industrial productivity and health, such as hospitalization of patients, are affected. Manju Yu, associated with this research, said that air quality is a major issue in urban areas, which affects people's lives. Nevertheless, the current observations are not sufficient to give comprehensive information. People do not get enough information from them so that they can plan ahead. He claims that although air pollution is measured by satellites and ground-based observations, these methods have some limitations. For instance, satellites can pass over a specific area every day at the same time. But they cannot measure the fluctuations in pollution levels every hour. Similarly, weather stations on the ground collect data continuously only at limited locations. In such a situation, to solve this problem, scientists have taken the help of deep learning technology [24]. With the help of this, he has analyzed nitrogen dioxide in the US city of Los Angeles on the basis of ground and satellite data. This gas is basically released from vehicles and power plants.

5 Conclusions

Everyone has a duty to fight air pollution. To reduce air pollution, we all need to work together and make more focused, coordinated efforts with the active participation of all relevant sectors. Government (federal, state, and municipal), cities, the general public, and people are all included in this.

1. To national governments: lower emissions and establish national requirements that satisfy WHO air quality standards. Invest in clean air and pollution research and education—these are crucial resources.

2. Cities and local communities: All public initiatives must take into account public health from the outset and be supported by adequate data and evaluation methods.

3. Regarding people: Continue to speak out for your right to a sustainable and healthy environment. Require your governments to account.

4. We are all responsible, whether we are in the government, the commercial world, or as individuals. Consider and reconsider how you live, what you consume, and how you might make sustainable decisions for yourself, your kids, and their kids.

In such a situation, researchers believe that there is a need to revise and make them more stringent on air quality guidelines to limit the risk of future deaths and heart and respiratory diseases.

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