JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

MEASUREMENT AND CONTROL OF POLLUTANTS PRESENT IN AIR

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ABSTRACT

Air pollution is a significant environmental concern that has a profound impact on the well-being and health of people worldwide. It is crucial to measure and control air pollutants in order to minimize their effects on human health and the environment. Various methods are employed to measure air pollutants, including ambient air monitoring, emission monitoring, and remote sensing. To control air pollution, strategies such as regulation, technological advancements, alternative energy sources, and public education are implemented. All stakeholders, including governments, industries, and individuals, have a responsibility to contribute towards reducing air pollution levels and striving for a cleaner and healthier future. Additionally, air pollutants like tropospheric ozone and black carbon (soot) also contribute to the greenhouse effect. Black carbon is considered to be the second or third most significant anthropogenic contributor to global warming, while tropospheric ozone ranks fourth. Both pollutants are major components of indoor and outdoor air pollution. This study examines the existing literature on the health, economic, and climatic impacts of tropospheric ozone and black carbon emissions, along with potential mitigation options. The localized nature of many of these impacts, combined with their short atmospheric lifespan and the availability of cost-effective abatement technologies already widely used in developed countries, make reducing these emissions a highly effective climate mitigation option that aligns with the development strategies of industrializing nations.

1. INTRODUCTION

Air pollution is a major environmental problem that affects the health and well-being of people around the world. It is caused by various sources such as industrial emissions, transportation, and agricultural

activities. The measurement and control of pollutants present in the air are crucial for maintaining a healthy environment and protecting public health. Air pollution can have significant negative impacts on human health, ecosystems, and the economy. Therefore, it is essential to monitor and regulate the levels of pollutants in the air to ensure that they remain within safe limits. This report provides an overview of the measurement and control of air pollutants. There are many pollutants that are major factors in disease in humans. Among them, Particulate Matter (PM), particles of variable but very small diameter, penetrate the respiratory system via inhalation, causing respiratory and cardiovascular diseases, reproductive and central nervous system dysfunctions, and cancer. Despite the fact that ozone in the stratosphere plays a protective role against ultraviolet irradiation, it is harmful when in high concentration at ground level, also affecting the respiratory and cardiovascular system. Furthermore, nitrogen oxide, sulfur dioxide, Volatile Organic Compounds (VOCs), dioxins, and polycyclic aromatic hydrocarbons (PAHs) are all considered air pollutants that are harmful to humans. Carbon monoxide can even provoke direct poisoning when breathed in at high levels. Heavy metals such as lead, when absorbed into the human body, can lead to direct poisoning or chronic intoxication, depending on exposure.

2. SCOPE

The scope of this review is to provide an overview of the current methods and technologies used for measuring and controlling air pollutants. The review will cover the various types of air pollutants, their sources, and their impact on human health and the environment. It will also explore the different methods used for measuring air pollutants, including ambient air monitoring, emission monitoring, and remote sensing. The review will discuss the advantages and limitations of each method and their suitability for different types of pollutants and environments. The control of air pollutants will also be discussed, focusing on the strategies used to reduce their impact on human health and the environment. This will include regulatory measures, such as emissions standards and pollution taxes, as well as technological solutions, such as alternative energy sources and pollution control devices. The review will also explore the role of public education in raising awareness about air pollution and promoting behavior change to reduce emissions. Overall, this review aims to provide a comprehensive overview of the measurement and control of air pollutants, highlighting the importance of addressing this significant environmental issue to protect human health and the environment.

3. MAJOR POLLUTANTS

Major human activity produced primary pollutants are:

A. Carbon monoxide gas (CO) : CO is a dangerous substance that is both odourless and colourless. It is highly poisonous and can be released when fuel in an engine does not burn properly. Road traffic is the main source of 91% of all CO emissions. When CO combines with the haemoglobin in blood, it forms carboxyhaemoglobin (HbCo), which reduces the blood's ability to carry oxygen, leading to hypoxia. Exposure to 100ppm or more of CO can be harmful to human health, causing symptoms such as depression, confusion, and memory loss. While carboxyhemoglobin can be converted back to haemoglobin, the process is slow due to the stability of the HbCo complex. The most effective treatment for CO poisoning is still a topic of debate, but hyperbaric oxygen therapy is often used, despite uncertain results. By administering oxygen through a non-rebreathe mask, the half-life of CO can be reduced from 320 minutes to 80 minutes on normal air.

B. Ammonia (NH3) : Ammonia fumes pose a significant risk to children with asthma and can also trigger respiratory allergies. Prolonged exposure to ammonia can lead to various health issues, including tracheal and nasopharyngeal burns, as well as alveolar and bronchiolar edema. The destructive effects of ammonia on the airways can ultimately result in respiratory distress or failure.

C. Carbon dioxide gas (CO2) : is an invisible and odorless gas that is not flammable. It falls under the category of asphyxiate gases, which can interfere with the availability of oxygen for tissues. Scientific studies have confirmed that if oxygen is unavailable for a period of 3 to 5 minutes, it can result in brain damage or even death. In certain cases, CO2 generated by occupants can be used as an indicator of indoor air quality (IAQ). The content of CO2 can help predict the requirement for outdoor air, and according to ASHRAE guidelines, CO2 levels should be kept below 1000ppm. Generally, outdoor air has CO2 levels below 350ppm.

One of the significant characteristics of carbon dioxide is its role as a greenhouse gas. Greenhouse gases trap heat in the Earth's atmosphere, contributing to the natural greenhouse effect that sustains life on our planet. However, human activities have significantly increased the concentration of carbon dioxide in the atmosphere, leading to intensified greenhouse warming and climate change. The burning of fossil fuels like coal, oil, and natural gas is the primary source of anthropogenic carbon dioxide emissions. When these fuels are burned for energy production, the

carbon stored in them is released into the atmosphere as CO2. Deforestation and changes in land use also contribute to elevated CO2 levels by reducing the number of trees available to absorb carbon dioxide through photosynthesis.

D. Temperature and humidity : The safety of individuals and the development of our life abilities greatly depend on the accurate measurement of temperature. By monitoring temperature and analyzing the changes from historical to present times, particularly since the industrial revolution, we can effectively track the greenhouse effect using climate data. Humidity, a gaseous component, plays a crucial role in shielding us from harmful UV rays emitted by the sun and in retaining heat on Earth. This, in turn, contributes to maintaining a pleasant climate for human habitation. However, an increase in humidity levels leads to a rise in temperature, resulting in discomfort in our daily lives. Nonetheless, humidity remains indispensable for various storage and food processing facilities.

E. Hydrogen sulphide (H2S) : is an odorless, extremely poisonous gas that has a pungent smell often compared to the scent of rotten eggs. It is generated during the breakdown of organic matter by bacteria. H2S can lead to a range of health issues including nausea, asthma attacks, irritation of the eyes, lungs, and throat, sleep disturbances, headaches, loss of appetite, chest discomfort, and nasal congestion.

F. Smoke : Approximately one million individuals worldwide engage in tobacco smoking, with a significant portion hailing from developing nations. A 2007 report revealed that close to 4.9 million deaths occur annually as a result of smoking. Furthermore, secondhand smoke poses a grave risk to individuals of all ages, leading to 41,000 deaths each year. Smoking is detrimental to health and can result in severe illnesses like lung cancer, heart disease, and respiratory conditions.

G. LPG : LPG or liquefied petroleum gas, is a clear and odorless liquid that easily turns into a gas. To detect leaks, an odorant is typically added to it. This type of gas falls under the highly flammable category and can be labeled as a carcinogen and mutagen if the Butadiene content exceeds 0.1%. Leaks of LPG can occur in either gas or liquid form. When in gas form, it can ignite and cause burns or explosions upon contact with an ignition source.

H. Nitrogen Oxides (NOx) : The combustion of fuel in the engine is the primary cause of Nitrogen Oxides emissions. Approximately half of NOx is emitted from road traffic, leading to the formation of acid rain. Additionally, the combination of NOx with hydrocarbons results in the production of low-level ozone pollution, which has been linked to the development of lung cancer.

I. Hydrocarbons (HC) : Benzene, along with other hydrogen and carbon compounds, such as those found in diesel and petrol, make up the basic components of these substances. It is worth noting that approximately 35% of hydrocarbon (HC) emissions originate from road traffic. The emission of HC poses significant issues, as it is both carcinogenic and a key contributor to the formation of smog.

J. Gasoline and diesel exhaust : The pollutants in the affected areas lead to chronic worsening of asthma,

higher risk of cancer, asthma flare-ups, and various other health issues.

K. Particulate Matter : Particulate matter is a combination of various particles, including salt, smoke, soot, dust, acid droplets, organic chemicals, metals, and soil. These particles can be divided into two categories: inhalable coarse particles, with a diameter ranging from 2.5 to 10 micrometers, and fine particles, with a diameter equal to or less than 10 micrometers. When particles with a diameter less than 10 micrometers enter the body, they can cause serious health issues such as heart attacks, asthma attacks, and bronchitis. These particles pass through the throat and lungs and enter the lungs, posing a threat to our respiratory system. Additionally, particulate matter can weaken the immune system, particularly in children, making them more susceptible to infections.

4.CAUSES AND FACTORS RESPONSIBLE FOR AIR POLLUTION :

4.1 Natural Sources of Air pollution

- Dust from natural sources: These are usually large areas of land with very less or no vegetation.
- Methane: This is emitted during digestion of food by animals like cattle.
- Radon gas: It is extracted from radioactive decay within the crust of earth. Radon is a naturally occurring odourless and colourless radioactive noble gas formed from radium decay. It results in health hazard and can be accumulated in buildings like basement or other confined areas. After cigarette smoking, radon gas is considered as the second most frequent cause of lung cancer.
- Carbon monoxide: It is generated from wildfires.
- VOCs: An environmentally significant amount of VCOs is emitted in some regions of vegetation mainly on warmer days [6]. Then anthropogenic pollutants like NOx, SO2 and other carbon compounds react with each other and VOCs and produce a seasonal haze of secondary pollutants.
- Other natural sources can be volcanic activity that produces particulates of Chlorine, sulphur and ash.

4.2 Man-made sources

Mainly man-made sources of air pollutants are related to

burning of various kinds of fuel. Some of the man-made sources are:

- Stationary Sources: This includes manufacturing factories, power plants and waste incinerators along with furnaces and other types of fuel burning heating devices that generate smoke stacks. The major source of air pollutants in poor and developing countries are wood, dung and crop waste including traditional biomass.
- Mobile Sources: It includes aircraft, marine vessels, motor vehicles and effect of sound.
- In forestry and agriculture management of dust, chemicals and controlled burning practices also cause air pollution. In farming, greenhouse gas abatement, forest management and prairie restoration uses a prescribed or controlled burning technique. In both grassland and forest ecology, fire is a natural part and for foresters, a controlled fire can act as a tool .

- Waste deposition: Methane is generated from waste deposited in landfills that is highly flammable and forms explosive mixtures with air.
- Military: Air pollution is also generated by nuclear weapons, germ warfare, toxic gases and rocketry used by military.
- Other man-made sources of air pollution are fumes from hair spray, aerosol sprays, paint and other solvents.

5.EFFECT OF AIR POLLUTION ON HEALTH

The two most prevalent air pollutants are ground-level ozone and Particulate Matter (PM). Air pollution can be categorized into two main types: outdoor pollution, which refers to ambient air pollution, and indoor pollution, which is caused by the combustion of fuels within households. Individuals who are exposed to high levels of air pollutants may experience various disease symptoms and conditions of varying severity. These effects can be classified as either short-term or long-term effects on health. It is important for vulnerable populations, such as the elderly, children, and individuals with diabetes or pre-existing heart or lung diseases (particularly asthma), to be aware of measures to protect their health. However, the exact magnitudes of the short-term and long-term effects have not been fully elucidated due to differences in epidemiological methodologies and exposure errors, as highlighted in a recent epidemiological study conducted by Harvard School of Public Health. To address this, new models are being proposed to more accurately assess human exposure data for both short-term and long-term effects. Therefore, in this section, we will discuss the more common health effects associated with both short-term and long-term exposure, as well as general concerns. It is important to note that these effects are often influenced by environmental conditions, dosage, and individual susceptibility.

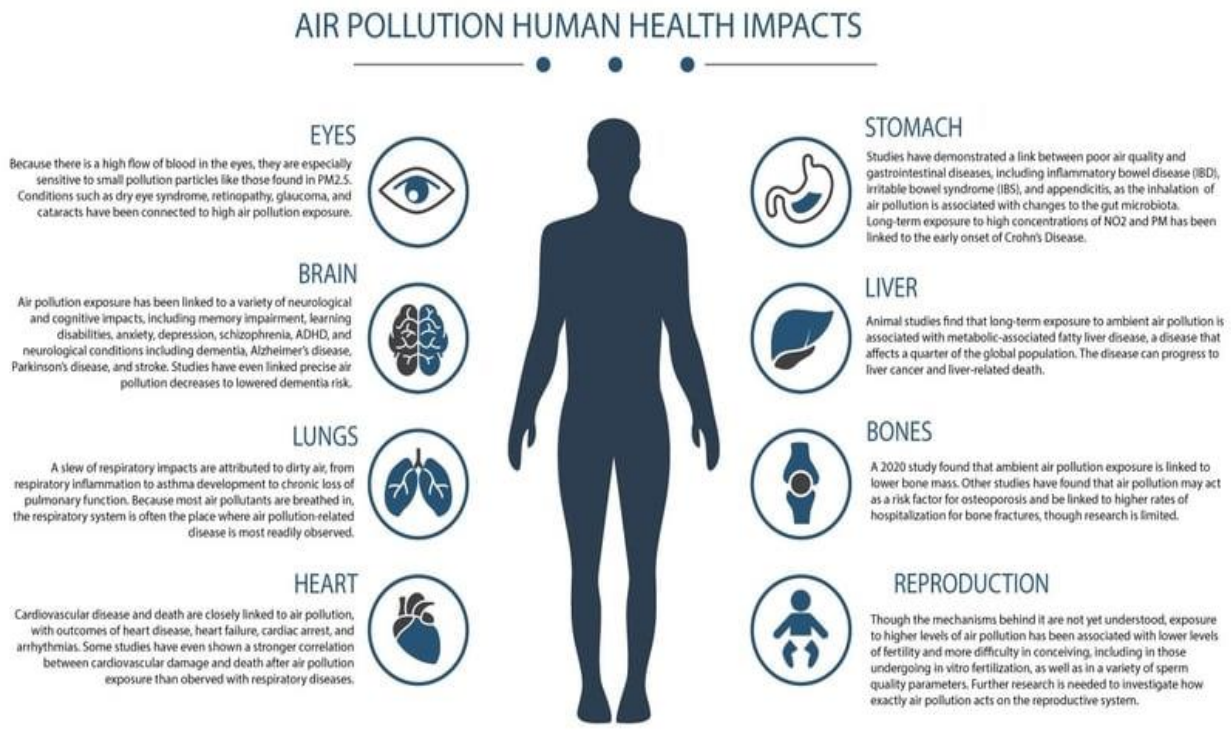

Figure.1.Impact of air pollutants on Health

6. MEASURES TO CONTROL AIR POLLUTION

Activated carbon is widely recognized as a highly effective method. This particular approach utilizes carbon pollution filters to minimize the release of harmful pollutants into the atmosphere. By actively absorbing pollutants, these filters play a crucial role in purifying the air and eliminating potential toxins.

Biofiltration is another effective and highly efficient form of air pollution control that harnesses the power of microorganisms, such as bacteria and fungi, to break down pollutants. Various industries, including food and waste plants, pharmaceutical companies, and wastewater management facilities, utilize biofiltration systems to combat air pollution. However, the main drawback of this method is the substantial space it demands for operation. Due to space constraints, numerous industries are unable to adopt biofiltration systems, leading to their disregard of this effective pollution control method.

Change in Fuel : This method entails utilizing cleaner fuel to mitigate air pollution. An instance of this approach is the substitution of high sulfur fuel with low sulfur fuel by electric utilities. It is

important to note that low sulfur fuel is significantly pricier compared to high sulfur fuel.

Another option for an electric utility is to utilize **natural gas** as a source of fuel. The practice of switching fuels depending on meteorological conditions or air pollution forecasts has been implemented in numerous regions to mitigate air pollution issues.

Utilizing oil with minimal ash content or natural gas in a dryer at an asphalt plant to minimize particulate matter serves as another illustration of this approach. The implementation of compressed natural gas, propane, ethanol, and oxygenated fuels in vehicles has contributed to the decrease in air pollutants.

Nuclear power plants are considerably cleaner in terms of pollution compared to coal-fired power plants. Nevertheless, they have been a topic of debate due to their broader environmental implications.

Improve Dispersion: The fundamental principle behind this method is that by diluting air pollutants before they reach the ground, the levels of exposure for the population can be reduced. However, the US EPA discourages the implementation of this approach in the industrial sector.

The emissions from the plant are passed through a **control device** before releasing to atmosphere. The pollutants are removed, destroyed or transformed in the control device before discharging into ambient air.

Regulation: Governments have the authority to control emissions from industrial sources by establishing restrictions on the quantity of pollutants that can be released. This can be achieved by enforcing environmental laws and regulations.

Technology: Advancements in technology have resulted in the creation of cleaner and highly efficient industrial procedures that generate reduced levels of pollutants.

Public Education: Raising awareness among the general public regarding the detrimental effects of air pollution on both human health and the environment can serve as a catalyst for individuals to adopt proactive measures. These measures may include minimizing their reliance on personal vehicles and actively endorsing clean energy initiatives.

7. MEASUREMENT OF AIR POLLUTANTS

Monitoring air pollutants is crucial in pinpointing the origins and concentrations of pollutants in the air. There are various methods for measuring air pollutants, including:

Ambient Air Monitoring: Air samples are collected from different locations to measure the concentration of pollutants in the atmosphere. Subsequently, these samples are analyzed in a laboratory to ascertain the levels of pollutants.

Emission Monitoring: Industrial emissions, such as those from factories and power plants, are quantified by installing monitoring devices at the emission points to measure the level of pollutants being released.

Remote Sensing: Utilizing satellite imagery and various remote sensing technologies to assess air pollution levels from afar.

8. AIR POLLUTION INDEX

The Air Quality Index (AQI) serves as a daily report on the quality of the air, informing the public about the current level of pollution and its impact on human health. Also referred to as the Air Pollutant Index (API) or Pollutant Standards Index (PSI), the AQI ranges from 0 to 500. A higher AQI value indicates a higher level of air pollutants, with the index based on the concentration of five key pollutants: particulate matter, ozone, nitrogen dioxide, sulfur dioxide, and carbon dioxide. The AQI is categorized as good, moderate, unhealthy, very unhealthy, or hazardous. An AQI value of 0-50 signifies good air quality, while a value of 51-100 indicates standard air quality. Values between 201-300 are considered very unhealthy and dangerous, while a range of 300-500 is classified as hazardous. Air pollutant concentrations are measured in units such as parts per million (ppm) and micrograms per cubic meter (µg/m3). Refer to Table 1 for the standard AQI levels and their corresponding health concerns.The air quality index can be measured using the following formula:

$$AQIpollutant = \frac{Pollutant\ \ concentration}{pollutant\ standard\ concentration} \text{ X } 100$$

In general, data readings are translated on to a linear scale based on relevant air quality standards to derive the AQI values for the hourly AQI and daily AQI. The maximum of individual pollutant indexes at a monitoring station is then taken as the overall index for that station.

Table 1**:** AQI values and the level of health concerns

Sl. No	AQI values (when the AQI value is in the range)	Levels of health concern (air quality conditions)
1	0 to 50	Good
2	51 to100	Moderate
3	101 to 150	Unhealthy for sensitive groups
4	151 to 200	Unhealthy
5	201 to 300	Very unhealthy
6	301 to 500	Hazardous

9. CONCLUSION

It is crucial to monitor and manage air pollutants to safeguard human health and the environment. Governments, industries, and individuals all play a part in reducing air pollution levels. Through the implementation of regulations, advancements in technology, utilization of alternative energy sources, and public awareness campaigns, we can strive towards a cleaner and healthier future. Clean air is essential for sustaining the well-being of both humans and ecosystems, especially with the rise of industrial activities leading to the release of harmful particulate matter and gases. There are various methods available to control air pollution, the key lies in their appropriate application. This article explores different technologies used across industries and the importance of utilizing cleaner fuels to combat air pollution. With a multitude of pollutants causing chronic and acute health issues, it is imperative to adhere to set standards to limit the presence of harmful particles in the air.

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