Journal of Environmental Informatics Letters 10(2) 115-131 (2023)

Journal of Environmental Informatics Letters

www.iseis.org/jeil

Air Pollution: A Review of Its Impacts on Health and Ecosystems, and Analytical Techniques for Their Measurement and Modeling

G. Mekuria[1] *

[1] Department of Industrial Engineering, College of Engineering, Debre Berhan University, PO Box 445, Debre Berhan, Ethiopia

Received 30 June 2023; revised 07 August 2023; accepted 29 August 2023; published online 15 November 2023

ABSTRACT. Air pollution is a significant global problem that affects human health and the natural environment. This research article aims to provide a comprehensive review of the impacts of air pollution on health and ecosystems and present various analytical techniques used for its measurement and modeling. The study uses a systematic review method to identify and evaluate research articles that deal with air pollution, its impacts on health and ecosystems, analytical techniques, and modeling that are only available in English and published between 2012 and 2023. The findings outlined in this article contribute to an enhanced understanding of the detrimental effects of air pollution and provide insights into effective monitoring and mitigation strategies. In conclusion, by implementing effective policies, adopting clean technologies, promoting sustainable practices, and raising awareness, we can mitigate the impacts of air pollution and create a healthier and more sustainable future.

Keywords: air pollution, health, ecosystems, analytical techniques, air quality modeling, air pollution modeling

1. Introduction

Air pollution refers to harmful substances in the environment that can cause adverse effects on human health, ecosystems, and the environment. These substances, known as air pollutants, can be natural or anthropogenic. Air pollution is a complex issue that requires a multidisciplinary approach to understand its causes, impacts, and mitigation strategies. Air pollution can arise from various sources, including industrial emissions, vehicular exhaust, agricultural activities, power generation, and natural phenomena such as volcanic eruptions and dust storms. These materials discharge a wide range of particulate matter, nitrogen oxides, sulfur dioxide, volatile organic compounds, and greenhouse gases into the atmosphere. Air pollution is a global problem that knows no boundaries (Fuller and Amegah, 2022). It affects both developed and developing countries, although the magnitude and nature of the pollution may differ (Singh et al., 2021). The impacts of air pollution are not only limited to human health but also extend to ecosystems, climate change, and the economy. Air pollution has significant implications for human health, affecting various organ systems and increasing the risk of numerous diseases (Nathaniel and Duan, 2021). Extensive research has established strong associations between air pollution exposure and respiratory diseases, cardiovascular disorders, cancer, neurological disorders, developmental effects, diabetes, immune system dysfunction, and skin health issues (Rice et al., 2021). Air pollution has significant impacts on human health, including respiratory and cardiovascular diseases, as well as neurological and immune dysfunctions (Yadav et al., 2020; Dominski et al., 2021; Kuppala, 2021). It is also associated with adverse effects on the developing fetus, such as low birth weight and stillbirth (Toledo de Almeida Albuquerque et al., 2020). Overall, air pollution is a significant public health concern that requires multidisciplinary approaches and preventive measures to reduce its impact on human health and ecosystems.

Besides harming human health, air pollution harms ecosystems, biodiversity, and the natural environment. The release of air pollutants can lead to acid rain, ozone depletion, biodiversity loss, soil and water contamination, forest decline, and crop damage (Singh et al., 2023). Air pollution affects ecosystems by contributing to global environmental changes, including global warming and the spread of air pollution worldwide. Analytical techniques, such as in situ measurements, emission inventories, satellite observations, and modeling activities, are used to understand the causes and effects of air pollution. These techniques help in assessing the concentrations of pollutants, modeling air quality, and developing environmental policies. Accurate measurement and monitoring of air pollution are essential for understanding spatial and temporal patterns, identifying pollution sources, and evaluating the efficacy of mitigation strategies. Various analytical techniques and instruments measure air pollutants, including ambient air monitoring, remote sensing, chemical analysis, biomonitoring, and air quality modeling. Air pollution modeling plays a crucial role in understanding the behavior and impact of air pollutants in the atmos-

* Corresponding author. Tel.: +251923388799; fax: +251-116812065.
E-mail address: getahunmekuria3@gmail.com (G. Mekuria).

ISSN: 2663-6859 print/2663-6867 online
 doi:10.3808/jeil.202300116

phere. Various simulation techniques and approaches, as well as health risk assessment and pollution control effectiveness evaluation, are based on modeling. Dispersion, receptor, and integrated assessment models are several types of these models.

Air pollution is a pressing global issue that affects not only the environment but also human health. Meanwhile, the detrimental effects of air pollution on physical and mental well-being have been extensively studied and documented. Additionally, air pollution has far-reaching consequences for ecosystems and biodiversity. Therefore, this comprehensive review will delve into the various aspects of air pollution, its impacts on health and ecosystems, and the analytical techniques and modeling used to study and monitor it. The remainder of this article is organized in chronological order as follows. The Materials and Methods section details the method for conducting a literature review. In addition, the discussion sections provide a thorough justification for the study. Finally, the conclusion section presents the conclusions of this study.

2. Materials and Methods

The study uses a systematic review method to identify and evaluate research articles that deal with air pollution, its impacts on health and ecosystems, analytical techniques, and modeling. A systematic review is a rigorous research method that involves searching for all the relevant studies on a topic, evaluating the quality of those studies, and synthesizing the findings. This method involves the following steps:

(a) Formulating the inclusion and exclusion criteria: The first step is to create clear and specific criteria. As an illustration, consider publications on air pollution, its impacts on health and ecosystems, analytical techniques, and modeling that are only available in English and published between 2012 and 2023.

(b) Identifying relevant studies: after determining the inclusion and exclusion criteria, the next step is to search for relevant research. One way to do this is to search academic databases for research. Table 1 summarizes numerous databases.

(c) Screening studies: After identifying a list of studies, the next crucial step is to screen them to establish their relevance to the research topic (see Figure 1). This screening process entails reading through the titles and abstracts of the studies.

(d) Extracting data: Data extraction comes next after compiling a list of pertinent research.

(e) Synthesizing the evidence: After extracting the data, the next step is to analyze the included article on air pollution, its impacts on health and ecosystems, analytical techniques, and modeling.

3. Discussion

3.1. Health Impact of Air Pollution

Respiratory System: The respiratory system is particularly vulnerable to the effects of air pollution due to its direct exposure to inhaled pollutants. Particulate matter, ozone, nitrogen dioxide, and sulfur dioxide can cause or exacerbate respiratory conditions such as asthma, chronic obstructive pulmonary disease (COPD), bronchitis, and pneumonia (Gull et al., 2013; Kantipudi et al., 2016; Nakao et al., 2018; Slama et al., 2019; Unver et al., 2019; Copat et al., 2020; Grzywa-Celińska et al., 2020; Jalili et al., 2020; Qing et al., 2020; Tiotiu et al., 2020; Bălă et al., 2021; Bobrowska-Korzeniowska et al., 2021; Santos et al., 2021; Hahm and Yoon, 2021; Saleem et al., 2022; Yadav and Pacheco, 2023). Long-term exposure to air pollution can also lead to reduced lung function, impaired lung development in children, and increased susceptibility to respiratory infections.

Table 1. List of Databases

Databases	Link
Emerald	https://www.emerald.com/insight/
Taylor & Francis	https://taylorandfrancis.com/
Elsevier Science Direct	https://www.sciencedirect.com/
Google Scholar	https://scholar.google.ca/
Springer Link	https://link.springer.com/
PubMed/Medline	https://pubmed/Medline
JSTOR	https://www.jstor.org/
CrossRef	https://www.crossref.org/
WorldCat	https://www.worldcat.org/
PsycINFO	https://www.apa.org/pubs/databases/psycinfo
IEEE Xplore	https://ieeexplore.ieee.org/Xplore/home.jsp
EBSCO	http://search.ebscohost.com
DOAJ	https://doaj.org/
ProQuest	https://www.proquest.com/
Web of Science	http://webofknowledge.com

Cardiovascular System: Air pollution is associated with an increased risk of cardiovascular diseases, including heart attacks, strokes, and hypertension. Small particulate matter, especially those with a diameter of < 2.5 micrometers ($PM_{2.5}$), can penetrate the lungs and enter the bloodstream, triggering inflammation, oxidative stress, and vascular damage (An et al., 2018; Laeremans et al., 2018; Kolpakova et al., 2019; Enkhjargal et al., 2020; Shah et al., 2020; Bhatnagar, 2022; Bourdrel, 2022; Costa and Pasquinelli, 2022). These effects contribute to the development of atherosclerosis, blood clot formation, and heart rhythm abnormalities (Wold et al., 2012; Newby et al., 2015; Rao et al., 2017; Hamanaka and Mutlu, 2018; Fauzie and Venkataramana, 2019; Lelieveld et al., 2019; Neuberger, 2019; Al-Kindi et al., 2020; Hahad et al., 2020; Miller and Newby, 2020).

Cancer: Air pollution is a significant risk factor for various types of cancer, including lung cancer, bladder cancer, and childhood leukemia. Carcinogenic substances present in air pollutants, such as benzene, formaldehyde, and polycyclic aromatic hydrocarbons, can damage DNA and promote the development of cancerous cells (Huang et al., 2014; Turner et al., 2017; Cong, 2018; Parascandola et al., 2018; Villeneuve et al., 2018; White et al., 2019; Amadou et al., 2020; Bai et al., 2020; Moon et al., 2020; Ou et al., 2020; Turner et al., 2020; Coleman et al., 2021; Dehghani et al., 2021; Huang et al., 2021; So et al.,

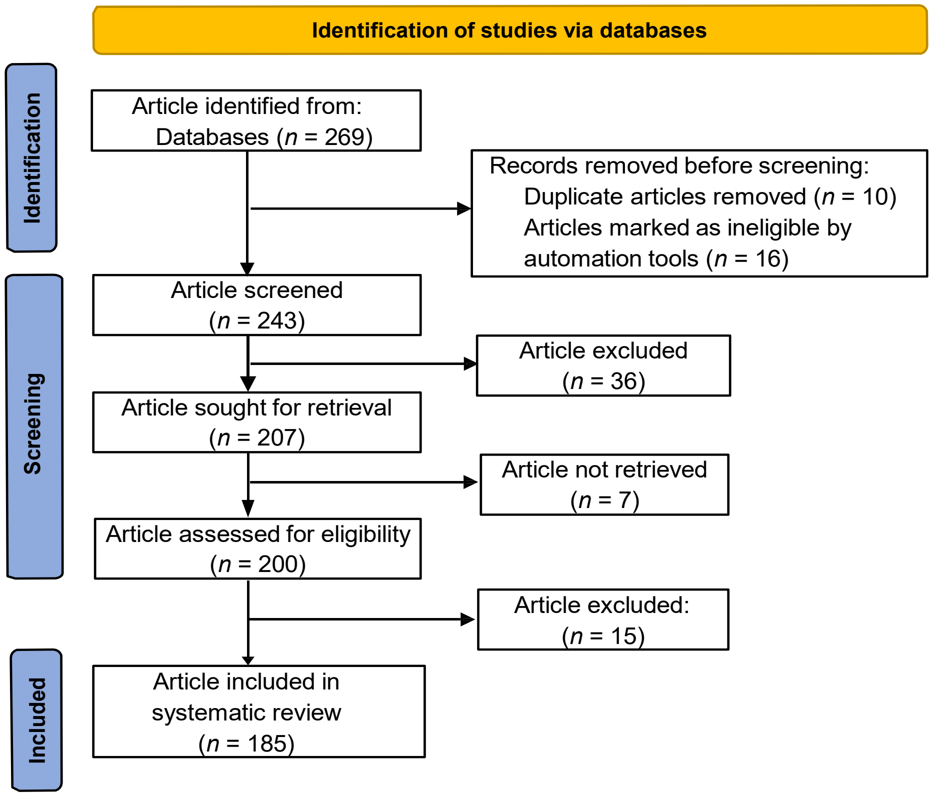

Figure 1. Flow chart of systematic literature review.

2021; Chen et al., 2022; Xue et al., 2022). Long-term exposure to air pollution, particularly in industrial and urban areas, increases the likelihood of cancer development.

Neurological Disorder: Mounting evidence suggests that air pollution can adversely affect the central nervous system and increase the risk of neurological disorders. Dusty particulate matter and toxic gases can enter the brain through the olfactory nerves or systemic circulation, leading to neuroinflammation, oxidative stress, and neuronal damage (Ying et al., 2013; Li et al., 2017; Azarpazhooh and Hachinski, 2018; Gładka et al., 2018; Jia et al., 2018; Thomson, 2019; Gu et al., 2020; Kim et al., 2020; Xue et al., 2021; Fu et al., 2022; Sirbu et al., 2022). Studies have linked air pollution exposure to neurodevelopmental disorders in children, cognitive decline in adults, and an increased risk of neurodegenerative diseases like Alzheimer's and Parkinson's.

Development Effects: Exposure to air pollution during pregnancy and early childhood can have long-lasting effects on developmental outcomes. Pregnant women exposed to air pollutants, particularly dusty particulate matter, may experience adverse birth outcomes such as preterm birth, low birth weight, and developmental abnormalities. Children exposed to air pollution have a higher risk of impaired lung function, cognitive deficits, behavioral problems, and developmental disorders (Vrijheid et al., 2012; Raz et al., 2013; Roberts et al., 2013; Sram et al., 2013; Xu et al., 2014; Forns et al., 2018; Kerin et al., 2018; Jo et al., 2019; Qiu et al., 2019; Carvalho et al., 2020; Ferrari et al., 2020; McGuinn et al., 2020; Thygesen et al., 2020; Volk et al., 2020; Heo and Kim, 2021; Wang et al., 2021; Johnson et al., 2021; Yang et al., 2022; Decrue et al., 2023; Lee et al., 2023).

Diabetes and Metabolic Disorder: The air pollution has emerged as a potential risk factor for diabetes mellitus and metabolic disorders (Tamayo et al., 2014; Eze et al., 2015; Münzel et al., 2017; Park, 2017; Alhowikan et al., 2019; Jo et al., 2019; Kim et al., 2021; Rammah et al., 2021; Chen et al., 2022; Hussein et al., 2022; Zorena et al., 2022; Luo et al., 2023). Long-term exposure to high levels of air pollutants, particularly $PM_{2.5}$ and nitrogen dioxide, has been associated with an increased prevalence of diabetes, insulin resistance, and metabolic syndrome. The mechanisms underlying this association include systemic inflammation, oxidative stress, insulin resistance, and disruption of metabolic homeostasis.

Immune System: Air pollution can modulate the immune system, causing increased susceptibility to infections, allergic reactions, and autoimmune diseases. Exposure to air pollutants can trigger airway inflammation, impair immune cell function, and alter the balance between pro-inflammatory and anti-inflammatory responses. Allergic rhinitis, asthma, allergic sensitization, and autoimmune diseases such as rheumatoid arthritis and systemic lupus erythematosus are associated with air pollution exposure (Bousquet et al., 2018; Cong et al., 2019; Flood-Garibay et al., 2019; Garibay et al., 2019; Arias-Pérez et al., 2020; Cahueñas, 2020; Glencross et al., 2020; Eguiluz-Gracia et al., 2020; Croft et al., 2021; Abdelnasser, 2022; Serafini et al., 2022; Yong et al., 2022; Sampath et al., 2023).

Skin Health: Air pollution harms the state of the skin and speeds up aging (Manceb and Wang, 2015; Park et al., 2018; Nakhjirgan et al., 2019; Nobile et al., 2020; Schikowski and Hüls, 2020; Calderón-Garcidueñas et al., 2021; Park ea al., 2021; Wang et al., 2021). Meanwhile, it also causes several dermatological problems. Particulate matter, heavy metals, and volatile chemical compounds associated with air pollution can enter the skin and cause inflammation, oxidative stress, and DNA damage. Therefore, this can result in skin allergies, acne, eczema, psoriasis, pigmentation disorders, and accelerated skin aging.

3.2. Ecosystem Impact of Air Pollution

Acid Rain: Acid rain is one of the most well-known ecosystem effects of air pollution. Emissions of sulfur dioxide and nitrogen emissions from industrial activities and combustion processes can react with atmospheric moisture to form sulfuric and nitric acids (Zuolin et al., 2012; Cass, 2014; Seo et al., 2017; Wang et al., 2017; Sanmi, 2018; Liu et al., 2019; Siddiqi and Farsi, 2019; Zhang et al., 2019; Pham et al., 2020; Debnath et al., 2021; Fatima ea al., 2021). These acids are then deposited onto the surface through precipitation, leading to the acidification of soil and water bodies. Acid rain harms aquatic ecosystems, including lake, stream, and river acidification, which can kill fish, amphibians, and other aqueous animals.

Ozone Depletion: Air pollutants such as chlorofluorocarbons (CFCs) and halons contribute to the depletion of the ozone layer in the stratosphere. The ozone layer plays a vital role in protecting life on Earth by absorbing harmful ultraviolet (UV) radiation from the sun. Depletion of the ozone layer increases UV radiation reaching the Earth's surface, leading to increased risks of skin cancer, cataracts, and damage to marine and terrestrial ecosystems (Tai et al., 2014; Carter et al., 2017; Manjula, 2018; Schiferl and Heald, 2018; Wilson et al., 2019; Sampedro et al., 2023).

Biodiversity Loss: Air pollution poses a significant threat to biodiversity, with potential consequences for the stability and functioning of ecosystems (Cotrozzi et al., 2018; Stevens et al., 2020; Thimmegowda et al., 2020). High levels of air pollutants can harm plants, including crop species, by damaging their leaves, reducing photosynthesis, and interfering with nutrient uptake (Atator et al., 2021). Accordingly, this can lead to reduced crop yields, decreased food availability, and disordered ecological interactions. Additionally, air pollution can contribute to the decline of sensitive plant and animal species, destroying biodiversity.

Soil and Water Contamination: Airborne pollutants can be deposited onto the soil and water surfaces, contributing to the contamination and degradation of these vital resources. Heavy metals, persistent organic pollutants, and other toxic substances can accumulate in soil and water bodies, posing risks to terrestrial and aquatic organisms. Soil contamination can affect plant growth and productivity, while water contamination can harm marine species and compromise water quality for human consumption (Lochman et al., 2002; Duan et al., 2017).

Forest Decline: Forests are particularly vulnerable to the impacts of air pollution due to their exposure to airborne pollutants and their role in regulating air quality. Elevated levels of ozone and nitrogen compounds can harm forest ecosystems by damaging tree foliage, inhibiting photosynthesis, and altering nutrient cycling (Livesley et al., 2016; Sonwani et al., 2022). Meanwhile, this can result in low forest productivity, increased susceptibility to pests and diseases, and overall forest decline.

Crop Damage: Air pollution has significant implications for agricultural productivity and food security. In line with this, high amounts of ozone, nitrogen dioxide, and sulfur dioxide can damage crop plants, leading to low yields and poor-quality produce (Wendel, 2014; Chen and Liao, 2017; Ekiyor et al., 2019; de Matos Nascimento et al., 2020; Pandya et al., 2022). Ozone, in particular, can cause visible leaf injury, decreased photosynthesis, and an impaired progenitor system. Poor air quality in agricultural regions can also lead to increased respiratory problems in farm workers and livestock.

3.3. Analytical Techniques for Measuring Air Pollution

Ambient Air Monitoring: Ambient air monitoring is a systematic method of collecting and analyzing air samples from specific locations to assess pollutant concentrations (Crilley et al., 2017; Spinelle et al., 2017; Feenstra et al., 2019; Long et al., 2019; Genner et al., 2020; Jordan et al., 2020; Liang et al., 2021; Sau et al., 2021). It utilizes a network of monitoring stations equipped with instruments that measure various pollutants, including particulate matter, gases (e.g., nitrogen dioxide, sulfur dioxide and ozone), volatile organic compounds, and heavy metals. These monitoring stations provide valuable data for assessing air quality, identifying pollution hotspots, and tracking long-term trends.

Remote Sensing: Remote sensing techniques utilize satellite, aircraft, or ground-based sensors to measure air pollution over large areas. Satellite-based remote sensing provides extensive coverage and allows for the monitoring of air pollution on a global scale. It measures various parameters, including aerosol optical depth, tropospheric ozone, and nitrogen dioxide concentrations (Demetillo et al., 2020; Chudnovsky, 2021; Muthukumar et al., 2021; Pathakoti et al., 2021; Roy, 2021; Xiong et al., 2021; Ji et al., 2022; Scheibenreif et al., 2022; Wang et al., 2022; Zhu et al., 2022; Zhang et al., 2022; Zhao et al., 2022; Abu El-Magd et al., 2023; Wang et al., 2023). Ground-based remote sensing techniques, such as lidar and sun photometry, provide detailed information about the vertical profiles of pollutants and can be used to validate satellite measurements. The chemical analysis involves the laboratory analysis of air samples to quantify the concentrations of specific pollutants (Fan et al., 2014; Li et al., 2017). This technique employs various analytical methods, such as gas chromatography, mass spectrometry, and atomic absorption spectroscopy, to detect and quantify insoluble compounds, including volatile organic compounds, heavy metals, and toxic gases. The chemical analysis provides detailed information about pollutant composition, source apportionment, and chemical reactions. Chemical analysis methods have been developed to quantify different classes of pollutants in air and water at trace and ultra-trace levels. These methods enable researchers to selectively determine pollutants such as metals, anions, organic pollutants, and hazardous gases. The analysis of atmospheric pollution processes involves simulating and calculating the concentration values of atmospheric pollutants, considering physical processes, chemical conversions, and emission processes. This quantitative analysis provides insights into the impact of these processes on various pollutants in the atmosphere during heavy pollution periods. Additionally, chemical modeling plays a crucial role in understanding air pollution problems and their regulatory applications It helps in studying the formation, health effects, and regulatory context of pollutants, as well as predicting their behavior and impacts on air quality.

Biomonitoring: Biomonitoring involves the measurement of air pollution impacts on living organisms, such as plants, animals, and humans (Santos et al., 2015; Siontorou et al., 2019; Chaparro et al., 2020; Cauci et al., 2021; Giordano et al., 2021; Quyet et al., 2021; Svozilík et al., 2021; Abecasis et al., 2022; Belguidoum et al., 2022; Dhaouadi et al., 2022; Shukla and Aggarwal, 2022). Based on their sensitivity and reaction to contaminants, bioindicators such as lichens, mosses, and certain plant species are used to measure air pollution levels. Biomonitoring air pollution is an effective method for assessing and monitoring the presence of pollutants in the environment. Moss and lichens are suitable bioindicators for air pollution because they capture and accumulate contaminants over time. In particular, black poplar leaves have been used to monitor metal pollution in urban environments, indicating the sources of pollution such as traffic, waste burning, and soil contamination. Moss transplants have also been used to assess environmental pollution, with different moss species showing variations in metal accumulation and uptake mechanisms. Using biomonitoring techniques, such as moss and lichen analysis, provides valuable information on the distribution and impact of air pollution, complementing traditional physicochemical methods. These findings highlight the importance of biomonitoring in understanding and mitigating the effects of air pollution on human health and the environment. Biomonitoring also includes the measurement of pollutant concentrations in biological samples, such as blood, urine, and tissues, to assess human exposure and health effects.

Air Quality Modeling: Air quality modeling utilizes computer simulations to predict pollutant concentrations in the atmosphere and understands the complex interactions between emission sources, atmospheric processes, and meteorological conditions (Isakov et al., 2014; Bang et al., 2018; Asif and Chen, 2019; Kadaverugu et al., 2019). These models incorporate data on emission inventories, meteorology, topography, and chemical reactions to simulate air pollutant dispersion and transformation. Air quality models are valuable tools for assessing future scenarios, evaluating the impacts of emission reduction strategies, and supporting policy and decision-making.

3.4. Classification of Analytical Air Pollution Monitoring Techniques

In summary, ambient air monitoring, remote sensing, chemical analysis, biomonitoring, and air quality modeling are all essential air quality monitoring techniques used to measure different aspects of air pollution. The choice of approaches depends on the specific needs of the monitoring program. Table 2 summarizes the different air quality monitoring techniques, their components, working principles, and categories.

3.5. Limitations and Challenges of Analytical Air Pollution Monitoring Techniques

The limitations of ambient air monitoring can hinder progress in combating air pollution in several ways. Firstly, traditional monitoring methods are expensive and have spatial constraints, making it arduous to monitor air pollution in broader areas (Grainger and Schreiber, 2019). This limitation restricts the ability to gather comprehensive data on air quality, which is crucial for identifying and addressing pollution issues (McGrath et al., 2020). Secondly, the lack of portability and real-time monitoring capabilities in existing systems hinders the ability to monitor pollutants such as $PM_{2.5}$ and PM_{10}, which are responsible for hazy weather conditions (Tatavarti, 2021). Additionally, detecting air pollutants at lower levels through analytical techniques highlights the need for appropriate quality control procedures and method validation to ensure meaningful and accurate results (Jaiswal, 2019). Furthermore, the complexity and challenges posed by ambient air quality monitoring require a consensus among various stakeholders, including nations, governments, regulatory bodies, NGOs, scientists, researchers, and private citizens (Forbes, 2015; Pinder et al., 2019). Besides, unexpected situations, such as damage to monitoring equipment or the relocation of monitoring stations, can result in a lack of monitoring data (Ma et al., 2021). This missing data can hinder accurate analysis and research on air quality, impeding efforts to develop effective strategies for pollution control (Bathiya et al., 2016). Additionally, the lack of widespread and ubiquitous monitoring networks can lead to gaps in data coverage, making it challenging to assess the full extent of air pollution and its impacts (Tiwari et al., 2020).

Despite its limitation, however, the possible solutions to the drawback of ambient air monitoring include implementing low-cost solid-state gas and PM sensors that can operate in real-time, providing high spatial and time resolution monitoring (Tatavarti, 2021). These sensors require proper evaluation and calibration before implementation. Another solution is the expansion of smart sensors that can measure pollutants in real-time and at small scales, allowing for target-specific monitoring, personal exposure assessment, and real-time alertness. Such smart sensors have attracted the interest of environmmental researchers, authorities, and local communities (Nagendra et al., 2021). Additionally, implementing an ambient air quality integrated monitoring device, which includes a quartz crystal balance sensor, oscillation circuit, reference frequency source, and microprocessor, can provide accurate and simultaneous monitoring of multiple corrosivity problems in the air (Tiwari et al., 2020). Table 3 summarizes the limitation and gaps of air quality monitoring techniques.

Remote sensing has limitations that can hinder progress in combating air pollution. One limitation is the difficulty of obtaining the detailed information about the air pollutants' spatial and

Table 2. Summary of Air Quality Monitoring Techniques, Components, Working Principles, and Categories

Techniques	Components	Working Principle	Categories	Description
Ambient Air Monitoring	Sampler, filter, detector, and data logger	Collects air samples from a fixed location and measures the concentration of pollutants in the air	In situ	This is the most common type of air quality monitoring. It involves the use of sensors to measure the concentration of air pollutants at a specific location and time. Ambient air monitoring stations are typically located in urban areas, industrial zones, and other areas where air pollution is a concern.
Remote Sensing	Instruments that emit a beam of light or radiation and measure how the light or radiation is reflected or absorbed by the pollutants in the air	Measures the concentration of pollutants in the air from a distance	Remote	This technique uses satellites or aircraft to measure the concentration of air pollutants from a distance. Remote sensing is a valuable tool for monitoring air pollution over large areas, such as entire cities or countries. However, it is not as accurate as ambient air monitoring for measuring the concentration of air pollutants at a specific location.
Chemical Analysis	Gas chromatographs, mass spectrometers and spectrophotometers	Measures the concentration of pollutants in air samples	Laboratory-based chemical analysis, field-based chemical analysis, and online chemical analysis	This technique involves collecting an air sample and analyzing it for the concentration of air pollutants in a laboratory. Chemical analysis is the most accurate method for measuring the concentration of air pollutants, but it is also the most time-consuming and expensive.
Biomonitoring	Living organisms that absorb pollutants from the air and store them in their tissues	Measures the concentration of pollutants in the air using living organisms	Biomarker analysis, bioaccumulation analysis, and biomonitoring of ecosystems	This technique involves measuring the concentration of air pollutants in biological tissues, such as plants, animals, or humans. Biomonitoring can be used to track the long-term exposure of people and wildlife to air pollution. However, it is not as accurate as ambient air monitoring or chemical analysis for measuring the concentration of air pollutants in the air.
Air Quality Modeling	Computers and mathematical models	Predicts the concentration of pollutants in the air	Computational	This technique uses computer models to simulate the transport and dispersion of air pollutants in the atmosphere. Air quality modeling can be used to predict the concentration of air pollutants at a specific location and time, and to assess the impact of air pollution policies and regulations.

temporal distribution, including greenhouse gases (GHGs) (Sivaramakrishnan et al., 2020; Scheibenreif et al., 2021). Existing models for surface-level air pollution rely on extensive land-use datasets, which are often locally restricted and temporally static (Scheibenreif et al., 2021). Another limitation is the time-consuming nature of monitoring air pollution data using current algorithms, resulting in low monitoring efficiency and accuracy (Liu et al., 2020). Additionally, "using sensors for air pollution monitoring requires highly durable sensors that can operate for long periods under severe conditions such as high humidity, solar radiation, and dust" (Kendler and Zuck, 2020). The need for consumable-free dust removal devices to protect sensors from clogging and maintain consistent performance is also a drawback (Camarillo-Escobedo et al., 2021). Finally, the analysis and processing of data from portable monitors is still limited, with a need for more advanced models to analyze and interpret the collected data (Hernández-Gordillo et al., 2021). These limitations in remote sensing and sensor technology can impede the collection of accurate and comprehensive data necessary for effective air pollution mitigation strategies. Meanwhile, possible solutions to the limitations of remote sensing for air pollution include implementing deep learning approaches that rely on globally available and frequently updated remote sensing data, such as optical satellite imagery and satellite based atmospheric column density air pollution measurements (Paleczek et al., 2021). Another solution is the development of artificial intelligence-based algorithms for quantitative remote sensing monitoring of air pollution, which can provide relevant information with high monitoring efficiency, a vast monitoring range, and high monitoring accuracy (Scheibenreif et al., 2021).

Chemical analysis has limitations that can hinder progress in combating air pollution. One limitation is the reliance on priority pollutants, which can lead to the misconception that these chemicals represent the universe of toxic substances (Goldman et al., 2021). Another limitation is the inability of selective and sensitive analytical techniques to detect all chemicals in the surrounding environment (Devier et al., 2011). Inadequate and imprecise toxicological databases also hinder the significance determination of identified chemicals of concern (Burkholder et al., 2017). Chemical analysis limitations may impede efforts to tackle air pollution by underestimating the levels and potential dangers of toxic substances in the environment. Meanwhile, to overcome these limitations, integrated bioanalytical approaches have emerged as promising tools to improve environmental risk assessment by considering the link between chemical presence and biological effects (McNeill, 2019). There are limitations in the chemical analysis of air pollution that require attention. One possible solution is the development of sensitive and selective analytical methods to detect a wide range of analyses, allowing for a better understanding of this complex field

Table 3. Summary of the Limitation and Gaps of Air Quality Monitoring Techniques

Techniques	Limitations	Gaps
Ambient Air Monitoring	Limited spatial coverage, limited temporal resolution, high cost	Not suitable for capturing short-term changes in air pollution or for monitoring large areas
Remote Sensing	Limited accuracy, limited spatial resolution, limited temporal resolution	Not suitable for measuring small-scale variations in air pollution or for tracking changes in air pollution over time
Chemical Analysis	Time-consuming, costly, requires specialized equipment	Not suitable for monitoring air pollution in real-time or for large areas
Biomonitoring	Not all pollutants can be biomonitored, can be affected by other factors, and requires long-term data collection	Not suitable for measuring all air pollutants or for detecting short-term changes in air pollution exposure
Air Quality Modeling	Its inaccurate requires a lot of data and can be computationally expensive	Not suitable for predicting air pollution in new or rapidly changing environments

(Forbes, 2020). Another solution is to apply IoT and machine learning algorithms to detect and analyze pollutant gases, estimating air quality (Goldman et al., 2021). Meanwhile, new technologies such as the Carbonator system can remove carbon dioxide emissions and redirect emissions from fixed sources into depleted reservoirs, reducing air pollution (Choy et al., 2021).

Biomonitoring has limitations in the context of combating air pollution. The identification of lichens as bioindicators is restricted to expert researchers, limiting their widespread use (Giordano et al., 2021). Additionally, the effectiveness of tree species as bioindicators depends on their tolerance and sensitivity to air pollution, which are evaluated using the air pollution tolerance index (APTI). However, the APTI alone is not sufficient for determining the suitability of tree species for green belt development (Chiari et al., 2020). Furthermore, biomonitoring using bryophytes can capture long-term deposition of pollutants, but it may not provide real-time information on air pollution concentrations (Almeida et al., 2017). However, to overcome its drawback, one possible solution is to develop alternative bioindicators not limited by factors of the vegetative season, moisture demand, and exposure to severe weather conditions. Spider webs are abundant, easy to collect, and can be found all year round, making them a promising bioindicator for air pollution monitoring (Chiari et al., 2020). Utilizing various types of plants that are specifically susceptible to certain air pollutants and exhibit unique signs of damage is a viable solution. This approach allows for monitoring the presence or absence of air pollutants (Giordano et al., 2021). Additionally, the development of mathematical models and indices, such as the air pollution tolerance index, can provide a more comprehensive understanding of the role of plants in monitoring air pollution (Rutkowski et al., 2018).

Air quality modeling in the context of combating air pollution has several limitations. Air pollution modeling is a complex and challenging task that involves simplifications and assumptions. Models rely on numerous input data and parameters, which may have uncertainties and limitations (East et al., 2021). Unpredictability can arise from incomplete or inaccurate emission inventories, meteorological data, and chemical reaction mechanisms (Ferreira et al., 2020). Models also face challenges in simulating complex atmospheric processes, such as atmospheric chemistry, heterogeneous reactions, and interactions between different pollutants (Silveira et al., 2019). Additionally, model predictions may be affected by the spatial and temporal resolution of the model grid and the representativeness of the monitoring data used for model evaluation. Possible solutions to the limitations of air quality modeling for air pollution monitoring include implementing machine learning techniques such as deep belief networks (DBN) and neural networks to supplement missing monitoring data (Ma et al., 2021). Data-driven models, such as Random Forest (RF) and Support Vector Regression (SVR), can be developed to predict pollutant concentrations based on readily available data, improving the spatial resolution of air monitoring (Shifa and Rathi, 2021).

In line with this, blockchain technology can provide a tamper-proof record of air quality data, ensuring data reliability in pollution monitoring systems (Gryech et al., 2020). Equipping gas sensors on mobile devices or vehicles is a mobile solution that enables active and cooperative detection of air pollution. It provides finer-grained monitoring and flexibility in choosing monitoring station locations (de Tazoult et al., 2019; Wang, 2019). These solutions offer potential improvements in air quality modeling and monitoring, addressing the limitations of traditional fixed-location monitoring stations.

3.6. Modeling Air Pollution

Uses of Air Pollution Models: Air pollution models serve multiple purposes, including regulatory compliance, policy development, and scientific research. Meanwhile, this model can be used to predict and assess pollutant concentrations, identify pollution sources, estimate human exposure levels, evaluate the effectiveness of emission control strategies, and support decision-making. Air pollution models also help in understanding the long-range transport of pollutants, assessing the impacts of climate change on air quality, and predicting future air pollution scenarios.

Type of Air Pollution Models: Different models are used to simulate air pollution, each with strengths and limitations. Dispersion models, such as Gaussian and computational fluid dynamics models, simulate the transport and dispersion of pollutants in the atmosphere based on meteorological conditions and emission sources. Receptor models, such as chemical mass balance and positive matrix factorization models, help to identify and apportion pollution sources based on measured pollutant concentrations. Integrated assessment models combine multiple models to analyze the interactions between air pollution, climate change, and human activities.

Input Data and Parameters: Air pollution models require several input data and parameters to simulate pollutant dispersion and transformation correctly. These inputs include emission inventories, meteorological data, land use data, and chemical reaction mechanisms. Emission inventories provide information about the types and amounts of pollutants released into the atmosphere from various sources. Accurate meteorological data, including wind speed, direction, temperature, and stability, are crucial for simulating pollutant transport. Chemical reaction mechanisms describe the complex chemical reactions in the atmosphere and influence pollutant transformation and formation.

Modeling air pollution involves the statistical simulation of how air pollutants spread and react in the environment, impacting the quality of atmospheric air (Kakareka and Salivonchyk, 2021). Various modeling approaches have been used, including deterministic, statistical, and hybrid models (Raheja et al., 2021). These models are used for different purposes, such as event forecasting and long-term planning in air quality management (Itahashi, 2021). Additionally, modeling can be used to assess the air quality of urban areas, considering factors like toxic levels and variations in pollutant levels (Yadav et al., 2020). Furthermore, deep learning frameworks, such as the temporal sliding long short-term memory extended model (TS-LSTME), have been proposed to predict air quality in the following 24 hours. These models integrate historical pollutant concentrations, meteorological data, and temporal information to achieve accurate predictions. Overall, modeling air pollution plays a crucial role in understanding and managing air quality in urban areas.

3.7. Strategies for Combating Air Pollution

Policy and Regulation: By establishing emission limits, encouraging the use of clean technology, and enforcing compliance, government policies and regulations play a critical part in lowering air pollution. These policies may include criteria for automobile emissions, objectives for renewable energy, and pollution prevention measures. These regulations can also incentivize the use of cleaner fuels, the implementation of emission-reduction technologies, and the adoption of sustainable practices.

Alternative Energy Sources: Transitioning from fossil fuels to cleaner and renewable energy sources is a critical strategy for reducing air pollution and combating climate change. Renewable energy sources, such as solar, wind, hydropower, and geothermal, generate electricity without emitting air pollutants or greenhouse gases. Increasing the share of renewable energy in the global energy mix can significantly reduce air pollution, enhance energy security, and promote sustainable development.

Transportation Solutions: The transportation sector is a crucial contributor to air pollution, particularly in urban areas. Implementing transportation solutions, such as improving public transportation systems, promoting electric vehicles, and encouraging active modes of transport like walking and cycling, can help reduce vehicle emissions. Investing in infrastructure for electric vehicle charging stations, promoting carpooling, and ridesharing, and creating pedestrian-friendly cities can significantly decrease air pollution from transportation.

Industrial Emission Controls: Industries are significant sources of air pollution, emitting various pollutants during production operations. Implementing emission control technologies, such as scrubbers, catalytic converters, and particulate filters, can reduce the release of harmful substances into the atmosphere. Industries can also adopt cleaner production techniques, use alternative raw materials, and improve energy efficiency to minimize pollution. Regular monitoring and enforcement of emission standards are essential to ensuring compliance.

Public Awareness and Education: Raising public awareness about the impacts of air pollution and promoting individual actions can contribute to lowering pollution levels. Education campaigns can inform people about the health risks associated with air pollution, the importance of sustainable practices, and the benefits of using clean technologies. Encouraging behavioral changes, such as reducing reliance on private vehicles, conserving energy, and practicing proper waste management, can help individuals contribute to cleaner air.

3.8. Future Perspective and Challenges

Climate Change and Air Pollution: Air pollution and climate change are interconnected challenges that require integrated solutions. Many air pollutants, such as carbon dioxide, methane, and black carbon, are also greenhouse gases that contribute to climate change. As cleaner technology and practices frequently result in reduced greenhouse gas emissions, reducing air pollution can also aid efforts to mitigate global warming. Addressing climate change can lessen the effects of air pollution by reducing the frequency of extreme weather events and improving air quality.

Technological Innovations: Advancements in technology have the potential to revolutionize air pollution monitoring, mitigation, and control. Real-time air quality monitoring and individualized exposure assessment are now possible because of the development of low-cost sensors, portable electronics, and wearable technology. Furthermore, innovations in clean energy technologies, emission reduction technologies, and pollution control devices can significantly reduce air pollution levels. It should be a priority to encourage this kind of research and development and make it easier for creative ideas to be adopted.

International Collaborations: Air pollution is a global problem that requires international collaboration and cooperation. Countries must work as one to share best practices, exchange knowledge, and develop joint strategies for reducing air pollution. International agreements, such as the United Nations Convention on Long-Range Transboundary Air Pollution and the Minamata Convention on Mercury, facilitate collaboration and promote the adoption of pollution control measures. Continued efforts to strengthen international cooperation are essential for addressing the transboundary nature of air pollution and achieving global air quality goals.

Sustainable Development Goals: Air pollution is closely associated with several United Nations Sustainable Development Goals (SDGs), including health, climate action, clean energy, sustainable cities, and life on land. Integrating air pollution management into sustainable development strategies can help achieve multiple SDGs simultaneously. Accordingly, this requires a holistic approach that considers a social, economic, and environmental aspect of sustainability. Policy coherence, stakeholder engagement, and multi-sectorial collaboration are essential for aligning air pollution management with sustainable development objectives.

4. Conclusions

Air pollution poses significant risks to human health, ecosystems, and the environment. It is a complex and multifaceted issue necessitating comprehensive understanding, collective action, and innovative solutions. By implementing effective policies, adopting clean technologies, promoting sustainable practices, and raising awareness, we can mitigate the impacts of air pollution and create a healthier and more sustainable future. The fight against air pollution is a global endeavor that demands collaboration, commitment, and continuous efforts to safeguard the well-being of present and future generations.

Acknowledgments. I am grateful to the JEIL Editorial Office and reviewers for investing the time and effort necessary to evaluate the manuscript. My sincere gratitude goes out to everyone who offered wise comments and suggestions that helped me improve the quality of the manuscript.

References

Abdelnasser, M. (2022). Environmental pollution and the immune system. *Al-Azhar Medical Journal*, 51(4), 1-4. https://doi.org/10.21608/amj.2022.265021

Abecasis, L., Gamelas, C.A., Justino, A.R., Dionísio, I., Canha, N., Kertesz, Z. and Almeida, S.M. (2022). Spatial distribution of air pollution, hotspots and sources in an urban-industrial area in the Lisbon metropolitan area, Portugal-A biomonitoring approach. *International Journal of Environmental Research and Public Health*, 19 (3), 1364. https://doi.org/10.3390/ijerph19031364

Abu El-Magd, S., Soliman, G., Morsy, M. and Kharbish, S. (2023). Environmental hazard assessment and monitoring for air pollution using machine learning and remote sensing. *International Journal of Environmental Science and Technology*, 20(6), 6103-6116. https://doi.org/10.1007/s13762-022-04367-6

Alhowikan, A.M., Al-Ayadhi, L.Y. and Halepoto, D.M. (2019). Impact of environmental pollution, dietary factors and diabetes mellitus on Autism Spectrum Disorder (ASD). *Pakistan journal of medical sciences*, 35(4), 1179-1184. https://doi.org/10.12669/pjms.35.4.269

Al-Kindi, S.G., Brook, R.D., Biswal, S. and Rajagopalan, S. (2020). Environmental determinants of cardiovascular disease: lessons learned from air pollution. *Nature Reviews Cardiology*, 17(10), 656-672. https: //doi.org/10.1038/s41569-020-0371-2

Almeida, S.M., Wolterbeek, H., Markert, B. and Loppi, S. (2017). Biomonitoring of atmospheric pollution: Possibilities and future challenges. *Environmental Science and Pollution Research*, 24, 11865-11866. https://doi.org/10.1007/s11356-016-7060-z

Amadou, A., Praud, D., Coudon, T., Danjou, A.M.N., Faure, E., Leffondre, K., Romancer, M.L., Severi, G., Salizzoni, P., Mancini, F.R. and Fervers, B. (2020). Chronic long-term exposure to cadmium air pollution and breast cancer risk in the French E3N cohort. *International Journal of Cancer*, 146(2), 341-351. https://doi.org/10.1002/ijc.32257

An, Z., Jin, Y., Li, J., Li, W. and Wu, W. (2018). Impact of particulate air pollution on cardiovascular health. *Current Allergy and Asthma Reports*, 18, 1-7. https://doi.org/10.1007/s11882-018-0768-8

Arias-Pérez, R.D., Taborda, N.A., Gómez, D.M., Narvaez, J.F., Porras, J. and Hernandez, J.C. (2020). Inflammatory effects of particulate matter air pollution. *Environmental Science and Pollution Research*, 27(34), 42390-42404. https://doi.org/10.1007/s11356-020-10574-w

Asif, Z. and Chen, Z. (2020). A life cycle based air quality modeling and decision support system (LCAQMS) for Sustainable Mining Management. *Journal of Environmental Informatics*, 35(2), 103-117. https://doi.org/10.3808/jei.201900406

Atator, L.T., Kamou, H., Bawa, A., Agbodan, K.M.L., Polo, A.A., Akpavi, S.B. and Akpagana, K. (2021). Determination of air pollutant concentrations in plant species in relation to pollution sources. *Open Journal of Air Pollution*, 10, 53-62. https://doi.org/10.4236/ojap.2021.103004

Azarpazhooh, M.R. and Hachinski, V. (2018). Air pollution: a silent common killer for stroke and dementia. *International Journal of Stroke*, 13(7), 667-668. https://doi.org/10.1177/1747493018784476

Bai, L., Shin, S., Burnett, R.T., Kwong, J.C., Hystad, P., van Donkelaar, A., Goldberg, M.S., Lavigne, E., Weichenthal, S., Martin, R.V., Copes, R., Kopp A. and Chen, H. (2020). Exposure to ambient air pollution and the incidence of lung cancer and breast cancer in the Ontario Population Health and Environment Cohort. *International Journal of Cancer*, 146(9), 2450-2459. https://doi.org/10.1002/ijc.32575

Bălă, G.P., Râjnoveanu, R.M., Tudorache, E., Motișan, R. and Oancea, C. (2021). Air pollution exposure-the invisible risk factor for respiratory diseases. *Environmental Science and Pollution Research*, 28, 19615-19628. https://doi.org/10.1007/s11356-021-13208-x

Bang, H.Q., Khue, V.H.N., Tam, N.T. and Lasko, K. (2018). Air pollution emission inventory and air quality modeling for Can Tho City, Mekong Delta, Vietnam. *Air Quality, Atmosphere and Health*, 11, 35-47. https://doi.org/10.1007/s11869-017-0512-x

Bathiya, B., Srivastava, S. and Mishra, B. (2016). Air pollution monitoring using wireless sensor network. *2016 IEEE international WIE conference on electrical and computer engineering (WIECONECE)*. Pune, India, 112-117. https://doi.org/10.1109/wiecon-ece.2016.8009098

Belguidoum, A., Haichour, R., Lograda, T. and Ramdani, M. (2022). Biomonitoring of air pollution by lichen diversity in the urban area of Setif, Algeria. *Biodiversitas Journal of Biological Diversity*, 23(2), 970-981. https://doi.org/10.13057/biodiv/d230240

Bhatnagar, A. (2022). Cardiovascular effects of particulate air pollution. *Annual Review of Medicine*, 27(73), 393-406. https://doi.org/10.1146/annurev-med-042220-011549

Bobrowska-Korzeniowska, M., Jerzyńska, J., Polańska, K., Kaleta, D., Stelmach, I., Kunert, A. and Stelmach, W. (2021). The effect of air pollution on the respiratory system in preschool children with contribution of urban heat islands and geographic data-the aim of the study and methodological assumptions. *International Journal of Occupational Medicine and Environmental Health*, 34(4), 453-460. https://doi.org/10.13075/ijomeh.1896.01651

Bourdrel, T. (2022). Air pollution: The most important environmental threat to the cardiovascular system. *Trends in Cardiovascular Medicine*, 32(8):499-500. https://doi.org/10.1016/j.tcm.2021.10.005

Bousquet, J., Antó, J.M., Annesi-Maesano, I., Annesi-Maesano, I., Dedeu, T., Dupas, E., Pépin, J.L., Eyindanga, L.S.Z., Arnavielhe, S., Ayache, J., Basagaña, X., Benveniste, S., Venturos, N.C., Chan, H.K., Cheraitia, M., Dauvilliers, Y., Garcia-Aymerich, J., Jullian-Desayes, I., Dinesh, C., Laune, D., Dac, J.L., Nujurally, I., Giovanni

P., Picard, R., Rodo, X., Tamisier, R., Bewick, M., Billo, N.E., Czarlewski, W., Fonseca, J., Klimek, L., Pfaar, O. and Bourez, J.M. (2018). POLLAR: Impact of air Pollution on Asthma and Rhinitis; a European Institute of Innovation and Technology Health (EIT Health) project. *Clinical and Translational Allergy*, 8(36), 1-13. https://doi.org/1 0.1186/s13601-018-0221-z

Burkholder, J.B., Abbatt, J., Abbatt, J.P.D., Barnes, I., , Roberts, J.M., Melamed, M.L., Ammann, M., Bertram, A.K., Cappa, C.D., Carlton, A.G., Carpenter, L.J., Crowley, J.N., Dubowski, Y., George, C., Heard, D.E., Herrmann, H., Keutsch, F.N., Kroll, J.H., McNeill, V.F., Ng, N.L., Nizkorodov, S.A., Orlando, J.J., Percival, C.J., Picquet-Varrault, B., Rudich, Y., Seakins, P.W., Surratt, J.D., Tanimoto, H., Thornton, J.A., Tong, Z., Tyndall, G.S., Wahner, A., Weschler, C.J., Wilson, K.R. and Ziemann, P.J. (2017). The essential role for laboratory studies in atmospheric chemistry. *Environmental Science and Technology*, 51(5), 2519-2528. https://doi.org/10.1021/acs.est.6b04947

Cahueñas, B. E. (2020). *Effects of Air Pollution on the Respiratory Health and the Respiratory Immune System: Studies in Ecuadorian Children.* Department of Immunology, Central University of Ecuador.

Calderón-Garcidueñas, L., Stommel, E.W., Rajkumar, R.P., Mukherjee, P.S. and Ayala, A. (2021). Particulate air pollution and risk of neuropsychiatric outcomes. What we breathe, swallow, and put on our skin matters. *International Journal of Environmental Research and Public Health*, 18(21), 11568. https://doi.org/10.3390/ijerph182111568

Camarillo-Escobedo, R.M., Flores-Nuñez, J.L., Camarillo-Escobedo, J.M., Marin-Montoya, P., Amparan-Estrada, J.R. and Garcia-Torales, G. (2021). Remote sensing system to monitoring of quality air using unmanned aerial vehicles and LoRa communication. *Infrared Remote Sensing and Instrumentation XXIX*, 11830, 137-146. https://doi.org/10.1117/12.2595060

Carter, C.A., Cui, X., Ding, A., Ghanem, D., Jiang, F., Yi, F. and Zhong, F. (2017). Stage-specific, nonlinear surface ozone damage to rice production in China. *Scientific Reports*, 7(1), 44224. https://doi.org/10.1038/srep44224

Carvalho, M.A., Hettfleisch, K., Rodrigues, A.S., Benachi, A., Vieira, S.E., Saldiva, S.R.D.M., Saldiva, P.H.N., Francisco, R.P.V. and Bernardes, L. S. (2021). Association between exposure to air pollution during intrauterine life and cephalic circumference of the newborn. *Environmental Science and Pollution Research*, 28(8), 9701-9711. https://doi.org/10.1007/s11356-020-11274-1

Cass, L. R. (2014). Air pollution and acid rain. *Routledge Handbook of Global Environmental Politics* (1st Edition). Routledge. https://doi.org/10.4324/9780203799055

Cauci, S., Tavano, M., Curcio, F. and Francescato, M. P. (2022). Biomonitoring of urinary metals in athletes according to particulate matter air pollution before and after exercise. *Environmental Science and Pollution Research*, 29, 26371-26384. https://doi.org/10.1007/s11356-021-17730-w

Chaparro, M.A.E., Chaparro, M. A.E., Castañeda-Miranda, A.G., Marié, D.C., Gargiulo, J.D., Lavornia, J.M., Natal, M. and Böhnel, H.N. (2020). Fine air pollution particles trapped by street tree barks: In situ magnetic biomonitoring. *Environmental Pollution*, 266, 115229. https://doi.org/10.1016/j.envpol.2020.115229

Chen, K C., Tsai, S.W., Shie, R.H., Zeng, C. and Yang, H.Y. (2022). Indoor air pollution increases the risk of lung cancer. *International Journal of Environmental Research and Public Health*, 19(3), 1164. https://doi.org/10.3390/ijerph19031164

Chen, L.Y. and Liao, H. (2017). Engineering crop nutrient efficiency for sustainable agriculture. *Journal of Integrative Plant Biology*, 59(10), 710-735. https://doi.org/10.1111/jipb.12559

Chen, X., Zhao, X., Jones, M. B., Harper, A., de Seymour, J.V., Yang, Y., Xia, Y., Zhang, T., Qi, H., Gulliver, J., Cannon, R.D., Saffery, R., Zhang, H., Han, T. and Baker, P.N. (2022). The relationship between hair metabolites, air pollution exposure and gestational diabetes mellitus: A longitudinal study from pre-conception to third trimester. *Frontiers in Endocrinology*, 13, 1060309. https://doi.org/10.3389/fendo.2022.1060309

Chiari, M., Anhê, A.C.B.M., Costa, W.R. and dos Santos Senhuk, A.P.M. (2020). Biomonitoring of air pollution: a dichotomous key for lichen species identification. *Ciência e Natura*, 42, e77. https://doi.org/10.5902/2179460x41851

Choy, W.C., Kassim, A.M. and Ul-Saufie, A.Z. (2021). Prediction of Carbon Monoxide (CO) Atmospheric Pollution Concentrations with Machine Learning and Time Series Analysis in Langkawi, Malaysia. *ASM Science Journal*, 16, 1-12. https://doi.org/10.32802/asmscj.2021.756

Chudnovsky, A.A. (2021). Monitoring air pollution in the urban environment by remote sensing. *Urban Remote Sensing*, 391-422. https://doi.org/10.1002/9781119625865.ch18

Coleman, N.C., Ezzati, M., Marshall, J.D., Robinson, A.L., Burnett, R.T. and Pope III, C.A. (2021). Fine particulate matter air pollution and mortality risk among US cancer patients and survivors. *JNCI Cancer Spectrum*, 5(1), pkab001. https://doi.org/10.1093/jncics/pkab001

Cong, L., Bremer, P. and Mirosa, M. (2019). Chinese Consumers' Perceptions of Functional Foods: A netnography study of foods that help the immune system recover from air pollution. *Journal of Food Products Marketing*, 25(6), 628-646. https://doi.org/10.1080/10454446.2019.1626316

Cong, X. (2018). Air pollution from industrial waste gas emissions is associated with cancer incidences in Shanghai, China. *Environmental Science and Pollution Research*, 25, 13067-13078. https://doi.org/10.1007/s11356-018-1538-9

Copat, C., Cristaldi, A., Fiore, M., Grasso, A., Zuccarello, P., Gea., O.C., Signorelli, S. and Ferrante, M. (2020). A first review to explore the association of air pollution (PM and NO_2) on Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-2). *Preprints*. https://doi.org/10.20944/preprints202005.0299.v1

Costa, A. and Pasquinelli, G. (2022). Air pollution exposure induces vascular injury and hampers endothelial repair by altering progenitor and stem cells functionality. *Frontiers in Cell and Developmental Biology*, 27(10), 897831. https://doi.org/10.3389/fcell.2022.897831

Cotrozzi, L., Townsend, P.A., Pellegrini, E., Nali, C. and Couture, J.J., (2018). Reflectance spectroscopy: a novel approach to better understand and monitor the impact of air pollution on Mediterranean plants. *Environmental Science and Pollution Research*, 25(9), 8249-8267. https://doi.org/10.1007/s11356-017-9568-2

Crilley, L.R., Shaw, M., Pound, R., Kramer, L.J., Price, R., Young, S., Lewis, A.C. and Pope, F.D. (2018). Evaluation of a low-cost optical particle counter (Alphasense OPC-N2) for ambient air monitoring. *Atmospheric Measurement Techniques*, 11(2), 709-720. https://doi.org/10.5194/amt-11-709-2018

Croft, D.P., Burton, D.S., Nagel, D.J., Bhattacharya, S., Falsey, A.R., Georas, S.N., Hopke, P.K., Johnston, C.J., Kottmann, R.M., Litonjua, A.A., Mariani, T.J., Rich, D.Q., Thevenet-Morrison, K., Thurston, S.W., Utell, M.J. and McCall, M.N. (2021). The effect of air pollution on the transcriptomics of the immune response to respiratory infection. *Scientific Reports*, 11(1), 19436. https://doi.org/10.21203/rs.3.rs-440415/v1

de Matos Nascimento, A., Maciel, A.M., Silva, J.B.G., Mendonça, H.V., de Paula, V.R. and Otenio, M.H. (2020). Biofertilizer application on corn (Zea mays) increases the productivity and quality of the crop without causing environmental damage. *Water, Air, and Soil Pollution*, 231, 1-10. https://doi.org/10.1007/s11270-020-04778-6

de Tazoult, C. T., Chiky, R. and Foltescu, V. (2019). A distributed pollution monitoring system: The application of blockchain to air quality monitoring. *Computational Collective Intelligence: 11th International Conference,* ICCCI 2019, Hendaye, France, September 4-6, 2019, Proceedings, Part II 11, 688-697. https://doi.org/10.1007/978-3-030-28374-2_59

Debnath, B., Sikdar, A., Islam, S., Hasan, K., Li, M. and Qiu, D. (2021). Physiological and molecular responses to acid rain stress in plants and the impact of melatonin, glutathione and silicon in the amendment of plant acid rain stress. *Molecules*, 26(4), 862. https://doi.org/10.3390/molecules26040862

Decrue, F., Townsend, R., Miller, M.R., Newby, D.E. and Reynolds, R. M. (2023). Ambient air pollution and maternal cardiovascular health in pregnancy. *Heart*. 109, 1586-1593, https://doi.org/10.1136/heartjnl-2022-322259

Dehghani, S., Abedinzade, A. and Vali, M. (2021). Ambient air pollution exposure and thyroid cancer incidence in Iran. *Journal of Air Pollution and Health*, 6(1), 30-41. https://doi.org/10.18502/japh.v6i1.7603

Demetillo, M.A.G., Navarro, A., Knowles, K.K., Fields, K.P., Geddes, J.A., Nowlan, C.R., Janz, S.J., Judd, L.M., Al-Saadi, J.A., Sun, K., McDonald, B.C., Diskin, G.S and Pusede, S.E. (2020). Observing nitrogen dioxide air pollution inequality using high-spatial-resolution remote sensing measurements in Houston, Texas. *Environmental Science and Technology*, 54(16), 9882-9895. https://doi.org/10.1021/acs.est.0c01864

Dévier, M.H., Mazellier, P., Aït-Aïssa, S. and Budzinski, H. (2011). New challenges in environmental analytical chemistry: Identification of toxic compounds in complex mixtures. *Comptes Rendus Chimie*, 14(7), 766-779. https://doi.org/10.1016/j.crci.2011.04.006

Dhaouadi, S., Khalloufi, N., Ayati, K., Ayeb, N. and Béjaoui, M. (2022). Use of lichen species for air pollution biomonitoring: Case of Dar-Chichou forest (Cap-Bon, North-East Tunisia). *Environmental and Sustainability Indicators*, 16, 100211. https://doi.org/10.1016/j.indic.2022.100211

Dominski, F.H., Branco, J.H.L., Buonanno, G., Stabile, L., da Silva, M.G. and Andrade, A. (2021). Effects of air pollution on health: A mapping review of systematic reviews and meta-analyses. *Environmental research*, 201, 111487. https://doi.org/10.1016/j.envres.2021.111487

Duan, K., Sun, G., Zhang, Y., Yahya, K., Wang, K., Madden, J. M., Caldwell, P.V., Cohen, E.C. and McNulty, S.G. (2017). Impact of air pollution induced climate change on water availability and ecosystem productivity in the conterminous United States. Climatic Change, 140, 259-272. https://doi.org/10.1007/s10584-016-1850-7

East, J., Montealegre, J.S., Pachon, J.E. and Garcia-Menendez, F. (2021). Air quality modeling to inform pollution mitigation strategies in a Latin American megacity. *Science of the Total Environment*, 776, 145894. https://doi.org/10.1016/j.scitotenv.2021.145894

Eguiluz-Gracia, I., Mathioudakis, A.G., Bartel, S., Vijverberg, S.J.H., Fuertes, E., Comberiati, P., Cai, Y.S., Tomazic, P.V., Diamant, Z., Vestbo, J., Galán, C. and Hoffmann, B. (2020). The need for clean air: the way air pollution and climate change affect allergic rhinitis and asthma. *Allergy*, 75(9), 2170-2184. https://doi.org/10.1111/all.14177

Ekiyor, T.H., Horsfall, I.T., Kalagbor, A.I. and Egbara-Dedua, B.A. (2019). Evaluating the effects of air pollution on the agricultural yield of selected crops in Eleme, Nigeria. *Journal of Applied Sciences and Environmental Management*, 23(10), 1771-1778. https://doi.org/10.4314/jasem.v23i10.1

Enkhjargal, A., Burmaajav, B., Tsegmed, S., Suvd, B., Norolkhoosuren, B., Unurbat, D. and Batbayar, J. (2020). Impact of ambient air pollution and meteorological factors on hospital admission to the cardiovascular system disease on Ulaanbaatar City of Mongolia. *Open Journal of Epidemiology*, 10(02), 100-114. https:// doi.org/10.4236/ojepi.2020.102009

Eze, I.C., Schaffner, E., Foraster, M., Imboden, M., von Eckardstein, A., Gerbase, M.W., Rothe, T., Rochat, T., Künzli, N., Schindler, C. and Probst-Hensch, N. (2015). Long-term exposure to ambient air pollution and metabolic syndrome in adults. *PloS one*, 10(6), e0130337. https://doi.org/10.1371/journal.pone.0130337

Fan, Q., Yu, W., Fan, S., Wang, X., Lan, J., Zou, D., Feng, Y. and Chan, P.W. (2014). Process analysis of a regional air pollution episode over Pearl River Delta Region, China, using the MM5-CMAQ model. *Journal of the Air and Waste Management Association*, 64 (4), 406-418. https://doi.org/10.1080/10962247.2013.816387

Fatima, F., Fatima, N., Amjad, T., Anjum, A., Afzal, T., Riaz, J. and Razzaq, H. (2021). A review on acid rain: An environmental threat. *Pure and Applied Biology*, 10(1), 301-310. http://dx.doi.org/10.19045/bspab.2021.100032

Fauzie, A.K. and Venkataramana, G.V. (2019). Effects of chronic exposure to particulate air pollution on cardiovascular system: An Experimental Study Using Mice Models. *Journal of Physics: Conference Series*, 1351(1), 012098. https://doi.org/10.1088/1742-6596/1351/1/012098

Feenstra, B., Papapostolou, V., Hasheminassab, S., Zhang, H., Der Boghossian, B., Cocker, D. and Polidori, A. (2019). Performance evaluation of twelve low-cost $PM_{2.5}$ sensors at an ambient air monitoring site. *Atmospheric Environment*, 216, 116946. https://doi.org/10.1016/j.atmosenv.2019.116946

Ferrari, L., Borghi, F., Iodice, S., Catelan, D., Rossi, S., Giusti, I., Grisotto, L., Rovelli, S., Spinazzè, A., Alinovi, R., Pinelli, S., Cantone, L., Dioni, L., Ischia, B., Rota, I., Mariani, J., Rota, F., Hoxha, M., Stoppa, G., Monticelli, D., Cavallo, D., Bergamaschi, E., Vicenzi, M., Persico, N., Biggeri, A., Cattaneo, A., Dolo, V., Miragoli, M., Mozzoni, P. and Bollati, V. (2020). INSIDE project: Individual air pollution exposure, extracellular vesicles signaling and hypertensive disorder development in pregnancy. *International journal of environmental research and public health*, 17(23), 9046. https://doi.org/10.3390/ijerph17239046

Ferreira, J., Lopes, D., Rafael, S., Relvas, H., Almeida, S.M. and Miranda, A.I. (2020). Modelling air quality levels of regulated metals: Limitations and challenges. *Environmental Science and Pollution Research*, 27, 33916-33928. https://doi.org/10.1007/s11356-020-09645-9

Flood-Garibay, J.A., Méndez-Rojas, M.Á. and Pérez-Cortés, E.J. (2020). Respiratory immune system and consequences due to particulate matter in air pollution. *Revista Médica del Instituto Mexicano del Seguro Social*, 57(3), 170-180.

Forbes, P. (2019). Atmospheric Chemistry analysis: a review. *Analytical Chemistry*, 92(1), 455-472. https://doi.org/10.1021/acs.analchem.9b04623

Forbes, P.B. (2015). Perspectives on the monitoring of air pollutants. *Comprehensive Analytical Chemistry*, 70, 3-9. https://doi.org/10.1016/bs.coac.2015.09.001

Forns, J., Sunyer, J., Garcia-Esteban, R., Porta, D., Ghassabian, A., Giorgis-Allemand, L., Gong, T., Gehring, U., Sørensen, M., Standl, M., Sugiri, D., Almqvist, C., Andiarena, A., Badaloni, C., Beelen, R., Berdel, D., Cesaroni, G., Charles, M.A., Eriksen, K.T., Estarlich, M., Fernández, M.F., Forhan, A., Forhan, A., Jaddoe, V.W.V., Korek, M., Lichtenstein, P., Lertxundi, A., Lopez-Espinosa, M.J., Markevych, I., de Nazelle, A., Raaschou-Nielsen, O., Nieuwenhuijsen, M.J., Pérez-Lobato, R., Philippat, C., Slama, R., Tiesler, C.M.T., Verhulst, F.C., von Berg, A., Vrijkotte, T.G.M., Andersen, P.K., Andersen, A.M.N., Heude, B., Ursula, K., Heinrich, J., Tiemeier, H., Forastiere, F., Pershagen, G., Brunekreef, B. and Guxens, M. (2018). Air pollution exposure during pregnancy and symptoms of attention deficit and hyperactivity disorder in children in Europe. *Epidemiology*, 29(5), 618-626. https://doi.org/10.1097/ede.0000000000000874

Fu, C.L., Kuang, D.B., Zhang, H., Ren, J.X. and Chen, J.L. (2022). Different components of air pollutants and neurological disorders. *Frontiers in Public Health*, 10, 959921. https://doi.org/10.3389/fpu bh.2022.959921

Fuller, C.H. and Amegah, A.K. (2022). Limited air pollution research on the african continent: time to fill the gap. *International Journal of Environmental Research and Public Health*, 19(11), 63 59. https://doi.org/10.3390/ijerph19116359

Genner, A., Martin-Mateos, P., Moser, H. and Lendl, B. (2020). A quantum cascade laser-based multi-gas sensor for ambient air monitoring. *Sensors*, 20(7), 1850. https://doi.org/10.3390/s20071850

Giordano, S., Spagnuolo, V. and Capozzi, F. (2021). Biomonitoring of air pollution. *Atmosphere*, 12(4), 433. https://doi.org/10.3390/atmos12040433

Gładka, A., Rymaszewska, J. and Zatoński, T. (2018). Impact of air pollution on depression and suicide. *International journal of occupational medicine and environmental health*, 31(6), 711-721. https://doi.org/10.13075/ijomeh.1896.01277

Gładka, A., Zatoński, T. and Rymaszewska, J. (2022). Association between the long-term exposure to air pollution and depression. *Advances in Clinical and Experimental Medicine*, 31(10), 1139-1152. 31, 0-0. https://doi.org/10.17219/acem/149988

Glencross, D.A., Ho, T.R., Camina, N., Hawrylowicz, C.M. and Pfeffer, P.E. (2020). Air pollution and its effects on the immune system. *Free Radical Biology and Medicine*, 151, 56-68. https://doi.org/10.1016/j.freeradbiomed.2020.01.179

Goldman, G.T., Desikan, A., Morse, R., Kalman, C., MacKinney, T., Cohan, D.S., Reed, G. and Parras, J. (2022). Assessment of air pollution impacts and monitoring data limitations of a spring 2019 chemical facility fire. *Environmental Justice*, 15(6), 362-372. https://doi.org/10.1089/env.2021.0030

Grainger, C. and Schreiber, A. (2019). Discrimination in ambient air pollution monitoring? *AEA Papers and Proceedings*, 109, 277-282. https://doi.org/10.1257/pandp.20191063

Gryech, I., Ghogho, M., Elhammouti, H., Sbihi, N. and Kobbane, A. (2020). Machine learning for air quality prediction using meteorological and traffic related features. *Journal of Ambient Intelligence and Smart Environments*, 12(5), 379-391. https://doi.org/10.3233/ais-200572

Grzywa-Celińska, A., Krusiński, A. and Milanowski, J. (2020). 'Smoging kills'-effects of air pollution on human respiratory system. *Annals of Agricultural and Environmental Medicine*, 27(1), 1-5. https://doi.org/10.26444/aaem/110477

Gu, H., Yan, W., Elahi, E. and Cao, Y. (2020). Air pollution risks human mental health: an implication of two-stages least squares estimation of interaction effects. *Environmental Science and Pollution Research*, 27(2), 2036-2043. https://doi.org/10.1007/s11356-019-06612-x

Gull, N., Nawaz, Y., Ali, M., Hussain, N., Nawaz, R. and Mushtaq, S.K. (2013). Industrial air pollution and its effects on human's respiratory system (a sociological study of Bhoun Shugar Mill District Jhang, Pakistan). *Academic Journal of Interdisciplinary Studies*, 2 (3), 535. https://doi.org/10.5901/ajis.2013.v2n3p535

Hahad, O., Lelieveld, J., Birklein, F., Lieb, K., Daiber, A. and Münzel, T. (2020). Ambient air pollution increases the risk of cerebrovascular and neuropsychiatric disorders through induction of inflammation and oxidative stress. *International Journal of Molecular Sciences*, 21(12), 4306. https://doi.org/10.3390/ijms21124306

Hahm, Y. and Yoon, H. (2021). The impact of air pollution alert services on respiratory diseases: Generalized additive modeling study in South Korea. *Environmental Research Letters*, 16(6), 064048. https://doi.org/10.1088/1748-9326/ac002f

Hamanaka, R.B. and Mutlu, G.M. (2018). Particulate matter air pollution: effects on the cardiovascular system. *Frontiers in endocrinology*, 16(9), 680. https://doi.org/10.3389/fendo.2018.00680

Heo, Y.J. and Kim, H.S. (2021). Ambient air pollution and endocrinologic disorders in childhood. *Annals of Pediatric Endocrinology and Metabolism*, 26(3), 158-170. https://doi.org/10.6065/apem.2142132.066

Hernández-Gordillo, A., Ruiz-Correa, S., Robledo-Valero, V., Hernández-Rosales, C. and Arriaga, S. (2021). Recent advancements in low-cost portable sensors for urban and indoor air quality monitoring. *Air Quality Atmosphere and Health*, 14, 1931-1951. https://doi.org/10.1007/s11869-021-01067-x

Huang, Y., Zhu, M., Ji, M., Fan, J., Xie, J., Wei, X., Jiang, X., Xu, J., Chen, L., Yin, R., Wang, Y., Dai, J., Jin, G., Xu, L., Hu, Z., Ma, H. and Shen, H. (2021). Air pollution, genetic factors, and the risk of lung cancer: a prospective study in the UK Biobank. *American Journal of Respiratory and Critical Care Medicine*, 204(7), 817-825. https://doi.org/10.1164/rccm.202011-4063oc

Huang, Y.B., Song, F.J., Liu, Q., Li, W.Q., Zhang, W. and Chen, K.X. (2014). A bird's eye view of the air pollution-cancer link in China. *Chinese Journal of Cancer*, 33(4), 176-188. https://doi.org/10.5732/cjc.014.10030

Hussein, M.A., Farman, K.S. and Ismail, M.M. (2022). The effect of particulate pollution on patients with type 2 diabetes and insulin resistance. *International Journal of Health Sciences*, 6(S4), 7853-7860 https://doi.org/10.53730/ijhs.v6ns4.10427

Isakov, V., Arunachalam, S., Batterman, S., Bereznicki, S., Burke, J., Dionisio, K., Garcia, V., Heist, D., Perry, S., Snyder, M. and Vette, A. (2014). Air quality modeling in support of the near road exposures and effects of urban air pollutants study (NEXUS). *International Journal of Environmental Research and Public Health*, 11(9), 8777-8793. https://doi.org/10.3390/ijerph110908777

Itahashi, S. (2021). Air pollution modeling: Local, regional, and global-scale applications. *Atmosphere*, 12 (2), 178. https://doi.org/10.3390/atmos12020178

Jaiswal, A.S. (2019). Real-time ambient air quality monitoring system using sensor technology. *International Journal for Research in Applied Science and Engineering Technology*, 7(IV), 736-739. https://doi.org/10.22214/ijraset.2019.4132

Jalili, M., Mazidi, F., Ehrampoosh, M.H., Badeenezhad, A., Ebrahimi, V. and Abbasi, F. (2020). Relationship of air pollution and daily hospital admissions due to respiratory disease: A time series analysis. *Journal of Environmental Health and Sustainable Development*, 5(1), 971-980. https://doi.org/10.18502/jehsd.v5i1.2479

Ji, X., Li, S., Jiang, N., Wang, F., Fan, L. and Niu, X. (2022). The impact of economic development of the guangdong-hongkong-Macao greater bay area on air pollution: Investigation based on remote sensing data of nighttime lights and air pollution. *Frontiers in Marine Science*, 9, 954361. https://doi.org/10.3389/fmars.2022.954361

Jia, Z., Wei, Y., Li, X., Yang, L., Liu, H., Guo, C., Zhang, L., Li, N., Guo, S., Qian, Y. and Li, Z. (2018). Exposure to ambient air particles increases the risk of mental disorder: findings from a natural experiment in Beijing. *International Journal of Environmental Research and Public Health*, 15(1), 160. https://doi.org/10.3390/ijerph15010160

Jo, H., Eckel, S.P., Chen, J.C., Cockburn, M., Martinez, M.P., Chow, T., Lurmann, F.W., Funk, W.E., Xiang, A.H. and McConnell, R. (2019a). Gestational diabetes mellitus, prenatal air pollution exposure, and autism spectrum disorder. *Environment International*, 133, 105110. https://doi.org/10.1016/j.envint.2019.105110

Jo, H., Eckel, S.P., Wang, X., Chen, J.C., Cockburn, M., Martinez, M.P., Chow, T., Molshatzki, N., Lurmann, F.W., Funk, W.E., Xiang, A.H. and McConnell, R. (2019b). Sex-specific associations of autism spectrum disorder with residential air pollution exposure in a large Southern California pregnancy cohort. *Environmental Pollution*, 254, 113010. https://doi.org/10.1016/j.envpol.2019.113010

Johnson, N.M., Hoffmann, A.R., Behlen, J.C., Lau, C., Pendleton, D., Harvey, N., Shore, R., Li, Y., Chen, J., Tian, Y. and Zhang, R. (2021). Air pollution and children's health-a review of adverse effects associated with prenatal exposure from fine to ultrafine particulate matter. *Environmental Health and Preventive Medicine*, 26, 72. https://doi.org/10.1186/s12199-021-00995-5

Jordan, N., Garner, N.M., Matchett, L.C., Tokarek, T.W., Osthoff, H.D., Odame-Ankrah, C.A., Grimm, C.E., Pickrell, K.N., Swainson, C. and Rosentreter, B. W. (2020). Potential interferences in photolytic nitrogen dioxide converters for ambient air monitoring: Evaluation of a prototype. *Journal of the Air and Waste Management Association*, 70(8), 753-764. https://doi.org/10.1080/10962247.2020.1769770

Kadaverugu, R., Sharma, A., Matli, C. and Biniwale, R. (2019). High resolution urban air quality modeling by coupling CFD and mesoscale models: A review. *Asia-Pacific Journal of Atmospheric Sciences*, 55, 539-556. https://doi.org/10.1007/s13143-019-00110-3

Kakareka, S.V. and Salivonchyk, S.V. (2021). Modeling atmospheric air pollution of an industrial city with fine particulate matter. *Russian Meteorology and Hydrology*, 46(5), 331-340. https://doi.org/10.52002/0130-2906-2021-5-62-75

Kantipudi, N., Patel, V., Jones, G., Kamath, M. and Upton, A.R. (2016). Air pollution's effects on the human respiratory system. *Critical Reviews™ in Biomedical Engineering*, 44(5), 383-395. https://doi.org/10.1615/critrevbiomedeng.2017019757

Kendler, S. and Zuck, A. (2020). The challenges of prolonged gas sensing in the modern urban environment. *Sensors*, 20(18), 5189. https://doi.org/10.3390/s20185189

Kerin, T., Volk, H., Li, W., Lurmann, F., Eckel, S., McConnell, R. and Hertz-Picciotto, I. (2018). Association between air pollution exposure, cognitive and adaptive function, and ASD severity among children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 48, 137-150. https://doi.org/10.1007/s10803-017-3304-0

Kim, H., Kim, W.H., Kim, Y.Y. and Park, H.Y. (2020). Air pollution and central nervous system disease: a review of the impact of fine particulate matter on neurological disorders. *Frontiers in Public Health*, 8, 575330. https://doi.org/10.3389/fpubh.2020.575330

Kim, J.H. (2021). Ambient air pollution and pediatric diabetes. *Clinical and Experimental Pediatrics*, 64(10), 523-534. https://doi.org/10.3345/cep.2021.00122

Kolpakova, A.F., Sharipov, R.N. and Kolpakov, F.A. (2017). Air pollution by particulate matter as the risk factor for the cardiovascular diseases. *Gigiena i Sanitariia*, 96(2), 133-137. https://doi.org/10.18821/0016-9900-2017-96-2-133-137

Kuppala, G., 2021. Ecological and Health Impacts of Air Pollution. *Journal of Environmental Hazards*, *5*(3), 1-2. https://doi.org/10.37421/jeh.2021.05.139

Laeremans, M., Dons, E., Avila-Palencia, I., Carrasco-Turigas, G., Orjuela, J.P., Anaya, E., Cole-Hunter, T., de Nazelle, A., Nieuwenhuijsen, M., Standaert, A., Van Poppel, M., De Boever, P. and Panis, L.I. (2018). Short-term effects of physical activity, air pollution and their interaction on the cardiovascular and respiratory system. *Environment International*, 117, 82-90. https://doi.org/10.1016/j.envint.2018.04.040

Lee, K.S., Min, W.K., Choi, Y.J., Jin, S., Park, K.H. and Kim, S. (2023). The effect of maternal exposure to air pollutants and heavy metals during pregnancy on the risk of neurological disorders using the national health insurance claims data of south korea. *Medicina*, 59(5), 951. https://doi.org/10.3390/medicina59050951

Lelieveld, J., Klingmüller, K., Pozzer, A., Pöschl, U., Fnais, M., Daiber, A. and Münzel, T. (2019). Cardiovascular disease burden from ambient air pollution in Europe reassessed using novel hazard ratio functions. *European Heart Journal*, 40(20), 1590-1596. https://doi.org/10.1093/eurheartj/ehz135

Li, H., Cai, J., Chen, R., Zhao, Z., Ying, Z., Wang, L., Chen, J., Hao, K., Kinney, P.L., Chen, H. and Kan, H. (2017). Particulate matter exposure and stress hormone levels: a randomized, double-blind, crossover trial of air purification. *Circulation*, 136(7), 618-627. https://doi.org/10.1161/circulationaha.116.026796

Li, W., Li, H., Li, J., Cheng, X., Zhang, Z., Chai, F., Zhang, H., Yang, T., Duan, P., Lu, D. and Chen, Y. (2018). TOF-SIMS surface analysis of chemical components of size-fractioned urban aerosols in a typical heavy air pollution event in Beijing. *Journal of Environmental Sciences*, 69, 61-76. https://doi.org/10.1016/j.jes.2017.04.005

Liang, L. (2021). Calibrating low-cost sensors for ambient air monitoring: Techniques, trends, and challenges. *Environmental Research*, 197, 111163. https://doi.org/10.1016/j.envres.2021.111163

Liu, Y., Jing, Y. and Lu, Y. (2020). Research on quantitative remote sensing monitoring algorithm of air pollution based on artificial intelligence. *Journal of Chemistry*, 2020, 1-7. https://doi.org/10.1155/2020/7390545

Liu, Z., Yang, J., Zhang, J., Xiang, H. and Wei, H. (2019). A bibliometric analysis of research on acid rain. *Sustainability*, 11(11), 3077. https://doi.org/10.3390/su11113077

Livesley, S.J., McPherson, E.G. and Calfapietra, C. (2016). The urban forest and ecosystem services: Impacts on urban water, heat, and pollution cycles at the tree, street, and city scale. *Journal of Environmental Quality*, 45(1), 119-124. https://doi.org/10.2134/jeq2015.11.0567

Lochman, V., Bíba, M. and Fadrhonsová, V. (2002). Air pollution load of forest stands in Vojířov and the impact on soil and run-off water chemistry. *Journal of Forest Science*, 48(7), 292-309. https://doi.org/10.17221/11889-jfs

Long, C.M., Briggs, N.L. and Bamgbose, I.A. (2019). Synthesis and health-based evaluation of ambient air monitoring data for the Marcellus Shale region. *Journal of the Air and Waste Management Association*, 69(5), 527-547. https://doi.org/10.1080/10962247.2019.1572551

Luo, H., Huang, Y., Zhang, Q., Yu, K., Xie, Y., Meng, X., Kan, H. and Chen, R. (2023). Impacts of physical activity and particulate air pollution on the onset, progression, and mortality for the comorbidity of type 2 diabetes and mood disorders. *Science of The Total Environment*, 890, 164315. https://doi.org/10.1016/j.scitotenv.2023.164315

Ma, Y., Li, J. and Guo, R. (2021). Application of data fusion based on deep belief network in air quality monitoring. *Procedia Computer Science*, 183, 254-260. https://doi.org/10.1016/j.procs.2021.02.056

Mancebo, S.E. and Wang, S.Q. (2015). Recognizing the impact of ambient air pollution on skin health. *Journal of the European Academy of Dermatology and Venereology*, 29(12), 2326-2332. https://doi.org/10.1111/jdv.13250

Manjula Ph D, P.M. (2018). Economics and air pollution-an analysis of chennai city. *International Review of Business and Economics*, 1(3), 17. https://doi.org/10.56902/irbe.2018.1.3.17

Marichal, T. (2022). Effect of air pollution on the human immune system. *Nature Medicine*, 28(12), 2482-2483. https://doi.org/10.1038/s41591-022-02093-7

McGrath, S., Flanagan, C., Zeng, L., and O'Leary, C. (2020). IoT personal air quality monitor. *Irish Signals and Systems Conference*, 1-4. https://doi.org/10.1109/issc49989.2020.9180199

McGuinn, L.A., Windham, G.C., Kalkbrenner, A.E., Bradley, C., Di, Q., Croen, L.A., Fallin, M.D., Hoffman, K., Ladd-Acosta, C., Schwartz, J., Rappold, A.G., Richardson, D.B., Neas, L.M., Gammon, M.D., Schieve, L.A. and Daniels, J.L. (2020). Early life exposure to air pollution and autism spectrum disorder: Findings from a multisite case-control study. *Epidemiology (Cambridge, Mass.)*, 31 (1), 103-114. https://doi.org/10.1097/ede.0000000000001109

McNeill, V.F. (2019). Addressing the global air pollution crisis: chemistry's role. *Trends in Chemistry*, 1(1), 5-8. https://doi.org/10.1016/j.trechm.2019.01.005

Miller, M.R. and Newby, D.E. (2020). Air pollution and cardiovascular disease: Car sick. *Cardiovascular Research*, 116(2), 279-294. https://doi.org/10.1093/cvr/cvz228

Moon, D.H., Kwon, S.O., Kim, S.Y. and Kim, W.J. (2020). Air pollution and incidence of lung cancer by histological type in Korean adults: A Korean national health insurance service health examinee cohort study. *International Journal of Environmental Research and Public Health*, 17(3), 915. https://doi.org/10.3390/ijerph17030915

Münzel, T., Sørensen, M., Gori, T., Schmidt, F.P., Rao, X., Brook, J., Chen, L.C., Brook, R.D. and Rajagopalan, S. (2017). Environmental stressors and cardio-metabolic disease: Part I-epidemiologic evidence supporting a role for noise and air pollution and effects of mitigation strategies. *European Heart Journal*, 38(8), 550-556. https://doi.org/10.1093/eurheartj/ehw269

Muthukumar, P., Cocom, E., Nagrecha, K., Comer, D., Burga, I., Taub, J., Calvert, C.F., Holm, J. and Pourhomayoun, M. (2021). Predicting PM2. 5 atmospheric air pollution using deep learning with meteorological data and ground-based observations and remote-sensing satellite big data. *Air Quality, Atmosphere and Health*, 15, 1221-1234. https://doi.org/10.1007/s11869-021-01126-3

Nagendra, S.M.S., Schlink, U. and Khare, M. (2021). Air quality measuring sensors. *Urban Air Quality Monitoring, Modelling and Human Exposure Assessment*, 89-104. https://doi.org/10.1007/978-981-15-5511-4_7

Nakao, M., Ishihara, Y., Kim, C.H. and Hyun, I.G. (2018). The impact of air pollution, including Asian sand dust, on respiratory symptoms and health-related quality of life in outpatients with chronic respiratory disease in Korea: A panel study. *Journal of Preventive Medicine and Public Health*, 51(3), 130-139. https://doi.org/10.3961/jpmph.18.021

Nakhjirgan, P., Mahmoodi, M., Kashani, H., Firooz, A., Nabizadeh, R., Kermani, M. and Yunesian, M. (2019). Air pollution and exacerbation of skin itching and sleep disturbance in Iranian atopic dermatitis patients. *Journal of Environmental Health Science and Engineering*, 17, 811-816. https://doi.org/10.1007/s40201-019-00397-4

Nathaniel M, W. and Duan, X. (2021). Environmental pollution and health effects-addressing pollution (air, water, and noise) challenges in Africa and possible solutions towards attaining sustainable green environment. *International Journal of Environmental Sciences and Natural Resources*, 27(4), 1-8. https://doi.org/10.19080/ijesnr.2021.27.556220

Neuberger, M. (2019). Effects of involuntary smoking and vaping on the cardiovascular system. *International Journal of Occupational and Environmental Medicine*, 1(1), 10-18. https://doi.org/10.14302/issn.2690-0904.ijoe-19-2792

Newby, D.E., Mannucci, P.M., Tell, G.S., Baccarelli, A.A., Brook, R.D., Donaldson, K., Forastiere, F., Franchini, M., Franco, O.H., Graham, I.A., Graham, I.D., Hoek, G., Hoffmann, B., Hoylaerts, M., Künzli, N., Mills, N., Peters, A., Piepoli, M.F. and Rajagopalan, S. (2015). Expert position paper on air pollution and cardiovascular disease. *European Heart Journal*, 36(2), 83-93. https://doi.org/10.1093/eurheartj/ehu458

Nobile, V., Schiano, I., Peral, A., Giardina, S., Spartà, E. and Caturla, N. (2021). Antioxidant and reduced skin-ageing effects of a polyphenol-enriched dietary supplement in response to air pollution: A randomized, double-blind, placebo-controlled study. *Food and Nutrition Research*, 65. https://doi.org/10.20944/preprints202009.0564.v1

Ou, J.Y., Hanson, H.A., Ramsay, J.M., Kaddas, H.K., Pope III, C.A., Leiser, C.L., VanDerslice, J. and Kirchhoff, A.C. (2020). Fine particulate matter air pollution and mortality among pediatric, adolescent, and young adult cancer patients. *Cancer Epidemiology, Biomarkers and Prevention*, 29(10), 1929-1939. https://doi.org/10.1158/1055-9965.epi-19-1363

Paleczek, A., Szafraniak, B., Fuśnik, Ł., Brudnik, A., Grochala, D., Kluska, S., Jurzecka-Szymacha, M., Maciak, E., Kałużyński, P. and Rydosz, A. (2021). The heterostructures of CuO and SnO_x for NO_2 detection. *Sensors*, 21(13), 4387. https://doi.org/10.3390/s21134387

Pandya, S., Gadekallu, T.R., Maddikunta, P.K.R. and Sharma, R. (2022). A study of the impacts of air pollution on the agricultural community and yield crops (Indian context). *Sustainability*, 14(20), 13098. https://doi.org/10.3390/su142013098

Parascandola, M. (2018). Ambient air pollution and lung cancer in Poland: Research findings and gaps. *Journal of Health Inequal*, 4(1), 3-8. https://doi.org/10.5114/jhi.2018.77639

Park, S., Ha, K.H., Kim, T.G., Kim, H.C., Kim, C. and Oh, S.H. (2021). Air pollution and risk of hospital outpatient visits for eczematous skin disorders in metropolitan cities of South Korea. *British Journal of Dermatology*, 185(3), 641-644. https://doi.org/10.1111/bjd.20079

Park, S.K. (2017). Ambient air pollution and type 2 diabetes: Do the metabolic effects of air pollution start early in life? *Diabetes*, 66(7), 1755-1757. https://doi.org/10.2337/dbi17-0012

Park, S. Y., Byun, E.J., Lee, J.D., Yoon, S.K., Kim, S. and Kim, H.S., (2018). Air pollution, autophagy, and skin aging: impact of particulate matter (PM_{10}) on human dermal fibroblasts. *International Journal of Molecular Sciences*, 19(9), 2727. https://doi.org/10.3390/ijms19092727

Pathakoti, M., Muppalla, A., Hazra, S., D Venkata, M., A Lakshmi, K., K Sagar, V., Sagar, V.K., Shekhar, R., Jella, S., Rama, S.S.M.V. and Vijayasundaram, U. (2021). Measurement report: An assessment of the impact of a nationwide lockdown on air pollution-a remote sensing perspective over India. *Atmospheric Chemistry and Physics*, 21(11), 9047-9064. https://doi.org/10.5194/acp-2020-1227

Pham, H.T., Nguyen, A.T., Nguyen, T.T. and Hens, L. (2020). Stakeholder Delphi-perception analysis on impacts and responses of acid rain on agricultural ecosystems in the Vietnamese upland. *Environment, Development and Sustainability*, 22, 4467-4493. https://doi.org/10.1007/s10668-019-00393-6

Pinder, R.W., Klopp, J.M., Kleiman, G., Hagler, G.S., Awe, Y. and Terry, S. (2019). Opportunities and challenges for filling the air quality data gap in low-and middle-income countries. *Atmospheric Environment*, 215, 116794. https://doi.org/10.1016/j.atmosenv.2019. 06.032

Qing, C., Zhang, H. and Zhao, Y. (2020). Ambient air pollution and daily hospital admissions for respiratory system-related diseases in a heavy polluted city in Northeast China. *Environmental Science and Pollution Research*, 27, 10055-10064. https://doi.org/10.1007/s11356-020-07678-8

Qiu, Y., Yang, F.A. and Lai, W. (2019). The impact of indoor air pollution on health outcomes and cognitive abilities: empirical evidence from China. *Population and Environment*, 40, 388-410. https://doi.org/10.1007/s11111-019-00317-6

Quyet, N.H., My, T.T.T., My, N.T.B., Frontasieva, M., Zinicovscaia, I., Son, N.A., Thanh, T.T., Nam, L.D., Hong, K.T., Mai, N.N., Trung, T.D., Thang, D.V and Hang, N.T.T. (2021). Biomonitoring of chemical element air pollution in hanoi using barbula indica moss. *Environmental Engineering and Management Journal*, 20(5), 791-800. https://doi.org/10.30638/eemj.2021.074

Raheja, S., Obaidat, M.S., Sadoun, B., Malik, S., Rani, A., Kumar, M. and Stephan, T. (2021). Modeling and simulation of urban air quality with a 2-phase assessment technique. *Simulation Modelling Practice and Theory*, 109, 102281. https://doi.org/10.1016/j.simpat.2021.102281

Rammah, A., Whitworth, K.W., Amos, C.I., Estarlich, M., Guxens, M., Ibarluzea, J., Iñiguez, C., Perez, M.S., Vrijheid, M. and Symanski, E. (2021). Air pollution, residential greenness and metabolic dysfunction during early pregnancy in the INfancia y Medio Ambiente (INMA) Cohort. *International Journal of Environmental Research and Public Health*, 18(17), 9354. https://doi.org/10.1289/isee.2021.p-642

Rao, X., Zhong, J., Brook, R.D. and Rajagopalan, S. (2018). Effect of particulate matter air pollution on cardiovascular oxidative stress pathways. *Antioxidants and Redox Signaling*, 28(9), 797-818. https://doi.org/10.1089/ars.2017.7394

Raz, R., Roberts, A. L., Lyall, K., E., H. J., Hart, J. E., Just, A. C., Laden, F., Ascherio, A., and Weisskopf, M. G. (2013). Exposure to particulate matter air pollution during pregnancy is associated with increased risk for autism spectrum disorder. *Environmental Health Perspectives*. https://doi.org/10.1289/isee.2013.o-3-08-03

Rice, M., Balmes, J., and Malhotra, A. (2021). Outdoor air pollution and your health. *American Journal of Respiratory and Critical Care Medicine*, 204(7), 13-14. https://doi.org/10.1164/rccm.2046p13

Roberts, A.L., Lyall, K., Hart, J.E., Laden, F., Just, A.C., Bobb, J.F., Koenen, K.C., Ascherio, A. and Weisskopf, M.G. (2013). Perinatal air pollutant exposures and autism spectrum disorder in the children of Nurses' Health Study II participants. *Environmental Health Perspectives*, 121(8), 978-984. https://doi.org/10.1289/ehp.1206187

Roy, A. (2021). Atmospheric pollution retrieval using path radiance derived from remote sensing data. *Journal of Geovisualization and Spatial Analysis*, 5(26), 1-11. https://doi.org/10.1007/s41651-021-00093-8

Rutkowski, R., Rybak, J., Mach, T. and Rogula-Kozłowska, W. (2018). Spider webs in monitoring of air pollution. *SHS Web of Conferences*, 57, 02011. https://doi.org/10.1051/shsconf/20185702011

Saleem, A., Naureen, I., Aziz, M.K., Shahzadi, I., Hassan, Z., Raza, N. and Butt, F. (2022). Effects of air pollution on respiratory system (lungs) and modern techniques to control pollution. *Haya Saudi J Life Science*, 7(6), 191-198. https://doi.org/10.36348/sjls.2022.v07i06.003

Sampath, V., Aguilera, J., Prunicki, M. and Nadeau, K.C. (2023). Mechanisms of climate change and related air pollution on the immune system leading to allergic disease and asthma. *Seminars in Immunology*, 101765. https://doi.org/10.1016/j.smim.2023.101765

Sampedro, J., Waldhoff, S., Sarofim, M. and Van Dingenen, R. (2023). Marginal damage of methane emissions: ozone impacts on agriculture. *Environmental and Resource Economics*, 84(4), 1095-1126. https://doi.org/10.1007/s10640-022-00750-6

Sanmi, A. (2018). Effect of air pollution on rainwater: A case study of Ado-Ekiti, Nigeria. I*nternational Journal of Advanced Engineering Research and Science*, 5(8), 19-24. https://doi.org/10.22161/ijaers.5.8.3

Santos, A.P.M., Segura-Muñoz, S.I., Nadal, M., Schuhmacher, M., Domingo, J.L., Martinez, C.A. and Magosso Takayanagui, A.M. (2015). Traffic-related air pollution biomonitoring with Tradescantia pallida (Rose) Hunt. cv. purpurea Boom in Brazil. *Environmental Monitoring and Assessment*, 187(2), 1-10. https://doi.org/10.1007/s10661-014-4234-3

Santos, U.D.P., Arbex, M.A., Braga, A.L.F., Mizutani, R.F., Cançado, J.E.D., Terra-Filho, M. and Chatkin, J.M. (2021). Environmental air pollution: respiratory effects. *Jornal Brasileiro de Pneumologia*, 47 (1), e20200267. https://doi.org/10.36416/1806-3756/e20200267

Sau, T.K., Truong, N.X., Hanh, T.T.T., Le Hung, B., Thang, N.D. and Le Lan Anh, T. (2021). Ambient air monitoring around the dioxin remediation site in Da Nang, Vietnam, using passive air samplers. *Environmental Monitoring and Assessmen*t, 193, 1-14. https://doi.org/10.1007/s10661-021-09223-7

Scheibenreif, L., Mommert, M. and Borth, D. (2021). Estimation of air pollution with remote sensing data: Revealing greenhouse gas emissions from space. *arXiv preprint*. https://doi.org/10.48550/arXiv.2108.13902

Scheibenreif, L., Mommert, M. and Borth, D. (2022). Toward global estimation of ground-level NO_2 pollution with deep learning and remote sensing. *IEEE Transactions on Geoscience and Remote Sensing*, 60, 1-14. https://doi.org/10.1109/tgrs.2022.3160827

Schiferl, L.D. and Heald, C.L. (2018). Particulate matter air pollution may offset ozone damage to global crop production. *Atmospheric Chemistry and Physics*, 18(8), 5953-5966. https://doi.org/10.5194/acp-18-5953-2018

Schikowski, T. and Hüls, A. (2020). Air pollution and skin aging. *Current Environmental Health Reports*, 7(1), 58-64. https://doi.org/10.1007/s40572-020-00262-9

Seo, H.J., Jeong, R.H., Boo, J.H., Song, J. and Boo, J.H. (2017). Study on chemical removal of nitric oxide (NO) as a main cause of fine dust (air pollution) and acid rain. *Applied Science and Convergence Technology*, 26(6), 218-222. https://doi.org/10.5757/asct.2017.26.6.218

Serafini, M.M., Maddalon, A., Iulini, M. and Galbiati, V. (2022). Air Pollution: Possible Interaction between the Immune and Nervous System? *International Journal of Environmental Research and Public Health*, 19(23), 16037. https://doi.org/10.3390/ijerph192316 037

Shah, S. (2020). Effects of particulate matter from air pollution on cardiovascular system of the body. *International Journal of Applied Research*, 6(11), 281-285. https://doi.org/10.22271/allresearch.2020.v6.i11e.7813

Shifa, A. and Rathi, S. (2021). Air pollution evaluation by combining stationary, smart mobile pollution monitoring and data-driven modelling. *International Journal of Advances in Engineering and Management*, 3(6), 2545-2549. https://doi.org/10.35629/5252-030625452549

Shukla, K. and Aggarwal, S.G. (2022). A technical overview on beta-attenuation method for the monitoring of particulate matter in ambient air. *Aerosol and Air Quality Research*, 22(12), 220195. https://doi.org/10.4209/aaqr.220195

Siddiqi, S.A. and Al Farsi, B. (2019). The contribution of greenhouse gas emissions on future acid rain in States of Gulf cooperation council: Measures to adopt. *Journal of Geoscience and Environment Protection*, 7(04), 82-98. https://doi.org/10.4236/gep.2019.74006

Silveira, C., Ferreira, J. and Miranda, A.I. (2019). The challenges of air quality modelling when crossing multiple spatial scales. *Air Quality, Atmosphere and Health*, 12, 1003-1017. https://doi.org/10.1007/s11869-019-00733-5

Singh, A.K., Kumar, M., Bauddh, K., Singh, A., Singh, P., Madhav, S. and Shukla, S.K. (2023). Environmental impacts of air pollution and its abatement by plant species: A comprehensive review. *Environmental Science and Pollution Research*, 30, 79587-79616. https://doi.org/10.1007/s11356-023-28164-x

Singh, R., Ravichandran, S. and Sri, R.M. (2021). Air pollution: A major threats to sustainable development. *International Journal of Clinical Biochemistry and Research*, 8(3), 176-178. https://doi.org/10.18231/j.ijcbr.2021.037

Siontorou, C.G., Kakos, A.S. and Batis, G. (2019). GIS-based computer aided air pollution biomonitoring for impact assessment-application in the case of materials deterioration. *International Conference of Computational Methods in Sciences and Engineering*, 647-652. CRC Press. https://doi.org/10.1201/9780429081385-159

Sîrbu, C A., Stefan, I., Dumitru, R., Mitrica, M., Manole, A.M., Vasile, T.M., Stefani, C. and Ranetti, A.E. (2022, June). Air pollution and its devastating effects on the central nervous system. *Healthcare*, 10 (7), 1170. https://doi.org/10.3390/healthcare10071170

Sivaramakrishnan, K.N., Deka, L. and Gupta, M. (2020). Use of remote sensing data to identify air pollution signatures in India. *Geo-Intelligence for Sustainable Development*, 109-125. https://doi.org/10.1007/978-981-16-4768-08

Slama, A., Śliwczyński, A., Woźnica, J., Zdrolik, M., Wiśnicki, B., Kubajek, J., Turżańska-Wieczorek, O., Gozdowski, D., Wierzba, W. and Franek, E. (2019). Impact of air pollution on hospital admissions with a focus on respiratory diseases: A time-series multi-city analysis. *Environmental Science and Pollution Research*, 26(17), 16998-17009. https://doi.org/10.1007/s11356-019-04781-3

So, R., Chen, J., Mehta, A.J., Liu, S., Strak, M., Wolf, K., Hvidtfeldt, U.A., Rodopoulou, S., Stafoggia, M., Klompmaker, J.O., Samoli, E., Raaschou-Nielsen, O., Atkinson, R., Bauwelinck, M., Bellander, T., Boutron-Ruault, M. C., Brandt, J., Brunekreef, B., Cesaroni, G., Concin, H., Forastiere, F., van Gils, C.H., Gulliver, J., Hertel, O., Hoffmann, B., de Hoogh, K., Janssen, N., Lim, Y.H., Westendorp, R., Jørgensen, J.T., Katsouyanni, K., Ketzel, M., Lager, A., Lang, A., Ljungman, P., Magnusson, P.K.E., Nagel, G., Simonsen, M.K., Pershagen, G., Peter, R.S., Peters, A., Renzi, M., Rizzuto, D., Sigsgaard, T., Vienneau, D., Weinmayr, G., Severi, G., Fecht, D., Tjønneland, A., Leander, K., Hoek, G. and Andersen, Z. J. (2021). Long-term exposure to air pollution and liver cancer incidence in six European cohorts. *International Journal of Cancer*, 149(11), 1887-1897. https://doi.org/10.1002/ijc.33743

Sonwani, S., Hussain, S. and Saxena, P. (2022). Air pollution and climate change impact on forest ecosystems in Asian region-a review. *Ecosystem Health and Sustainability*, 8(1), 2090448. https://doi.org/10.1080/20964129.2022.2090448

Spinelle, L., Gerboles, M., Kok, G., Persijn, S. and Sauerwald, T. (2017). Review of portable and low-cost sensors for the ambient air monitoring of benzene and other volatile organic compounds. *Sensors*, 17(7), 1520. https://doi.org/10.3390/s17071520

Sram, R.J., Binkova, B., Dostal, M., Merkerova-Dostalova, M., Libalova, H., Milcova, A., Rossner, P., Rossnerova, A., Schmuczerova, J., Svecova, V., Topinka, J. and Votavova, H. (2013). Health impact of air pollution to children. *International Journal of Hygiene and Environmental Health*, 216(5), 533-540. https://doi.org/10.1016/j.ijheh.2012.12.001

Stevens, C., Bell, J.N.B., Brimblecombe, P., Clark, C., Dise, N.B., Lovett, G. and Wolseley, P. (2020). The impact of air pollution on terrestrial managed and natural vegetation. *Philosophical Transactions of the Royal Society A*, 378(2183), 20190317. https://doi.org/10.1098/rsta.2019.0317

Svozilík, V., Svozilíková Krakovská, A., Bitta, J. and Jančík, P. (2021). Comparison of the air pollution mathematical model of PM_{10} and moss biomonitoring results in the Tritia region. *Atmosphere*, 12(6), 656. https://doi.org/10.3390/atmos12060656

Tai, A.P., Martin, M.V. and Heald, C.L. (2014). Threat to future global food security from climate change and ozone air pollution. *Nature Climate Change*, 4(9), 817-821. https://doi.org/10.1038/nclimate2317

Tamayo, T., Rathmann, W., Krämer, U., Sugiri, D., Grabert, M. and Holl, R.W. (2014). Is particle pollution in outdoor air associated with metabolic control in type 2 diabetes? *PloS One*, 9(3), e91639. https://doi.org/10.1371/journal.pone.0091639

Tatavarti, R. (2021). Ambient Air Quality Monitoring: Impetus, Complexities, Challenges, and Solutions. *Global Journal of Science Frontier Research*, 41-58. https://doi.org/10.34257/gjsfrhvol21is4p g41

Thimmegowda, G.G., Mullen, S., Sottilare, K., Sharma, A., Mohanta, R., Brockmann, A., Dhandapany, P.S. and Olsson, S.B. (2020). A field-based quantitative analysis of sublethal effects of air pollution on pollinators. *Proceedings of the National Academy of Sciences*, 117(34), 20653-20661. https://doi.org/10.1073/pnas.2009074117

Thomson, E. M. (2019). Air pollution, stress, and allostatic load: linking systemic and central nervous system impacts. *Journal of Alzheimer's Disease*, 69(3), 597-614. https://doi.org/10.3233/jad-190015

Thygesen, M., Holst, G.J., Hansen, B., Geels, C., Kalkbrenner, A., Schendel, D., Brandt, J., Pedersen, C.B. and Dalsgaard, S. (2020). Exposure to air pollution in early childhood and the association with Attention-Deficit Hyperactivity Disorder. *Environmental Research*, 183, 108930. https://doi.org/10.1016/j.envres.2019.108930

Tiotiu, A.I., Novakova, P., Nedeva, D., Chong-Neto, H.J., Novakova, S., Steiropoulos, P. and Kowal, K. (2020). Impact of air pollution on asthma outcomes. *International Journal of Environmental Research and Public Health*, 17(17), 6212. https://doi.org/10.3390/ijerph17176212

Tiwari, S., Chen, B. and Singh, A.K. (2020). Monitoring and assessment of air pollution. *Air Pollution Environmental Health*, 20, 9-35. https://doi.org/10.1007/978-981-15-3481-2_2

Toledo de Almeida Albuquerque, T., Santos, J.M. and Andrade, M.D.F. (2020). Urban air quality, climate, and pollution: from measurement to modeling applications. *Environmental Science and Pollution Research*, 27 (29), 35873-35874. https://doi.org/10.1007/ s11356-020-09336-5

Turner, M.C., Andersen, Z.J., Baccarelli, A., Diver, W.R., Gapstur, S.M., Pope III, C.A., Prada, D., Samet, J., Thurston, G. and Cohen, A. (2020). Outdoor air pollution and cancer: An overview of the current evidence and public health recommendations. *CA: A Cancer Journal for Clinicians*, 70(6), 460-479. https://doi.org/10.3322/caac.21632

Turner, M.C., Krewski, D., Diver, W.R., Pope III, C.A., Burnett, R.T., Jerrett, M., Marshall, J.D. and Gapstur, S.M. (2017). Ambient air pollution and cancer mortality in the cancer prevention study II. *Environmental Health Perspectives*, 125(8), 087013. https://doi.org/10.1289/ehp1249

Ünver, E., Bolat, E., Altın, S., Çoban, A., Aktaş, M., Fıçıcı, M., Tecer, L.H. and Saral, A. (2019). The effect of air pollution on respiratory system disease admissions and health expenditures. *Eurasian Journal of Medical Investigation*, 3(2), 137-143. https://doi.org/10.14744/ ejmi.2019.56609

Villeneuve, P.J., Goldberg, M.S., Crouse, D.L., To, T., Weichenthal, S.A., Wall, C. and Miller, A.B. (2018). Residential exposure to fine particulate matter air pollution and incident breast cancer in a cohort of Canadian women. *Environmental Epidemiology*, 2(3), e021. https://doi.org/10.1097/ee9.0000000000000021

Volk, H.E., Park, B., Hollingue, C., Jones, K.L., Ashwood, P., Windham, G.C., Lurman, F., Alexeeff, S.E., Kharrazi, M., Van de Water, J. and Croen, L.A. (2020). Maternal immune response and air pollution exposure during pregnancy: Insights from the Early Markers for Autism (EMA) study. *Journal of Neurodevelopmental Disorders*, 12, 42. https://doi.org/10.1186/s11689-020-09343-0

Vrijheid, M., Martinez, D., Aguilera, I., Bustamante, M., Ballester, F., Estarlich, M., Fernández-Somoano, A., Guxens, M., Lertxundi, N., Martinez, M.D., Tardón, A., Sunyer, J. and Project, I. (2012). Indoor air pollution from gas cooking and infant neurodevelopment. *Epidemiology*, 23(1), 23-32. https://doi.org/10.1097/ede.0b013e31823a4023

Wang, H.L., Shen, L.J., Zhang, J.K., Xie, X.Y. and Guan, X. (2023). Editorial: Air pollution remote sensing and the subsequent interactions with ecology on regional scales-Volume II. *Frontiers in Environmental Science*, 1-3. https://doi.org/10.3389/fenvs.2023.1165474

Wang, R., Li, J., Wang, J., Cheng, H., Zou, X., Zhang, C., Wu, X., Kang, L., Liu, B. and Li, H. (2017). Influence of dust storms on atmospheric particulate pollution and acid rain in northern China. *Air Quality, Atmosphere and Health*, 10, 297-306. https://doi.org/10.1007/s11869-016-0421-4

Wang, S.Y., Cheng, Y.Y., Guo, H.R. and Tseng, Y.C. (2021). Air pollution during pregnancy and childhood autism spectrum disorder in Taiwan. *International Journal of Environmental Research and Public Health*, 18(18), 9784. https://doi.org/10.3390/ijerph18189784

Wang, W., Zhang, W., Zhao, J., Li, H., Wu, J., Deng, F., Ma, Q. and Guo, X. (2021). Short-term exposure to ambient air pollution and increased emergency room visits for skin diseases in Beijing, China. *Toxics*, 9(5), 108. https://doi.org/10.3390/toxics9050108

Wang, Y. C. (2019). Mobile Solutions to Air Quality Monitoring. *Mobile Solutions and Their Usefulness in Everyday Life*. Springer, Cham, pp 225-249. https://doi.org/10.1007/978-3-319-93491-4_12

Wendel, J. (2014). Air pollution an overlooked factor in climate-related crop damage. *Eos, Transactions, American Geophysical Union*, 95(31), 280. https://doi.org/10.1002/2014eo310005

White, A.J., Keller, J.P., Zhao, S., Carroll, R., Kaufman, J.D. and Sandler, D.P. (2019). Air pollution, clustering of particulate matter components, and breast cancer in the sister study: A US-wide cohort. *Environmental Health Perspectives*, 127(10), 107002. https://doi.org/10.1289/ehp5131

Wilson, S.R., Madronich, S., Longstreth, J.D. and Solomon, K.R. (2019). Interactive effects of changing stratospheric ozone and climate on tropospheric composition and air quality, and the consequences for human and ecosystem health. *Photochemical and Photobiological Sciences*, 18(3), 775-803. https://doi.org/10.1039/c8p p90064g

Wold, L E., Ying, Z., Hutchinson, K.R., Velten, M., Gorr, M.W., Velten, C., Youtz, D.J., Wang, A., Lucchesi, P.A., Sun, Q. and Rajagopalan, S. (2012). Cardiovascular remodeling in response to long-term exposure to fine particulate matter air pollution. *Circulation: Heart Failure*, 5(4), 452-461. https://doi.org/10.1161/circheartfailure.112.

966580
Xiong, X., Liu, J., Chen, L., Ju, W. and Moshary, F. (2021). Remote sensing of greenhouse gases and air pollution. *Remote Sensing*, 13 (11), 2057. https://doi.org/10.3390/rs13112057
Xu, X., Hu, H., Ha, S. and Roth, J. (2014). Ambient air pollution and hypertensive disorder of pregnancy. *Journal of Epidemiol Community Health*, 68(1), 13-20. https://doi.org/10.1136/jech-2013-202902
Xue, S., Zhang, B. and Zhao, X. (2021). Brain drain: The impact of air pollution on firm performance. *Journal of Environmental Economics and Management*, 110, 102546. https://doi.org/10.1016/j.jeem.2021.102546
Xue, Y., Wang, L., Zhang, Y., Zhao, Y. and Liu, Y. (2022). Air pollution: A culprit of lung cancer. *Journal of Hazardous Materials*, 434, 128937. https://doi.org/10.1016/j.jhazmat.2022.128937
Yadav, A. and Pacheco, S.E. (2023). Prebirth effects of climate change on children's respiratory health. *Current Opinion in Pediatrics*, 35 (3), 344-349. https://doi.org/10.1097/mop.0000000000001241
Yadav, R., Trivedi, P., Sahu, L.K., Beig, G. and Tripathi, N. (2020). Air pollution modeling. *Air Pollution and Environmental Health*, 37-55. https://doi.org/10.1007/978-981-15-3481-2_3
Yang, Y., Yang, T., Zhou, J., Cao, Z., Liao, Z., Zhao, Y., Su, X., He, J. and Hua, J. (2023). Prenatal exposure to concentrated ambient $PM_{2.5}$ results in spatial memory defects regulated by DNA methylation in male mice offspring. *Environmental Science and Pollution Research*, 30(12), 35142-35152. https://doi.org/10.1007/s11356-022-24663-5
Ying, Z., Xu, X., Bai, Y., Zhong, J., Chen, M., Liang, Y., Zhao, J., Liu, D., Morishita, M., Sun, Q., Spino, C., Brook, R.D., Harkema, J.R. and Rajagopalan, S. (2014). Long-term exposure to concentrated ambient $PM_{2.5}$ increases mouse blood pressure through abnormal activation of the sympathetic nervous system: A role for hypothalamic inflammation. *Environmental Health Perspectives*, 122(1), 79-86. https://doi.org/10.1289/ehp.1307151
Yong, S.B., Gau, S.Y., Guo, Y.C. and Wei, J.C.C. (2022). Allergy from perspective of environmental pollution effects: from an aspect of atopic dermatitis, immune system, and atmospheric hazards-A narrative review of current evidence. *Environmental Science and Pollution Research*, 29(38), 57091-57101. https://doi.org/10.1007/s11356-022-21582-3
Zhang, L., Chao, Y., Huang, F., Wang, C., Yue, Y., Liu, S. and Duan, J. (2019). Study on the relationship between acid-rain pH value and fog-water conductivity. *Earth and Environmental Science*, 358(2), 022077. https://doi.org/10.1088/1755-1315/358/2/022077
Zhang, Y., Wang, L., Tang, Z., Zhang, K. and Wang, T. (2022). Spatial effects of urban expansion on air pollution and eco-efficiency: Evidence from multisource remote sensing and statistical data in China. *Journal of Cleaner Production*, 367, 132973. https://doi.org/10.1016/j.jclepro.2022.132973
Zhao, C., Zhang, C., Lin, J., Wang, S., Liu, H., Wu, H. and Liu, C. (2022). Variations of urban NO_2 pollution during the COVID-19 outbreak and post-epidemic era in China: A synthesis of remote sensing and in situ measurements. *Remote Sensing*, 14(2), 419. https://doi.org/10.3390/rs14020419
Zhu, S., Xu, J., Zhu, H., Zeng, J., Wang, Y., Zeng, Q., Zhang, D., Liu, X. and Yang, S. (2022). Investigating impacts of ambient air pollution on the terrestrial Gross Primary Productivity (GPP) from remote sensing. *IEEE Geoscience and Remote Sensing Letters*, 19, 1-5. https://doi.org/10.1109/lgrs.2022.3163775
Zorena, K., Jaskulak, M., Michalska, M., Mrugacz, M. and Vandenbulcke, F. (2022). Air pollution, oxidative stress, and the risk of development of type 1 diabetes. *Antioxidants*, 11(10), 1908. https://doi.org/10.3390/antiox11101908
Zuolin, L., Jie, L., Wanming, X., Xuemei, Z., and Chenghua, Z. (2012). On current status of acid rain pollution in Nan'an district of Chongqing and its cause. *Journal of Southwest China Normal University (Natural Science Edition)*, 37(7), 135-141 https://doi.org/10.13718/j.cnki.xsxb.2012.07.016