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REVIEW ARTICLE

Impacts of air pollutants on human health, global climate regime, ecosystem services, food and livelihood security

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Abstract

Air pollution is a major environmental issue that affects human health, global climate regime, ecosystem services, food and human livelihood security worldwide. The sources of air pollutants include natural phenomena induced dust storms and poisonous gases emission through volcanic eruption, earth quacks and flash floods as well as anthropogenic activities induced dust and greenhouse gases including methane, Carbon monoxide (CO), Carbon dioxide (Co2) and other toxic gases emission through agricultural activities, transportation, mining, weapon testing, industrial processes and energy production activities. Particulate Matters (PM), nitrogen oxides, sulphur dioxide, ozone, black carbon and carbon monoxide are the main pollutants of concern, as they have been found to be linked with high incidence of respiratory diseases, cardiovascular diseases, cancer, mental retardation and neurological disorders in both human and animals. The impacts of indoor air pollutants like toxic dust particles, CO, CO2, Methane and Volatile Organic Compounds (VOCs) on human health vary depending on the level and duration of exposure but it can have devastating and long-lasting impacts on human health by causing acute respiratory diseases (ARD), chronic respiratory diseases (CRD), chronic obstructive respiratory diseases (COPD), neurological disorders, Alzheimer, mental retardation and cardiovascular diseases. The short-lived climate pollutants (SLCPs) such as tropospheric ozone, hydrofluorocarbons (HFCs), and black carbon have been reported to have devasting impacts on global climate regime, ecosystem services and threaten food and human livelihood security. To mitigate adverse impacts of air pollutants on global environment and food security, it is important to reduce emissions of major air pollutants including SLCPs through adoption of clean energy sources, implementing emission standards, increase green cover and promoting sustainable occupational and lifestyle practices. Continued research and public education efforts are essential to protect public health and the environment from the detrimental impacts of air pollutants at regional and global scale.

Key words: Air Pollutants; Human Health; Respiratory Diseases; SLCPs; Global Climate; Ecosystem Services; Food Security; Livelihood

1. Introduction

Pollution may be defined as the addition of undesirable materials into the environment as a result of human activities or natural events. Agents such as unintentionally releasing physical, chemical or biological substances into the environment causing physicochemical change in the environment are called pollutants. These pollutants can be harmful directly or indirectly to humans and other living organisms and tend to have detrimental impacts on global climate regime, ecosystem services, food security and human livelihood. According to World Health Organization (WHO, 2018), air pollution is defined as "*contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere*". WHO also classifies pollutants into six major categories which include particle pollution, ground-level ozone, carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), and lead. Air pollution is a major threat to biodiversity components and human health, and it reduces ecological efficiency and productivity by inducing different types of stresses on biological resources, disrupt food chains and pose serious threats to human health, food security and livelihood security (Emberson et al., 2003; Feifei et al., 2017) As far as human health is concerned, air pollutants are reported to be responsible for increased mortality among children and aged population due to acute and chronic respiratory diseases (ARD, CRD, COPD), heart diseases, stroke, lung cancer and neurological dysfunctions (Abbey et al., 1999; Kelly and Fussell, 2011). In terms of fatalities, WHO reported that air pollution silently kills 7 million people annually. Globally, 9 people out of 10 are breathing air containing high levels of pollutants, and the indoor air pollutants such as dust particles, toxic chemicals, methane gases, excess concentration of carbon dioxide (CO2) and CO are highly carcinogenic to human health that triggers inflammation, cancer and neurological disorders on prolong exposure (WHO, 2018). Increased concentration of fine particulate matters (PM) resulting from ambient air pollution of urban and rural areas causes strokes, heart diseases, acute respiratory diseases (ARD), chronic respiratory diseases (CRD), chronic obstructive pulmonary diseases (COPD) and lung cancer (WHO, 2016). WHO's data also informed that population of lower-income countries of south-east Asia and Eastern Mediterranean countries are the most affected region of the world (Hajat et al., 2015, WHO, 2022). This review delved into major types and sources of air pollutants and also highlights negative impacts of air pollutants on human health, global climate regime, ecosystem services and food security. In conclusion, the article examined important control measures that could help in mitigation of air pollution and its hazardous impacts on health, crops, food security and livelihood.

2. Types of air pollutants

2.1. Atmospheric pollutants

Troposphere is the lowest strata of the atmosphere surrounding the earth surface in which human beings along with other forms of biological resources thrives and proliferates. Tropospheric pollution occurs due to the presence of undesirable gaseous or particulate matters in the air.

2.1.1. Gaseous pollutants

The burning of fossil fuel have been reported to be the primary cause of gaseous pollutants, which greatly alter the composition of the atmosphere (Katsouyanni, 2003). Gaseous air pollutants are mainly oxides of nitrogen, carbon and sulphur, hydrogen sulphide, hydrocarbons, and ozone (Hamid et al., 2010). Nitrogen oxides are released as NO that combines rapidly with ozone or other airborne radicals to generate NO2. Mobile and stationary combustion sources are the principal anthropogenic sources of nitrogen oxide pollution (Bowman, 1992). Additionally, sunlight triggers a sequence of processes involving NO2 and volatile organic molecules that results in the formation of ozone in the lower atmospheric layers (Li et al., 2022). On the other hand, incomplete combustion also results in the production of CO. While the majority of natural sources of SO2 are volcanoes and the ocean, anthropogenic SO2 is produced when sulphur-containing fossil fuels (mostly coal and heavy oils) are burned (Kampa and Castanas, 2008).

2.1.2. Particulate matters (PM)

Particulate matters (PM) are the generic term used for a type of air pollutants, consisting of complex and varying mixtures of particles suspended in the breathing air, which vary in size and composition, and they are produced by a wide variety of natural and anthropogenic activities (Pöschl, 2005). Particle diameter less than 10 µm float and move freely with the air current and more than 10 µm settle down. Less than 0.02 µm sized particles form a persistent aerosol (Modini et al., 2013). The effect of PM largely depends on its size while PM larger than 5 microns are likely to lodge in the nasal passage, whereas particles of about 10 microns easily enter the lungs (Kim et al., 2015). Figure 1 shows major polluted cities and urban settlements with annually reported measurements of PM.

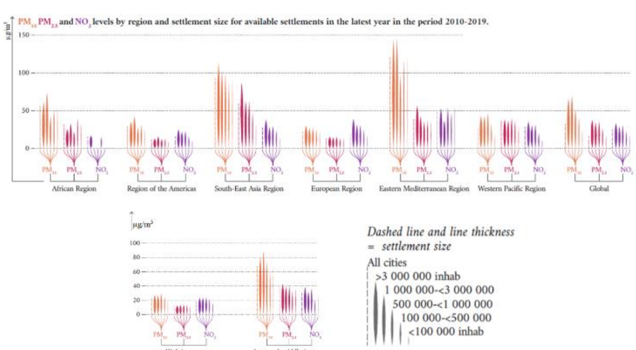


Figure 2. $PM_{2.5}$, PM_{10}, and NO_2 annual mean level by region and per-capita income with settlement size for available settlements data from 2010 to 2019 (adapted from WHO, 2022).

Particulate pollutants are fundamentally classified into dust, mist, fumes, smoke, and smog. Among them, smog has been reported to be the major and most hazardous form of pollutant to human and other living creatures including plants. Smog, the word is derived from smoke and fog (Choudhary and Garg, 2013). This is the most common example of air pollution that occurs in many cities throughout the world. There are two types of smog namely classical smog and photochemical smog (Clayton, 2015). Classical smog occurs in a cool humid climate and it is a mixture of smoke, fog and sulphur dioxide (Brimblecombe, 2017). Chemically, it is a reducing mixture and so it is also called reducing smog. One such great but notorious example of classical smog is the London smog of 1952. On the other hand, photochemical smog occurs in a warm, dry and sunny climate. The main components of the photochemical smog result from the action of sunlight on unsaturated hydrocarbons and nitrogen oxides produced by automobiles and factories (Haagen-Smit, 1952). Photochemical smog has a high concentration of oxidizing agents and, therefore, called oxidizing smog. Photochemical smog, also known as Los Angeles smog (Rani et al., 2011) occurs predominantly in urban areas having larger numbers of automobiles and heavy industries.

3. Major sources of air pollutants

Inefficient burning of fossil fuels emits carbon monoxide (CO) and other toxic pollutants like nitrogen oxides (NOx) into the air (Kampa and Castanas, 2008). Inhaling polluted air emitted through the burning of natural gas and fossil fuel reduces the heart's ability to adequately pump enough oxygen (Asubiojo, 2016). Furthermore, nitrogen oxides have been reported to be responsible for acid rain and the formation of smog (Najjar, 2011) whereas annual mean NO2 emissions have been found to be higher in lower income group countries (Figure 2). This could be due to the fact that lower income nations are compelling commoners to depend maximally on the cheaper source of transportation and energy. When fossil fuels are burned, they emit more than just CO2. For example, Coal-fired power stations alone account for 35% of harmful mercury emissions in the US, two-thirds of SO2 emissions cause acid rain and the majority of dust (PM2.5 and PM10) are released in air due to burning of fossil fuel (Lu et al., 2020). PM also showed the same trend as NO2 in terms of annual mean emission (Figure 2).

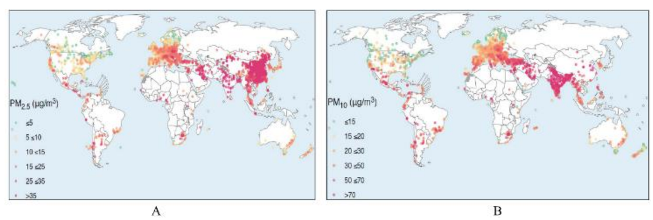
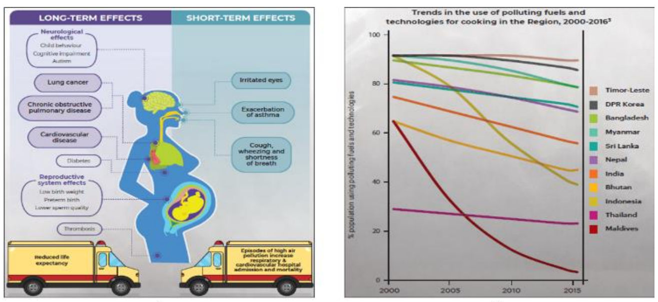


Figure 1. Cities and urban settlements of the world with annual reported measurements of PM. A. $PM_{2.5}$ (µm/m³); B. PM_{10} (µm/m³) (adapted from WHO, 2022).

Industrial activities emit several pollutants into the air that affect the air quality more than one can even imagine. PM2.5 and PM10, NO2, SO2, and CO are the key pollutants that have been reported to be emitted from industries (Saradhi et al., 2008; Streets and Waldhoff, 2000). Massive CO2 emissions from industries are not new. Global warming has escalated recently due to this increased level of CO2 in the atmosphere. Natural or anthropogenic activities induced wildfires have increased PM2.5 and carbonaceous aerosol in the atmosphere (Marlier et al., 2014). Wildfires also release gaseous pollutants such as CO, CO2, O3 precursor, NOx, PM (both 2.5 and 10), VOCs, metals including mercury, organic acids and other toxic gases in enormous quantity wherein CO2 have been reported to be the major constituents (Dennekamp and Abramson, 2011). Microbial Decaying Process have been reported to be one of the major sources of air pollution that are largely ignored to date. Bacteria and fungi play a fundamental role in the biogeochemical cycles in nature. They are the key indicators of environmental abnormalities. Decaying of organix matters by these microorganisms' releases methane gas which is highly toxic, and these microorganisms also emits other toxic pollutants during the decaying process (Bingemer and Crutzen, 1987). Open burning of garbage releases tons of toxic gases, where dioxins have been reported to be the major components (Cogut, 2016). Construction and demolition sites have been reported to be the primary sources of PM and other air pollutants including VOCs (Holman, 1999). VOCs found in paints, cleaners and personal care products such as perfume and deodorants have been reported to be the principal causes behind common health issues (Halios et al., 2022).

4. Major air pollutants and associated health risks

Air pollution exerts various health risks in children and old-aged individuals (Figure 3). It depends on various factors such as critical age of development, type of pollutant, gender, and patients suffering from any chronic diseases. Various air pollutants compositions, levels, and durations of exposure, as well as the fact that humans are frequently exposed to mixtures of pollutants rather than single pollutant, can have various detrimental impacts on human health (Kampa and Castanas, 2008). Exposure to gaseous air pollutants can result into a variety of serious health problems, including respiratory problems such as ARD, CRD, COPD, skin and eye irritation, and cancer (Nwosisi et al., 2021). According to epidemiological and animal model evidence, it was suggested that the cardiovascular and pulmonary systems sustain most of the damage, with other organs possibly experiencing functional changes due to ARD and CRD (Cohen et al., 2005). The major air pollutants which pose serious health risks include nitrogen dioxide, carbon monoxide and ozone.



A B

Figure 3. A. Long-term and short-term human health effects of air pollution (WHO, 2019). B. Trends in the use of fuels and technologies in different regions of the world between 2000 to 2016 (WHO, 2019).

4.1. Nitrogen dioxide

Nitrogen dioxide (NO_2) is a member of a group of highly reactive gases known as nitrogen oxides (NO_x) or oxides of nitrogen. NO_2 exposure results in the irritation of the respiratory system (such as difficult breathing, coughing and wheezing) and prolonged exposure to a greater level of NO_2-polluted air has the potential to cause asthma and found to be potentially increase the susceptibility to respiratory diseases (Gamble et al., 1987; Kelly and Fussell, 2011). Children, the elderly, and people with asthma were more likely to encounter major health risks as a result of NO_2 exposure (Bernstein et al., 2004). It was observed that the relationships between nitrogen dioxide and mortality were sensitive to black smoke, suggesting that the nitrogen dioxide reflected a combination of traffic-related air pollution where bulk amount of NO_2 were generated from motor vehicles (Burnett et al., 2004). Studies conducted in Boston, MA, USA, showed that an implantable cardioverter defibrillator (ICD) is necessary for therapeutic treatments due to the relationship between nitrogen dioxide and a life-threatening arrhythmia (Brunekreef and Holgate, 2002).

Another study involving 8 different communities showed NO_2 to have a detrimental effect on lung function (Garcia et al., 2021). Experiments with mice exposed to nitrogen dioxide have demonstrated adverse and alarming health-related complications such as emphysema-like lesions (Wegmann et al., 2005).

4.2. Carbon dioxide (CO_2)

Carbon dioxide (CO_2) is a gas that is essential for life on Earth, but excess concentration (400 ppm and above) can have harmful effects on humans and the environment. High levels of CO_2 (10-15%) and continuous exposure to CO_2 in indoor ambience at higher concentration (<1000 ppm) causes inflammation and cancer, kidney calcification and oxidative stress, reduced cognitive ability, headache, dizziness, restlessness, tiredness, difficult breathing due to elevated blood pressure which increase heart rate, endothelial dysfunction and consequent collapse of the lung (White et al., 1952; Jacobson et al., 2019). At higher concentration (17-30%), or elevation of CO_2 level at <5000 ppm poses direct health risks and also reported to be responsible for loss of conciseness leading to coma and death of human within a minute of exposure. Increase concentration of CO_2 level (<400 ppm) in the atmosphere significantly contributes to the global warming and regional climate change which increase the risk of extreme weather events, shifting of flowering and fruiting season of many forest and cultivated food crops, affects food chain and food security, and threaten human livelihood security. It was also found to increase the risks of infectious diseases and mental health problems (Wong, 1992; Jacobson et al., 2019).

4.3. Carbon monoxide

Carbon monoxide (CO) is a colourless, odourless, and poisonous gas that can cause serious tissue damage and death if inhaled in larger amounts. It can interfere with the ability of red blood cells to carry oxygen to the body's organs and tissues. The symptoms of CO toxicity include dizziness, headache, nausea, vomiting, general weakness, confusion, chest pain and loss of consciousness. It affects heart, brain, lung and long-term neurological disorders (Dubey and Chouksey, 2017; Akcan et al., 2021). CO bind to hemoglobin and reduce carry oxygen capacity by modifying its conformation (Badman and Jaffé, 1996). Several organs, especially those with high oxygen requirements, including the brain and heart are affected due to the reduced oxygen supply, causing disorientation, sluggish reflexes, and attention problems. CO is also reported to be linked with myocardial infection (Kampa and Castanas, 2008). The myocardial impairment of animal has been reported to begins at low level of 20% COHgb. The CO poisoned death in animal is mainly attributed to the combined hypoxia and ischemia in acute event (Gozubuyuk et al., 2017)

4.4. Ozone

Epidemiological studies have reported connection between ozone exposure and development of asthma. It has been reported that children in California who were participated in outdoor activities had a higher risk of developing asthma due to exposure to ozone, which can worsen airway inflammation and reactivity as well as enhance the body's response to inhaled allergens (McConnell et al., 2002; Parnia et al., 2002). Controlled studies on the effects of exposure to ozone on healthy human volunteers have repeatedly shown a reduction in forced vital capacity, pain in the chest during inspiration, and an increased non-specific airway hyper-responsiveness (Koren et al., 1989). Neutrophil inflammation often occurs within 1 hour after exposure to ozone at concentrations between 0.10 and 0.4 ppm, and it was found to be lasted for up to 24 hours (Nightingale et al., 1999). Outdoor exercises on days when air quality index is poor, sensitive individuals should avoid outdoor exercise. Exposure to ozone during exercise were found to reduce forced vital capacity, increased respiratory frequency, and increased airway resistance (Castillejos et al., 1995; McConnell et al., 2002). For asthmatic patients, pre-existing chronic inflammation of the lower airways were most likely the cause of higher ozone in the troposphere (Vagaggini et al., 2002). Numerous studies on ozone's inflammatory effects on the respiratory system were conducted *in vitro* and *in vivo* using animal models, and it discovered a strong correlation (DeLorme et al., 2002; Kafoury et al., 1999; Longphre et al., 1999; Pearson and Bhalla, 1997).

4.5. Particulate matters (PM)

Increasing PM level in the atmosphere is one of the alarming problems facing the modern world today. The small-sized (2.5 microns) particles may be inhaled, pass through blood-brain, placental, nasal, and lung barriers, and have been found to be systemic effects once they have entered the body (Wang et al., 2022). According to Valavanidis et al (2005), the major biological effects of fine PM are the generation of reactive oxygen species (ROS) and the activation of oxidative stress responses. Direct toxicity to the cardiovascular system or indirect injury from oxidative stress and systemic inflammation brought on by PM were found to be the two possible mechanisms for cardiovascular diseases (Xia et al., 2006). According to two cohort studies conducted in the US between the 1970s and 1980s, breathing in small PM was linked with a shortened life span (Brunekreef, 1997). In another cohort study, PM with a diameter of fewer than 10 microns (PM10) was found to have substantial impact on male lung cancer mortality and non-malignant respiratory deaths in both sexes (Abbey et al., 1999). A significant correlation between exposure to fine particles and their acidity and lung function, bronchitis symptoms, but not asthma have been found among children living in 24 US and Canadian communities (Dockery et al., 1996; Raizenne et al., 1996). Children who moved from high to low pollution areas (or vice versa) were shown to have experienced changes in lung function that mirrored changes in exposure to PM (Avol et al., 2001), and exposure to particles were also found to be linked with reduced lung function growth in children (Gauderman et al., 2002).

Diesel exhaust particle (DEP) is also a matter of concern during this automobile-dominant era of 21st century. DEP comprised of a carbon core which absorbed mixtures of metals, and inorganic ions, organic chemicals include carcinogens, elemental carbon (EC), organic carbon (OC), polycyclic aromatic hydrocarbons (PAH). Recent research on humans, animals, and epidemiology has shown that DEPs considerably worsen airway inflammation, aggravate asthma, and even trigger allergies (Bernstein et al., 2004; Li and Nel, 2006; Farahani et al., 2021). People living next to a busy road were found to be under increased risk of asthma hospitalizations, declined lung function, as well as an increased frequency and intensity of wheezing and allergic rhinitis (Diaz-Sanchez et al., 2003; Farahani et al., 2021).

5. Indoor air pollutants

Majority of the world population, especially lower-income countries rely primarily on fossil fuels, wood or coal for cooking and heating. According to the WHO (2018), indoor air pollution is responsible for 2.6 million of the 7 million premature deaths that occur each year due to air pollution. Further, ischemic heart disease accounts for roughly 32% of home pollution-related fatalities, stroke accounts for 23%, lung cancer accounts for 6%, and COPD accounts for 19% (WHO, 2022). It is not surprising that women is the most vulnerable and negatively impacted by indoor air pollution, but it is astonishing that children are at the top of the list of health risks. It causes half of all pneumonia deaths in children under five, accounting for 15% of all under-five child mortality (WHO, 2016). According to the WHO, exposure to air pollutants during pregnancy and the first few years of life increases the chance of developing chronic lung disorders as an adult, impaired lung development, and reduced lung function. Even though every nation is making an effort to eliminate harmful cooking practices, when taking into account the per capita income of each nation, the trend for PM and NO2 remains the same (Figure 2) (WHO, 2022).

Since people spend maximum time in indoor ambience and when there is a little air exchange between indoor and outdoor spaces owing to poor ventilation, indoor volatile organic compounds (VOCs) have become a public health problem, particularly in high-income countries (HICs). High levels of VOCs' reactivity with the mucosa membrane and airway epithelium result in lung illnesses. Smoking in public places or ignoring mold-infested walls were also found to be contributing to the indoor air pollution, which in turn increases the persistence and severity of asthma morbidity (Fitzpatrick et al., 2011). VOCs such as benzene, formaldehyde, propylene glycol and glycol ethers react strongly with the mucous membrane and epithelial lining of the respiratory tract (EPA). Numerous pertinent research (Daisey et al., 2003; Jacobson et al., 2019; Farahani et al., 2021) indicated favourable connections between asthma and VOCs, leading them to draw the conclusion that schools should enhance ventilation to lower VOC concentrations in classrooms.

6. Impacts of air pollutants on global climate, ecosystem services, food and livelihood security

Increasingly air pollution and global climate change tend to disrupt ecosystem services and food production-supply chain and trigger hunger and malnutrition at both regional and global scale. The short-lived climate pollutants (SLCPs) which include tropospheric ozone, hydrofluorocarbons (HFCs), black carbon and methane have been reported as powerful climate forcers that accounts for approximately half of the global warming in recent decades (Garnett, 2011; Najjar, 2011; CCAC, 2022). The climate change in terms of increasing temperature in atmosphere promote variability in weather events which triggers heat waves and natural disasters which have become frequent phenomenon and frequent event resulting in reduced crop yields in recent decades (WHO, 2022). The SLCP has been reported to be responsible for stunts crop growth of major staple crops such as wheat, corn, rice, soya, maize and sugarcane, even wild forest crop by reducing the photosynthesis efficiency which ultimately affects nutritional contents of food crops (Emberson et al., 2003; Feifei et al., 2017). Reducing SLCPs can prevent climate change, protect ecosystem services and food security which will ensure better human livelihood. Climate and Clean Air Coalition (CCAC, 2022) of UNEP initiatives estimated that reduction of SLCPs would prevent up to 0.6°C of global warming by 2050 by limiting the near-term temperature increase and this would help in reducing the food security risks.

Air pollutants have been reported to be weakening the photosynthesis mechanism resulting stunt crop growth. The tropospheric ozone alone has been reported to cause annual yield losses of nearly 110 million tonnes of soybean, rice wheat and maize which accounts for around 4% of the total annual global crop production, and up to 15% in some regions of the world (UNEP and WMO, 2011; CCAC, 2022). One of major air pollutant namely, black carbon ($PM_{2.5}$) has been reported to be very harmful to crops which affects photosynthesis efficiency by covering the green leaves and prevent absorption of sunlight (Feifei et al., 2017). This phenomenon increases the temperature of crop plants, alter crop physiology and affect growth and yield. The black carbon affects photosynthesis efficiency of food and forest crop plants by reducing the sunlight reaching the earth and also disrupt rainfall patterns and triggers draught and crop failures, disrupt ecosystem services and food supply chain in high climate risk region of the world (Emberson et al., 2003; Garnett, 2011; UNEP and WMO, 2011; WHO, 2022).

In worldwide scale, 2.5 billion people are mainly dependent on agriculture for their food security and livelihoods. However, in recent years, 1 in 9 people suffer from hunger each day leading to severe malnourishment and death (CCAC, 2022). Even small changes in the climate and stunt crop growth can have immediate and devastating effects on many small and marginal farmers (Emberson et al., 2003; CCAC, 2022). Further, it is estimated that the global crop losses can be reduced to half in 2050 by reducing the methane emission which is an ingredient in the tropospheric ozone formation, and also by reducing other major air pollutants such as black carbon and the elevated CO2 level in the atmosphere (Burney et al., 2010; UNEP and WMO, 2011; CCAC, 2022).

7. Mitigation measures

Though air pollution is a trans-boundary and cumulative effect of a number of both natural and anthropogenic activities, it can be controlled by enacting strict laws and legislations along with the compliance of international laws that will make motor vehicles and industries comply with anti-pollution regulations. Maintenance of old pieces of machinery and adapting to the vehicle with a dual switch engine mode equipped with lithium-ion battery could minimize excessive fuel combustion and pollutants gases emission. Awareness among the people about the causes and dangers of air pollution could be an important aspect to control air pollution. Training and awareness programmes focused on reduction techniques of SLCPs emission will definitely prevent health, ecosystem and food security risks associated with global warming and climate change triggered by air pollution. Homes with proper ventilation, especially kitchens burning wood, coal and oil with proper ventilation can dramatically reduce indoor air pollution causalities. Tree plantation and indoor pot herbs are the well-known methods for controlling air pollution, therefore, government premises, schools, and roadsides plantation drive may be carried out through active involvement of the stakeholders. Industries should be established far away from the residential and city area while solid waste including non-biodegradable plastic and hazardous organometallic chemicals and pesticides should be properly disposed in safer places through awareness and active engagement of the community. Burning of fossil fuels and plastic materials should be banned to prevent emission of methane, SO2, CO and NOx gases which are proven harmful for both human and environment.

8. Conclusion

Air pollution is a major concern for the public health because it can have several adverse impacts on human health, including respiratory diseases, cardiovascular diseases, cancer, strokes, heart diseases and neurological disorders, coma and eventual death. The main sources of air pollutants are emitting from both natural and anthropogenic induced activities. Major pollutants of air have been reported to be PM, nitrogen oxides, sulphur dioxide, ozone, carbon dioxide and carbon monoxide. These pollutants pose both short-term and long-term health risks, depending on the level and duration of exposure while long term exposure to indoor air pollutants like dust particles, elevated CO and CO2 level, methane and VOCs have been reported to cause endothelial inflammation leading to ARD, CRD, COPD, lung cancer, Alzheimer and neurological disorders syndromes. It is essential to reduce air pollution levels to minimize the health risks associated with exposure to these pollutants. The SLCPs which comprised of hydrofluorocarbons (HFCs), tropospheric ozone, methane and black carbon have been reported to have devasting impacts on global climate regime, ecosystem services and threaten food security and human livelihood. Governments, industries, civil societies and individuals all have a role to play in reducing air pollution levels. Some effective measures suggested to reduce air pollution include adopting to clean energy sources, improving public transportation systems, implementing emission standards, promoting green cover, adopting climate smart agricultural practices and sustainable lifestyle practices. Overall, it is important to have continued dialogue and pragmatic action supported through research and public educational tools to mitigate adverse impacts of air pollutants on health, environment and food security, and to take science-based mitigation measures through active engagement of the stakeholders and community in general to reduce emissions of both SLCPs and other major air pollutants.

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Authors' contributions

SA and MH conceptualized the idea and equally contributed in literature review, secondary data collections, and finalized the manuscript. All the authors read and approved the manuscript before submission for publication.

Declaration of conflict of interests

Authors have no conflict of interests

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