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Impacts of Air Pollution on Climate Change: The Health Implication

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Abstract
In recent years, air pollution has caused more deaths worldwide, making it a major concern of public health. However, future climate change may exacerbate such human health impacts by increasing the frequency and duration of weather conditions that enhance air pollution exposure. Air pollution significantly affects health, causing close to 7 million premature deaths annually with a larger number of people hospitalized. Continued reductions in air pollution and greenhouse gas (GHG) emissions are essential because they pose serious threats to both people's health and the environment across the world. Air pollution and climate change influence each other through complex interactions in the atmosphere.
Increasing levels of GHGs alter the energy balance between the atmosphere and the Earth's surface which, in turn, can lead to temperature changes that change the chemical composition of the atmosphere. Direct emissions of air pollutants such as black carbon or emissions from sulfate and ozone can also influence the energy balance.
It was observed that emissions are linked to air quality and climate change, on this thematic issue the presents review investigates the trade-offs and co-benefits that may be gained from reducing both long-lived GHGs, responsible for climate change, and air pollutants, responsible for adverse impacts on human health, ecosystems and the climate.

Keyword: Air Pollution, Climate Change, Emission, Health,

Introduction

Reducing particulate matter (PM) has clear health benefits but understanding the impact of this reduction on climate change is essential if mutual benefits for climate and health are to be achieved. Climate change is an important factor that influences air quality. Atmospheric variables such as temperature, humidity and wind direction are directly impacted by Pollutant emission, transport, dispersion, chemical transformation and deposition [1]. Anthropogenic emissions of air pollutants have direct health concerns and are in many cases associated with concurrent emission of pollutants that have important impacts on global climate (e.g., carbon dioxide, black carbon, sulfur dioxide, and others). Generally, climate change is worsen air quality in many densely populated regions by changing atmospheric ventilation and dilution, precipitation and other removal processes and atmospheric chemistry [2].
Reduced air quality is a consequence of climate change, For instance, Fang et al. [3] stated that from pre-industrial (1860) to present (2000), the global population-weighted fine particle (PM2.5) concentrations increased by 5% and near-surface ozone concentrations by 2% due to climate change. Also Silva et al. [4], asserted that the change from pre-industrial era resulted in up to 111,000 and 21,400 additional premature fine particle- and ozone-related deaths due to climate change, respectively.
This study focuses on the ways in which health relevant measures of air quality, including ozone, PM, and aeroallergens, may be affected by climate variability and change. Because many detailed reviews have been published on the impacts of air pollution on human health, those impacts are only briefly summarized here. However, the small but growing literature focusing on climate impacts on air quality and the implications for human health was reviewed.

Effect of Ozone and Particulate Matter (PM) on Air Quality-The Health Implications

Ozone is a secondary pollutant formed from the interaction of precursor compounds with sunlight, including UV radiation [5]. The main precursors for ozone formation include several primary and other secondary pollutants such as VOCs, CH4 and CO that react with hydroxyl radical (OH) to ultimately produce ground-level ozone (Fig. 1).
The rate of formation is temperature-dependent. Ozone formation increases with greater sunlight and higher temperatures and become unhealthy during the warm half of the year. Poor air quality is also caused by emissions of nitrogen oxides, methane and other volatile organic compounds that combine in the lower atmosphere to produce ozone. Ground-level ozone is a serious pollutant, which at high levels, damages human health by increasing the risk of asthma related complications and premature death. [6, 7, 8]. Changing environmental conditions, including rising temperatures caused by climate change, are expected to increase concentrations of ground-level ozone.

In Europe, it is currently estimated that around 21,000 hospital admissions a year can be linked to ozone exposure and I has been noted that particles, especially from combustion, can affect cardiopulmonary mortality, hospitalization and respiratory disease (e.g. asthma, chronic bronchitis, rhinitis) [9]. Recent evidence supports associations with diabetes [10], rheumatic diseases [11], cognitive functioning [12] and neurodegenerative diseases [13]. Studies have confirmed that higher ozone concentrations can cause preterm birth [14]. Secondary pollutants like ozone affect crop yields which in turn affect food security and public health [15, 16].

Particulate matter (aerosols), $PM_{2.5}$, is a complex mixture of solid and liquid particles that is less than 2.5_m in aerodynamic diameter. $PM_{2.5}$ originates from various sources, primary particles emitted directly from sources and secondary particles that form via atmospheric reactions of precursor gases. $PM_{2.5}$ is emitted in large quantities by anthropogenic combustion of fuels by motor vehicles, furnaces, power plants, wildfires, and, in arid regions, windblown dust [17]. Climate change alters the emissions of biogenic volatile organic compounds (BVOCs) due to higher temperatures and changed plant metabolism; this will affect secondary organic aerosols (SOAs) resulting in changes in secondary particle levels [18]. Due to climate change (mainly due to weaker global circulation and a decreasing frequency of mid-latitude cyclones), annual mean $PM_{2.5}$ concentrations will change by ± 1 μg/m3 in the USA and Europe [19]. One type of PM, namely black carbon (BC), remains in the atmosphere for a relatively short time (one week), but strongly absorbs solar radiation and may be carried long distances from their source regions. Black carbon emitted from domestic burning of solid fuels, particularly indoors, and high-emitting diesel engines is likely to contribute to climate warming. [20]. Secondary particulates, such as sulphate particles, cool the climate and contribute to aerosol–cloud interactions [21, 22].
Because of their small size, PM2.5 particles have relatively long atmospheric residence times (on the order of days)

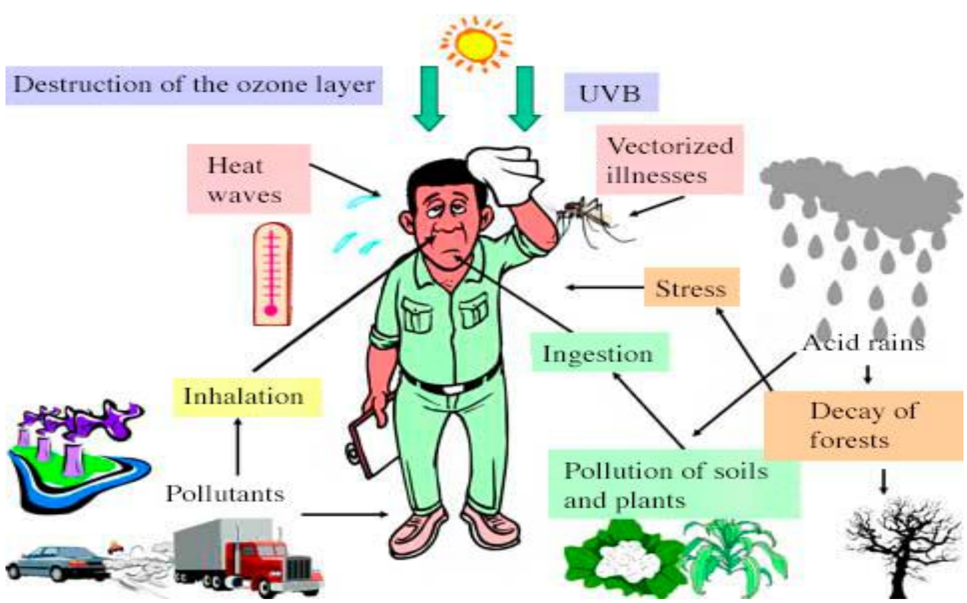

Figure 1. The main health effects of air pollution. The pollutants are directly inhaled. Deposited on the ground and vegetation, they pollute surface water and food, which are then ingested. The destruction of the stratospheric ozone layer reduces the barrier against UV rays, increasing the

risk of skin cancer. The increase in the concentration of greenhouse gases may increase the severity and frequency of heat waves, diseases transmitted by mosquitoes

Climate Change and Air Pollution: The inter-relationship

Climate influences the state of the atmosphere and in turn has an impact on the development and flow of air pollutants, for example, it can change the height of different atmospheric layers and the rate of chemical reactions in the air. Higher temperatures and elevated carbon dioxide (CO_2) concentrations usually results to increased emissions of ozone-relevant volatile organic compounds (VOC) precursors [23].

There are basically two types of pollutants, primary pollutants which are released directly into the atmosphere and secondary pollutants which are products of the chemical reactions between the primary pollutants. These secondary pollutants include strong acids, such as sulphuric acid and nitric acid, as well as strong oxidants such as ozone (O_3). The atmosphere is thus the site of intense chemical activity, between compounds that are mostly in trace amounts.

This phenomenon is called the greenhouse effect a phenomenon that arises as a result of absorbed gases that warm the lower layer of the atmosphere plays a role that is compared to that of the glass or plastic wall of a gardener's greenhouse. The greenhouse effect occurs naturally in the atmosphere, mainly due to the presence of water vapour and carbon dioxide as absorbent gases. This phenomenon enables us to have mild temperatures on Earth. Without this effect, the average temperature at the Earth's surface would be about 35°C lower than the one we enjoy. Pollution has increased the intensity of greenhouse effect significantly and in a way altered the earth's climate as illustrated in fig 2.

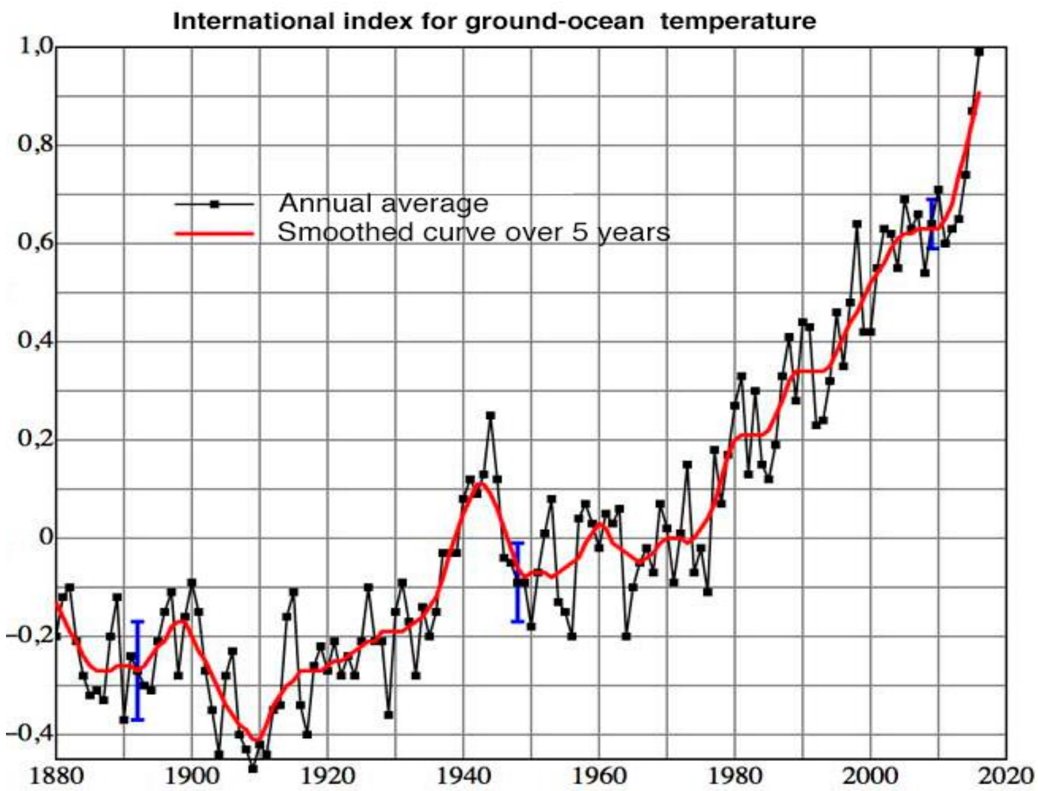

Figure 2. Increase in the average global temperature since 1880. [Source: en.wikipedia.org]

Mitigation and Recommendation

The main mitigation of climate change is reductions in human (anthropogenic) emissions of GHGs. Generally, GHG such as CH_4 and N_2O can be converted to energy and nitrogen based fertilizers respectively [7].

Mitigation may also be achieved by increasing the capacity of carbon sinks, for example, through reforestation and reduction of forest clearing or lumbering. Other measures of mitigation include switching to low-carbon energy sources, such as wind, solar, and nuclear energy, and expanding forests and other "sinks" to remove greater amounts of CO2 from the atmosphere [24].

Reduction in the amount of PM and ozone in developing countries also mitigate the negative effect of climate change. Replacing indoor solid fuel stoves with clean-burning stoves using biomass (plant material) provided the greatest combined health and climate benefits compared with costs in terms of mitigation.

Several Asia Pacific countries have collaborated with the US EPA to improve air quality in their countries. China has promoted integrated air quality and regional multi-pollutant air quality management strategies, and developed the frameworks and technical capacities to adopt effective emission reduction strategies, such as emission control and trading mechanisms [25]. They have also developed sulfur dioxide emission cap and trading mechanisms to promote cleaner fuels and vehicle emission reductions. China had also established the AirNOW international monitoring system in Shanghai. [25]. In Indonesia, the US EPA has collaborated to evaluate air emissions from forest fires and to phase out lead in gasoline. Over the years, the US EPA has been cooperating with their Indonesian partners and the United Nations Environment Programme through the Global Partnership for Clean Fuels and Vehicles. Other countries like Japan and Australia were involved in The Clean Air and Climate Coalition to reduce short-lived climate pollutants. Under this initiative, partners will provide technical assistance, training, and capacity building during their transition toward having more sustainable waste management options [25].

Conclusion

Climate change increases air pollution concentrations, although a decrease in emitted pollutant would reduce the negative effects of climate change.

Reduction in air quality impacts of climate change requires aggressive emissions controls to be put in place. The adaptation measures needed are the same as those already in place: reduced emissions of key ozone precursors, especially NO_x. Measures to further reduce emissions from vehicles must be strictly enforced. Also carbon sink offered by reforestation and afforestation projects must be implemented to absorb carbon monoxide from the atmosphere for a cleaner air.

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