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INCREASING THE VISIBILITY AND KNOWLEDGE BASE ON AIR QUALITY WITH BIG DATA AND ITS IMPACT ON THE POPULATION HEALTH

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NATURE (FOREST FIRE, VOLCANIC ERUPTION)

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1 INTRODUCTION

Air pollution is often linked to human activities such as industrial emissions and transport. However, nature itself can be a significant source of air pollution through a variety of phenomena such as forest fires, volcanic eruptions, desert storms and other phenomena. These natural events have the potential to release large quantities of pollutants into the atmosphere, which can have far-reaching impacts on human health, ecosystems and climatic conditions. This text focuses on an analysis of the major natural phenomena that contribute to air pollution, analyses the different types of pollution, examines their effects on the environment, presents possible measures to mitigate these effects, and evaluates them based on current scientific knowledge from at least fifteen scientific articles and other sources.

2 BACKGROUND

2.1 Most serious air polluters in Nature

2.1.1 Wildfire

Forest fires contribute significantly to air pollution by releasing large amounts of pollutants, including carbon dioxide (CO_2), carbon monoxide (CO), methane (CH_4), and fine particulate matter ($PM_{2.5}$), and a variety of organic and inorganic pollutants (Johnston et al., 2012). For example, wildfires in 2020 in Australia released approximately 715 million tonnes of CO_2 into the atmosphere (Giglio et al., 2013). These substances can have serious health and environmental consequences. Fine dust particles penetrate deep into the lungs, causing respiratory and cardiovascular problems and increasing the risk of chronic disease and premature mortality (Johnston et al., 2012). Carbon monoxide can cause poisoning, and methane contributes to the formation of ground-level ozone, which is harmful to the respiratory tract (Wegesser et al., 2009).

Forest fires also release toxic substances such as polycyclic aromatic hydrocarbons (PAHs), which have carcinogenic properties (Giglio et al., 2013). In addition to direct air pollution, wildfires can also affect climate conditions through increased CO_2 emissions, contributing to global warming. Prevention and effective management of forest fires are therefore key to reducing their negative impact on air quality and public health (Flannigan et al., 2009).Pollution caused by forest fires can persist for weeks to months and has a significant

impact on air quality. High concentrations of fine dust particles ($PM_{2.5}$) can penetrate deep into the lungs and cause respiratory and cardiovascular problems (Wegesser et al., 2009). Long-term exposure to these particles is associated with an increased risk of chronic disease and premature mortality (Johnston et al., 2012).

2.1.2 Volcanic eruptions

Volcanic eruptions are a major source of air pollution, with widespread environmental and climatic impacts. During eruptions, large quantities of gases and particulates are released into the atmosphere, including sulphur dioxide (SO_2), carbon dioxide (CO_2), water vapour, fly ash and dust. SO_2 can combine with water vapor in the atmosphere to form sulfuric acid, which contributes to aerosols and acid rain (Carn et al., 2016).

Volcanic ash and aerosols can have immediate and long-term effects on air quality and climatic conditions. In the short term, they can cause a sharp drop in temperature (called volcanic winter) due to the reflection of solar radiation (Harrison & Prentice, 2003). This is because aerosols reduce the amount of solar radiation reaching the Earth's surface, which can lead to a cooling of the Earth's surface, known as "volcanic winter" (Robock, 2000). For example, the 1991 eruption of Mount Pinatubo volcano caused a global temperature drop of approximately 0.5°C (McCormick et al., 1995). Long-term effects include ozone depletion and changes in atmospheric circulation, which can have far-reaching climatic consequences (Thornton et al., 2012).

Ash and fine particles can affect air quality over long distances, with negative health consequences, including respiratory problems and increased mortality (Baxter et al., 1981).

Eruptions also release CO_2, which contributes to the greenhouse effect and global warming (Gerlach, 2011). Monitoring and predicting volcanic eruptions are key to minimizing their negative impacts on air quality and human health.

2.1.3 Dust (desert) storms

Dust storms are a significant source of air pollution, especially in arid and semi-desert regions. During dust storms, large quantities of dust particles are released into the atmosphere, which may contain a variety of chemicals including heavy metals and toxic minerals (Goudie & Middleton, 2006). These particles can be transported over long distances, often across continents, thereby affecting air quality in remote areas (Prospero et al., 2003).

Dust storms can significantly reduce air quality, leading to respiratory problems and impaired visibility. Fine dust particles ($PM_{2.5}$) penetrate deep into the lungs where they can cause respiratory and cardiovascular problems. Long-term exposure to these particles is associated with an increased risk of asthma, bronchitis, heart disease, and premature mortality (Griffin,

2007). In addition to health impacts, dust storms can also reduce visibility, which can lead to traffic accidents and air traffic disruptions (Goudie & Middleton, 2006).

In addition, dust particles can affect climatic conditions by altering the radiative balance of the atmosphere and influencing cloud formation (Prospero et al., 2003), which can have far-reaching climatic consequences (Shao et al., 2011). Measures to mitigate the impacts of dust storms include reforestation, establishment of windbreaks, and sustainable agricultural practices that help stabilize the soil and reduce its erosive properties (Goudie & Middleton, 2006).

2.1.4 Biological pollution

Biological particles such as mould spores, pollen and bacteria are a significant source of air pollution and can have serious impacts on human health and ecosystems. These particles can be released into the air by natural processes or human activities such as agriculture (Burrows et al., 2009).

Mould spores, which are often released into the air, can cause respiratory problems and allergic reactions such as asthma and sinusitis (Dales et al., 2007). Pollen grains, especially from plants such as grasses and trees, are a major contributor to seasonal allergies and can irritate the respiratory tract (Eriksson et al., 2013).

Bacteria present in the air can also have a negative impact on health, some of which can cause infections, allergic reactions and respiratory problems in susceptible individuals. Elevated concentrations of airborne biological particles have been linked to seasonal allergies and asthma attacks (Archer & Jacobson, 2005).

For example, bacteria in the genera Bacillus and Clostridium can be airborne and contribute to respiratory problems (Burrows et al., 2009). In addition, biological particles can affect air quality by reducing visibility and affecting climatic conditions when combined with aerosols and other pollutants (Maki et al., 2012).

Monitoring and control of biofouling are key to protecting public health, particularly in areas with high concentrations of pollen and fungal spores, and in environments where people are exposed to high concentrations of bacteria (Burrows et al., 2009; Eriksson et al., 2013).

2.1.5 Natural emissions of volatile organic compounds (VOCs)

Volatile organic compounds (VOCs) are emitted not only from human activities but also naturally from plants and soil. The most well-known VOCs are isoprene and monoterpenes, which are released primarily from forests and vegetation (Guenther et al., 1995). These compounds can react with nitrogen oxides (NOx) to form ground-level ozone, which is a significant air pollutant and has negative impacts on human health and vegetation (Atkinson & Arey, 2003).

VOCs also contribute to the formation of secondary organic aerosols (SOA), which are an important component of fine particulate matter in the atmosphere. These particles can affect air quality and climatic conditions by altering the optical properties of the atmosphere and cloud cover (Kanakidou et al., 2005).

2.1.6 Biogenic methane emissions

Methane (CH_4) is a potent greenhouse gas that is emitted not only from anthropogenic sources, but also from natural sources such as wetlands, rice paddies and ruminant digestion. Wetlands are one of the largest natural sources of methane, with anaerobic bacteria in these ecosystems decomposing organic material to produce methane (Bridgham et al., 2015). This gas has a significant impact on the global climate, as its capacity to trap heat is approximately 25 times greater than that of CO_2 on a timescale of 100 years (Myhre et al., 2013).

2.1.7 Waste organic material and biomass burning

Organic material waste, such as leaves, needles and other plant residues, is another source of air pollution. The decomposition of organic material releases CO_2, methane and nitrous oxide (Davidson & Janssens, 2006). Biomass burning, whether natural or anthropogenic, also contributes to air pollution through the emission of various gases and particulate matter (Crutzen & Andreae, 1990).

2.2 Measures to reduce natural air pollution

Reducing air pollution caused by natural phenomena is a challenge because these phenomena are largely beyond the direct control of humans. However, there are some measures that can mitigate their impacts:

- ***Landscape rehabilitation and fire prevention:*** Landscape rehabilitation, such as reforestation and wetland restoration, can help reduce the risk of forest fires and methane emissions. In wildfire-prone areas, fire prevention measures such as removal of dry vegetation, establishment of buffer strips, and regular monitoring are important (Tilman et al., 2002).
- ***Monitoring and warning systems:*** Advanced monitoring technologies, such as satellite imagery and air quality sensors, can aid in the rapid identification and response to natural events that cause air pollution. Warning systems can alert the population and responsible authorities to increased risk of natural phenomena such as volcanic eruptions or forest fires (Flannigan et al., 2009).

2.3 Research and development of carbon capture and storage technologies

Investing in research and development of carbon capture and storage (CCS) technologies can help mitigate the impacts of CO_2 emissions from natural sources such as forest fires and volcanic eruptions. Although these technologies are still in the experimental phase, they represent a potential option for mitigating climate change caused by natural emissions (Lackner et al., 1995).

Natural air pollution, caused by events such as forest fires, volcanic eruptions, dust storms, and biological pollution, poses a significant challenge to the protection of public health and the environment. To mitigate the negative impacts of these natural phenomena, various other more specific measures are being taken that can help reduce their impact on air quality and public health.

a. Forest fire prevention and management

Forest fires are a significant source of air pollution, releasing large amounts of carbon dioxide (CO_2), carbon monoxide (CO) and fine particulate matter ($PM_{2.5}$). In order to minimize their impact, it is necessary to:

- Active forest management: this includes regular controlled burning and maintenance of forest areas to reduce the amount of combustible material (Flannigan et al., 2009). Controlled burning can reduce the risk of large and destructive fires by removing excess biomass.
- Improve monitoring and early warning: the use of satellite technology and meteorological models to predict and track forest fires can help provide early warning and coordinate firefighting interventions (Giglio et al., 2013). Technologies such as sensors and cameras can provide real-time data on the evolution of fires.
- Promote research and education: fire prevention awareness raising and training for firefighters and foresters are key to effective wildfire management and response (Johnston et al., 2012).

b. Volcanic eruption management

Volcanic eruptions release sulphur dioxide (SO_2), fine dust particles and other pollutants into the air, which can have widespread impacts on air quality and climatic conditions:

- Monitoring volcanic activity: the use of seismic sensors, satellites, and airborne monitoring stations to track volcanic eruptions can help predict and manage their impacts (Carn et al., 2016). These technologies allow for early warning and a better understanding of volcanic emissions.

- Improve warning and evacuation plans: rapid and effective communication with the public and evacuation planning are essential to protect the public from the toxic effects of volcanic eruptions (Robock, 2000).
- Maintenance and recovery: After eruptions, air cleanup and implementation of mitigation strategies such as filtration systems in high pollution areas should be ensured (McCormick et al., 1995).

c. Dust storm management

Dust storms release large quantities of dust particles into the atmosphere, which can affect air quality and health:

- Soil stabilization: implementing soil erosion prevention measures such as reforestation, planting windbreaks, and sustainable agricultural practices can reduce the frequency and intensity of dust storms (Goudie & Middleton, 2006). Reforestation helps stabilize the soil and reduces the amount of dust that enters the air.
- Control and monitoring: the use of sensors and monitoring systems to track dust particle concentrations and identify major sources of dust storms can help in designing effective measures (Shao et al., 2011).
- International cooperation: Collaboration within international initiatives and programmes such as the United Nations Environment Programme (UNEP) can contribute to more effective dust storm management at a global level (Prospero et al., 2003).

d. Management of biological pollution

Biological particles such as mould spores, pollen and bacteria can also affect air quality and human health:

- Plant and pollen control: regulating the growth of plants that produce allergenic pollens and monitoring airborne pollen concentrations can help reduce allergic reactions and respiratory problems (Eriksson et al., 2013).
- Indoor environmental maintenance: reducing indoor humidity and regular maintenance of air filters can reduce mould growth and improve indoor air quality (Burrows et al., 2009).
- Education and Awareness: Raising awareness of biological particles and their impact on health can help in the prevention and management of biological pollution (Dales et al., 2007).

Effective reduction of natural air pollution requires an integrated approach that combines prevention, monitoring and control. These measures, supported by technological innovation

and international cooperation, can make a significant contribution to protecting air quality and human health. The implementation of these strategies and ongoing research are key to tackling the challenges of natural pollution.

2.4 International cooperation and knowledge exchange

International cooperation is key to tackling global environmental problems. Knowledge exchange between countries and regions can help to improve measures to mitigate the impacts of natural air pollution. Joint initiatives, such as forest monitoring and protection programmes, can be an effective tool to address these challenges (Ahlström et al., 2015).

3 CONCLUSION

Natural phenomena such as forest fires, volcanic eruptions, dust storms, and biological pollution contribute significantly to air pollution. Although it is not possible to eliminate these sources of pollution completely, there are a number of measures that can help to mitigate their impacts. Monitoring, management, education and technological innovation are key components in the fight against air pollution caused by natural phenomena. Current scientific knowledge and technological advances provide tools and strategies that can make a significant contribution to protecting air quality and population health.

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