Mini Review
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Dynamics of microorganisms in the air: effects on health and the environment

Abstract

This review focuses on the presence of microorganisms in atmospheric particles, their sources, composition, and effects on human and environmental health. Furthermore, it highlights the importance of understanding these impacts to develop mitigation strategies.

Keywords: microorganisms in airborne particles, health effects due to bioaerosols, particulate matter in the environment

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Introduction

Due to its implications for human health and the environment, studying air contamination by microbiological particles has gained attention around the world.[1,2] In this sense, the study of microorganisms found in atmospheric particulates has become more challenging since their composition and quantity vary depending on geographical and anthropogenic factors.[3,4] Moreover, it is known that these microorganisms have the potential to impact both human health and environmental integrity, which highlights the need to comprehend their dynamics and the mechanisms underlying their dispersion.[5,6]

The sources of microbiological contamination and particulate matter include human activities like burning fossil fuels, farming, and building, as well as natural sources like volcanic eruptions and pollution storm.[7,8] However, the microorganisms are also released through biological activities, such as the breakdown of organic materials. Furthermore, environmental factors, such as climate and air quality, affect the buildup of microbiological particles in the atmosphere.[9,10]

Methodology

34 articles were reviewed for the preparation of this mini review, where the used methodology is described in detail in certain articles. For example, recent research has employed various sampling techniques, such as high-volume air samplers, impactors, and filters, to collect bioaerosols from different environments.[11–13] These samples are then studied using molecular techniques including polymerase chain reaction (PCR) and next-generation sequencing (NGS) to identify and quantify microbial communities.[14,15] Furthermore, microscopy and culture-based approaches are employed to investigate these microorganisms' morphology and viability.[16] Combining these methodologies results in a more complete understanding of the composition and behavior of airborne microbial particles.

Composition of airborne microbial particles

Numerous microorganisms and particles, including bacteria, fungi, viruses, pollen, pollutants, and heavy metals, have been found in the air.[17] As expected, their composition and concentration varied depending on their geographic location, the time of year, and human activities [11]. These particles have many implications for human and environmental health (Table 1).[12]

Table 1 Composition of microbial particles in the air

Particle type	Example	Reference
Bacteria and fungi	*Aspergillus, Penicillium, Staphylococcus*	14,15
Virus	Aerosols with pathogenic potential	14,15
Pollen and spores	Seasonal allergy triggers	14,15
Particulate matter (PM)	Heavy metals, dust, organic waste	14,15

Environmental impacts of microbial particles

Microbiological contamination can harm the environment by affecting water bodies and surfaces because the deposition of pathogenic microorganisms and toxic substances, which contributes to soil and water acidification, changing biodiversity, and lowering agricultural productivity (Table 2).[16,18,19]

Table 2 Environmental impacts of microbial particles

Environmental impact	Consequence	Reference
Soil and water pollution	Deposition of pathogenic microorganisms and toxic substances	20–22
Alteration of ecosystems	Soil and water acidification, loss of biodiversity	16,23
Spread of diseases in crops	Airborne pathogens that reduce agricultural quality and productivity	24,25

Effects on human health

In addition to causing allergic reactions, exposure to microbiological particles may increase the risk of respiratory, cardiovascular, and cancer diseases.[26–28] In this sense, some studies suggested that prolonged exposure to microbial contamination may also have an impact on embryonic development (Table 3).[29–31]

Table 3 Effects on human health from exposure to microbial particles

Impact on health	Consequence	Reference
Respiratory diseases	Asthma, bronchitis, pneumonia	32
Allergies and inflammatory reactions	Fungal spores and pollen	33,34
Cardiovascular and respiratory diseases	Associated with the inhalation of fine particulate matter (PM2.5)	27
Cancer and teratogenic effects	Risk of lung cancer and alterations in fetal development	26,28

The underlying mechanisms responsible for these effects involve oxidative stress, chronic inflammation, and changes to the immune system.

Considerations and future research needs

Furthermore, a deeper understanding of the environmental factors influencing the composition and abundance of atmospheric microorganisms is needed, as well as the long-term effects on human and environmental health because of the exposure to these particles. Developing effective strategies to mitigate these risks is essential for environmental conservation and public health protection. Some suggested strategies to lessen exposure to microbiological particles include: Monitoring and controlling air quality; Implementing stricter environmental standards; Filtration technologies: Using HEPA-filtering face masks and air purification systems; Control of anthropogenic sources: Lowering industrial emissions and improving biological waste management.

Conclusion

An important environmental issue with significant implications for both human health and the environment is air contamination by microbiological particles. More research is required to better understand the effects of these particles and to develop effective strategies to lower the risks associated with their exposure. In this sense, studying the microorganisms found in atmospheric particles is an evolving field with significant implications for both human health and the environment. More research is required to comprehend the presence and effects of these microorganisms and to develop effective strategies to lower the risks associated with exposure to these contaminants.

Future study should focus on these areas; Long-term exposure research to better understand the long-term effects of bioaerosols on human health and ecosystems; Advanced detection methods include developing more sensitive and specific procedures for recognizing and measuring airborne microbes; Strengthening environmental policies and regulations to control anthropogenic sources of bioaerosols and protect public health; Mitigation Strategies evaluating the efficiency of current mitigation measures and developing novel approaches, such as biofilters and green infrastructure, to reduce bioaerosol emissions.

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Conflicts of interest

The authors declare no conflict of interest in writing the manuscript.

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