A Brief Note On Bioaerosols

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Abstract: Bioaerosols are airborne biological particles which may exist in solid or liquid form. The bioaerosols consists of various types of living organisms. They may contain harmful pathogens such as virus, bacteria or fungi. As they get entrained in the atmosphere and take a long time to get deposited, they have a high potential to contaminate the environment and pose health risks to human beings and other life forms. In present article the characteristics, sources and the control mechanisms of the bioaerosols has been discussed briefly.

Introduction

Aeromicrobiological studies involve the study of microorganisms that float freely in the air. The term bioaerosol is often used to refer these microorganisms. Various airborne contaminants such as, viruses, bacteria or fungi dispersed from the source can eventually get deposited on any solid surface. Therefore, they can contaminate food or drinking water. Some of the airborne microorganism may have pathogenic characteristics. Therefore, they can cause significant degradation of human health. Bioaerosols are the tiny airborne particles that pose a serious threat to human health and environment [1], [2]. These microbe particles vary widely in size and composition depending on various factors such as, the type of bioaerosols, the types of other suspended particles and gases in air that interact with the bioaerosols. Airborne microbes can carried away with the wind flow from their sources to a significantly large distance and consequently may precipitate and increase the chance of various infectious diseases.

The size range of the bioaerosols is very wide (0.02-100 μm). In spite of having a wide size range, two size categories are most widely used: PM_{10} (particulate matters with the aerodynamic diameter <= 10μm) and $PM_{2.5}$ (particulate matters with the aerodynamic diameter <= 2.5 μm). The average size of the aero microorganisms is approximately 5 μm. Bioaerosols may be composed of liquid aerosols or solid particles or both. Most of the airborne microorganisms are observed to be associated with airborne dust or tiny droplets of water.

Factors determining the survival of bioaerosols in ambient air

The survival of the airborne microorganisms depends on various environmental factors including relative humidity (RH), solar radiation and temperature. Irrespective of the types, the environmental exposure is detrimental to the airborne microorganisms [3].

Humidity: The effect of RH on the airborne microorganisms was studied long back. It was observed that, the inactivation of airborne microorganism happens in maximum extent at around 50% RH. The reasons behind this can be acute dehydration of the cells and development of hypersensitivity of the cells to toxins [4].

Solar radiation: Ultraviolet radiation of sunlight can potentially harm the airborne microorganisms [5]. The nucleic acids in the living cells can absorb the radiation of wavelength ranging 200 nm to 300 nm. The energy can damage the structure of the nucleic acids and pyrimidine dimmers may form which can hinder the DNA replication process and prevent the protein formation which leads to the death of the microorganism. Besides, the

effects of UV radiation on microorganisms are related to the relative humidity of the atmosphere. UV inactivation of microorganisms decreases with the increase in RH [6].

Temperature: The impact of ambient temperature on airborne microorganisms varies widely with the species of the microorganisms. The thermophilic microorganisms can survive in the temperature range of 55-85 °C. Therefore, it reflects that these organisms cannot survive in low temperature regions. A very low ambient temperature inhibits the growth of microbes.

Sources of airborne microorganisms

There are various kinds of microorganisms in air but air is not the natural habitat of all type of microorganisms because it does not constitute perfect moisture and nutrient for the growth of microorganisms. Bioaerosols source can be natural or anthropogenic. The natural sources are pollen, spores, indigenous microorganisms etc. The major anthropogenic sources of bioaerosols are waste disposal area (such as, landfill, biological waste treatment facility, wastewater treatment plants etc.), livestock, horticulture, refrigeration facilities etc. [7]. Apart from this, the nasal discharge from infected patients is another major source of bioaerosols. The pathogens can be released into the atmosphere during the sneezing and coughing of the patients with the discharged droplets. The infectious microorganisms can get re-entrained in air after the drying of the discharge.

Routes of exposure

Airborne microorganisms can be transported and infect human beings directly through respiratory pathway, through dermal contact or by ingestion. Besides, they can indirectly enter into the human body during the handling of contaminated waste materials.

Fate of bioaerosols in atmosphere

Aero microorganisms are transported into the human body and environment by various agents, pathogens and other forms, through the three main routes: launching, transport and deposition [8-12]. In launching stage, microbe particles get suspended in the earth's atmosphere. In this process both terrestrial and aquatic sources of microorganisms are involved. Loading of microorganisms occurs in higher degree from terrestrial sources than aquatic sources.

The airborne particles may get released and transported by wind current from various point sources, area sources or line sources. Dispersion from the point sources can be classified as instantaneous point sources and continuous point sources. On the contrary, line sources and area sources are generally larger sites of pollutant release. Transport of airborne microbes is dependent on the spatial and temporal range [13-15]. The transportation over a short period (less than 10 minutes) and short distance (less than 100 m) is defined as sub micro scale transport. Sub micro scale transport is commonly observed within small buildings or in a small enclosed space. The transport over the duration of 10 minutes to 1 hour and over a distance of 100 m to 1 km is known as microscale transport. Mesoscale transport is the transport of airborne microbes over long duration (several days) and long distance (more than 100 km or more). As most of the airborne microbes are unable to survive for a long time in the atmosphere, the most widely used scales considered for aerobiological studies are in sub-micro level and micro level. However, some viruses and bacteria were observed to be transported in mesoscale and microscale.

Bio aerosol deposition process in which the microbe loaded particles adhere to the surface. The three main processes is Gravity settling, surface impaction, rain deposition.

Mechanisms to control bioaerosols

The control of aero microbe particles mechanisms is used are the ventilation of the facilities, filtration of the air, UV treatment, use of chemical agents for attenuating the microorganisms, and physically isolating the contaminated space [10].

Ventilation: Proper ventilation of the contaminated areas is a common approach used to control the spread of airborne pathogens. In ventilation, air flow is created through areas where airborne microbe's contamination takes place. In this process facilitating air circulation inside the room is crucial in order to enable dispersion.

Filtration: Filtration is an effective way to control microbe's contamination by the use of HEPA filters or High-efficiency particulate air filters. HEPA filters are usually installed in the biosafety cabinets. However, as their cost is significantly high, they are not generally used constructing common air filters. The most commonly used filtration system is the air filtration system that relies mainly on the principles of baghouse filtration that works exactly the same as the vacuum cleaner bag.

Biocidal agents: These agents are used for additional teartment of air and they can be employed for elimination of most of the airborne microbes with an affirmation of their non-viability and non-infectiousness. Control measures of bioaerosols may involve dehydration, UV irradiation, super heating and ozonation. The most commonly employed, however, is the Ultraviolet Germicidal Irradiation (UVGI). This biocidal agent has the capability to control variegated airborne microbes but some of them have various degrees of resistance against it.

Physical isolation: Physical Isolation is defined as the barrier created between different compartments of an environment by creating positive or negative pressure gradients of air and using airtight seals. When negative isolation approach is used, air is flown into the isolation chamber to protect the people outside the chamber. On the other hand, in positive isolation approach in air is flown out of the chamber to avoid the contamination inside the isolation chamber.

Conclusion

The potential impacts of bioaerosols on human health are diverse. It includes infectious diseases, severe toxicity and even cancer. The consequence of significant bioaerosol contamination is potentially pandemic. Although several means are available to control the dispersion of bioaerosol, much research works are in progress to develop better contamination control measures and assessment tools for bioaerosol-induced health risks.

References

[1] H. Burger, "Bioaerosols: prevalence and health effects in the indoor environment.", Journal of Allergy and Clinical Immunology 86, pp. 687-701, 1990.
[2] J. Douwes, Pl Thorne, N. Pearce and D. Heederik, "Bioaerosol health effects and exposure assessment: progress and prospects.", The Annals of occupational hygiene 47, pp. 187-200, 2003.
[3] J.W. Tang, "The effect of environmental parameters on the survival of airborne infectious agents.", Journal of the Royal Society Interface 6, pp. S737-S746, 2009.
[4] E.W. Dunklin and T.T. Puck, "The lethal effect of relative humidity on air-borne bacteria.", Journal of Experimental Medicine 87, pp. 87-101, 1948.
[5] J. Peccia, H.M. Werth, S. Miller and M. Hernandez, "Effects of relative humidity on the ultraviolet induced inactivation of airborne bacteria.", Aerosol Science & Technology 35, pp. 728-740, 2001.
[6] R.L. Riley and J. E. Kaufman, "Effect of relative humidity on the inactivation of airborne Serratia marcescens by ultraviolet radiation.", Appl. Environ. Microbiol. 23, pp. 1113-1120, 1972.
[7] V. Kummer and W.R. Thiel, "Bioaerosols–sources and control measures.", International journal of hygiene and environmental health 211, pp. 299-307, 2008.
[8] I.L. Pepper, C.P. Gerba, T.J. Gentry and R.M. Maier, eds. Environmental microbiology, Academic Press, 2011.

[9] Mahesh, K. V., Singh, S. K., & Gulati, M. (2014). A comparative study of top-down and bottom-up approaches for the preparation of nanosuspensions of glipizide. *Powder technology*, *256*, 436-449.
[10] Vaid, S. K., Kumar, B., Sharma, A., Shukla, A. K., & Srivastava, P. C. (2014). Effect of Zn solubilizing bacteria on growth promotion and Zn nutrition of rice. *Journal of soil science and plant nutrition*, *14*(4), 889-910.
[11] Kumar, V., Singh, S., Singh, J., & Upadhyay, N. (2015). Potential of plant growth promoting traits by bacteria isolated from heavy metal contaminated soils. *Bulletin of environmental contamination and toxicology*, *94*(6), 807-814.
[12] Mukherjee, R. (2020). Electrical, thermal and elastic properties of methylammonium lead bromide single crystal. Bulletin of Materials Science, *43*(1), 1-5.
[13] National Research Council, Biosolids applied to land: advancing standards and practices, National Academies Press, 2002.
[14] Mahesh, K. V., Singh, S. K., & Gulati, M. (2014). A comparative study of top-down and bottom-up approaches for the preparation of nanosuspensions of glipizide. *Powder technology*, *256*, 436-449.
[15] I.L. Pepper and C.P. Gerba, "Aeromicrobiology.", In Environmental Microbiology, pp. 89-110, Academic Press, 2015.