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Short review on the atmospheric bioaerosols

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Abstract: The variability of bioaerosols cut across seasonal changes, indoor encasements, outdoor sources, and atmospheric conditions. Hence, the easiest way to curb disease-carrying bioaerosols requires an in-depth understanding of the factors mentioned above. In this short review, the physical and biological properties of bioaerosols were discussed. It was discovered that its biological and physical properties are salient to determine its diffusion, deposition, control, and measurement.

1. Introduction

These are particles of biological origin that are mainly found in the air, i.e., they are "airborne". Bioaerosols may include both living and non-living organisms. Bioaerosols are secondary divisions of biological particles obtained from land habitats (e.g., microorganisms such as bacteria, fungus, pollen, virus) and aquatic ecosystems [1]. Bioaerosol also consists of dead cells. It is a minute particle that can be suspended in the air and is transferred or carried around by the wind to different places of the earth. Bioaerosols are mostly harmful to the health of living things as they come from things within the environment. Pollen is a non-living organism type of bioaerosols, i.e., gotten from plants, trees, etc. It is made up of a mass of microspores found in a seed-bearing plant, which usually comes out like fine dust. It is the dusty bloom seen on the body of an insect. Bioaerosols are a very harmful chemical being taken into our body system through our lungs. It, therefore, leads to lung infections. Research shows that there is a relatively higher diffusion of these bioaerosols through birds such as pigeons, bats, etc., [2]. Viral bioaerosols may be considered a more dangerous bioaerosol because they are smaller than others and travel quickly and faster when released into the air. It can manifest as a severe acute respiratory syndrome (SARS), H1N1 influenza, and the H5N1 avian influenza, etc., [3]. Nazaroff [4] believes that particle deposition in different regions of the respiratory tract about their particle sizes. This type of deposition occurs under the Brownian diffusion of bioaerosols in the lungs.

It was discovered that bioaerosols concentration is relatively higher in indoor environments than outdoor environments as outdoors usually have at least a little free space, unlike an indoor place that is enclosed [5]. The variability of bioaerosols both at the indoor and outdoor at different seasons are presented in Figure 1. It can be observed that bioaerosols are highly concentrated in sealed places such as the basement. Another salient characteristic of bioaerosols, as seen in Figure 1, is that it varies concerning seasons. For example, more bioaerosols are produced during the summer.

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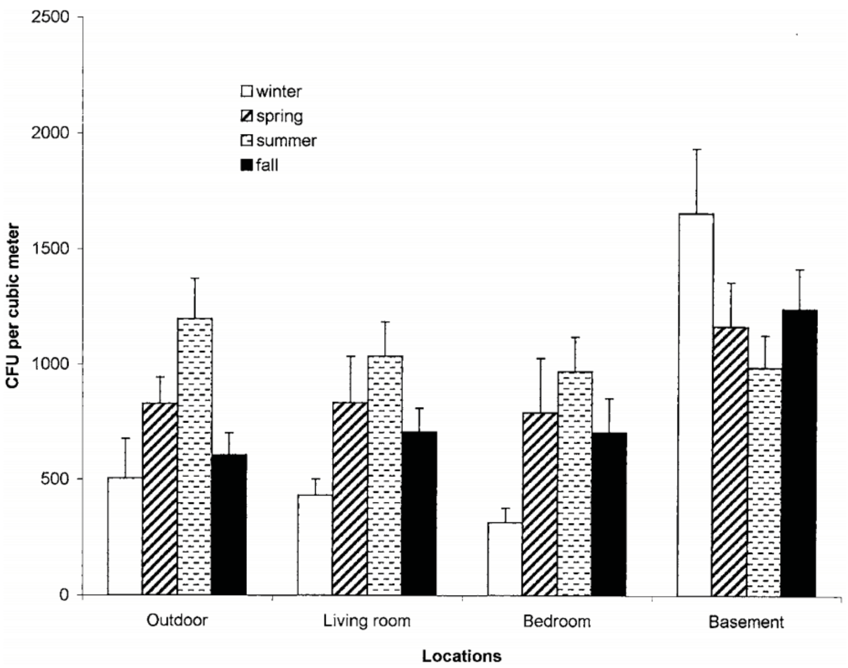

Figure 1: Variability of bioaerosols at indoor and outdoor conditions [5].

Studies have shown that the number of occupants had a significant effect on total particle concentrations within an area. This idea means that the magnitude of occupancy can increase bioaerosols concentration within an area. Adams et al. [6] illustrated in Figure 2, how particles are most strongly impacted by occupancy (>5 µm).

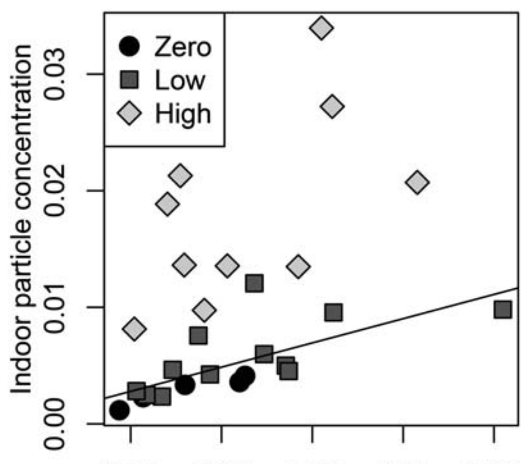

Figure 2: Mean concentrations of particles larger than 5 microns.

It was shown that indoor particle concentrations with no or low occupancy loads correlate with outdoor particle concentrations (Figure 2).

2. Bioaerosols in the air-ways of human

Bioaerosols refer to minute airborne molecules, ranging from approximately 0.001 to 100 μm, that emanate biologically from living and non-living things [7]. It may include a whole microscopic formation, such as intact spores and bacterial cells, the cysts of protozoa, spores, and cells of fungal, pollen grain of plants, etc. It is the presence of cell fragments (such as decayed particles of airborne microbial, animal, and plant matter; dust form grain and wood; arthropods dried body parts and droppings; urine, saliva, feces and animal skin particles) in the atmosphere. Bioaerosols are biological originated substances that can cause an effect on human beings. The infectious agent enters the body through inhalation, and this mode of infection is the most difficult to control. By air, an infectious agent can meet a large number of likely hosts other than physical contact. Sneezing and coughing eject particles with great efficiency than when humans release droplets from mouth and esophagus while breathing [8]. Sneezing carry less infectious agents than coughing. There are four main deposition forces, i.e., Brownian motion, inertial impaction, gravitational settling, and interception [9]. Nazaroff [4] revealed the impact of these forces on bioaerosols deposition in the lungs. It was observed that particles in size range 0.5–1 μ m have a deposition loss rate coefficient of ~ 0.2–0.3 per hour while particles in the range 3–10 μ m have deposition loss rate coefficient of 2–10 per hour. This result means that the deposition of bioaerosols in the lungs is more dangerous at smaller sizes.

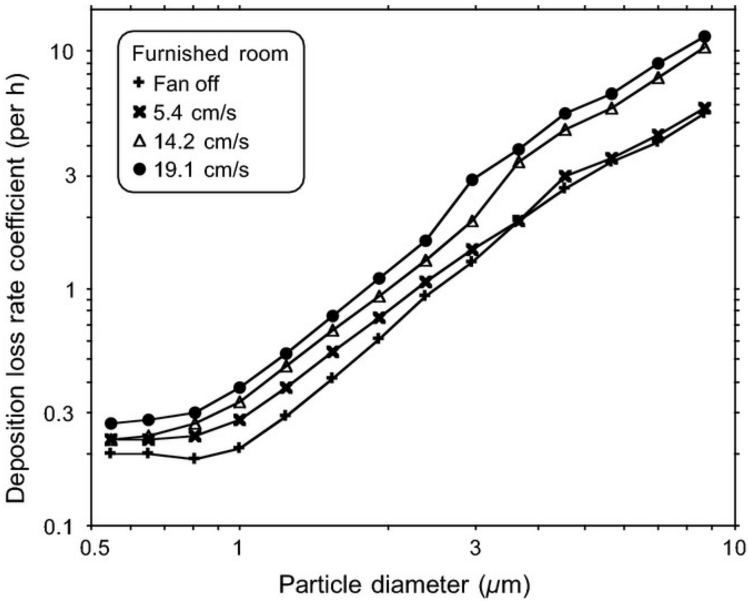

Figure 3: Deposition rate at specific conditions [4]

Some common airborne diseases can be associated with harmful bioaerosols in the environment. For example, legionnaires' disease is caused by the specie legionella pneumophila and its approximately 2 μm in length and 0.3-0.9 μm wide. It is transmitted through inhalation of water aerosol containing the bacteria. The specie Mycobacterium tuberculosis causes tuberculosis, and its approximately 2-4 μm in length and 0.2-0.5 μm wide. It is transmitted through the air from persons to persons. The species Bordetella pertussis causes whooping cough, and its approximately 2-4 μm in length and 0.2-0.5 μm wide. It is transmitted through direct contact or inhalation of airborne particles. The specie Bacillus anthracis spore causes anthrax, and its approximately 3-5 μm in length and 1.0-1.2 μm wide. It is transmitted through inhalation of air containing anthrax spores or by contact with infected animals and insects like flies [10].

Sturm [11] investigated the deposition of bioaerosols of varying sizes for probands of different ages. Two remarkable discoveries were made, i.e., nose breathing results in higher extrathoracic deposition rates than mouth breathing; bioaerosols have lower chances to reach the alveoli in infants' and children’s lungs. However, it is postulated that bioaerosols' health effects depend on the lung penetrability of biogenic particles under different breathing conditions [12].

3. Air Sampling Techniques

Bioaerosols air sampling techniques include grabbing sampling, short-term exposure sampling, full-shift exposure sampling, passive sampling, active sampling, etc.

Passive sampling is the preferred sampling technique because of its availability and easy economic access and relies on particles settling using gravity. The active sampling works on the principle of mass and inertia of particulates. The main challenge of active sampling is the assumption that particles tend to have the same mass due to particulate size and particles having a discrete finite number of particles, and this could easily lead to error [13].

One of the most reliable means for detecting bioaerosols is using the bioaerosol RNA extraction technique. RNA means Ribonucleic Acid. It is known as a messenger in our body, as it helps to pass information from the DNA (deoxyribonucleic acid). It is an acid that exists in every living cell. Its primary function or use is to analyze, interpret, regulate express genes. RNA is a gathered chain of nucleotides, and it is seen more in nature as a single strand instead of a paired double-strand. The organisms that are made up of cells use the messenger RNA to pass across genetic information that guides the synthesis of specific proteins [14]. Bioaerosol RNA Extraction Technique has to do with the removal procedure of bioaerosol through ribonucleic acid.

This technique is used to gather or collect pathogens that have these biological aerosols present in them. There are air samplers that help sample the air and extract the bioaerosol, i.e., it checks the air and sees if it is infected with the bioaerosol, and if it is, it is then filtered. There are two operations under which the air sampling method works, namely filtration, and gravitational or inertial force. During filtration, air samples are collected in different types of filters and then after being collected they are then extracted from the filters by a method called the elution buffer, during this process, it is paramount that the particles to be analyzed are removed from the filter to avoid any form of restriction from the filters. Filters consist of resembling fibers and thin transparent forms. Filters consist of four types, i.e., high pass filters (separates the particles with a higher frequency), low pass filters (separate particles with a low frequency), bandpass filters (filters within a specific range), and band-reject filters (separates those not within the range).

Bioaerosols are introduced into the cyclone during gravitational or inertial force technique, where it can be separated by the principle of gravitational or inertial force [15]. Cyclone relies on the kinetic potential of the particle to be deposited on the wall of the sampler as the aerosol circles around inside the chamber; this is similar to the impactor. The collection efficiency of cyclones relies on the flow rate. Cyclones are less vulnerable to particle rigidness than impactors and can hold a larger mass of material. There are also electrostatic samplers for bioaerosol use where substances are gathered because of the charges they possess and then move through an electrostatic field. The benefit of using electrostatic samplers is that the size of the particle desired for analysis can be picked. This type of sampler is recommended for locations with seasonal dynamics of DNA and RNA viral bioaerosol e.g., daycare [16].

4. Conclusion

The dynamics of the bioaerosols concerning its biological and physical properties are salient to determine its diffusion, deposition, control, and measurement. Its variability cuts across seasonal changes, indoor encasements, outdoor sources, and atmospheric conditions. Hence, the easiest way to curb disease-carrying bioaerosols requires an in-depth understanding of the factors mentioned above. Bioaerosol control is being developed due to environmental health hazards, and the innovations are being put in use by various sciences. The role of bioaerosols in climate offers numerous research opportunities and advancement of DNA extraction from bioaerosols.

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