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A review on recent progress in observations, and health effects of bioaerosols

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ABSTRACT

Bioaerosol is a particulate mixture of solid and semi-solid matter combined with biotic matter like pollens, microbes and their fragments. The present review stresses on a cumulative understanding of sources, components, quantification and distribution of bioaerosols with respect to size, and its significant impacts on human health. The present review will be instrumental in devising strategies to understand and manage bioaerosols and reducing their human exposure and associated health hazards. The present review aims explore the relationship between particle and associated biological agents responsible for behaviours like dispersal, total potential health hazards and toxicology level during exposure to bioaerosol.

1. Introduction

Bioaerosols are a particulate mixture of dust, microbes and their fragments. They are transmitted through air with a particle size ranging from 0.001 nm to 100 μm. The pathophysiological effects of these bioaerosol pollutants depend on their size, concentration, physiochemical properties and size distribution (Mandal and Brandl, 2011). Because of the micro to nano scale size, bioaerosol scan easily deposit in various parts of the body via lungs, and circulatory system. Such deposition can cause a number of health complications involving single organ to an entire organ system (Georgakopoulos et al., 2009). These are alarming reasons why awareness of bioaerosols is of great importance and hence it becomes necessary to investigate the source distributions and their impacts on human health.

Massive industrial development and population expansion has caused deleterious anthropogenic activities (waste sorting and composting, agricultural, the livestock industry and food processing activities) (Ghosh et al., 2015). Exposure of human to bioaerosols in populated countries like China, India etc. is a primary concern because of associated adverse health impacts (Pearson et al., 2015). Many recent studies revealed that enhancement in the level of bioaerosols has become a serious environmental concern (Ghosh et al., 2015; Lacey and Dutkiewicz, 1994). Not only humans but pet and husbandry animals are also distressed from increasing prevalence of the bioaerosol exposer. In recent decades, bioaerosols are reported to contribute as much as up to 34% indoor air pollution with life threatening consequences (Mandal and Brandl, 2011).

Previous (Mandal and Brandl, 2011; Chen and Hildemann, 2009) indicated generation of bioaerosol due to human activities (i.e., sneezing/coughing, washing floors/toilet cleaning, walking/talking etc.). Dedesko et al. (2015) demonstrated the influence of meteorological parameters (i.e., temperature, and humidity) on formation and dispersion of bioaerosols. Moreover, Srikanth et al. (2008) suggested the relationship between bioaerosols and human diseases such as influenza, lungs diseases, allergies etc. The immunomodulatory or immunostimulatory effects of bioaerosols contribute significantly in the development of adaptive immunity. However, the over exposure can cause hyperactive stimulation of immune system causing allergic responses (Severson et al., 2010). A number of bioaerosol studies assesses the impact of bioaerosols on living organisms, but the exact role and mechanism of pathogenesis remain illusive. Fig. 1 highlights different types of microorganisms associated with bioaerosols and associated diseases.

A comprehensive review has been presented through reviewed approximately published article in English language journals only that reported bioaerosols, source and its impact on human health. The findings from computer searches by using of some keywords (i.e., bioaerosols, diseases, exposure, and health problems), will help to readers for better understanding on impact of bioaerosols on human health.

2. Sampling methods

Size and composition of airborne bioaerosol depend on their

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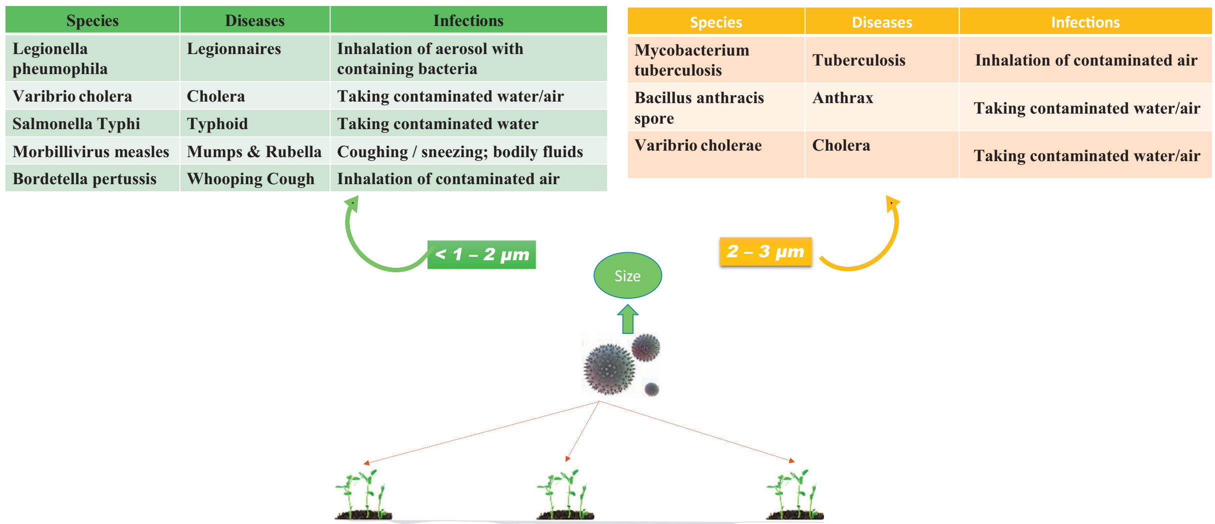

Fig. 1. Microbes in bioaerosols and their related diseases.

formation and mechanical stress in particular environmental conditions. Therefore, the selection of sampling tool to monitor the concentration level of bioaerosol should be quite different from the general employed procedure for analysis. Very few research articles could be found on new sampling methods to assess the bioaerosol and its microbial analysis. However, previous employed methods such as impingers, cyclones, impactors, filters, spore traps, electrostatic precipitation, thermal precipitators, condensation traps, gravitational samplers, etc. of common particle are being used to collect the bioaerosol with or without modification (Haig et al., 2016). Moreover, many samplers have been reported to separate the particle from the air through gravity (Wang et al., 2001), centrifugal force (Haig et al., 2016) and other methods (i.e., Filtration, Electrostatic Precipitator Thermal Precipitator etc.) (Ghosh et al., 2015). According to particle size, few options are available such as inertial bioaerosol sampler (i.e., sieves, stacked sieves, and impactors), which rely on properties of the particle to deviate from laden gas flow due to inertia (Haig et al., 2016). Moreover, non-inertial bioaerosol samplers (i.e., filtration, electrostatic precipitator, and thermal precipitator) are also available to show non-dependency (i.e., less reliant on particle size) upon the selective particle size (Ghosh et al., 2015).

Impingers and cyclones method are being used to collect airborne particle in the liquid medium. In case of impinge, it is operated through the gas flow from the inlet to collection chamber containing liquid, where number of factors (i.e., gas flow rate, distance from inlet to outlet, and surface of the liquid) are influenced by the size and diameter of the particle (Han and Mainelis, 2012). On the other hand, centrifugal force worked in cyclone (conventional), where air is forced into the collection chamber by the vortex formed in the system. Macher et al. (1995) reported that new cyclone sampling techniques to collect the sample through standard centrifuge tube from the top of the sampler chamber instead of the peripheral portion of the system. Such an optimization makes procedure very simple (Macher et al., 1995). Moreover, the investigators also reported high efficiency with multiple tubes to identify size fractioned samples (i.e. large, medium and small – sized bioaerosols) in initial (centrifuge) tube, second tube, and filter, respectively.

Media plays a vital role in the collection of bioaerosol. The most commonly used is a filter to transfer bioaerosol on a plate or in liquid for further analysis (i.e., microscopic examination or culturing experiments) (Wu et al., 2010). Several studies are reported stating utilization of different forms of cultivation media like maltextractagar (MEA) (Lehtinen et al., 2013), Sabouraud dextrose agar (SDA) (Park et al., 2015), dichloran rose-bengal chloramphenicol (DRBC) (Tolvanen and Hänninen, 2006), and yeast extract glucose chloramphenicol (YGC) (Borrego et al., 2012). Fibrous filter made of a fine fibrous mat, where the particle is captured while passing the filter is also very efficient. Similarly, few filters have a pore-like structure in which particles are deposited (Uhrbrand et al., 2011). However, it can be seen that the efficiency is affected by several factors such as measurement time, relative humidity, temperature, microbial species (Wang et al., 2001). Moreover, glass – impinger method was found to be very suitable method to collect bacteria and fungi from the air streams (Thorne et al., 1992). Li (1999) compared to using impinger to collect bioaerosol and filtration methods.

3. Components of bioaerosols

Bioaerosols pose a substantial health risk globally (Burger, 1990; Kim et al., 2017). Bioaerosols comprise of diverse classes of microorganisms and their products. The major microbial constituents are fungi and bacteria while their products constitute endotoxin, mycotoxins, and allergens (Kim et al., 2017). A recent focus is also stretched upon the presence of Beta-glucans (a common cell-wall component of fungi) in bioaerosol which causes a number of health-related consequences such as cancer, auto-immune diseases and severe respiratory tract dysfunctions. Looking at the severity of bioaerosol in health management, it is, therefore, essential to understand the nature and components of bioaerosols. This section discusses the classification of major microbial (and their products) constituents of bioaerosols.

3.1. Fungi

Fungi are ubiquitously present in nature over a wide range of environmental condition (Lee et al., 2006). The kingdom fungi consist of a diverse group of eukaryotic organism ranging from microscopic to macroscopic in size. A recent survey estimates about 2.2 million to 3.8 million species of fungus existing in almost all the terras of the earth (Hawksworth and Lücking, 2017). The pathogenic fungal species like *Aspergillus* spp., *Fusarium* spp., *Scedosporium* spp., and *Mucorales* spp. are most common components in bioaerosol (Diaz-Guerra et al., 2000; Grigis et al., 2000; Jung et al., 2009). These fungi are known to cause a number of health-related related complications such as acute toxicity, hypersensitivity (majorly asthma), invasive mycoses and respiratory abnormalities (Bush and Portnoy, 2001; Jung et al., 2009; Verhoeff and Burge, 1997).

Near all the known species of fungi possess the ability to propagate (in air or water as a particulate) via sporulation. The fungal spores can