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Research Article

Bio-Particulates in Atmosphere - A Brief Review

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Abstract

Bioaerosols encompassing viruses, bacterial cells, protozoa and their cysts, fungal cells, pollen grains and toxic spores from these organisms pose direct threat to human health. Epidemics like Severe Acute respiratory Syndrome and Middle East Respiratory syndrome are reported to be caused by aerosols. In this brief review we have provide detailed description of various bioaersol agents, their role and affects on human health like COPD, Bronchites etc.

Keywords: Bioaerosols; Bioparticulates; Endotoxins; Biofragments

Introduction

Bio-particulates or bioaerosols comprise of particulates of biological origin in size range of approximately 0.02 to 100 µm. It encompasses viruses, intact bacterial cells, protozoa and their cysts, fungal cells and plant pollen grains and spores. These agents are responsible for evoking responses like hypersensitivity, irritations and inflammation in addition to infectious diseases [1,2]. The exposure to the bioaerosols has been reported to cause severe outbreaks like severe acute respiratory syndrome (SARS) [3], the H1N1 flu [4] and Middle East respiratory syndrome (MERS) [5] etc. There has been a well-established study on relationship between exposure to bioaerosols and their health impacts [6,7]. Various government and private organisations have set standards and guidelines for bioaerosol limits (Table 1) [8]. Usually whole microorganism are responsible to cause infections, but allergic reactions can be caused by microbial fragments or by products [9] like endotoxins and β-(1-3)-D-glucans [10]; microbial VOCs [11] and mycotoxins [12]. Besides impact on health, these also serve as nuclei for cloud formation and atmospheric nuclei [13]. Organic acids present in the atmospheric cloud are utilised by certain bacterial cells to carry their metabolism [6]. There are a variety of factors responsible for differences in indoor as well as outdoor bioaerosol composition. For outdoor environments geographic location, meteorological parameters, population density and vegetation cover are main factors while for indoor environments the factors include dust resuspension, kitchen activities, plants internal air characteristics and air conditioning [14-16]. The dust events over continents carry large pulses of microbes and biogenic particles like endotoxins and pollens enlarging their biogeographical scope. It has been estimated that the mean concentration of bioaerosols in ambient air be 1×10^4 cells m−3 on land while it is two to three times more in magnitude over oceans [17]. The global average of bioaerosols in lower troposphere constitutes about 25% of the total mass of atmospheric aerosols [18]. Biomes like Amazon rainforests the bioaerosols constitute about 74% of the total aerosol mass concentration biomes with [19] with only fungal spores constituting 30 - 50% [20].

Materials and Methods

A mini review was carried on Google scholar, Research gate, NCBI and Pub-Med Databases using search words like “Bioaerosol”, “Aerobiology” and “Bio-particulates” etc. and relevant articles were surveyed and included in the study.

Microbial aerosols

Bacteria and fungi

Bacteria and fungi are abundant in atmosphere and reported to remain reproducible even after aerosolization [31]. These bio-particles have tendency for disease outbreaks and damage the crops [32] and affect the livestock. Bacteria are associated with everything and enter into the atmosphere from all surfaces [33] inhabiting in air for several days. Before removal these can be transported to large distances by wind [34,35]. Bacteria and fungi are present in both outdoor as well as indoor environments. In a study in subway systems in Barcelona, in addition to viruses, the commuters were exposed to a diverse genome of bacteria and fungi especially *Aspergillus fumigatus* [36]. *A. Fumigates* has the tendency to get ac-

Organization	Guideline	Remarks	Reference
American Conference of Governmental Industrial Hygienists (ACGIH)	<100 CFU/m^3	Low	[21]
	100 - 1000 CFU/m^3	Intermediate	
	>1000 CFU/m^3	High	
American Industrial Hygiene Association (AIHA)	There is no safe level of an uncontained pathogenic organism		[22]
Commission of the European Communities (CEC)	For houses		[23]
	<50 CFU/m^3	Very Low	
	<200 CFU/m^3	Low	
	<10^3 CFU/m^3	Intermediate	
	<10^4 CFU/m^3	High	
	>10^4 CFU/m^3	Very High	
Healthy Buildings International	<750 CFU/m^3	Total airborne bacteria and fungi is OK if species are not infective or allergenic	[24]
Indoor Air Quality Association (IAQ)	<300	Common fungi is OK	[25]
	<150	Mixed fungi other than pathogenic orexigenic is OK	
IAQ in office buildings: a technical guide	>50	One species should be investigated	[26]
	<150	If mixture of species is OK	
The Netherlands/research methods in biological indoor air pollution	>104	Total fungi is a threat to health	[27]
	>500	One species of potentially pathogenic nature is a threat to health	
Occupational Safety and Health Administration (OSHAA)	>1000	Indicates contamination	[28]
	>106 fungi/g of dust	Indicates contamination	
Environment Canada (EC)	Pathogenic and toxigenic fungi	Unacceptable in Indoor air	[29]
	>50 CFU	One species should be investigated	
	<150	OK If mixture of species	
	<500	OK if Cladosporium or other common phyllo-plane	
Ministry of environment (ME), Republic of Korea	<800	OK	[30]
CPCB/ MOEFCCC India	No standard set for Bioaerosols		

Table 1: Quantitative standards and guidelines for bioaerosols in air by governmental and private organizations (Kim., *et al.* 2018 with some modifications).

cumulated in the lungs evoking an immune response [37]. Concentration of aerosols usually vary with seasons. Fungi were found up to the concentration of 177 CFU/m^3 during winter [38] whereas during summer it increased to 357 CFU/m^3 in summer [39]. This variation may be due to the availability of optimum conditions for bioaerosols to multiply and survive in summers. Similar seasonal variation was observed by Thorne., *et al.* (1992) [40] while studying the bacterial bioerosol in waste water treatment facility. In addition to meteorological parameters the higher number of bacteria in air during summer is attributable to abundant vegetation cover providing sufficient dwelling place for bacteria [41,42]. In the indoor environment the concentration of bacteria in addition to outdoor concentrations depend on the number of inhabitants, their activities and insufficient ventilation [43].

Viruses

Viruses are the particles that multiply when present in a living tissue or cell. Although they are present in non living environment these may pose a public health threat because of unstable genetic composition mutating to unexpected virulent forms. Unlike bacteria and fungi, viruses need a host to replicate as well as show an impact. There have been sparse evidences relating the presence of viruses in aerosols. Studies carried on the outbreak of viral events like MERS in 2012 took place due to transmission of infectious aerosolized particles via airborne route of exposure primarily over close contact [44]. The rate under hospital set ups have been reported to be 1.1 - 10% [45,46]. Same may be attributed to the previous SARS-CoV outbreak and recent 2019 nCoV outbreak in Wu-

han China which became a global medical emergency within short period of time leaving more than 3000 dead worldwide [47]. The viruses may spread through fomite contacts as well, but studies reveal that the fomite exposures were not significant in outbreak of coronaviruses [48]. The symptoms to exposure of viruses depend on the type of virus that enters the body. But the entry of viruses through airborne route targets the respiratory tract as the first target. For example the coronavirus infections are characterised by Sore throat, Nausea, diarrhoea, shortness of breath and pneumonia and death [49]. The study of presence and transmission through airborne route need more studies to be carried.

Endotoxins

Endotoxins are the lipopolysaccharides present as a vital structural component of membranes of gram negative bacteria [50]. Airborne endotoxins are significantly associated with fine particulate matter [51]. Fine and ultra fine particulate matter is not only a dust particle but a mixture of elements of crustal origin, metals, PAHs and biologically active endotoxins that are easily deposited in the alveoli and small airways [52]. In combination with other airborne agents like bacteria, fungi and viruses, endotoxins increase the severity of immune response leading to adverse health effects [53]. However, only a few studies have reported the airborne concentration of endotoxins [54] especially regarding continuous observations [51]. Exposure to endotoxins prompt and aggravate wheezing in children as well as adults [54], impaired lung function [56] COPD [57], acute inflamatory response with increase in blood cytokine levels like neutrophils, interleukin-6 etc [58,59].

Discussion and Conclusions

Bioparticulates or bioaerosols are associated with the particulate matter as bacteria, fungi, viruses, spores and their biofragments like endotoxins. These constitute the biological component of the atmosphere and pose serious health problems on inhalation having an immediate impact on respiratory system. Exposure to these components may cause serious illnesses like COPD, Bronchites and may even sometimes result in serious outbreaks especially, in case of viruses. Although research is going on their presence in aerosolised form, extensive studies are required to be carried to understand their role in climate change and impact on biosphere as a whole.

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