



Bioaerosols and the healthy air concept

Introduction

Healthy lives are lived in a healthy environment. Healthy air is a key part of a healthy environment. While various clean air initiatives have raised awareness of the harms of poor air quality and air pollutants, relationships between the biological components of air (bioaerosols) and our health are neither well communicated nor widely recognised.

We want to encourage a new way of thinking about air quality, evolving from clean air to healthy air. The healthy air concept aims to recognise the ever-present nature of bioaerosols and consider both the potential benefits or harms bioaerosols may have on our health.

What is a bioaerosol?

There is no single accepted definition of a bioaerosol, but we normally use the term to mean a suspension of solid particles of biological origin in air. Bioaerosols include a mixture of different microbes such as bacteria, fungi and viruses, and particles originating from plants and animals like pollen or microscopic fragments of house dust mite, animal dander (skin/fur/feathers), human skin or soil (these microscopic fragments are commonly referred to as dust).

Where do bioaerosols come from?

Any living thing, or substance derived from living things, can be a source of bioaerosols. Bioaerosols are formed when biological matter is disturbed in a way that causes tiny particles to become airborne. This could happen when wind blows over flowers, when a bird flaps its wings, when a farmer ploughs the soil, when we sneeze, when we mill wheat to make flour, or when the warm air rises through a compost heap. There are countless examples, some natural and some resulting from human activity.

As anything biological can be a source, and any disturbance can cause these tiny particles to become airborne, it is not hard to understand why bioaerosols are everywhere. This is true anywhere in the world, outdoors and indoors. The amount and types of bioaerosols depends on the local environment and changes with time.

How can bioaerosols impact our health?

We have evolved to live alongside bioaerosols. Every human body is host to billions of microbes - in our intestines, on our skin, and in our respiratory system (i.e. our mouth, nose, throat, and lungs). They become part of us from our first breath, forming communities that change with us throughout our lives depending on our environment and the microbes we encounter everyday.

This co-existence can be beneficial to health. “Friendly” microbes can provide physical barriers against infection with harmful microbes, aid the breakdown of food and drugs into their beneficial products and remove environmental chemicals, and/or help produce key vitamins, minerals, and compounds with anti-inflammatory and anti-cancer properties. Current research suggests that



contact with a wide range of different microbes promotes good health, especially during the first few years of life to help the normal development of our immune system. Studies have shown that the immune system of animals living within sterile environments does not develop normally. Growing up in clean air, free from any bioaerosols, as well as being impossible to achieve, is unlikely to be good for our health.

While the idea of “friendly” bioaerosols is relatively new, there is widespread public knowledge and understanding that air also contains harmful “bugs” that are bad for our health. We generally accept that certain airborne diseases such as the common cold (spread by bioaerosols containing viruses) are an everyday hazard that is hard to avoid. The Covid pandemic created universal public awareness of the potentially fatal consequences of infectious airborne diseases. There is also increasing understanding of the negative health impacts of breathing in bioaerosols such as plant pollen or mould from damp indoor environments. These health impacts include allergic and inflammatory reactions, which may be relatively mild for some (e.g. hay fever, wheeze, cough) but of serious risk to health and life in susceptible individuals (e.g. asthma and hypersensitivity pneumonitis).

What is healthy air?

It may never be possible to precisely define healthy and unhealthy air, we certainly can't do it with our current knowledge. This is due to there being so many different types of bioaerosols that may have positive, negative or no effect(s) on health depending upon the circumstances of contact, and humans having very different susceptibilities to disease (e.g. due to age, ethnicity, nutrition, pre-existing medical conditions etc). So, while we should be very careful with generalisations, we argue that we should work towards a way of thinking and talking about the biology of healthy air that recognises the ever presence of bioaerosols and the fact that we have evolved to co-exist with the bioaerosols we encounter in our everyday lives.

An exciting future prospect of an improved understanding of unhealthy vs healthy air is the ability to engineer our air to minimise harms and promote benefits to health. For example, reducing harmful emissions generated through human activity (such as waste treatment facilities and intensive farms) and boosting exposure to beneficial bioaerosols through better design of our homes, gardens, and parks.

Conclusions

The idea of “clean” air does not fit with the ever-present nature of bioaerosols. Current research supports the concept that both outdoor and indoor air contain many different types of bioaerosols that can both benefit and harm our health. Based on this existing knowledge, we propose that healthy air comprises a wide diversity of bioaerosols, while unhealthy air contains fewer types of bioaerosols in usually high concentrations. Tackling unhealthy air involves reducing the chances of breathing in harmful amounts of (specific) bioaerosols. The characteristics of biological healthy air are not the same for everyone, as we are all biologically different. We all have unique immunity and sensitivity to bioaerosols. Therefore, breathing biologically healthy air is not risk-free, nor is it a hazard to all, which means it is not possible to remove risk



completely for everyone. The creation and management of healthy outdoor and indoor air requires an improved understanding of biologically healthy air, broad societal buy-in as to what is an acceptable risk, and empowerment of individuals to improve their own air quality by making healthy living choices based on their own specific requirements.

Healthy air is just one component of a healthy environment, which requires consideration of all our air, land and water environments and how they interact with each other and us. As our knowledge of our complete environment increases, it will become possible to create healthier natural and semi-natural spaces for the benefit of all.

NOTES TO READERS

The UKRI BioAirNet network has authored this document with the objective of shaping perspectives on bioaerosols within the context of air quality. It is important to note that this document is an evolving work in progress and not a final product. Therefore, it should be interpreted within its full context and not viewed in isolation.