Pollen and Spores as Bioaerosols

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1 Birch Pollen, 2 Fungal Spore

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Spores and Pollen – major players in bioaerosol composition

Volatile biological particles do affect atmospheric chemistry and physics and this way contribute to global climate building. Furthermore the so called **bioaerosols** influence human, animal and plant health as well as ecological processes in the biosphere (Després et al., 2007). Within the pool of biological particles of different origins, spores and pollen typically contribute to the coarse size fraction with diameters up to a hundred microns (Elbert et al., 2007).

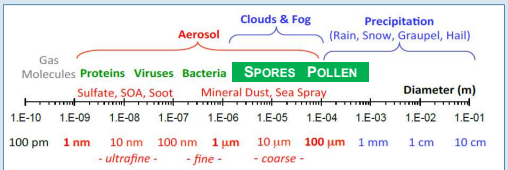


Figure 1: Typical size range of aerosols and bioaerosols in specific, showing spores and pollen to be mainly part of the coarse mode fraction (adapted from Pöschl and Shirawa, 2015).

	Number concentration [m^{-3} air]	Mass concentration [$\mu g\ m^{-3}$]	Size range	References
Bacteria	~ 10^4	~ 0.1	PM_{10}	Bauer et al. (2002a); Burrows et al. (2009a)
Plant debris (free cellulose)		~ 0.1–1	PM_{10}	Sánchez-Ochoa et al. (2007)
Viral particles	~ 10^4	~ 10^{-1}		This work, Sect. 2.4
Fungal spores	~ 10^3–10^4	~ 0.1–1	TSP	Elbert et al. (2007); Fröhlich-Nowoisky et al. (2009)
Fungal hyphal fragments	~ 10^3			Pady and Gregory (1963)
Pollen	~ 10 (up to ~ 10^3)	~ 1	TSP	Sofiev et al. (2006); Fröhlich-Nowoisky et al. (2009)
Algae	~ 100 (up to ~ 10^3)	~ 10^{-1}		Reisser (2002)
Fern spores	~ 10 (up to ~ 10^3)	~ 1	TSP	Mücke and Lemmen (2008)

Table 1: Characteristic magnitudes of the number and mass concentrations of bioaerosols in air over vegetated regions (Després et al., 2012).

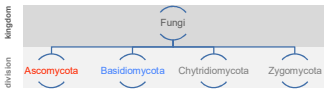
Despite many distinctions in morphology, origin and further properties the aerial dispersal of spores and pollen answers the same purpose: they serve as dispersal units of organisms. Depending on their aerodynamic behavior and wind conditions bioaerosols can be transported over land and oceans for long distances and high altitudes (e.g. Prospero et al., 2005; Jones and Harrison, 2004). In the course of this, it should be considered that bigger particles, like spores and pollen, are more likely to be affected by dry deposition due to their weight.

Spores – reproductive cells or cells at duration stadia

Figure 2: A) Compound of different fungal spores B) Fern spore C) Fungal spore (adapted from Graham et al., 2001).

Spores can be built as sexual and asexual reproductive entities as well as duration stadia to endure harsh environments (Elbert et al., 2007; Purves et al., 2011). Beneath fungal organisms some plants such as ferns and mosses are able to produce and release spores. As a rule they are larger and less frequent than fungal spores (Graham et al.,2003; Elbert et al.; 2007).

Fungal spores do account for one of the most abundant bioaerosol classes.
45% of the **coarse mode fraction** in pristine tropical rainforest air are composed of **fungal spores** (Elbert et al., 2007)



The majority of fungal spores which were detected in environmental air samples belong to the divisions Ascomycota and Basidiomycota (e.g. Hasnain et al., 2005). Spores can be released passively or by an active process like osmotic pressure 'canons' (Pringle et al., 2005).

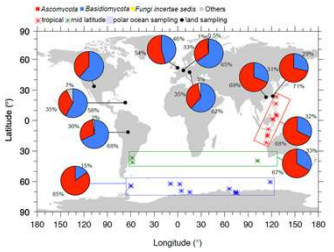


Figure 3: Distribution of different classes of fungal spores over the globe (adapted from Fröhlich-Nowoisky et al.,2012).

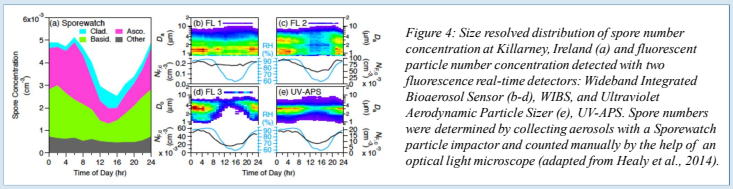


Figure 4: Size resolved distribution of spore number concentration at Killarney, Ireland (a) and fluorescent particle number concentration detected with two fluorescence real-time detectors: Wideband Integrated Bioaerosol Sensor (b-d), WIBS, and Ultraviolet Aerodynamic Particle Sizer (e), UV-APS. Spore numbers were determined by collecting aerosols with a Sporewatch particle impactor and counted manually by the help of an optical light microscope (adapted from Healy et al., 2014).

Pollen – male reproductive units of plants

With a diameter of 10-100 µm Pollen grains are amongst the biggest bioaerosol particles. They are produced and released from plants and do contain the male gamete (Després et al., 2012). According the high diversity within the plant's kingdom, pollen show various shapes, surface structures and other properties. Mostly they are enveloped in a robust shell, which is supposed to protect the gamete from environmental stress (Després et al., 2012). Especially during rain pollen grains tend to burst. Therefore, not only intact pollen can be detected in bioaerosol collections but also pollen fragments (Taylor et al., 2002, 2004).

Figure 5: Overlay image of a birch pollen recorded in brightfield and fluorescence mode (λ_{ex} = 470/40 nm and 560/20 nm).

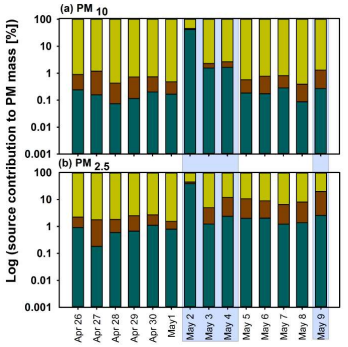
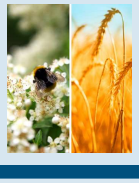


Figure 6.: Particular mass fraction of pollen, fungal spores and others apportioned by using EPA-CMB model (version 8.2) during spring 2013 (Rathnayake et al., 2016). Sucrose, glucose, fructose, and mannitol were used as fitting species to determine the bioaerosol mass.



Pollen concentration change according to the **seasonal flowering cycles** of the plant sources.

Since they can be up-drafted to high altitudes and have long residence times, they still may act as ice nuclei.

Spores and Pollen and their effects as bioaerosols

climate

Influence on climate processes:
- light scattering
- Light absorption
- Bioaerosols acting as cloud condensation nuclei – leading to cloud & precipitation formation (for references see Després et al., 2012)

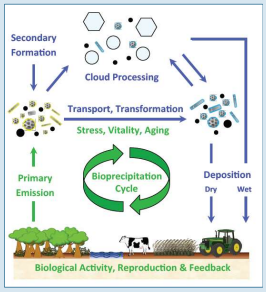


Figure 7: Cycling and effects of bioaerosols in the earth's system (adapted from Pöschl and Shirawa, 2015)

human & animal health

Pollen as well as spores cause a broad variety of diseases, especially allergies, asthma and fungal infections. These diseases can be distributed by bioaerosols across long distances.

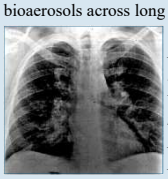


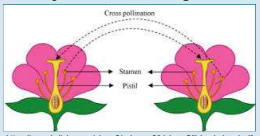
Figure 8: Farmer's lung showing widespread fungal mycelium (source: Bioaerosol lecture, Eckhard Thines)

agriculture/ plant health

Figure 9: Botrytis cinera infection on grapes. The mold fungus is distributed via aerborne spores. Depending on the point of time of infection it can cause severe harvest losses.

ecology

Pollen and spores are reproductive units. Their ability to be airborne enabled the distribution of certain organisms and species all over the globe.



https://www.kullabs.com/class-8/science-8/biology-2/living-beings/pollination-and-fertilization-in-plants

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