Primary Biological Atmospheric Aerosols

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"Quantitative PCR and microscopy revealed that viable bacterial cells represented on average around 20% of the total particles in the 0.25 to 1 µm diameter range … suggesting that bacteria represent an important and underestimated fraction of micrometer-sized atmospheric aerosols". (DeLeon-Rodriguez, *et al*, 2013) Even if that statement covers only a certain situation and a certain part of the troposphere, it clearly shows that primary biological aerosol particles are a major fraction of the atmospheric aerosol.

While most primary particles of the atmospheric aerosol (maritime, mineral, etc) have sources limited to certain regions of the world, like the oceans, the deserts, etc, the primary biological aerosol particles (PBAP) are produced from all available surfaces of the world. The continental biosphere (leaves, animals, dead subjects) is a source for primary biological particles. Since the oceans are full of biological (dead and alive) material, each ejected sea spray particle contains biological material. Rock varnish may contain considerable amounts of organic material which sometimes may be responsible for the gel-like or lacquer-like appearance of the surface. The grey or black films may sometimes consist predominantly of dry cyanobacteria.

Partition	Global emissions (Tg yr^{-1})	Size range	References
PBAP	<10 (dominated by plant debris and fungal spores)	diameter: 4 µm for fungal spores; diameter not specified for plant debris	Winiwarter *et al* (2009)[1]
Biogenic	56 (0-90)	diameter <1 µm	IPCC (2001)[1]
PBAP	78 (includes only bacteria, fungal spores and pollen)	PM_{30}	Hoose *et al* (2010a)[1]
PBAP	186	split equally into the two coarse size fractions: 2.5-5 and 5-10 µm (PM_{10})	Mahowald *et al* (2008)[1]
PBAP	296 (includes only bacteria, fungal spores and pollen)	diameters as above	Jacobson and Streets, (2009)[1]
PBAP	~1000 (includes cellular fragments)	Total	Jaenicke (2005)[1]
Sea Spray	3340	Total	Penner et al (2001)
Mineral (Soil) Dust	2150	Total	Penner et al (2001)
Biomass Burning	54	0-2 µm	Penner et al (2001)

[1] Després et al (2012)

Rocks outside of deserts often are also covered by a varnish. Parts of biological soil crusts can also be ablated from desert surfaces and all these particles may contribute to the content of biological material in dust transported over long distances during storms (Despres et al 2012). In addition recent studies in Japan suggest that numerous culturable bacteria are transported with Asian dust over the East China Sea from the arid and semi-arid regions of Asia.

In the last years much research effort had been directed to the role of biological particles as ice nuclei and in forming clouds and rain. It is well known, that biological material acts much earlier (in term of freezing) then mineral (inorganic) material. So the cryosphere (deposited precipitation) is full of biological material. Resuspension of ice crystals then might add to the primary biological atmospheric aerosols.

Atmospheric biological particles have also an impact on hygiene and could cause adverse respiratory effects on humans.

The Table gives an impression about the source strength estimates published so far on global sources of primary biological particles. The other sources Sea Spray, Mineral Dust, Biomass Burning are given for comparison. That Table shows clearly, what an important fraction of the Atmospheric Aerosol the Primary Biological Particles are.

Selected references so far:

DeLeon-Rodriguez, N. *et al*. (2013) Microbiome of the upper troposphere: Species composition and prevalence, effects of tropical storms, and atmospheric implications. Proceedings of the National Academy of Sciences. www.pnas.org/cgi/doi/10.1073/pnas.1212089110

Després, V.R. *et al* (2012) Primary Biological Aerosol Particles in the Atmosphere: A Review. Tellus B, **64**, 015598, DOI: 10.3402/tellusb.v64i0.15598

Penner, J. E. *et al* (2001) Aerosols, their direct and indirect effects. In: *The scientific basis. Contribution of working group I to the third assessment report of the intergovernmental panel on climate change* (eds. Houghton, J. T., Y. Ding, D. J. Griggs, M. Noguer, P. J. van der Linden *et al).*, Cambridge, UK and New York, NY, USA, 289-348.