Bioaerosol sampling and collection techniques

Alexandra Tamm and Nina Ruckteschler
Max Planck Institute for Chemistry, Mainz/Germany
Bioaerosol class retreat in Bad Münster am Stein, Ebernburg, 12/13 Sep. 2016

Gutenberg Lehrkolleg

MAX-PLANCK-INSTITUT FÜR CHEMIE

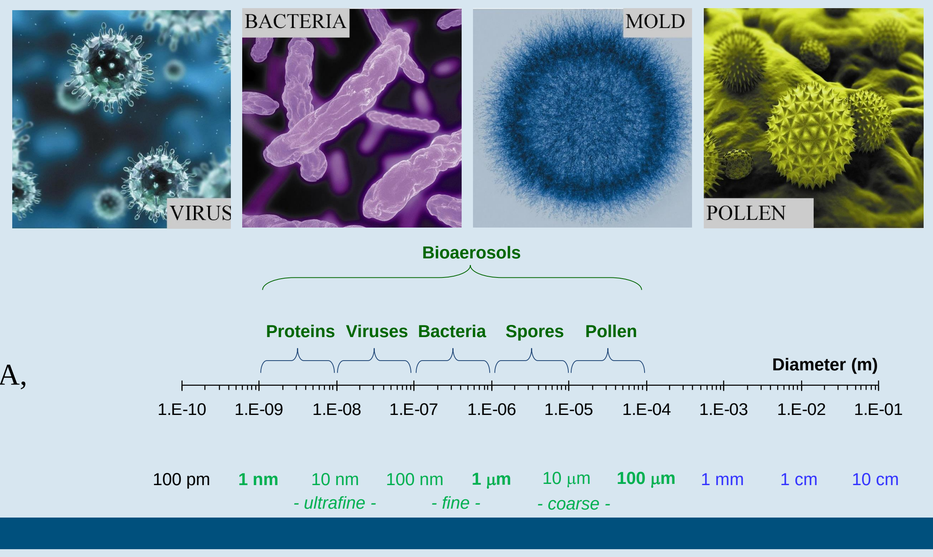
MAX-PLANCK-GESELLSCHAFT

1. What are bioaerosols?

Bioaerosols (*biological aerosols*) are suspensions of airborne particles that contain or were released from living organisms.

Bioaerosols comprise pathogenic and non-pathogenic, living (mostly infectious?) **and dead** (mostly climate relevant?) **material such as:**

- viruses
- bacteria
- fungi, oomycetes
- algae
- cyanobacteria
- archaea
- lichens
- bryophytes
- vascular plants
- pollen and spores
- cell fractions, DNA, proteins, debris, excrements



2. Relevance of bioaerosol sampling

We inhale 10 m³ of air per day and in each m³ air are approx. **1000 cultivable microorganisms**.

Bioaerosols have influence on:

- health (especially respiratory tract and skin)
- agriculture and forestry
- precipitation: cloud condensation nuclei or ice nuclei → interaction with radiation→ effect on climate

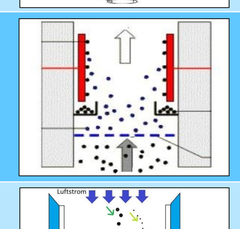
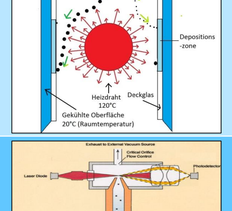
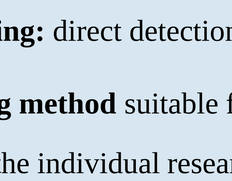
Sampling is influenced by:

- ➢ *particle aerodynamic diameter*
- ➢ *wind velocity*
- ➢ *direction*
- ➢ *inlet characteristic*
- ➢ *sampling time*
- ➢ *mechanical stress*
- ➢ *desiccation*

Keep in mind:

- various sampling techniques differ in detectable particle size range
- often pre-separator/pre filter are necessary
- What is the available budget for the sampling?

3. Methods

Pro	Technique		Contra
• economically feasible • direct collection of microorganisms	**Impaction** • air is forced to change direction → larger particles hit the surface, smaller particles follow the airstream • collection on different kinds of substrate (e. g. glass slide, agar plate, filter, gelatine) • impactor types: virtual, slit and cascade		• quantification: culture based • overloading of culture plate→ overlap of colonies • bounce off particles → transport in the next impaction stage • effect of wind speed • desiccation → low recovery efficiency
• liquid collection medium: reduction of overloading and desiccation stress of microorganism	**Impingement** • airstream is led into a liquid collection medium → microorganisms are collected by immersion		• quantification: post collection processes • evaporation of liquid medium → miscalculation of quantification • not compatible with size fractionation • no size fractionation
• economically feasible • potential for size fractionation • portable	**Filtration** • airstream is forced to go through different filters types of different materials (e. g. cellulose, glass, quartz, plastic) • filter types: fiber (A), membrane (B), porous foam (C), capillary pore (D)		• quantification: post collection processes • overloading of culture plate → overlap of colonies • desiccation → low recovery efficiency • effect of wind speed
• good collection efficiency → reduced particle bounce • low pressure drop (higher flow rates)	**Cyclone** • swirling air and centrifugal force is used to capture microorganisms into a liquid		• evaporation of liquid medium → miscalculation of quantification
• good recovery efficiency → reduced stress on microorganisms • quantification possible • no vacuum pump needed	**Electrostatic precipitation** • particles are charged at the inlet an exposed to an electrical field inside the sampler → particle migration over charged plate		• viability of bacteria is effected by electric charge • few study on this technique → less data for comparison
• good collection efficiency for smaller particles • determination of particle size distribution • air flows freely through the sampler → small pressure drop	**Thermal precipitation** • hot and cold surface → along a temperature gradient particles move to the cooler surface and will be collected (thermophoretic motion)		• low collection rate • small collection area • high temperature → effect on viability of the microorganisms
• ultrafine bioaerosol particles can also be sampled and detected easily • very low detection limit	**Condensation technique** • airstream is forced to go through a saturator → evaporated liquid condenses on particles → spectroscopical detection		• complex system → expertise required • high temperature → effect on viability of the microorganisms
• economically feasible • no vacuum pump needed	**Gravity** • agar plate/SEM plate → microorganisms from air settle on a plate		• not accepted by official guidelines • relies on air currents • weakly correlated with counts of quantitative methods (primary larger particle settle down, smaller stay in air longer)

4. Artefacts

Definition: Physical, physicochemical and chemical changes / sources of errors, which cause a change of composition.

Positive artefacts: Filter material with a high surface activity can adsorb gas phase components (especially quartz fiber filters!).

Negative artefacts: Evaporation of aerosol particles due to pressure and temperature changes.

Chemical artefacts: Changes in composition through reactions, e.g. with oxidants.

5. Conclusion

Offline sampling: collection of aerosols
→ opportunity for cultivation and identification and often also for quantification

Online sampling: direct detection of number and size of particles.

THE sampling method suitable for collection of different types of bioaerosol **does not exist!**

It depends on the individual research question which sampling methods will be the best.

In most cases: **Combination of** different (bio)aerosol **detectors**/collectors.

References:
Ghosh, Lal, and Srivastava 2015, Review of bioaerosols in indoor environment with special reference tosampling, analysis and control mechanisms, Environment International 85, pp. 254–272
Haig, Mackay, Walker, Williams, 2016, Bioaerosol sampling: sampling mechanisms, bioefficiency and field studies, Journal of Hospital Infection 93, pp. 242 – 255

Pictures of box 1: http://www.secondwindairpurifier.com/usercontent/images/BIOAEROSOLS%20COLLAGE.jpg
Pictures of box 3: http://www.merckmillipore.com/
http://www.bbc.co.uk/staticarchive/29aad063f307bfada03bbf212d584b846eb620a9.gif
http://aerosol.ees.ufl.edu/Thermophoresis/section03.html; http://images.slideplayer.com/18/5697374/slides/slide_68.jpg