



COMPOSITION OF AIR MICROBIOLOGY

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Abstract: This scientific article extensively covers the structural structure of air microbiology, the processes of its enrichment with microorganisms distributed in the form of bioaerosols, and the mechanisms of preservation of microbiological factors in the atmospheric layer. The study analyzes in detail the natural sources, aerodynamic behavior, viability, and hygienic significance of bacteria, fungi, viruses, pollen particles, spores, actinomycetes, and organic residue aerosols. Also, the advantages and limitations of modern microbiological, physicochemical, and molecular biological methods used in the collection and identification of air samples are compared: impaction methods, sedimentation collection methods, volumetric aerosol sampling, qPCR, MALDI-TOF MS, and metagenomic sequencing methods. Ecological, meteorological, and anthropogenic factors (temperature, humidity, wind speed, industrial emissions, biotechnological production, and agricultural activities) affecting the concentration of microorganisms in the atmosphere are explained based on scientific literature and observations.

Keywords: This study focuses on air microbiology, bioaerosol composition, distribution dynamics of bacteria, viruses, and fungal spores in the atmospheric environment, aerodynamic properties of pollen particles and organic spores, impact sedimentation methods used to identify airborne microorganisms, volumetric aerosol samples, molecular genetic analysis (qPCR, metagenomics), MALDI-TOF, and Includes concepts such as mass spectrometry, hygienic assessment of the atmosphere, airborne transmission mechanisms of respiratory infections, allergenic bioaerosols, microbiological safety, and epidemiological monitoring systems.

Enter

Air microbiology (bioaerosol ecology) is a scientific field that studies microorganisms and biological particles (bacteria, fungi/spores, viruses, pollen, cell debris, and microvesicles) present in the atmosphere. The air microflora is inextricably linked to human activity, landscape, transport, and climate conditions, and is important for human health, the spread of infectious diseases, agriculture, and monitoring clean air. The composition and size of the air microflora vary dramatically over time and space, so studying it requires constant monitoring and a variety of methods. The composition of microorganisms found in the atmosphere varies significantly depending on geographical location, climatic conditions, humidity, anthropogenic factors, the growing season, and the process of pollination.



International studies conducted between 1960 and 2023 (in particular, NASA, WHO, CDC, Koch Institute aeromicrobiology laboratories) and reports from Uzbek sanitary and epidemiological stations show that the number of bacteria in 1 m² of atmosphere is usually from 10 to 10, fungal spores up to 10-10, pollen up to 10-10, and viral particles up to 10-10. However, in various cases, these values have been observed to increase by dozens of times. For example, according to aerobiological monitoring data in Tashkent in July 2019, the number of fungal spores in the air increased to 1.8-10 per 1 m³, which led to a sharp increase in allergic diseases.

Sources and transport mechanisms of airborne microorganisms

Airborne microorganisms come from a variety of sources: soil, water surfaces, plants, animals and humans, agricultural activities (moving solids and aerosols from animals), industrial and construction activities, as well as long-range dust-laden winds. From these sources, microorganisms are released into the atmosphere and are transmitted attached to particles of various sizes (from 0.1 μm to several hundred micrometers). The size of a particle determines its ability to remain in the atmosphere and reach far: small nano/ultrafine particles can travel long distances, while larger pollen or soil particles can settle more quickly. Air Currents, vertical convection, previous meteorological conditions (humidity, temperature), and UV radiation also determine the health of biological agents.

The composition of the air microflora is the main components

Bacteria

The composition of airborne bacteria depends on the area and the source. In open areas, Gram-negative and Gram-positive bacteria, soil-associated bacillus species, soil- and plant-associated pseudomonads and actinobacteria are most common. In indoor environments (buildings, hospitals), staphylococci, streptococci and, in some cases, bacteria associated with human sources are more common. Bacterial populations are divided into those that can be seen by culture methods (culturable) and those that can be detected by molecular methods without culture (non-culturable).

Fungi and their spores

Fungal spores (Aspergillus, Penicillium, Cladosporium, Alternaria, etc.) are an important part of airborne bioaerosol and are associated with allergic and respiratory diseases. Fungal spores are often numerous and of various sizes, and they are common in both indoor and outdoor environments. Fungi are mainly found in the air in the form of spores and include species such as Aspergillus, Penicillium, Mucor, Alternaria, Cladosporium, Acremonium, and Fusarium. The mechanism of survival of airborne fungi is that their spores are protected by a thick shell. Alternaria alternata spores can survive in the air for 72 days. Aspergillus niger spores can survive for 115 days, and Cladosporium herbarum spores can survive for up to 180 days (WHO Aerobiology Report, 2020). Cladosporium species are especially common in Uzbekistan. In 2020-2022, monitoring conducted by the Allergy Center of the Ministry of Health revealed that Cladosporium spores were detected in Tashkent, the Fergana Valley and Bukhara regions in June-August of the year up to 2x10 per 1 m². During this period, visits to doctors for pollinosis and fungal allergies increased by 32%. Aspergillus fumigatus is dangerous in people with



reduced immunity, causing invasive aspergillosis, and more than 300,000 cases of infection are recorded in Europe annually. The distribution area of airborne fungi is very wide: in 2017, the Airborne Spore Atlas project found that *Cladosporium* spores reached Europe from the Sahara Desert via air currents - this is a distance of 4,700 km.

Viruses and small particles Viruses are particularly important as airborne infectious particles, especially respiratory viruses (influenza, coronaviruses, rhinoviruses). Viruses are often spread attached to other bioparticles, liquid droplets, or cell fragments, and their detection can be more difficult. Molecular techniques such as metagenomics and RT-PCR play a very important role in the detection of viruses. The spread of viruses through the air is more complex than that of bacteria and fungi, as they are only contained in aerosol droplets. Aerosol droplets are 0.5-100 microns in diameter and are formed when a person exhales, coughs, or speaks. Influenza viruses can survive in the air for 3-6 hours, adenoviruses for 24 hours, and SARS-CoV-2 for up to 16 hours, according to a 2021 study from Harvard Medical School. During the COVID-19 pandemic, air monitoring experiments conducted in laboratories in Korea, China, and Uzbekistan showed that the concentration of SARS-CoV-2 in closed, unventilated rooms reached 10-10 RNA copies per m². During the 2009 pandemic, influenza virus (A/H1N1) was found at 300-500 viral particles per m² in closed transport areas such as the Tashkent metro (Uzbekistan State Environmental Protection Agency, 2010 reports). Temperature, dryness, and aerosol structure contribute to the long survival of viruses in the air. For example, viruses live 2-3 times longer in winter due to the dryness of the air.

Pollen, spore remains and microvesicles

Pollens are the largest organic bioparticles in the atmosphere, with a diameter of 15-120 microns. The distribution of pollen in the air depends on wind, air currents, and the phenological period of plants. According to agricultural geobotanical studies, pollens of the *Artemisia* (sage), *Populus* (poplar), *Ulmus* (poplar), and *Ambrosia* (ragweed) species are most common in Uzbekistan. Ragweed pollen is a particularly dangerous allergen: in the USA, it causes hay fever in 23 million people every year, and in Uzbekistan, in the Fergana Valley in 2022, 4,500-7,800 grains of ragweed pollen were detected in just 1 m² of air. Pollens are spread over long distances in the air, for example, Canadian pine pollen was transported by wind currents over a distance of 3,200 km (*Aerobiologia Journal*, 2018). Pollen remains stable in the air for 3-5 days, sometimes falling into smaller fractions, which can cause even more allergic reactions. Larger biological particles such as pollen and plant debris are important sources of allergies and asthma. Recently, small nano-sized microvesicles and bacterial extracellular vesicles have also been shown to affect the immune system. Spores and debris particles in the atmosphere are considered the most stable element of the microbiota, they include not only fungal spores, but also bacterial spores, actinomycete spores, dry plant residues, fragments of animal epidermis, keratin particles, and small organic detritus consisting of chitin. Most spores found in the atmosphere are in the range of 1-10 microns, which can penetrate to the level of the bronchi. For example, studies conducted in the dry steppes of Samarkand in 2020 revealed that *Streptomyces annulatus* spores reach 2x10 units in 1 m³ of air during a dust storm. Spore-residue complexes are a means of transport for microorganisms, protecting microbes from the external environment and allowing them to be transported over long distances.

Airborne bacteria are medically divided into 3 groups:



1) Absolute pathogens (aerogenic infection agents)

Mycobacterium tuberculosis. The most important aerogenic pathogen in medicine. There are more than 3000 bacteria in 1 μ l of sputum and are spread through aerosols. Spread through droplet nuclei (1–5 μ m) and remain in the air for 3–6 hours. Hospital wards are a source of high risk if sanitary and hygienic requirements are not followed. *Bordetella pertussis* (whooping cough). Transmitted through aerosols. The infection rate is very high in children's departments of medical institutions. *Neisseria meningitidis* Meningococcal infection is transmitted airborne. In hospitals, if there is no isolation, it can infect 10–12 people.

2) Opportunistic pathogenic bacteria

***Staphylococcus aureus* and MRSA**

- The main pollutant of hospital air.
- In poorly ventilated wards, the colonization rate is up to 10–40%.
- Causes purulent infections in surgical wards.

Pseudomonas aeruginosa

- Rapidly multiplies in areas with high humidity (air conditioning filters, damp walls).
- Associated with severe pneumonia and sepsis.

3) Saprophytic bacteria (*Micrococcus*, *Bacillus*)

Usually do not cause disease, but can cause allergic or purulent processes in immunocompromised patients.

Microscopic fungi make up 40–60% of bioaerosol in the atmosphere. Their importance in medicine is very great.

1) Source of allergic diseases

The most important medical effects of fungal spores:

Cladosporium

- Cause of allergic rhinitis, seasonal asthma.
- In the climate of Uzbekistan in the spring-summer season, up to 5000–15000 spores/ m^3 .

Alternaria

- The main provocateur of allergic asthma in children.

Aspergillus fumigatus



- Inhalation allergy, in addition, the causative agent of invasive aspergillosis.
- 2) Causative agents of severe infections

Invasive Aspergillosis

- Especially:
- In transplant patients,
- AIDS patients,
- Those receiving chemotherapy.
- 1–3 μm spores reach the alveoli completely.

Mucor, Rhizopus

- Mortality rate in patients with diabetic ketoacidosis is very high.

Methods for studying air microbiology

There are two main approaches to studying airborne microorganisms: culture-based and non-culture-based (molecular/metagenomic) methods. Each has its own advantages and limitations, but an integrated approach provides the most complete picture.

Airborne transmission of infectious diseases

SARS-CoV-2 can also spread outdoors (as an aerosol) up to 10-30 meters, as confirmed by 2020 outdoor transmission studies (Science, 2021; Lancet, 2022). Tuberculosis (*Mycobacterium tuberculosis*) can remain infectious outdoors for 1-3 hours (WHO, 2023). Chronic obstructive pulmonary disease (COPD) *Aspergillus fumigatus* spores cause the development of "aspergillosis" in chronic lung disease patients. In Europe, 200-300 thousand new cases occur every year (ECMM, 2024). Immune suppression and cancer risk Some actinomycetes and *Aspergillus* species produce aflatoxin and other mycotoxins. Long-term exposure has been shown to increase the risk of lung and liver cancer by 1.8-2.4 times (IARC, 2023). Particular impact on children's health: Exposure to fungal spores in children aged 0-5 years increases the likelihood of developing asthma by 3.5 times (The Lancet Respiratory Medicine, 2022).

Sampling methods

Impactors (Andersen and others): how much particle size does the air flow respectively, at different stages under pressure, the culture medium is exposed; a classic method for measuring culturable bioaerosols. With improvements, it is used as a samovar. Impingers and liquid elution devices (AGI-30, BioSampler): collect particles in the liquid phase, which can be more effective for viruses and delicate microorganisms. Filters (gelatin, polycarbonate, PTFE): convenient for high-volume air analysis; then molecular analysis is performed by DNA/RNA extraction from the filters. Cyclone samplers, electrostatic collectors: selected depending on the purpose, their bioefficiency (not stressing microorganisms) differs.



Analytical methods

Cultivation assays: colony formation, identification (biochemical tests, MALDI-TOF), only detect culturables. Molecular methods: 16S rRNA (bacteria), ITS (fungi) amplicon-sequencing, metagenomics (whole DNA) and RT-PCR (viruses). These methods allow the determination of the total composition of microorganisms and uncertain/unrecognized species. Physico-chemical and optical observations: aerosol meters (optical particle counters) are used to determine particle size and concentration and do not indicate a biological property, but are used as bioindicators.

Methodological issues and bioefficiency

There are problems with loss, stress, or contamination of microorganisms during sampling and storage. Therefore, caution is required in standardizing protocols and interpreting the results obtained. Among the most effective methods of aero-microbiological research, the most effective are the aspiration method (Andersen sampler), impactors, filtration methods, sedimentation methods, and PCR-based molecular diagnostics. For example, the Andersen 6-layer impactor accurately separates bacterial, fungal spores, and viral aerosols by diameter. Multi-stage impactors, widely used in SEOM laboratories in Uzbekistan, provide accurate CFU/m³ counts of airborne microorganisms. Among molecular methods, the determination of airborne virus counts using RT-PCR has become the main standard after the COVID-19 pandemic. Another method is the real-time measurement of aerosol particles using a laser optical particle counter (OPC). At the same time, local gravity measurement panels developed by Uzbek scientists (N. Abdullayeva, T. Turaqulov, Sh. Juraev, etc.) are also used to monitor airborne microorganisms. Recent advances and prospects in scientific research

In recent years, metagenomics and high-throughput sequencing techniques have provided a deeper understanding of the air microbiome: these methods have helped to identify bioaerosol species, resistomes (antibiotic resistance genes), and functional potential at regional and global scales. In addition, new work is underway to integrate high-volume filters with filters used in air quality monitoring networks and to predict microbiome dynamics using artificial intelligence models. Research in Uzbekistan and Central Asia - Local Uzbek literature and textbooks (e.g. "General Microbiology", "Ecology of Microorganisms: Water, Air, Soil Microflora") provide an overview of the main concepts of air microbiology and regional samples. Some practical work carried out in the Uzbek context has focused on studying regional sources and the impact of industrial/agricultural activities.

Factors and seasonal dynamics of air microflora

Meteorological factors: temperature, relative humidity, wind speed and direction, precipitation, and UV radiation affect the detection and viability of bioaerosols. For example, high humidity allows more airborne spores of many fungi to survive, but UV radiation can reduce bacterial activity. Seasonality: bioaerosols associated with pollen and agricultural sources increase during spring and summer; dry and dusty periods increase soil-associated bacteria and dust-based microflora. Anthropogenic factors: transportation, industry, biosecurity levels, and ventilation systems within buildings have a significant impact on indoor bioaerosol composition.

Effects on health



Airborne microorganisms are associated with allergies (fungal spores, pollen), infections (respiratory viruses, some bacteria), and toxic reactions (mycotoxins). High levels of bioaerosols in indoor environments can pose a risk to immunosuppressed individuals in settings such as hospitals, schools, and offices. Therefore, air monitoring and ventilation/filtration strategies are important. Monitoring, control and preventive measures Continuous monitoring: Regional bioaerosol monitoring networks are recommended using high-volume air filters and metagenomic analyses. Indoor environmental management: HEPA filtration, proper ventilation, humidity control, and sanitation measures reduce bioaerosol loads. Standard procedures: Development and implementation of standard protocols for sampling, storage, and analysis allow for comparison of results.

Recommendations (practical for Uzbekistan and the region)

1. Regional monitoring program: implementation of air bioaerosol monitoring in urban and rural areas based on filter collection and metagenomic analyses.
2. Integration with healthcare: indoor environment monitoring, HEPA filters and ventilation system inspections in hospitals and schools.
3. Support for local scientific research: Bioaerosol research appropriate to the ecological and climatic conditions of Uzbekistan; updating of practical manuals and textbooks in the Uzbek language.

Summary

Air microbiology is a field of science of strategic importance for human health and environmental monitoring. Modern methods (metagenomics, high-volume filters, integrated monitoring) have greatly facilitated the understanding of bioaerosols, but methodological standards and local databases are still important. It is recommended to expand regional studies in Uzbekistan and implement a monitoring system based on international protocols. The air microbiome is not just "pollution", but also an important factor in human health. The average city dweller inhales an average of 10-50 million microbial cells every day. This load increases the risk of allergies, asthma, infectious diseases and even oncological diseases. Therefore, the European Union and the United States are making "bioaerosol monitoring" mandatory in the national air quality monitoring program starting in 2024.

References and sources used:

1. Mainelis G., et al. "Bioaerosol Sampling: Classical Approaches, Advances" (review on samplers and bioefficiency).
2. Ghosh B., et al. "Review of bioaerosols in indoor environment with special.." (2015).
3. Xie W., et al. "The source and transport of bioaerosols in the air: A review." (2021).
4. Romano S., et al. "Bioaerosols: Composition, Meteorological Impact, and " (2023).
5. Yang J., et al. "Composition Analysis of Airborne Microbiota in Outdoor" (2023, AAQR).



6. Fayziyev V.B., Ju'rayeva U.M., Eshboyev F.B., Vahabov A.H. "General Microbiology" (Uzbek textbook, 2020).
7. "Ecology of microorganisms: water, air, soil microflora" (Uzbek source).
8. Ziyodullaeva I.B. "Distribution of microbes in the environment: microflora of water, air and soil" (local article/resource).