Composizione biologica e proprietà fisiche degli aerosol atmosferici: risultati dalle campagne di monitoraggio del progetto BIO-MASTER

S. Romano[1], M. Fragola[1], D. Peccarrisi[1,2], O. Gavrichkova[3], P. Pollegioni[3], F. D'Alò[3], G. Quarta[1], L. Calcagnile[1]

[1]Department of Mathematics and Physics, University of Salento, Lecce, Italy
[2]Institute of Atmospheric Sciences and Climate, National Research Council, Lecce, Italy
[3]Research Institute on Terrestrial Ecosystems, National Research Council, Porano (TR), Italy

NAPOLI PM 2026

Dipartimento di Matematica e Fisica "Ennio De Giorgi"

UNIVERSITÀ DEL SALENTO The University of the two seas

CEDAD CEntro di Fisica Applicata, DAtazione e Diagnostica

BIO-MASTER

CNR IRET Istituto di Ricerca sugli Ecosistemi Terrestri

Introduction – BIO-MASTER project

BIOaerosol **M**onitoring **A**nd classification: development of a **S**tandardized procedure by integrating different data analysis **T**echniques and **E**xperimental **R**esearch methodologies (**BIO-MASTER**)

The BIO-MASTER project aims to develop a standardized protocol for the sampling, classification, and characterization of bioaerosols, with a particular focus on their impact on air quality and public health.

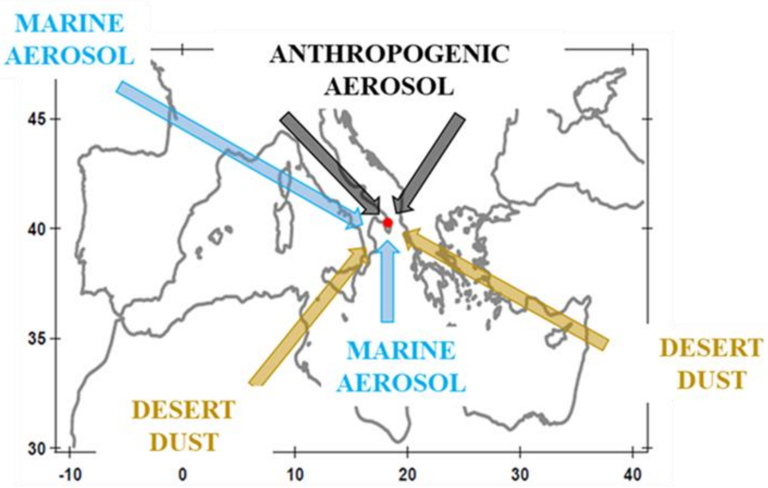
As part of this ongoing research, two intensive monitoring campaigns were carried out at the University of Salento site (Lecce, southern Italy) during two periods: December 2023 – March 2024 and June – October 2024.

The primary goal of these campaigns is to investigate the relationships between biological composition and the optical/physical properties of atmospheric aerosol samples in a Central Mediterranean environment.

This presentation focuses on the results from the first campaign, which combined a variety of different sampling and analytical techniques, including fluorescence-based and metagenomic approaches.

Monitoring Site and Campaign

Aerosol & Climate Laboratory
Mathematics and Physics Department
University of Salento (Lecce, Italy)



N°	Sampling Type	Start exposure	End Exposure	Air Mass Origin (96 h)
1	WD (week-day)	12/12/2023 12:00	14/12/2023 12:00	Atlantic Ocean
2	WE (week-end)	15/12/2023 12:00	17/12/2023 12:00	Eastern Europe
3	WD (week-day)	20/12/2023 12:00	22/12/2023 12:00	Eastern Europe
4	WD (week-day)	09/01/2024 12:00	11/01/2024 12:00	Eastern Europe
5	WE (week-end)	12/01/2024 12:00	14/01/2024 12:00	Eastern Europe
6	WD (week-day)	16/01/2024 12:00	18/01/2024 12:00	Marine
7	WE (week-end)	19/01/2024 12:00	21/01/2024 12:00	Eastern Europe
8	WD (week-day)	23/01/2024 12:00	25/01/2024 12:00	Northeastern Europe
9	WE (week-end)	26/01/2024 12:00	28/01/2024 12:00	Northeastern Europe
10	WD (week-day)	30/01/2024 12:00	01/02/2024 12:00	Eastern Europe
11	WE (week-end)	02/02/2024 12:00	04/02/2024 12:00	Northeastern Europe
12	WD (week-day)	06/02/2024 12:00	08/02/2024 12:00	Marine
13	WE (week-end)	09/02/2024 12:00	11/02/2024 12:00	Marine / Desert
14	WD (week-day)	13/02/2024 12:00	15/02/2024 12:00	Northeastern Europe
15	WE (week-end)	16/02/2024 12:00	18/02/2024 12:00	Eastern Europe / Marine
16	WD (week-day)	21/02/2024 12:00	23/02/2024 12:00	Northeastern Europe
17	WE (week-end)	23/02/2024 12:00	25/02/2024 12:00	Marine / Desert
18	WD (week-day)	27/02/2024 12:00	29/02/2024 12:00	Marine
19	WE (week-end)	01/03/2024 12:00	03/03/2024 12:00	Marine
20	WD (week-day)	05/03/2024 12:00	07/03/2024 12:00	Marine

Sampling devices and methodologies

SWAM 5A Dual Sampler
FAI Instruments

Simultaneous sampling of atmospheric aerosol (TSP) on quartz and Teflon filters

⬇

gravimetric, chemical, and microbiological analyses

ACD-200 BOBCAT
InnovaPrep

atmospheric aerosol (TSP) collection on electret filters

⬇

microbiological analyses

WIBS-5 NEO
Droplet Measurement Technologies

Real-time fluorescence-based detection of atmospheric aerosol (TSP)

⬇

characterization and classification of biological aerosol particles

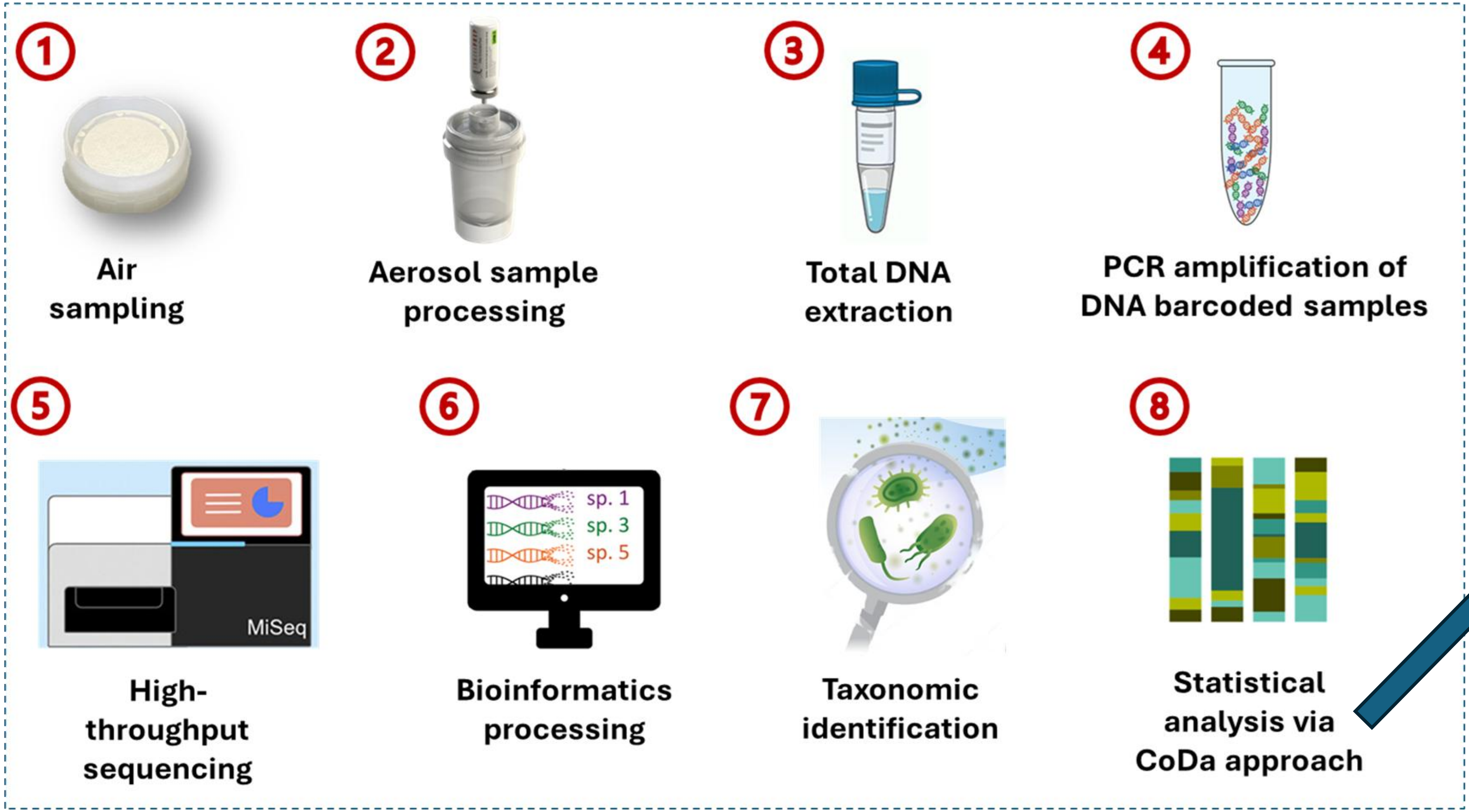
Metagenomic Approach

16S rRNA gene metabarcoding

Airborne BACTERIAL community characterization

ITS rRNA gene metabarcoding

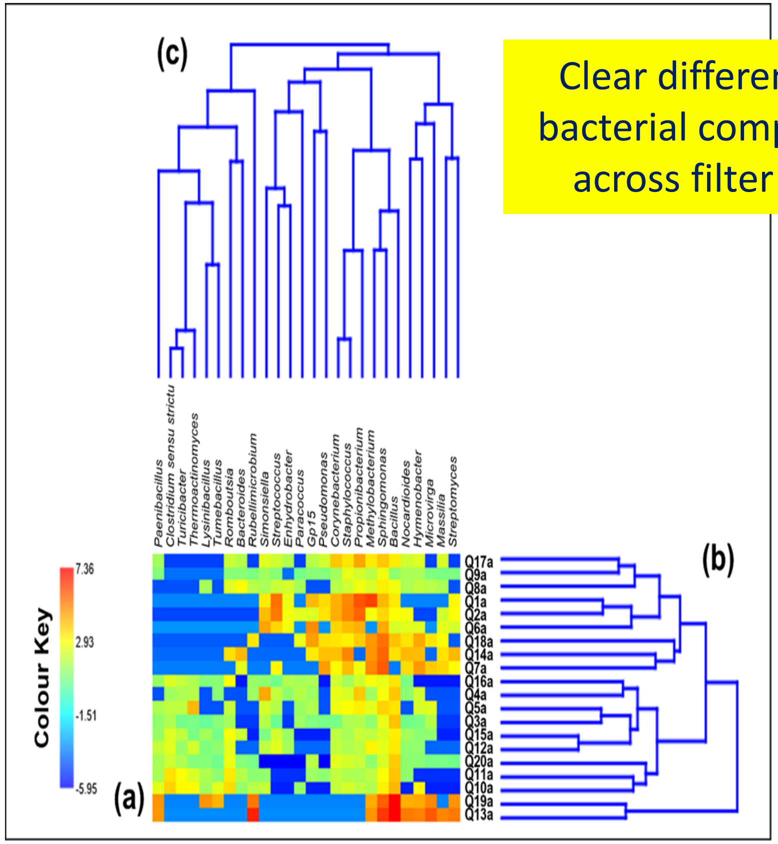
Airborne FUNGAL community characterization



This approach is mainly based on **centered log-ratio (CLR) transformation** of the original data, **Aitchison distance** for both clustering and ordination, and a **compositional principal component analysis (PCA) via singular value decomposition (SVD)** to point out the main relations among the observed variables

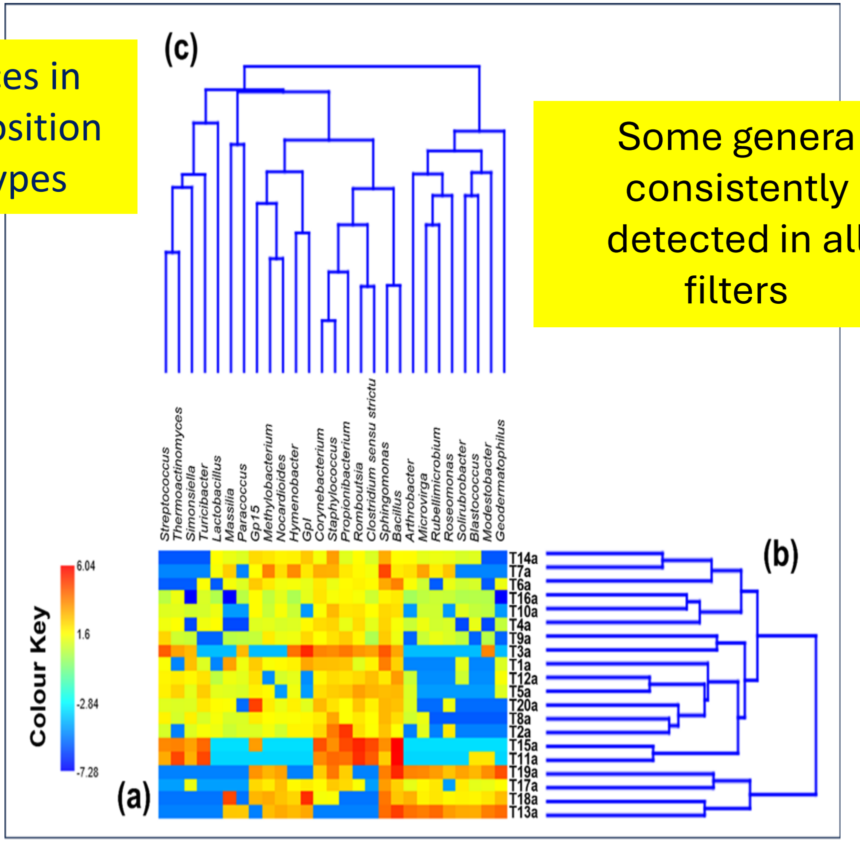
Romano et al., Atmosphere, 2024

Results from Metagenomic Approach (airborne bacterial community)



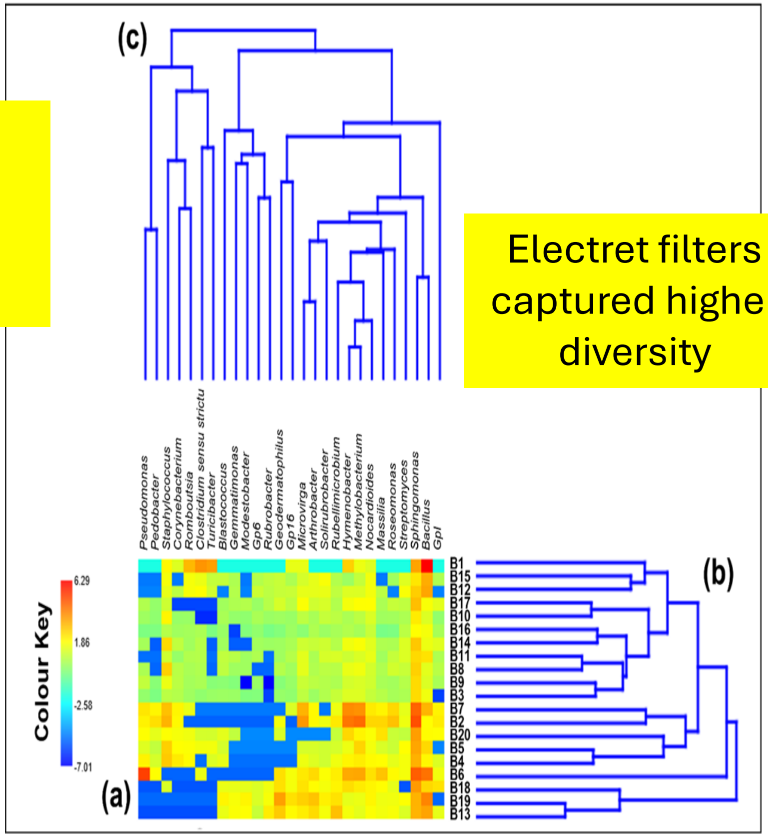
Clear differences in bacterial composition across filter types

Quartz Filter



Some genera consistently detected in all filters

Teflon Filter



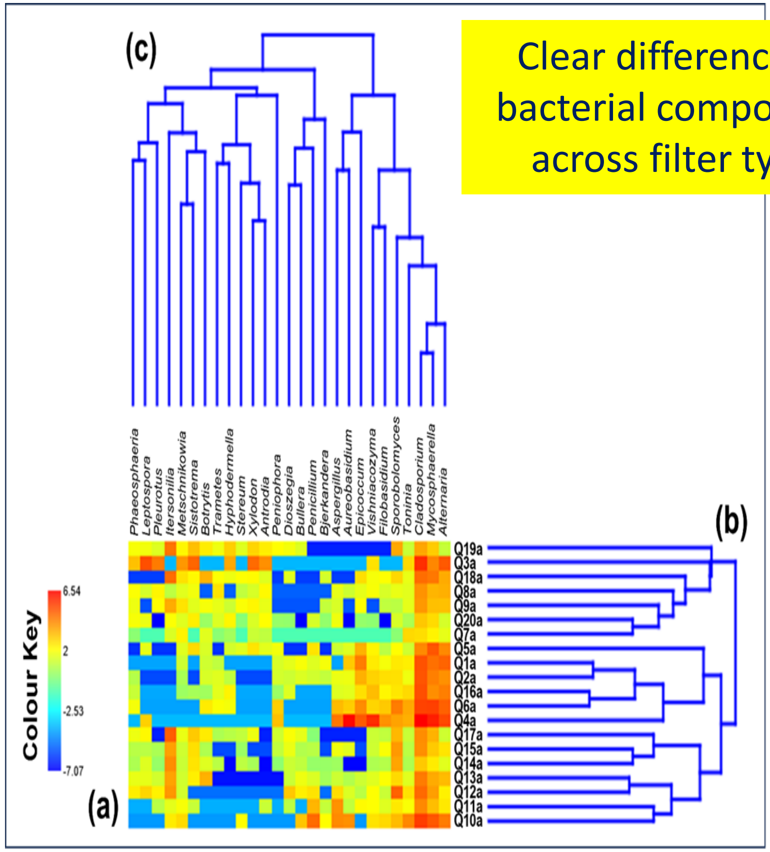
Electret filters captured higher diversity

Electret Filter

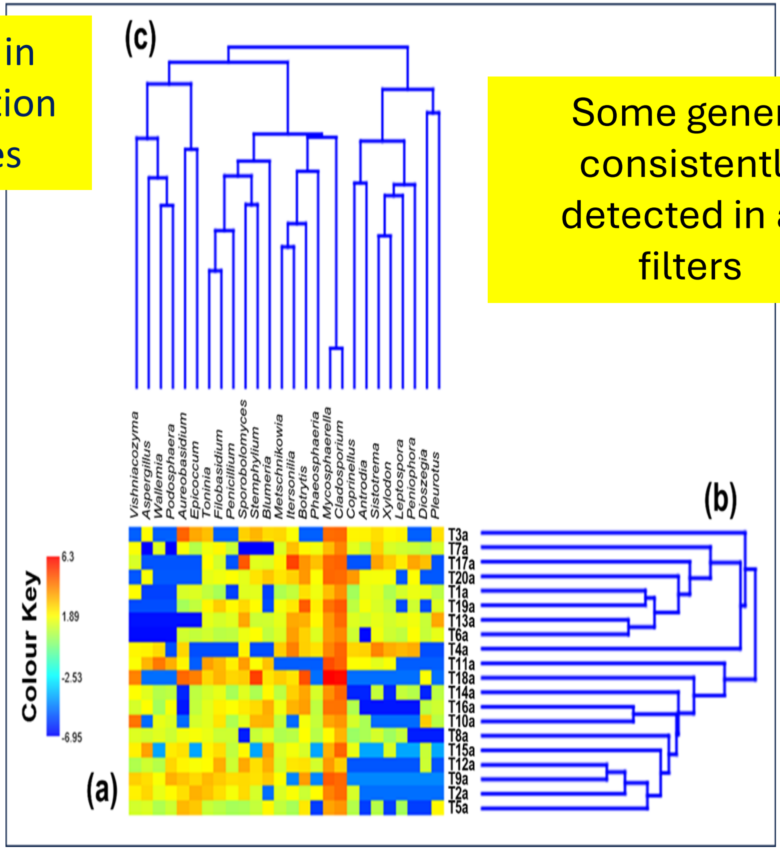
SWAM 5a Dual Sampler
FAI Instruments

ACD-200 BOBCAT
InnovaPrep

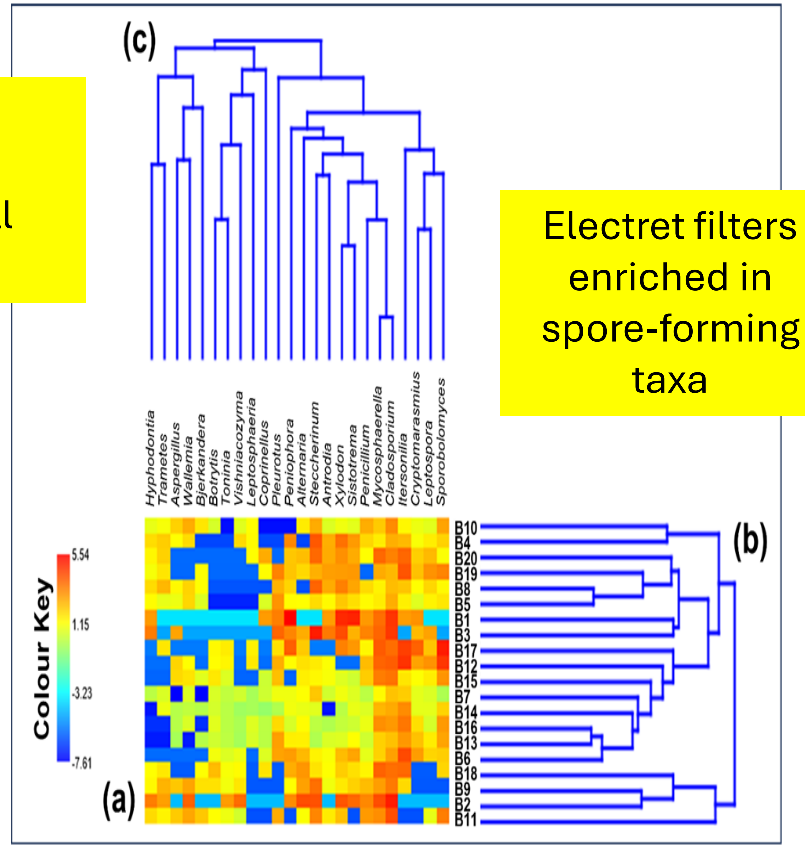
Results from Metagenomic Approach (airborne fungal community)



Clear differences in bacterial composition across filter types



Some genera consistently detected in all filters



Electret filters enriched in spore-forming taxa

Quartz Filter

Teflon Filter

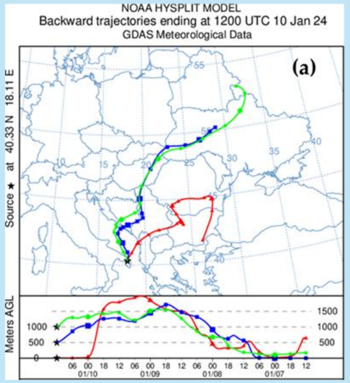
Electret Filter

SWAM 5a Dual Sampler
FAI Instruments

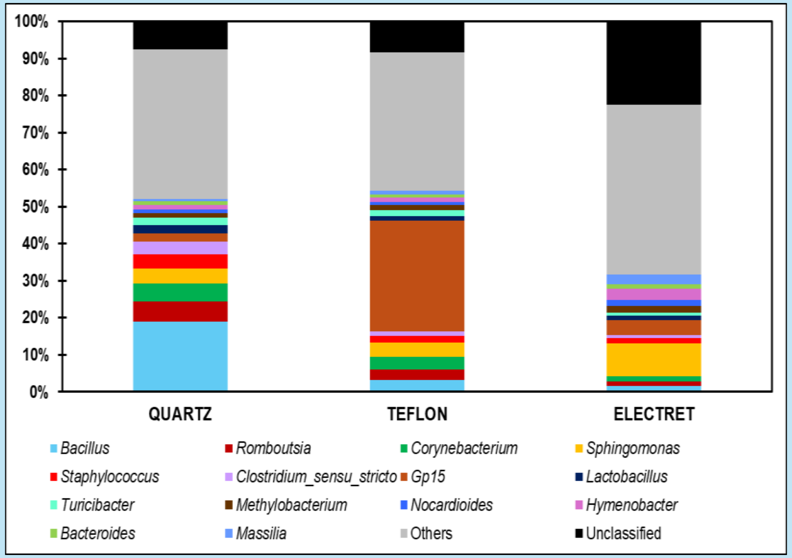
ACD-200 BOBCAT
InnovaPrep

Metagenomic Results on Case Studies

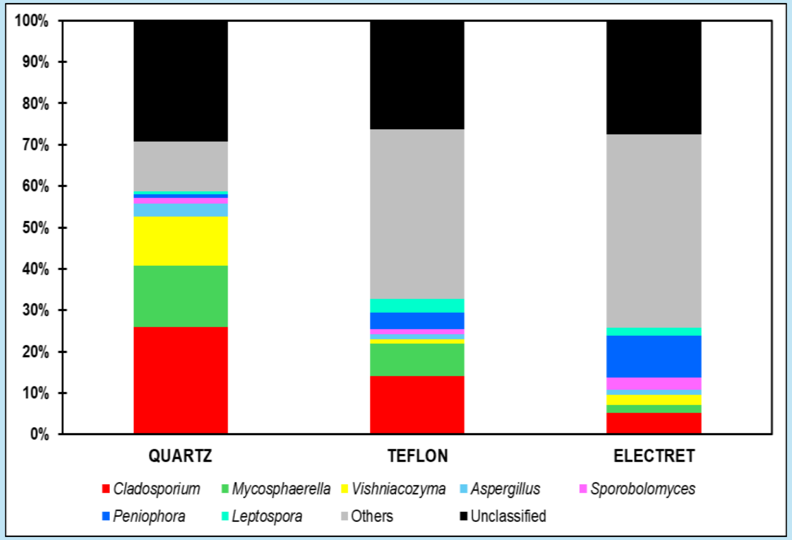
Case Study I 10 January 2024



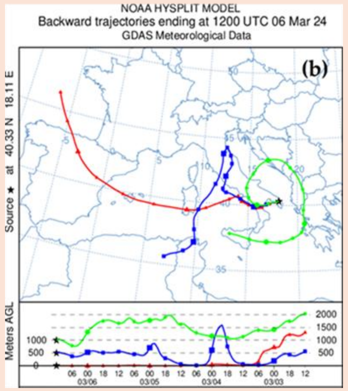
Bacterial genera



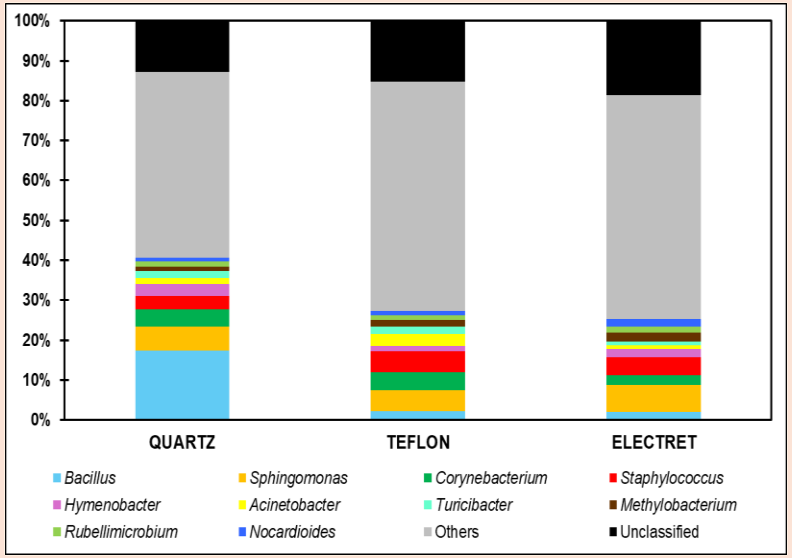
Fungal genera



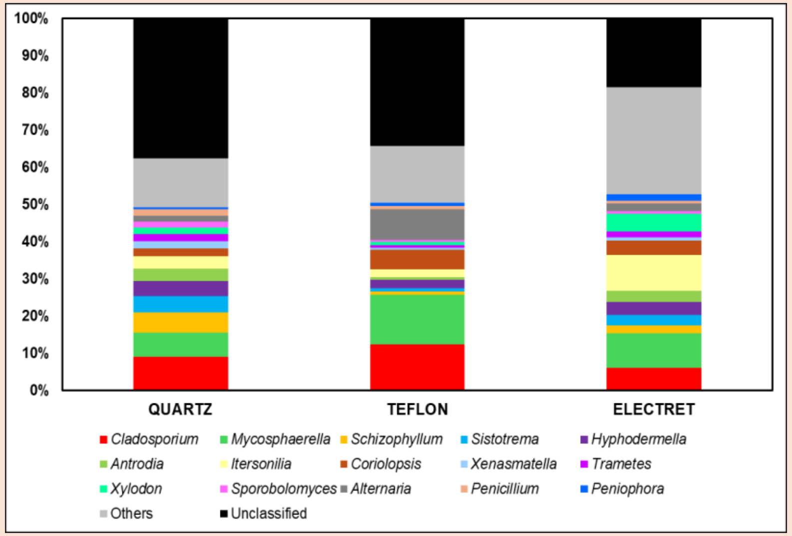
Case Study II 6 March 2024



Bacterial genera

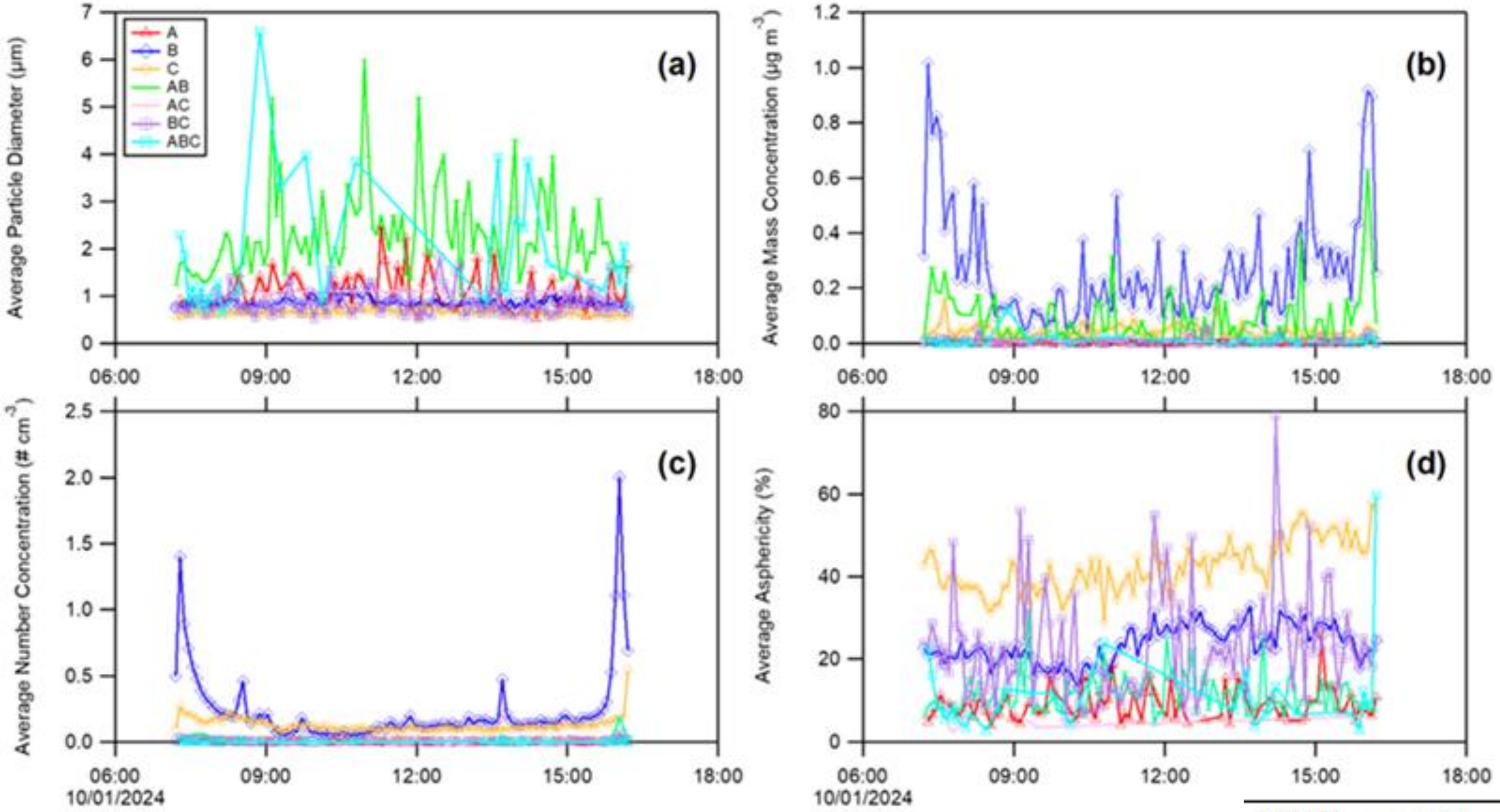


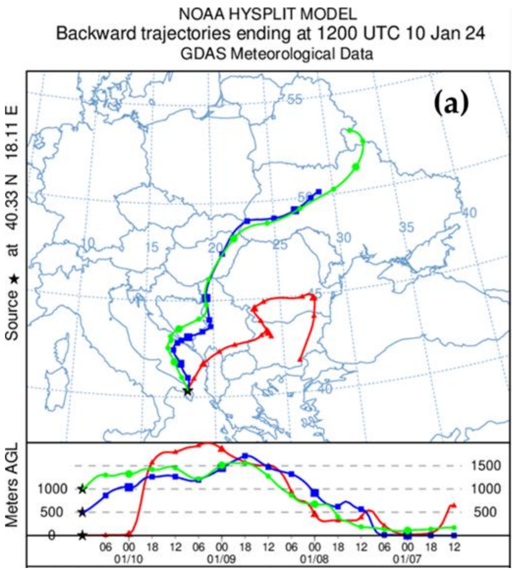
Fungal genera



Case Study I: 10 January 2024

WIBS-5 NEO
Droplet Measurement Technologies





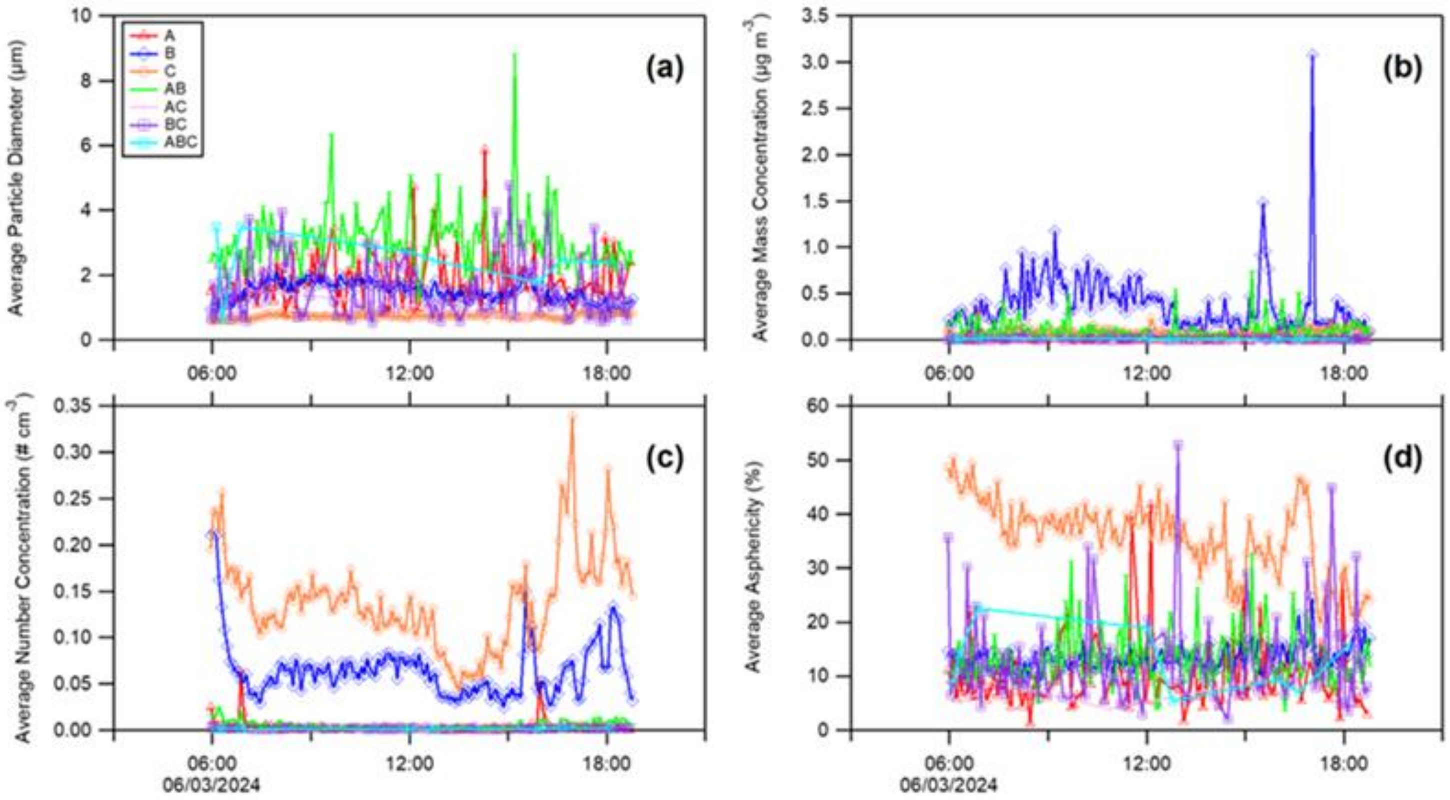
Fragola et al., Aerobiology, 2024

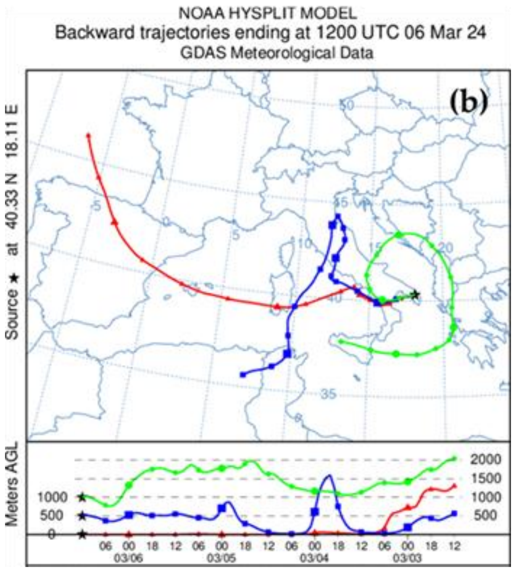
Daily mean values	A	B	C	AB	AC	BC	ABC
particle diameter (µm)	1.08	0.87	0.65	2.28	0.99	0.84	1.92
mass concentration (µg/m³)	0.004	0.266	0.043	0.088	0.001	0.006	0.010
number concentration (particle/cm³)	0.004	0.227	0.127	0.012	0.001	0.006	0.001
asphericity (%)	9.0	23.6	42.4	11.3	6.4	23.6	11.1

WIBS Fluorescent Category	Aerosol/Bioaerosol Particles (Size Range)
A	Bacteria (<5 µm), fungi (2–9 µm), soot (<1 µm), mineral dust (2–7 µm)
B	Soot (<1 µm), HULIS (≈1 µm), mineral dust (2–7 µm)
C	Pollen fragments (<10 µm)
AB	Bacteria (1–5 µm), fungi (2–9 µm), pollen fragments (<10 µm), mineral dust (2–7 µm)
AC	
BC	HULIS (≈1 µm), pollen fragments (<10 µm)
ABC	Fungi (2–9 µm), pollen fragments (<10 µm), clothing fibers (3–10 µm)

Case Study II: 6 March 2024

WIBS-5 NEO
Droplet Measurement Technologies





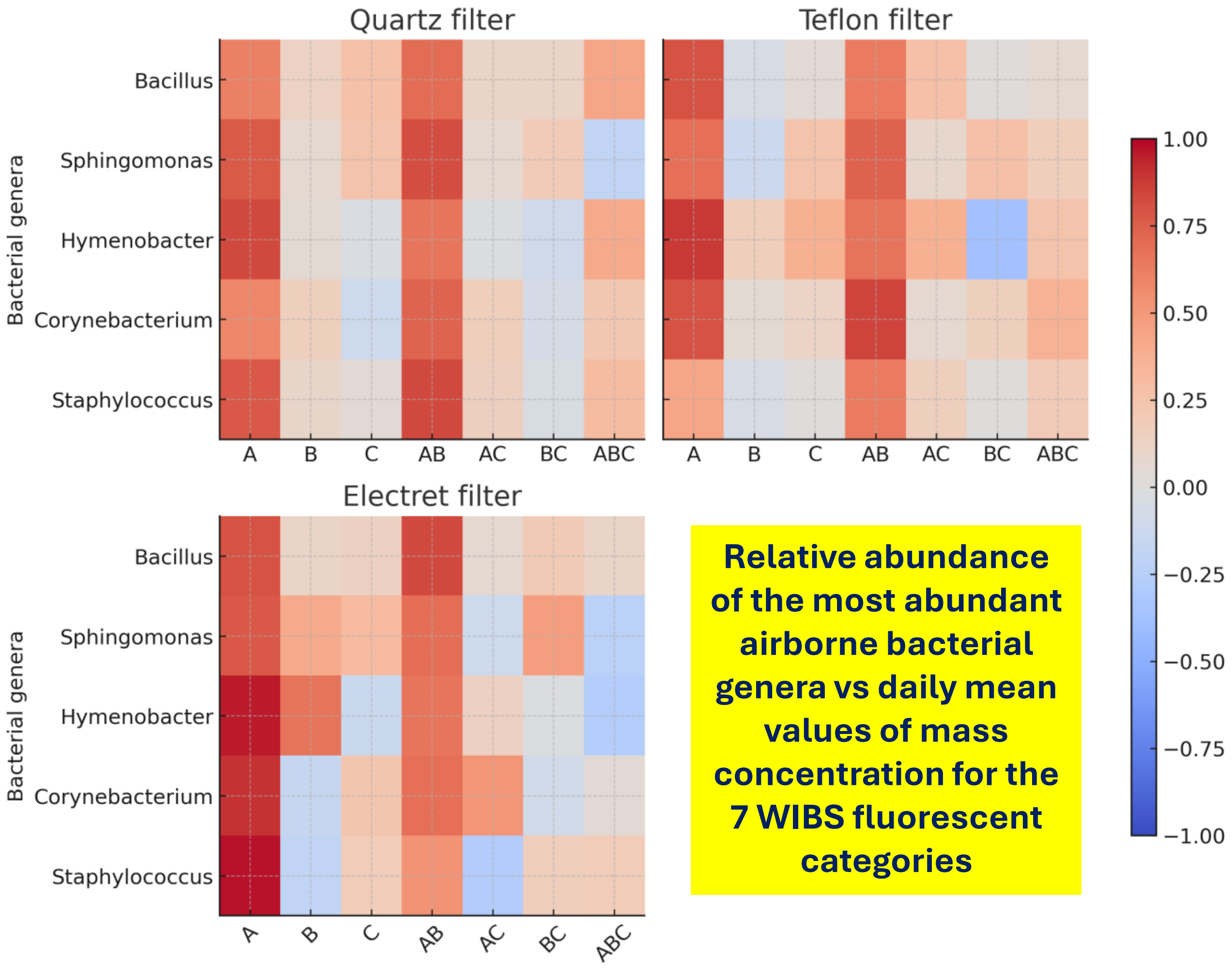
Fragola et al., Aerobiology, 2024

Daily mean values	A	B	C	AB	AC	BC	ABC
particle diameter (µm)	1.83	1.49	0.73	**3.04**	1.41	1.60	**2.42**
mass concentration (µg/m³)	0.014	**0.380**	0.080	**0.112**	0.003	0.009	0.010
number concentration (particle/cm³)	0.003	**0.065**	**0.138**	0.005	0.001	0.001	0.001
asphericity (%)	10.1	13.4	**35.8**	13.3	8.5	12.6	12.7

WIBS Fluorescent Category	Aerosol/Bioaerosol Particles (Size Range)
A	Bacteria (<5 µm), fungi (2–9 µm), soot (<1 µm), mineral dust (2–7 µm)
B	Soot (<1 µm), HULIS (≈1 µm), mineral dust (2–7 µm)
C	Pollen fragments (<10 µm)
AB	Bacteria (1–5 µm), fungi (2–9 µm), pollen fragments (<10 µm), mineral dust (2–7 µm)
AC	
BC	HULIS (≈1 µm), pollen fragments (<10 µm)
ABC	Fungi (2–9 µm), pollen fragments (<10 µm), clothing fibers (3–10 µm)

Relationships between Biological Composition and Optical/Physical Properties (airborne bacterial community)

This analysis is based on all the 20 samples collected during the monitoring campaign



Relative abundance of the most abundant airborne bacterial genera vs daily mean values of mass concentration for the 7 WIBS fluorescent categories

No substantial effect of filter material was detected on the observed relationships

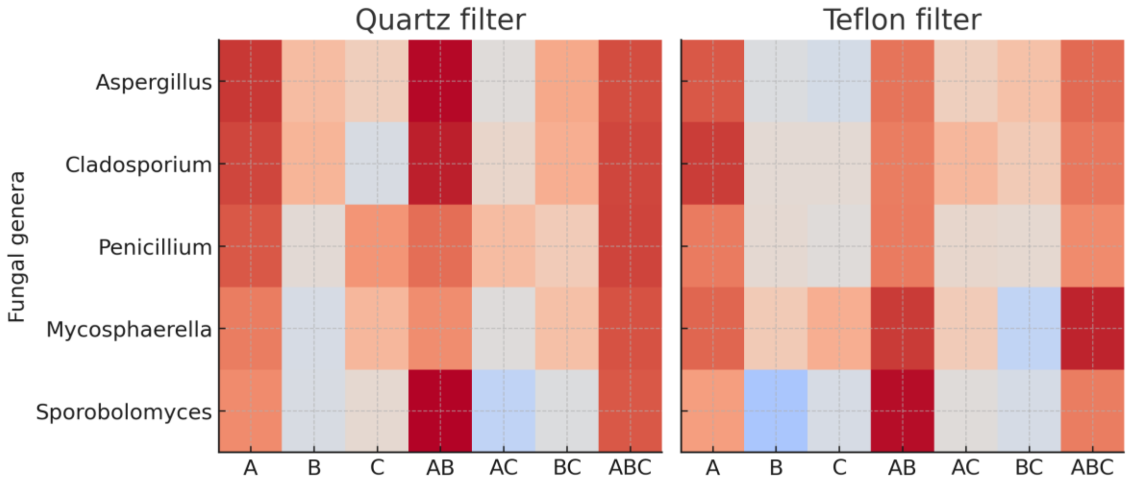
Stronger correlations observed for WIBS A and AB categories

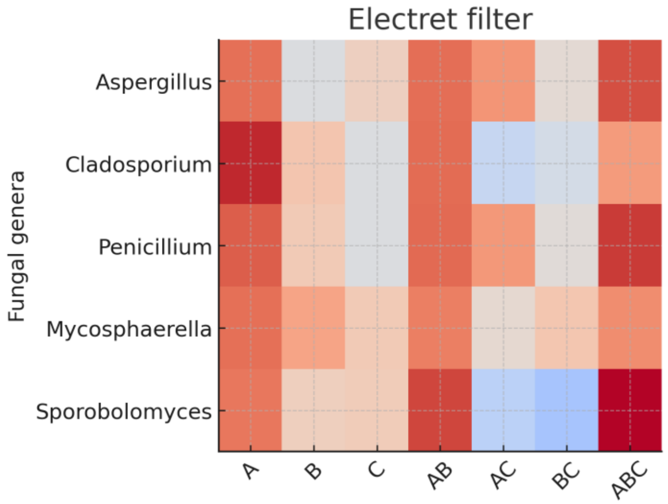
WIBS Fluorescent Category	Aerosol/Bioaerosol Particles (Size Range)
A	Bacteria (<5 µm), fungi (2–9 µm), soot (<1 µm), mineral dust (2–7 µm)
B	Soot (<1 µm), HULIS (≈1 µm), mineral dust (2–7 µm)
C	Pollen fragments (<10 µm)
AB	Bacteria (1–5 µm), fungi (2–9 µm), pollen fragments (<10 µm), mineral dust (2–7 µm)
AC	
BC	HULIS (≈1 µm), pollen fragments (<10 µm)
ABC	Fungi (2–9 µm), pollen fragments (<10 µm), clothing fibers (3–10 µm)

WIBS-5 NEO Droplet Measurement Technologies

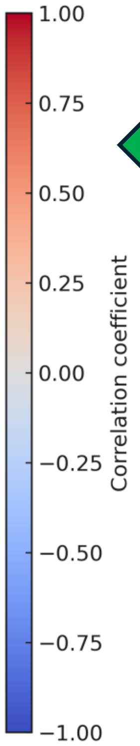
Relationships between Biological Composition and Optical/Physical Properties (airborne fungal community)

This analysis is based on all the 20 samples collected during the monitoring campaign





Relative abundance of the most abundant airborne fungal genera vs daily mean values of mass concentration for the 7 WIBS fluorescent categories



No substantial effect of filter material was detected on the observed relationships

Stronger correlations observed for WIBS A, AB, and ABC categories

WIBS Fluorescent Category	Aerosol/Bioaerosol Particles (Size Range)
A	Bacteria (<5 µm), fungi (2–9 µm), soot (<1 µm), mineral dust (2–7 µm)
B	Soot (<1 µm), HULIS (≈1 µm), mineral dust (2–7 µm)
C	Pollen fragments (<10 µm)
AB	Bacteria (1–5 µm), fungi (2–9 µm), pollen fragments (<10 µm), mineral dust (2–7 µm)
AC	
BC	HULIS (≈1 µm), pollen fragments (<10 µm)
ABC	Fungi (2–9 µm), pollen fragments (<10 µm), clothing fibers (3–10 µm)

WIBS-5 NEO Droplet Measurement Technologies

Conclusion

- Airborne bacterial and fungal genera were consistently detected across all filter types, highlighting the robustness of the metagenomic approach during a monitoring campaign in Southern Italy.
- The type of filter material (quartz, teflon, and electret) did not substantially influence the observed relationships between biological composition and optical/physical properties.
- The strongest correlations were found for WIBS categories A and AB (bacteria) and A, AB, and ABC (fungi).
- The integration of real-time WIBS data with metagenomic analyses provides a valuable framework for advancing the characterization of atmospheric bioaerosols.

The work was supported by the Italian PRIN Project **BIO-MASTER** (*BIOaerosol Monitoring And classification: development of a Standardized procedure by integrating different data analysis Techniques and Experimental Research methodologies*, 202249BMWR) funded by the Italian Ministry of Education, University and Research.

salvatore.romano@unisalento.it