Transforming the real-time detection and characterisation of bioaerosols

Zaheer Ahmad Nasir

Cranfield University, UK

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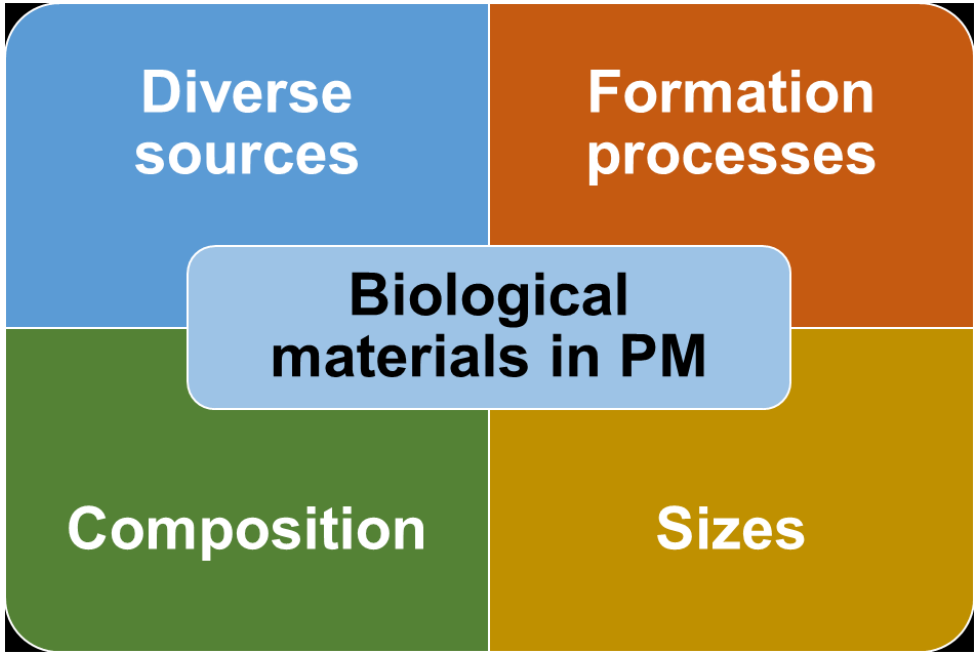
Sources and impact of bioaerosols



- **Public health (allergenicity, toxicity, infectivity)**
- **Climate (absorbing/scattering light)**
- **Ecosystems (nutrient transport/ dispersal of reproductive units)**

Detection and characterisation of bioaerosols

**Good body of knowledge - ** PM physical properties (mass, number, size) and chemical composition (chemical speciation).

Less progress - Biological materials in particles and the interaction between its abiotic and biological components.

Key barriers - Mono-disciplinary perspective and associated methodological constraints, resulting in data of low temporal resolution and an incomplete understanding of bioaerosols.

This significantly limits understanding of the complex physico-chemical and biological matrix of PM and the role and impact of bioaerosols in the context of public and planetary health.

Advances in bioaerosols detection and characterization

Fluorescence spectroscopy has shown promise to broadly classify organic compound including biological materials in real time.

Interrogates the characteristic intrinsic fluorescence emission of PM.

The main biological fluorophores relevant to potential biological materials in airborne particles are **amino acids, co enzymes, structural compounds, pigments** and **secondary metabolites.**

Single particle UV-LIF detection systems combined with optical particle measurements (size and shape) have been developed.

Spectral Intensity Bioaerosol Sensor (SIBS)

Spectral Intensity Bioaerosol Sensor (SIBS) - Droplet Measurement Technologies Inc. USA

- Dual wavelength excitation multiple fluorescence band system, providing information on size, shape and generating highly resolved spectral information of single particles in real time.

Excitation at **285** nm and **370** nm

Unique feature of SIBS is the **16 wavelength bands** of fluorescence measurement, from 298 – 735nm along with an estimate of **particle size and shape**.

Offers range of option to classify particles and identify subpopulation

Channel No.	Lower λex	Upper λex
1	298.2	316.4
2	316.4	344.8
3	344.9	362.5
4	377.5	401.5
5	401.5	429.7
6	430.2	457.5
7	456.7	485.6
8	486	514
9	514.1	542
10	542	569.8
11	569.9	597.6
12	597.6	625.2
13	625.3	652.8
14	652.8	680.2
15	680.3	707.5
16	707.5	734.7

Characterisation of bioaerosols from real-world environmental sources

Agricultural field

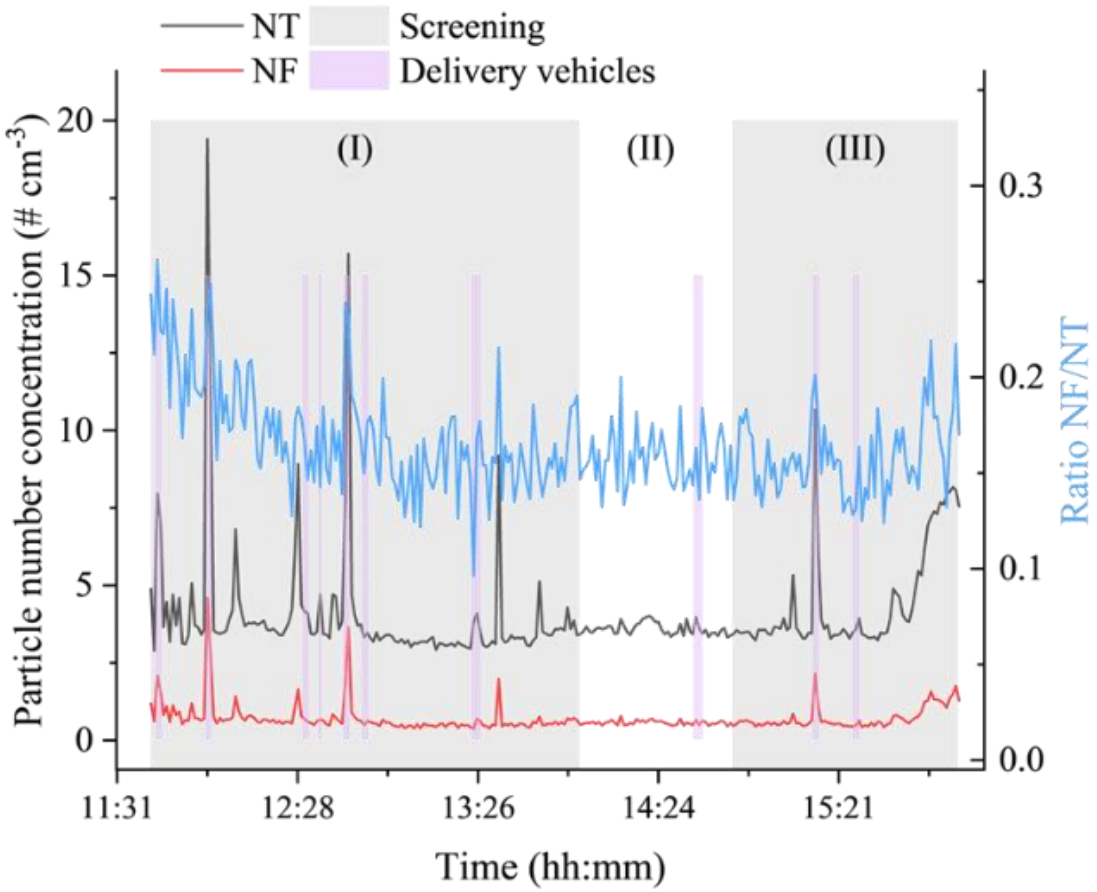
Composting

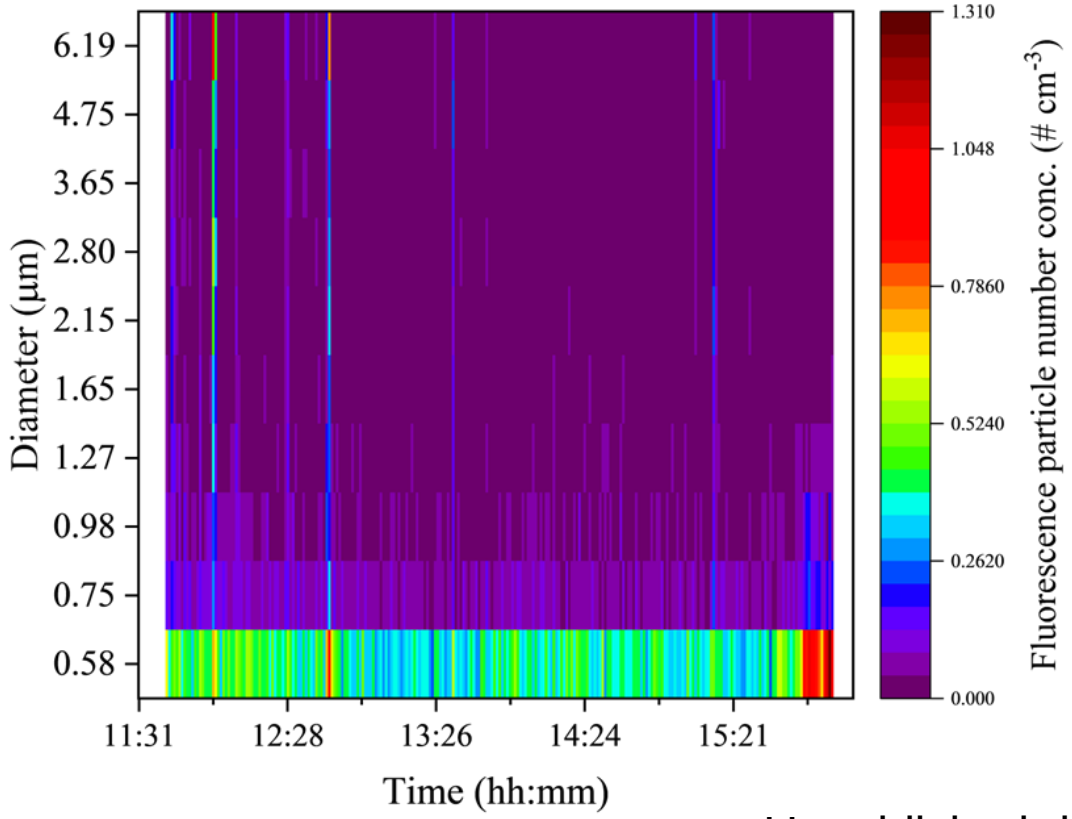
Chicken Farm

WWTP

Quantification, temporal and size distribution characterisation

Temporal profile of number size distribution of particles at a composting site





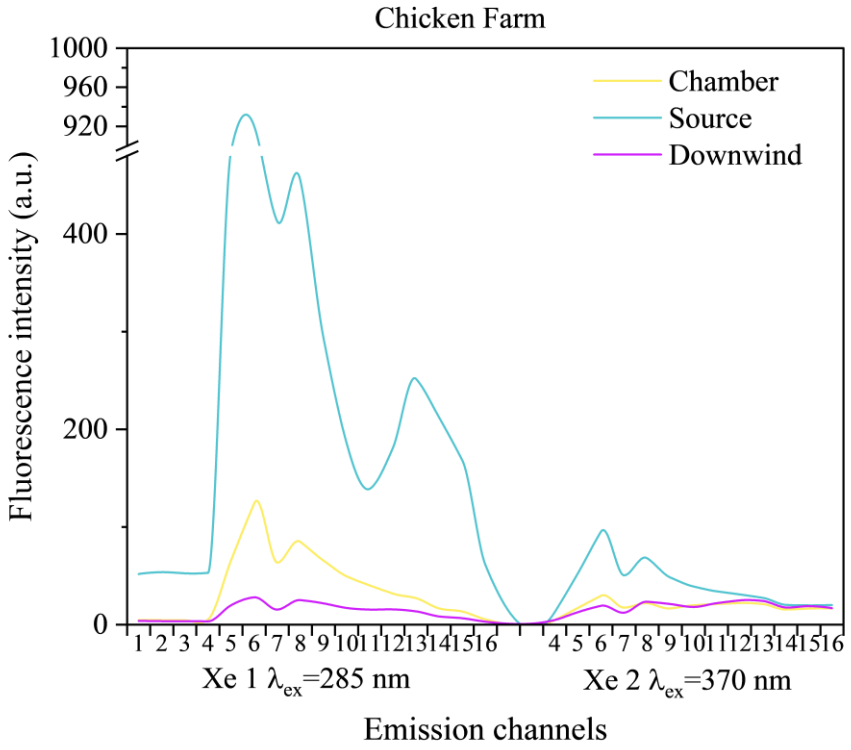
Unpublished data

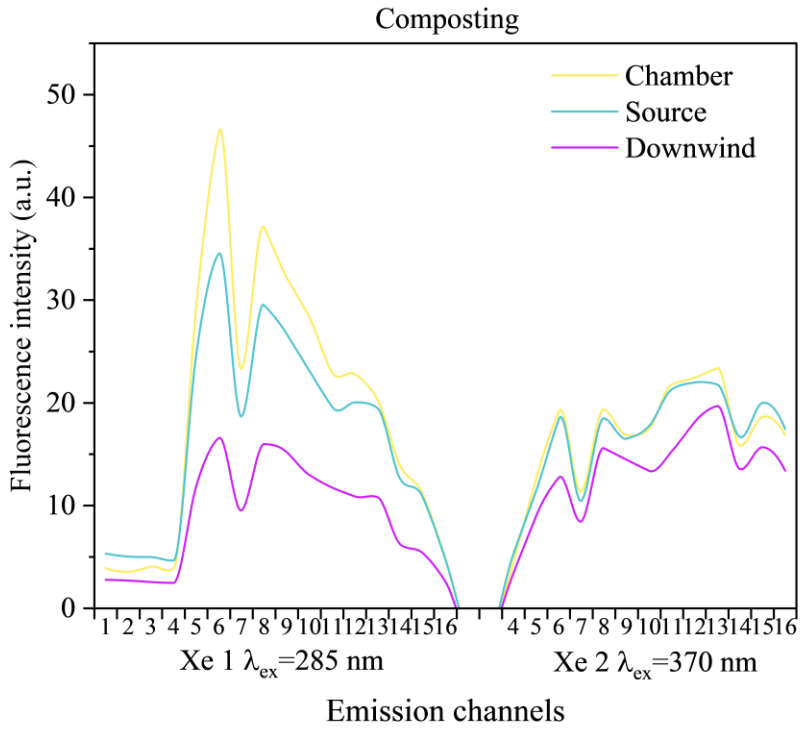
NT – Number of total particles ; NF – Number of fluorescent particles

Identities and composition of bioaerosols

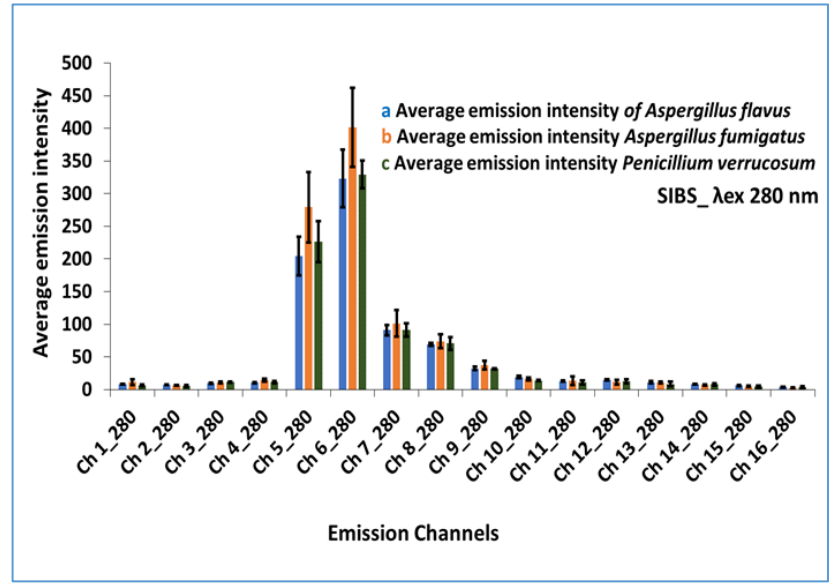
Improved spectral resolution and selectivity capability

Emission spectra for chicken farm, composting and fungal species





Fungal species



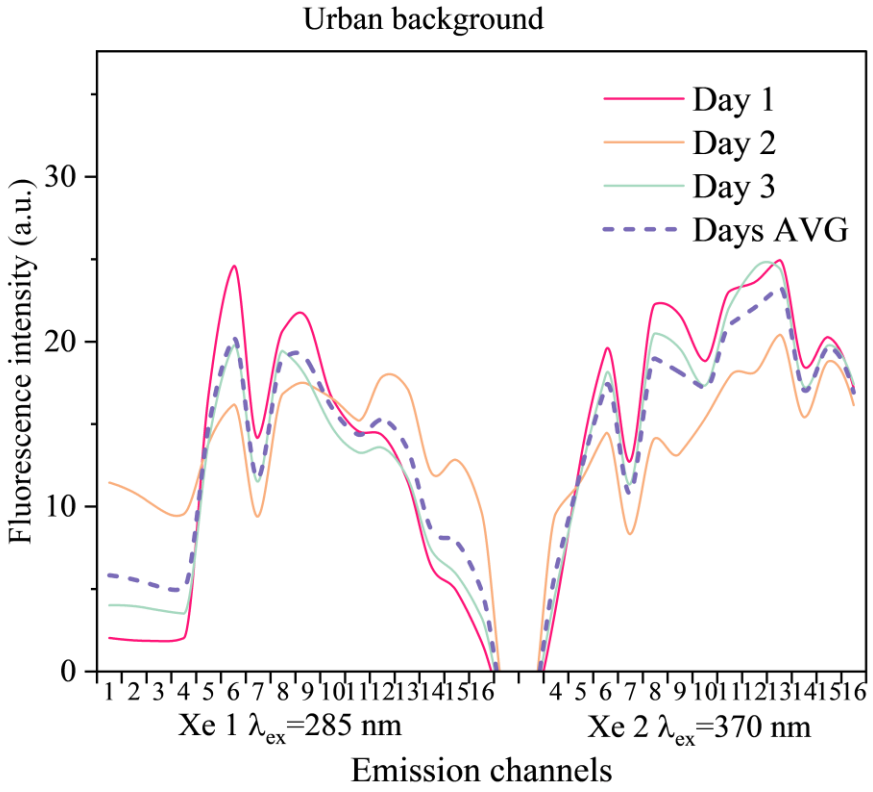
Fluorophore	Emission wavelength
Amino acids	Ch 1 - 3
Cellulose, Chitin, Lignin, Pyridoxine	Ch 4 - 8
Flavins	Ch 9-10
Secondary metabolites, pigments	Ch 11-16

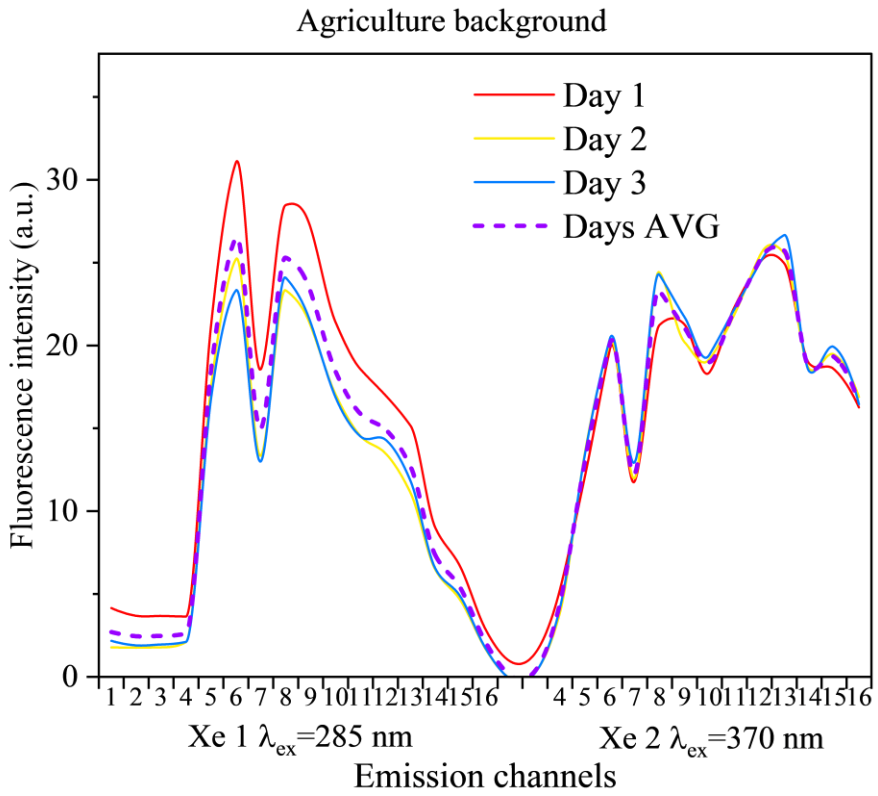
Unpublished data

Identities and composition of bioaerosols

Improved spectral resolution and selectivity capability

Emission spectra for urban and agricultural background





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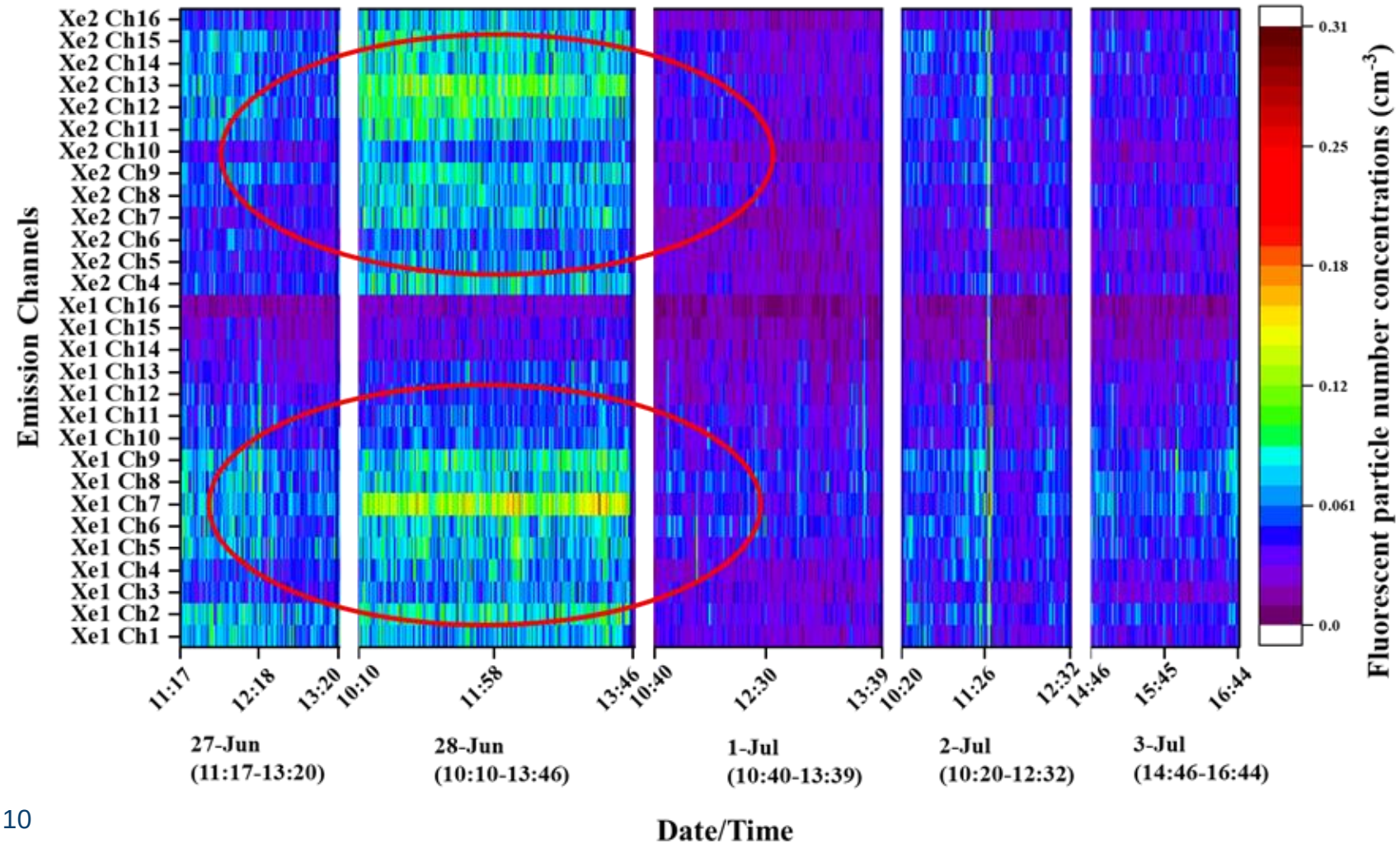
Temporal profile of fluorescence signatures/biological composition

Channel by channel number concentrations of fluorescent particles at an urban background site



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SIBS relevant excitation emission assignment to potential fluorophores https://doi.org/10.1016/j.scitotenv.2020.137629

Conclusions

Physico-chemical and biological properties of aerosols, arising from diverse sources.

Quantification, identification and temporal profiles.

Optical-fluorescence signatures – source specific, potential indicator of structural compounds and cell metabolism.

Provide a step change for an integrated understanding of bioaerosols, their interactions, and likely human and environmental health impacts in the context of changing sources and exposure scenarios due to climate and land use changes.

Developing rapid biodetection and response systems suitable for different domains (Agriculture, security, public health).

Informing policy decisions on clean air interventions for building healthy and resilient environments.

Challenges and forward look

Setting fluorescence threshold.

Discriminating interferants.

Assigning spectral responses to bioaerosols class/type/composition.

Development of appropriate data analysis tools to deal with big and complex data sets (Data Ecosystems).

Lab-based studies with atmospherically relevant biological fluorophores/aerosols in order to build comprehensive fluorescence spectra library.

Real-world studies in conjunction with other complementary methods to improve the certainty and validation of assigning highly resolved spectral signatures to atmospherically relevant biological fluorophores.

Thank You

Website: https://bioairnet.co.uk/

Twitter: @BioAirNet1

Get in touch: contact@bioairnet.co.uk

Frederic Coulon and Sean Tyrrel
Cranfield University, Cranfield, UK

Cheng Yan
School of Environmental Studies, China University of Geosciences, Wuhan, PR China

Jianghan Tian
School of Chemistry, University of Bristol, UK

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