WeBIOPATR 2023

The Ninth International WEBIOPATR
Workshop & Conference
Particulate Matter: Research and Management

Abstracts of Keynote Invited Lectures and Contributed Papers

Milena Jovašević-Stojanović,

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VInča Insitute of Nuclear Sciences

National Institute of the Republic of Serbia, University of Belgrade

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PREFACE

Dear Colleagues,

Welcome to the 9th WeBIOPATR Conference, to be held at Vinca Institute of Nuclear Sciences and Mechanical Faculty, University of Belgrade, Serbia, 29.11.–1.12.2023.

The first WeBIOPATR – „International Workshop and Conference, Particulate Matter: Research and Management“ was held in Belgrade in 2007. Its aim was to create a forum for Serbian and Western-Balkan experts and air pollution stakeholders to inform each other about state of knowledge in atmospheric research in Serbia and internationally, and about opportunities and barriers to reduce air pollution and especially, particulate matter (PM) towards safer levels.

Since the first conference which became a bi-annual event, we have learnt much about the levels and negative effects of PM in Serbia and Western Balkan. The research carried out in Serbia has been significantly expanded, and better integrated in the international research community. The air pollution burden in Serbia and in particular, in Belgrade, has been much reduced. Our common quest is however not over – in line with the World Health Organization’s latest air quality guidelines, ambient pollution must further be reduced, in residential areas of large and small cities, in industrial areas, and in small settlements, bringing both the outdoor and the indoor levels towards safer levels.

New challenges have arisen: the COVID-19 pandemic brought with it better understanding of pollution sources and the role of PM in virus transmission. New health-relevant metrics to assess PM properties have been established. New technologies have been developed for use at all observing platforms. Low-cost air quality sensos are now used in research and assessment as well as to raise awareness of air pollution in the society. Artificial Intellingence allows us to combine non-traditional data sources , and we can generate better emission estimates and precise finely time- and space resolved concentration fields that help us to develop mitigation strategies. Not least, European Research Infrastructures are now supporting harmonized methods and tools to generate, store and access research data on atmosphere, for the benefit of the wider scientific community and the society.

This year's event brings to you 60 key-notes, lectures and posters, presented in-person and online, touching upon the new developments and demonstrating the solid basis research in Serbia rests on. The conference is supported by the European Union co-funded projects VIDIS (2020-2024, Grant Agreement ID 952433, https://vidis-project.org/), and WeBASOOP (2022-2025, Grant agreement ID: 101060170, https://webasoop.vinca.rs), by the Ministry of Science, Technological Development and Innovation of Serbia, by the Embassy of the Italian Republic in Serbia, by Vinca Institute of Nuclear Sciences Serbia, and by the Environment and Climate Research Institute NILU, Norway.

We are grateful to you, the participants, and to our sponsors, for the opportunity to meet here in Belgrade. Welcome to Vinca and online and have a stimulating and productive time!

We would also like to express our thanks to Dr Duška Kleut and Bojana Petrović for their technical assistance with this Book of Abstracts.

Milena Jovašević-Stojanović and Alena Bartoňová

Belgrade, November 2023

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A. Alastuey (1), M. Savakoohi (1), M. García Marlés (1), M. Pandolfi (1), M. Monge-Azemar (1), T. Petäjä (2), X. Querol (1)

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Atmospheric aerosols greatly affect climate and air quality (AQ), and accordingly human health, in both cases with a strong dependence on their size, composition and sources. The recent WHO guidelines and the proposal of revision of the EU Ambient Air Quality Directive stressed the need to further investigate new AQ metrics, such as ultrafine particles (UFP), ammonia (NH3), black carbon (BC) and the oxidative potential (OP) of the particulate matter, to support scientific understanding of their effects on health and the environment. It is crucial to understand the sources of the different PM components and ultrafine particles, the reactions and processes involved in the generation of secondary PM constituents, and their potential health effects. This is of special relevance given the observed changes on PM composition and UFP sources in the last few years. RI-URBANS project (H2020, European Green Deal), coordinated by CSIC and UHEL, aims to demonstrate the applications of advanced air quality service tools in urban Europe to the assessment of policy decisions in order to better abate pollution and supply accurate information for health studies. Among other objectives, RI-URBANS aims to assess the measurement of novel AQ metrics and key source tracers and to provide advanced measurements and source apportionment STs for PM and nanoparticles. We will present the preliminary results obtained in RI-URBANS mainly related with UFP, BC and PM chemistry, and their sources.

1.2 THE SCIENCE BEHIND INDOOR AIR QUALITY STANDARDS FOR PUBLIC SPACES

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Legislated indoor air quality standards should be the basis for building design and operation but we cannot routinely monitor indoor air in the same way as outdoor air. Firstly, every indoor space is different, so monitoring needs to be conducted in every public indoor space. Secondly, we cannot use bulky and expensive compliance monitors for every indoor space. And thirdly, pathogens related to indoor airborne infection transmission cannot yet be routinely monitored indoors in real-time. Therefore, we must carefully choose what to monitor, balancing the need to gather information on pollutants that are key health risks or their proxies, but also considering which pollutants can realistically be routinely measured for compliance with indoor air quality standards based on existing technologies. In doing this we still need to address several scientific challenges. Among them is the need for a scientific bridge between particle number concentrations monitored by sensors and particle gravimetric mass concentrations to relate to the existing health guidelines, and a new approach to low-cost sensor data interpretation to enable determination of the origin of the particles (from indoors or outdoors), to inform control measures.

1.3 AN OVERVIEW OF AMBIENT PARTICULATE MATTER UNDER STATE AND LOCAL MONITORING NETWORKS IN THE REPUBLIC OF SERBIA IN 2022

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The Environmental Protection Agency every year, publishes an annual report on the state of air quality in the Republic of Serbia, which contains data and all relevant information from air quality monitoring stations from state and local networks, with the aim of assessing air quality .and informing the population about the state of air quality.

Valid data obtained by fixed measurements using automatic methods as well as the gravimetric method for PM_{10} and $PM_{2.5}$ were used to assess air quality.

The largest data submission on air quality by local self-governments was registered in 2022, by which local self-governments that finance air quality monitoring fulfilled their legal obligation. Data were collected and processed from a total of 220 automatic stations and measuring points.

In 2022, out of 68 measuring points where fixed measurements of PM_{10} were made, the limit annual value (40 $\mu g/m^3$), was exceeded in 13, while the number of days with an exceedance (daily limit value 50 $\mu g/m^3$) was recorded at 54 measuring points. Allowed number of days with exceedances is 35 in calendar year. According to both criteria, Valjevo is at the very top of the list during these two years. Fixed measurements of PM_{10} particle concentrations in 2021 show that, out of 58 stations where measurements were made, 5 exceeded the annual limit value, while the number of days with exceedances was recorded at 45 measuring points.

As for the fixed measurements of suspended $PM_{2.5}$ particles, in 2022, out of 40 stations where measurements were taken, 17 were exceeded. Novi Pazar is in first place, as the city with the highest annual average value, and Valjevo, Užice and Pancevo are also in the category with polluted air.

The most common cause of excessive air pollution in the Republic of Serbia is the presence of suspended particles, both PM_{10} and $PM_{2.5}$. Air quality plans in accordance with the Law on air protection should show a more detailed analysis of air quality and sources of pollution in those cities where it is characterized as excessively polluted.

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2. LOW-COST SENORS CALIBRATION

2.1 NEW PERSPECTIVES FOR ACCURATE AND SCALABLE CALIBRATION OF LOW COST AIR QUALITY MULTISENSOR DEVICES

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Low-Cost Air Quality Multisensor devices can represent a valid solution to the problem raised by the sparseness of regulatory grade automatic monitoring stations which constitute the backbone of current air quality monitoring networks worldwide (Schneider et al., 2017). Due to the lack of accuracy of their raw data, which is in turn due to non-linearities and non-specific response of their base sensors, they need to be calibrated in order to provide useful, high-resolution and hence actionable data for the operating entities (D' Elia et al., 2022). Unfortunately, the state of the art field calibration procedures are inherently not scalable which prevents or makes very costly the deployment and long-term operation of a hundreds-scale network of these ancillary devices. Along with research institutions, some companies are now exploring a set of technologies mostly based on IoT, Edge computing and AI technologies that appear very promising in finally providing a solution to this long-standing problem. This work will explore, review and compare, for performance and operating requirements grounds, these novel approaches which exploit OSINT data and sensors characteristics by using EU projects data, including the VIDIS project.

The work will analyse and compare modern calibration methodologies including Remote Calibration (Miskell et al., 2019) and Global Calibration (De Vito et al., 2024) comparing it with standard vendor-based calibration and the state of the art field calibration methodologies. Operative needs of the above-mentioned approach will be reviewed, highlighting strengths and weaknesses of each. For Remote calibration, both moment matching and data truncation approaches will be proposed and tested. By exploiting a multi-seasonal dataset featuring 30 field deployed multisensory devices, the techniques will be compared in term of basic performance indicators for the estimation of concentration of both particulate matter and concerning pollutants including NO_2, O_3, CO (De Vito et al.). An overview of the performance obtainable in multiple seasons will be given for each methodology with different choices of the relevant parameters. Suggestions will be explored for an architectural overview for their implementation. Perspectives for new approaches to the model selection problem will be also given with a specific focus on modern deep-learning approaches including Graph Neural Network which appear promising for both calibration and high spatial resolution measurements data interpolation (Ferrer et al., 2021; Robin et al., 2022).

New methodologies can effectively provide accurate concentration estimations simultaneously reducing the inherent calibration and maintenance cost by orders of magnitude. This will make it possible to implement the deployment of hundreds of devices in both operational and research settings. However, they need careful evaluation of the operating scenario in order to adequately exploit the available sources of data. For remote calibration methodology, for example, results will show that adequate choice of the remote station and data pre-processing steps are crucial to obtain adequate quality levels for the concentration estimation problem.

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2.2 LEVEL OF AGREEMENT (VARIABILITY) OF PM10 AND PM2.5 DETECTED WITH EQUIVALENT V.S. LOW-COST MONITORS INSTALLED IN FOUR MUNICIPALITIES

D. Kleut (1), D. B. Stojanović (1), M.Davidovic (1), A. Bartonova (2), S. De Vito (3), Z. Ristovski(4) , M. Jovašević-Stojanović (1)

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Among the other pollutants in air, particulate matter with diameter less than 10 μm (PM_{10}), 2.5 μm ($PM_{2.5}$) and even smaller fractions of PMs has posed one of the major threats to public health worldwide (Li, 2018). To evaluate the effects of air pollution on human health, proper exposure assessment methods are needed. Therefore, monitoring networks which are usually operated by governments, were commonly used as a source of reference data in low-cost sensor investigations (Lin, 2017, Jiang Y. et al, 2021) due to their reliability and continuous operational capability. However, a comprehensive understanding of measurements remains difficult because these stations are generally sparsely distributed within large areas,leading to ignorance of spatial variance of air pollutants concentrations (Du, 2019).

In this investigation, in 4 cities in Serbia (Čačak-C, Užice-U, Kosjerić-K and Novi Pazar-NP), PM_{10} and $PM_{2.5}$ were monitored by an equivalent Optical Particle Sensor (OPS), Grimm EDM 180, installed at an automatic monitoring station (AMS) belonging to the air quality monitoring state network. Recorded concentrations were compared with those obtained at 3 locations in each of the above cities with low-cost sensing devices. Actually, pollutants were monitored with KlimerkoPro devices equipped with low-cost OPS (Plantower PMS7003) in three schools in each of the cities, during the period May 2022-January 2023. We evaluated the performance of PM low-cost sensors with PM equivalence monitors installed at AMS station on the dataset using coefficient of determination (r^2) and index of agreement (IA) (Jiang et al, 2021). IA varies between 0 and 1, and higher value indicates better agreement between compared monitors. Recently, Jiang et al. (2021) used IA as one of the indicators for low-cost (LC) sensor accuracy in calibration procedure of collocation next to the reference monitors. In this study we used IA as an indication of agreement/variability of PM_{10} and $PM_{2.5}$ levels detected with low-cost sensors installed far-off AMS, at distances lying between 150 m (Užice) and 12 km (Kosjerić municipality).

Input data collected with low-cost sensors in this work have been a part of a larger study where 135 units of KlimerkoPro were deployed in three schools each in 15 municipalities. Input data collected with equivalence PM monitors are an open data download from the Serbian Environmental Protection portal, http://www.sepa.gov.rs/ . However, only four of fifteen municipalities have been equipped with AMS where PMs were detected. This situation gives us opportunity to check how data from AMS are comparable with data collected with PM LC sensors in selected cities. Based on obtained levels of IA and r^2, we can prove that the KlimerkoPro measurements offer useful information about PM pollution in parts of Serbia where there is a lack of such information. In this case, in these four municipalities it is identified that IA at monthly level is distributed between 0.20 and 0.99, but mostly very high, particularly for $PM_{2.5}$ where 45% of IA lies between 0.82 and 0.96.

Obtained results are excellent indicator of both agreement of PM levels but also of variability due to differences in local sources as well as orography.

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2.3 THE VIDIS LOW-COST SENSOR NETWORK DEVELOPMENT: IMLEMENTATION IN THE CITY OF NOVI SAD

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Air quality monitoring sensor networks coupled together with advancements in miniaturization of particulate matter and other sensors enable a cost-effective paradigm shift in way in which air pollution is accessed. Compared to the traditional ways of monitoring of air pollutants low-cost sensor networks provide a number of advantages. Increased accessibility due to near real time data available from sensors, increased spatial resolution due to possibility to deploy larger number of network nodes while simultaneously being cost effective and more simple deployment and maintenance procedures. Regional (1 station), national (2 stations) and local networks (4 stations) in the city of Novi Sad have 7 stations in total (Davidović et al., 2021), however only automatic monitoring station Rumenačka, which is a part of national network, measures particulate matter fractions PM_{10} and $PM_{2.5}$ with 1 hour temporal resolution. This illustrates clear advantage of low-cost sensor network approach which can produce data with ~1 minute temporal resolution. However, particle matter (PM) pollution data reported by the sensor network need not only be accessible but also reliable, highlighting the need for a rigorously science-based metrological assessments of sensor networks (Saverio De Vito et al., 2023). This involves assessing the propagation of measurement uncertainty, overall performance evaluations, and a new approach to utilizing information and data regarding individual sensors and their interactions within the network to establish an adequate metrology system for particulate matter air pollution.

In the current implementation, Vinča deployed sensor network in the city of Novi Sad spans the area of ~50 km^2. Sensors are placed at 10 locations, each with redundancy in terms of the number of sensors, and accuracy can be quantified in accordance with the long-term calibration campaign which sensors were subjected to before deployment. In addition to the particulate matter fractions (PM_1, $PM_{2.5}$, and PM_{10}) each sensor network node is also equipped with sensors for temperature, humidity, and pressure. All sensors are housed in a 3D printed casing, equipped with a fan which actively promotes air flow through the sensors, thereby enhancing the device's response time. The device also incorporates a built-in GPS module that continuously records its location, allowing the VIDIS device even to be used for mobile monitoring in the future. Storage of time-series data produced by sensors was facilitated (Naqvi et al., 2017) via InfluxDB time-series database.

Having an oversight of sensor network accuracy is not a simple endeavour. Several procedures were conducted in order to ensure proper functioning of the deployed network nodes, and to determine sensor properties regarding particulate matter measurements. Firstly, common colocation before deployment was performed in order to verify functionality of all devices before their integration into the network. During the deployment, short term colocation with laboratory-grade instruments was performed by collocating selected network nodes with high-quality laboratory instruments at various locations. Redundancy and stability of the sensors monitoring is facilitated and can be inspected by using transfer of calibration with pre-calibrated low-cost devices. Finaly, short term colocation with reference station was performed for additional verification of measurement accuracy and to keep track of the possible calibration location – deployment location mismatch.

Acknowledgments
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2.4 LOW-COST COMMERCIAL SENSORS FOR AIRBORNE PARTICULATE MATTER: A SIMPLIFIED LABORATORY PERFORMANCE EVALUATION

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Low-cost commercial particulate matter sensors (LCPMS) have emerged as a promising tool for widespread air quality monitoring. However, their performance and reliability need to be thoroughly evaluated before widespread adoption.

The scientific literature is rich in articles on the performance of miniaturized and economical PM sensors. This has led to a need for laboratories equipped to evaluate these devices as they come onto the market, as well as to propose new technological approaches for the measurement of atmospheric particulate matter (Alfano et al. 2020).

Deploying affordable PM sensors requires significant effort to ensure the reliability of their data. These sensors must be calibrated with reference instruments and fully characterized under a variety of environmental conditions. Therefore, developing characterization chambers in the laboratory is essential for facilitating realistic testing in a controlled environment.

The laboratory characterization phase, under controlled environmental conditions and pollution levels, allows for the evaluation of the performance of low-cost sensors before their field deployment and the assessment of possible differences in their responses within the same family of LCPMS. This latter assessment is particularly relevant for their application in sensor networks (Carratù et al. 2020).

In general, an airborne particulate chamber consists of three main sections:

Test chamber (TC): This chamber is isolated from the external environment and equipped with a PM reference instrument, as well as humidity (RH) and temperature controls.

Purified air system: This system is required to provide clean reference air into the TC.

PM generator: This generator ensures a controllable PM concentration within the TC.

Thanks to funding from the S.A.L.V.O. project (National Programs (PON) of the Italian Ministry of Economic Development (MISE), grant number B48I20000050005 - Prog n. F/190012/01/X44), we were able to equip a laboratory for the controlled study of these devices and develop many years of experience in the study of compact sensors for atmospheric PM.

This paper presents a simple but effective apparatus for testing PM sensors in the laboratory. We have installed all the necessary instrumentation in a 500Lt plexiglass box. The box is located in a room with filtered and climate-controlled air.

We will show the behavior of several commercial devices and compare the results with what the literature offers in order to better evaluate the accuracy of our measurements and the limitations and potential for the use of our equipment.

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2.5 DEPLOYMENT AND EVALUATION OF NETWORK OF OPEN LOW-COST AIR QUALITY SENSOR SYSTEMS

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Low-cost air quality sensors have the potential to complement the regulatory network of air quality monitoring stations, with respect to increased spatial density of observations, however, their data quality continues to be of concern. Here we report on our experience with a small network of open low-cost sensor systems for air quality, which was deployed in the region of Stavanger, Norway, under Nordic winter conditions. The network consisted of AirSensEUR sensor systems, equipped with sensors for fine particulate matter. The systems were co-located at an air quality monitoring station, for a period of approximately six weeks. A subset of the systems was subsequently deployed at various roadside locations for half a year, and finally co-located at the same air quality monitoring station again, for a post-deployment evaluation. The co-location results indicate a good inter-unit consistency, but poor average out-of-the-box performance ($R2 = 0.25$, $RMSE = 9.6\ \mu g\ m{-}3$). While Köhler correction did not significantly improve the accuracy in our study, filtering for high relative humidity conditions improved the results ($R2 = 0.63$, $RMSE = 7.09\ \mu g\ m{-}3$). A post-deployment co-location showed a slight and significant decrease in inter-sensor consistency for fine particulate matter. Our study provides valuable insights on the operation and performance of an open sensor system for air quality, particularly under challenging Nordic environmental conditions.

3. PM LCS NETWORKS

3.1 ONE-YEAR DATA EVALUATION OF LOW-COST SENSOR NETWORK FOR ATMOSPHERIC PARTICULATE MATTER MONITORING IN 15 MUNICIPALITIES IN SERBIA

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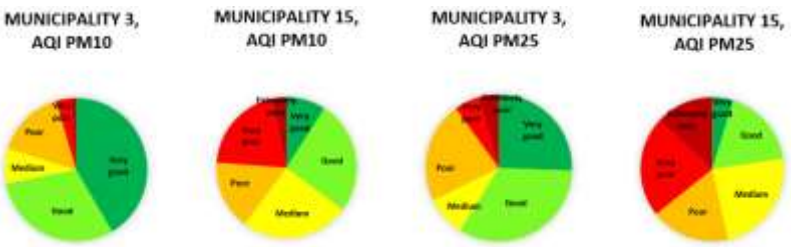
Performance of low-cost sensors varies spatially and temporally, as it depends on the atmospheric composition and the meteorological conditions. Actually, the performance varies from sensor to sensor, which makes it necessary to examine the data quality of each node before its use (Castell, 2017). By connecting a set of sensors into the network, air quality information can be transmitted to the community in the near to real- time as well as to analyse data over larger area. In this way, larger, richer, and more opened data information can be obtained and used not only for mapping of the pollutants, but also for identifying the sources, tracking changes, and predicting extreme air quality events (Mao, 2019). In addition, different approaches to complement data from low-cost sensors in air quality models have been proposed to increase spatial and temporal resolution (Ahangar, 2019).

In this investigation, the low-cost sensor (KlimerkoPro) network includes 45 devices in 15 municipalities in central and western Serbia (the basins of two rivers: Velika Morava and Zapadna Morava). KlimerkoPro devices equipped with low-cost OPS (Plantower PMS7003) were deployed in three schools in each of the cities, in the period: April 2022-March 2023. We present results for every municipality and compare them with the other municipalities within the network and we discuss the results obtained for specific schools and compare them with the other locations within the same city. Air quality was examined by observing PM_{10} and $PM_{2.5}$ at all sites in each of 15 municipalities and described through monthly and yearly statistics with air quality index (European Air Quality Index - AQI).

At figure bellow it is presented examples of yearly distribution of 24h AQI, for both, PM_{10} and $PM_{2.5}$, in two representative municipalities with different levels of registered PM pollution. Municipality 3 had mostly good and very good AQI for both PM fractions, while for same period for Municipality 15 AQI for $PM_{2.5}$ was mostly poor.

EEA 24h AQI	PM10 $\mu g/m^3$	PM2.5 $\mu g/m^3$
Very good	0-20	0-10
Good	20-40	10-20
Medium	40-50	20-25
Poor	50-100	25-50
Very poor	100-150	50-75
Extremly poor	150-1200	75-800



PM10 and PM2.5 annual average values exceeded limit values of 40 $\mu g/m^3$ and 25 $\mu g/m^3$ respectively in majority of municipalities. In almost all municipalities' most polluted months were during winter period.

Acknowledgments

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3.2 COMPARISON OF PM LOW-COST SENSOR NETWORKS: UNICEF PILOT NETWORK IN SCHOOLS IN WESTERN SERBIA V.S. NOVI SAD NETWORK

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Sensor networks represent the basis for many areas of positive and sustainable development, enable affordable and effective digital transformation, and have diverse set of possible applications that range from strictly regulated areas all the way to the "Internet of Things". Sensor networks in general, and sensor networks for air pollution monitoring in particular, offer new opportunities in metrology, such as co-location, on-the-fly calibration and self-calibration of measuring instruments, as well as detection and monitoring of fluctuations and pollution episodes that are based on rapidly available data. Such networks are especially usefull when spatial coverage provided by national, regional and local networks is sparse, can complement data obtained in mobile monitoring campaigns and enable insights into the current state of air quality, which would not be otherwise possible.

Vinča Institute recently participated in calibration (and related metrology aspects) and deployment of two air quality low cost sensor networks, namely UNICEF pilot network in schools in Western Serbia, and air quality network in Novi Sad deployed within the project "Mapping particulate matter air pollution in near-real time in Novi Sad using data from sensor networks and statistical/physical modeling" (City Administration for Environmental Protection Novi Sad project no. VI-501-2/2022-35в-11). Before that, our research team conducted an extensive mobile monitoring campaign in Novi Sad in 2022 heating and non heating season. The two LCS networks enable monitoring of several air quality parameters, and in this work we focus on particulate matter concentration. The deployment goals of the UNICEF and Novi Sad network were somewhat different. UNICEF pilot network deployment goals were to monitor outdoor air quality in schools in Western Serbia, and 15 selected municipalities in Western Serbia had collocated low-cost devices (3 in total) deployed in outdoor environment of selected schools within the municipality. Novi Sad network was on the other hand city wide, and each of the 10 deployment locations had collocated low-cost devices (2 in total in each location).

Figure 1. a) 15 municipalities that participated in the UNICEF pilot project (blue) and the city of Novi Sad (red) b) Sensor locations within the network of the Vinča Institute (blue marker), the network of the Institute for Public Health of Vojvodina (purple marker) and AMS Rumenačka (white marker). Solid lines represent mobile monitoring routes

Averages in analysed periods of 2022/23 were compared, agregated for the selected municipalities in Western Serbia and the city of Novi Sad. In addition to the data from low-cost sensor networks, data obtained in mobile monitoring campaign conducted in the city of Novi Sad during 2022 were also aggregated and compared.

Acknowledgments This work was financially supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia, Grant No. 451-03-47/2023-01/200017; City Administration for Environmental Protection Novi Sad project no. VI-501-2/2022-35в-11; the European Union's Horizon Europe Research and Innovation program under GA No.101060170, WeBaSOOP and Horizon 2020 Research and Innovation program under GA No. 952433, VIDIS project.

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Web portal of the Novi Sad project (https://vidis-project.org/index.php/about/vidis-synergistic-projects)

3.3 ENHANCED MONITORING OF RESIDENTIAL WOOD COMBUSTION PM2.5 EMISSIONS IN NORDIC CITIES USING LOW-COST SENSORS

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Residential Wood Combustion (RWC) is a prevalent household heating source in Nordic countries, posing substantial air quality concerns due to fine particulate matter (PM) emissions containing health-detrimental polycyclic aromatic hydrocarbons (PAHs). The research indicates that RWC contributes to 50–80% of household heating PM2.5 emissions in Nordic areas, a significant environmental issue (Kukkonen et al. 2020). Conventional air quality monitoring techniques fail to capture the Localized impacts of RWC adequately. This study employs airly low-cost sensor systems (Airly-GSM-1; https://airly.org/en/) to monitor PM2.5 induced by RWC in Kristiansand, Norway, during winter, supplementing traditional air quality monitoring methods. Data from additional Nordic Cities Stored on NILU's Sensor Data Platform (https://nordicpathlive.nilu.no/) were used to validate the sensor data technology, part of the broader NordicPATH project (Nordic Participatory, Healthy, and People-Centered Cities; https://nordicpath.nilu.no/) aiming for healthier Nordic cities. A five-step data processing scheme was used to calibrate network data, which was then integrated with the uEMEP air quality model through data assimilation techniques to produce high-resolution air quality maps at a 100m scale. Leave-one-out cross-validation confirmed that this approach substantially improved the model's accuracy, reducing RMSE, MAE, and bias by 44-56%, 38-48%, and 41-52%, respectively. This study extensively examines the commercial Airly sensor system for capturing the spatiotemporal variability of RWC-induced air pollution, thereby enhancing our understanding of its public health impacts.

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3.4 A LOW-COST SOLUTION FOR MOBILE AIR QUALITY MONITORING

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Air pollution is a global concern as the exposure to air pollutants is directly linked to adverse health effects (WHO, 2013). Citizens are exposed to high levels of air pollutants being essential to develop urban management strategies.

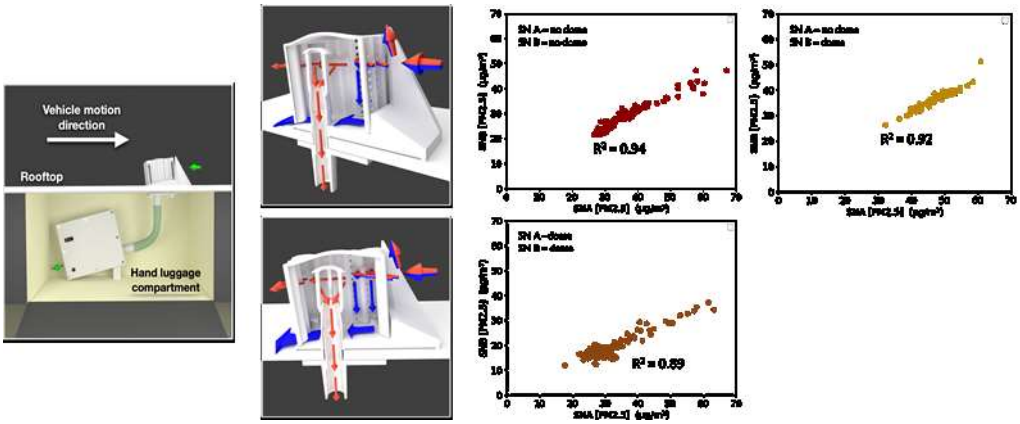
Traditionally, air pollution is monitored using static air quality (AQ) reference networks, which are reliable but sparsely installed due to the high costs. Low-Cost Sensors (LCS) can complement the reference data and produce high resolution AQ maps to identify hotspots, emission sources, among others. Typically, LCS are installed in static conditions but n in motion they can characterise AQ with a high spatio-temporal detail.

The ExpoLIS project aimed to characterise urban AQ in order to support urban management policies, inform and raise awareness among the citizens and, ultimately improve the AQ levels in cities. In this context, we have developed a non-static AQ LCS network that monitors the concentrations of particulate matter, carbon monoxide and nitrogen dioxide. This system can be installed in any vehicle, such as in public buses.

Although there are advantages to monitoring AQ in motion, it is usually associated with poor quality LCS readings due to the air movement (due of motion) and to the interference of the weather (e.g. rain). We developed a structure to be installed in the vehicle with a protection in the air inlet, to which we called the dome (Figure 1). This structure protects the system from the effect of wind, moisture or dust while maintaining the quality of the readings.

To assess the ability of the system to monitor AQ in motion, we evaluated the dome system in static conditions and in motion. We then evaluated the ExpoLIS system (LCS and the dome) in motion in a controlled test. Results show that the use of the dome did not reduce the ability of the LCS to measure PM concentrations (Figure 2). Furthermore, a second test showed that the ExpoLIS system can produce reliable AQ data in motion.

In conclusion, this study has shown that the ExpoLIS System can be efficiently used in mobile applications. The data produced is suitable for providing detailed urban AQ information, supporting urban planning policies, informing the citizens and making them aware of the lack of AQ they are exposed to on their daily commute routes.



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3.5 MAPPING PARTICULATE MATTER POLLUTION USING LOW-COST SENSOR NETWORK: NOVI SAD CASE STUDY

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Air pollution due to respirable particles has rightfully received increased attention in recent years, compared to other air pollutants, both in indoor and in outdoor environments. In 2013, the International Agency for Research on Cancer (IARC) categorized ambient air pollution, particularly air pollution stemming from respirable particles, as Group 1 carcinogenic substances — substances proven to be carcinogenic to humans. Annual average concentrations of fine particles with an aerodynamic diameter of less than 2.5 micrometres ($PM_{2.5}$) are several times higher than the World Health Organization guidelines in many European cities. Furthermore, the WHO Air Quality Guidelines (AQGs) for 2021 recommend an annual mean concentration of $PM_{2.5}$ not exceeding 5 $\mu g/m^3$. In contrast, the corresponding WHO AQGs for 2005 set the value for $PM_{2.5}$ at 10 $\mu g/m^3$. Monitoring outdoor ambient air quality typically occurs through national and local networks. Despite the high-quality instrumentation they employ, these networks are often sparse, may lack comprehensive parameter monitoring and temporal resolution, and offer limited insights into personal exposure. In specific situations where rapid deployment and enhanced temporal resolution are of more interest, IoT (Internet of Things)-enabled low-cost sensors can offer valuable complementary data (Davidović et al., 2021). By interpolating particulate matter concentrations obtained from a low-cost sensor network, it is possible to create air pollution maps. This work will use data obtained during realisation of the project "Mapping particulate matter air pollution in near-real time in Novi Sad using data from sensor networks and statistical/physical modelling" (City Administration for Environmental Protection Novi Sad project no. VI-501-2/2022-35в-11), to determine the performance of spatial interpolation (Kitanidis, 1997; Murphy, 2014).

The Vinča Institute recently participated in the calibration (and related metrology aspects) and deployment of low-cost air quality network in Novi Sad. Before that, our research team conducted an extensive mobile monitoring campaign in Novi Sad in the 2022 heating and non-heating seasons. The Vinča deployed LCS network enables monitoring of several air quality parameters, and in this work we focus on particulate matter concentration. The Novi Sad network is city-wide, covering area of ~50km^2, and each of the 10 deployment locations had collocated low-cost devices (2 in total in each location). The concentrations of particulate matter at 10 deployment locations for the 2022 heating and non-heating seasons within a certain buffer radius are known, based on a mobile monitoring campaign, and are compared to the interpolated sensor network output. Variogram fitting and kriging interpolation was performed using PyKrige (Murphy, 2014), and leave-one-out-cross validation was conducted.

Based on the created concentration maps of particles in the area of Novi Sad, particularly at specific locations and parts of the city where increased concentrations have been identified, it will be possible to compare the number of healthy individuals and those with chronic obstructive pulmonary disease (COPD) who spend most of their time at the observed locations. This opens further avenues for research into the levels of ultrafine particles (UFP) in the indoor environment and the assessment of the exposure of the citizens of Novi Sad to respirable particle fractions depending on the intensity and type of individuals' activities.

Acknowledgments

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4. VIRUSES TRANSMISSION AND PROTECTION

4.1 WHAT IS CRITICAL FOR THE SURVIVAL OF AIRBORNE VIRUSES

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The transmission of respiratory viruses has gathered increased public and scientific attention, particularly in light of the SARS-CoV-2 pandemic. While there was an ongoing debate at the beginning of the pandemic on the role of airborne transmission, the scientific evidence collected so far strongly supports that the airborne route us one of the dominant mechanisms of respiratory virus transmission. The effectiveness of airborne transmission of respiratory viruses hinges on the survival rate following aerosolization. Once exhaled into the atmosphere, within respiratory fluid droplets, viruses are exposed to various atmospheric conditions. Understanding how factors such as temperature, relative humidity, atmospheric oxidants, light, etc., impact the survival of airborne viruses is crucial for effectively managing the spread of infectious diseases.

Once airborne, these viruses aren't freely suspended but rather enclosed within particles formed from the fluid in which they multiply—respiratory fluid. Consequently, the chemical and physical characteristics of the microenvironment within respiratory aerosols play a crucial role in defining the infectivity of airborne respiratory viruses. It is critical to understand the interaction between the properties of respiratory particles (protein content, acidity, salinity, etc.) and the atmospheric conditions (temperature, relative humidity, etc.) they encounter. This understanding is essential for developing insights into the survival of airborne viruses and, consequently, for effectively controlling the spread of respiratory diseases.

A comprehensive examination of the current understanding of factors impacting the transmission of airborne viruses will be provided, along with recommendations on utilizing this knowledge to control the spread of diseases.

4.2 RISKS AND CONSEQUENCES OF *COXIELLA BURNETTI* AEROSOL TRANSMISSION

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Q fever is globally distributed zoonosis with large number of reservoirs caused by *Coxiella burnetii*, an obligate gram-negative, highly infectious intracellular bacterium that can remain viable and virulent for months in the environment, animal products and contaminated dust as well as in aerosol droplets. Ticks can also be infected with *C.burnetti*. The bacterium is considered as a potential biological weapon as well as a serious occupational hazard. In animals, the disease is mostly asymptomatic, but it can cause abortions and stillbirths (Honarmand, 2012). Human infection can be acquired via inhalation or skin contact with contaminated products and usually appears in acute form as flu-like disease or acute pneumonia, but in rare cases it becomes chronic with possible fatal endocarditis especially in patents with pre-existing heart valve disease (Dragan and Voth, 2020). Serological tests based on detection of Class I and II IgM and IgG antibodies are mainly used in routine laboratory practice. Considering the importance of *C.burnetti* in human and veterinary medicine, as well as being a bio-threat, and its increasing incidence among patients with COVID-19 (Park et al, 2021) and in post-Covid patients, it is necessary to improve permanent monitoring of its presence. This includes the use of molecular detection methods in aerosols in field and laboratory conditions and mathematical modelling of its spread, because the bacterium could travel long distances in air before entering other hosts. This is an important investigational task requiring optimization of aerosol sampling procedures (Abeykon et al, 2022) as well as DNA extraction, concentration and quantification methods. Consideration needs to be given to the fact that *C.burnetti* has a really complex genetic structure, and the difficulty of working with animal models due to their inability to adequately mimic human infection (Park et al, 2021).

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4.3 PANDEMIC RESPONSE: A NEW PARTICLE FILTERING RESPIRATOR PERFORMANCE STANDARD FOR CANADA

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Strong demand for respirators at the start of the Covid-19 pandemic encouraged new manufacturing operations in Canada. Canadian legislation requires regulatory approval for all respirators used in workplaces: historically the US National Institute for Occupational Safety and Health (NIOSH) has been the accepted approval body. Extra demand on NIOSH, and its prioritization of US needs, caused long approval times for Canadian manufacturers. This challenged respirator availability for healthcare needs at a critical time.

To aid supply, in August 2020, Health Canada issued a temporary specification and began to approve certain respirator types for healthcare use. Work also started by CSA Group on a respirator performance standard as part of a new Canadian certification system. An expert technical committee from manufacturers, regulatory, occupational health and user groups began work in October 2020, resulting in a new standard in October 2021: CAN/CSA Z94.4.1 “Performance of Filtering Respirators”. The new certification system covers products only for Canada and applies in parallel with NIOSH approvals, so existing manufacturers are unaffected.

Product classifications are similar to NIOSH, but there are some new requirements, plus features and terminology imported from other standards (European, ISO). New aspects include quantitative fit testing using a human subject panel for all respirator types, comfort assessment and breathability classification, shelf-life indication and tests for biocompatibility and strap strength.

The first edition of the standard only addresses particle filtering respirators, but it is planned sequentially to expand to all types. The new certification system is now in effect and managed by CSA Group.

4.4 THE SIZE DISTRIBUTION OF SARS-COV-2 GENETIC MATERIAL IN AIRBORNE PARTICLES SAMPLED IN HOSPITAL AND HOME CARE ENVIRONMENTS OCCUPIED BY COVID-19 POSITIVE SUBJECTS

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Expiratory human activities such as coughing, sneezing, and speaking generate a large size spectrum of respiratory particles which size can range from the sub-micrometric range to several hundreds of μm (Morawska et al., 2009; Nazaroff, 2022). The aerodynamic diameter is an important parameter for airborne particles since it can serve as a vector of pathogens which could be carried away by air currents or air jets (Bourouiba, 2020). Characterizing the size distribution of airborne particles carrying SARS-CoV-2 virus is essential for understanding and predicting airborne transmission and spreading of COVID-19 disease in hospitals as well as public and home indoor settings. Nonetheless, few data are currently available on virus-laden particle size distribution. Therefore, the aim of this study is reporting the total concentrations and size distributions of SARS-CoV-2- genetic material in airborne particles sampled in hospital and home environments. A nanoMOUDI R122 cascade impactor (TSI, USA) was used to collect size-segregated aerosol down to the sub-micron range in home and in three different hospital environments in presence of infected patients in order to provide the concentration of airborne SARS-CoV-2 genetic material for each particle size range at different sampling locations. Providing one of the largest datasets of detailed size-fractionated airborne SARS-CoV-2 RNA to date, we found that 45.2 % of the total sub- and super-micrometric fractions were positive for SARS-CoV-2 with its genetic material being present in 17.7 % of sub-micrometric (0.18–1 μm) and 81.9 % of super-micrometric (>1 μm) fractions. The highest concentration of SARS-CoV-2 genetic material in total suspended particles (5.6 ± 3.4 RNA copies m^{-3}) was detected in the room occupied by patients with more severe COVID-19 symptoms, collected during the patients' high flow nasal oxygen therapy. The highest concentration at certain particle size fraction strongly depends on the sampling environment. However, the contribution of SARS-CoV-2 genetic material was in favour of super-micrometric compared to sub-micrometric particle size range. The evaluation of the individual risk of infection was carried out on the basis of the obtained data considering a hypothetical exposure scenario. The results obtained indicate the necessity of protective masks in the presence of infected subjects, especially while staying for longer periods of time in hospital environments.

This study was supported by the Foundation of Croatian Academy of Sciences and Arts (project: Evaluation of airborne SARS-CoV-2 transmission and size-distribution in the primary respiratory-intensive care centre for the treatment of COVID-19 positive patients), Croatian Science Foundation (IP-2018-01-3105: Biochemical responses of oligotrophic Adriatic surface ecosystems to atmospheric deposition inputs, BiREADI) and European Regional Development Fund (project: AIRQ - Expansion and Modernization of the National Network for Continuous Air Quality Monitoring).

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5. HEALTH ASPECTS OF ATMOSPHERIC PARTICULATE MATTER I

5.1 BETWEEN MAN AND TECHNOLOGY: ADDRESSING IAQ IN NORWEGIAN SCHOOLS

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At least 80 % of our time is spent in buildings (Klepeis et al., 2001; Schweizer et al., 2007) that are globally responsible for 30% of energy use and 37% of CO_2 emission (UNEP, 2022). Buildings are the low-hanging fruit for energy efficiency, addressed through stricter international codes for building envelopes and ventilation. These codes do not specifically consider wellbeing, productivity, and health, but this in many instances is a concern for the building owners: how shall they balance the need for energy efficiency with the need to provide a safe and healthy environment, and not least, how should they assess if the environment is safe and healthy?

Data on indoor air quality (IAQ) are limited and suffer from little-defined data collection procedures: there are no overall regulations on what levels are to be achieved, and thus, no agreed procedures as to how the compliance is to be assessed. There are many possible candidate indicators for IAQ, including several kinds of temperature, humidity, air pollutants (including CO_2, particulate matter, and volatile organic compounds), biological pollution (e.g., viable spores of molds), and more technical parameters such as air exchange rate. Emissions indoors are also difficult to evaluate: they depend on activities, occupancy, or materials chosen in the building process or for interior equipment. And not least, the available information comes from multitude of uncoordinated sources: building management systems, additional monitoring such as using low-cost sensor devices, or the occupants themselves.

The largest owner of buildings in the public sector, the Oslo Municipality, had initiated a research and innovation project to develop a tool that would allow the municipality to effectively address the IAQ in schools. The project ests on a combination of three data sources: data from data management systems, data from IoT low-cost sensor devices, and perceptions of the building occupants. If a predictive model could be developed based on these three data sources, this could be used for a more effective and health relevant management of the IAQ in schools.

Is it at all possible to achieve? While relevant technologies exist, can they be applied in one and the same building? And will the resulting data lead to a reproducible outcome? There are still more questions than answers. First experiences show – perhaps not surprisingly – that data management systems are an underused resource for data mining for a very good reason: there is no standardization of protocols, the data repositories are proprietary, data ownership is spread across owners, and not least, nobody has been asking for such data! Further, while there are suitable low-cost monitoring systems for indoor use, similar to other sensor systems, the data flows to users have to be established which is a challenge if more than one unit is involved: there is a need to develop their own system. And data that would provide information about the perceptions of occupants? Occupant voting systems do exist and have been used in office buildings (Khan et al. 2020) – can they be developed for assessment of health and well-being, e.g., at schools?

We will share our first experiences from working in Norwegian schools towards developing a knowledge-based IAQ management system that takes regard not only of the technical data but also of the school occupants, highlighting the main challenges and barriers towards development of an indoor air quality monitoring and management system for use in schools.

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5.2 PARTICLES AND CHEMICALS IN OUTDOOR AND INDOOR AIR: IN VITRO TOXICITY AND HEALTH EFFECTS

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The exposure to chemicals and their effects on human health is becoming an increasingly important topic in European and national policy development, and recent chemical regulations and initiatives like Green Deal and the Zero Pollution strategy aim at a non-toxic environment. Air pollution is known as a main cause for the onset of adverse health outcomes in Europe and in the world. In 2019 WHO estimated outdoor air pollution to cause 4.2 million premature deaths worldwide, mainly in relation to exposure to particulate matter (PM), causing respiratory and cardiovascular diseases and cancer (WHO, 2022). As we spend most of our time in indoor environments, indoor air quality, despite having received less attention compared to the outdoor, is also of crucial importance for our health. Wood burning, the use of materials and products, and indoor activities such as cooking, are the main sources of compounds of possible concern for our health. These include persistent, bio-accumulative, and potentially toxic compounds such as flame retardants and plasticizers, which have been connected to developmental, reproductive, neurological, and immune effects in humans. While epidemiological studies can (and have) highlight(ed) the association between exposure to (outdoor) air pollution and the onset of adverse health effects, toxicological investigations support these associations providing evidence of the molecular and biological mechanisms underlying these effects. Besides, within the highly heterogeneous mixture of air pollutants, the identification of the specific compounds and physico-chemical properties responsible for the adverse outcomes on human health is of crucial importance also in a regulatory perspective. Toxicology coupled with analytical chemistry provides a powerful tool to tackle this issue. Here an overview is given about the complex topic of outdoor and indoor air pollution and the related health effects, and how (in vitro) toxicology has addressed and can address this topic.

5.3 PARTICULATE MATTER IN HEALTH CLUBS: IMPACT OF SPORT ACTIVITY

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Regular exercise provides countless health benefits and improves overall physical and mental well-being. However, if conducted in polluted environment, the exposure to health hazardous pollutants, such as particulate matter (PM) can cause negative outcomes. During exercise, breathing rate increases, potentially leading to higher PM exposure. The elevated air flow velocity of breathing during exercise may cause transport of pollutants into the deepest part of the respiratory system, further increasing the potential risks of adverse consequences. In adition, the type of respiration (i.e. nasal vs. oral) is relevant as particle penetration into the lower respiratory tract is dependent on breathing route. Finally, the lower workout performance (due to the reduced tolerance) can essentially lead to subject discouragement and further hinder the mental benefits of exercise. In view of the limited existing data, this work aimed to evaluate the levels of particulate pollution in fitness facilities and to estimate the respective exposures during different fitness activities.

PM was monitored in 2020-2021 during group classes (n=138; across 10 fitness centres) considering four main types of classes: (i) dancing; (ii) group classes focused on whole body workouts with a defined class choreography that contained both cardiovascular exercising and strength training); (iii) body & mind classes (such as yoga and Pilates) that involved balance, strength and flexibility training; and (iv) self-defence techniques. PM mass (range: 300 nm to 25 µm) was assessed by the Lighthouse Handheld particle counter (model 3016 IAQ; Lighthouse Worldwide Solutions, Fremont, USA) while particle number counts (PNC, $N_{20\text{-}1000\ nm}$) were monitored with a TSI P-Trak™ condensation particle counter sample (model UP 8525; TSI Inc., MN, USA); logging interval was set to 1 min. The inhalation doses were estimated for five different age groups (16 – 61 yrs) using the nation-specific body weight parameters; gender-, age-, and activities-dependent inhalation rates were retrieved from US Environmental Protection Agency exposure handbook (USEPA, 2011).

The results showed that classes with vigorous human movements (i.e., activities that led to particles and dust re-suspension) resulted in the highest indoor PM as follows: self-defence (PM_{10} mean = 178.4 µg/m^3; range: 119.9 – 295.9 µg/m^3; $PM_{2.5}$ mean = 63.5 µg/m^3, range: 54.0 – 98.8 µg/m^3), being followed by dancing (PM_{10} mean = 52.2 µg/m^3; range: 6.0 – 144.5 µg/m^3; $PM_{2.5}$ mean =24.5 µg/m^3, range: 4.3 – 41.3 µg/m^3). During body & mind and body workout classes, the observed levels were lower: PM_{10} of 44.7 µg/m^3 (range: 8.1 – 179.2 µg/m^3), $PM_{2.5}$ of 27.1 µg/m^3 (range: 6.8 – 109.5 µg/m^3), and PM_{10} of 20.8 µg/m^3 (range: 5.2 – 82.4 µg/m^3), $PM_{2.5}$ of 9.1 µg/m^3 (range: 0.5 – 67.5 µg/m^3). Regarding PNC, the observed levels varied between 9095 and 9237 #/cm^3 (range: 2919 - 36650 #/cm^3) for dancing and groups workouts, while it was 7008 and 7225 #/cm^3 (range: 2168 - 28955 #/cm^3) in body & mind and self-defence. Type of the conducted activities was relevant for the inhalation exposure, with the highest magnitude of inhaled total doses (across all ages and both genders) obtained for self-defence activities, being 1.3-5.6 times higher than for others activities. These results indicate that even short-term physical activity (or more specifically its intensity) might strongly contribute to the daily inhalation dose.

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5.4 OCCUPATIONAL EXPOSURE TO PARTICULATE MATTER: CASE STUDY OF PORTUGUESE FIREFIGHTERS

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Scientific data have demonstrated strong associations between climatic and meteorological conditions in European countries and the occurrence of forest fires. While firefighting is essential for public safety, this occupation can expose workers to various hazardous pollutants (IARC, 2022), including particulate matter (PM). PM exposure is particularly significant during firefighting activities, with variations depending on the type of fire (urban, industrial, forest, etc.), the severity and duration of the event, and the utilization of personal protective equipment. Moreover, repeated exposure during the fire season adds an additional layer of complexity. The proper assessment requires, first of all understanding the baseline values of firefighters' exposure to PM. Therefore, this work aimed to assess PM_{10} and $PM_{2.5}$ exposure at Portuguese fire stations and to quantify the particle respiratory deposition of the respective workers.

The study was conducted at eight firehouses (FH) in northern Portugal during the summer of 2021. PM levels and distribution (ranging from 230 nm to 20 μm) were measured using aerosol spectrometers (model 1.108, GRIMM Aerosol Technik GmbH & Co. KG, Ainring, Germany) and a particle counter (model 3016 IAQ; Lighthouse Worldwide Solutions, Fremont, USA) with a logging interval of 1 minute. Particle deposition in the human respiratory system was simulated using a multiple-path particle dosimetry model (version 3.04, Applied Research Associates, Arlington, VA, USA), incorporating age- and gender-specific population (n=147) characteristics of each FH.

The results showed that across all firehouses, PM distributions were significantly different ($p<0.05$) but all FHs fulfilled the PM mass concentration limits set by Portuguese legislation for public spaces (25 and 50 $\mu g/m^3$ for $PM_{2.5}$ and PM_{10}, respectively, for an 8 h period; Ordinance No. 138-G/2021). Evaluating the respiratory deposition, both genders exhibited the main deposited fraction in the head region (78.5 – 99.2% for males; 73.7 – 98.9% for females), with female workers being slightly more vulnerable to higher pulmonary deposition (0.120 – 12.8% for females and 0.073 – 10.8% for males). Considering the different parts of the lungs, the highest deposited fractions were identified in the right - lower lobe (RL: 0.19 – 4.00% for males and 0.27 – 4.70% for females), whereas the lowest depositions were identified in the right – middle lobe, regardless to the gender.

Whereas all indoor PM exposures were relatively low, the chronic occupational exposures, even in small quantities, require further assessment to determine the associated health risks.

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5.5 SHORT-TERM HEALTH EFFECTS OF WILDFIRE EMISSIONS

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Climate change has been increasing the frequency and lasting drought conditions, which augment the risk of wildland fires, as evidenced by intensity, persistence and subsequent severe impacts on the environment, human health, and economy (EC 2021; IARC 2015; USEPA 2022). This study systematically gathers and provides analysis of pollutant levels emitted from wildfire and their impact on short-term health effects of affected populations.

The available literature was searched according to Population, Exposure, Comparator, Outcome and Study design (PECOS) database defined by the World Health Organization (WHO) and a meta-analysis was conducted whenever possible. Data obtained through PECOS characterized information from the USA, Europe, Australia, and some Asian countries; South American countries were seldom characterized, and no data were available for Africa and Russia. Extremely high levels of pollutants, mostly of fine fraction of particulate matter (PM) and ozone, were associated with intense wildfire emissions in North America, Oceania, and Asia and reported to exceed several-fold the WHO guidelines. Adverse health outcomes include emergency department visits and hospital admissions for cardiorespiratory diseases as well as mortality (Augusto et al., 2020; Cascio, 2018; Oliveira et al., 2019). Despite the heterogeneity among exposure and health assessment methods, all-cause mortality, and specific-cause mortality were significantly associated with wildfire emissions in most of the reports. Globally, a significant association was found for all-cause respiratory outcomes including asthma, but mixed results were found for cardiovascular-related effects. For the latter, estimates were only significant several days after wildfire emissions, suggesting a more delayed impact on the heart (Barros et al., 2023).

Different research gaps were identified, including the need for application of standardized protocols for assessment of both exposure and adverse health risks. Mitigations actions also need to be strengthened, including dedicated efforts to communicate with the affected populations, to engage them for adoption of protective behaviours and measures.

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5.6 APPLICATION OF DITHIOTHREITOL (DTT) ASSAY – CONSISTENCY OF PROTOCOLS FOR DETERMINATION OF THE OXIDATIVE POTENTIAL OF AMBIENT PARTICLES

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Increasing exposure to ambient particulate matter (PM) has been linked to a number of detrimental health effects. The capability of particulate matter to produce reactive oxygen species (ROS) and induce oxidative stress in biological systems has been recognized as one of the most important mechanisms of PM toxicity. Oxidative potential (OP) has been proposed as a valuable descriptor for this ability. Numerous acellular (cell-free) assays used to determine OP can be found in the literature. However, this paper will emphasize the dithiotreitol (DTT) assay, one of the most applied methods for determining OP. A significant problem in the application of this assay is the lack of a standard procedure, which makes comparing the results obtained in different studies complex. The authors of this work offer a novel procedure for carrying out this test to overcome this issue and ensure that the findings may be compared.

The experimental methodology suggested by Cho et al. (2005) has seen extensive adoption among researchers using the DTT test. Nevertheless, a few researchers have used the methodology proposed by Li et al. (2009), a modified and simplified form derived from Cho's original technique. Although most authors refer to one of these two methods, there are certain modifications in each study. Additionally, in each study, the individual steps from the extraction process to the application of the various reagents were not explained in detail or were sketchy. For these reasons, the extraction is done in different ways (various extraction techniques and use of different solvents), the concentrations of DTT and DTNB (5,5-dithiol-bis-(2-nitrobenzoic acid)) are in a wide range, or some steps in applying of this assay are omitted.

In order to enable the most accurate application of the DTT assay to real PM samples, the composition of which can vary significantly depending on the source, it is first necessary to remove potential errors that may arise due to inadequate extraction procedure and the method itself. In this paper, the authors, after a detailed analysis of the existing literature and experimentally tested conditions, propose new protocol for DTT assay. In addition, for the first time in this work, all the parameters that can affect the application of this assay are combined, and all the steps that can affect the final result of the measurement are explained in detail. This could be an excellent starting point in solving this critical issue and gaining new knowledge in this literature gap.

Current research hypothesises that many adverse health effects are derived from oxidative stress in biological systems caused by the deposition of PM into the lungs. Oxidative stress is a significant cause of toxicity generated from PM, and measuring oxidative potential (OP) in PM might be the first step in understanding this process. DTT is one of the most widely used assays for determining OP, given its relatively simple application and low reagent cost. On the other hand, comparing the results obtained with this technique is difficult due to the lack of a standard procedure. For this reason, this paper presents a new procedure proposal with detailed steps and unified conditions that can lead to potential errors originating from the method itself.

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6. INDOOR PARTICULATE MATTER

6.1 SOURCE APPORTIONMENT OF INDOOR PARTICULATE MATTER: A REVIEW

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Source Apportionment (SA) is the practice of deriving information about the emission sources of air pollutants and their contributions to air pollution. SA for indoor air pollution is challenging due to the high variability of indoor sources, the complex physical/chemical processes, and the interconnection with the outdoor environment. This study reviews our current understanding of SA for particulate matter (PM) in indoor air, through reviewing information on the modeling techniques used, the tracers used, along with knowledge gaps in this research field. This work has been conducted in the frame of INDAIRPOLLNET COST Action CA17136.

A literature search covering SA for indoor air was conducted using the Google Scholar, Science Direct, Scopus and Web of Science search engines. Literature in the English language, published between January 2009 and December 2022 was included.

Positive Matrix Factorization, Principal Component Analysis and Chemical Mass Balance were the most frequently used receptor models. The overwhelming majority of the studies used PM or dust chemical composition or PM size distribution as tracers to apportion the measured concentrations to their potential sources. The source categories revealed are as follows: i) building materials and furniture, ii) indoor combustions, iii) cooking, iv) resuspension, v) cleaning and consumer products, vi) secondary pollutants formation, and vii) other products and activities. The typical outdoor sources (traffic, long-range transport, combustion, natural sources) contribute to a differing extent to the indoor levels, due to local/regional conditions, as well as the selected SA technique.

The need for more comprehensive research on the characterization of sources, e.g., by specifying the detailed chemical profiles of sources with highly varying characteristics is underlined. A number of research gaps regarding indoor air pollution SA were highlighted, including optimization of indoor air monitoring and data selection and the incorporation of indoor air physical and chemical processes in the already developed SA methodology.

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6.2 SOURCES OF PAHS IN SERBIAN SCHOOLS DURING HEATING SEASON

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Different pollution sources emit pollutants with varying degrees of toxicity. Source apportionment allows for an understanding of the specific sources contributing to the levels of harmful substances like polycyclic aromatic hydrocarbons (PAHs). This information is crucial for assessing the potential health impacts on the exposed population. PAHs are ubiquitous environmental pollutants, and their presence in the air has raised concerns due to their potential health effects, including carcinogenicity. This study compared the performance of principal component analysis-multiple linear regressions (PCA-MLR) and positive matrix factorization (PMF) models on particle-bound and gas phase PAHs data collected in the school microenvironments in Serbia during workdays, from January 2011 to April 2012.

In order to identify and quantify the contributions of different emission sources of PAHs two methods were applied, PCA-MLR and PMF, on six datasets. Two data sets represented TSP-PAHs, the other two data sets represented gas phase PAHs, and the remaining two data sets represented total PAHs (sum of TSP-PAHs and gas phase PAHs).

The sources of PAHs estimated by the PCA-MLR and PMF models were compared and evaluated from three aspects. First, the appropriateness of the given models was evaluated based on the correlation coefficient (r^2) of predicted and measured ∑PAH concentration obtained in both models. Both models gave high correlation coefficients (>0.9), so it can be concluded that both models are satisfactory in terms of receptor modeling of PAHs. Second, the number of potential sources obtained in both models was compared. Thus, the PMF provided a greater number of sources. Third, in terms of source type identification, both models yielded somewhat comparable mean contributions of traffic and coal combustion emissions to total indoor PAHs. The contribution at PCA was 31% and at PMF 30.2% for coal combustion. Also, the contribution of traffic was 46% for PCA, while for PMF, if the contributions of gasoline, diesel and unburned fuel emissions are considered together, the total contribution of traffic was 50.8%. The PCA seems to have given more importance to traffic as the main source of PAH emissions. Also, it seems that PMF contributed more to sources such as coal and biomass burning, as well as to stationary sources, which is more realistic given that it is a heating period.

The PMF method provided much better insight into potential sources and their contributions compared to PCA-MLR. Stationary sources, coal and biomass burning were identified as the main sources of total PAHs in the indoor and outdoor environment of schools in Serbia during the heating season. Both models could be combined with other receptor models on air quality data to explore and inter-compare the outcomes, and to determine how the model results are affected by modifications to input data and model parameters.

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6.3 SPATIOTEMPORAL PATTERNS OF INDOOR AND OUTDOOR PM2.5 IN LEGIONOWO, POLAND

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Monitoring indoor air quality is of vital importance in the pursuit of creating healthier indoor environments, considering that a substantial portion of people's daily activities takes place indoors. Particulate matter with an aerodynamic diameter less than 2.5 μm (PM2.5) constitutes a significant atmospheric pollutant with well-documented adverse health effects. Indoor PM2.5 is the combined result of the internally generated and outdoor infiltrated particles. Therefore, it becomes necessary to simultaneously monitor both indoor and outdoor PM2.5 to comprehensively assess indoor air quality trends and establish an informed strategy to minimize personal exposure to PM2.5.

The main objective of this research is to analyze the spatiotemporal patterns of indoor and outdoor PM2.5 levels in the vicinity of Legionowo, Poland, a town selected as the pilot site for the "GREEN HEAT – Towards Collaborative Local Decarbonization" project (https://greenheat.kezo.pl/en/). This analysis is conducted using a network of low-cost sensors (outdoor sensor: Airly – Airly GSM, SP. Z o.o., Poland and indoor sensor: IQAir) that are maintained by local residents. PM2.5 and basic meteorological parameters such as temperature and relative humidity are measured within the participants' households. In addition to the spatiotemporal analysis of indoor and outdoor PM2.5 at different time intervals, this study evaluates two methodologies to examine the infiltration factor for quantifying the portion of outdoor PM2.5 penetrated indoors. Firstly, the infiltration factor is assumed to be equal to the indoor/outdoor (I/O) concentration ratio when significant indoor emissions are missing. In the second method, the infiltration factor is approximated to the temporally averaged I/O change under the steady-state assumption.

6.4 VENTILATED AND NON-VENTILATED SOURCES OF INDOOR DUST DEPOSITION IN A HISTORICAL HOUSE MUSEUM IN THE PIESKOWA SKAŁA CASTLE IN POLAND

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The aim of this work was to develop a resource efficient method to assess the ventilated and non-ventilated fractions of the water-soluble ions measured in total indoor particle/dust deposition. The measurements were made in the Pieskowa Skała castle museum in Krakow, Poland, with an aim also to aid to the preventive conservation efforts in the museum (Grøntoft, 2023). The work was funded as an EEA Financial Mechanism 2014-2021 project within the program "Culture" Outcome 1: "Cultural Heritage Management Enhanced". The measurements were made with low-cost passive outdoor and indoor sampling of the particle- and ion-deposition, and NO2 gas. The analysis was made by analysis of the regression values and residuals of the correlations between the outdoor measurements of the air pollution (Anda and Haagenrud, 1984; Ferm and Bloom, 2010) and the measurements of the indoor particle deposition. Seasonal values were obtained by seasonally resolved measurements.

The measures of "correlation" between the outdoor air pollution and indoor measured iondeposition was set to indicate the ventilated fraction of ions from outdoors, and the remaining measure of the "nor-correlating" residuals was set to indicate the non-ventilated fraction of ions that probably had indoor sources. The term "indication" is used to stress that such analysis is affected by unavoidable uncertainty but offers a much lower cost alternative to annual continuous measurements and chemical analysis of particles in the outdoor and indoor air. The study subsequently allowed analysis of the salt composition and a discussion of the likely sources of the identified ventilated and non-ventilated salts.

The key result from the study was that a dominating source of "soil and building dust" was found all year round, probably partly from renovation works of the castle, with larger total infiltration in the winter-spring but with a higher proportion of ventilation ingress in the summer-autumn. C. 60-80%, by mass, of the water-soluble ions in the soil and building dust were calcium- and probably some magnesium-bicarbonate (Ca (HCO3)2, Mg (HCO3)2), and about 10-20% sulfates (SO4 --) with calcium (Ca++) and several other cations. The other main source of the ion-deposition was identified as air pollution, with chloride (Cl-), sulfate (SO4 --), and nitrate (NO3 -), from outdoor combustion sources, like traffic, residential heating, and industry, mainly in the colder parts of the year (Lighty, Veranth and Sarofim, 2000; Pan et al., 2022). Fewer particles, of a different composition, penetrated to the more closed locations of the showcases, and to c. 5 m away from a, closed, window in a book room. A higher deposition and ion-fraction in the summer-autumn, of non-ventilated sulfate (SO4 --) in two showcases than just outside them in a display room, indicated a small source of sulfate (SO4 --) in the showcases. In the more closed book room, than display room, the chloride (Cl-) and sulfate (SO4 --) from combustion air pollutants were found to only be ventilated and not reside in the room. The study showed good enclosure protection of museum objects against exposure to particle pollution, but also the need to avoid the trapping of particle pollution inside showcases or closed rooms.

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7. HEALTH ASPECTS OF ATMOSPHERIC PARTICULATE MATTER II

7.1 AIR QUALITY MONITORING IN LOCAL MUNICIPALITIES-LEGAL POINT OF VIEW

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Local municipalities are bound to provide air quality monitoring on their territory in accordance with the law (law on air protection). However, many local municipalities lack technical and especially human resources, and it is often the case that only one person is responsible for all environmental issues in the municipality itself, which makes action almost impossible due to a large number of law and by-law documents, not only for air quality, but for other environmental matters as well. Such a situation results in personnel being preoccupied and not able to comprehend all of the legal acts related to environmental protection, and not having enough information and knowledge on how to perform air quality monitoring in local municipalities. For all these reasons stated above, the aim of this work is to address the key acts of laws and by-laws documents from the field of air quality monitoring.

The methodology used in this paper is a literature review. In contrast to usual scientific work, where the review of scientific literature is focused on preparation of a research report, in this work, a review of legal and by-law documents in the field of air quality monitoring was carried out. The most important articles from the literature were presented in order to create a kind of guide on air quality monitoring in local municipalities.

By creating an out-of-the-ordinary type of scientific work, a short guide is produced that includes the most important articles of the current legislation. This refers primarily to the law on air protection and the regulation on monitoring conditions and air quality requirements, targeting most important acts related to the monitoring of air quality in the local network:

• Legal obligations on air quality monitoring in the local network

• Creation of a program on air quality monitoring in the local network

• Implementation of the air quality monitoring program in the local network - monitoring must be implemented by an authorized legal entity that receives a license from the Ministry of Environmental Protection, primarily based on the actual accreditation certificate, which is accompanied by the scope of accreditation that includes all pollutants foreseen by the program on air quality monitoring in the local network.

• Application of standard reference methods or methods that have been shown to be equivalent to them, such as determination of the fraction of PM10 and PM2.5 in suspended particles (SRPS EN 12341:2015), assessment of air quality based on annual reports, preparing of air quality plans, reporting and information on air quality, adoption and application of an air quality index.

Many years of experience about the practical problems of air quality monitoring in the Republic of Serbia indicated the need to create this kind of work in order to ensure that the collected data are of appropriate quality, representing the real state of the air quality. The quality of the collected data is also very important so that they can be further used for scientific purposes such as modelling, health risk assessment and other needs.

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7.2 PARTICULATE MATTER EXPOSURE AND DOSE IN URBAN ENVIRONMENTS: AN AGENT-BASED MODELING APPROACH

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In urban environments, exposure to airborne particulate matter (PM) is a significant concern due to its potential adverse health effects. However, exposure estimates alone do not account for the amount of the pollutant that enters the human body through respiration. A comprehensive understanding can be achieved by calculating the intake dose, considering inhalation rate as minute ventilation (air entering the lungs per minute). (Greenwald et al. 2019; Novak et al. 2020). Such a dose provides deeper insights into the effects of activities, micro-locations, indoor-outdoor exposure, and personal characteristics on PM exposure.

An agent-based model (ABM) was created to provide a stochastic approach to modelling $PM_{2.5}$ exposure and assessing the dose, with the outcomes published in Novak et al. (2023). This model considers various features and characteristics, such as age and gender, and their influence on selecting activities. Results from the ABM were then contrasted with real-world data from the ICARUS project, collected with wearable PM and biometric monitors. Both datasets exhibited coinciding trends, underscoring the potential accuracy and applicability of the ABM. However, discrepancies were observed in activities with the highest mean dose values, highlighting areas for refinement in the model. The ABM was expanded to incorporate agents influencing modal decision-making, impacting intake dose. Figure 1 shows the relationship between PM2.5 dose and outdoor PM2.5 concentration in the modified ABM. While non-activist agents exhibit a linear increase in mean cumulative dose with rising PM2.5 concentrations, the divergence of lines connecting activist agents' increasing doses at higher PM2.5 concentrations underscores their pronounced influence on PM2.5 dose as pollution levels intensify.

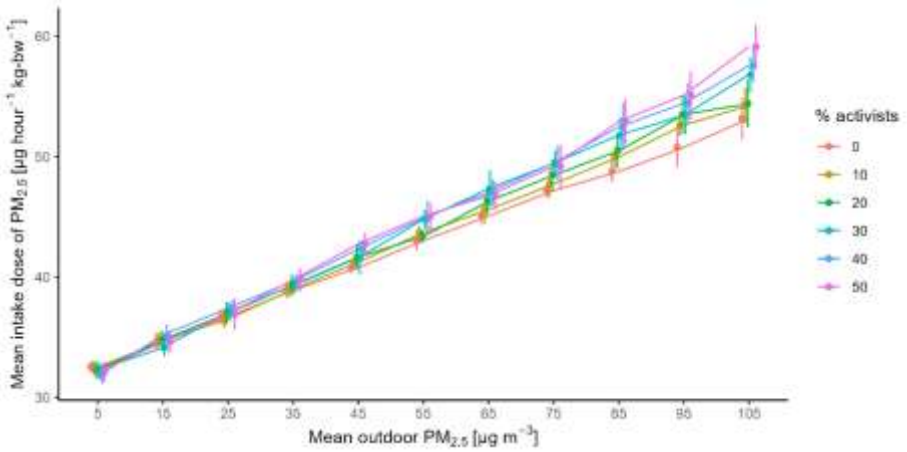

Figure 1: Average PM2.5 Dose for All Agents in the Modified ABM

Future work in the scope of the URBANOME project (urbanome.eu) will be to integrate some of the aspects explored in this study. One aim is to further validate the behavioural aspects of cyclists when choosing modality options. By using the ABM as a form of digital twin we seek to explore how behaviour, modality choices, external influences, and interactions between agents and the environment impact PM exposure and dose.

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7.3 INFLUENCE OF PM10/PM2.5 RATIO AIRBORNE PARTICLES ON HEALTH RISK IN BELGRADE

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In cities, where the population is mostly situated, there is huge energy consumption, waste emissions, and a majority of industrial and economic activities. Reducing air pollution in urban areas is set as one of the key objectives of the strategy of environmental protection in the countries of Eastern and South Eastern Europe (EEA, 2013; EEA, 2014; EEA, 2015a) as well as in our National Environmental Protection Program and National Sustainable Development Strategy. Particulate matter (PM) is a complex heterogeneous mixture whose size and chemical composition can change in time and space due to different chemical species bonded on their surfaces. PM less than 10 μm and 2.5 μm, directly affects air quality and human health. The aim of this paper was to evaluate PM10 and PM2.5 level concentration as well as PM10/PM2.5 ratio and health risk assessment in the Belgrade urban area.

Concentrations of particulate matter PM10 and PM2.5 were investigated at fourteen different stations, in the framework of local monitoring network in greater Belgrade area. Sampling was conducted daily, during 2022 (one year sampling), by automatic monitors. The obtained results have shown a high value for daily PM10 concentration, maximum value was 516,5 μg/m3 at a measurement site in Belgrade suburban region, in winter. At the same site, the concentration of PM 2.5 was 506,0 μg/m3. PM10/PM2.5 ratio was from 0.64 to 0.71 at all measurement sites. PM2.5 can provoke more severe health effects due to its small size and chemical species adsorbed on its surface which enables their penetration deep into the lungs. The Risk Assessment Information System (RAIS) was used to assess human health risk and influence on health.

8. PM SOURCE APPORTIONMENT

8.1 SOURCES APPORTIONMENT OF PM2.5 USING DISPERSION MODEL EITHER RECEPTOR MODEL IN BOSNIA AND HERCEGOVINA DURING WINTERS TIME FROM 2020 TO 2022

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This particular source apportionment study was conducted using two methodological approaches using chemical analysis of daily PM2.5 samples or the emissions inventories for both the cities of Sarajevo and Banja Luka in Bosnia and Hercegovina (BiH). The study was conducted by the Swedish Meteorological and Hydrological Institute (SMHI) on behalf of the Swedish Environmental Protection Agency (SwEPA) and with the participation of the Institute for Public Health of Belgrade (IPH) as part of the IMPAQ project, funded by the Swedish Agency for International Development (Sida).

Receptor modelling using Positive Matrix Factorisation (PMF) model 5.0 was one of the methods. The IPH has gathered more than 90 daily samples of PM2.5 in 6 cities in BiH during winter 2020-2021 (1st winter). The sampling was repeated the winter after in 2021-2022 (2nd winter) in Sarajevo and Banja Luka only. For each sample, the analytical measurements of 12 elements, 8 ions, elemental and organic carbon, 3 anhydrosugars and total mass were performed. The PMF model produced satisfactory results for the 1st winter with up to 6 sources. A time-series of activity and meteorology as well as bivariate polar plots was used to help identifying the sources. The result was satisfactory again for the 2nd winter and 8 sources and was consistent with the previous one.

The result related to the 1st winter suggest that around 25% of PM2.5 pollution is emitted from biomass burning mostly used for heating purposes. Furthermore, 20% of PM2.5 could be attributed to fossil fuel combustion including coal burning and vehicle engines. The portion of long-range transport aerosols represented more than 25% of the total PM2.5. The result related to the 2nd winter mainly confirmed the previous results and provided more detailed information. The result shows also that some episodic and isolated sources can be significant contributors and that their chemical and temporal signature may help to trace back them.

Dispersion modelling using the regional Eulerian MATCH model was the other method. The local emissions from the cities of Sarajevo and Banja Luka have been compiled for the main sectors by using the data provided by both Hydrometeorological Institutes, local consultants, municipalities, as well as the available European databases. The emissions from household heating was derived from UrbanAtlas, BiH household energy consumption, and BiH building typology report. The meteorological layers were produced using the HCLIM38 model and the regional boundary conditions using the regional emission data from CAMS- REG v4.2. The model gave satisfactory results with a 500m resolution when compare against the on-site official monitoring.

The results confirmed that domestic heating was a significant PM2.5 contributor in the winter, up to 50-60% in Sarajevo and in Banja Luka, while the transport sector contributed ca 15%. The result shows the significant effect of the temperature inversion associated to low boundary layer height that flattens the air pollution to the ground.

The comparison of both different results over the same period of winter time, confirms that the traffic-related contribution is significantly underestimated and that the related emissions inventory needs improvement. The inter-comparison confirms that a non-burning source, specific to Banja-Luka is worth investigating further.

This study has provided a scientific basis for policy making. The results can be used to determine focus sectors for policy implementation, and to determine how specific actions could affect overall emission totals and their impact on air pollution levels.

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8.2 SOURCE APPORTIONMENT OF BLACK CARBON IN OSLO (NORWAY) AND VINCA (SERBIA)

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Black Carbon (BC) particles damage health and affect climate. There are major uncertainties both health and climate effects arising due to lack of knowledge of source strengths of BC from various sectors, including fossil fuel combustion and particularly residential heating. Furthermore, there is likely to be a considerable geographical variability in BC emissions. With very few online measurements of BC in Eastern Europe and the Balkans in particular, measurement data and source apportionment of BC in these regions is crucial to improving public health. Here we present a preliminary source apportionment based on online aethalometer measurements at Vinca Institute, 12 km from Belgrade, from the EMEP intensive measurement campaign, winter 2017-2018. We combine novel (non-negative matrix factorisation) and conventional (aethalometer model) approaches to quantifying BC sources at the Vinca Institute and contrast our results with similar analyses in other major European cities such as at Sofienbergparken in Oslo, Norway. Results show that there is a significant contribution from biomass burning (most likely from residential heating) in winter in the Vinca area. Oslo has a slightly lower biomass burning contribution compared to Vinca. Summertime data from Oslo show a lower biomass burning contribution. These results are consistent with our understanding of annual cycles in residential heating emissions (Yttri et al. 2021) and demonstrate the utility of the new source apportionment technique.

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8.3 COMPARISON OF ONLINE AND OFFLINE PMF SOURCE APPORTIONMENT RESULTS IN A PREALPINE VALLEY WITH TRAFFIC, BIOMASS BURNING AND INDUSTRIAL SOURCES

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To reduce harmful effects of PM, and therefore to increase air quality, extensive composition measurements and identification of its sources are needed (Ito et al, 2006). Prior work had shown that including additional species to traditional Positive Matrix Factorization (PMF) dataset (e. g. Borlaza et al, 2021) and increasing the time resolution of the methods (Manousakas et al, 2022 and reference therein; Via et al, 2023) enable resolving more sources. Despite the advantages, source apportionment (SA) studies, using traditional 24-hour filter samples as well as high-resolution data are limited.

The objective is to compare offline and online PMF results to obtain more accurate and complete identification and quantification of sources in an alpine-urban-background site. Quartz filter samples of PM10 were collected daily from November 2020 to November 2021 and analyzed using different chemical techniques. In the same period equivalent black carbon (eBC) measurements were taken with the Aethalometer AE33. In addition, hourly elemental composition of PM10 as well as of PM2.5 were measured with Xact 625i from February until May. The PM10 chemical species together with the source-specific eBC (Sandradewi et al, 2008) were then analyzed using PMF model (offline PMF). The final offline PMF results were compared to online PMF-factors of elemental PM data using an orthogonal regression.

We found a very good agreement between offline and online PMF results. Factors with the highest correlation were domestic heating and traffic (both $R^2 = 0.8$). A high correlation ($R^2 = 0.7$) was observed between offline chloride-rich and online chlorine-rich factors and when comparing offline secondary biogenic oxidation and sulphate-rich as one factor with online regional factor. Offline mineral dust correlation with merged online dust and calcium-rich factor was high ($R^2 = 0.5$) as well. However, a moderate association ($R^2 = 0.3$) between calcium-rich and cement dust was also found.

Extensive and high quality sampled and analyzed data enabled us to identify more sources and to obtain more accurate, quantitative SA results at the site. With this approach we managed to identify sources of anthropogenic and natural origin and distinguish between local and regional sources and also sources' aerosols formation mechanisms

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8.4 PM2.5 SOURCE APPORTIONMENT AT A PORT/INDUSTRIAL AREA OF ATTICA, GREECE

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Ambient air quality in near-port, industrialised cities and coastal areas is often very poor due to the presence of many pollution sources nearby (Saraga et al., 2019). These sources vary between ship traffic, industry and other usual sources such as residential emissions (Mueller et al., 2011). Although numerous studies on road traffic-related air pollution have been conducted, little is known about the magnitude of air pollution near ports and industrial sites. A comprehensive study on ambient air quality was conducted in Elefsina broader area, a highly-polluted area in Attica, Greece. Elefsina is a municipality of the West Attica Prefecture, located at a distance of about 20 km from the centre of Athens. It covers an area of 20 sq km and has a population of 24,910 inhabitants (2011 census). The area is characterized by intense industrial activity (i.e. oil refinery). The present study aims to identify the chemical fingerprints of PM2.5 sources at the broader area of Elefsina and estimate their weight to the ambient air quality, while focusing on the quantification of the industrial zone and shipping activities contribution.

For the purpose of the study, a comprehensive monitoring campaign was conducted over a 7-month period, from February to October 2019. Ambient $PM_{2.5}$ data were collected at three sampling locations around the greater area of Elefsina to achieve better spatial coverage. The sampling sites selection followed EU Directive 2008/50/EC while taking into consideration the characteristics of the surroundings of each area. The PM mass determination was conducted according to EN 12341:2014. The collected samples were then analysed for ionic, carbonaceous, elemental and polyaromatic hydrocarbon components. Meteorological data were also collected during the monitoring period, to assess the correlation between air pollution episodes and the wind. For the source apportionment study, Positive Matrix Factorization (PMFv.5) model was applied on PM2.5 chemical composition data. The source apportionment results were also associated with the prevailing meteorological patterns.

PMF model resulted in seven factors/sources: 1) traffic (26%) 2) secondary aerosol formation (21%) 3) oil refinery emissions (16%) 4) shipping (12%) 5) other industrial emissions (7%) 6) soil and road dust resuspension (11%) and 7) sea salt (7%).

The outcome of the study confirmed the simultaneous contribution of regional and local emission sources and revealed the direct and indirect impact of the port's presence on the broader area's PM levels. Overall, the study underlines the principal role of reliable and quantitative information on emission sources for the implementation of the air quality directives and guidelines for public health. The implementation of certain mitigation measures to tackle air pollution from harbour activities, would bring additional air quality benefits.

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8.5 AIR QUALITY ASSESSMENT AND SOURCE APPORTIONMENT OF AEROSOLS IN LIEPAJA

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This comprehensive study presents the results of a one-year analysis of aerosol data collected in a major urban centre in Latvia employing passive sampling. Aerosol data for the period comprised a substantial dataset, that was used to identify and quantify the main aerosol sources contributing to air quality utilizing a robust receptor model Positive Matrix Factorization (PMF) in conjunction with MODIS satellite data and back-trajectory analysis.

In the course of the study, five distinct aerosol source groups were singled out: combustion activities, mineral dust, marine aerosols, secondary sulphate aerosol formations and road dust. The identified sources demonstrated both spatial and temporal variability, with distinct seasonal patterns that were corroborated by employing additional analysis techniques.

The integration of MODIS data provided a broader perspective on aerosol-environment interactions. The MODIS Aerosol Optical Depth (AOD) data enabled the characterization of aerosol loading and distribution across the study area, serving as an essential complement to the PMF analysis.

Trajectory analysis was also employed to investigate the origins and transport pathways of aerosols. Back-trajectories traced the movement of air masses that carried aerosols to the sampling site, contributing to a more comprehensive understanding of regional sources and long-range transport events. This information proved instrumental in linking the aerosol sources identified through PMF and MODIS data to their specific regions of influence.

The results of the study may prove to be useful in providing critical information for air quality management, climate research, and urban planning, both on a local and regional level, proving the need for holistic approaches in aerosol studies. The research will continue with including aerosol spectrophotometric properties into the dataset to further illustrate the complex interplay of various emissions in an urban environment.

9. PM RESEARCH INFRASTRUCTURE AND PM SOURCES

9.1 AEROSOL, CLOUDS AND TRACE GASES RESEARCH INFRASTRUCTURE – ACTRIS THE EUROPEAN RESEARCH INFRASTRUCTURE SUPPORTING ATMOSPHERIC SCIENCE

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ACTRIS is the new European Research Infrastructure consortium for short-lived atmospheric constituents, supporting fundamental research and excellence in Earth system observation. The primary objective of ACTRIS is to produce high-quality integrated datasets in the field of atmospheric sciences and to provide services, including access to instrumented platforms, tailored for scientific and technological use. Established with a long-term perspective, with financial commitments from 17 European countries and the European Commission, ACTRIS services are open to the global community of scientists involved in atmospheric research and beyond. It is expected that ACTRIS will have a strong impact enhancing excellence in Earth system observation and research, providing information and knowledge for the development of sustainable solutions to societal needs (Laj et al, 2023).

This presentation will introduce ACTRIS and explain the various components, procedures and opportunities. ACTRIS focuses on producing high-quality observations of short-lived atmospheric components. These components have a residence time in the atmosphere from hours to weeks and the short lifetimes make their concentrations highly variable in time and space. ACTRIS is covering more than 150 variables on aerosol particles, cloud microphysics and reactive trace gases. The origin of ACTRIS data is from more than 80 observational sites and 20 atmospheric simulation chambers measuring properties of either ambient or artificial atmosphere. All observations are made available from the ACTRIS Data Centre.

The presentation will also show new online tools linked to ACTRIS and developed as a part of the EU-project ATMO-ACCESS (Sustainable Access to Atmospheric Research Facilities). The aim of these virtual tools is to serve campaigns, interpretations of measurements, and users applications on their specific needs. A new footprint analysis tool for interpretation of observations of greenhouse gases, aerosols, reactive trace gases will be introduced. In particular, the model service using the FLEXPART for interpretation of short-lived atmospheric measurements and understanding of emissions and source regions will be demonstrated. All users can request model runs to produce data products for their decided locations, or search and use the already produced products.

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9.2 SOURCES AND PROCESSES AFFECTING LEVELS AND COMPOSITION OF ATMOSPHERIC DEPOSITION TO THE ADRIATIC COASTAL AREAS AND BIOGEOCHEMICAL IMPLICATIONS

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Numerous pollutants, including particulate matter (PM), are continually emitted directly into the atmosphere from pollution sources or are formed in the atmosphere from natural and/or anthropogenic pollutant precursor species. Once in the atmosphere, atmospheric pollutants undergo various dynamic, physical, and chemical processes from emission to deposition back on land or water. Atmospheric deposition (AD) is a major environmental issue in different parts of the world due to concerns over acidification and eutrophication, bioaccumulation of toxics, leading to adverse effects on biodiversity, human health, and global climate change (e.g., Clark et al., 2013). Therefore, better understanding of AD is important for tracing the circulation and transfer of nutrients (Milinković et al, 2022) and pollutants (Penezić et al, 2021) from the atmosphere to other ecosystems, including aquatic environments. The main objective of this study is to give insight into atmospheric material reaching the coastal areas of the Adriatic Sea via AD and the data interpretation in relation to different sources and seasonal behaviour patterns.

This study provides the first insight into the variability of the amount, composition, and sources of atmospheric material that reaches the Northern Adriatic (protected area of Brijuni National Park) as well as Central Adriatic (Šibenik archipelago) coastal areas by AD through monitoring of: i) meteorological parameters, ii) mass concentrations and composition (main ions, black and organic carbon) of PM_{10}, wet and bulk deposition samples, iii) seasonal changes of local, regional and long-range air pollution sources.

The Brijuni National Park area was significantly affected by regional and long-range air pollution from the Northern Italy region, which contributed to the elevated concentrations of acidic ions in PM_{10}, as well as in wet and bulk deposition samples. During the spring, the area was also significantly influenced by Saharan dust intrusions, which increased PM_{10} mass concentrations and altered the ionic composition of the PM_{10} and deposition samples. Seasonal variations of PM_{10} composition at the Central Adriatic were affected by local land and maritime traffic and open biomass burning (BB) events, long-range transport and meteorology. Atmospheric N species as nutrients for marine systems, deposited from the atmosphere to the sea surface could significantly support new primary production at the Adriatic coastal areas. The atmosphere could be a particularly important external source of nutrients in coastal areas where sporadic but intense events such as Saharan intrusions as well as BB episodes occur. This could have strong implications for global air-sea exchange processes, including those of climate relevant gases. This study also serves as a basis of comparison for future studies addressing air quality and pollution source apportionment in the Adriatic and/or the Mediterranean coastal regions in efforts of mitigation and adaptation to climate change.

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9.3 MOSS BAG BIOMONITORING OF AIRBORNE ELEMENTS IN URBAN BACKGROUND AMBIENT DURING SAHARAN DUST EPISODES: A PRELIMINARY STUDY

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Moss transplants in bags have been extensively used for the assessment of airborne element pollution within differently polluted areas. However, background air pollution has been rarely evaluated by the moss bag technique (Aničić Urošević et al, 2017). In this study, at a site representative for suburban background air pollution, the moss bag exposure time and different moss species were investigated as crucial parameters in the technique application. During the spring/summer season 2019, characterized by several Saharan dust episodes, two moss species, *Hypnum cupressiforme* and *Sphagnum girgensohnii*, were exposed for twelve consecutive periods of 15-days, and also for one-, two-, three-, four-, five- and six months; both at open space and under an improvised roof. In addition, particulate matter (PM10 and PM2.5) was sampled during the identified dust episodes and several days after the episodes. As an estimate of the dust amount to which the moss bags were exposed during 15-day periods, we used MERRA-2 (The Modern-Era Retrospective analysis for Research and Applications, Version 2) predictions of dust concentrations at ground level, averaged over these periods. The concentrations of 22 potentially toxic elements (PTEs), Al, Ba, Ca, Fe, K, Mg, Mn, P, S, Sr, Zn, Ni, V, Cr, Co, Cu, As, Cd, Pb, Ga, Y, and Tb were measured in the moss and PM samples. The results showed that 15-day bag exposure at the background location could not provide a valuable 'signal' of the PTEs in the moss transplants, except for Al, V, As, Ga, Y, and Tb. Extended moss bag exposure of a couple of months provided a stabile enrichment of the majority of the elements in the mosses, above the limit of quantification for the moss bag technique (LOQt). The moss bags exposed at open space were significantly more enriched with the elements than the moss bags that were exposed under the improvised roof. *S. girgensohnii* moss provided better replicability of the results, unlike *H. cupressiforme*. An increase of the PM mass concentrations, essspecially coarse particle fraction (PM10-PM2.5), but still below the daily threshold values, was measured at the studied site during two of three recorded Saharan dust intrusions. Elemental characterization of the PM10 samples showed that only Al, V, Ga, Y, and Tb concentrations were increased multifold during one of the episodes that was particularly intense. The same elements in the *S. girgensohnii* moss bags, consecutively exposed for 15-day periods in the season, showed a slight increase of the concentrations that overlapped with these episodes. The ratio of crustal elements (Ca/Al and Mg/Al) in PM10 (dust days) and moss samples (3-month exposed) were in line of those reported for dust transported from western Africa (Moreno et al, 2006; Scheuvens et al, 2013). The increase of V/Al, Ga/Al, and Tb/Al concentration ratio values was observed in PM10 for dust days and in *S. girgensohnii* moss samples for the period 15.1d, in comparison with the samples not affected by dust. Contrary, the As/Al ratio in PM10 and moss samples corresponding to dust episodes were smaller than those for non-dust days/periods. This ratio could be used to distinguish between moss bag samples dominantly affected by natural sources (dust) from those dominantly affected by anthropogenic pollution. The results suggest that the moss bag technique could be used as a simple tool for tracking the long-range transported elements, but only after prolonged moss bag exposure (3 months). This pilot study points out the advantages of a multidisciplinary and multi-technique approach (model results, instrumental, and biomonitoring measurements) to the perception of air pollution issues (Aničić Urošević et al, 2022).

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9.4 AIR QUALITY IN BOR (SERBIA) DURING THE COPPER SMELTER RECONSTRUCTION PERIOD

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In the period from 2016 up to today, at the copper smelter in Bor (Serbia), flash-smelting technology was used to smelt copper concentrate, whereby all waste gases from the flash furnace were processed in the sulfuric acid plant. However, part of the waste gases from the flame-refining process was still emitted without adequate treatment until the end of April 2022. Due to the increase in the volume of production, a greater number of accidents, and irregularities in the operation of the plant in the copper smelter, as well as the processing of domestic, and imported copper concentrates with increased content of arsenic, lead, cadmium, nickel and other accompanying elements, increased air pollution occurred. In the period 2019 - 2022, concentrations of SO2 regularly exceeded the daily limit value, at certain measuring points even for more than 100 days annually [Tasić et al, 2023]. The new desulfurization plant in the copper smelter started operating in August 2021, so most of the waste gases from the copper smelting process were processed in this plant before being released into the atmosphere

In the period from May 2022 to the end of April 2023, the copper smelter in Bor did not work due to reconstruction and capacity expansion. During the reconstruction period, no increased concentrations of sulfur dioxide were detected above the prescribed limit values for hourly and daily concentrations. During the reconstruction period, no occurrence of exceeding the daily limit value of lead concentration in PM10 was detected. Also, during the reconstruction period, no exceeding the target value for the average annual concentration of cadmium and nickel in PM10 were detected at any measuring point. Exceeding the target value for the average annual concentration of arsenic in PM10 was detected only at the measuring point JP. This measuring point is exposed to the influence of flotation tailings, ore tailings, and traffic. It is located in the dominant wind direction that blows pollution from point and fugitive sources of air pollution from the copper smelter. This is the closest measuring point to the city's landfill, which can occasionally catch fire and emit air pollution.

During the reconstruction period, significantly lower values of pollutants in the air were recorded. The analysis showed that the smelter and other facilities are the main emitter of pollution in the Bor agglomeration. Unfortunately, during the reconstruction, pollutant, such as arsenic, were recorded in higher concentration, which indicates the existence of other significant sources of this pollutant.

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9.5 ANTALYA-MANAVGAT FOREST FIRES: A WRF-CHEM AND REMOTE SENSING ANALYSIS

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Forest fires pose a significant environmental challenge with profound impacts on air quality, ecosystems, and public health (WHO, 2023). This research employs a multifaceted approach, integrating the Weather Research and Forecasting with Chemistry (WRF-Chem) model, advanced emissions data, and remote sensing technology to address these complex phenomena. The primary objectives of this study encompass a thorough investigation of air pollution during forest fires, an assessment of the accuracy of the WRF-Chem model (version 4.51) in simulating air pollutants, and the validation of model simulation through comparative analysis with remote sensing data. By examining the alignment between model predictions and satellite imagery, the research aims to identify discrepancies and factors contributing to the model's performance or limitations.

This research utilizes the Weather Research and Forecasting with Chemistry (WRF-Chem) model (Grell et al.,2005), version 4.51, configured with a two-nested domain setup, providing spatial resolutions of 9 km and 3 km, tailored for the Antalya-Manavgat region. Multiple emissions datasets, including FINN v2.5, EDGAR-HTAP, are integrated to comprehensively represent emission sources during forest fires. Remote sensing technology is pivotal for data collection, sourcing satellite imagery from MODIS, MAIAC, VIIRS, and Sentinel-5P, offering real-time and high-resolution data for forest fire and air quality monitoring. A comparative analysis aligns the WRF-Chem model's predictions with satellite data for a rigorous assessment. Data undergo extensive processing and analysis to extract insights and pinpoint congruence or disparities between model predictions and satellite information.

Key results of the study:

- The WRF-Chem model is successfully validated, indicating its proficiency in replicating air pollutant dynamics during forest fires. The model closely aligns with Aqua Modis imagery, highlighting its precision in capturing air quality patterns during forest fires.
- Discrepancies with the WRF CHEM model and MAIAC dataset, Offline UV Aerosol Index underscore specific challenges tied to satellite scanning regions and satellite data processing algorithms.

In conclusion, the WRF-Chem model has proven to be a valuable and successful tool in simulating smoke dispersion and atmospheric conditions, as evidenced by the outcomes of this study and supported by existing literature (Rooney et al., 2020; 2015; Nuryanto, 2015). The model's ability to accurately represent the complex dynamics of smoke dispersion in the atmosphere is a testament to its reliability and proficiency in addressing critical environmental challenges, such as those posed by forest fires.

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10. SOURCES AND FORMATION OF PARTICULATE MATTER

10.1 PHOTOCHEMISTRY OF PHYTOPLANKTON LIPIDS AT THE AIR-WATER INTERFACE AS A SOURCE OF VOLATILE ORGANIC COMPOUNDS INFLUENCING NEW PARTICLE FORMATION

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The global importance of abiotic oceanic production of volatile organic compounds (VOCs) still presents a source of high uncertainties related to secondary organic aerosol (SOA) formation. A better understanding of the photochemistry occurring at the ocean-atmosphere interface is particularly important, as it covers >70% of the Earth's surface. Naturally-occurring surface-active organic material (OM) accumulates at the air-water interface and forms surface films (Frka et al, 2012). When irradiated, surface films may undergo photochemical reactions leading to the abiotic production of unsaturated and functionalized VOCs (Ciuraru et al, 2015a). Although previous studies have demonstrated photoinduced VOCs production from artificial surfactants in laboratory-grade water, saline solutions, and biofilm-containing solutions comprising a mixture of microorganisms (Bruggemann et al, 2017), these experiments were typically conducted under far from ambient conditions, or for a limited number of authentic samples.

For the first time, photochemical processing at the air-water interface containing OM from an authentic culture of the marine diatom *Chaetoceros pseudocurvisetus* was studied (Penezić et al, 2023). Abiotic VOC production upon irradiation of material originating from total phytoplankton culture as well as the fraction containing only dissolved material was monitored by PTR-ToF-MS. Isolated biogenic lipid material was also investigated after its deposition at the air-water interface. Simultaneously, OM photochemical transformation in aqueous phase was followed by changes in concentration of surface-active substances (SAS) measured by phase sensitive alternating current (a.c.) voltammetry as described in details previously (Frka et al, 2012b). Experiments were conducted in a photochemical reactor and an atmospheric simulation chamber, to study VOCs formation upon irradiation and implications for aerosol formation and growth, respectively.

Investigated biogenic samples acted as a source of VOCs, producing saturated oxygenated compounds as well as unsaturated and functionalized compounds. The highest normalized flux intensity determined for the lipid material suggests that biogenic lipids, as less water-soluble substances, i.e., efficient SAS present at the air-water interface, are primarily responsible for the photochemistry leading to the VOC production from diatom OM exposed to irradiation. Furthermore, we demonstrated that the emitted VOCs can significantly affect the oxidation potential of the atmosphere and promote new aerosol formation and growth. Oxidation by dark ozonolysis and subsequent particle formation demonstrated the formation and release of unsaturated VOCs.

Given that marine biogenic lipids are common natural SAS and can be considered ubiquitously present at air-water interfaces, such as on rivers, lakes, oceans, aerosol particles, and cloud droplets, photo-induced abiotic VOCs production can be expected to occur globally, influencing ocean-atmosphere exchange processes as well as atmospheric chemistry on a large scale.

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10.2 PRELIMINARY ANALYSIS OF DIURNAL AND SEASONAL VARIATION OF SUBMICRON AMBIENT PARTICLE SIZE DISTRIBUTION IN BELGRADE URBAN AREA

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This study presents a comprehensive analysis of the diurnal and seasonal variations in the submicron ambient particle size distribution in the urban area of Belgrade. Two distinct measurement campaigns were conducted in different seasons, the first at the Chemical Faculty site in 2020 (January-March), and the second at the Ada Marina site in 2023 (June-October). Using a Scanning Mobility Particle Sizer Spectrometer covering a size range of 10 nm-400 nm, particle concentrations were monitored as a function of time and diameter. The amalgamated data from both campaigns revealed a substantial disparity in pollution levels between seasons and sites, with notably higher particle concentrations observed at the Chemicak Faculty site during winter season. On the Ada Marina site, the average particle concentrations for the entire period, summer and early autumn, were 627,87 particles per cubic centimeter (cm ^{3}) for particles in the 10-20 nm range, 1354, 52 particles/cm^3 for particles in the 20-100 nm range, and 111,02 particles/cm^3 for particles in the 100-400 nm range. However, the Chemical faculty site exhibited higher average concentrations, recording 430,4 particles/cm^3, 3727,74 particles/cm^3, and 2385,7 particles/cm^3 for the respective size ranges. Temporal analysis revealed two distinct periods of increased particle concentrations, Figure 1.. From 7 AM to 12 PM, a rise in concentration of smaller, finer particles was observed. Subsequently, from 11 AM to 1 AM, a second region with high particle concentrations emerged, initially characterized by larger particles that gradually filled the entire spectrum before dissipating around 1 AM. These findings contribute valuable insights into the temporal dynamics of submicron particle distribution in an urban setting, underscoring the importance of location-specific factors in understanding air quality variations ().

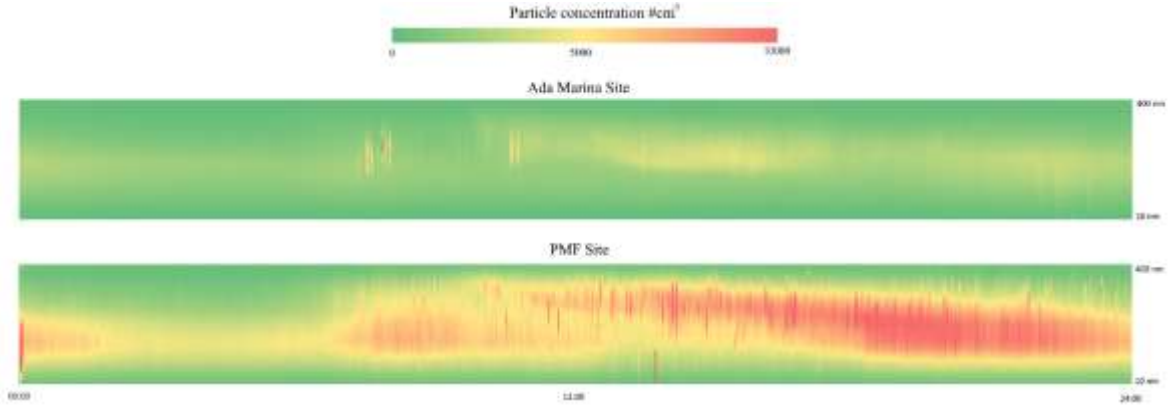

Figure 1. Heat map for particles between 10 and 450 nm averaged for summer 2023 and winter 2020. camaings in Belgrade background area

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10.3 QUANTITATIVE ASSESSMENT OF PARTICULATE MATTER POLLUTION SOURCES IN DIFFERENT SEASONS

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Identifying sources of particulate matter pollution is essential for many reasons: it enables quantification of sources of air pollution and the development of effective means of reducing atmospheric pollution. Where a broad assessment of the chemical composition of particulate matter is available, different modelling methods, such as analysis of key components factoring of positive matrices, can be effectively used. However, scanning electron microscopy, supplemented by the energy dispersive method (SEM EDX), is one of the more efficient methods for assessing the morphology and composition of particulate matter and identifying pollution sources. This study carried out a systematic (2022-2023) assessment of the mass, morphology and composition of particulate samples in Liepaja (Latvia) to assess the variability of pollution in different seasons, both with heating and without heating. Additionally, results profiling has been carried out to identify the main sources of contamination. The results of the analyses show a prevalent (sometimes up to 70%) presence of mineral particles, a significant proportion of biogenic particles (up to 25%) and sea salt (up to 60%) particles, and a relatively small (1-5%) proportion of tyre wear and metallic particles.

10.4 SECONDARY ORGANIC AEROSOL FORMATION FROM CHEMICAL DEGRADATION OF AROMATIC COMPOUNDS IN URBAN ATMOSPHERE

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The urban atmosphere is a complex atmospheric system containing volatile organic compounds (VOCs) where aromatic hydrocarbons (AHs) play an essential role. AHs have an important contribution to the formation of atmospheric photooxidants (30% of total) and are responsible for up to 10% of global anthropogenic secondary organic aerosol (SOA) formation (Seinfeld and Pandis, 2016). From the class of aromatics, the hydroxyaromatics, either directly emitted into the atmosphere or formed from the chemical degradation of benzene, toluene, xylenes or other alkylbenzenes, are the most reactive VOCs towards the oxidative species in the atmosphere, mainly the OH radicals (Calvert et al., 2011).

These investigations explore the SOA formation pathways from hydroxyaromatics, employing Centre of Research on Atmospheric Chemistry simulation chamber (Cork, Ireland) using state of the art techniques (Fourier Transform Infrared Spectroscopy (FTIR) and Scanning Mobility Particle Sizer (SMPS) together with analytical techniques and instruments to monitor the particle number, NOx and relative humidity (RH%). The investigations were carried out in a 3.9 m^3 fluoro-ethylene-propylene foil chamber surrounded by two types of photolytic lamps;18 lamps emitting light in the range of 300-500 nm (λ_{max}: 360 nm) and 10 lamps with spectral light between 280-315 nm (λ_{max}: 305 nm), in clean air at atmospheric pressure and temperature of (25 ± 2) °C in Cork, Ireland. IR spectra were recorded at a spectral resolution of 1 cm^{-1} using an Excalibur IR spectrometer equipped with a mercury-cadmium-telluride (MCT) detector. A White-type multiple reflection mirror system operating at a total optical path length of (229.6 ± 0.4) m is coupled with the FTIR spectrometer used for reactant and product analysis. The aerosols distribution has been recorded by using an SMPS system TSI model 3080 connected to a DMA 3081 and CPC 3010 particle counter.

SOA formation yields from photooxidation of 2,6-dimethylphenol (26DMP) (~ 17-35%) have been measured in various experimental conditions. Yields of SOAs have been found dependent of the presence of pre-existing seed aerosol, relative humidity (RH), NOx and HOx concentration, etc. For the first time in these studies four different sources of OH radical formation (HONO, H_2O_2 and methyl nitrite photolysis and alkene+O_3) have been used. The experimental SOA yield has been fitted using Odum model considering one major component for the partition between gas and particle phase. The results are comparable with other literature data for cresols and xylenes, however, no literature data are available for studies of SOA formation from dimethylphenol oxidation initiated by OH radicals. The results contribute significantly to the understanding of chemistry of urban atmosphere.

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11. POSTER SESSION

11.1 HEAT FLUX IMPACT ON LIVE PINUS NIGRA BRANCHES AND CHARACTERIZATION OF GASEOUS EMISSIONS

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Combustion and emissions during wildland fires are influenced by the type, quantity, properties, and conditions of wildland fuels. A crucial source of wildland fires lies in the chemistry of cellulosic biomass fuels, which are highly temperature-sensitive due to thermal degradation (Sullivan, 2017). Flammability studies mainly focus on flaming combustion, while non-flaming combustion, such as glowing and smoldering, is rarely considered. The combustion of forest fuels during smoldering fires and their gaseous products is not described enough (Weise & Wright, 2014). Gaseous compounds from forest fires consist of a wide range of gases, aerosols, and particulate matter, with the most common constituents including CO_2, CO, CH_4, and other volatile organic carbon compounds (VOCs) (Fateh et al., 2016). This study aimed to characterize gaseous emissions from burning live *Pinus nigra* branches under varying combustion conditions, driven by different heat flux levels and the presence or absence of an ignition source. As an ignition source, piloted ignition was used.

In laboratory conditions, controlled combustion of *Pinus nigra* branches was conducted using a mass loss calorimeter, with the testing environment modified to evaluate gaseous concentrations. The identification of gaseous compounds and concentration measurements were performed using an FTIR gas analyzer (Gasmet DX 4000, Finland). The experiment was designed to test fuel samples under various heat flux values, both with and without an ignition source. The samples were exposed to heat flux, representing the first experimental factor, and were varied across three levels (50, 60, and 70 kW/m^2) The second experimental factor is the ignition source, which has two levels: conducting the experiment with and without the source of ignition.

With piloted ignition, all samples ignited at all heat flux values. As expected, the ignition time of the samples became shorter with increasing heat flux values. However, in non-piloted ignition, the samples only ignited at a heat flux of 70 kW/m^2. When using pilot ignition, there is a decreasing trend in peak heat release rate (PHRR) values as the heat flux level increases. At a heat flux of 70 kW, the results indicate that ignition time is shorter with pilot ignition, while the average PHRR value remains approximately the same. The correlation between the flammability parameters and gaseous emissions was conducted. The following compounds are detected: H_2O, CO_2, CO, NO, NH_3, CH_4, and C_2H_4. Additionally, the presence of NO_2 was detected only when nonpiloted ignition was used. Concentration identification of the mentioned compounds was conducted across all possible experimental treatments throughout three phases of combustion: the pre-ignition phase, the flaming phase, and the smoldering phase. The heat release rate (HRR) is a flammability parameter that can be correlated with various gaseous emissions, such as H_2O, CO_2, and NO, released throughout the entire combustion process. The concentrations of H_2O, CO_2, and NO reach their peak values concurrently with the HRR.

The provided experimental design enables the understanding of the flammability characteristics of the representative conifer species *Pinus nigra*, considering two combustion scenarios – flaming and non-flaming combustion. This research provides information relevant to wildland fuel management. Furthermore, this study can be valuable for predicting gaseous emissions at various stages of wildland fires and for incorporating them into field condition modeling applications.

Acknowledgments
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11.2 THE USE OF AEROSOL LIDAR IN STUDY OF PM10 POLLUTION IN BELGRADE, SERBIA

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Improved understanding of conditions that contribute to elevated PM10 concentrations is necessary in order to design effective air pollution control measures. Knowledge of the aerosol vertical profile, along with vertical profiles of meteorological parameters, is important to understand the dispersion of PM10, the development of air pollution and the contribution of long-range transported particles to surface PM10 concentrations. Aerosol lidar provides information on vertical profiles of aerosol optical properties. It is also used to observe the temporal changes of the atmospheric boundary layer (ABL) height, using aerosols as tracers.

The aim of this study is to explore the application of aerosol lidar observations in analysis of PM10 pollution in Belgrade. Aerosol lidar measurements at 355 nm, conducted in the period of 2018-2020 in Belgrade are used, excluding data collected in the presence of low- or mid-altitude clouds. Lidar data are analyzed to derive vertical profiles of aerosol backscatter coefficient (Klett, 1981; Fernald, 1984) and ABL height (Ilić et al., 2018). The thermodynamic stability of the ABL is analyzed based on radiosounding measurements in Belgrade. The ABL height values derived from daytime lidar measurements are generally in agreement with those obtained from Global Data Assimilation System (GDAS). Furthermore, the relationship between the average backscatter coefficient within the ABL and the corresponding PM10 concentrations at ground level is analyzed. PM10 concentrations in Belgrade are obtained from the Serbian Environmental Protection Agency (SEPA) automatic monitoring stations. Large variability of values of the average backscatter coefficient in the ABL is observed in cases of elevated PM10 pollution in Belgrade, and discussed based on the corresponding vertical structure of backscatter coefficient and the ABL height temporal changes. Additionally, the use of lidar measurements in investigation of the contribution of long-range transported particles to surface PM10 concentrations is demonstrated.

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11.3 INDICATIVE MEASUREMENTS OF AIR QUALITY IN THE CITY OF BOR (SERBIA) BY USING LOW-COST SENSORS

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Most of the cities in the Republic of Serbia have poor air quality. The risk of premature deaths caused by air pollution is high because people live in areas where air pollution is high. The initiatives for citizens' inclusion in the air quality monitoring process resulted in higher awareness of the air pollution problem. In the Republic of Serbia, the project of deployment of self-made sensor kits "Klimerko - Air to the Citizens" started in 2018 (Klimerko, 2018). Klimerko measures a) air humidity, b) air temperature, c) air pressure, and d) concentration of PM_1, $PM_{2.5}$, and PM_{10}. The "Klimerko - Air to the Citizens" project aims to inform, raise awareness, and educate. About 190 Klimerko devices are deployed on the entire territory of the Republic of Serbia. Since 2018 eleven Klimerko devices have been deployed in the city of Bor. This work aims to present the results of a comparison of measurements from one of the Klimerko devices, deployed in the city of Bor, with the results of the nearest Air Quality Monitoring (AQM) station from the state AQM network, to evaluate the Klimerko results in a year-long period.

The results obtained by the Klimerko device (PM_{10} and $PM_{2.5}$ (sensor PMS7003), air temperature (T), air pressure (P), and relative air humidity (RH) (sensor BME280)) were compared to the results obtained by the reference instruments located at the AQM station: Bor - Town Park. The comparison of the results was carried out during a year, from the 1st of October 2022 to the 1st of October 2023.

Determination coefficients obtained by the comparison of mean hourly levels of PM ($R^2 = 0.41$ for PM_{10}, and $R^2 = 0.60$ for $PM_{2.5}$), RH ($R^2 = 0.72$), T ($R^2 = 0.92$), and P ($R^2 = 0.99$) from the Klimerko device deployed in the Bor town and reference instrument (from SEPA station in Bor) indicate a moderate (PM), high (RH), and very high (T and P) linear relationship between the measurement results of the reference instruments and the low-cost sensors from the Klimerko device.

The Klimerko device showed good stability and reliability during the comparison period with the reference instruments. So, the Klimerko devices could be applied to indicate PM mass concentrations in ambient air.

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11.4 MULTISENSORY WEARABLE SENSOR NODE FOR SAFETY APPLICATIONS

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The state of the art of multisensory wearable systems for safety applications is currently characterized primarly by prototype systems integrating commercial sensor arrays. They typically do not have the ability to locate themselves in space, except for the ability to recognize danger zones by means of wireless markers. The integration of chemical or particle sensors in these applications is widely underestimated and generally does not consider the specificities of chemical transduction and/or particulate matter. This work is intended to describe the latest improvements in the design of a sensor node part of an Internet of Things (IoT) architecture aimed at collecting relevant data of workers and the surrounding environment in which they are operating. The sensor node has been conceived to integrate gas sensors as VOC, CO, CO2 and O2, with a particulate matter sensor, locating capabilities indoor and in open air, movement and gesture recognition and networking capabilities.

The sensor node has been built together with an IoT architecture that enables remote detection of anomalies in both indoor and outdoor environments by means of a RTLS system and a GPS module and enables automated alarms. The entire system architecture is composed of: the sensor node, the wireless network based on LoraWan™ protocol and the remote data handler that exploits the services offered by a cloud IoT platform. The TagoIO cloud platform has been chosen to provide a range of tools and features for IoT solutions, including data visualization, real-time alerts, data storage, and integration with other platforms. The sensor node is logically divided into the Multi Sensor Node (MSN) and Communication Board (CB). The MSN embeds a complete set of environmental and motion STMicroelectronics sensors temperature-humidity HTS221, pressure LPS22DF and 6-axis inertial LSM6DSOX while CB embeds a Teseo-LIV3F GNSS module which provides outdoor position and LoRa connectivity STeval-STRKT01. Moreover, the air quality monitoring is carried out by means of PM (Plantower PMS 7003) and VOC, CO2, CO, O2 sensors. For indoor positioning, an external board for the real time location system (RTLS) was used to detect the point in space in which a worker was located. The node also monitors the noise level thanks to a separate audio board (STLCS01V1) that elaborates the audio signal and raises an alarm when the preset safe limit is exceeded. Lastly, a buzzer, LED and vibration motor reports an instantaneous alarm to the worker.

The most important findings of this work are the integration in a single compact node of capabilities of gas monitoring, particulate matter concentration measuring and locating capabilities that are not present in sensor nodes for safety in workplaces at the present time to the best of authors' knowledge. Moreover, the new node has been conceived to be worn by the worker without affecting the ability to move.

The sensor node has been designed to achieve the innovative features envisaged by the initial project: ease of wearing, battery autonomy and integration of the full set of capabilities described. At the same time, it constitutes a real development test bench from which further improvements, optimizations and miniaturization to make it an industrial product can be made. It is part of a set of active Personal Protective Equipment devices little represented in the scientific and industrial landscape with strengths that make it noteworthy. The presence of a dual-technology localization system operable in indoor, outdoor and mixed scenarios, combined with multi-pattern sensing solutions (physical/chemical) enables the introduction of remote assisted technologies based on augmented reality. Future improvements will concern the implementation of solutions for device-to-near-device communication and the development of AI algorithms for the recognition of complex patterns in the field of safety workplaces.

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11.5 APPLICATION OF EUROPEAN $PM_{2.5}$ LAND USE REGRESSION MODEL ON NOVI SAD MUNICIPALITY, SERBIA

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Land use regression (LUR) methodology is mainly used as an air pollution explanatory and prediction tool within metropolitan areas or small regions (Wang et al., 2014). Developed LUR models efficiently forecast spatial variations in air pollution concentrations (conc.) (such as nitrogen oxides, fine ($PM_{2.5}$) and coarse (PM_{10}) particulate matter) on a small scale, and variations regarding long-term air pollution (Azmi et al., 2023) (Ghassoun et al., 2019). Within the European Study of Cohort for Air Pollution Effects (ESCAPE), regional and European LUR models (EU-LUR) were developed for nitrogen oxides and $PM_{2.5}$. This research aimed to apply the regression equation of the EU-LUR $PM_{2.5}$ model on the urban area of Novi Sad (NS) and its data sets, during the winter and summer seasons of 2020/2021, and examine the behaviour of calculated potential NS predictor variables by prediction results for $PM_{2.5}$ conc. on 21 sites. Potential predictor contributions were examined too.

Potential predictors for $PM_{2.5}$ in NS were calculated in QGIS and collected from public institutions. $PM_{2.5}$ data collected by low-cost sensors were previously calibrated by a reference air monitoring station in NS, and adjusted by winter and summer $PM_{2.5}$ conc. from the national reference station in NS, following the ESCAPE study manual for LUR methodology (Brunekreef, 2008). Instead of a regional background predictor, urban background (BCG) was used and two research scenarios (scen.) were examined. In the first, BCG values from local urban BCG stations were used, while in the second, four potential BCG sites among 21 sites, were selected for the rest of the localities. In the second case, predictions were made for 17 sites. The contributions were calculated as the product of the given predictor value for NS and the β coefficient for the same predictor from the EU-LUR model final equation.

Predictions in both scen. gave unsuitable results. Measured and predicted $PM_{2.5}$ ranges in the first scen. for winter were from 28.26-50.02 $\mu g/m^3$ and 10-22.27 $\mu g/m^3$, and for the summer were from 9.85-16.63 $\mu g/m^3$ and 9.50-23.38 $\mu g/m^3$. In the second scen. measured and predicted $PM_{2.5}$ conc. during winter were from 28.26-50.03 $\mu g/m^3$ and 34.52-42.68 $\mu g/m^3$ and for the summer were from 9.84-16.63 $\mu g/m^3$ and 10.55-16.10 $\mu g/m^3$. Predictor contributions were highest for the BCG predictor in the second scen., and for the rest were negligible. In the first $PM_{2.5}$ prediction scen., absolute error (AE), relative error (RE), and root mean square error (RMSE) for winter were 20.06, 52.4%, and 22.182. For summer were 0.92, 7.9%, and 5.35 in the same order. In the case of the second $PM_{2.5}$ scen. AE, RE, and RMSE for the winter season were 6.06, 16.6%, and 7.39, and for the summer season were 1.65, 12.7%, and 1.93. In the second scen. results were significantly better.

Leaving aside the fact of different research areas, results still gave significant indications. Less detailed data for traffic intensities had a major impact on the predictions, also the BCG site according to the first scen. Second scen. indicated that local urban BCG site might not be adequate as an explanatory variable for all sampling sites, so the selection of four new potential BCG sites with a similar surrounding environment, domestic or thermal powerplant heating, gave smaller errors during winter, implicating presence of diverse local pollution particularly during the winter season.

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11.6 A COUPLED PARTICULATE MATTER (PM10, PM2.5) INDOOR MODEL BASED ON OUTDOOR MEASUREMENTS

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It is recognized that indoor pollution of fine particulate matter (PM2.5) is considered to be the most significant form of contamination, leading to the greatest risk to human health. The diversity of sources of pollution is high - cooking, physical activity, cleaning rooms. However, infiltration of particulate matter from the outside is no less essential. Outdoor pollution is considered a significant factor of anthropogenic origin due to the intense operation of ventilation systems in the indoor with substantial increases. This study analyses indoor particulate matter pollution and its link to outdoor pollution. As a result of the analysis, a regression model has been prepared by which it is possible to predict the pollution level in typical premises in the future, provided that the range of sources of pollution and the intensity of activities do not change. The model was developed using case measurements during the January of 2022 measurements in Riga (Latvia).

11.7 IMPACT PROJECT OVERVIEW: ROAD TRAFFIC AS A SOURCE OF ATMOSPHERIC MICROPLASTICS

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Microplastics (MPs) emission originated from road traffic are acquiring a rising interest from the scientific community due to its dangerous potential of being inhaled. A diversity of processes and conditions, such as pavement conditions, vehicle weight, driving processes, local environmental conditions, seasonal tyres, and heteroaggregation processes, can influence the MPs release. Non-exhaust particles generated by road traffic are less studied than the exhaust particles, and still remain unregulated (Baensch-Baltruschat et al, 2020).

Road traffic pollution affects residents, drivers, pedestrians, cyclists, passengers and other road users. In urban traffic environments, the mixture and intensity of sources are distinct. The iMPact project is the first known mission to study simultaneously different environments from road simulator, road tunnel, urban road traffic in Lisbon downtown area, Portugal, and will account the contribution of road traffic emissions as a potential vector of microplastics in the environment.

iMPact project comprises the collection and characterization of MPs from roads to ambient air, and quantitatively apportion the contribution of the source to urban ambient atmospheric particles by using receptor models. Each sampling surrounding, due to its innate characteristics, provide specific data: air pollution in road tunnels is formed almost exclusively by fresh car emissions; local road dust re-suspension provides comprehensive information on traffic-related emissions; and road simulator test allows maximum control of experimental conditions, enabling the characterization of particles derived exclusively from tyre wear. Therefore, the availability of reference data on source types and contributions is a key prerequisite for lowering the risk of exposure misclassification error. In order to estimate the contribution of road traffic emissions to the environment, it is important to understand several factors including sources, pollutant chemical characteristics and quantitative contributions. Thus, it is essential to estimate these contributions under real-world mixed source traffic emissions.

Moreover, this project will evaluate the human exposure potential. Oxidative stress results when the generation of reactive oxygen species, or free radicals, exceeds the available antioxidant defenses and has been suggested as an important underlying mechanism of action by which exposure to particles may lead to adverse health effects. The MPs may contribute to human exposure through their inhalation and ingestion (Janssen et al, 2014). Information on the potential human health effects of MPs is currently scarce. The iMPact project will help to fill this gap performing laboratory assays to assess any potential cellular interaction or toxicity of the MPs.

The project outcomes will help to formulate effective strategies to control MPs levels in urban populated areas and present public mitigation policies to protect human health.

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11.8 INFLUENCE OF RELATIVE HUMIDITY ON THE PERFORMANCE OF A PM LOW-COST SENSOR

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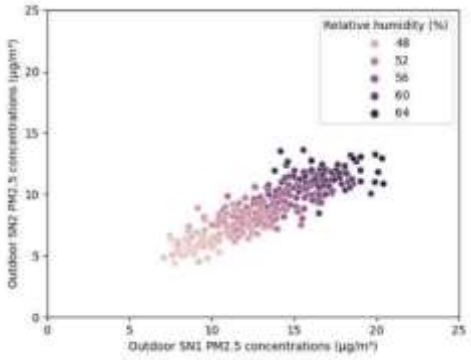
Air pollution is a major threat to human health, increasing the risk of mortality and morbidity (Pinault et al., 2017). Air Quality (AQ) monitoring is therefore a priority and is usually monitored using equipment from Fixed Monitoring Stations. Although very reliable, the small number of units installed limits the spatial and temporal knowledge of air pollutant concentrations. As a result, citizens' exposure is usually not correctly estimated which introduces bias into the estimates that support epidemiological studies. Low-cost sensors (LCS) used for AQ monitoring can complement the reference data as they can be installed in large numbers in urban areas. While the use of LCS has some limitations, including accuracy and susceptibility to meteorological factors, LCS can provide reliable information on AQ if a calibration protocol is applied. In fact, meteorological factors (e.g. temperature and relative humidity), can cause artefacts in the LCS measurements (Samad et al., 2020). For example, high levels of relative humidity can promote the condensation around particles that grow hygroscopically, being associated with higher measured PM concentrations (Figure 1). There is therefore the need for a correction algorithm that accounts for these effects.

The ExpoLIS project has developed an AQ LCS network that includes a particulate matter (PM) LCS (OPC-N3, Alphasense). The system, installed in Lisbon, aims to contribute with new knowledge related to the assessment of the citizens' exposure, the identification of hotspots and the factors influencing performance of the LCS. To assess which is the influence of RH on PM LCS measurements, we first placed two PM LCS in parallel (Figure 1) and verified that, as expected, higher relative humidities were associated with an in increase in PM concentrations. Furthermore, correcting for the effect of relative humidity (by considering it and the data from the reference PM station), resulted in an improvement in the quality of the PM data.



Based on this, we tested several methods, such as, multilinear regression and machine learning approaches that improved the accuracy of the readings and, ultimately, increased the ability of the sensors to provide valuable information about the citizens' exposure to air pollution.

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11.9 COMPARATIVE ANALYSIS OF MEASUREMENTS OF SUSPENDED PARTICLES IN THE CITY OF NIŠ (SERBIA) DURING THE HEATING SEASON

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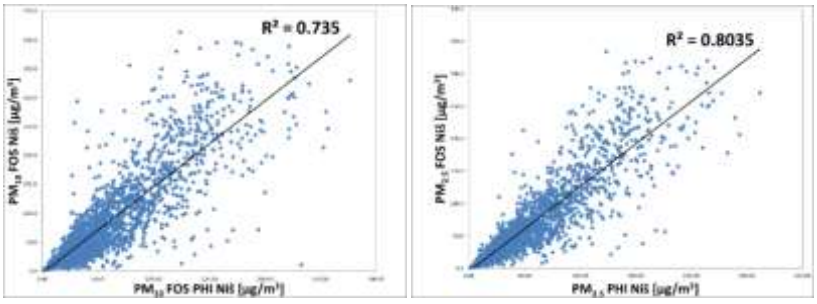
Exposure to particulate matter (PM), has been linked to increased mortality and morbidity, particularly in cases of cardiovascular and respiratory diseases. In Serbian cities, the concentrations of PM, frequently exceed daily limit values, especially during the heating season.
The Serbian Environmental Protection Agency (SEPA) operates with the national Air Quality Monitoring (AQM) network with more than 40 stationary AQM stations. Almost half of the AQM stations are equipped with reference-equivalent GRIMM EDM180 analyzers for the real-time monitoring of PM mass concentration (PM_{10} and $PM_{2.5}$). However, the high costs of these analyzers and their maintenance costs pose significant obstacles to widening the national AQM network. Additionally, the spatial distribution of AQM stations and stationary automatic PM monitors in most Serbian cities is uneven. Therefore, real-time PM monitors that are both affordable and reliable are needed for assessing the impact of PM concentrations on human health. In that aim a new PM monitor, PAQMON 1.0, was developed. The monitor utilizes a cost-effective NOVA SDS011 sensor for real-time PM_{10} and $PM_{2.5}$ mass concentration measurements (http://en.novasensor.cn/?list_13/55.html). This study aims to compare the matching of the results obtained by the PAQMON 1.0 monitor with those obtained from the AQM station during the heating season in Niš.
The results obtained by the PAQMON 1.0 device (PM_{10} and $PM_{2.5}$, PM sensor NOVA SDS011), located at the Faculty of Occupational Safety (FOS Niš), were compared with the results obtained by the AQM station Niš Traffic (PM_{10} and $PM_{2.5}$, GRIMM EDM180), located at the Public Health Institute (PHI NIŠ) about 2.4 km far from FOS Niš. The comparison of the results was carried out during the heating season, from December 7, 2022, to March 19, 2023.

The hourly mean values of PM mass concentrations (PM_{10} and $PM_{2.5}$) obtained by PAQMON 1.0 were compared with those from the AQM station. The analysis revealed a significant positive linear relationship for both PM fractions, as evidenced by the coefficient of determination (R^2) values of 0.735 for PM_{10} and 0.8035 for $PM_{2.5}$ mass concentrations.



The PAQMON 1.0 device demonstrated excellent stability and reliability compared to the reference instrument. Thus, this instrument is suitable for indicative measurements of PM mass concentrations in the ambient air.

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11.10 THE SEPARATION OF ARSENIC SPECIES IN PM SAMPLES BY USING DISPOSABLE CARTRIDGES

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Arsenic is a naturally occurring element that is found in the Earth's crust. It can be released into the environment from natural sources, such as volcanic eruptions and weathering of rocks, or from human activities, such as mining and smelting. Arsenic can exist in two oxidation states: As(V) (arsenate) and As(III) (arsenite). Arsenite is generally considered to be more toxic than arsenate. This is because arsenite is more easily absorbed by the body and can cross the blood-brain barrier. Arsenite can also damage DNA and proteins, leading to cell death (Ardini, 2020). This study aims to describe an optimized quantitative liquid extraction procedure for the chemical speciation of arsenic in atmospheric particulate and the application of the technique to study the concentration, speciation, and origins of arsenic in PM_{10} samples collected in the city of Bor, located in the southeast of the Republic of Serbia. Bor Municipality area is constantly influenced by air pollution due to technological processes in the Copper Smelting Plant. Emissions from the Copper Smelter are principally sulfur oxides and particulate matter enriched with cancerogenic elements such as, As, Cd, and Pb.

The application of disposable cartridges is a convenient and inexpensive way to separate arsenic species. These cartridges are packed with a selective adsorbent that can remove arsenate (As(V)) from liquid extracts. Arsenite (As(III)) remains in the filtered extract (Xiaoguang, 1998). PM_{10} samples were collected with the low-volume samplers (Sven/Leckel LVS3) on quartz fiber filters (Whatman QMA, 47mm) as collection medium. For comparing the results, half of the filters were prepared for chemical analysis following the standard procedure of SRPS EN 14902: 2013. Half of the filter is placed in a plastic tube. The extraction of the arsenic species was achieved using 100 mmol/ l $NH_2OH.HCl$ (10 ml) with the aid of an ultrasonic bath for 30 min. After the extraction part of the liquid extract is used for the total arsenic content, and the other part is passed through the cartridge to determine the As^{3+} concentration. The concentration of As^{5+} is determined from the difference between the concentration of total arsenic and the concentration of As(III). (Abhijnan, 2023).

The sum of the individual arsenic species showed good agreement with the total arsenic concentration (92-113 % recovery). As(V) represented 78% of the total arsenic and did not differ significantly from the values reported by others (D.Sanchez-Rodas, 2007).

There are several advantages to using disposable cartridges for arsenic speciation. First, it is a simple and rapid method that can be easily performed in the field. Second, it is a cost-effective method that can be used to analyze large numbers of samples. Third, it is a reliable method that is effective in a variety of environmental samples.

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11.11 75TH ANNIVERSARY OF THE DONORA AIR POLLUTION INCIDENT WHICH INITIATED CLEAN AIR LEGISLATION IN THE USA

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October 2023 is the 75th Anniversary of an air pollution incident that killed twenty people which led to the first legislation countering air pollution in the United States of America.

The industrial town of Donora, Pennsylvania with a population of 14,000, contained steel mills and a zinc ore processing plant which converted zinc sulphide ore to the metal with an output of over 37,000 tonnes per year. Emissions from the plant included zinc, cadmium and lead particulates as well as hydrogen fluoride and sulphur dioxide. Chimneys 46 meters high were in fact 120m below the height of the valley in which the town was located. In October 1948, pollutants accumulated in the still air for six days when a temperature inversion trapped the emissions until rain fell and dispersed them. Twenty people died from inhalation of the polluted air, thousands more suffered respiratory problems. All fatalities were people over 55 years old who did not work the plant.

The incident led to the first Act of Congress in 1955 addressing air pollution in the USA - The Air Pollution Control Act. This covered research programmes but did not regulate pollution. The first legislation respecting control of air pollution came in 1963, when legislation was expanded to control air pollution levels nationally. There was major upgrade in 1970, the same year as the Environmental Protection Agency was established, which administers the Clean Air Act since then. Additional regulations addressing vehicle and industrial emissions have been added in 1977 and 1990.

11.12 THE IMPACT OF THE COVID-19 PANDEMIC ON PARTICULATE AIR POLLUTION IN THE REPUBLIC OF SERBIA

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In recent years, the global community has been confronted with the profound challenges presented by the COVID-19 pandemic, which originated in late 2019 in China and swiftly escalated into a global crisis in 2020. To mitigate the spread of the virus, numerous countries implemented a range of measures, including restrictions on movement, the adoption of remote work arrangements, the transition to virtual education, and the curtailment of economic activities. From an environmental perspective, this worldwide health crisis, despite inflicting substantial negative impacts on public health and global well-being, yielded a favourable outcome in the reduction of pollutant emissions. Research outcomes consistently indicate an overall improvement in air quality during the lockdown period when compared to pre-lockdown, post-lockdown, and historical reference periods. Specifically, in the countries with higher levels of air pollution witnessed notable reductions in NO2 and PM concentrations. In contrast, the concentrations of O3 primarily saw an increase, while the levels of SO2 and CO exhibited greater variability (Rodríguez-Urrego and Rodríguez-Urrego, 2020; Kumari and Toshniwal, 2022).

The Republic of Serbia, like many other nations, declared a state of emergency during the pandemic, implementing curfews and various regulations aimed at curtailing citizen activities. The principal objective of this study was to evaluate the influence of the state of emergency and the accompanying regulatory measures on air quality in the Republic of Serbia. This evaluation was conducted through the analysis of pollutant concentrations obtained from monitoring stations within the National network of automatic stations for air quality monitoring (SEPA, 2023). While suspended particulate matter was chosen as the primary pollutant of interest, concentrations of other pollutants were also included in separate analyses.

Out of the 35 monitoring stations contributing data to the European Monitoring Network (EEA, 2023) in the Republic of Serbia, only five stations provided data for suspended particles during both the pre-COVID and COVID periods, with one station measuring both PM10 and PM2.5 concentrations. These selected monitoring points were predominantly located in urban areas, particularly in Belgrade and Niš, with the station at Kamenički Vis near Niš serving as the background location. The analysis spanned two eight-week periods: the first commencing with the declaration of the state of emergency on March 15, 2020, and concluding on May 6, 2020, while the second involved data collected during the same eight-week period from the preceding three years (i.e., from March 15 to May 6 in 2017, 2018, and 2019).

We used a sophisticated data analysis methodology encompassing statistical techniques, predictive machine learning models, and explainable artificial intelligence (Jovanovic et al, 2023; Stojić et al, 2022) to explain the complex relations between particle concentrations, the concentrations of other pollutants, meteorological variables, and anthropogenic activities. This approach is designed to foster a comprehensive understanding of the mechanisms that underlie the initiation of air pollution.

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11.13 ASSOCIATION BETWEEN AIR POLLUTION AND ATOPIC DERMATITIS IN NIŠ, SERBIA

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Atopic dermatitis is a major public health issue worldwide and a common, chronic skin disease in children (Angles et al, 2022.). As air pollution remains a critical environmental factor impacting human health, it is important to investigate the relationship between different air pollutants and atopic dermatitis, specially in sensitive population groups, such as children still remains debatable (Fadadu et alm, 2023.). Moreover, studies evaluating the effects of air pollution on atopic disease in children are scarce. The aim of the study was to examine the long-term associations between air pollution and atopic dermatitis in two groups of children exposed to different levels of air pollution.

We used an anamnestic retrospective study, done on 354 children, aged between 11 and 14 years, living for more than 10 years at the same location in the city of Niš, Serbia. Their parents were asked about skin changes among their children. The prevalence of atopic dermatitis was assessed from the medical reports of subjects. The air concentrations of black smoke, nitrogen dioxide and sulphur dioxide in Niš city were determined from last ten years.

Exposed children had a higher prevalence of many skin symptoms than non-exposed children ($P<0.01$). Also, the prevalence of atopic dermatitis in children exposed to higher concentrations of air pollutants was higher than in non-exposed children 1 38 (95% CI 1.02-1.87).

Our study suggests that long-term exposure to ambient air pollution was associated with an increased prevalence of skin changes in children and contributes to higher prevalence of atopic dermatitis in childhood in the city of Niš.

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11.14 HOW DID THE 2020 COVID-19 LOCKDOWN INFLUENCE PARTICULATE MATTER-BOUND PAH CONCENTRATIONS IN BELGRADE'S ATMOSPHERE?

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The COVID-19 pandemic and the subsequent implementation of lockdown measures have offered a unique opportunity to investigate the impact of anthropogenic emissions on air pollution. Air pollution in Belgrade is caused by human activities such as industrial operations, transportation, energy production, household energy and heat generation, agriculture activities, and landfills which eventually affect the city's air quality.

This study examines the influence of the 2020 COVID-19 lockdown on particulate matter-bound polycyclic aromatic hydrocarbon (PAH) concentrations in Belgrade's atmosphere. Data on PAH concentrations were collected at four measurement stations in Belgrade from March to May in 2020, and corresponding periods in previous and next years. Measurement sites were selected within the local monitoring network of the Public Health Institute of Belgrade to represent suburban, urban, and industrial influence. The PM_{10} samples were collected using European reference low-volume air samplers, and PAH concentrations were determined using gas chromatography-mass spectrometry (GC-MS) analysis. Benzo[a]pyrene (B[a]P) is utilized to represent the concentration of PAHs. Within the group of PAHs, B[a]P is acknowledged as an indicator of the carcinogenic potency of the PAH mixture.

The findings of this study indicate that the levels of B[a]P concentrations during the period from March to May 2020 were consistently higher in comparison to the concentrations observed in 2019 and 2021. This trend was observed across all three months and at all measurement sites, suggesting a notable and sustained increase in particulate matter-bound polycyclic aromatic hydrocarbon levels during the COVID-19 lockdown period in Belgrade. The notable rise in B[a]P concentrations raises important questions about the factors contributing to this increase and underscores the intricate relationship between human activity and air quality.

11.15 AN EXPLORATORY STUDY FOR THE IMPLEMENTATION OF THE OXIDATIVE POTENTIAL ASSESSMENT OF PARTICULATE MATTER IN PORTUGAL

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Particulate matter (PM), especially its fine fraction (PM2.5), has been identified as one of the main air pollutants damaging human health (Almetwally et al., 2020). The prime mechanism of PM toxicity is the excessive generation of reactive oxygen species (ROS), inducing oxidative stress in biosystems. Oxidative potential (OP) has been proposed to measure the PM capacity to generate ROS. Among the developed assays to determine OP, the dithiothreitol (DTT) assay is one of the most widely applied (Jiang et al., 2019). The main goal of the present study is to implement the methodology of OPDTT assessment at C2 TN (Portugal). For this, a set of PM2.5 samples was selected to perform the OPDTT assessment by applying one of the most used protocols nowadays (Chirizzi et al., 2017)). Moreover, the evaluation of the use of the reference material SRM 1648 (Urban Particulate) as a standard for determining OP using the DTT assay was also conducted. This could be a valuable tool to evaluate the quality of the results in such type of analysis.

The OP of the water-soluble fraction of a quarter of the PM2.5 sampled filters (from an urban-industrial environment) was assessed following the DTT assay described by Chirizzi et al. (2017). A solution of the reference material SRM 1648 (Urban Particulate - NIST, USA), with a concentration of 10 mg.L-1 , was prepared with deionized water. This solution was used as a standard and evaluated regarding its OP level following the same procedure as the PM2.5 extracts.

Up to now, the OP of thirty PM2.5 samples (out of a total set of 120 filters) was already assessed by the DTT method at DISTEBA, Italy (for training purposes). Samples presented mean levels of DTT activity (normalized to the mass) of 11.9 ± 6.8 pmol/min*µg, ranging from 2.6 to 26.1 pmol/min*µg. Other PM2.5 samples of the 120 filters set were already analysed in Portugal, and the results were comparable. The OP level of the standard solution was also successfully assessed.

This study contributes to the implementation of the OP assessment of particulate matter at C2 TN facilities (Portugal), which will allow to assess the OP of PM samples from different environments and to try to identify one of the major drivers of the toxicity of PM. The identification of a reference standard for the OP analysis will provide a useful tool fo quality assurance.

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