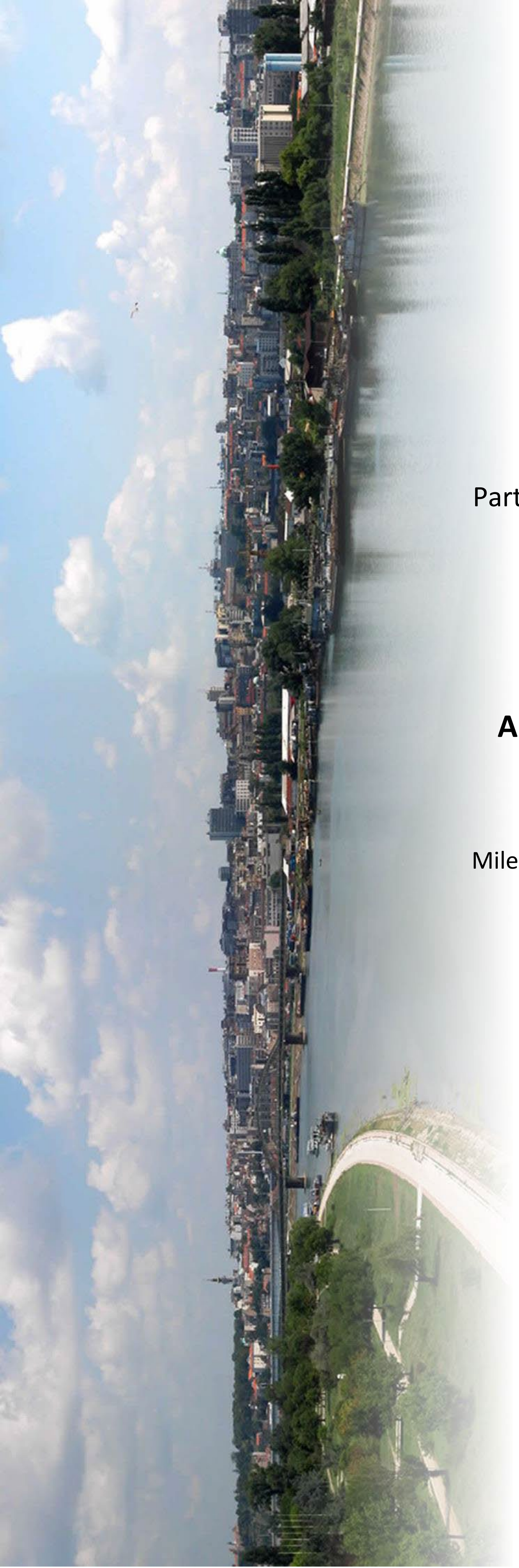

WeBIOPATR 2019

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

Abstracts of Keynote Invited Lectures and Contributed Papers

Milena Jovašević-Stojanović and Alena Bartoňová, Eds

Public Health Institute of Belgrade

Belgrade 2019

ABSTRACTS OF KEYNOTE INVITED LECTURES AND CONTRIBUTED PAPERS

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Particulate Matter: Research and Management

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   i. Sources and formation of particulate matter
   ii. Particulate matter composition and levels outdoors and indoors
   iii. Environmental modeling
   iv. Nanoparticles in the environment
2. **Particulate Matter and Health**
   i. Exposure to particulate matter
   ii. Health aspects of atmospheric particulate matter
   iii. Full chain approach
3. **Particulate Matter and Regulatory Issues**
   i. Issues related to monitoring of particulate matter
   ii. Legislative aspects
   iii. Abatement strategies

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Particulate Matter: Research and Management, WEBIOPATR 2019

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PREFACE

The International Workshop and Conference, Particulate Matter: Research and Management – WeBIOPATR is a biennial event held in Serbia since 2007. The conference addresses air quality in general and particulate matter specifically. Atmospheric particulate matter arises both from primary emissions and from secondary formation in the atmosphere. It is one of the least well understood local and regional air pollutants, has complex implications for climate change, and is perhaps the pollutant with the highest health relevance. It also poses many challenges to monitoring.

By WeBIOPATR, we aim to link the research communities with relevance to particulate matter with the practitioners of air quality management on all administrative levels, in order to facilitate professional dialogue and uptake of newest research into practice. The workshops usually draw an audience of about 70, and attract media attention in Serbia. It enjoys support of the responsible authorities: Ministry of Education, Science and Technological Development, Ministry of Health, Ministry of Environment, and the Serbian Environmental Agency whose sponsorship is indispensable and gratefully acknowledged. We enjoy also support of international bodies such as the WHO.

The 1st WeBIOPATR Workshop was held in Beograd, 20.-22. May 2007, associated with a project funded by the Research Council of Norway. The 2nd workshop was held in Mecavnik, Serbia, 28.8.-1.9. 2009. WeBIOPATR2011 was held in Beograd 14.-17. 11. 2011 and for the first time, included a dedicated student workshop. WeBIOPATR2013 was held in Beograd 2.-4. 10. 2013. It covered the traditional PM research and management issues, discussions on how to encourage citizens to contribute to environmental governance, and how to develop participatory sensing methods. WeBIOPATR2015 was held in Beograd 14.-16.10. 2015. Own sessions were devoted to sensor technologies for air quality monitoring, utilizing information and input from the EU FP7 funded project CITI-SENSE (http://co.citi- sense.eu) and the EU COST action EuNetAir (www.eunetair.it). WeBIOPATR2017, the 6th conference, was held in Beograd 6.-8.9. 2017, with a wider than before Western Balkan participation.

WeBIOPATR2019 will be held 1.-3 -10-2019 in the Mechanical Faculty, University of Belgrade. It has attracted a record 58 contributions, and is bringing together scientists from 12 countries, documenting that the issues of atmospheric pollution, with their wide implications for climate change, human health and ecosystem services, are no less important today.

We are grateful to our unrelenting national and international partners for their support for this event.

Welcome to Beograd, and have a stimulating and productive time!

Milena Jovašević-Stojanović and Alena Bartoňová

TABLE OF CONTENTS

1. COLLABORATING WITH PUBLIC 1

1.1. AIR QUALITY IN THE AGENDA 2030-AN OPPORTUNITY FOR ACHIEVING BETTER HEALTH AND SUSTAINABILITY

E. Paunovic
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This paper is aiming to highlight the important role of strategic international political frameworks such as Agenda 2030, EU's 7th Environment Action Program and the 2017 Ostrava Ministerial Declaration on Environment and Health, in bridging the gap between science and policy and establishing and maintaining a strong evidence base for policy-making in the steadily evolving area of protecting health form air pollution. Nowadays, there is a paradox that the scientific research and data related to the impacts on air quality to human health are paramount, but the policy response, uptake and impact of these data on policy making and subsequent interventions is not introducing the distal dimension of air quality, health and well-being.

The most comprehensive strategic framework on closing the gap and improving everyone's health, as well as accelerating the rate of improvement of the health of those most impacted, and those with the highest risk of inequity, is tackled by the United Nations agenda: "Transforming our world: the 2030 Agenda for Sustainable Development" and the unanimously agreed 17 Sustainable Development Goals (SDGs) and 169 targets, adopted by the United Nations General Assembly in September 2015.The United Nations 2030 Agenda for Sustainable Development has created a new impetus for transformative approaches to achieving the goals of better health and well-being for all. Health is a determinant, an enabler, a key component and an outcome of all the SDGs, including these related directly and indirectly to the improvement in air quality in order to improve human health. Strategies related to improved air quality are linked with climate change mitigation targets, access to clean energy, waste management, and other aspects of socio-economic development, but it seems that under current policies, these SDGs will not be met. It is easier to say that SDG Agenda is transformative, than to really make a change. The biggest challenge is to apply integrative approach by addressing all three pillars of sustainability: social, environmental and economic. Interactions between human health and planetary boundaries including ecosystem health is exceeded in many aspects and only primary prevention approaches can bring success, but addressing simply the hazards, as it was and is mainly applied approach will not bring the success. Social dimension and complexity are underpinning physical environment, and the main reason for science-policy gap is hidden somewhere in this complexity. SDG Agenda is providing a joint strategic platform for integrative approach, as the risk to human health is not fragmented, although for the sake of better understanding and for overcoming the limitations in the scientific research it is quite often addressed in a very limited and fragmented way. Greater synergies between health and other sectors could be achieved by framing the SDGs in such a way that their attainment requires policy coherence and shared solutions across multiple sectors (energy, transport, agriculture, health, urban planning etc.). In order to achieve policy coherence, it is essential to strengthen the analytical framework, the institutional framework and the monitoring and evaluation. Refering to air quality and health monitoring, under the SDGs implementation, the WHO databases on household energy and air quality are unique resources used by scientists, UN agencies, countries and others to monitor global progress towards clean air. They supply data to track progress on SDG 7.1.2 (access to clean fuels and technologies), as well as SDG 11.6.2 (improving air quality in urban areas). They are the basis for determining disease burden from air pollution for SDG 3.9.1. Both national sustainable development strategies (SDSs), health policies (NHPs) and air quality policies are influenced by the global context (including scientific research data and WHO recommendations), but they are heavily shaped by the national economic, political, cultural and social conditions.

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Annex 1. Compendium of possible actions to advance the implementation of the Ostrava Declaration. Copenhagen: WHO Regional Office for Europe; 2017 (http://www.euro.who.int/__data/assets/pdf_file/0008/341945/Annex1_13June.pdf?ua=1, accessed 17 July 2018).

1.2. AIR QUALITY AND PUBLIC PERCEPTION IN BELGRADE

<u>M. Jovašević-Stojanović</u> (1), M. Davidović (1), I. Lazović (1), M. Živković(1) , D. Topalović(1,2), M. Jovanović(1), N. Castell (3), M.F. Fredriksen (3), H.Y. Liu (3), A. Bartonova (3)

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Background and Aim: Air pollution is a global public health emergency. In 2015, EEA estimated 422 000 premature deaths attributed to $PM_{2.5}$ exposure in 41 European countries, while 79 000 and 17 700 premature deaths due to exposure to NO_2 and O_3 respectively. For $PM_{2.5}$, the highest numbers of premature deaths and Years of Life Lost (YLL) was estimated for the countries with the largest populations. When considering YLL per 100 000 inhabitants, the largest impact was observed in central and eastern European countries including Serbia (EEA, 2018). A FP7 collaborative project CITI-SENSE aimed to raise awareness of air pollution by developing a user-friendly citizen's observatory (COT) for air quality, ultimately aiming to reduce exposure to harmful pollutant(s).

Methods: Belgrade (pop. >1,6 mil), the capital of Serbia, was one of nine European cities where CITI-SENSE was conducted. The COT, (https://co.citi-sense.eu, Liu et al 2018), is a combination of citizen science approaches with an ICT infrastructure for objective monitoring (static and mobile air quality devices) and subjective assessment of air quality (questionnaires and CityAir app, https://play.google.com/store/apps/details?id=io.cordova.CityAir). CityAir is a smartphone application for the public to express their perception of outdoor air quality at their location, Users rate the air quality in their immediate surrounding using a colour code: Green – very good; Yellow – good; Orange – poor; Red – very poor. The app also allows users to indicate the assumed source of air pollution, and to write a comment. An on-line air quality perception questionnaire (http://w.civicflow.com/task/participate/151) can be answered by anybody anywhere. The questionnaire includes three sections: participants' personal information, specific questions on the participants' air quality perception and feedback from the participant.

Results: Figures 1 and 2 show responses of citizens of Belgrade during CITI-SENSE project campaign.

Figure 1. The view of CityAir app in Belgrade.

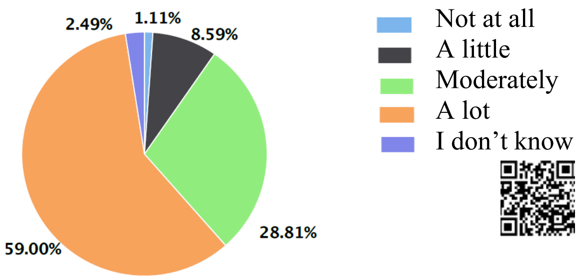

Figure 2. To what extent do you think that the air quality in your city affects your health?

Conclusions: Filling questionnaire and participatory mapping provide practical opportunities with which to bridge the environmental knowledge gap and encourage more citizens to be more inform about air pollution sources and consequences and to participate in environmental decision making.

ACKNOWLEDGEMENTS

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2. HEALTH EFFECTS

2.1. CURRENT KNOWLEDGE ON HEALTH EFFECTS OF PM

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Air pollution is a ubiquitous environmental exposure with a number of well-documented adverse health effects. Global Burden of Disease Study from 2015 estimated that 4.2 million deaths and 101.3 million lost years of healthy life worldwide were attributed to fine particulate matter ($PM_{2.5}$) (Cohen et al. 2017), with the majority of deaths caused by cardiovascular disease (60-80%), followed by chronic respiratory diseases, cerebrovascular disease, and lung cancer. The most recent calculation reported the dramatic doubling in number of deaths attributable to air pollution, to that of 8.9 million (close to number of deaths attributable to tobacco smoke), and reduction in the mean life expectancy by 2.2 years (Lelivield et al. 2019). This doubling in number of deaths is largely explained by inclusion of highly prevalent diseases, such as diabetes and hypertension, which were recently linked to air pollution (Lelivield et al. 2019). Overall burden of air pollution is not yet fully elucidated and current research is rapidly pushing forward to identify new links between air pollution and chronic diseases (neurodegenerative and psychological diseases, cancers other than lung, etc.). This talk will give an overview of epidemiological evidence on health effects related to exposure to PM including: all-cause and cause specific mortality and morbidity from cardiovascular and cerebrovascular disease, chronic respiratory disease, cancer, diabetes, neurodegenerative diseases (dementia, parkinson's disease, multiple sclrosis), as well as pregnancy and early life-outcomes. Summary on the strength of evidence on each specific disease will be given, along with reflection on current research gaps.

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2.2. HEALTH IMPACTS OF AIR POLLUTION IN MAIN CITIES IN REPUBLIC OF SERBIA

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WHO estimated that exposure to ambient air pollution accounted for 4.2 million premature deaths per year (https://www.who.int/airpollution/en/) due to stroke, heart disease, lung cancer and chronic respiratory diseases, globally in 2016, including 500 000 in the WHO European Region. Of this total, an estimated 6 592 deaths and 131 183 years of life lost (YLL) were due to air pollution in Serbia. Around 91% of the world's population lives in places where air quality levels exceed WHO limits. Long-term exposure to air pollution leads a relevant percentage of the population to die prematurely, according to a comprehensive investigation on the impact of air quality on health in World. The aim of the work is the assessment of air pollution impacts on health in the main Serbian cities with a detailed analysis of the situation of Belgrade. This work presents the results of monitoring of PM10, in ambient air of main Serbian cities and examine possible association between air pollution and mortality. Suspended particles were in 2016, as in previous years, the dominant pollutant in the Republic of Serbia (http://www.sepa.gov.rs/download/VAZDUH2016.pdf). Long-term and short-term exposure to air pollution also increases mortality risk. Exposure to air pollution, especially airborne PM, is associated with increased mortality and morbidity, particularly from cardiovascular and respiratory diseases. Assessments of air quality based on data from monitoring stations managed by national authorities indicate that the concentrations of air pollutants, especially PM, regularly exceed the levels that protect human health in Republic of Serbia.

A thorough data collection of air pollution data has been associated with an extensive collection of population and health data covering the period 2010 - 2016. The application of the AirQ+ by WHO has allowed to process data from the main Serbian cities to calculate the attributable proportion of deaths due to air pollution.

Exceedance of WHO air quality targets, as well as EU air quality limit values, have been recorded in several Serbian cities.

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https://www.who.int/airpollution/en/
http://www.sepa.gov.rs/download/VAZDUH2016.pdf

2.3. INDOOR PARTICULATE MATTER IN NURSERY AND PRIMARY SCHOOLS: IMPACTS ON CHILDHOOD ASTHMA

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Indoor air quality in public and private buildings where people spend a large part of their lives is an essential determinant of health and people's welfare (WHO, 2010). Thus, the main objective of this study was to assess the impact of indoor particulate matter (PM) in nursery and primary schools on childhood asthma. This study was approved by both the Ethics Commission for Health of *Centro Hospitalar Universitário de São João, Porto*, and the Ethics Commission of University of Porto.

Four different fraction ratios of PM (PM_1, $PM_{2.5}$, PM_{10} and TSP – total suspended particles) were continuously sampled in 63 rooms (50 classrooms, 2 bedrooms, and 19 classrooms) from 25 nursery and primary schools, located in both urban and rural sites from Northern Portugal (Branco et al., 2019). Samplings occurred twice in each room (cold and warm seasons), from 24h to 9 consecutive days, and considering both weekdays and weekend. A TSI DustTrak DRX 8534 particle monitor using light-scattering laser method was used. Hourly means were calculated, allowing to draw daily patterns. To understand the size distribution PM fraction ratios ($PM_1/PM_{2.5}$, $PM_{2.5}/PM_{10}$, and PM_{10}/TSP) were also calculated. The study population included 1530 children attending the studied nursery and primary schools (60% from urban areas, and 58% primary school children). Five health outcomes were considered, namely: i) reported active wheezing, obtained from a questionnaire based on ISAAC (The International Study of Asthma and Allergies in Childhood); ii) reported asthma, obtained also from the same questionnaire; iii) diagnosed asthma, according to Global Initiative for Asthma guidelines (GINA, 2018), if at least one asthmatic symptom was reported simultaneously with spirometry results revealing both airflow limitation (obstruction, $FEV_1/FVC < 0.90$) and excessive variability in lung function (positive bronchodilator reversibility test with increase in FEV_1 higher than 12% predicted); iv) obstructive disorder, diagnosed in children reporting asthmatic symptoms with spirometry reveiling $FEV_1/FVC < 0.90$; and v) dysfunction – reduced lung function, diagnosed in children reporting asthmatic symptoms with spirometry reveiling $FEV_1 < 80\%$ predicted. Children's daily exposure and inhaled dose of indoor PM in nursery and primary schools was estimated based on a microenvioronmental modelling approach (Branco et al., 2014), considering time-activity-location information obtained from parent-reported diaries. Multivariate logistic regression models were used to assess the association between exposure/inhaled dose and each outcome. Models were adjusted for potential confounders.

Higher PM concentrations were found during classes and in the periods of entrance and exit of the schools, mainly due to resuspension phenomena. Indoor/outdoor ratios were above 1, meaning that PM was mainly influenced by indoor sources. PM concentrations were significantly higher (p-value < 0.05) in cold season and in urban settings, and they also varied significantly with age group of the children. $PM_{2.5}$ exceeded the protection limit concentrations for indoor air in the Portuguese legislation and in World Health Organization guidelines, respectively in 54.9% and 69.0% of the studied classrooms. Exposure (and inhaled dose) to PM in nursery and primary schools was not significantly associated with asthma diagnosed. However, exposure to $PM_{2.5}$ and PM_{10} were significantly associated with dysfunction – reduced FEV_1 (OR = 1.82 and 2.13 respectively, p-value < 0.001). Similar results were found for inhaled dose of $PM_{2.5}$ and PM_{10} (OR = 1.94 and 1.86 respectively, p-value < 0.001).

In short, this study concluded that children were exposed and inhaled high doses of PM in nursery and primary schools, especially finer fractions ($PM_{2.5}$), which were associated with reduced lung function. Mitigation measures are needed to reduce PM in nursery and primary schools, thus reducing PM impacts on children's health.

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2.4. HEALTH RISK ASSESSMENT OF SO2 AIR POLLUTION: A CASE STUDY

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There is increasing evidence linking air pollution in the city with acute and chronic diseases among all age groups. One of the major air pollutants measured in ambient air is SO_2 gas (European Environment Agency, 2018; Joksic, al, 2009), which has been shown to have a detrimental effect on human health (World Health Organization, 2016).

In this study, a health risk assesment was conducted to evaluate the health risks of SO_2, a common pollutant in breathing air. An analysis of data published in recent papers dealing with the health impact of SO2 has been performed. Exposure estimates were also made based on a series of data on daily concentrations of SO_2 in air in Belgrade. Dose rates for all population categories were estimated based on the concentration of pollutants in different activity zones (residential, industrial and commercial). Because the primary objective of this study was to estimate maximum (possible) doses of pollutants in different zones for different age groups, the maximum concentrations of SO2 pollutants during the day were used.

The categories in which positive findings are assumed are considered. The lowest observed adverse effect level (LOAEL) was calculated based on data related to positive dose-response relationships. Children due to their respiratory parameters, as well as their habits, were the most exposed of all age groups. In general, the risk is posed in some part of the city.

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2.5. AIR POLLUTION AND AUTISM SPECTRUM DISORDERS: IS THERE A LINK OR BIAS?

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Autism is a mental disorder that affects communication and behavior. Although autism could be diagnosed at any age, symptoms generally appear in the first three years of life. It is known as a spectrum" disorder (ASD) because there is wide variation in the type and severity of symptoms. Etiology of ASD is not fully recognized despite its serious health and social impact. Genetic factors probably play the major role. However, in recent years, many researchers suggest that ASD is the result of complex interactions between genetic and environmental risk factors (Kim and Leventhal, 2014).
The number of studies on link between environmental chemical exposures and autism is huge. They include estimates of exposure to food contaminants, air pollutants, vaccines, life style etc. Among chemicals possible causes are metals (lead, methylmercury), alcohol, retinoids, polychlorinated biphenyls, organophosphate and organochlorine pesticides, endocrine disruptors, automotive exhaust, polycyclic aromatic hydrocarbons, brominated flame retardants, perfluorinated compounds and many other (Kalkbrenner et al, 2014). Air pollution contains many of these toxicants, so there are numerous epidemiological studies that seek to link it with autism.
We searched internet NCBI data using key words autism and air pollution or more specific particulate matter air pollution. From more than 100,000 results, based on the title and abstract, we selected the articles that we considered the most relevant.
The essential question is the relevance of air pollution exposure to the etiology of autism. A "redox/methylation hypothesis of autism implies that oxidative stress, initiated by environment factors in genetically vulnerable individuals may lead to ASD (Deth et al, 2008). There is a possibility that small particles, including PM2.5 and ultrafine particles (UFP) may reach the the fetus brain and produce neuroinflammation and oxidative stress (Block and Calderon-Garciduenas, 2009; Lucchini et al, 2012; Allen et al, 2017).
Many epidemiology studies suggest the link between ASD and air pollution exposure before, during, and after pregnancy. Exposure to traffic-related air pollution, nitrogen dioxide, PM2.5, and PM10 during pregnancy and during the first year of life was associated with autism (Volk et al, 2013). Higher maternal exposure to PM2.5 during pregnancy, particularly the third trimester, was associated with greater odds of a child having ASD (Raz et al, 2015). On the contrary, recent study on air pollution and autism in Denmark suggests that air pollutants exposure in early infancy, but not during pregnancy, increases the risk of being diagnosed with autism (Ritz et al, 2018.) Exposures to PM1, PM2.5 and PM10 during the first three years of life were associated with the increased risk of ASD and there appeared to be stronger effects of ambient PM pollution on ASD in the second and the third years (Chen et al, 2018). On the other side, there are studies which do not support association between pre- or postnatal exposure to air pollution from road traffic and neurodevelopmental disorders in children (Gong et al, 2014; Guxens et al, 2016).
When studying environmental causes of autism, some confounding may be of concern. For instance, living in cities (with greater air pollution than in rural areas) may be connected with higher prevalence of ASD just because of better ascertainment. There are also many additional potential causal risk factors like stress, maternal diet, exposure to pesticides or other food contaminants. Despite the current efforts, to recognize the prevalence, the rate of increase and risk factors for ASD, more cohorts in humans and experimental studies in animals are needed.

Acknowledgments
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3. COLLABORATING WITH PUBLIC 2

3.1. URBAN INNOVATIVE ACTION AIR-HERITAGE: LOW COST SENSORS IN ACTION

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Air quality is one of the most concerning drivers of global population health. As most human beings are now living or moving to cities, obtaining accurate and precise information of people exposure is paramount for urban planning. Regulatory Air Quality monitoring networks cannot achieve sufficient spatial resolution for assessing citizens groups exposure, particularly in small cities. Procurement and maintenance costs along with the EU regulatory framework (EC, 2008), in facts, basically prevent to deploy adequately dense network to cope with the spatial and temporal variability of the pollutant distribution phenomena. Thus, Public Authorities lack relevant data and tools to design targeted improvement and remediation policies. At the same time, citizens lack information about their air pollution exposure contributing to either under- (or, sometimes over-) estimation of health threats (Broody and Peck, 2004). Moreover, significant institutional authoritativeness and cultural barriers between citizens and PAs have grown, in the last decade, distorting the shared perception and diminishing the participation and hence impacts of air pollution remediation policies. AIR-HERITAGE, a project proposed by the city of Portici, aims to build a framework based on pervasive AQ monitoring, integrating regulatory monitoring stations, solid state based fixed stations and citizens mobile personal exposure analyzers in a fully synergistic network. Funded by the Urban Innovative Action framework of EU along with Helsinki, Ostrava and Marseille (UIA Website, 2018), the Portici city area and community will be transformed by the project in an innovation laboratory tackling the multifaceted air quality problem with a unified technological, social and political approach. Portici is, in facts, a relatively small city (4.32 Km^2) with high density of population (>60k actual inhabitants), characterized by intense car traffic (33k private cars) and a general lack of commitment to sustainable mobility. The social aspects of the project will be tackled by enrolling the citizens of Portici (schools, associations) in AQ monitoring contests and pervasive AQ information campaigns designed to motivate their participation in the challenges of high density AQ monitoring in the city. They will obtain their own data trough technological enablers like the field calibrated and validated portable AQ multisensors systems called MONICA (Italian Acronym for Cooperative Air Quality Monitoring). The system is equipped with NO_2, CO, O_3 (Alphasense, inc.) and PM (Plantower) low cost sensors. Citizen engagement in AQ policies will be hence innovated through the availability of personal exposure feedbacks and targeted data sharing. PA officers and citizens associations will cooperate providing their own monitored AQ data, recorded during daily activities. Coupled with high resolution modeling tools, data will be used to fuel an innovative AQ Policy Decision Support System. As a result, the crowdsensing social network will become part of the policy making process. Eventually AirHeritage will improve PA capability to design efficient and participated policies. As an ultimate goal, the cooperative nature of AIR-HERITAGE will bridge the existing gap among the AQ relevant actors, increasing citizens engagement in policies for reducing air pollution levels to the benefit of the citizenship health. This keynote contribution will address project multidisciplinary and multilateral approach with a special focus on technological challenges including Multisensors design, calibration and validation procedures, Network design and deployment, Data fusion and assimilation schemas. Machine learning along with edge computing concepts will have a primarily role in the implementation and management of multisensors calibration. Shallow neural networks will be actually used as calibration function distilling colocation data (Esposito et al., 2016). Network weights will be stored in project's cloud facility from which it will downloaded by users smartphone apps at connection time to be able to assess real time exposure and accurate concentrations data. The SIRANE pollutant emission and diffusion model will be shown as a prospective method for integrating measured data in to a predictive system at the base of the AirHeritage policy DSS.

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3.2. INFORMING THE CITIZEN: PARTICULATE MATTER IN EUROPE

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Since the air pollution episodes and smog situations in the 1950's and acid rain of the 1970's and 1980's, European air has undergone a highly positive development. Not only has our understanding increased considerably, but Europe has been able to develop a comprehensive system of monitoring and assessment of air quality and polluting emissions, systemized in air quality directives and in directives and regulations regarding the most important anthropogenic pollution sources. It is well documented that the legislative instruments have led to significant reductions in the emissions to air for most pollutants since 1990's (EEA, 2015; EEA, 2018). We can also observe improvements of ambient air for a number of pollutants (Colette et al., 2016), while the trends in ambient concentrations of other pollutants are not so positive, especially in urban areas (Henschel et al., 2015; Guerreiro et al., 2014). Overall, despite improvements, the efforts to clean the air have not reached all objectives (EEA, 2015; EEA, 2018) and the air quality is not brought to "safe" levels. This is especially true for particulate matter which remains the pollutant that is most difficult to control.

Europeans perceive air quality as one of the most important environmental issues, as can be seen e.g., from the Eurobarometer survey (EU, 2017). Over time, countries in Europe have developed a system to measure, monitor and assess air quality, and to inform the public, as a collaboration between all governance levels – European, national, regional and local, with their respective roles in each country. Municipalities are increasingly developing air quality dissemination solutions in collaboration with the public (not only for the public), responding both to the citizens needs and to the information requirements posed by the legislation.

With proliferation of low cost sensor technologies, we find ourselves in a situation where on one hand, we have available a large quantity of thoroughly quality controlled but relatively spatially sparse data on air quality across Europe provided by the monitoring systems built up according to the requirements of the legislation, provided to the public by the authorities. On the other hand, we have clusters of data of unknown quality and uneven information value that seem to address the concerns and needs of the public, and are often used for the purpose to raise awareness of the authorities of local air quality problems. Miniaturized sensor systems pose an opportunity for the public, as they allow obtaining instantaneous information directly relevant to individuals.

The challenge is to make these two system work together to create a more efficient monitoring and information system. For example, for the municipalities, there is a challenge to engage with the public in new ways: for example, they could use the public as a resource and harvest data from large numbers of diverse miniaturized sensor systems. This requires Internet-of-Things approaches, and quality control and quality assessment of a new type.

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3.3. AIR QUALITY MONITORING – REAL TIME REPORTING AND PUBLIC RELATIONS

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Fast and unstoppable development of online communication capabilities, as well as everyday expansion of mobile phone applications and air quality monitoring equipment have a powerful impact on all aspects of life, including information on air quality in big cities. This fact, with all the benefits that citizens' awareness brings with it, unambiguously and proportionately opens the possibilities for unintentional or deliberate, tendentious interpretations of air quality data. Such case occurred in winter 2018-2019 when City of Belgrade was marked on several occasions as the one with the worst air quality in the World (nationalgeographic.rs, politika.rs). In order to provide accurate and timely information on the state of air quality to its fellow citizens Institute of Public Health of Belgrade (IPH) releases real-time air quality data on its own website.

Air quality is presented through an air quality index (AQI) that is accompanied by recommendations for behaviors of the general population and vulnerable groups, as well as health effects of deteriorated air quality (beoeko.com). AQI is calculated and updated every hour. Pollutants and calculation grid for AQI calculations are those that are used for the calculation of Common Air Quality Index (airqualitynow.eu). Health impact, and behavioral recommendations are created using existing EPA (epa.gov) recommendations enhanced and adapted by the IPH medical team.

The key result of interactive approach is that residents, visitors and anyone else interested in the air quality is able to get accurate and timely information on the state of air quality in Belgrade and to adjust their behavior to the current situation.

It is necessary to be proactively engaged in public relations through intensive activities in both electronic and written media to get information to public at the right moment. For this purpose, all types of communication should be used to help people get organised in order to improve health and quality of life in general, and raise awarenes on environmental issues.

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4. CHEMICAL CHARACTERISATION

4.1. FIELD EVALUATION OF REAL-TIME REACTIVE OXYGEN SPECIES MONITORS

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WHO has estimated that atmospheric pollution is responsible for more than 7 million premature deaths each year. A large contributor to this mortality is due to atmospheric particulate matter (PM), with PM being linked to lung cancer, cardiovascular disease, and lung disease. A proposed mechanism to explain these health outcomes is through oxidative stress. The oxidative stress hypothesis is aimed at explaining the link between particulate matter (PM) and adverse health effects. PM generated through combustion processes introduce a group of free radicals known as reactive oxygen species (ROS) to cells when inhaled. These ROS impede cell function creating oxidative stress, which can lead to inflammation and cell death.

To investigate this hypothesis, instrumentation to accurately measure the ROS content (oxidative load) of PM is essential. Several systems have been developed to address this, using both commercially available and in-house designed instrumentation coupled with either the DCFH-DA or DTT probes (Fuller et al. 2014). These systems are limited in effectiveness by probe reaction times, time resolution, sensitivity, and ease of use. For this reason, a new ROS probe, BPEAnit profluorescent nitroxide (Stevanovic et al. 2012), was combined with a purpose built particle collector and miniature flow-through fluorimeter to create the particle into nitroxide quencher (PINQ) (Brown et al. 2018). This instrument has a faster response time and lower limit of detection than any other instrument presented in the literature.

The PINQ collects PM for oxidative load measurements with > 97% efficiency and a cut-off size of >20 nm, regardless of chemical composition. This is achieved through a custom made steam collection device known as the insoluble aerosol collector (IAC). Aerosol is continuously sampled, grown into water droplets, and collected into a solution of DMSO and the BPEAnit probe inside a vortex collector. The liquid sample is then debubbled and passed through the fluorimeter for quantification of ROS.

This system was coupled with a flow switching assembly to alternate between total and gas phase samples, with the difference in fluorescence response being proportional to particle phase ROS. The system is fully automated, with a time resolution as low as one minute and software providing real time data analysis. In this configuration the instrument has operated for a total of over 3 months over 3 separate campaigns in the Chinese cities of Guangzhou, Heshan, and Beijing.

Data will be presented on high time resolution diurnal profiles of PM oxidative potential in the aforementioned cities. Observations of pollution events and correlations with other PM and gas pollutants will also be discussed.

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4.2. PARSING ENVIRONMENTAL FACTORS WHICH SHAPE PARTICULATE MATTER POLLUTION USING EXPLAINABLE ARTIFICIAL INTELLIGENCE

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The unpredicted rate and the diversity of modern world development lead to unprecedented changes in the environment which require deep understanding of their nature and measures that might be undertaken to prevent further environment deteoritation. To tackle the root causes which shape air pollution, understanding the fundamental mechanisms of nature must rely on highly sophisticated machine learning algorithms and the interpretation frameworks aimed at delivering explainable predictive analytis (Stojić et al. 2018). In this paper, we utilize the statistical analysis of SHapley Additive exPlanation (SHAP) values to reveal the environmental conditions which shape PM_{10} pollution in an urban area (Belgrade, Serbia).

To examine the evolution of PM levels in the context of the urban environment, eXtreme Gradient Boosting regression analysis (XGBoost) was performed to obtain dependency between PM_{10} and criteria air pollutants (NO_x, NO, NO_2, SO_2, CO), volatile aromatics (benzene, toluene, ethylbenzene and xylene), meteorological factors (visibility, ceil height, wind speed and direction, relative humidity, dew point, atmospheric pressure, temperature and 25 1-degree-Global Data Assimilation System surface parameters), as well as temporal and seasonal variations (trend, day length, daylight, weekday, weekend, sunrise angle, month and season). All the measured concentrations and parameters were obtained from the automatic monitoring network of the Institute of Public Health Belgrade, Serbia. XGBoost is a supervised ensemble learning method which implements iterative combining of ensembles of weak prediction models into a single strong learner (Stojić et al. 2019). The dataset was divided into stratified training (80%) and validation (20%) sets. Hyperparameter tuning was implemented using an advanced grid search and stratified cross-validation replicated ten times. Moreover, to test the stability of the obtained model, 100 times replicated bootstrap procedure was performed.

Subsequently, SHAP framework was applied on the obtained regression function to deliver model explanations. The framework is based on unification of additive attribution algorithms, individualized for each prediction, offering uniquely consistent and locally accurate attribution values. It overcomes the drawback of other methods inconsistency, suppressing the possibility of underestimating the importance of a feature with a certain attribution value. Finally, fuzzy clustering of SHAP attributions was performed to obtain clusters of environmental factors (forces) which govern PM evolution in complex urban environment.

Six clusters of forces were identified, all dominated by CO, but with the ambivalent impact on PM levels. Namely, the clusters which represent the ambient in which the highest PM_{10} concentrations occur, are related to the highest concentrations of CO and benzene. On the contrary, essentially different interrelations between these compounds can be attributed to a lower concentration range of PM, suggesting different emission sources regime and different atmospheric chemistry. Also, visibility appears to be extracted as the most important variable, which clearly depicts fundamentally different atmospheric conditions regarding PM occurrence in different environmental clusters.

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4.3. BLACK CARBON AND FINE PARTICULATE MATTER CONCENTRATIONS DURING HEATING SEASON AT SUBURBAN AREA OF BELGRADE - PRELIMINARY ANALYSES

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Carbonaceous aerosols, organic carbon (OC) and black carbon (BC) or elemental carbon (EC), play important roles on radiative transfer, health effects, and atmospheric chemistry. OC might cause mutagenic and carcinogenic effects due to its polycyclic aromatic hydrocarbons components, while BC further influences climate. Depending on surrounding environment (urban, suburban or rural), ambient aerosols contain on average between 10% and 40% of carbonaceous aerosols (Bautista, 2014). The main sources of BC are incomplete burning of biomasses and fossil fuels. In this work we presented preliminary results of monitoring campaign conducted during winter period, from December 13st 2017 till March 5th 2018, at suburban site of Belgrade, at location of the Institute Vinča (IV). Parallel samples were collected with different techniques: on-line (1 minute resolution) and off-line (daily). On-line measurements were performed with an aethalometer, a real time optical instrument which measures the absorption of light by aerosols. By measuring the absorption at seven wavelengths it is possible to deduce a spectral dependence of the aerosols. Content of equivalent black carbon (eBC) in atmospheric particles was estimated by measuring the light attenuation in the aerosols accumulated on a quartz filter at the standard wavelength λ=0.88µm by a Magee Aethalometer model, AE33. $PM_{2.5}$ and PM_1, were collected on quartz filters with reference gravimetric pumps, LVS Sven Leckel. After gravimetric measurements of PM fraction levels, punches from filters there were analyzed for OC and EC by termo-optical Carbon Aerosol Analyzer (Sunset Laboratory Inc.). Thermal protocol EUSAAR_2 with a transmittance optical correction for pyrolysis was used since this is a European standard thermal protocol (EN16909, 2017). Table 1 and Figure 2, show the first results of OC, EC and eBC for winter period.

Table 1. Average concentration and standard deviation of carbonaceous aerosols OC and EC at IV site (µg/m^3)

	PM	OC	EC	OC/EC
$PM_{2.5}$	31,31(16,74)	8,56(4,26)	1,3(0,59)	6,37(1,76)
PM_1	23,65(14,25)	7,16(2,69)	1,25(0,49)	5,80(1,28)

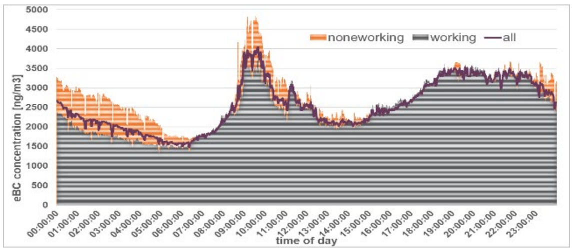

Figure 1. One minute average of eBC at IV site

Further analyses of this data set will be primary focused on source apportionment and source contribution of carbonaceous aerosols from district heating facility of the Institute Vinca buildings, residential heating sources from suburban area in vicinity as well as from short and long range transport of atmospheric aerosols.

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4.4. PRELIMINARY ANALYSIS OF PAHS IN PM2.5 IN BOR AND ZAJEČAR, SERBIA

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Polycyclic aromatic hydrocarbons (PAHs) are a large group of organic compounds comprised of two or more fused benzene rings arranged in various configurations and they are of great concern as their carcinogenicity and mutagenicity with benzo[a]pyrene (BaP) being the most harmful PAH to human health (Kim et al, 2013). BaP is therefore the chosen as PAHs 'marker' (Galarneau, 2008). In Serbia National network of automatic stations for air quality monitoring has only five stations that can determine this pollutant. This is insufficient to cover whole territory of the country, and it is no surprise that many urban and industrial sites in Serbia have limited data regarding concertation of this pollutant in the ambient air. The main aim of this study is to determine levels of PAH in PM2.5 and their diagnostic ratio aiming to identify PAHs emission sources. For the purpose of this study, sixteen priority PAHs in $PM_{2.5}$ are identified and quantified in two different urban environments in the Republic of Serbia. The 14-day measurement campaign was conducted in two nearby towns (Bor and Zaječar) located in eastern Serbia, during March 2019. The distance between these two cities is less than 30 km. Both cities/municipalities have population of about 40,000 citizens. Due to the proximity and because of that the certain influence of the copper smelter to the Bor town urban areas, the sampling site is classified as urban-industrial, rather than typical urban site. At both sites $PM_{2.5}$ samples were collected using the low volume samplers (Sven/Leckel LVS3) and quartz fiber filters (Whatman QM-A, 47mm) as collection medium. PAHs levels in collected $PM_{2.5}$ samples were determined by the GC-MS.The preliminary results show that $PM_{2.5}$ levels in Bor varied from 10.9 to 46.9 μg/m^3 with average mass concentrations of 27.2 μg/m^3 and standard deviation (SD) of 10.3 The $PM_{2.5}$ levels in Zaječar varied from 19.2 to 172.1 μg/m^3, with an average mass concentrations of 75.9 μg/m^3 and SD of 39.3 The total mass concentrations of analyzed PAHs in $PM_{2.5}$ in Bor were in the range from 4.1 to 18.4 ng/m^3 with an average of 10.0 ng/m^3 and SD of 4.1 and in Zajecar from 24.1 to 327.5 ng/m^3 with an average of 87.1 ng/m^{3}and SD of 77.9. Diagnostic ratio has been a convenient approach to help identify possible emission sources in former studies although the ratios should be used with much attention as PAH profiles are different from those in the sources and can be altered due to the chemical reaction with other atmospheric pollutants (Kong et al, 2010). The ratio of Flu/(Flu + Pyr) is lower than 0.40 for the petroleum source, and higher than 0.50 for biomass and coal combustion (Han et al, 2011). For the 4-ring PAH isomer indicator BaA/(BaA + Chr), a ratio higher than 0.35 signals pyrolytic sources, lower than 0.2 indicates petrogenic sources, and between 0.2 and 0.35 could be either petrogenic or pyrolytic sources (Gao et al, 2011). The ratio of Ant/(Ant + Phe) 0.1 is taken as an indication of petroleum. The ratio of Ant/(Ant + Phe) <0.1 is taken as an indication of petroleum, while ratio > 0.1 indicates a dominance of combustion (Han et asl, 2011). By applying such ratios on our data we have identified that traffic emission is the most dominant source of PAHs in Bor, while coal and wood burnings are the major sources of PAHs in Zaječar.

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5. INHALATION EXPOSURE AND MICROENVIRONMENTS

5.1. MODELING OF PARTICULATE MATTER DEPOSITION IN HUMAN AIRWAYS: A CASE STUDY IN PORTO METROPOLITAN AREA

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Particulate matter (PM) ranks as the fifth leading risk factor for global deaths and sixth one for disability-adjusted life-years (Cohen et al, 2017). While some studies have focused on measuring levels of particulate matter in different indoor environments (e.g. Madureira et al, 2016; Slezakova et al, 2018), few works have examined the particle deposition in respiratory tract (Manojkumar et al, 2019; Islam et al, 2017). In these referred studies, the dose calculations were based on ambient levels (i.e. measured outdoors). Lung dosimetry of an individual who spent majority of time indoors is expected to be different from that of outdoors due to differences in emission sources, particle concentrations but also because of the different physicochemical characteristics of the particulate matter itself. This study aims to investigate PM10, PM2.5 and ultrafine particle (UFP) deposition in human lungs by mathematical modelling.

Real-time sampling of PM10, PM2.5 and UFP was conducted in 65 Portuguese homes located in Porto Metropolitan Area during heating and non-heating season. Multiple Path Particle Dosimetry (MPPD) Model (v.3.04) was used to calculate total and regional deposition of particulate matter. Airway structures of infants (3 months) and adults (21-30 years; 31-40 years and 41-51 years) are considered for the study.

Results showed that total deposition fraction in the respiratory system was higher for PM10 than for PM2.5 and UFP. Accordingly, 86-96% of inhaled PM10 was deposited in human airways, followed by PM2.5 (60-75%) and UFP (29-40%). PM10 and PM2.5 were deposited mainly in the head (53-86%), while the UFP was deposited more in the pulmonary region (46%). Except for the infant age group, PM2.5 demonstrated maximal deposition in tracheobronchial and pulmonary regions. In the case of lobar depositions, all three fractions of particulate matter exhibited high deposition in left lower (37%) and right lower lobe (30%) whereas the lowest one was observed in the right medium lobe (8%).

These results can be used as a preliminary study to assess the toxicity of particulate matter. Moreover, the evaluation of particulate matter with different sizes at homes is an important step toward human exposure assessment and consequent reduction of public health risks.

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5.2. THE ISO STANDARD FOR RESPIRATORY PROTECTIVE DEVICES

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The International Organization for Standardization (ISO) is an independent, non-governmental organisation established in 1946, composed of members from the national standards bodies of 164 countries, which facilitates world-wide coordination and unification of industrial standards. Standards for personal safety equipment are included and work started in 2002 to generate a series of documents relevant to respiratory protection, with finalization of the complete set in 2021. ISO headquarters in Geneva coordinates overall activities, but standards generation is undertaken by consensus committees of volunteers delegated by national bodies.

Over forty documents addressing respirator performance requirements, test methods, selection guidance and supporting studies are being published by ISO. Results of relevant research to support standards development are included as technical reports. The parts addressing equipment performance comprise purely requirements for which a device can demonstrate conformity. ISO does not organise certification nor conduct approvals testing itself: the respective standards and specifications are created for reference and use by product certification and regulatory bodies in various domains world-wide.

Rather than follow a conventional method of formulating requirements to match established equipment designs, the principal approaches in setting requirements are:

- Addressing human performance needs: extensive study was undertaken during the preliminary stages to establish human performance requirements in terms of work rate and oxygen demand.
- To be as minimally design-prescriptive as possible: classification and performance requirements are based on the factors important for protection of the wearer, including work rate, particulate filtering efficiency, gas/vapour capacity and a protection level based on inward leakage.
- Classification and selection are based as much as possible on demonstrated equipment capability and not the traditional concept of an assigned protection factor based on design.

The standard on performance is divided into multiple parts covering user needs. There are comprehensive basic requirements for devices for workplace use that supply a breathable gas, and for those which filter available air. The classification and testing structure addresses devices as complete systems as far as possible, though there are defined tests on individual components such as the respiratory interface and filters. Proposed requirements for filters include six levels of particulate filter efficiency, as well as classes providing for multiple capacity levels for general groups of gases and vapours – regular and low-boiling organic vapours, acid and alkaline gases and nitrogen oxides, and additionally as specific requirements for a number of individual gases and vapours.

For needs beyond general industry, there is a set of “special applications” requirements, in which there are enhanced evaluation methods over the basic performance levels to reflect specific working conditions. These include firefighting, marine, mining, welding, abrasive blasting chemical-biological-radiological-nuclear (CBRN) and radiological-nuclear (RN) applications. CBRN devices are for first responders in the emergency services and medical communities involved in response to intentional release of hazardous materials. Targets here are provision of protection against a broad range of hazards and aggressive chemical agents, while providing simple logistical choices for responder units. The RN requirements address needs of the general nuclear workplace, decommissioning activities and those of responders to radiological release incidents. Requirements are being developed in consultation with the industry and responsder user community as much as possible.

Overall, these ISO performance standards will provide a comprehensive structure addressing respiratory protection needs covered by existing world-wide standards domains. The focus on human needs rather than technologies means they should have a long lifetime. Their adoption will establish a common standard of respiratory protection equipment world-wide, promoting trade and creating a common level to minimize the effect of economic circumstances on performance of available personal protective equipment.

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Standards documents can be obtained from https://www.iso.org/ics/13.340.30/x/

5.3. PERFORMANCE OF COMMERCIAL LOW-COST DEVICES TO ASSESS INDOOR PARTICULATE MATTER IN NURSERY AND PRIMARY SCHOOLS

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Indoor air quality (IAQ) has gained an increasing concern worldwide (Kumar et al., 2016). In this sense, a special attention has been given to particulate matter (PM), because it has been recognized as a priority pollutant and also due to its potential to induce various adverse effects to human health (pulmonary diseases, asthma and other respiratory problems) (Liu et al., 2018; WHO, 2010). Children constitute a particular group of sensitive population to indoor air pollution health effects. Therefore, schools are a crucial study environment, because, apart from home, children spend there a great part of their day. Commercially low-cost air pollution technologies emerged as a promising revolutionary advance in indoor PM monitoring, and consequently, as a tool to improve citizen's health, quality of life and well-being (Rai et al., 2017). Thus, the main aim of this work was to evaluate the performance of three PM commercially available low-cost devices for evaluation of IAQ in one nursery and primary school.

Three PM commercially available low-cost devices were selected to monitor IAQ continuously in school environments in accordance with major criteria: (i) cost less than 500 EUR; (ii) range measurement and limit of detection; and (iii) data acquisition, storage and privacy. Thus, during more than one month (from June to July 2019), uRADMonitor A3, AirVisual Pro and PurpleAir SD were deployed with a reference instrument (TSI DustTrak DRX 8534 Aerosol Monitor) in five different rooms for different age groups (varying between 0 and 10 years old) and one lunchroom from one nursery and primary school located in Porto district influenced by traffic emissions. Three fractions of PM, namely PM_1, $PM_{2.5}$ and PM_{10}, were measured by all commercial low-cost devices. Indoor hourly mean concentrations and daily mean profiles were performed, as well as a descriptive statistic. To evaluate low-cost devices' performance, a correlation assessment was performed among the commercial low-cost devices and with the reference instrument. Moreover, PM low-cost devices were calibrated using reference instrument measurements resorting to univariate linear regression models.

Daily mean profiles presented an expectable behaviour with similar profiles for all three studied fractions PM_1, $PM_{2.5}$ and PM_{10}, which were characterized by higher concentrations during occupancy periods. In general, for all measurement period, inter-correlation between all low-cost devices were high (R^2 = 0.55 – 0.96). In turn, the correlation between all three PM low-cost devices and the reference instrument were not so high and varying from room to room. Additionally, higher correlations were observed for background periods than for occupancy ones. Regression analyses showed that for finer particles uRad and PurpleAir (R^2 = 0.55) presented better correlation than AirVisual (R^2 =0.49), while for PM_{10} the opposite occurred (R^2 = 0.22 for uRad, R^2 = 0.24 for PurpleAir and R^2 = 0.42 for AirVisual). Generally, univariate linear regression allowed to slightly improving the correlations between the studied PM low-cost devices and reference instrument. These results showed the ability of low-cost sensor technology being used as a tool for air quality management for community in schools, however, more and deeper studies are recommended.

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5.4. INTEGRATION OF LOW-COST PARTICULATE MATTER SENSOR NODES FOR INDOOR AIR QUALITY MONITORING

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Hazards of particulate matter (PM) to human health are well known. While there are a high number of studies focusing on PM in outdoor air, poor indoor air quality (IAQ), especially regarding PM concentrations may be equally damaging, if not more, because humans spend nearly 90% of their time indoors (Klepeis et al., 2001). Integration of low-cost sensors to monitor IAQ can provide a unique solution to this problem. With their low-cost, low maintenance & power requirement, scalability, and ease of use, they can continuously monitor indoor air to detect pollutant levels (Snyder et al., 2013), enabling people to act and reduce levels. However, low-cost sensors have been traditionally associated with design compromises leading to poor data reliability, low repeatability, and limit of detection issues (Koehler and Peters, 2015). Therefore, this study aimed to review the recent developments and existing challenges in the integration of low-cost PM sensor nodes for IAQ monitoring.

An up-to date analysis from 2014-2019 was performed using *ScienceDirect*, *IEEE*, and *Scopus* databases. Publications considering only a single indoor pollutant were not included. Monitoring of indoor environments such as offices, homes, classrooms, hotels were included but for mines, quarries, subway stations, etc. were excluded. Both research articles and conference articles were included.

Sixteen out of 35 device development projects included a PM sensor. SHARP's GP2Y1010AU0F PM sensor was the most common sensor as a majority of the projects (9 out of 16) used it even though a study showed siginificant shortcomings in using it: accuracy deficiency over long term monitoring, inter-sensor variability, lower sensitivity at higher PM concentrations, and scattered distributed measurements at low temperature (0 ºC) (Wang et al., 2017). Further, only 3 of the 16 studies added a pump/fan in their device to facilitate an airflow, which is crucuial for PM measurements (although, some sensor nodes have an in-built fan). Seven studies conducted calibration or validation to test the PM sensor after developing the device and only three of these did a quantitative validation with a professional-grade reference instrument. Interestingly, none of these studies used SHARP's sensor in the final device developed. (Gillooly et al., 2019) used Alphasense OPC-N2 particle counter (n=1) against TSI SidePak™ AM510 Personal Aerosol Monitor and got $R^2 = 0.47$ (1-hour average) for $PM_{2.5}$. (Wang et al., 2017) validated their PMS3003 dust sensor (n=6) against a TSI Dustrak and got $R^2 = 0.82$-0.9 for $PM_{2.5}$ and $R^2 = 0.68$-0.89 for PM_{10}. (Parkinson et al., 2019) did not mention the sensor node they used. Their device was validated (n=100) with TSI DustTrak II 8532 and obtained average standard error of estimate of 0.024 mg/m^3 (±0.010).

This review showed that only 3 studies out of 16 conducted a quantitative validation. Most of the studies did not include or mention a fan/pump system in their device and used the sensors without any laboratory calibration before using them in the field. The onus of the validation of low-cost sensors and testing their credibility lies on the scientific community. Thus, there is a need of more studies to fix the low validation to device development ratio.

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5.5. ASSESSMENT OF PM2.5 CONCENTRATIONS IN INDOOR AND OUTDOOR ENVIRONMENTS OF DIFFERENT WORKPLACES

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The objectives of this study are to determine indoor-outdoor concentrations of $PM_{2.5}$ concentrations at selected seven different workplaces in Eskişehir and evaluate the indoor/outdoor (I/O) ratio for these workplaces. photocopy center, bakery, restaurant, hairdresser, dry cleaner, market, and hotel were investigated for their existing indoor and outdoor quality in Eskişehir, Turkey. All sampling periods consist of different time zones for each workplace. sampling period was conducted on both weekday and weekend each workplace to investigate the change between intensity and $PM_{2.5}$ levels at weekday and weekend. The indoor and outdoor concentrations were measured simultaneously and samples, during the periods when the workplaces were less-active and busy hours, were collected in 1-hour periods. real-time measurement of indoor and outdoor $PM_{2.5}$ concentrations was performed with two Dust-Trak 8530 aerosol monitors. The recording interval of the aerosol monitors were set to 1 min and the monitor recorded 60 data for each period. During the weekdays and weekend periods at all workplaces the busy periods of the indoor measurement results were greater than those obtained during less-active periods. According to the weekday results, the highest indoor measurement, in busy and less-active hours were observed at the hairdresser respectively (1123.92 $\mu g/m^3$, 1037.50 $\mu g/m^3$). The lowest indoor measurement in busy and less-active hours was observed at the Hotel respectively (27.20 $\mu g/m^3$, 3.58 $\mu g/m^3$). Also, indoor $PM_{2.5}$ concentrations were higher than outdoor busy hours in restaurants, bakeries, and hairdressers during busy hours weekdays. According to the weekend results, again the highest indoor measurement, in busy and less-active hours were observed at the hairdresser respectively (3076.00 µg/m3, 2575. $\mu g/m^3$). The lowest indoor measurement in busy hours was measured at the hotel (77.13 $\mu g/m^3$), in less-active hours was obtained in the grocery store (in 59.80 $\mu g/m^3$). In addition, indoor $PM_{2.5}$ concentrations were higher than outdoor busy hours in restaurant, bakery, dry cleaner and hairdresser during the busy hours at the weekend. Measurement results obtained from restaurant, dry cleaner and hairdresser on both weekdays and weekends during less-active hours showed that indoor $PM_{2.5}$ concentrations were higher than outdoor concentrations. When I/O ratios were evaluated Hairdresser and Restaurant were higher than 1 in all sampling periods respectively (I/O=7.26-72.34, I/O=1.60-17.32). In the dry cleaner except for busy weekday period, were higher than 1 all ratios (I/O=0.90). The ratios obtained during weekday and weekend busy hours at the bakery were higher than 1 (weekday I/O=1.84, the weekend I/O=2.19). In general, measurement results showed that $PM_{2.5}$ concentrations varied due to several factors such as the presence of strong indoor sources, activities, ventilation effect, building's location, traffic density around the building, ventilation of workplace etc.

Key words: $PM_{2.5}$, indoor and outdoor air measurement, workplaces.

6. MONITORING AND MEASUREMENTS

6.1. MEASURING ABSORPTION - DIRECT AND INDIRECT MEASUREMENTS, SOURCES AND AGEING

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There are many indirect methods of aerosol light absorption measurement. Most commonly employed instrumetns are filter absorption photometers. They draw air through a filter on which the sample is deposited and measure the light transmission through the filter. Some measure light reflection from the filter and some measure both, employing a light transport model in the filter. They convert these measurements to mass concentration of equivalent black carbon (eBC) using a mass calibration. Some report the aerosol absorption coefficient. These conversions assume the filter properties and use external or measured parameters to determine the measurement non-linearities (Drinovec et a., 2015, and references therein). Their cross-sensitivity to scattering needs to be taken into account at high sample single-scattering albedo (SSA).

To avoid these non-linearities, in-situ methods that measure aerosol suspended in the air are employed. The first is an indirect method: a separate measurement of extinction (using cavity attenuated phase shift methods) and scattering to determine their difference – the absorption. This method works well at low sample single-scattering albedo (SSA), but the absorption cannot be determined at high SSA.

Direct methods make use of the change in the sample due to the absorption of light. They are in-situ and measure aerosol suspended in the air. They typically use a high-power laser to heat the sample and then probe the effects of the transfer of heat from the particles into the surrounding air. Photoacoustic instruments use a microphone to measure the pressure wave in a resonant acoustic cell due to the change of density. Photothermal interferometers (PTI) measures the change of the refractive index in the heated the sample with lower density. PTI detection is linear and can be traced to first principles (Moosmüller and Arnott, 1996; Sedlacek, 2006).

We can use the (in)direct in-situ methods that measure aerosol absorption to calibrate the filter photometers. This is a pedantic and time consuming taks, but it needs to be performed only periodically. Using calibrated filter photometers, many interesting measurements can be taken both in the laboratory and ambient air.

We present chamber measurements of aerosol ageing from different sources. The vehicle exhaust campaign was the first to show that aerosol absorption changes with ageing (Platt et al., 2013). In wood-stove ageing measurements, we have determined the mass absorption cross-sections of primary and secondary organic aerosol (Kumar et al., 2018). With a well quality controlled long-term campaign, we have determined the enhancement of absorption due to secondary organic coatings (Zhang et al., 2018).

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6.2. SOME PRACTICAL CHALLENGES OF PM MOBILE MONITORING - EXPERIENCES FROM BEOAIRDATA CAMPAIGN

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Aim and background: BeoAirDATA campaign [1] was an air pollution data acquisition campaign which was a part of ongoing intensive efforts of Institute Vinca to monitor and characterize air pollution in Belgrade. Before the BeoAirDATA campaign, in cooperation between research teams from Institute Vinca and Institute of physics Belgrade, fixed monitoring campaign was realized in the beginning of 2018. This initial campaign, that lasted for two months, and included sophisticated measurements of large number of volatile organic compounds and particulate matter inspired further research, in which fixed monitoring was extended to also include mobile monitoring. This extension was realized via BeoAirDATA project, supported by Green fund of Serbian Ministry of Environmental protection.

Method: Ambient PM data were collected during mobile monitoring campaign conducted in Belgrade, Serbia, for three weeks at the end of November 2018 (winter campaign). Each day, one vehicle (Renault Megane III with petrol engine) with PM monitoring instrumentation inside the vehicle, conducted two sampling runs - one in the morning and one in the afternoon/night. In between the runs maintenance was done on the instruments (inlet cleaning, battery recharging, zero testing, data acquisition). Vehicle aerosol inlet was cone shaped, mounted to the right-hand side of the vehicle, and two sampling tubes guided the ambient air from cone-shaped inlet to the instrumentation which was inside the passenger cabin. The instrumentation consisted of laboratory grade instruments: TSI NanoScan SMPS Model 3910 (13 channels from 10nm to 420nm with 1-minute resolution) and TSI Optical particle sizer 3330 (17 channels from 0.3um to 10um with 1-second resolution). Each measurement point was geolocated and timestamped. During one part of the campaign dashcam recorded vehicle's front windscreen view allowing for later analysis, identification of sources and explanation of sudden spikes in air pollution.

Results: Figure below shows raw results of mobile monitoring of PM10 concentration. Color scheme was AQI inspired, and concentration limits for different color codes are derived from percentiles of PM10 mass concentration. Initial map allows for easy inspection of various air pollution phenomena, such as daily variation on a specified location, and similar. Note that further data processing is needed to include corrections for temperature variation which is very significant for ultrafine particles [2], and to adequately take into account sampling system losses. The obtained data can be used for various purposes, such as development of LUR models [3], or specific predictors for already existing models (for example PM urban background concentration). Detailed size distribution which was recorded allows for narrowing down set of possible sources of air pollution at specific urban locations.

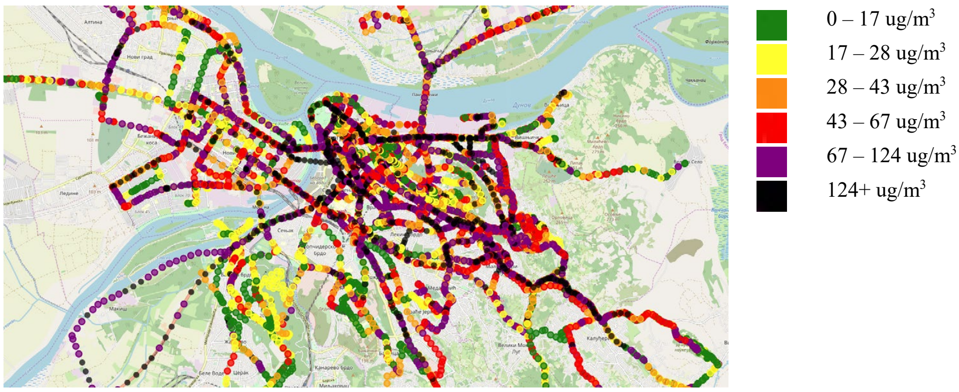

Figure 1. a) PM mass concentration obtained via mobile monitoring. Marker color scheme is AQI inspired

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6.3. VALIDATION OF LOW-COST SENSOR SYSTEMS FOR ESTIMATING AN INDIVIDUAL'S EXPOSURE TO PARTICULATE MATTER

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Low-cost sensors offer new opportunities for determining air quality with stationary or mobile units. With lower cost, low energy usage and greater temporal resolution these instruments allow researchers a plethora of different uses. On the other hand, simplified sensing techiniques of pollutants in low-cost sensors require that the sensors are critically evaluated and validated against reference instruments in different envionments. Validated data can than be used for modelling personal exposure to different pollutans.

Particulate matter sensors were validated by comparing the results with reference sensors and using them in real-life conditions. Low-cost sensors were collocated in the same room to determine the variability between the senosor and with research grade reference sensors to determine the validity of collected data. The first collocation took place in August 2018 for three weeks and the second in February 2019 for one week. While the data for some parameters had a significant deviation from the reference instruments, others proved to be usefull to give a general assessment of air quality, focusing on particulate matter.

Low-cost stationary units were placed in households of participants, recording 9 different parameters (ambiental, meteorological and air quality). Mobile units were placed on the participants and carried around during the 7 day observation period.

Previous research on the usability and accuracy of low-cost sensors (Fishbain et al., 2017; Mazaheri et al., 2018; Rai et al., 2017; Schneider et al., 2017; Spinelle et al., 2015), determining respiratory rate from heart rate (Zuurbier et al., 2009) and calculating personal exposure to particulate matter (Cozza et al., 2015), combined with the results of sensor validations, provided the necessary basis for assessing personal exposure to particulate matter with low-cost sensor data.

An informative assessment was prepared for participants in the research, providing them with general data about their exposure to particulate matter. Results of this research have shown that low-cost sensors have certain advantages, especially low cost and simple installation, but without validation and calibration, data should not be trusted blindly.

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6.4. MEASUREMENTS OF THE AEROSOL LIGHT ABSORPTION COEFFICIENT – METHOD COMPARISON AND CHARACTERIZATION OF A NEW INSTRUMENT

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Measurement of light absorbing aerosols is still challenging, and different approaches exist. Filter absorption photometers deposit the sample on a filter and measure the transmission/reflection of light through/from the filter. They convert these measurements to mass concentration of equivalent black carbon (eBC) or to the aerosol absorption coefficient. This is done by assuming the filter enhancement, and assuming, postprocessing for or measuring the non-linearities, potentially using in-filter light-transport models. Photoacoustic instruments use a microphone to measure the pressure wave caused by light absorption and the subsequent heating of the sample in a resonant acoustic cell. A photothermal interferometer (PTI) probes the change of the refractive index caused by light absorption in (and the subsequent heating of) the sample – the detection is linear and can be traced to first principles.

The PTI instrument is based on a folded Mach-Zender interferometer design (similar to Moosmüller, Arnott, 1996; Sedlacek, 2006). The He-Ne probe beam is split in two beams, one of which passes the sample chamber, while the other serves as the reference. A modulated Nd:YAG (1064 nm) with 0.75 W of optical power is focused in the sample chamber using an axicon (patent pending). The quadrature point is maintained using a pressure cell. The interferometer signal is detected by two photodiodes and a lock-in amplifier.

Ambient measurements were performed at an urban background location in Ljubljana, Slovenia. The sample air was drawn through the PTI sample chamber by the Aethalometer AE33 running at 2 l/min for simultaneous measurement of black carbon concentration.

The PTI signal agrees well with ambient eBC (Fig. 1) with a high degree of correlation (r^2=0.95) over a large range (Fig. 2). Using an appropriate calibration, the PTI is a good candidate for a reference measurement of aerosol light absorption. We will compare different approaches, discuss their time resolution, limits of detection, (dis)advantages and uncertainties, and show quality control approaches.

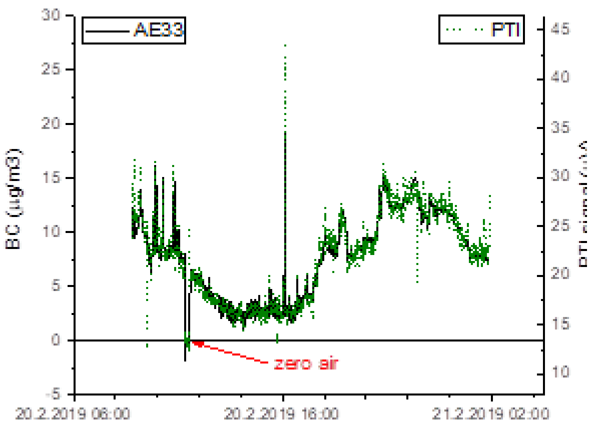

Figure 1. The time series of ambient eBC measured by the Aethalometer AE33 and the PTI instrument**.**

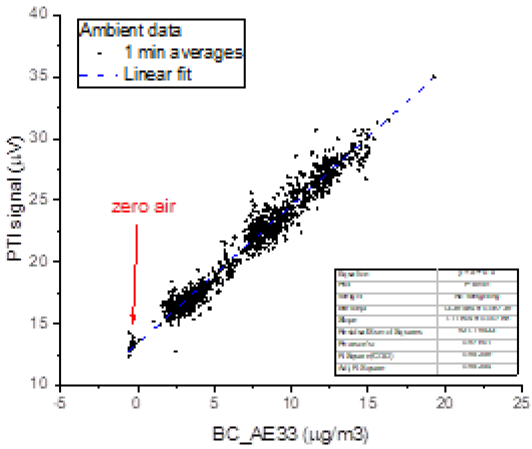

Figure 2. The regression between the PTI and the Aethalometer measurements.

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7. SOURCE CHARACTERISATION 1

7.1. ULTRAFINE PARTICLES LEVELS IN OUTDOOR AND INDOORS ENVIRONMENTS

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In terms of particulate matter (PM), major attention has shifted towards ultrafine particles (UFP); they represent a subgroup of PM with aerodynamic diameter below 100 nm. Due to their smaller size, UFP contribute only little to overall PM mass but dominate the number concentrations. Exposures to UFP have been considered relevant mainly in the urban areas due to their origin from anthropogenic emissions sources (such as internal combustion engines, power plants, incinerators, residential heating emissions, etc.), but UFP are also formed by natural processes (Oliveira et al., 2019). Activities, such as wood and coal burning, cooking, smoking, use of cleaning products, fan heaters and printers, have been reported among the relevant sources of UFP in confined spaces, where due to the lesser degree of particle dispersion and higher occupants' density, exposures can be especially large (Fonseca et al., 2014; Slezakova et al., 2019; 2018; 2015). UFP are highly biologically active, and due to their small sizes and large surface area, highly chemically reactive. They can carry other toxic pollutants (such as heavy metal elements and organic gases) and interact with lung cells, which makes them more toxic and inflammatory than fine PM (Chen et al, 2016). The current epidemiologic evidence is far from comprehensive.

Conducting physical activity on regular basis is recognised as one of the steps to maintain healthier lifestyle. The positive outcomes though can be outweighed if conducted in polluted atmosphere. Furthermore, the specific inhalation during exercising, which results in bypass of nasal filtration systems and deeper penetration into the respiratory system, might result in higher risks especially to pollutants such as UFP.

This work aims to review the exposure to UFP during conducting physical activities in different indoor and outdoor sport environments; the respective inhalation doses were estimated for various exposure scenarios and considering different physical activities based on the World Health Organization recommendations for physical activity (WHO, 2010).

The results showed that UFP highly varied across the characterized oudoor and indoor sites; on international level, the obtained outdoor UFP levels in the metropolitan area of OPorto (north of Portugal) were comparable with other countries. The highest UFP levels were obtained when exercising next to trafficked streets. Sites such as gardens, city parks exhibited 2–4 times lower UFP, thus indicating the relevance of vegetation for urban healthy environments. UFP inhalation dose while walking (commuting to work and/or schools) were 1.6–7.5 times lower than when conducting sport activities. In order to optimize health benefit of exercises, environmental characteristics of the places to conduct physical activities should be considered.

This work was supported by EU (FEDER funds through COMPETE) and National Funds (Fundação para a Ciência e Tecnologia) through project UID/QUI/50006/2019 Associate Laboratory Research Unit for Green Chemistry - Technologies and Processes Clean – LAQV with financial support from FCT/MEC through national funds and co-financed by FEDER.

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7.2. CHARACTERISATION OF PM10 IN THE SECONDARY SCHOOL AND IN THE AMBIENT AIR NEAR THE COPPER SMELTER IN BOR, SERBIA

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There are no systematic monitoring programs dealing with indoor air quality in educational buildings in the Republic of Serbia. Indoor air quality in educational buildings is of great importance since children and students spend a large part of their time in classrooms. Because of that, the research of the air quality in the indoor air of educational institutions is carried out periodically in the framework of scientific projects supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

The town of Bor is assumed as representative of hot spot urban-industrial environment in the Republic of Serbia because of the emissions of sulfur oxides and particulate matter from the copper smelter facilities, situated close to the town urban areas.

These work present results of an ongoing study on student's and teacher's exposure to suspended particles in the selected classrooms and offices in the Bor town. The aim of this work was to compare the mass concentration and the chemical composition of the suspended particles of the PM_{10} fraction in the indoor air of the secondary electro-mechanical school in Bor (in periods when there were and when there were no pupils in the classroom) and in ambient air. The school building is located about 2 km SW from the copper smelter facilities. The mass concentrations of PM_{10} were measured simultaneously in the selected classroom and in outdoor air for 5 consecutive days from 21.01. to 25.01.2019 (Monday to Friday). Sven/Leckel low-volume samplers LVS3 were used to collect the PM_{10} gravimetric samples.

The indoor average daily concentration of PM_{10} was 49.0 $\mu g/m^3$. Similarly, the outdoor average daily concentration of PM_{10} was 25.1 $\mu g/m^3$. The obtained results indicate that the average concentrations of PM_{10} particles measured in the classroom were on average two times higher than those measured in the ambient air. Also, the concentrations of PM_{10} particles were on average 1.6 times higher in the period when the pupils were in the classroom (58.7 $\mu g/m^3$), compared to the period when there were no pupils in the classroom (36.8 $\mu g/m^3$).

The mass concentrations of 22 chemical elements from the PM_{10} samples were determined. Major elements (Fe, Mg, Ca, K) and trace elements (As, Cd, Pb, Ni, Zn, Cu, Sr, Co, V, among others) were analyzed by Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES) and Inductively Coupled Plasma Mass Spectrometry (ICP MS), respectively. The concentrations of chemical elements detected in PM_{10} fraction were on average 2.0 times higher (1.2-3.5) in the period when pupils were in the classroom compared to the period when there were no pupils in the classroom. Also, the concentrations of chemical elements determined in the classroom were on average 1.8 times higher (0.3-4.3) compared with the concentrations determined in the ambient air near the school.

ACKNOWLEDGEMENTS

This work is supported by a grant from the Ministry of Education, Science and Technological Development of the Republic of Serbia, as a part of the project III42008: “Evaluation of Energy Performances and Indoor Environment Quality of Educational Buildings in Serbia with Impact to Health.”

7.3. INFLUENCE OF TRAFFIC REDIRECTION IN SENSITIVE AREA/CITY

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This study evaluates impact of redirecting a part of the traffic out of the city centre on the air quality. Celje is the 3rd biggest city in Slovenia with 38.079 inhabitants (SURS, 2017). Due to city location on the intersection of 2 Pan European corridors (V. and X.) density of traffic is high. Celje is situated in a basin surrounded by hills which cause unfavourable conditions for air pollution dispersion during winter. Nowadays cars are still the main means of transport although the city council is looking toward to more sustainable transport (Mestna občina Celje, 2017). Combination of traffic and other sources of PM_{10} particles lead to frequent exceedance of daily limit value (50 $\mu g/m^3$) especially during the winter, which lead to unhealty environment for their inhabitants. Due to the accepted the most favourable measurements, the city council conducted the study which shows the influenc of traffic redirection on the bypass road.

Our studied hypothetical measures the construction of bypass road that would redirect 30 % of the traffic from city centre to edges. For this purpose, CALPUFF modelling system (The Exponent, 2019) was used to calculate PM_{10} dispersion. Calculations of prognostic mesoscale model were used as first guess wind field in CALMET and data from one meteorological station were used. Emissions from road traffic were calculated by COPERT (Emisia, 2019) based on the traffic counting that was carried out on a day in June. Time varying area sources were used in CALPUFF to represent diurnal traffic cycle. In the CALPUFF model the 2 measurment locations were included. First is in the city center, close by the main cross-section and the second is situated on the edge of the city or close by the bypass road.

Current situation was estimated firstly, with the aim to calculate PM_{10} concentrations that are a consequence of current traffic density and road network. Secondly it was assumed that 30 % of traffic from two main roads would be redirected to bypass road due to the asumptation that those vehicles only pass the city on their way. Concentrations with hypothetical traffic density and road network were calculated and difference between both situations was evaluated.

Results show noticeable reduction in PM_{10} concentration especially on the main crossroads. CALPUFF modelling system in combination with COPERT software and traffic counting proved to be an efficient, low cost and fast means of evaluating effects of possible measures in initial stages. This enables selection of the best option between a vary possibilities.

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7.4. IMPACTS ON AIR QUALITY OF PM SHIP-RELATED EMISSIONS IN PORTUGAL

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International shipping has been recognized as a significant source of pollutants mainly nitrogen oxides (NO_x), sulphur oxides (SO_x) and particulate matter (PM), although their contribution to the air quality degradation on regional level is not yet well documented (Brandt et al., 2013; Corbett et al., 2007; Nunes et al., 2017). Once 70 % of emissions from ships in international routes occur until 400 km from the coast and can be easily transferred hundreds of kilometres towards the mainland, ships have the potential to contribute significantly to air quality degradation, mainly in the countries with a large maritime coastline (Eyring et al., 2009). In fact, the Portuguese coastline has an extension of 1 230 km and a high geostrategic importance in the connection of maritime traffic from the Americas and Africa to Europe due to its Atlantic centrality. Thus, this work aimed to quantify the impacts of PM ship-related emissions on air quality in Portugal for 2015 and to find out if there were inland regions where the European Commission air quality standards and WHO air quality guidelines were exceeded due to shipping. To evaluate the contribution on $PM_{2.5}$ and PM_{10} concentrations over Portugal, shipping emissions were obtained from an Automatic Identification System (AIS) based emission inventory using Ship Traffic Emission Assessment Model (STEAM) (Johansson et al., 2017) and the EMEP/MSC-W chemistry transport model which was run for two scenarios: i) with shipping emissions scenario; and ii) without shipping emissions (Simpson et al., 2012). The annual mean concentrations for each inland grid cell were compared with: i) EU air quality standards for $PM_{2.5}$ (25 µg m^3 for annual mean) and PM_{10} (40 µg m^3 for annual mean); and ii) WHO air quality guidelines for $PM_{2.5}$ (10 µg m^3 for annual mean) and PM_{10} (20 µg m^3 for annual mean) (European Comission, 2018; WHO, 2018). The relative impact of shipping emissions on PM concentrations was more evident in the sea areas along the Portuguese coastline in the main shipping routes and especially in the south close to the Strait of Gibraltar, with contributions of 25-50% for $PM_{2.5}$ and 20-35% for PM_{10}. Although the contribution of shipping emissions to PM concentrations has been most evident in sea areas close to the coastline, they also contributed to increase inland concentrations. Shipping emissions generally contributed to increase around 15-25% and 10-20% $PM_{2.5}$ and PM_{10} concentrations, respectively, especially close to the coastal areas (mainly in port areas) and over the south region of Portugal. The EU annual limit standard for $PM_{2.5}$ and PM_{10} and the PM_{10} WHO air quality guideline were not exceeded. Regarding the $PM_{2.5}$ WHO air quality guideline, exceedances were verified close to the Ports of Viana do Castelo, Leixões, Lisboa and Setúbal and far from the coastline (towards inland) in Viana do Castelo. The above results confirm that PM ship-related emissions can contribute negatively to air quality, both in coastal and in inland areas of Portugal and should not be neglected.

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7.5. SOURCE APPORTIONMENT OF PAHS IN SINPHONIE`S SCHOOLS IN SERBIA DURING HEATING SEASON

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Air quality in schools is important as pollutied air can affect to children's health, attendance and learning performance. PAHs represent a major class of toxic pollutants because of their carcinogenic and mutagenic characteristics. In the aim of determination level of numerous air pollutants including five days average concentration od BaP in PM, 114 primary schools and kindergartens from 54 cities in 23 Europian countries participated in the SINPHONIE project study including 5 primary schools and 2 kindergartens from Serbia [Csobod et al., 2014].

We performed extended experiment and detal analyses in framework of the SINPHONIE capmaings. We performed extended experiment and detal analyses in framework of the SINPHONIE capmaings. In this study we presented results of measurements indoor and outdoor 16 US EPA priority PAHs bounded on TSP, PM_{10}, $PM_{2.5}$, as well as PAHs in gas-phase. The sampling campaigns in duration of five days, from Monday to Friday, in each school were conducted simultaneously in both indoor and outdoor environments during winter 2011/2012. Samples were collected using the low volume reference sampler Sven/LACKEL LVS3 (LVS) for 24 hours period. PAHs were collected, prepared and analyzed according to Compendium Method TO-13A. Analysis was performed using GC-MS. Diagnostic ratios (DR), principal component analysis (PCA) and positive matrix factorization (PMF) were calculated in order to conduct source apportionment of the measured PAHs.

The indoor and outdoor concentration of total PAHs in the $PM_{2.5}$ and PM_{10} were ranged 0.61-127.17 ng/m^3 and 3.21-166.61 ng/m^3, respectively. The concentration of sum TSP and gas-phase PAHs was ranged 72.10-3174.72 ng/m^3. The most abutant PAH was naphthalene in gas phase. Results show very similar components and factor profiles identified by PCA and PMF. Combustion sources and vehicle emissions were identified as major sources of PAHs in both PM_{10} and $PM_{2.5}$, contributing more than 50% of the total PAHs emissions. On the other hand, the factor identified as representing evaporative/unburned fuel dominates the percent contribution to total PAHs for sum of TSP and gas-phase PAHs.

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8. SOURCE CHARACTERISATION 2

8.1. DETERMINATION OF PARTICULATE MATTER POLLUTION ON CONSTRUCTION SITES IN CITY OF NOVI SAD

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In developing countries like Serbia air pollution by particulate matter (PM) is very significant and complex physicochemical problem. PM has excellent Sorbent Surface for all types of organic and inorganic pollutants. Pursuing developed countries and under constant urbanisation processes PM pollution in Serbia is becoming daily routine. Urban alterations result in large number of open construction sites. With the long term PM pollution sources defined and legislative arranged for monitoring, construction site remain undefined and unmonitored as PM pollution sources.

The aim of this paper is to define and confirm construction sites as significant particulate matter pollution sources. Empirically observing construction sites can be considered as stationary continual pollution hot spots with longer or shorter lifetime expectancy depending on project scale. Scientific confirmation of empirical definition is systematically modelled in three stages (literature research, PM emission monitoring on construction sites and experimental result analysis). For the PM emission monitoring purposes low cost conventional sensor OPC-N2 (optical particle counter developed by Alphasense) was selected due to demonstrated high accuracy. OPC-N2 was used to provide real time data and continual monitoring of construction sites. PM emission data obtain in construction sites sensor monitoring is used for assessing the pollution levels, determining threat and confirming goal of the planed research. Monitoring of particulate matter emission was managed and carried out on five representative construction sites located in city of Novi Sad. This kind of research is for the first time preformed in Novi Sad and Serbia.

Assessment of PM emissions data determined via sensor monitoring on construction sites provides scientific confirmation that construction sites can be defined as stationary continual pollution hot spots.

Key words: Sensor, particulate matter, monitoring, construction sites

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8.2. A MAJOR SAHARAN DUST INTRUSION OVER ROMANIA

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Saharan dust intrusion represents a source of aerosols in European countries (i.e. in the Mediterranean basin and in southeastern region). These intrusions happen especially during spring and are important because they can have impact on human health, causing respiratory and cardiovascular problems.

In March 2018, an unusual Saharan dust intrusion was observed in the southern part of Romania. The particularity of these event was the deposition of the aerosols together with a snow layer. The aim of this study is the synergetic characterization of the unusual dust event.

The synoptic conditions were evaluated by using ERA-25 Interim reanalysis; the MSG-SEVIRI desert dust imagery; analysis and forecast from Copernicus Service. Dust and snow samples were collected in order to derive the chemical composition, physical properties and the particle morphology. The techniques used were Inductively Coupled Plasma-Optical Emission Spectrometry and Scanning Electron Microscopy with energy disperse X-ray spectrometry (SEM/EDX). Also, the optical parameters were evaluated from absorption and scattering measurements.

These complementary analyses were used to find the source of the sampled aerosols. The derived elemental ratio (Ca+Mg)/Fe of 1.39 was characteristic for north Sahara (Scheuvens et al. (2013). The SEM/EDX analysis emphasized the presence of calcite, quartz and clay minerals. The observed geometric diameter of the particles varied from 1 µm up to 40 µm, these values being specific for dust aerosols. For the fine re-suspended aerosol fraction, the optical parameters (the asymmetry parameter at 550 nm of 0.604, the single scattering albedo of 0.84–0.89) were representative for dust aerosols (Ealo et al., 2016). Also, the synoptic scale circulations confirmed the north African origin of the sampled particles.

The measurements performed at the Romanian RADO/ACTRIS site were used to explain the unusual event with dust intrusion during winter conditions observed in Southestern Europe.

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8.3. NANOPARTICLES EMITTED BY PYROTECHNICS DURING A FOOTBALL MATCH

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Football matches are among the most popular sport events worldwide, attracting up to tens of thousands of spectators to the stadia. In many countries, despite being explicitely forbidden, football fans bring pyrotechnics to matches, most prominently handflares and smoke bombs. While burning, pyrotechnics emit particulate matter, and, as many studies have shown so far, these are toxic for humans (Pöschl, 2005; Remškar et al, 2015).

Here, we present the results of a case study where we measured the size distribution and chemical composition of particles emmited by pyrotechnical devices during a football match in an open roof stadium. The Slovenian First Football League match, NK Olimpija Ljubljana vs. NK Maribor, took place in the Stožice stadium in Ljubljana in March 2019. The match was chosen for nanoparticle monitoring as the two teams have a long-running rivalry and are each supported by their dedicated fans (ultras) – therefore one could expect that pyrotechnics will be used some time during the event.

The particle size distribution was determined by a scanning mobility particle sizer (SMPS) in the range from 12 nm to 570 nm. The samples for the chemical analysis were collected using a Dekati® low-pressure cascade impactor (DLPI). The samples were collected on an aluminum foil and characterized with energy-dispersive X-ray spectroscopy (EDS) inside a scanning electron microscope (SEM). The size distribution of the particles was continuously measured before, during, and after the match, while the samples for the chemical analysis were collected only during the course of the match itself.

In total, fans set out pyrotechnics five times during the match, including handflares, sparklers, smoke bombs, and unindentified home-made devices. A high number of nanoparticles with diameters below 200 nm were detected. Chemical analysis evidenced the presence of a series of elements, present in pyrotechnical products, such as Na, K, P, Ba, Fe, Cl, and others. The total concentration of the particles with size bellow 570 nm reached 70000 particles/cm^3, which in comparison with background value of 6000 particles/cm^3 represent a 10 fold enhancement of air pollution by particulate matter.

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8.4. BIOAEROSOL NANO-PARTICULATE POLLUTION OVER RESIDENTIAL URBAN AREAS

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The purpose of this study was to first identify, through lidar monitoring, the characteristic areas with increased concentrations of aerosol pollutants and to designate control points for the study of particulate matter (PM). We present a study of the air pollution over urban areas with heavy traffic in the city of Sofia, the capital of Bulgaria. It is focused on the presence of nanosized iron particulate matter (NPM) in the bioaerosol and the ability to find them through remote control. The NPM in general behave similarly to gas molecules and will therefore penetrate down to the alveoli, and can translocate further into the cell tissue and body fluids.Transition metals present in such particles, especially iron, increase the production of reactive oxygen species *in vivo*.Thus, they can be hazardous to human health. In these study, the NPM aspirated *in situ* using a Hygitest 106 (Maimex) device. The methodology was described in work (Dimitar Stoyanov et al, 2019). The dust was collected on a filter consisting of a layer of ultrathin threads (diameter of 1.5 μm) deposited on a piece of fabric and designed to collect aerosol particles of sizes exceeding and smaller than 0.1 μm. Additionally, the material collected *in situ* on the filters after three hours of aspiration during remote sensing was studied by number of physical methods. The chemical phase composition and the particle size distribution were analyzed using powder X-ray diffraction (XRD). The experiments were conducted during the winter-spring transition period of 2019 and highlighted an alarming trend of increased content of the iron over the permissible concentration value. The XRD, IR Spectroscopy and EDAX did not yield a clear picture of the iron containing phases in the powder. The good characterization of the PM thus necessitated additional Mössbauer spectroscopy (MöS) investigation. ^{57}Fe MöS was used, as it allows one to look deeply into the PM characteristics and make clearer conclusions about the iron-bearing chemical compounds present and of their quantity and dispersion.The hyperfine effective fields of all magnetic phases registered showed both spinel and hematite phases and permitted us to conclude that the particle size of these oxide phases is lower than 20 nm, so that one could speak for NPM. The NPM originating from an area with heavy traffic was 29% concern the quantity of the present phases and the particle size. Due to the oxidation of the powder, the boundaries between magnetite and maghemite needle-like crystals found are very thin, on the nano-size level and creates preconditions for potential health hazards.

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9. ATMOSPHERIC PROCESSES AND MODELING

9.1. MODELING PARTICULATE MATTER IN URBAN AREAS: EXPERIENCES OF THE INSTITUTE OF PHYSICS BELGRADE

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Due to the global urbanisation that has resulted in a half of the world's population being urban at the beginning of the new millennium, we are the witnesses of both cities growth and tremendous effects the growing process has on human health, the environment, and climate. The continuous air pollution burden on the environment is dependent not only on the increasing pollutant load, but also on many processes such as pollution transport, dispersion and deposition, atmospheric chemistry, meteorological factors, and topography. This makes the environment for the unlimited set of pathways for interactions which reflects the complexity of the urban ecosystem. Moreover, the complexity of the environmental phenomenon and the depth of its interpretation, determine the complexity of the methods needed to be applied to represent the phenomena and to formalize the principles being analyzed. For these reasons, environmental research focused on root causes that shape air pollution must rely on innovative, sophisticated, and advanced modelling techniques and their hybridization (Stojić et al. 2018).

This talk systematizes analytical methods capable of contributing substantially to the contemporary perception and interpretation of the factors and processes that generate particulate matter (PM) air pollution, govern its spatio temporal dynamics, and determine its environmental fate. It will cover the experiences of the Institute of Physics Belgrade in application, utilization and development of: (1) methods for preprocessing raw data and obtaining relevant statistical distributions (Perišić et al. 2015, Stojić et al. 2015); (2) methods for determining the shares of localy generated, transported, and background pollution; (3) source apportionment methods for dominant and individual emission source characterization in broader areas; (4) machine learning methods and fluctuation analysis for capturing pollutant non-linear dynamics and their relationships with relevant environmental factors (Stojić et al. 2016); (5) explainable artificial intelligence methods for characterization of ambient conditions responsible for air pollutant spatio-temporal behaviour in the environment that shapes it (Stojić et al. 2019); (6) dispersion and three dimensional hybrid receptor models for the identification of pollution circulation patterns and its altitude distributions on various spatial scales, and characterization of remote emission sources (Stojić et al. 2017); and (7) methods for interactive results visualization.

The profound insights anticipated into the environmental processes and factors driving PM concentrations, obtained by using sophisticated and synergistic modeling, aims to provide data-driven conclusions and deepen scientific understanding of the air pollution issue. Besides the scientific community, these results could be significant for the general public and policymakers, thus providing considerable benefit to society and sustainable development.

ACKNOWLEDGMENTS

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9.2. THE USE OF MOSS FOR THE ASSESSMENT OF POTENTIALLY TOXIC ELEMENT DEPOSITION OVER A LARGE AREA

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The adverse health effects of particulate matter (PM) are deffined by its physical properties and chemical composition. Elements in the excess (potentially toxic elements, PTEs) contribute to the toxity of PM. The variability of airborne element concentrations in time and space emphasises the need for highly resolved measurements, which overcome the regulatory air pollution-monitoring network.

Biomonitoring represents an alternative approach for the assessment of pollution changes in the environment (Markert et al., 2003). However, the specific organism response to the pollution changes should be recognised and studied for its reliability. The use of mosses for the assessment of PTEs in an atmospheric deposition has been studied due to their morpho-physiological features orienting the moss to air as nutritional media. Thus, hypothetically, the content of the surrounding air should be reflected within the moss tissue. The biomonitoring features of moss has been investigated in numerous studies (Harmens et al, 2015; Aničić Urošević et al, 2017 and references therein), which has led to their systematically application in the PTE biomonitoring across Europe and beyond within the framework of the United Nations Economic Commission for Europe International Cooperative Program on Effects of Air Pollution on Natural Vegetation and Crops (UNECE, ICP Vegetation, https://icpvegetation.ceh.ac.uk/our-science/heavy-metals). The monitoring program has performed every five years aiming to detect the spatio-temporal distribution of PTEs in atmospheric deposition leading the pollution source detection. Serbia participated in the program since 2000. The most extensive survey was performed in 2015 when the moss *Hypnum cupressiforme* Hedw. was collected all over the country, at 212 sampling sites according to the previously established sampling grid (25×25 km). The sampling was performed according to the rules of Moss Monitoring Manual (Frontasyeva et al, 2015). The concentration of 25 macro- and microelements (Al, As, Cd, Cr, Cu, Fe, Ni, Pb, Sb, V, Zn, Ba, Ca, Ce, Co, In, Ga, K, Mg, Mn, Mo, Na, Rb, Sr, W) was determined using inductively coupled plasma-optical emission spectrometry (ICP-OES) and inductively coupled plasma-mass spectrometry (ICP-MS).

The results of the study showed that the moss sampled in the southern part of the country (Kosovo and Metohija) were the most enriched with the elements, especially As, Cd, Cr, Ni, Pb, Sb, V and Zn. This area is characterised by complex geological settings, followed by the mining, and the other accompanying activities (Aničić Urošević et al, 2018). Besides, the highest concentrations of Cu in the moss found in the region of the copper-mining basin in the north-eastern part of Serbia, as well in the north of the country in the vicinity of vineyard area. In general, a decreasing trend of the median element concentrations was observed in the moss through the years of investigation (the years of 2000, 2005 and 2015). Namely, considering 2000 vs. 2015, the median concentration of As, Cr, Cu, Fe, Ni, V, Zn decreased for more than 30%, while regarding 2005 vs. 2015, the median concentration of Cd, Pb, Sb fell more than 50%. Passive moss biomonitoring can be a helpful method for screening atmospheric deposition of PTEs over wide areas. Except for the pollutant level assessment in the air, these moss surveys leading to the new pollution source detection.

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9.3. MODELING OF IMMERSION FREEZING INITIATION ON MINERAL DUST IN DUST REGIONAL ATMOSPHERIC MODEL (DREAM)

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Mineral dust particles are atmospheric aerosol suspended from arid areas. The Sahara Desert is the major source of mineral dust, producing a significant part atmospheric aerosol. There is a large uncertainty in estimating role of dust in the Earth's climate system. Mineral dust particles influence the radiative balance of the planet in two different ways, by directly interacting with radiation and indirectly by playing a role in cloud formation. Research showed that mineral dust particles are very efficient ice nuclei, which glaciate supercooled cloud water through a process of heterogeneous ice nucleation even in regions distant from the desert sources (Cziczo et al, 2013). Due to recognition of the dominant role of dust as ice nuclei, parameterizations for immersion and deposition freezing specifically due to dust have been developed (Niemand et al, 2012; DeMott et al, 2015; Ullrich et al, 2017). A study by Atkinson et al, 2013, showed that feldspars are at least by an order of magnitude more efficient ice nucleating agents than other dust minerals. This breakthrough contrasts with the prevailing view that clay minerals are the most important component of atmospheric mineral dust for ice nucleation.

The calculation of the number of ice nuclei in the operational DREAM model is based on atmospheric parameters and on dust concentration (Nickovic et al, 2016). The immersion and deposition ice nucleation parameterizations due to dust have been implemented in the model, not taking into consideration the mineral composition of dust. In this study, we use DREAM model to simulate atmospheric cycle of different mineral fractions of dust. Dust concetration, thermodynamic quantities and dust mineral composition are used to calculate ice nucleating particle concentration based on mineral specific immersion freezing parameterizations. We compare the model results with relevant observations from remote sensing instruments and ice nucleation chambers. We analyze the results to explore how the mineral composition of dust and appropriate parameterization of its effects on ice initiation could further improve ice nucleation representation in the model.

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10. POSTER SESSION 1

10.1. SEASONAL VARIATIONS OF CONCENTRATIONS OF LOW-MOLECULAR WEIGTH ORGANIC ACIDS IN ATMOSPHERIC AEROSOLS

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In addition to inorganic ions, low-molecular weight organic acids (LMWOA) form one of the major components of atmospheric aerosols (Djordjević et al, 2012; Joksić et al, 2009). LMWOAs contribute significantly to the presence of organic matter in the aerosol. LMWOA concentrations as well as inorganic anions concentrations vary significantly depending on location and season (Todorović at al, 2018). In this paper, samples of atmospheric aerosols sampled in Belgrade are analyzed for LMWOA content and its seasonal variation.

In the analyzed samples of atmospheric aerosols, eight LMWOAs were detected, namely formate, glyoxylate, methanesulfonate, glutarate, succinate, malate, malonate, and oxalate. In aerosol particles, the presence of oxalate is dominant.

The seasonal variations of the LMWOAs analyzed for the one-year sampling period are different for individual LMWOAs. In most cases, the time trend can be represented by a square curve. Dominant oxalic acid shows a trend of decreasing concentrations in autumn and summer with maximum values in winter. Increased precursor concentrations and increased photochemical activity are the main reasons for the increase in LMWOA levels during this period. Significant seasonal variations of the LMWOA are influenced by different sources, meteorological parameters (Meseldžija at al, 2016) and physicochemical transformation processes that exist in the atmosphere (Wang at al, 2016).

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10.2. A CLIMATOLOGY OF SATELLITE DERIVED AEROSOL OPTICAL DEPTH OVER BELGRADE REGION, SERBIA

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Suspended particulate matter (PM) in the atmosphere, commonly known as atmospheric aerosol plays one of the most important roles in climate change, air quality, and human health. Atmospheric aerosol affects climate through the direct (scattering and absorption both solar and terrestrial radiation) and indirect effects (modification of cloud through aerosol-cloud interaction) introducing one of the major uncertainty in our quantitative understanding of the radiative forcing (IPCC, 2007). Numerous studies have shown a significant association between particle matter concentrations and health risk especially airborne particle matter with diameter less than 10 μm (PM_{10}) and 2.5 μm ($PM_{2.5}$) (Yang et al. 2018). As the evidence base for the association between PM and short-term, as well as long-term, health effects has become much larger and broader, it is important to regularly update the guidelines for PM and PM-bound components limit values. Usually ground-based monitoring networks are used for PM assessment but still with no adequate spatial and time coverage. For the last decade various studies have been conducted to overcome this problem and to get PM estimates from satellite measurements (Kumar et al. 2007, Li et al. 2015). One of the most important aerosol products retrieved from satellite measurement is aerosol optical depth (AOD) which is the integration of the aerosol extinction coefficient from the Earth's surface to the top of the atmosphere, and it represents the attenuation of solar radiation caused by aerosols. The relationship between AOD and surface PM concentrations depends on various factors, including aerosol vertical distribution, aerosol type and its chemical composition, as well as its spatial and temporal variability, which are governed by spatio-temporal distribution of emissions and meteorological conditions (Kong et al., 2016). Due to their short lifetime and the large variability in space and time it is necessary to establish a climatology of the aerosol distribution both on regional and global scale thus satellite-retrieved AOD has become an important indicator of ground-level PM and aerosol burden in the atmosphere. The Moderate Resolution Imaging Spectroradiometer (MODIS) is aboard two polar orbiting satellites Terra and Aqua and measures the upwelling radiance from the Earth–atmosphere system at 36 wavelength bands, ranging from 0.4 to 14 μm. MODIS provides a daily near-global distribution of AOD over both ocean and land (Sayer et al., 2013). In this study long-term temporal variation and trend of AOD over Belgrade region are presented. Monthly mean values of MODIS aerosol optical depth at 550 nm were examined for the 10 year period 2005–2015. The MOD08 Combined Dark Target and Deep Blue AOD data products from MODIS Terra platform (Collection 6.1, Level 3 AOD data downloaded through NASA GIOVANNI web portal https://giovanni.gsfc.nasa.gov/giovanni/) at 1 degree spatial resolution were utilized. Frequency distributions of the AOD values were examined together with monthly and seasonal variations. The annual AOD mean was 0.17 with standard deviation of 0.07 over ten year period. AOD values exhibited seasonal annual mean variation and slightly negative trend. Significant monthly AOD variability is observed with maximum in August (~0.28) and a minimum in winter months (~0.06). Analysis of long term time series of AOD data could reveal how AOD regarding ground-based PM measurement in Belgrade changes over time. The aerosol climatology can be useful in the climate change assessment, weather and environmental monitoring over Belgrade region with the potential for further application in particle matter estimates from satellite measurement.

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10.3. RECEPTOR ORIENTED MODELING OF URBAN PARTICULATE AIR POLLUTION: SOURCE CHARACTERIZATION AND SPATIAL DISTRIBUTION

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Urban atmosphere is a complex system, in which air pollutants' levels are not only driven by the features of emission sources and variations of meteorological conditions, but also by the pollutant interactions and area-specific factors which have an impact on atmospheric chemistry. Nowadays, the application of advanced analytical methods is required to gain reliable information for better understanding of underlying factors which shape the air pollution phenomena in the urban environment. In this paper, we used the methodology based on receptor oriented modeling (Stojić and Stojić 2017) to investigate the spatial distribution of pollutants, their concentrations and potential emission sources in the urban core of the City of Belgrade, Serbia.

The database used in this study included the concentrations of suspended particulates matter (PM_{10}), inorganic and organic gaseous pollutants (NO_X, SO_2, CO, benzene and toluene), measured during the period of two years at the monitoring site Institute of Public Health Belgrade (Serbia). The chosen station, within the Air Quality Monitoring Network of Belgrade, is located in a densely populated part of the city, near intensive traffic activities, exposed to emission of local fireboxes and central district heating, as well as under the influence of various industrial emissions. Based on the pollutant concentrations and meteorological parameters (wind speed and wind direction), measured at the sampling site, the developed receptor-oriented model provides a detailed information on pollutants' concentrations and their mutual correlations in a wide area, not covered by the regulatory monitoring network.

The obtained interactive maps contain the results of the correlation analysis, as well as the relations between the concentrations of benzene and toluene, and measured air pollutants (PM_{10}, NOx, CO, and SO_2). The highest correlations of benzene and PM_{10} ($r = 0.8$) were observed along the large traffic routes, in Brankova Street and Bulevar Kralja Aleksandra Street, as well as in the northwestern part of the city center, suggesting that the intensive traffic represents the common source of gaseous and particulate pollution (Stojić et al. 2018). Furthermore, high correlations ($r > 0.7$) between benzene and combustion gases (NOx, CO, SO_2) in the western region reflect the influence of distant sources associated with the thermal power plants Nikola Tesla in Obrenovac, while relatively low correlations between benzene and combustion gases in the northern and eastern part of the city indicate that benzene in this area possibly originates from industrial-petrochemical emissions near Pančevo (Stojić et al. 2015). Also, high correlations ($r > 0.7$) between toluene and NOx, which are indicators of fossil fuel combustion from traffic and heating, suggest the shared origin of these compounds in all the parts of the city included in the analysis, except for the old city core and Kalemegdan (north-west), where the toluene is probably present due to the enhanced retention of aged air in streets of urban-canyon type.

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10.4. DIFFERENT LEVELS PM10 IN COLD AND WARM SEASON AT URBAN STATIONS IN REPUBLIC OF SERBIA

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Bacground and Aims The presence of particulate matter PM_{10} is a major cause of excessive air pollution in Republic of Serbia. Urban areas have been characterized by high levels of this pollutant and population in cities are exposed to high levels of PM_{10}. According to emission data officially submitted to the Secretariat of the Convention on Long-range Transboundary Air Pollution (LRTAP Convention) residental heating (heating plants less than 50MW and households) in Serbia are the main source of PM_{10}, contribute with 57% in 2017.
The aim of this paper is to present to what extent during the cold months the effect of houshold heating is reflected on the concentration level and whether there are significant differences between cities/stations.
Methods Available data from National Air Quality Monitoring Network in 2018 were used. PM_{10} concentrations were determined by reference method, gravimetric method SRPS EN 12341, accreditated in line with SRPS ISO 17025 . Different periods were analyzed separately: calendar year, warm (April – September) and cold season (January-March, October-December) and prescribed criteria were applied. Results from two seasons for each station were compared to the annual limit value and the allowed number of days above daily limit value (LV) and 25th, 50th and 75th percentiles also were determined.
Key results of the study At the stations with the highest mean annual concentrations, Valjevo 70 $\mu g/m^3$, and Uzice 61 $\mu g/m^3$, the highest number of days with exceedances during the year, 170 and 154, respectively, also recorded the highest mean value of concentrations for the warm and cold seasons. Analyzing the warm half of the year it turned out that Valjevo and Uzice have a mean concentration slightly lower than the annual limit value (Valjevo 37.3 $\mu g/m^3$, Uzice 36.1 $\mu g/m^3$) and at the stations Uzice, Novi Sad Liman, Kosjeric and Kragujevac the number of days with exceedances is generally twice less than the allowed number of exceedances during the year. In Belgrade and Valjevo this number is higher, 18 and 19 days .
Conclusions Air quality monitoring results for 2018 confirm high PM_{10} concentration levels in urban areas. Average concentration of daily PM_{10} values in warm season in Valjevo and in Uzice show significant influence of other sources then residental heating. Number of daily exceedances of LV in Belgrade

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10.5. EFFECT OF CAPACITY AND FUEL TYPE ON DUST EMISSION FROM RAFINERY FURNACE FOR ATMOSPHERIC DISTILLATION

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In order to investigate effect of fuel type and refinery furnace for atmospheric distillation capacity on dust emission field tests are performed. Tests include two different fuels (only refinery gas and mixture of 30% fuel oil and 70% refinery gas) and two different furnace capacity (80% and 100%). Those selected condition have been chosen for tests, as a most possible operating conditions. Usage of fuel oil or its mixture with refinery gas depends of current fuels availability within the refinery, while furnace capacity depends on current refinery production process. All procedures for field test are defined and performed in line with ISO 9096 *Stationary source emissions — Manual determination of mass concentration of particulate matter,* which describes a reference method for the measurement of particulate matter (dust) concentration in waste gases of concentrations from 20 mg/m^3 to 1 000 mg/m^3 under standard conditions and EN 13284-1 *Stationary source emissions – Determination of low range mass concentration of dust – Part 1: Manual gravimetric method* (for dust concentrations bellow 5 mg/m^3). Furnace construction has been designed in that way that flue gases are discharging through three identical stacks, which are positioned along the top of furnace. All test are performed during the constant operating conditions and on each of stacks. Achieved results indicates that usage of mixture of fuel oil and refinery gas has higher potential for dust emissions comparing with usage of refinery gas only, namely significant difference in dust concentrations is noticed, while effect of furnace capacity on dust emissions, for both tested fuels, doesn't show significant influence.

10.6. EVALUATION OF TRAFFIC'S INFLUENCE NEARBY SCHOOL FRONT DOORS WITH LOW-COST PM2.5 MONITORING

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Nowadays, in Belgium, traffic and heating systems are the main sources of PM in cities (Service Public de Wallonie, 2017). In Wallonia, the urban planning of the streets nearby schools is modified to allow area for "kiss and ride". During school activities, dropping off the children to school slows down the traffic. A lot of parents don't turn off the motor of their vehicles for this short time. This behaviour affects negatively the air quality while children, persons at risk, are present (Requia et al, 2018).

A $PM_{2.5}$ measurement campaign on the surrounding of a school located in Arlon (a small rural city in Wallonia) was realized with low-cost sensors. The sensors are fixed on the building walls, above the entrance doors. The purpose of this study was to measure the concentration of $PM_{2.5}$ to which the children are exposed when they access the school. The criteria for the selection of the school are: the presence of (i) several entrances, (ii) several streets surrounding the school and (iii) a schoolchildren population (between 6 and 18 years old). The school has 3 entries and is surrounded by 3 streets. The establishment comprises an elementary school and a high school for a total of 1950 students. The streets are configured as follows: the first is one-way street and serves the main entrance with a "kiss and ride" area, the second is a two-way street and serves the second entrance, the last, a one-way street with a "kiss and ride" area, is sloping and serves the elementary school.

Lab made devices, called 3PM, consisting of 3 low-cost sensors $PM_{2.5}$ (Honeywell HPM Series – HPMA115S0-XXX, laser-based light scattering particle sensing), one climate sensor (temperature, relative humidity, pressure), a data acquisition system, an SD card and a battery, are used in this study. The data recording is done every minute and in this case, the battery life is approximately 9h.

Firstly, an intra-comparison of each 9 PM sensors is performed in order to check the reproducibility of measurements. The sensors are located in ambient air next to each other during 7 days. The data sets show a Pearson correlation coefficient, r, close to 1.

In a second step, sensors are compared to an air quality monitoring station equipped with a GRIMM EDM180 instrument for PM, in the field during 3 days. Linear relations are obtained and used to evaluate the low-cost sensors with the reference measurements.

After these preliminary checks, the devices are fixed above each entrance of the school at a height of about 3m. The campaign was realized during a total of 14 days including week-end, holiday and school days between the end of May 2018 and June 2018. The devices were working from 7h30 to 17h (±9h). Typical traffic profiles were derived from measurements made with radars TMSSA for the 3 streets during the different periods. They give the number of vehicles and their speed.

The traffic profile shows 4 categories of profiles: school days, school holidays, Saturdays and the last category comprises Sundays and public holidays. Data analysis shows an increase of $PM_{2.5}$ concentrations of about a factor 2 during school days. The $PM_{2.5}$ values seem to indicate that the main entrance is the most used and that the additional $PM_{2.5}$ pollutions due to traffic is more than 25 $\mu g/m^3$ during the peak hour.

In the case of this school, the dropping off children impacts the air quality. It induces that people being there are exposed to concentrations higher than 25 $\mu g/m^3$ (1hour) while background concentration is 20 $\mu g/m^3$.

Due to the results of this preliminary study, a new campaign is planned during more days including different seasonal periods and various school activities.

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10.7. DESIGN OF THE MOBILE AMBIENT AIR QUALITY TESTING LABORATORY

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A mobile ambient air quality testing laboratory (MobLab) for both stationary and mobile measurements of particles and gases in ambient air was developed. Major efforts were made to design a vehicle, power supply, air conditioning system and the instrumental setup. The instruments on board are able to analyze the ambient air particles (PM10, PM2.5) concentration, trace gas concentrations (CO, SO_2, NO, NO_2, VOC, O_3) and meteorological parameters (temperature, relative humidity, pressure, wind, solar radiation, precipitation). All used measurements are either based on reference methods or the equivalence ones. MobLab also contains a data acquisition, handling and remote sensing tools.

Design of the platform option (trailer, camper, van), power supply option (electricity network, gasoline power supply engine), type of inlet system, span gas calibration setup, PM instruments configuration (TEOM, beta-ray attenuation, gravimetric, laser-scattering), as well as air conditioning, are evaluated.

This system is designed to be used for field investigation of anthropogenic influence on air quality, but also stationary ambient air monitoring. MobLab design was compared with modern approach used in this field (Bukowiecki at al, 2002; Marć at al, 2012; Seakins at al, 2002; Wang at al, 2009). Several interlaboratory measurement campaigns at different locations were done with this mobile platform and the measurement results were compared with the measurement results of other air monitoring stations. Challenges associated with remote approach to extract the real-time information from the mobile platform are also discussed. Several examples of applications of this MobLab are presented.

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10.8. CASE STUDY OF THE VERTICAL DISTRIBUTION OF SAHARAN DUST OVER BELGRADE

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Mineral dust aerosol is ubiquitous in the troposphere around the globe, and dominant in terms of mass concentration (Grini et al., 2005). Sahara is the largest source of dust emission and atmospheric dust loading in the world (Choobari et al., 2014). Strong low-level winds and convection can uplift mineral dust particles into the free troposphere, where they are transported over large distances even at intercontinental scales (Goudie and Middleton, 2001). Dust aerosols have a direct impact on the global radiative budget of the atmosphere by scattering and absorbing shortwave and longwave radiation. Also, dust aerosols can change the microphysical characteristics of clouds and precipitation due to their role in the nucleation of cloud ice and droplets (Rosenfeld et al., 2001). Furthermore, dust impacts air quality even at locations distant from its source region (Prospero, 1999). To improve understanding of these effects, it is important to characterize dust horizontal and vertical distribution, as well as meteorological conditions that lead to dust outbreaks in region of interest.

In this study, four episodes of long-range transport of Saharan dust to Balkans will be investigated based on results of numerical model and available ground-based measurements. Synoptic circulation patterns and airmass backtrajectories during these events will also be analyzed. For dust forecast, we used the Dust Regional Atmospheric Model – DREAM. The model was developed to predict the concentration of dust aerosol in the troposphere, and includes processes of dust emission, dust horizontal and vertical turbulent mixing, long-range transport and dust deposition (Ničković et al., 2001). Modeled dust concentration vertical profiles and concentrations at surface level during the selected events will be discussed. A qualitative comparison of modeled dust vertical profiles and results of LIDAR (Light Detection and Ranging) measurements in Belgrade will be presented. Furthermore, comparison of modeled dust surface concentrations with the measurements of PM_{10} particle mass concentration in two urban background stations in Belgrade will be shown, to give insight into the effect of dust on air quality during these dust episodes.

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10.9. ANNUAL PROFILE OF PM10 CONCENTRATION IN THE TOWN OF PANČEVO FOR 2017 AND 2018 YEAR

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Air pollution is a significant problem faced by urban areas in the world, and as such has a global character. Department of Public Health Institute Pančevo is a preventive health care institution, which through its activities covering South Banat district. One of the activities of the Institute is the quality control of the environment through performing air quality testing and estimation of its impact on human health. Department of Public Health Pančevo meets all the requirements set by international standard SRPS ISO/IEC 17025:2017 in terms of competence and equipment, the sampling and testing ambient air with manual and automated methods of monitoring. Ambient air quality in Pančevo indicate that air pollution comes primarily from particulate matter: soot and other toxic species.

The Public Health Institute of Pančevo conducts the measurement of PM_{10} at two locations, "Strelište" and "Narodna Bašta" site. "Strelište" represents an urban area where dominant sources of pollution come from traffic and individual heating sources, while "Narodna Bašta" represents an *urban background* site At the "Strelište" site, PM10 testing is performed by using the standard reference method SRPS EN 12341:2015 every third day, while at the "Narodna Bašta" site, tests are conducted with the GRIMM EDM 180 automatic measuring system. On the basis of results of measurements of PM_{10} the Air Quality Index (AQI) has been determined.

Table 1. PM_{10} at "Strelište" and "Narodna Bašta" sites in 2017 and 2018: samples number, daily exceedance number and its percentage, and maximum recorded concentration

year	. "Strelište" site					"Narodna Bašta" site				
	samples	above 50 μg/m³		maxium		samples	above 50 μg/m3		maxium	
		number	%	μg/m³	date		number	%	μg/m³	date
2017	119	37	31,9	208	06/12	347	155	44,7	235	06/12
2018	112	32	28,9	146	29/01	268	144	53,7	275	29/01

The majority of exceedances of the PM_{10} daily limit value at both location were registered during heating seasion, from middle of October till middle of April. According to the Regulation, the daily limit value of 50 μg/m³ can be exceeded a maximum of 35 times per year. In 2017 at "Strelište" there were 37 exceedances, while in 2018 there were 32 exceedances of PM_{10} daily limit values. At the location „Narodna Bašta" especially high number of PM10 daily level exceedence happened during month January.

Analysis of the air quality index for PM_{10} suspended particulates at the location "Strelište" revealed that during 2017 it belonged to the class "polluted" for 19 days, and to the class "heavily polluted" for 18 days, while during 2018 the air quality index belonged to the class "polluted" for 23 days, and the class "heavily polluted" for 9 days.

Analysis of the air quality index for PM_{10} suspended particulate matter at the location "Narodna Bašta" revealed that during 2017 it belonged to the class "polluted" for 81 days, and to the class "heavily polluted" for 74 days, while during 2018 the air quality index belonged to the class "polluted" for 99 days, and the class "heavily polluted "for 45 days.

Data of air quality at measuring locations indicated that air pollution in the city of Pančevo primarily come from particulate matter. The presence of suspended particulate matter in the air of the town Pančevo is a decade-long problem, especially in winter, during heating season. At both sites, as in previous years, the average concentrations of PM_{10} in winter are much higher than the average concentrations in summer. Increased concentrations of PM_{10} in winter, especially in clean residential areas such as the location "Strelište", suggest that PM pollution originates primarily from combustion of individual fireboxes.

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10.10. CFD SIMULATIONS OF WIND FLOW CHARACTERISTICS INFLUENCE ON FIREWORK BLAST PARTICULATE MATTER FRAGMENTS SPATIAL DISTRIBUTION

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Increasing occurrence of firework events represents a major contributor to air pollution (Brink et al, 2019; Scerri et al, 2018; Yao et al, 2019). The main air pollutants are found in a form of particulate matter, released as a result of an intensive fragmentation caused by firework's explosion (Zohdi and Cabalo, 2017).

Particulate matter dispersion may be hard to fully access using traditional experimental technics (Tanda et al, 2019). The main aim of this paper is to suggest novel model, based on Computational Fluid Dynamics (CFD) and Lagrangian particle tracking, able to simulate fireworks' particulates spatial and temporal evolution and their concentration distribution.

The main model feature is its ability to simulate both fireworks' particulates and gaseous phase – air behavior in a single framework. Thus, the performed simulations offer insight into the influence of different wind flow configurations on fireworks blast front development and particulate matter concentration. The obtained results showed that, although significant part of particulate matter is concentrated on the ground area surrounding firework's event site, the majority of particles with aerodynamic diameter of 10 µm and lesser, in coarse, fine and even smaller fractions, is taken by the wind flow, into upper levels of atmospheric boundary layer.

It can be concluded, based on the simulation results, that CFD proved to be an efficient tool for fireworks PM matter distribution determination. Future simulations will include Lagrangian tracking of a larger number of PM particles in order to get a finer resolution of their concentration distribution.

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10.11. IDENTIFICATION OF THE SOURCES OF FINE PARTICLES COLLECTED IN AN URBAN-INDUSTRIAL SITE IN BOR, SERBIA

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During the last several decades, special attention was given to fine particles ($PM_{2.5}$) due to their adverse effects on human health. Air pollution with particulate matter (PM) enriched with cancerogenic elements such as As, Cd and Pb is a serious issue in Bor, a city located in the eastern part of the Republic of Serbia. Due to vicinity of the Copper Smelter Complex Bor the Municipality of Bor is known as one of the major industrially contaminated site and environmental hotspot in Serbia. For this reason, the main goal of the present study was to identify the potential sources of fine particles applying the Principal Component Analysis (PCA) method.

$PM_{2.5}$ samples were collected in Bor during summer and winter periods. The sampling campaigns were conducted at the urban-industrial site, approximately 2 km south-southwest from the Copper Smelter Complex Bor. The summer campaign was performed from August 11 to August 30, in 2016, while the winter campaign was conducted from December 26, 2016, to January 14, 2017. $PM_{2.5}$ particles were collected on quartz fiber filters (Whitman® QM-A, 47 mm), using a low volume sampler (Sven/Leckel LVS3, Germany). The analyses of organic (OC) and elemental carbon (EC) were done by Carbon Aerosol Analyzer (Sunset Laboratory Inc., USA), using the NIOSH-5040 method (Birch and Cary, 1996). Determination of the water-soluble organic carbon (WSOC) and water-soluble inorganic ions was performed from water extracts, using TOC-VCPN (Shimadzu, Kyoto, Japan) organic carbon analyzer and ion chromatograph DX-300/DX200 (Dionex Inc., Sunnyvale, CA, USA), respectively. The quantification of major and trace elements was achieved using the inductively coupled plasma mass spectrometry (ICP-MS) (model 7700, Agilent, CA, USA).

It was found that $PM_{2.5}$ concentrations were higher during the winter campaign, with a mean value above the annual limit value (25 $\mu g/m^3$) (EC Directive, 2008). The concentrations of some carcinogenic elements (As, Cd and Pb) detected in $PM_{2.5}$ samples were higher in the comparison with the concentrations detected at most of the other urban and industrial cities in Serbia (SEPA Report 2016). The concentrations of arsenic identified in $PM_{2.5}$ samples exceeded the annual limit value (6 ng/m^3) prescribed for the As content in PM_{10} (twice during the summer campaign and seven times during the winter campaign). By applying the PCA factor analyses method, four factors were extracted, that explained 81.9% of data variance. The first factor was identified as a combination of biomass burning and secondary aerosols; the second factor represents the $PM_{2.5}$ pollution from the copper smelter; the third factor is also identified as a combination of soil and industrial dust and finally, the fourth factor was identified as the industry factor.

Even though a small number of samples were investigated, it was observed that different industrial activities within the mining-metallurgical complex in Bor contributed the most to the $PM_{2.5}$ pollution, regardless of the season. Biomass burning and secondary aerosol formation were the most important sources of $PM_{2.5}$ pollution in the winter period. Although district heating is more prevalent in Bor than in the other cities in Serbia, this factor indicates that domestic heating is an important source of $PM_{2.5}$ pollution in Bor during the winter.

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10.12. THE EFFECT OF INTENSE IONIZATION ON THE CHANGE IN THE CONCENTRATION OF TOBACCO SMOKE FINE PARTICLES

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Background: Particulate matters (PM) generated by cigarette smoke is one of most harmful indoor air pollutants. It is unhealthy not only for smokers but also for non-smokers inhaling PM. There are several ways for reduction of number concentration of PMs, notable examples being ventilation and filtering. These approaches might be somewhat aided by ionization of the air in certain scenarios.

A preliminary study of influence of artificially generated ions on cigarette smoke particles size distribution is presented. In theory, bipolar ionizer generates primary electrified particles of both polarities. After ionization process, primary ions evolve within microseconds through process of hydration into charged nano-aerosols, known as small air ions (SI). SI are typically charged clusters with electric mobilities of 1–2 $cm^2V^{-1}s^{-1}$, size range of 0.6–1 nm (Tammet & Kulmalla, 2005) and typical lifetime of 5–60 s. Processes of SI neutralization are by ion-aerosol attachment, ion-ion recombination and by the deposition on non-conductive (electrostatic) surfaces.

Methods: Bipolar barrier discharge ionizer (Bioclimatic GmbH) was used to generate up to 20 000 ions cm^{-3} per each polarity, while single cigarette burning was generating PMs of different sizes. PMs was measured using TSI NanoScan SMPS 3910 (measuring range from 11.5 to 365.2 nm), while SI concentration was measured using Counter and spectrometer of air ions CDIS (Kolarž et al., 2012). Experiment was conducted in small office where PMs and SI was measured with and without ionization. During the measurements, there were no disturbances in the room. Ionization was switched on 3 minutes after the cigarette was burned (yellow line in Figure 1) and SI concentration was in the range 9000 to 19000 ions cm^{-3} for positive and 7000 to 14000 ions cm^{-3}.

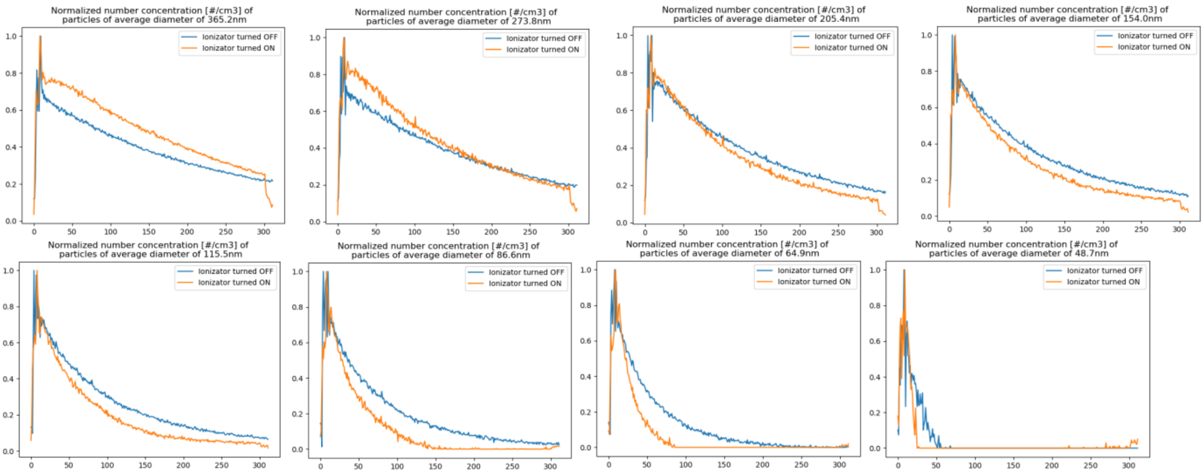

Figure 1. PM concentration reduction over time (min.) with (yellow line) and without (blue line) ionization.

Conclusion: The results (Figure 1) showed faster decrease in concentration of smaller PMs, up to 205 nm, as a consequence of SI to PM attachment mechanism. SI, as ions with higher mobility, quickly attaching on PMs and thus electrifying them. Electrified PMs are also attaching to other PMs and thereby significantly increasing mass and reducing mobility. According to our measurements, this process of aggregation of small PMs and ions takes place up to 200 nm of PMs diameter. After that PMs concentration during ionization is decreasing much slower than without ionization due to generation of new particles by ion induced aggregation process.

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10.13. INDUSTRIAL EMISSIONS COUNTRY PROFILES BASED ON EUROSTAT DATA AND THE EUROPEAN POLLUTION RELEASE AND TRANSFER REGISTER

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Industrial pollution puts pressure on all environmental media (air, water, land and biota). These pressures are caused by different types of pollutants originating from a variety of industrial processes. According to Regulation (EC) No 166/2006 concerning the establishment of a European Pollutant Release and Transfer Register, operators that undertake one or more activities specified in Annex I of the E-PRTR Regulation above the capacity threshold have to report their releases to air, water, land, off-site transfers of waste and of pollutants in waste water. EU Member States are obliged to submit the releases and transfers that do exceed the threshold values specified in Annex II of the Regulation to the European Commission. The EEA-33 Member Countries, Norway, Iceland, Liechtenstein, Norway and Switzerland, have committed themselves to report in line with the EU-28 Member States. 2007 was the first year for which data was reported. E-PRTR is an annual reporting obligation. Serbia is defined as one of the 'cooperating countries' to the EEA and have been reporting data to the E-PRTR since 2009.

In order to better describe environmental pressures from industry, the European Environment Agency (EEA), together with the European Topic Centre for Air Pollution and Climate Change Mitigation (ETC/ACM, 2014-2018), has developed country profiles on industrial pollution in Europe. Country profiles are now being generated by the ETC Air pollution, Transport, Noise and Industrial pollution (ETC/ATNI, 2019-2021).

The aim of the country profiles is to provide insights into the key industrial pressures in the EEA member countries and, therefore, contribute to decision making. These country profiles can also be used to inform the research and scientific communities on data issues that prevent analysis and clear decision-making. The profiles aim to monitor the progress of, and present findings on the state of industrial pollution. The addition of EEA-33 and EU-28 profiles enables a broader overview of industrial pollution in Europe. Data for Serbia is presented and compared with an extended "EEA-34" group of countries constituing EEA-33 and Serbia.

The scope of industry in this respect includes in short, all industrial activities reported under the European Pollutant Release and Transfer Register (E-PRTR) excluding agriculture (activity code 7.(a) and 7.(b)). The data sources include Eurostat, the E-PRTR, greenhouse gas (GHG) emissions reported under the Monitoring Mechanism Regulation (MMR) and air pollutant emission inventories reported under the Convention on Long-range Transboundary Air Pollution (CLRTAP), each of which have their own data categories. A recently developed EEA-mapping which align these different categories is used (EEA, 2019a). The data sources and industry scope is presented in full detail in the Annexes following this report.

The water and air pollutants including greenhouse gases are selected based on criteria related to their relative impact. Emissions of heavy metals to air and water have been combined by weighted averages using both eco toxicology and human toxicology characterisation factors (USEtox, 2017).

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The results are based on continuous work of EEA and a number of European topic centers. The current team (2019) comprises of Torleif Weydahl (NILU), Katrina Young (Aether), Kathryn Hampshire (Aether), Justin Goodwin (Aether), Marthe Granger (EEA), Bastian Zeiger (EEA). The latest report describes the current work (ETC/ATNI, 2019a). Numerous visualisations are available (EEA, 2019b).

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11. POSTER SESSION 2

11.1. THE EFFECT OF SMOKING ON PM10 AND PM2.5 PARTICLES CONTENT IN RESTAURANTS

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In restaurants, the level of presence of PM10 and PM2.5 respiratory particles in the air is different from restaurant to restaurant. What the concentration will be depends on external influences (traffic, urban settlements, proximity to industry) and internal influences, among which are food preparation and in particular guest behavior regarding cigarette smoking. This paper focuses on the impact of guest smoking on PM2.5 and PM10 levels in the air inhaled by guests and restaurant employees, whether or not they are smokers. This study (Damnjanović, 2019) covers several dozen restaurants in Belgrade. In most restaurants, about 90% of those surveyed are allowed to smoke. The measurements were performed with a portable multi-gas detector operating on the principle of laser beam scattering.

The effect of measurement, ventilation and smoking locations on both PM2.5 and PM10 levels was examined. Particular attention was paid to the presence of smokers, their number and distance from the measuring point. The results show that the presence of smokers has the greatest influence on particle concentration. Also, it can be seen that the distance of the smoker from the instrument is a very important factor, in that the particle concentration decreases drastically from the smoker distance for both types of particles. Measurements in restaurant gardens show less concentration than for the same number of smokers and their equal distance, indicating the influence of wind strength and direction (Meseldžija at al, 2015).

The presence of artificial ventilation as well as natural ventilation (open door, open window) significantly reduces the concentration values. Concentrations of smaller particles (PM2.5) were generally above the air pollution limit value and often above the tolerable value, even in some situations where there were no smokers. After quenching the cigarette, and when there is no active smoker, particle concentrations remain significant for a short period of time.

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11.2. SOME EFFECTS OF NEW COPPER SMELTER OPERATION ON AIR QUALITY IN BOR, SERBIA

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In terms of air quality, for many years the town of Bor has been the most polluted town in the Republic of Serbia and beyond. This was primarily due to extremely high concentrations of SO_2 emitted from copper smelter due to obsolete smelting technology and a low percentage of waste gas processing. In this paper, a preliminary analysis of the impact of the operation of the new smelter on the air quality in Bor was carried out. The analysis covered data collected at two measuring points located in the urban areas (Technical Faculty - TF and Town Park - TP), in the period of the old smelter operation (2014-2015), as well as in the period when the new smelter was fully operational (2016-2018). The concentrations of SO_2, PM_{10} and content of Pb, Cd, Ni, and As in PM_{10} were analyzed. The results of the analysis show that the concentrations of SO_2 after the construction of a new smelter are mainly within the legally prescribed limits (Table 1), as well as the concentration of PM_{10}. However, the content of As in PM_{10} (Table 2) was well above the permitted annual limit value. This situation requires the urgent actions in order to reduce the concentration of As in PM_{10} at the legally prescribed level.

Table 1. Mean annual levels of SO_2, and number of days above the daily limit in the period from 2014 to 2018 (LV - annual limit value, NDALV - number of days above daily limit value)

Year	SO_2 TF (μg/m³)	TF NDALV	SO_2 TP (μg/m³)	TP NDALV
2014	123.2	133	321.3	245
2015	92.2	94	240.8	204
2016	56.4	17	48.5	19
2017	49.5	17	43.7	12
2018	55.0	9	45.5	5
LV	**50**		**50**	

Table 2. Mean annual levels of PM_{10}, Pb, Cd, Ni, and As, at TF, and TP sites in the time interval from 2014 to 2018 (LV - annual limit, N - number of days sampled)

Year	PM_{10}_TF	Pb_TF	Cd_TF	Ni_TF	As_TF	N
	μg/m³	ng/m³	ng/m³	ng/m³	ng/m³	
2014	31.4	611.0	10.5	4.0	63.0	68
2015	31.3	151.0	4.4	3.0	64.4	34
2016	42.9	155.0	3.8	4.1	67.3	56
2017	55.3	149.6	4.4	5.7	137.4	63
2018	63.4	163.5	4.1	7.8	95.6	201
	PM_{10}_TP	Pb_TP	Cd_TP	Ni_TP	As_TP	N
	μg/m³	ng/m³	ng/m³	ng/m³	ng/m³	
2014	22.6	502.1	4.2	3.7	37.9	67
2015	26.5	206.5	4.3	3.2	60.7	68
2016	30.5	125.8	3.5	4.2	62.9	57
2017	31.7	115.9	3.1	4.5	116.5	57
2018	40.2	119.9	3.9	8.3	84.7	56
LV	**40.0**	**500.0**	**5.0**	**20.0**	**6.0**	

11.3. MICROBIOLOGICAL ANALYSIS OF AMBIENT CONDITIONS IN ARCHIVES

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The microbiogical quality of indoor air is of major importance in museums, libraries and archives deposits. Many fungi and bacteria produce serious damage in historic materials, which may be decomposed by the impact of specific enzymes, cellulases, proteases and organic acids. In addition to bioterioration, the microbiological agents may also cause pigmentation and physical damage. Fungi are particularly dangerous due to their tolerance to environmental conditions such as lower humidity. The aim of our investigation was to estimate the microorganism presence in archive interiors, both airborne andpresent on surfaces and to isolate the predominant microorganisms which may deteriorate the arcive artifacts. 49 samples of air were collected using sedimentation method and 40 sterile cotton swabs were wiped along the surfaces. The isolated agents were predominantly Gram-positive saprophytic bacteria included the genera *Bacillus* in 32 samples (*B. cereus, B. megaterium, B. clausii, B. amiloliquefaciens, B. altitudinis, B. simplex, B. spp*), *Micococcus luteus* in 8 samples, *Staphylococcus epidermidis* and *Staph. saprophyticus* in 4 samples, but pathogenic *Staphylococcus aureus* was also isolated in 2 samples. The filamentous fungi most frequently isolated species were *Penicillium spp.* in 14 samples, *Aspergilus spp.* in 10 samples and *Alternaria spp.* in 4 samples. Less frequent were *Cladosporium*, *Acremonium* and *Ulocladium*, which were present in one sample each. The obtained results indicate a microbioal air load containing both filamentous fungi and bacteria strains, including some opportunistic pathogens which can damage both archive artifacts and human health.

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11.4. ALLERGY ONSET IN EXHIBITION ENVIRONMENT – CASE REPORT

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Quality of indoor air in working environments is strictly regulated by contemporary standards when working process generates harmfull components. In such environments various technical and techonological measures need to be applied, as well as the individual protective garments. In general, in working environments such as exhibition theatres the quality of air is not particularly regulated, so protective measures are not defined whatsoever.

In spring 2018, during preparation of exhibition in improvised gallery, 4 of 7 employees reported health disorders in form of skin rush of unknown origin. Possible agents were not isolated. All exposed personell were engaged in another object and transfered to this theatre just for the exhibition where they were spending 10-12 hours daily. In the exhibition theatre there are no permanently employed persons. The exhibited items were part of the private collection, kept in unknown condition and included old clothes, vehicles, and even one stuffed animal. Total of 20 samples were collected using passive air sampling method and analyzed. Not one pathogenic bacteria or fungi was isolated. However, the entire theatre was contaminated with dust, and there was plenty of unused furniture. Systemic DDD measures were not conducted. To prevent futher health problems, the theatre was thoroughly cleaned and disinfected which results in consequent withdrow of symptoms in all exposed personell within 2 days.

This case indicates the need for permanent conduction of hygienic measures in indoor environments that are occasionally used in order to prevent such contact diseases.

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11.5. AMBIENT AIR POLLUTION AND OBESITY – IS THERE A CONNECTION?

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Background and Aims. Substantial epidemiological evidence implicates air pollution as a major adverse risk factor with serious consequences on human health in both industrialized and developing countries, but the contribution of air pollution to metabolic disorders such as obesity remains understudied. This review examines evidence related to potential impact of exposure to ambient air pollution on the overweight and obesity.

Methods. A literature search was conducted in the PubMed and Web of Science for peer-reviewed articles published until June 2019 that assessed the relationship between air pollution and body weight status.

Key results of the study. Nineteen studies, conducted in nine countries (USA, China, Canada, Denmark, Spain, Serbia, Italy, South Korea and The Netherland) met the selection criteria and were included in the review. The studies adopted a longitudinal or a cross-sectional study design. Almost half studies found air pollution to be positively associated with body weight, 42% reported a null finding, and the remaining 10% found air pollution to be negatively associated with body weight. The reported associations between air pollution and body weight status varied by sex, age group, and type of air pollutant. According to The Framingham Heart Study living closer to a major roadway was associated with higher overall and abdominal adiposity (Li et al, 2016.).The results of the study conducted in Denmark supported the hypothesis that, with respect to risk of obesity, men with the O phenotype are more susceptible to airborne occupational exposures than men with other phenotypes (Suadicani et al, 2005.). After adjusting for confounding factors, air pollution is positively associated with an increased likelihood of obesity or overweight in the population of 30,056 children (aged 2-14 years), from Northeast China (Dong et al, 2014.). Traffic pollution was also positively associated with body mass index in USA children aged 5–11 years (Jerrett et al, 2014.). Moreover, air pollution is associated with Serbian children's height and weight, specially before the age of 9 years (Nikolic et al, 2014.). Air pollution may lead to unhealthy body weight through metabolic dysfunction like increased oxidative stress and adipose tissue inflammation, elevated risk for chronic disease, and disruption of regular physical activity.

Conclusions. Concurrent evidence regarding the impact of air pollution on body weight status remains mixed. Some studies suggest that exposure to ambient air pollution is associated with risk for overweight and this may open up new possibilities for clarifying mechanisms.

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11.6. EXPLAINABLE RELATIONS OF PARTICULATE MATTER AND ENVIRONMENTAL FACTORS IN AN URBAN AREA

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In this study we focused on examining the dependencies between particulate matter (PM), and other air pollutants and atmospheric conditions in an urban environment. Briefly, eXtreme Gradient Boosting regression (XGBoost) was performed to obtain the relations between concentrations of PM_{10} and volatile organic compounds, inorganic gaseous pollutants, measured and modeled meteorological parameters, as well as parameters representing temporal and seasonal variations (Stojić et al. 2018). The relations were further analyzed by the use of Shapley Additive exPlanation (SHAP) summary and dependence distributions. The details about the methods applied are given elsewhere (Stojić et al. 2019).

The results indicate that, although CO individually achieves the highest impact on PM_{10} levels, meteorological conditions play the major role in shaping its environmental fate in an urban environment. Among other polluting species, the relation with benzene can be considered to be substantial, while the impact of other compounds found in the urban atmosphere, such as inorganic gaseous pollutants or other aromatics, can be considered to be significantly lower. The influence of CO is different, depending on the CO concentration range. The concentrations below 1 mg m^{-3} are associated with lower PM; in the CO concentration range between 1 and 1.5 mg m^{-3} the influence on PM levels can be considered negligible, while an increase in CO above 1.5 mg m^{-3} is accompanied by an increase of PM_{10}. This impact is largely determined by seasonality, indicating a strong influence of emission source, particularly the combustion of fossil fuels for heating purposes. However, it can be noticed that, even during the colder part of a year, low CO concentrations, being always followed by low concentrations of NO_x, SO_2 and volatile aromatics, stay related with lower PM levels. High-level CO concentration range is associated with complex interactions with other environmental factors, which need to be further addressed.

Low ceil height, even when being registered along with low visibility, does not have to be unambiguously associated with increased levels of PM. However, it can be seen that low cloudiness generally leads to a decrease in PM concentrations, which cannot be attributed to an increase in humidity or wet deposition, because with the highest relative humidity (Rh) values, the contribution of low cloudiness to an increase in PM can be extremely high. On the other hand, several of the most extreme PM events, associated with the highest impact on PM concentration, occurred with good visibility and max ceil height. Low visibility conditions, on their own, lead to an increase in PM levels. The lowest impact was observed for the highest concentrations of CO and benzene, and the lowest concentrations of other aromatics during the colder part of a year, and thus can be attributed to the the activation of the combustion emission sources emitting a lower share of PM. The ambient conditions which correspond to lower Rh (lower than 60%) and higher visibility contribute to the decrease in PM concentrations. Only with humidity above 80% and reduced visibility, an increase in PM concentrations up to about 10 µg m^{-3} was evident. The highest positive impact of relative humidity cannot be associated with high low and medium cloudiness, while the situation is indeterminate as for high cloudiness. At the end of the analyzed period, there was a noticeable change in the impact of the temporal trend on PM levels. The results clearly identify the suppression of the combustion sources which, in addition to CO emission, contain PM. This event was followed by the appearance of a pronounced combustion source which, besides CO, emits a large amount of particulatte pollution.

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11.7. EXPOSURE TO BIOMASS FUEL SMOKE AND OCCURRENCE OF SPONTANEOUS ABORTION

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Background. Biomass fuel smoke is associated with pregnancy outcomes (Milanzi and Namacha,2017; ; Wylie et al,2015; Page et al,2015). The current knowledge about the mechanisms by which exposure to biomass smoke may cause adverse pregnancy outcomes support the theory that the large quantities of carbon monoxide (CO) which can bind with hemoglobin in the blood and produce carboxyhemoglobin is the key component of adverse health effects and pregnancy outcomes (Franklin et al, 2019; Wylie et al,2014).
Aim. The aim of our paper was to investigate the association between exposure to biomass fuel smoke and occurrence of spontaneous abortion in Niš.
Method. The present cohort study was carried during 2017. In this study we evaluated data from a sample of 976 never-smoking pregnant women, ages 20-40 years, who have lived in part of the town with low concentrations of outdoor air pollutants and has not been professionally exposed to air pollution. Pregnant women of both groups do not have symptoms of any cardiovascular or pulmonary diseases, anemia, diabetes and pathological condition of pregnancy. All of these pregnant women are enrolled in early pregnancy (gestational age <10 weeks). Exposure to biomass fuel smoke is ascertained indirectly by type of fuel used for cooking or heating. The question was, 'What type of fuel does your household mainly use for cooking and heating?' which was followed by the above list of fuels: wood, coal, oil, electricity, liquid petroleum gas, and a residual category of other fuels. We use information from these questions to group pregnant women in two groups: exposed and non-exposed. The exposed group of pregnant women (n=523) use wood, coal and oil for cooking and heating, while the pregnant women from non-exposed group (n=453) use electricity and liquid petroleum gas for cooking and heating. Data on pregnancy were collected on the basis of physical examinations, fetal ultrasounds and hospital registrations in the Gynecological and Obstetrics Clinic, Niš (Serbia). Multiple logistic regression analyses were performed to analyze the relationship between occurrence of spontaneous abortion and exposure to biomass fuel smoke.
Results. The mean age of the pregnant women was 34 years. Women's education was high (over 60% of women had ≥12 grades). Over forty percent of these individual reported exposure to passive smoking at home. Out of a total number of studied pregnant women, over 66% were multiparous. The main types of fuel used by the households were as follows: electricity (379, 38.83%), liquid petroleum gas (74, 7.58%), coal (34, 3.48%), oil (11, 1.14%), and wood (478, 48.97%). The associations between exposure of biomass smoke and occurrence of spontaneous abortion (OR (95% CI):0.97 (0.67–1.02)) was not found to be statistically significant.
Conclusion.This study have shown, that occurrence of spontaneous abortion is not related to exposure to biomass fuel smoke.
Key words: spontaneous abortion**,** biomass fuel smoke**,** pregnancy outcomes, women, air pollution.

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11.8. PROCESSING LEVELS FOR LOW-COST AIR QUALITY SENSORS

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Low-cost sensors for air quality are a disruptive technology that has taken the measurements of air quality from the realm of expert applications to our every day life. This technological proliferation has brought by a number of previously unencountered issues that we have to address if we wish to take advantage of the devleopments. Some of them are described e.g., in Morawska et al (2018). One such issues is related to the nature of output from low-cost sensor based monitoring instrumentation: due to various, often undocumented, signal and data processing algorithms employed by the producer and the final user, it is often impossible to say what is the nature of the data we are using (Hagler et al, 2018).

This issue has beed addressed by Schneider et al. (2019) who propose to classify the outputs based on an analogy from satellite data processing, into the following processing levels:

Level	**Name**	**Definition**
Level-0	Raw measurements	Original measurand produced by sensor system
Level-1	Intermediate geophysical quantities	Estimate derived from corresponding Level-0 data, using basic physical principles or simple calibration equations, and no compensation schemes.
Level-2A	Standard geophysical quantities	Estimate using sensor plus other on-board sensors demonstrated as appropriate for artifact correction and directly related to measurement principle (Hagler et al., 2018)
Level-2B	Standard geophysical quantities-extended	As Level-2A but using external data demonstrated as appropriate for artifact correction and directly related to measurement principle (Hagler et al., 2018)
Level-3	Advanced geophysical quantities	Estimate using sensor plus internal/external inputs, not constrained to data proven as causes of measurement bias or related to measurement principle (Hagler et al., 2018)
Level-4	Spatially continuous geophysical quantities	Spatially continuous maps derived from network of sensor systems

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11.9. CAN LOW-COST AIR QUALITY SENSOR PLATFORMS HELP TO BUILD HEALTHIER CITIES?

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Air pollution in cities has been shown to pose a risk for the health of urban population. For an effective protection of health, air quality information at high spatial and temporal resolution is often valuable as it may provide guidance regarding which pollution reduction or exposure reduction measures may be the most effective. Conventional approaches to air quality monitoring consist of well-maintained sparse and static monitoring stations that comply with legislative requirements but do not provide enough spatial resolution to cover the city solely on the basis of their measurements. While they offer high quality data, they are are too expensive to be deployed in large numbers to capture the spatial heterogeneity of air pollution. New technologies are now available based on cheap sensors capable to detect ambient air pollution levels. Because of their lower price, low-cost sensor platforms can be deployed in significantly higher numbers throughout the urban environment.

We tested the performance in the laboratory and in the field of 24 commercial platforms (AQMesh) (Castell et al 2017). In carrying out this evaluation, we identified the main technical challenges associated with current commercial low-cost sensors, regarding the sensor robustness and measurement repeatability. Our results show that laboratory calibration is not able to correct for real world conditions and that it is necessary to perform a field calibration for each monitoring device individually. Despite that, we observed that currently some sensors are already capable of providing useful information about air quality (Castell et al 2018).

During January and March 2016, we deployed the 24 AQMesh nodes in Oslo. During January, high NO_2 levels were observed for several days in a row, coinciding with the formation of a thermal inversion. During March, we observed an episode with high PM_{10} levels attributable to road dust resuspension. Low-cost sensor nodes were able to reproduce the NO_2 and PM_{10} variability. The data from the sensors was used to generate detailed NO_2 and PM_{10} air quality maps using a data fusion technique (Lahoz and Schneider, 2014; Schneider et al 2017). This way, we were able to offer localized air quality information for the city of Oslo. This type of information could be suitable for applications that aim to raise awareness or engage the community by monitoring local air quality, as such applications do not require the same accuracy as scientific or regulatory monitoring.

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11.10. INNOVATIVE ENVIRONMENTAL MONITORING FOR NORWEGIAN MUNICIPALITIES USING LOW-COST SENSOR NETWORKS. THE IFLINK PROJECT

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Municipalities need to provide air quality data with high temporal and spatial resolution in order to improve air quality mitigation and to answer to citizen's demand. The currently deployed technologies do not provide such data. iFLINK will establish a scalable low-cost sensor network infrastructure for integration and quality control of data from different sources, for delivery of high-resolution outputs. iFLINK will use a seamless combination of sensing and ICT technologies to provide locally specific open environmental data for the municipalities and for citizens. iFLINK will also allow public and private actors to develop real time environmental services related to e.g., air quality, climate change, or noise, with interfaces to any local smart city development.

Low-cost sensor monitoring devices are compact and easy to use, allowing deployment of many units, but the generated data are often of questionable quality, and their deployment requires new ICT infrastructures (Castell et al. 2017, Schneider et al 2017). This includes sophisticated algorithm-based methods for calibration and quality assurance, and data fusion methods for merging sensor data with data from other sources, enabling municipalities and other actors to develop data-driven solutions and visualizations. Fully deployed, iFLINK will provide real-time accurate air quality information with high spatial and temporal resolution at an affordable cost. The project will have pilot studies in five municipalities (Bergen, Bærum, Drammen, Kristiansand and Oslo).

iFLINK is addressing the following key research issues:

- A scalable approach to heterogeneous data using Data-as-a-Service and Linked Data, allowing to handle increasing computational requirements in a cost-effective way
- Smart physical calibration of sensor networks combining big data algorithms with field procedures
- Machine learning algorithms to enable the use of low-cost air quality sensors in applications that require a high degree of accuracy
- Integration of data relevant for air quality from a variety of sources to assess air quality at a particular location and time with high accuracy by sophisticated data fusion techniques
- Enable development of effective and efficient information solutions.

The project implementation is dependent both, on availability of reseach results, and on practical issues. Most importantly, the five municipalities need to acquire the low-cost monitoring equipment. For this, a procurement process had to be initiated, with a specification the requirements the low cost devices will have to fulfill. Such specification includes the following elements: physical appearance (size and weight, type of power supply, weathering, easiness of maintenance and lifetime), metrological requirements (unit of measurement, limit of detection, measurement range, response time, and presision), documentation, data communication protocols, data storage and formats, and data security. Procurement of instrumentation has just started. In the absence of own monitoring outcomes, the project team works on visualization and on calibration and quality control methods on the basis of other already running projects. As the use of low-cost sensor systems and networks is expanding, the project will open for other municipalities for association.

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AUTHOR INDEX

Author	Section(s)
Topalović, D.	1.2
Urošević, M. Aničić	9.2
Urošević, T.	4.4
Vallejo, I.	11.1
Vasilescu, J.	8.2
Vaz, L.	2.3
Visser, B.	6.4
Vitelaru, C.	8.2
Vito, S. De	3.1
Višić, B.	8.3
Vogt, M.	11.1, 11.9
Vončina, R.	7.3
Weingartner, E.	6.4
Weydahl, T.	10.13
Üzmez, Ö. Ö.	5.5
Đorđević, V.	10.9
Đurkić, T.	11.1
Šoštarić, A.	3.3
Šunjević, M.	8.1
Živadinović, R.	11.7
Živković, M.	1.2, 4.3, 7.5, 10.10, 10.12

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