



HRVATSKO UDRUŽENJE ZA ZAŠTITU ZRAKA
CROATIAN AIR POLLUTION PREVENTION ASSOCIATION

INTERNATIONAL CONFERENCE AND 14TH CROATIAN
SCIENTIFIC AND PROFESSIONAL MEETING
AIR PROTECTION 2025

MEĐUNARODNA KONFERENCIJA I
ČETRNAESTI HRVATSKI ZNANSTVENO-STRUČNI SKUP
ZAŠTITA ZRAKA 2025

Zadar, Croatia
21st - 25th October 2025

**BOOK OF
ABSTRACTS**
ZBORNİK SAŽETAKA



**INTERNATIONAL CONFERENCE AND
14TH CROATIAN SCIENTIFIC AND PROFESSIONAL MEETING
AIR PROTECTION 2025**

BOOK OF ABSTRACTS

**MEĐUNARODNA KONFERENCIJA I
ČETRNAESTI HRVATSKI ZNANSTVENO-STRUČNI SKUP
ZAŠTITA ZRAKA 2025**

ZBORNIK SAŽETAKA



ISSN: 1848-185X

PUBLISHER / IZDAVAČ

Croatian Air Pollution Prevention Association
Zagreb, Ksaverska c. 2

FOR THE PUBLISHER / ZA IZDAVAČA

Ranka Godec

EDITOR / UREDNIK

Gordana Pehnec

TECHNICAL EDITORS / TEHNIČKI UREDNICI

Ranka Godec
Jasmina Rinkovec

REVIEWERS / RECENZENTI

Scientific Committee / Znanstveni odbor

DESIGN & LAYOUT / GRAFIČKO OBLIKOVANJE

Andrijana Marković

PRINT, EDITION / TISAK, NAKLADA

Cerovski d.o.o., 150 primjeraka /
Cerovski d.o.o., 150 copies

PUBLICATION FREQUENCY / PERIODIKA IZDANJA

Biennially / Jednom u 2 godine

UNDER THE AUSPICE OF / POKROVITELJ

Ministry of Environmental Protection and Green
Transition / Ministarstvo zaštite okoliša i zelene
tranzicije

Ministarstvo znanosti, obrazovanja i mladih /
Ministry of Science, Education and Youth

SCIENTIFIC COMMITTEE / ZNANSTVENI ODBOR

Gordana Pehnec - president
Pasquale Avino
Darijo Brzoja
Konstantinos Eleftheriadis
Goran Gajski
Selahattin Incecik
Mario Lovrić
Marijana Matek Sarić
Young Sunwoo
Martine Van Poppel
Bojana Žegura

ORGANIZING COMMITTEE / ORGANIZACIJSKI ODBOR

Ranka Godec - president
Silvije Davila
Ivana Hrga
Ivana Jakovljević
Marija Jelena Lovrić Štefiček
Velimir Milić
Marija Opačak Eror
Branko Petrinec
Gordana Pršlja
Jasmina Rinkovec
Vedran Vađić
Željka Zgorelec

ADVISORY COMMITTEE / SAVJETODAVNI ODBOR

Ivan Güttler
Iva Ivanković
Andrzej Jagusiewicz
Ana Lucić Vrdoljak
Thomas Reichert
Krešimir Šega
Vladimira Vađić
Nina Zovko

All of the information provided in this Book of abstracts is the sole responsibility of the authors of the manuscripts. The Publisher is not responsible for any misuse of the data appearing in this document.

Croatian Air Pollution Prevention Association
Institute for Medical Research and Occupational Health
Croatian Meteorological and Hydrological Service
European Federation of Clean Air and Environmental Protection Associations - EFCA
International Union of Air Pollution Prevention and Environmental
Protection Associations - IUAPPA

**MEĐUNARODNA KONFERENCIJA I
ČETRNAESTI HRVATSKI ZNANSTVENO-STRUČNI SKUP
ZAŠTITA ZRAKA 2025**

ZBORNIK SAŽETAKA

**INTERNATIONAL CONFERENCE AND
14TH CROATIAN SCIENTIFIC AND PROFESSIONAL MEETING
AIR PROTECTION 2025**



BOOK OF ABSTRACTS

Zadar, Croatia
21st - 25th October 2025



◆ CONTENT

◆ **FOREWORD** 11

◆ **AIR QUALITY MANAGEMENT**

Nataša Belšak Šel, Matjaž Mlinarič, Uroš Lešnik:
Assessment of air quality in rural area of Ptuj municipality, Slovenia, from 2020 to 2024 15

Lucia Bustin, Sebastian Harald Schmitt, Florian Dahlkoetter, Carsten Kykal, Oliver Felix, Bischof, Torsten Tritscher:
Characterization of individual instruments for UFP measurements in the framework of the new EU Ambient Air Quality Directive..... 16

Ivana Grljak, Darijo Brzoja:
Bridging the gap effective air quality communication in the age of misinformation 17

Marko Marić, Danijel Grgec, Želimira Cvetković, Jasna Bošnjir:
Ecological Map of the City of Zagreb 18

Marija Opačak Eror, Marijana Matek Sarić:
Air protection and sustainable tourism development: a review of economic methods 19

◆ **AIR POLLUTION SOURCES AND EMISSIONS**

Monika Babačić, Ivana Roksa:
Certification of BE-TO Sisak under the SURE Scheme for proving the use of sustainable forest biomass 23

Ivan Bešlić, Domagoj Mihajlović, Vedran Vadić:
The impact of weather conditions on air quality in the area of the Jakuševac landfill 24

Valentina Jagić, Vesna Gugec, Stipica Šarčević, Velimir Milić, Darijo Brzoja:
Air quality and environmental aspects of municipal waste management in the City of Zagreb, Croatia 25

Nikolina Račić, Mario Lovrić, Gordana Peh nec, Ivana Jakovljević, Zdravka Sever Štrukil, Silva Žužul, Jasmina Rinkovec:
Using explainable machine learning to understand what affects PAHs and heavy metals in PM₁₀ particles 26

Ivana Roksa, Monika Babačić:
Reduction of solid particle emissions from BE-TO Sisak by installation of an electrostatic precipitator 27

Suzana Sopčić, Ranka Godec, Gordana Peh nec:
Levoglucon levels in the PM₁ fraction at an urban site in Zagreb, Croatia: a five-year trend 28

Petar Uremović, Zoran Kovačević, Petar Maruna, Luka Lučić:
Measuring characteristic odours, distinctions and application of HRN EN 13725 and HRN EN 16841 standards 29

◆ **AMBIENT AIR POLLUTION MONITORING**

Darijo Brzoja, Mario Lovrić, Valentino Petrić, Bram Verbeek, Marko Kvakić, Vesna Gugec, Danica Kraljević, Velimir Milić, Valentina Jagić, Stipica Šarčević:
Leveraging machine learning for cost-effective air quality monitoring: the LIFE CityTRAQ case 33

Željko Čirović, D. B. Stojanović, Milena Jovašević-Stojanović:
Analysis of diurnal and seasonal variation of ultrafine particle size distribution in the City of Belgrade, Serbia 34

Dario Dabić, Goran Purić, Ksenija Kuna:
Trends in daily mean concentrations of PM_{2.5} and PM₁₀ at the Puntijarka monitoring station (2022–2025) 35



Ivana Jakovljević, Zdravka Sever Štrukil, Gordana Pehnek:

PAH concentrations at an urban traffic location in Croatia over five years 36

Renata Kovačević, Bojan Radović, Viša Tasić, Tatjana Apostolovski Trujić, Tamara Urošević, Duška Kleut,
 Milena Jovašević-Stojanović:

**Levels of airborne metals in urban air driven by different anthropogenic sources: Bor and
 Belgrade 37**

Uroš Lešnik, Jan Radanović:

**Results of air quality measurements in the measurement network of Maribor, Slovenia, and
 neighboring municipalities 38**

Bruna Mariani, Marin Vojković, Jadranka Šepić, Marina Kranjac:

**Seasonal variability of air pollutants and their relationship with meteorological conditions in
 Split, Croatia 39**

Ivona Mikić, Valentina Gluščić, Ivan Bešlić, Gordana Pehnek:

**Insight into seasonal variations of water-soluble inorganic ions in PM_{2.5} at a rural background
 site 40**

Zdravka Sever Štrukil, Ivana Jakovljević, Gordana Pehnek, Ivan Bešlić:

Polycyclic aromatic hydrocarbons in the air of Split and Plitvice lakes 41

Vedran Vadić, Predrag Hercog, Bojan Abramović:

Air quality monitoring at waste management centre Biljane Donje 42

♦ MACHINE LEARNING AND AIR QUALITY MODELLING

Vesna Gugec, Stipica Šarčević, Valentina Jagić, Velimir Milić, Darijo Brzaja:

**Projection of the impact of air pollution from thermal treatment of waste using the ADMS 6
 dispersion model 45**

Snježana Herceg-Romanić, Silvije Davila, Ivan Bešlić, Gordana Pehnek, Gordana Jovanović, Mirjana Perišić, Andreja Stojić:

**Revealing the impact of temperature on urban benzene using explainable AI
 methodologies 46**

Gordana Jovanović, Snježana Herceg-Romanić, Silvije Davila, Ivan Bešlić, Gordana Pehnek, Timea Bezdan, Mirjana Perišić,
 Andreja Stojić:

Advanced AI approaches for understanding benzene pollution in urban atmosphere 47

Marko Kvakić, Angelo Riccio, Darijo Brzaja:

**Improved regional air quality forecast using the Bayesian spatio-temporal method
 INLA-SPDE 48**

Darko Mekterović, Marija Čargonja, Domagoj Mateljak, Boris Mifka, Robert Pleše:

Conditional probability function with uncertainty estimates in air pollution research 49

Velimir Milić, Vesna Gugec, Darijo Brzaja:

**Estimation of dust, forest fire and sea salt contributions to surface concentrations of PM₁₀
 in Croatia 50**

Stipica Šarčević, Velimir Milić, Vedrana Džaja Grgičin, Marina Skender, Darijo Brzaja, Vesna Gugec, Valentina Jagić,
 Marko Kvakić:

**LOTOS-EUROS chemical transport model-based assessment of the spatial representativeness
 in the Croatian Air Quality Monitoring Network 51**

♦ DEVELOPING AND TESTING MEASURING METHODS

Darijo Brzaja, Bram Verbeek, Marko Kvakić, Vesna Gugec, Danica Kraljević, Velimir Milić, Valentina Jagić, Stipica Šarčević:

**Evaluating low-cost air quality sensors in urban environments: insights from the LIFE CityTRAQ
 project 55**

Mihriban Civan, Demet Arslanbaş, Abdulmounem Alcheikh Wis, Hilal Yilmaz, Ubaidullah Habibi and Serpil Yeniso:

**A modified digestion-extraction protocol for micro(nano)plastic detection in environmental
 and food matrices 56**



Silvije Davila, Marija Jelena Lovrić Štefiček, Ivan Bešlić: Field calibration of sensors for particulate matter	57
Ranka Godec, Helena Prskalo, Marija Jelena Lovrić Štefiček, Krešimir Šega, Gordana Pehnek: Comparing black carbon and elemental carbon mass concentrations: methodological similarities and differences	58
Predrag Hercog, Mario Šantolić, Mirela Poljanac, Vedran Vačić: Some important differences between old and new Croatian standards for ambient air quality	59
Branko Petrinc, Tomislav Meštrović, Luka Pavelić, Dinko Babić: Development and implementation of hybrid gamma-ray spectrometry methods for enhancing the capacity of environmental radiological monitoring around nuclear power plants	60
♦ HEALTH IMPACTS OF AIR POLLUTION	
Katja Kološa, Tim Ravnjak, Eva Kanalec, Sonja Žabkar, Luka Kazensky, Goran Gajski, Bojana Žegura: Genotoxic potential of benzo[a]pyrene (B[a]P) and dibenzo[a,h]anthracene (D[a,h]A) in human hepatocellular spheroid model	63
Matjaž Novak, Martina Štampar, Alja Štern, Michael J. Burgum, Gillian E. Conway, Goran Gajski, Shareen H. Doak, Bojana Žegura: Assessment of genotoxic and inflammatory responses to benzo[b]fluoranthene and benzo[g,h,i]perylene in a co-culture lung model at the pseudo-air-liquid interface	64
Gordana Pehnek, Ivana Jakovljević, Zdravka Sever Štrukil, Silvije Davila, Marko Gerić, Katarina Matković, Mandica Sanković, Antun Šumanovac, Goran Gajski: Genotoxic potential of PAHs bound to particulate matter in ambient air at different locations in Croatia	65
Jasmina Rinkovec, Silva Žužul, Magdalena Vincetić, Gordana Pehnek: Health risk assessment of heavy metals exposure in the ambient air of Zagreb, Croatia	66
♦ INDOOR AIR QUALITY, ENERGY EFFICIENCY AND HEALTHY BUILDINGS	
Daniela Dejacó, Heimo Gursch: Data quality and indoor air quality tools for cross-European comparison	69
Jose Feroso, Alicia Aguado, Sandra Rodríguez-Sufuentes, Rubèn González-Colom, Josep Roca, Alba Gómez-López, Benigno Sánchez, Alberto Rodríguez López, María Figols, Manel Sanz, Felipe López: Hospital IAQ assessment using a hybrid monitoring strategy: continuous low-cost sensing and targeted sampling at Hospital Clínic de Barcelona. K-HEALTHinAIR project	70
Tajana Horvat, Ivana Jakovljević, Gordana Pehnek: Toluene as a common volatile organic compound in homes: the Zagreb city area during two seasons	71
Stavroula Katsikari, Vassiliki Vassilatou, Konstantinos Granakis, Raquel Pimenta, Ketlyn Oliveira, Susana Marta Almeida, Drew Henderson, Robert Ferguson, Heidi Salonen, Konstantinos Eleftheriadis, Evangelia Diapouli: Characterization of ultrafine particle number concentration and size distribution in microenvironments critical to children's exposure across different European countries	72
Marija Jelena Lovrić Štefiček, Silvije Davila, Gordana Pehnek, Goran Gajski, Ivan Bešlić, Luka Kazensky, Ivana Banić, Mirjana Turkalj: A comparative statistical assessment of PM₁ mass concentration variation in residential environments in Zagreb, Croatia	73
Ivan Notardonato, Mario Lovrić, Alessandro Battaglia, Piergiorgio Cipriano, Pasquale Avino: Volatile organic compounds and aldehydic compounds: indoor/outdoor comparison across different living environments	74
Ivan Pavičić: Detection of asbestos in the ship's interior	75



Pedro Pena, Renata Cervantes, Carla Viegas:
Preliminary Assessment of Microbial Contamination from Winter Sampling Campaign in Portuguese Elementary School 76

Grigoris Protopsaltis, Chris Mountzouris, John Gialelis:
Reinforcement learning-based air purification control for enhanced indoor air quality 77

Valentino Petrić, Dejan Strbad, Nikolina Račić, Francesco Mureddu, Mario Lovrić:
Hybrid digital twin framework for real-time indoor air quality monitoring and filtration optimization 78

Iva Šunić, Dubravka Havaš Auguštin, Jelena Šarac, Kristina Michl, Rasmus Riemer Jakobsen, Mario Lovrić:
Microbial composition of household dust in Croatian homes: findings from EDIAQI project . 79

Silva Žužul, Marija Jelena Lovrić Štefiček, Gordana Pehnc, Ivan Bešlić:
Microplastics in the indoor air of Zagreb households 80

◆ **CLIMATE AND ENVIRONMENTAL IMPACTS OF AIR POLLUTION**

Ana Alebić-Juretić:
Impacts of climate change in the City of Rijeka, Croatia 83

Želimir Cvetković, Ivana Čosić, Ksenija Kuna, Danijel Grgec, Marko Marić, Jadranka Škevin-Sović, Jasna Bošnir:
The influence of inorganic compounds in precipitation on total deposited matter – a case study from Zagreb, Croatia 84

Gordana Sinčić Modrić, Tamara Cirković, Goran Crvelin:
Total deposited matter as an indicator of air quality: monitoring results in the City of Rijeka, Croatia, in 2024 85

Anita Vucić, Predrag Ilić, Sonja Kralj, Danijela Peroš- Pucar, Katarina Bukša, Sanja Bajić, Silvana Račić Milišić, Kasim Agović:
AllerShield: Strengthening crossborder solutions for managing allergenic plants and enhancing climate resilience 86

Željka Zgorelec, Gordana Pehnc, Aleksandra Perčin, Marija Galić, Iva Hrelja, Jasmina Rinkovec:
Platinum group elements in the urban environment (soil, plants and air) of Zagreb, Croatia . 87

◆ **EFCA SESSION: "METHANE TIME"**

Andrzej Jagusiewicz:
Targeting methane 91

Goran Kiš:
Methane emissions from livestock: sources, impact, and mitigation strategies 92

Martin Poulsen:
Ventilation air methane treatment for underground coal mines 93

Iva Prgomet Ernst, Tatjana Obučina, Nino Malešić:
Methane emissions and national inventory reporting 94

Jacek Skiba:
Preventing methane emissions from underground coal mines 95

◆ **IUAPPA SESSION**

Sohyun Jeon, Seoyeon Moon, Jihu Lee, Young Sunwoo:
An air pollution policy dilemma - ozone concentration changes under air quality policy implementation based on national climate change projections in Korea..... 99



FOREWORD

The great success of the "Air Protection 2023" conference, held in Mlini near Dubrovnik, Croatia, from 20th to 23rd September 2023, has encouraged us to continue with the international character of our event. The International Conference and 14th Croatian Scientific and Professional Meeting is being held this year in the beautiful and historic city of Zadar, known for some of the most outstanding architectural monuments and cultural heritage sites on the eastern Adriatic coast.

As with previous "Air Protection" editions, the main organizer is the Croatian Air Pollution Prevention Association (CAPP), in cooperation with the Institute for Medical Research and Occupational Health, the Croatian Meteorological and Hydrological Service and, since 2013, the European Federation of Clean Air and Environmental Protection Associations (EFCA). This year's co-organizer is also the International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA), further highlighting the international recognition and importance of our conference.

It is our great pleasure to present this Book of Abstracts, which includes 60 submitted abstracts. During the "Air Protection 2025" conference, 42 oral and 21 poster presentations will be held, covering the following topics:

- 1 - Air quality management
- 2 - Air pollution sources and emissions
- 3 - Ambient Air pollution monitoring
- 4 - Machine learning and air quality modelling
- 5 - Developing and testing measuring methods
- 6 - Health impacts of air pollution
- 7 - Indoor air quality, energy efficiency, and healthy buildings
- 8 - Climate and Environmental impacts of air pollution

As part of the conference, two special sessions will be held: the session "*Methane time*", organized under the auspices of EFCA, and a special session hosted by IUAPPA, focusing on global air protection challenges, which will be held in a hybrid format (in-person and virtual).

Due to the strong interest expressed for the topic "Indoor air quality, energy efficiency, and healthy buildings", the session will also be held in a hybrid format, to enable online participation by experts and researchers who may not be able to attend the conference in person. Indoor air quality has recently become the focus of numerous scientific studies, as modern lifestyles lead people to spend the majority of their time indoors. Despite its significance, indoor air quality remains under-researched and insufficiently regulated. We hope that this conference will contribute to advancing knowledge and awareness in this important field.

We trust that this year's edition of the "Air Protection" conference will provide a valuable platform for presenting research findings, encouraging discussion and the exchange of ideas, identifying current and emerging challenges, and supporting the development of informed strategies for future action.

The success of the "Air Protection 2025" conference would not be possible without the dedicated work of the Scientific and Organizing Committees, as well as the valuable input of the Advisory Board. CAPP extends its sincere appreciation to all co-organisers and sponsors for their continued support and collaboration.

We wish all participants a successful and inspiring conference experience, and an enjoyable stay in the beautiful city of Zadar!

Gordana Pehnec and Ranka Godec

AIR QUALITY MANAGEMENT





Poster presentation

Nataša Belšak Šel, Matjaž Mlinarič, Uroš Lešnik

ASSESSMENT OF AIR QUALITY IN RURAL AREA OF PTUJ MUNICIPALITY, SLOVENIA, FROM 2020 TO 2024

KEYWORDS: *air quality, PM₁₀, Ptuj, rural area*

Air quality is one of the most severe health problems for people living in cities and in rural areas. In 2020 in the European Union, 96 % of the urban population was exposed to levels of fine particulate matter above the health-based guideline level set by the World Health Organization, which resulted in 238,000 premature deaths in the EU-27. More influential sources are road transport, industry and domestic heating which contribute significantly to the worsening of this problem. The air quality indicates the level of pollution in the air we breathe, which is caused by various chemical substances present in the air, which, in turn, change the natural composition of the atmosphere. However, government measurement networks mainly focus on cities, overlooking of people that live in the countryside.

Measurement results show that PM₁₀ particles are the biggest problem in Slovenia. This study aimed to evaluate the particles - PM₁₀ in rural area compared to the urban area at the Municipality Ptuj in northeast Slovenia. Location at the urban area is part of the government measurement network, while location at the rural area is stationary measurement station on which air quality has been continuously monitored from 2020 to this date.

We analysed the ambient air quality in these areas in order to investigate whether there are significant differences between them. Assessments were performed on daily values between years 2020 and 2024.

We found that the concentrations of pollutants varied depending on the area and that PM₁₀ concentrations were higher at the rural area in winter months compared to urban area. By comparing both locations from the perspective of traffic and heating sources we investigated the reasons why there is a difference in air quality in these two locations. The results of high values in winter indicate the main pollutant, although there are also different meteorological conditions in winter that increase the values of pollutants in the outdoor air. Further efforts will be needed to meet the zero-pollution vision for 2050 of reducing air pollution to levels no longer considered harmful to health, also at the rural areas.



Oral presentation

Lucia Bustin¹, Sebastian Harald Schmitt¹, Florian Dahlkoetter¹, Carsten Kykal¹, Oliver Felix Bischof^{1,2}, Torsten Tritscher¹

CHARACTERIZATION OF INDIVIDUAL INSTRUMENTS FOR UFP MEASUREMENTS IN THE FRAMEWORK OF THE NEW EU AMBIENT AIR QUALITY DIRECTIVE

Keywords: CEN/TS 16976, CEN/TS 17434, CPC, monitoring, UFP, SMPS

The approval of the new EU Ambient Air Quality Directive by the EU Council on October 14th marks a milestone for ambient ultra-fine particle (UFP) measurements. EU member states are now obliged to include particle number (PN) as well as particle size distribution (PSD) measurements in their local ambient monitoring strategies. In the past years normative efforts have been undertaken to harmonize these measurements. Ambient PN is regulated in EN 16976:2024 with the final revision published in September 2024, and PSD is defined in the technical specification CEN/TS 17434:2024. Both documents describe measurement methods, data handling, as well as the sampling and conditioning of the particles to get a representative sample of ambient air.

Condensation Particle Counters (CPCs) are the most widely-used instruments for atmospheric measurements of PN concentrations, and especially the UFP fraction. CPCs can be used standalone or can be incorporated into Scanning Mobility Particle Sizers (SMPS; also referred to as 'Mobility Particle Sizer Spectrometer', MPSS). SMPS systems measure PSD of atmospheric aerosol particles and provide the integrated total number concentrations at the same time.

Both technologies, CPC (Model 3750-CEN10, TSI Incorporated, Shoreview, MN, USA) and SMPS (Model 3938W50-PP-CEN10, TSI), for continuous ambient monitoring will be presented alongside a concept to integrate these into existing monitoring networks.

For PN and PSD measurements the greatest challenge in the size range from 10 to 800 nm is diffusional loss of the smallest size fraction. For this, an ambient sampling system (Model 3750200, TSI) has been designed to minimize such losses. This inlet system consists of a PM₁₀ sampling head, a PM_{2.5} cyclone (both: BGI, Mesa Labs Inc.), a 90 cm single tube Nafion drier (MD700, Perma Pure), a flow splitter (Model 3708, TSI), as well as customized parts for connection, and is driven by a vacuum pump.

Results from characterization measurements with the whole setup in a realistic scenario realized in the SAPHIR-STAR chamber will be presented. This chamber is operated as a continuously stirred tank reactor, and in which the mixture of all air constituents including the aerosol can be precisely controlled (Baker et al. EGU sphere [preprint], 2023). Here we used ammonium sulfate and secondary organic aerosol (SOA) generated from photooxidation of alpha-pinene as well as mixtures of both systems. Our results display an excellent performance of the sampling system with losses being negligible over a wide size range. In the smaller diameter range, losses were less than the limit given in EN 16976:2024 (< 25% at 10 nm).

¹TSI GmbH, Neuköllner Strasse 4, 52068 Aachen, Germany

²Forschungszentrum Jülich GmbH, Institut für Energie- und Klimaforschung: Troposphäre (IEK-8), 52425 Jülich, Germany



Oral presentation

Ivana Grljak and Darijo Brzaja

BRIDGING THE GAP: EFFECTIVE AIR QUALITY COMMUNICATION IN THE AGE OF MISINFORMATION

Keywords: *air quality communication, environmental policy, misinformation, public engagement, public relations, science communication*

Air quality is not just an environmental concern - it is a pressing public health issue. Polluted air is linked to reduced life expectancy, chronic illnesses, and diminished quality of life. As scientific understanding grows, so do public expectations. People increasingly demand timely, reliable, and understandable information. They want to know what they are breathing and what institutions are doing to protect them. In this context, effective communication is no longer optional; it is a vital component of public service.

Scientists' voices often remain in the background while louder, less informed voices frequently dominate the public conversation. One of the reasons behind it could be that scientific institutions commonly focus on data accuracy, but may overlook how that data is interpreted by the public. This gap can lead to mistrust, confusion, or the perception that information is being withheld, even when it is not. Citizens and scientists often speak different "languages," and without proper translation, facts lose their power. This is particularly relevant for institutions such as the Croatian Meteorological and Hydrological Service (DHMZ), the Institute for Medical Research and Occupational Health, and public health institutes and authorities whose duty is to inform and protect.

At DHMZ, we have learned this firsthand. Earlier this year, we published Croatia's first-ever air quality forecasts through the ATMOSYS system. The public response was immediate and overwhelming: media inquiries surged, and citizens flooded us with questions. The same happens during episodes of poor air quality, each one becomes a communication stress test. These are moments of public vulnerability, when clear, fact-based, and empathetic communication can prevent panic and misinformation, and help people make informed decisions to protect their health.

This work provides an overview of essential communication tools, strategies, and real-life examples to help air quality professionals transform complex data into clear, compelling messages, adapt their communication for different audiences (citizens, journalists, and policymakers), respond effectively during moments of crisis and build public trust by making their expertise more visible and relatable. We can equip air quality professionals with the tools and confidence to take a more active role in public conversations, ensuring their work is heard, understood, and trusted by citizens, the media, and decision-makers. Ultimately, real change does not begin with data alone; it starts when people truly understand what that data means and why it matters.



Poster presentation

Marko Marić¹, Danijel Grgec¹, Želimira Cvetković¹, Jasna Bošnjir^{1,2}

ECOLOGICAL MAP OF THE CITY OF ZAGREB

Keywords: *air quality, Ecological Map, low-cost sensors, sensor validation*

The web GIS application “*Ecological Map of the City of Zagreb*” (<https://ekokartazagreb.stampar.hr>) is an online platform developed by Andrija Stampar Teaching Institute of Public Health in collaboration with the City of Zagreb, Croatia, and other institutions. The purpose of the *Ecological Map of the City of Zagreb* is to integrate existing relevant data and information on the state of the environment (air quality, water quality, soil quality, pollen, meteorological data) with newly collected data from additional monitoring stations. For air quality monitoring, a total of 49 low cost sensors have been installed at various locations throughout the city. The aim of this approach is to gain better insight into air quality in areas where it is not feasible to install reference automated stations for continuous air quality monitoring.

Low cost sensors are regularly validated by comparing their measurement data with the data obtained by reference methods at the Mirogojska cesta automatic measuring station for continuous monitoring of air quality.

For each of the 49 low cost sensors, data on six air pollutants are available via the Eco map: nitrogen dioxide (NO₂), sulphur dioxide (SO₂), ground-level ozone (O₃), carbon monoxide (CO), and particulate matter (PM₁₀ and PM_{2.5}). These data are updated every hour.

The Ecological Map uses the European Air Quality Index to show the current state of air quality, enabling users to better understand real-time air quality conditions across the City of Zagreb.

The air quality index is updated hourly and, depending on its level, health messages are displayed for each station, providing recommendations for the general population and for vulnerable groups of citizens. In addition to the low-cost sensor network, air quality data from four reference stations in the national monitoring network (Zagreb-1, Zagreb-2, Zagreb-3, and Zagreb-4), as well as three reference stations from the city network (Peščenica, Đorđićeva, and Vrhovec), are also available on the Eco Map. These stations are marked with the HQ (High Quality) label, indicating to users that the data provided are of the highest quality.

Since its launch in 2018, the *Ecological Map of the City of Zagreb* has generated strong public interest, clearly demonstrating that such a tool was needed to provide citizens with timely and accurate information about the current state of their environment.

¹Andrija Stampar Teaching Institute of Public Health, Mirogojska 16, 10 000 Zagreb

²University of Applied Health Sciences, Mlinarska 38, 10000 Zagreb



Invited lecture

Marija Opačak Eror¹ and Marijana Matek Sarić²

AIR PROTECTION AND SUSTAINABLE TOURISM DEVELOPMENT: A REVIEW OF ECONOMIC METHODS

Keywords: *air protection, economic assessment, SDG, sustainable tourism development*

Air quality preservation is increasingly recognized as a critical factor in the sustainable development of tourism destinations. As tourism grows, balancing economic benefits with environmental protection, particularly air quality, poses complex challenges for policymakers and stakeholders. This paper examines the present knowledge of economic methods used for assessing the link between air protection and sustainable tourism development in leading environmental science and tourism journals. While there is a noticeable regional imbalance in the literature, methodological inconsistencies across studies further complicate comparative analysis and policy transferability. Greater attention is needed on how air quality influences tourist behaviour, destination choice, and long-term destination competitiveness. Addressing these gaps can support the development of more robust, evidence-based frameworks for integrating air quality considerations into tourism planning. The purpose of this paper is to identify, synthesize and interpret the existing literature on environmental impact estimation in tourism destinations that plan their development in accordance with the United Nations (UN) 11th Sustainable Development Goal (SDG). The findings highlight the importance of incorporating economic impact assessments to shape more informed and sustainable decision-making.

^{1,2}University of Zadar, Department of Economics, Splitska 1, 23000 Zadar

AIR POLLUTION SOURCES AND EMISSIONS





Oral presentation

Monika Babačić¹ and Ivana Roksa²

CERTIFICATION OF BE-TO SISAK UNDER THE SURE SCHEME FOR PROVING THE USE OF SUSTAINABLE FOREST BIOMASS

Keywords: *CO₂ emissions, EU Emissions Trading System*

BE-TO Sisak (bioenergy-thermal power plant Sisak) is a cogeneration facility owned by HEP-Proizvodnja d.o.o., with an installed capacity of 3 MWe / 10 MWt, operating on wood biomass. It produces both electricity and thermal energy in the form of hot water and steam for the district heating system of the City of Sisak. The plant is included in the EU Emissions Trading System (EU-ETS) and is obliged to demonstrate, for each batch of purchased biomass fuel, compliance with sustainability criteria. This obligation is defined in Article 38(5) of Commission Implementing Regulation (EU) 2018/2066 on the monitoring and reporting of greenhouse gas emissions, and in Article 29(2–7, 10) of the Renewable Energy Directive (EU) 2018/2001 (RED II).

The scheme used to demonstrate the sustainability of forest biomass — including its cultivation, distribution/trade, and the use of biomass fuels for electricity and heat generation — is the SURE Scheme (*SURE – Compliance with RED II Sustainability Requirements for the Production of Electricity, Heating and Cooling from Biomass*). If the biomass used as fuel in EU-ETS installations does not comply with the sustainability requirements, the carbon content of that biomass is considered fossil, and CO₂ emission allowances must be purchased for the total emissions generated from the use of such non-sustainable biomass.

This paper outlines the certification process of BE-TO Sisak and all related activities and obligations undertaken by the plant under the international SURE Scheme to ensure the procurement and use of sustainable biomass for the generation of electricity and thermal energy.

¹HEP-Proizvodnja d.o.o. Zagorska 1, 10000 Zagreb

²HEP-Proizvodnja, TE-TO Sisak, Industrijska cesta 10, 44010 Sisak



Oral presentation

Ivan Bešlić¹, Domagoj Mihajlović², Vedran Vađić³

THE IMPACT OF WEATHER CONDITIONS ON AIR QUALITY IN THE AREA OF THE JAKUŠEVAC LANDFILL

Keywords: H_2S , Mixing Layer Height, NH_3 , PM_{10}

The air quality in the area surrounding the Jakuševac landfill in Zagreb has been monitored for many years. We analyzed a five-year dataset (2020–2024) to assess the impact of weather conditions on air quality, using daily concentrations of PM_{10} suspended particles, hydrogen sulfide (H_2S), and ammonia (NH_3). Additionally, meteorological radiosonde data were analyzed at the Zagreb Maksimir station during the aforementioned time period in order to calculate the Mixing Layer Height (MLH) using the bulk Richardson number methodology. The mixing layer height at 12 UTC and the mean daily temperature were included in the statistical analysis for analyzing relationships between meteorological variables and air pollutant concentrations.

The MLH at 12 UTC serves as a reliable indicator of atmospheric stability. When the mixing layer is low (MLH < 500 meters), vertical mixing is inhibited, preventing the dispersion of pollutants near the ground. Statistical analysis revealed that in 90% of cases where the MLH was below 500 meters, this occurred during the colder months. A mixing layer lower than 500 meters was recorded in winter (60% of cases) and autumn (30% of cases).

The five-year dataset of PM_{10} daily concentrations exhibited a strong seasonal pattern, with the highest values occurring during the colder months. Long-term temperature inversions were also observed during this period. The daily limit value of $50 \mu g/m^3$ was exceeded 147 times, with 88% of these exceedances occurring when MLH was below 1000 meters, and 60% when MLH was below 500 meters. A similar seasonal trend in PM_{10} concentrations, along with its dependence on MLH, was observed in other parts of the city. These findings suggest that there was no single dominant local source of PM_{10} pollution. Instead, increased emissions during the colder months, combined with restricted turbulent mixing during inversions, contribute to elevated concentrations.

A similar seasonal pattern and MLH dependence was also observed for H_2S concentrations. The daily limit value of $5 \mu g/m^3$ was exceeded 30 times, 23 of which occurred when MLH was below 1000 meters. These results indicate that, in addition to a continuous local source of hydrogen sulfide, elevated concentrations were also influenced by MLH, reinforcing the conclusion that H_2S can justifiably be considered a landfill gas.

The presence of ammonia during the warmer months suggests that its primary source was seasonal and independent of weather conditions. The observed seasonal trend in ammonia concentrations implies that its dominant source differs from that of hydrogen sulfide. Given that organic fertilizer processing and livestock farming are major sources of ammonia emissions, the cause of elevated concentrations should be investigated within this context.

Acknowledgement: *The results of this research were obtained using the facilities and equipment funded within the ERDF project KK.01.1.1.02.0007 and supported by EnvironPollutHealth – European Union – Next Generation EU (Class: 643-02/23-01/00016) project.*

¹Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

²Croatian Meteorological and Hydrological Service, Ravnice 48, 10 000 Zagreb, Croatia

³EKONERG-Energy and Environmental Protection Institute, Koranska 5, 10 000 Zagreb, Croatia



Oral presentation

Valentina Jagić, Vesna Gugec, Stipica Šarčević, Velimir Milić, Darijo Brzoja

AIR QUALITY AND ENVIRONMENTAL ASPECTS OF MUNICIPAL WASTE MANAGEMENT IN THE CITY OF ZAGREB, CROATIA

Keywords: *ADMS, landfill, thermal mixed municipal waste, treatment, waste management*

The management of mixed municipal waste is an increasing challenge for major European environments. In line with the sustainable development and circular economy policy, modern European cities are increasingly implementing systems that seek maximum separation of mixed municipal waste, which is then separately collected and disposed. Mixed municipal waste that cannot be recycled is disposed of by thermal treatment or in a landfill. This study explores the influence of municipal waste management practices on air quality in the city of Zagreb, Croatia.

The European regulatory framework defines the waste management hierarchy, the simplest approach to waste disposal is landfilling, a more complex disposal with the help of waste management centres, and an even more complex approach to waste management is the thermal treatment of waste. In the City of Zagreb, waste is disposed of by landfilling. Following the European directives, the City is developing a waste management system based on a more complex, integrated approach, with the help of a waste management centre. The planned centre should be of a closed type, designed to minimise the environmental impact, including the prevention of odours and harmful substances. The waste management centre would consist of three facilities. Installations for the reception and treatment of mixed municipal waste, installations consisting of a sorting plant for the mechanical treatment of dry recyclables (glass, plastic, and paper) and compost for the collection of biodegradable household waste. The most complex waste management approach is the thermal treatment of unsorted mixed municipal waste. Thermal treatment reduces waste volume and generates heat and electricity. In this study, ADMS dispersion model was used to project the environmental impact of emissions on air quality depending on the waste management approach. Meteorological data from the Zagreb Maksimir station and emissions from the waste sector obtained from CERC (Cambridge Environmental Research Consultants) for 2022 were utilized.

Landfilling involves the straightforward disposal of waste in designated areas. However, the role of modern waste management facilities is to reduce the amount of landfilled waste by increasing recycling and reuse. Thermal treatment further minimizes the volume of residual waste by applying advanced waste management technologies, thereby significantly reducing negative environmental and health impacts.



Poster presentation

Nikolina Račić^{1,2}, Mario Lovrić^{2,3}, Gordana Pehnek¹, Ivana Jakovljević¹, Zdravka Sever Štrukil¹,
Silva Žužul¹, Jasmina Rinkovec¹

USING EXPLAINABLE MACHINE LEARNING TO UNDERSTAND WHAT AFFECTS PAHs AND HEAVY METALS IN PM₁₀ PARTICLES

Keywords: *air pollution, machine learning, pollution sources, seasonality, spatial distribution*

Air pollution is a persistent environmental and public health concern, particularly in urban areas where multiple emission sources interact with complex meteorological conditions. This study investigates the spatial and temporal variability of airborne pollutants - polycyclic aromatic hydrocarbons (PAHs) and heavy metals in PM₁₀ particles, nitrogen dioxide (NO₂), and total particulate matter – across four monitoring stations in Zagreb, Croatia, over a four-year period. Explainable machine learning models, including Random Forest (RF) and Nonnegative Matrix Factorization (NMF), were applied to assess the impact of traffic intensity, heating activities, and meteorological parameters such as temperature, humidity, wind, pressure, and precipitation on pollutant concentrations. The results indicate that pollutant levels differ notably between locations and seasons. Higher concentrations of PAHs and some metals were observed during colder months, primarily due to increased residential heating. Areas with higher traffic density showed elevated levels of NO₂ and PM₁₀. Among all examined factors, temperature, solar radiation, and PM₁₀ levels were identified as the most influential contributors to pollutant variability. Spatial analysis suggests that, while NO₂ and PM₁₀ are likely associated with localized, short-range emissions, PAHs and certain metals are probably more affected by regional influences and seasonal trends. These findings show the importance of targeted, location-specific air quality management strategies that consider both anthropogenic sources and environmental conditions. The use of explainable machine learning models in this context supports a more transparent understanding of pollution dynamics and enhances the development of effective mitigation approaches.

Acknowledgement: *Measurements of metals and selected PAHs in PM₁₀ were conducted as part of the local and national air quality monitoring network, funded by the City of Zagreb and Environmental Protection and Energy Efficiency Fund, respectively. The results of this research were obtained using the facilities and equipment funded within the ERDF project KK.01.1.1.02.0007 and supported by EnvironPollutHealth – European Union – Next Generation EU (Class: 643-02/23-01/00016) project.*

¹Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

²The Lisbon Council, Rue de la Loi 155, 1040 Bruxelles, Belgium

³Institute for Anthropological Research, Gajeva ul. 32, 10000 Zagreb, Croatia



Oral presentation

Ivana Roksa¹ and Monika Babačić²

REDUCTION OF SOLID PARTICLE EMISSIONS FROM BE-TO SISAK BY INSTALLATION OF AN ELECTROSTATIC PRECIPITATOR

Keywords: *best available techniques, emissions reduction*

BE-TO Sisak (Biomass Cogeneration Plant Sisak) is Combined Heat and Power (CHP) plant with a capacity of 3 MWe / 10 MWt. It is designed for the production of electricity and heat for district heating in Sisak, Croatia.

The combustion of fuel in the plant generates emissions of solid particles, which primarily depend on the quality of the fuel. For flue gas cleaning before discharge into the atmosphere, a multicyclone is used. It consists of several small cyclones in which particles formed from the combustion of woody biomass are separated from the flue gases.

Due to new (stricter) emission limit values for air pollutants related to solid particles, it is necessary to increase the level of solid particle removal before flue gases are released into the atmosphere. This can be achieved by applying the Best Available Techniques (BAT).

Reducing air emissions in existing plants in accordance with BAT is achieved through technical measures that include the installation of flue gas purification equipment. To remove particles from flue gases in the BE-TO Sisak facility, an electrostatic precipitator (ESP) will be installed. In the electrostatic precipitator, particles are removed as the waste gas passes through an electric field, where the particles become electrically charged and are then collected on the collector electrode. The deposited dust is mechanically shaken off and falls into hoppers at the bottom of the filter, from where it is transported to a storage container.

This paper presents the obligations for reducing solid particle emissions in accordance with regulations, the current emission values of solid particles from BE-TO Sisak obtained from periodic measurements, the selection of the best available technique for emission reduction (installation of the electrostatic precipitator), and the expected effects of its implementation.

¹HEP-Proizvodnja d.o.o., TE-TO Sisak, Industrijska cesta 10, 44010 Sisak, Croatia

²HEP-Proizvodnja d.o.o. Zagorska 1, 10000 Zagreb, Croatia



Oral presentation

Suzana Sopčić, Ranka Godec, Gordana Pehnek

LEVOGLUCOSAN LEVELS IN THE PM₁ FRACTION AT AN URBAN SITE IN ZAGREB, CROATIA: A FIVE-YEAR TREND

Keywords: *biomass burning, particulate matter*

Although Zagreb is a predominantly urban area with an extensive natural gas infrastructure, the use of biomass as a fuel for residential heating remains relatively common, especially during the colder months. Biomass burning contributes to elevated levels of particulate matter (PM) and various gases in the atmosphere, which, together with unfavorable meteorological conditions and increased traffic emissions, often degrade air quality, especially during wintertime. Notably, 24-hour PM₁₀ and PM_{2.5} concentrations frequently exceed the World Health Organization (WHO) 2021 guideline values. Levoglucosan (LG), a combustion-derived anhydrosugar produced solely through pyrolysis of cellulose and hemicellulose, is a highly specific tracer for biomass burning. Unlike more commonly used indicators such as PAHs or potassium, LG enables clear source attribution to biomass burning. Although unregulated by now, the newly adopted EU Directive 2024/2881 recommends monitoring LG in PM_{2.5} to better understand the role of biomass burning in urban and rural air pollution.

Building on our previous research, which demonstrated that most LG is associated with particles smaller than 1 µm, this study focused on LG concentrations in the PM₁ fraction at an urban site in Zagreb over a five-year period (2019–2023). Daily PM₁ samples were collected using Pall quartz filters at a flow rate of 55 m³/day and analyzed gravimetrically, while LG concentrations were determined using ion chromatography with pulsed amperometric detection. Supporting meteorological data (temperature, wind speed and direction) were also analyzed for contextual interpretation. Over a five-year span, average annual PM₁ concentrations ranged between 9.6 and 13.9 µg/m³, showing a slight decreasing trend from 2019 to 2023. Meanwhile, LG levels ranged from 0.375 to 0.619 µg/m³, exhibiting no discernible trend during the monitoring period. Compared to other European cities, LG levels in Zagreb were slightly higher. Linear regression revealed moderate to strong correlations ($R^2 = 0.568 - 0.837$) between PM₁ and LG, highlighting biomass combustion as a consistent and significant source of particulate matter. A consistent negative relationship between LG and ambient temperature aligns with increased residential biomass use for heating during colder months. Wind pattern analysis indicated elevated LG concentrations associated with air masses from the north-northeast, corresponding to residential areas that are most likely reliant on solid fuel heating. However, PM₁ levels did not exhibit a consistent directional pattern.

Acknowledgement: *This study was performed using the facilities and equipment funded within the European Regional Development Fund project KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health", and funded by the European Union – Next Generation EU (Program Contract of 8 December 2023, Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006)-EnvironPollutHealth.*



Poster presentation

Petar Uremović, Zoran Kovačević, Petar Maruna, Luka Lučić

MEASURING CHARACTERISTIC ODOURS, DISTINCTIONS AND APPLICATION OF HRN EN 13725 AND HRN EN 16841 STANDARDS

Keywords: *HRN EN 13725, HRN EN 16841-1, HRN EN 16841-2, odour measurement*

In Croatia, the obligation to measure characteristic odours is mandated by the Waste Management Ordinance (NN 106/2022, Nuisance caused by waste odour, Article 23). Specifically, Article 23, paragraph (1) states: "The existence of nuisance caused by waste odour is determined by testing according to HRN EN 13725, HRN EN 16841-1 or HRN EN 16841-2 standards." This particular wording, allowing for testing according to any one of the listed standards, creates uncertainty for both plant operators and inspection bodies when deciding which method to implement or prescribe for odour measurement.

The decision on which method to apply depends on the nature of the odour source and the defined measurement objective. The difference between the mentioned methods lies in the interpretation of measurement results. With HRN EN 13725, the measured quantity is expressed as odour concentration in OU_E/m^3 (emission measurements). In contrast, HRN EN 16841-1 and HRN EN 16841-2 express the measurement result as the maximum odour reach distance and/or odour exposure area in meters and/or square meters (immersion measurements).

HRN EN 13725 is used for determining emission limit values (ELV) from sources or for verifying the efficiency of biofilters and process equipment used to reduce odour concentration. HRN EN 16841-1 and HRN EN 16841-2 are applied to determine the dispersion and maximum reach of odours originating from a source, particularly for assessing the presence of odour in the surrounding area and its impact on the population.

This paper aims to describe the differences and applications of these standards to assist plant users and inspection bodies in defining requirements for odour measurement.

AMBIENT AIR POLLUTION MONITORING





Oral presentation

Darijo Brzoja¹, Mario Lovrić², Valentino Petrić³, Bram Verbeek⁴, Marko Kvakić¹, Vesna Gugec¹,
Danica Kraljević¹, Velimir Milić¹, Valentina Jagić¹, Stipica Šarčević¹

LEVERAGING MACHINE LEARNING FOR COST-EFFECTIVE AIR QUALITY MONITORING: THE LIFE CityTRAQ CASE

Keywords: *LIFE City TRAQ, low-cost sensors, nitrogen oxides, ozone, particulate matter*

The dominant air pollutants in middle Europe with a major negative impact on health are currently particulate matter (fine dust, PM₁₀, PM_{2.5}), NO₂ (nitrogen dioxide), O₃ (ozone) and B(a)P (benzo(a)pyrene).

Non-compliance of the European limit values for PM₁₀ (40 µg/m³ annual average, 35 days with maximum beyond 50 µg/m³ for 24-hour average, Ambient Air Quality Directive EC/50/2008) in Maribor (Slovenia), Klagenfurt and Leibnitz (Austria) has led to the curiosity of exploring the influences of possible dominant sources (traffic, domestic heating, industry) and their contribution rates. Because of that during 2010–2013 National Laboratory of Health, Environment and Food has been a partner of the PMinter project (Operational Programme Slovenia-Austria 2007-2013, Interreg Project). The main objective of PMinter project has been the development of methods and air pollution control plans that facilitate a sustainable improvement of the air quality as well as a reduction of health hazards (because of polluted air) for the people of Klagenfurt in Lower Carinthia, Leibnitz in Southern Styria (Austria) and Maribor in Northern Slovenia.

Along with other research, air quality was measured by means of 10 mobile and stationary measurement stations in the regions of Klagenfurt, Leibnitz and Maribor. In Maribor has been established a stationary measurement station on which air quality has been continuously monitored to this date (Maribor Krekova/Tyrševa).

Outdoor air quality plans, which helped to reduce ambient concentration levels (along with renewal of car fleet, modernisation of heat devices, implementation of energy efficiency policy – thermal insulation of buildings etc) have been proven to be successful. A trend of dropping concentrations of PM₁₀ has been seen in measuring location Maribor Krekova/Tyrševa, annual limit value in the period 2013-2021 has been never exceeded, number of exceedances of daily limit value was over prescribed in years 2014, 2015 and 2016. In the 10-year monitoring of air quality, there is a noticeable trend of air quality improvement.

¹ Croatian Meteorological and Hydrological Service, Ravnice 48, 10000 Zagreb, Croatia

² Institute for Anthropological Research, Gajevo 32, 10000 Zagreb, Croatia

³ Ascalia d.o.o., Ul. Trate 16, 40000 Čakovec, Croatia

⁴ Vlaamse Milieumaatschappij, Dokter De Moorstraat 24-26 -9300 Aalst, Belgium



Oral presentation

Željko Ćirović, **Danka B. Stojanović**, Milena Jovašević-Stojanović

ANALYSIS OF DIURNAL AND SEASONAL VARIATION OF ULTRAFINE PARTICLE SIZE DISTRIBUTION IN THE CITY OF BELGRADE, SERBIA

KEYWORDS: UFP, Urban air quality, MPSS, size distribution, Belgrade city

Submicron particles, or particles with diameters less than 1 micrometer, are especially significant for environmental and health research studies due to their ability to penetrate deeply into the respiratory system, posing increasing risks to human health. However, even more interesting are particles with diameters <100 nm, known as ultrafine particles (UFP). This study presents a comprehensive analysis of the diurnal and seasonal variations in UFP size distribution at the Ada Marina site, at the city of Belgrade. The site lies along the Sava River and is bordered by extensive green spaces; nearby potential influences include numerous restaurants, a high-traffic arterial road, a major airport (~10 km), a coal-fired thermal power plant (~25 km), and other local emission sources. The data was collected between February and August, 2024 by using a Scanning Mobility Particle Sizer covering particle size range of 10 nm - 400 nm. Particle concentrations were monitored as a function of time and diameter. On the Ada Marina site, for the entire period, end of winter, spring and summer, the overall particle concentrations were:

- total range of collected particles (10-400 nm) 10522 cm^{-3} ,
- collected particles larger than UFP (100-400 nm) 1848 cm^{-3}
- range of UFP (10-100 nm) 8788 cm^{-3}

During the campaign, temporal analysis revealed a few distinct events of increased particle concentrations caused by meteorological factors and new particle formation. The influence of temperature and humidity on particle number concentrations was analysed, as well as the difference in concentration of particles during week days. This included the observation of average diurnal of nucleation, Aitken and accumulation mode patterns for working and nonworking days. Study results contribute to valuable insights into the temporal dynamics of UFP distribution in an urban setting, underscoring the importance of understanding locally specific air quality conditions and variations.

Acknowledgment: *This research was funded by: the European Union's Horizon Europe Research and Innovation Program under GA 101060170 (WeBaSOOP project) and the Ministry of Education, Science and Technological Development of the Republic of Serbia under GA 451-03-136/2025-03/200017.*



Poster presentation

Dario Dabić, Goran Purić, Ksenija Kuna

TRENDS IN DAILY MEAN CONCENTRATIONS OF PM_{2.5} AND PM₁₀ AT THE PUNTIJARKA MONITORING STATION (2022–2025)

Keywords: *air pollution monitoring, annual mean concentration, gravimetric sampling, particulate matter*

Particulate matter is a primary air pollutant and a reliable indicator of atmospheric pollution, affecting both visibility and human health. Elevated concentrations are typically recorded in winter due to increased emissions from heating systems and urban traffic. Meteorological conditions, such as persistent anticyclones, can exacerbate pollution episodes by limiting air dispersion and precipitation. PM_{2.5} particles have a greater potential for long-range atmospheric transport, while PM₁₀ concentrations are more indicative of local pollution sources.

The Puntijarka monitoring station on Medvednica mountain, Croatia, conducts gravimetric measurements of suspended particulate matter (PM_{2.5} and PM₁₀) using the Commde Derrenda PNS 16T 3-1 sampler, in accordance with HRN EN 12341:2023. Daily concentrations of PM₁₀ must not exceed 50 µg/m³ more than 35 times per year, while the annual limit value is 40 µg/m³. For PM_{2.5}, the indicative annual limit has been reduced to 20 µg/m³ since 2020. Nevertheless, annual mean concentrations of PM_{2.5} is assessed with a set limit value of 25 µg/m³. The highest recorded daily mass concentration of PM₁₀ was in 2024, reaching 115.3 µg/m³ at the Puntijarka station, while for PM_{2.5} it was 37.0 µg/m³.

During the period from 2022 to 2024, the recorded annual average concentrations of PM₁₀ were 9.6 µg/m³ (2022), 8.6 µg/m³ (2023), and 10.1 µg/m³ (2024), while PM_{2.5} concentrations for the same years were 5.5 µg/m³, 4.9 µg/m³, and 5.6 µg/m³, respectively. In 2025, the highest daily concentration of PM_{2.5} recorded so far occurred in February, reaching 22.6 µg/m³. For PM₁₀, the highest recorded value was 31.6 µg/m³. These results indicate that both PM₁₀ and PM_{2.5} concentrations at the Puntijarka station remained well below the regulatory annual limits throughout the 2022–2025 period, with exceedances being infrequent and short-lived.



Oral presentation

Ivana Jakovljević, Zdravka Sever Štrukil, Gordana Pehnc

PAH CONCENTRATIONS AT AN URBAN TRAFFIC LOCATION IN CROATIA OVER FIVE YEARS

Keywords: *benzo(a)pyrene, HPLC, PM₁₀, trend*

Polycyclic aromatic hydrocarbons (PAHs) are a significant group of semi-volatile organic compounds characterized by two or more condensed aromatic rings. They originate from various sources. Natural sources of PAHs include large forest fires and volcanic eruptions. Anthropogenic sources encompass industrial emissions (such as coal, crude oil, and heavy and light metal production), waste combustion, and uncontrolled burning of various plastics. Automobile exhausts and domestic heating also serve as important sources in urban areas. Due to the widespread distribution of PAHs in ambient air and their potential carcinogenic and mutagenic effects on human health, the US EPA has classified sixteen species as priority pollutants.

24-hour samples of PM₁₀ particle fraction were collected on quartz filters from about 55 m³ of air continuously over 5 years (2019–2023) at an urban traffic location in Zagreb, Croatia. PAH concentrations were determined by liquid chromatography (HPLC) with a fluorescence detector. The following PAHs were analyzed: fluoranthene (Flu), pyrene (Pyr), benzo(a)anthracene (BaA), chrysene (Chry), benzo(j)fluoranthene (BjF), benzo(b)fluoranthene (BbF), benzo(k)fluoranthene (BkF), benzo(a)pyrene (BaP), dibenzo(a,h)anthracene (DahA), benzo(ghi)perylene (BghiP), and indeno(1,2,3-cd)pyrene (IP). The study was carried out in order to assess the concentration trend.

The annual values of the total PAHs were 9.499 ng/m³, 10.339 ng/m³, 9.278 ng/m³, 7.570 ng/m³, and 7.563 ng/m³ for 2019, 2020, 2021, 2022, and 2023, respectively. The most investigated PAHs and the only one for which a limit value is set by EU Directive 2024/2881/EC (1.0 ng/m³) is benzo(a)pyrene, for which the annual concentrations were 1.200 ng/m³ (2019), 1.327 ng/m³ (2020), 1.178 ng/m³ (2021), 0.937 ng/m³ (2022), and 0.958 ng/m³ (2023). BaP annual concentrations were slightly higher than the limit value for the first three years, while from 2022 onward, they were lower than the limit values. The 5-year trends of all PAHs at the urban traffic location showed a decrease.

Acknowledgment: *This study was performed using the facilities and equipment funded within the European Regional Development Fund projects KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health" " and KK.06.2.1.02.0001 "AIRQ – Expansion and Modernisation of the National Network for Continuous Air Quality Monitoring". Measurements of BaP and some PAHs were carried out within national network for continuous air quality monitoring, funded by the Croatian Environmental Protection and Energy Efficiency Fund, while additional analysis were funded by the European Union – Next Generation EU (Program Contract of 8 December 2023, Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006) #EnviroPollutHealth*



Poster presentation

Renata Kovačević¹, Bojan Radović¹, Viša Tasić¹, Tatjana Apostolovski Trujić¹, Tamara Urošević¹,
Duška Kleut², Milena Jovašević-Stojanović²

LEVELS OF AIRBORNE METALS IN URBAN AIR DRIVEN BY DIFFERENT ANTHROPOGENIC SOURCES: BOR AND BELGRADE

Keywords: *elements, industrial activities, metal content, PM₁₀, urban pollution*

Atmospheric metals are produced by many natural and anthropogenic sources and their concentrations vary widely between different urban environments. In this study, we measured airborne concentrations of metals and ion content in PM₁₀ at two cities where there are dominant different anthropogenic sources: background sites in Bor that is influenced by industrial sources and background site of Belgrade that is under influence of traffic and biomass burning. Data were collected in the frame of the WeBaSOOP project 1-year long campaign at automatic monitoring stations: City Park in Bor located downwind of the copper smelter and dumped tailing soils of mining activities and related manufactures and Ada Marina in Belgrade located at Ada Ciganlija recreational area. Campaign was conducted in 2023 and 2024 and the total of 198 and 195 samples of PM₁₀ were collected in Belgrade and Bor, respectively. A total of 38 elements was determined from PM₁₀ samples. In the city of Belgrade the calcium was detected as the most abundant element in PM₁₀ with average mean values of 619.1 ng/m³. The light metal group (atomic number 20 and lower) including Na, K, Ca, Al, Mg and Fe were found in higher concentrations in PM₁₀ comparing with others present elements, while the heavy metals (As, Ba, Cd, Co, Cr, Cu, Ga, Mn, Mo, Ni, P, Pb, Rb, Sb, Se, Sn, Sr, Ti, Tl, V, Zn and Zr) were present in trace quantities (less than 100 ng/m³). Metals in Belgrade represented few percents above 10% of the mass concentration of PM₁₀ samples. In the city of Bor the most abundant element in PM₁₀ was Fe with average mean values of 1978.9 and 1753.3 ng/m³ during the non-heating and heating seasons, respectively. Fe was the most abundant metal in PM₁₀ fraction as it comes from various sources such as industrial activities, traffic and crustal dust. The light metal group elements, including Na, K, Ca, Al, and Mg, were found in higher concentrations in PM₁₀ comparing with others present elements. The metals were distributed in two groups: As Cu, Pb and Zn with concentration ranging from 155.3 ng/m³ to 785.9 ng/m³, while the other metals (Ag, Ba, Bi, Cd, Co, Cr, Mn, Mo, Ni, Rb, Sb, Se, Sn, Sr, Te, Tl and V) were present in trace quantities (less than 100 ng/m³). The metals represented around 20% of the mass concentration of PM₁₀ samples. The content of metals is higher in PM₁₀ samples collected in Bor. The mean concentrations of Ni, As, Cd and Pb were lower than annual target value during sampling campaign in Belgrade. Extremely high mean As contents, higher than 200 ng/m³ were recorded in Bor, as well as Cd mean that exceeded its target value. The presence of carcinogenic substances such as inorganic arsenic in ambient air in Bor is related to an anthropogenic origin, primary smelting operations which can impact urban and rural areas near industrial complexes. Local industrial activities are responsible for high As, Pb, Cd, Cu, and other metallic elements concentrations in PM₁₀ in Bor.

Acknowledgment: *This research was funded by: The European Union's Horizon Europe Research and Innovation Program under GA 101060170 (WeBaSOOP project) and the Ministry of Science, Technological Development and Innovation of the Republic of Serbia under No. 451-03-136/2025-03/200052 and GA 451-03-136/2025-03/200017*

¹ Mining and Metallurgy Institute Bor, Alberta Ajnštajna 1, 19210 Bor, Serbia

² VIDIS Centre, Vinča Institute of Nuclear Sciences, National Institute of the Republic of Serbia, University of Belgrade, Mike Petrovića Alasa 12-14, 11307 Vinča, Belgrade, Serbia



Poster presentation

Uroš Lešnik and Jan Radanović

RESULTS OF AIR QUALITY MEASUREMENTS IN THE MEASUREMENT NETWORK OF MARIBOR, SLOVENIA, AND NEIGHBORING MUNICIPALITIES

Keywords: meteorology, PM_{10} , seasonal differences

Measurements are the most reliable indicator of the outdoor air quality. Measurements have been carried out in Maribor and its surroundings since 1978. These data show that air quality has improved over the years, but some pollutant concentrations are currently still above the recommended values of the World Health Organization. Meteorological conditions have a great influence on pollutant concentrations, as the air is significantly more polluted in the event of adverse conditions (temperature inversion), and pollutants can also travel greater distances with air masses (Saharan dust, volcanic eruptions).

In 2023, measurements in Maribor and its surroundings took place at the following measuring points: Maribor Center (Maribor Titova), Vrbanški plato, Krekova/Tyrševa, Tezno, Radvanje, Pobrežje, Pohorje – Belvi, Ruše and Miklavž. In adverse weather conditions exceedances of the prescribed daily limit value for PM_{10} particles are measured at all measuring points. The highest

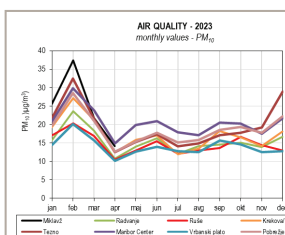
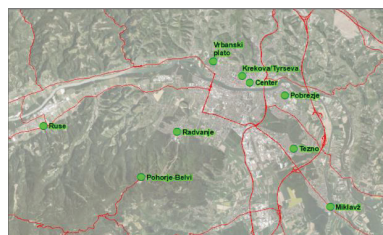


Figure 1. Measuring locations and monthly PM_{10} concentrations in 2023

At the monthly level, there are certain differences in PM_{10} particle pollution between the measuring points: a) pollution is higher in the winter months outside the city center (Tezno, Miklavž, occasionally also Pobrežje), which does not apply to Ruše and Radvanje; b) outside the heating season (April to October), the Maribor Center (Maribor Titova) measuring point is the most polluted; c) the lowest concentrations in almost all months in 2023 were measured at the Vrbanški plato measuring point, except for July (Krekova/Tyrševa) and September (Ruše).

The differences in measured values result from the greater use of wood biomass for heating outside the city center, where the concentrations of pollutants in the outdoor air are often unknown. As the example of the Maribor and neighboring municipalities Measurement Network shows, the air in suburban settlements can be more polluted with PM_{10} particles in the winter months than in city centers. Since air does not „recognize“ municipal borders and spreads beyond them, measures will need to be taken more broadly (beyond municipal borders) to further reduce pollution.

The new European directive, which will tighten the limit values for pollutants in outdoor air, will fully enter into force in 2030. Based on the current measurement results in the Maribor and neighboring municipalities measurement network and the proposed limit/target values, the problematic pollutants will be PM_{10} , $PM_{2.5}$ and NO_2 .



Oral presentation

Bruna Mariani, **Marin Vojković**, Jadranka Šepić, Marina Kranjac

SEASONAL VARIABILITY OF AIR POLLUTANTS AND THEIR RELATIONSHIP WITH METEOROLOGICAL CONDITIONS IN SPLIT, CROATIA

Keywords: *air quality, air pollution, atmospheric pollution, meteorological parameters*

Understanding the connection between local weather conditions and air pollution is a prerequisite for air quality management and assessment of urban quality of life. This is particularly important in the context of shifting climate conditions which affects prevailing and extreme meteorological conditions and pollutant dynamics. In this study, we investigate the relationship between air pollution levels and meteorological conditions in Split, Croatia. Using hourly pollutant data (with 10-minute intervals at one station), measured and collected at six stations within the period of 2014 - 2024, the concentrations and variability of key pollutants (PM_{10} , $PM_{2.5}$, NO_2 , O_3 , and SO_2) were analysed. Four stations are located in the Split municipal area, along with one station each in Solin and Kaštela. Simultaneously, relevant meteorological parameters including temperature, wind speed and direction, relative humidity, atmospheric pressure, and solar radiation were also analysed. The aim of this study was to identify meteorological patterns that influence pollutant levels in the urban area.

In addition to road and marine traffic, the main anthropogenic contributors to air pollution in Split are the waste depot Karepovac and the cement factory located in the Solin suburban municipality. The main natural contributors are plant pollens. The six measuring stations are located as follows: near the old city centre (SPLIT 1), near one of the main roads leading in and out of the city (SPLIT 2), in a residential area close to a popular beach (SPLIT 3), in city harbour (Bettair Node), and in two suburban areas: near a cement factory (SV. KAJO) and in Kaštel Sućurac (KAŠTEL SUĆURAC).

The results showed a pronounced seasonal variability of all pollutants. PM_{10} , $PM_{2.5}$, and NO_x levels peak during winter months, with PM_{10} and $PM_{2.5}$ species reaching most extreme values towards February, while NO_x peaks during December. The winter peak is closely associated with residential heating, increased atmospheric stability, and lower wind speeds. In contrast, O_3 levels rise in the summer, driven by increased photochemical activity and higher solar radiation. Analysis of meteorological conditions reveals that pollutants are often trapped within stable atmospheric layers overtopped by temperature inversions, which can, particularly in the winter, exacerbate near-surface pollutant concentrations.



Poster presentation

Ivona Mikić, Valentina Gluščić, Ivan Bešlić, Gordana Pehnc

INSIGHT INTO SEASONAL VARIATIONS OF WATER-SOLUBLE INORGANIC IONS IN PM_{2.5} AT A RURAL BACKGROUND SITE

Keywords: acidity, anion species, fine particulate matter, ion chromatography, cation species

Air pollution caused by elevated levels of fine particulate matter (PM_{2.5}) is a major scientific concern worldwide. Due to its small size and complex composition, PM_{2.5} can penetrate deep into the alveolar region of the human respiratory system, leading to severe illnesses such as cancer or even premature death. The acidity of particulate matter is closely related to the content and the balance of inorganic acidic and basic components, which can affect ecosystems. Because of its negative impact on human health, as well as on the climate and environment, fine particulate matter represents a significant environmental issue and remains a central focus of scientific research.

The aim of this study was to determine the mass concentrations of water-soluble ions in PM_{2.5}, examine their seasonal variation and to identify potential pollution sources. Daily PM_{2.5} samples were collected on quartz fiber filters over one year (from January 2024 to January 2025) at a rural background site that is part of the Croatian network for continuous air quality monitoring, located in the inland region of Northern Dalmatia. In order to evaluate seasonal variations, 30 samples were selected for each season. The mass concentrations of eight ionic species (Na⁺, NH₄⁺, K⁺, Mg²⁺, Ca²⁺, Cl⁻, NO₃⁻, SO₄²⁻) were quantified according to the HRN EN 16269 standard using ion chromatography. These represent the first data on the inorganic composition of PM_{2.5} in this region, providing valuable insights into possible sources of particulate matter in Northern Dalmatia.

The average seasonal mass concentrations of total water-soluble ions in PM_{2.5} followed the order: summer > autumn > spring > winter, ranging from 3.3 to 1.6 µg/m³. Water-soluble ions accounted for 31.9% of the total PM_{2.5} mass, with anions contributing 21.4% and cations 10.5%. The dominant ions were SO₄²⁻, NH₄⁺, and NO₃⁻ (47.6% of total ion mass), with the highest concentrations observed in winter. Similarly, Na⁺, Ca²⁺, and Mg²⁺ showed elevated levels in winter and the lowest in summer, with K⁺ and Cl⁻ following the same trend. However, significant seasonal differences were observed only for NO₃⁻, SO₄²⁻, NH₄⁺, K⁺, Cl⁻, and Na⁺.

The pH of PM_{2.5} water extracts varied seasonally, with the most acidic samples in summer (pH 4.57) and the least acidic in winter (pH 6.49). Correlation analysis revealed statistically significant correlations ($p < 0.05$) between pH and Ca²⁺ in winter ($r = 0.73$), spring ($r = 0.58$), and autumn ($r = 0.64$).

The seasonal NO₃⁻/SO₄²⁻ ratio followed the order: winter > spring > autumn > summer, ranging from 0.52 to 0.01, indicating that stationary sources, including coal combustion, are predominant contributors to PM_{2.5} at this rural background site; however, the contribution of mobile sources cannot be excluded.

Acknowledgement: Measurements of PM_{2.5} and water-soluble ions in PM_{2.5} were conducted within the national air quality monitoring program and were funded by the Croatian Environmental Protection and Energy Efficiency Fund. This research was conducted using facilities and equipment funded by the European Regional Development Fund projects REC-IMI (KK.01.1.1.02.0007) and AIRQ (KK.06.2.1.02.0001), and supported by the Next Generation EU project Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006 (EnvironPollutHealth).



Poster presentation

Zdravka Sever Štrukil, Ivana Jakovljević, Gordana Pehnek, Ivan Bešlić

POLYCYCLIC AROMATIC HYDROCARBONS IN AIR OF SPLIT AND PLITVICE LAKES

Keywords: HMW, HPLC, MMW, PAHs, PM₁₀ fraction, rural background, urban background

Polycyclic aromatic hydrocarbons (PAHs) are a large group of organic compounds composed of two or more fused aromatic rings. In the atmosphere, they are typically associated with particulate matter, particularly the PM₁₀ and PM_{2.5} fractions, and can be transported over long distances. Due to their persistence, bioaccumulation potential, and toxic properties, many PAHs are considered hazardous to human health and the environment. As such, monitoring their concentrations in ambient air, especially in background and remote areas, is important for understanding their distribution, seasonal variability, and potential impact on ecosystems and public health.

The study investigates the presence of PAHs in the air at two background monitoring stations in Croatia which are part of the national network for continuous air quality monitoring. One monitoring station is situated in the suburban area of Split and the other in the rural area near Plitvice Lakes National Park. The PM₁₀ particle fraction was sampled by 24-hour collection of approximately 55 m³ of air on quartz fiber filters (Whatman QMA) using low volume samplers (MicroPNS LVS 17, MCZ). Sampling was conducted continuously for 30 days in each season in 2024 and a total of 120 samples were collected at both locations. A high-performance liquid chromatography (HPLC) with a fluorescence detector was applied for the determinations of eleven PAHs.

At both locations a clear seasonal cycle was observed with the highest PAH concentrations during winter (the sum of 11 PAHs, Σ_{11} PAH, was 0.337 ng/m³ and 0.170 ng/m³), while the lowest PAH levels were obtained in summer (Σ_{11} PAH was 0.049 ng/m³ and 0.016 ng/m³) in Split and Plitvice Lakes, respectively. The mean benzo[a]pyrene (BaP) concentration for the overall period was 0.072 ng/m³ at Plitvice Lakes and 0.134 ng/m³ in Split and did not exceed the European Union limit value of 1 ng/m³ for an annual average. The classification of PAHs by molecular weight in two groups: medium molecular weight PAHs (MMW; 4 aromatic rings) and high molecular weight PAHs (HMW, 5 or more aromatic rings) can provide information about their sources. The highest contribution of HMW PAHs was observed in autumn (71%) at Plitvice Lakes, indicating a possible impact of biomass burning, a source mainly present during the heating season, and in Split (67%) in winter, most probably as a consequence of the accumulation of pollutants due to the unfavorable atmospheric conditions. In spring and summer, HMW PAHs had the lowest contribution and did not exceed 58% in Split and 63% at Plitvice Lakes. On the other hand, the MMW PAHs contribution was the highest in spring in Split and accounted for 42%, possibly due to increasing regional aerosol sources such as urban and marine traffic.

Acknowledgement: Measurements of PAHs were funded by Croatian Environmental Protection and Energy Efficiency Fund. This study was performed using the facilities and equipment funded by the European Regional Development Fund projects KK.01.1.1.02.0007 (Rec-IMI) and KK.06.2.1.02.0001 (AIRQ) and supported by program contract European Union—Next Generation EU No. 533-03-23-0006 (EnvironPollutHealth).



Poster presentation

Vedran Vadić, Predrag Hercog, Bojan Abramović

AIR QUALITY MONITORING AT WASTE MANAGEMENT CENTRE BILJANE DONJE

Keywords: *air quality, environment, automatic methods*

Air quality measurements at the new monitoring station Biljane Donje (BID), Croatia, were started in May 2023. Measurements of nitrogen dioxide (NO₂), sulphur dioxide (SO₂), ozone (O₃), ammonia (NH₃), methane (CH₄), benzene, mercaptans and particulate matter fraction PM₁₀ were established. All measurements were carried out by the Ekenerg Air Quality Monitoring Laboratory. Measurement of NO₂, SO₂, O₃ and benzene were carried out with automatic reference methods while measurements of NH₃, CH₄ and mercaptans were performed with non-reference automatic analysers. Measurement of PM₁₀ fraction of particulate matter were carried out with non-referent automatic method and the equivalence study according to the reference method is demonstrated.

In relation to the emission source, it is an industrial station set up for the purpose of assessing the impact of the Waste Management Center (WMC) Biljane Donje on air quality. The station is located in the northwestern part of the WMC Biljane Donje without any interference with the air flow in the immediate vicinity and allows measurement of possible impacts of air emissions from the WMC Biljane Donje.

By area type, it is a suburban measuring station. To the west is the City of Zadar, and to the southeast is the City of Benkovac and the nearest settlements of Suhovare, Gornji and Donji Zemunik, Donje Biljane, Smilčić and Donji Kašić are located within a radius of 1 to 4 kilometers from the facility around the Waste Management Center. The A1 motorway is located about 120 m west of the station. The station is connected with internet connection to a monitoring computer in the Ekenerg Air Quality Monitoring Laboratory.

Air quality monitoring results for all pollutants were analysed for the period May 2023 to December 2024. In the observed period, the concentrations of NO₂, SO₂, NH₃, benzene and mercaptans are significantly lower than the limit values and are lower than the upper and lower assessment thresholds, while the concentrations of O₃ are lower than the target value and the long-term objectives. All these pollutants do not exceed environmental objective, and the air quality is assessed as the first category.

Daily PM₁₀ concentrations exceed the daily limit value, but less than the allowed number of days exceeding the daily LV (35 days), while the annual mean concentration of PM₁₀ is lower than the limit value. Therefore, the PM₁₀ concentrations do not exceeded environmental objective and the air quality for PM₁₀ is also assessed as the first category.

MACHINE LEARNING AND AIR QUALITY MODELLING





Poster presentation

Vesna Gugec, Stipica Šarčević, Valentina Jagić, Velimir Milić, Darijo Brzaja

PROJECTION OF THE IMPACT OF AIR POLLUTION FROM THERMAL TREATMENT OF WASTE USING THE ADMS 6 DISPERSION MODEL

Keywords: ADMS 6, PM_{10} and $PM_{2.5}$ projection, waste incinerator

Mixed municipal waste represents an increasing challenge in urban European environments, including the city of Zagreb in the Republic of Croatia. There are several waste management models, with the simplest being land disposal. A more complex option is waste recovery in specialized management centers, while the most complex method is thermal treatment, i.e., the incineration of mixed municipal waste.

Thermal treatment of mixed municipal waste involves burning at high temperatures, which significantly reduces the volume of waste that needs to be disposed of. At the same time this process can be used to produce thermal and/or electrical energy. This can lead to reduced fossil fuel consumption for power generation. The impact of burning mixed municipal waste on the human population and ecological systems in the city of Zagreb was investigated using the ADMS 6 dispersion model (Atmospheric Dispersion Model). Data from 2022 were used for the model, including meteorological data (hourly values for wind direction and speed, temperature, and cloud cover) from the Zagreb Maksimir station, as well as particulate matter emissions ($PM_{2.5}$ and PM_{10}) from the waste sector, obtained from CERC. Different scenarios were considered based on various chimney heights: 25 meters (typical for smaller incinerators), 105 meters (the height of the Zagreb Cathedral's tower), 126 meters (the height of the Vienna incinerator's chimney), and 200 meters (the height of the Zagreb heating plant's chimney). In all scenarios, the chimney diameter remained constant at 2.5 meters. Estimated emissions of particulate matter $PM_{2.5}$ and PM_{10} from the incineration of mixed municipal waste are below the prescribed limit values for pollutant emissions from incineration facilities. Modeling results for all analyzed scenarios indicate that the impact of pollutant concentrations for particulate matter is low, and the optimal solution would be a height of 126 meters, i.e. the height of the chimney of the Vienna incinerator.

Incineration of mixed municipal waste produces thermal and electrical energy. Additionally, the amount of waste requiring disposal in landfills is significantly reduced. Emissions from the incineration process remain within prescribed limits, and the impact on surface concentrations of particulate matter is low. Based on the results, waste incineration can be considered as an efficient method of waste management, with minimal negative impact on the environment and public health.



Poster presentation

Snježana Herceg-Romanić¹, Silvije Davila¹, Ivan Bešlić¹, Gordana Pehneć¹, Gordana Jovanović², Mirjana Perišić^{2,3}, Andreja Stojić^{2,3}

REVEALING THE IMPACT OF TEMPERATURE ON URBAN BENZENE USING EXPLAINABLE AI METHODOLOGIES

Keywords: *air quality, benzene, machine learning, SHAP, temperature*

Understanding the influence of meteorological conditions on urban air pollution is critical for accurate forecasting and informed policy development. This study investigates the impact of near-surface air temperature on benzene concentrations in an urban setting, utilizing an artificial intelligence (AI) framework augmented with machine learning, metaheuristic optimization algorithms, used to improve model performance by efficiently searching for optimal solutions, and explainable artificial intelligence methodologies (XAI). The analysis employs hourly air quality measurements collected over a seven-year period (2017–2023) from a regulatory air quality monitoring station in Zagreb, Croatia, funded by the City of Zagreb. In conjunction with meteorological parameters obtained from the Global Data Assimilation System (GDAS). Benzene was chosen as the target variable due to its toxicological relevance and regulatory significance. Predictor variables included additional air pollutants (SO₂, NO₂, CO, and O₃) alongside key meteorological indicators. To interpret model outputs, SHAP (SHapley Additive exPlanations) values were applied, providing insights into the individual contribution of each predictor, particularly temperature, to the model's predictions.

Results reveal a distinct non-linear relationship between temperature and benzene concentrations. Specifically, low temperatures (particularly around 5°C and below) exhibit a strong positive influence on benzene levels, contributing up to 25% of the predicted concentration, likely attributable to increased combustion-related emissions and suppressed atmospheric dispersion. Conversely, higher temperatures are associated with negative SHAP values (up to -27%), reflecting enhanced dilution and decreased pollutant accumulation.

These findings underscore the pivotal role of temperature in modulating urban benzene dynamics and demonstrate the utility of XAI tools in uncovering complex environmental interactions. The methodology offers valuable insights for seasonally responsive air quality management strategies.

Acknowledgement: *Supported by Science Fund of the Republic of Serbia, Grant No. #7373, crAIRsis, European Union – Next Generation EU (project EnvironPollutHealth) and European Regional Development Fund project KK.01.1.1.02.0007 (ReC-IMI).*

¹Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

²Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade 11010, Serbia

³Faculty of Informatics and Computing, Singidunum University, Danijelova 32, Belgrade 11010, Serbia



Poster presentation

Gordana Jovanović¹, Snježana Herceg-Romanić², Silvije Davila², Ivan Bešlić², Gordana Pehneć², Timea Bezdan³, Mirjana Perišić^{1,3}, Andreja Stojić^{1,3}

ADVANCED AI APPROACHES FOR UNDERSTANDING BENZENE POLLUTION IN URBAN ATMOSPHERE

Keywords: *benzene, explainable artificial intelligence, machine learning, metaheuristics*

Benzene is a toxic, carcinogenic volatile organic compound (VOC), recognized as a Group 1 human carcinogen by the IARC. Despite often being present at low ambient levels, prolonged exposure can cause serious health effects. In urban settings, benzene primarily originates from traffic, fossil fuel combustion, and industrial processes, and also contributes to the formation of O₃ and secondary organic aerosols.

This study introduces an advanced artificial intelligence (AI) framework for understanding the interactions between benzene and co-occurring air pollutants in an urban environment. By integrating machine learning, (ML) metaheuristic optimization, and explainable AI techniques (XAI), the proposed model captures complex, nonlinear relationships within high-resolution environmental datasets. The analysis draws on seven years (2017–2023) of hourly data from an urban background monitoring station in northern Zagreb, Croatia, encompassing concentrations of benzene, SO₂, NO₂, CO, and O₃, alongside 29 meteorological variables obtained from the Global Data Assimilation System (GDAS). Benzene was selected as the target variable due to its toxicological and regulatory importance, while other pollutants and meteorological variables served as predictors. After testing multiple ML algorithms, the optimal model was fine-tuned using metaheuristic optimization. To interpret the model's behavior, XAI techniques, specifically SHAP (SHapley Additive exPlanations) and SAGE (Shapley Additive Global importance), were applied, offering detailed insight into the individual and combined effects of predictors.

Findings revealed that co-pollutants, particularly CO and NO₂, are key drivers of benzene variability. SHAP values indicated synergistic effects at elevated concentrations, suggesting common combustion-related sources. These results highlight the added value of XAI tools in unveiling hidden dependencies among pollutants, offering a transparent, data-driven foundation for refining emission inventories and shaping targeted mitigation strategies. Results showed that co-pollutants, particularly CO and NO₂ emerged as dominant predictors of the benzene patterns in air. SHAP analysis revealed that low concentrations of both gases reduce predicted benzene more effectively in combination than individually, while high levels of both suggest episodic co-emissions, likely linked to combustion sources. These results highlight the added value of XAI tools in unveiling hidden dependencies among pollutants, offering a transparent, data-driven foundation for refining emission inventories and shaping targeted mitigation strategies.

Acknowledgement: *Supported by Science Fund of the Republic of Serbia, Grant No. #7373, crAIRsis, European Union – Next Generation EU (project EnvironPollutHealth) and European Regional Development Fund project KK.01.1.1.02.0007 (ReC-IMI).*

¹Institute of Physics Belgrade, University of Belgrade, Pregrevica 118, Belgrade 11010, Serbia

²Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

³Faculty of Informatics and Computing, Singidunum University, Danijelova 32, Belgrade 11010, Serbia



Oral presentation

Marko Kvakić, Angelo Riccio, Darijo Brzaja

IMPROVED REGIONAL AIR QUALITY FORECAST USING THE BAYESIAN SPATIO-TEMPORAL METHOD INLA-SPDE

Keywords: *air quality prediction, FAIRMODE, NO₂, O₃, PM₁₀, PM_{2.5}*

The regional air quality prediction service provides daily estimates of key pollutants (NO₂, O₃, PM₁₀, and PM_{2.5}) across Croatia, integrating real-time observations with regional-scale numerical simulations. The current system (ATMOSYS OPAQ) employs a two-step methodology. The first step is to generate point forecasts of daily aggregated values (per pollutant) at monitoring stations for up to two days ahead, by combining historic observations with simulated outputs from a regional CTM and an NWP model (CAMS and Aladin, respectively). In the second step, a regression-kriging approach (RIO) spatially interpolates the forecast values, in which long-term concentration averages at observations stations are modeled using static spatial effects (e.g., land use, topography, population density), while the deviations of the daily aggregated forecast values are interpolated using ordinary kriging to areas where no observations exist. To improve spatio-temporal representation in the second step (interpolating the forecast values), we evaluate an alternative Bayesian approach using the Integrated Nested Laplace Approximation with Stochastic Partial Differential Equations (INLA-SPDE). This method explicitly models day-to-day variability in tandem with spatial dependencies between stations, by incorporating temporal autocorrelation and spatially varying uncertainty, enabling joint inference on hyperparameters and latent fields. Both methods are assessed using a 'fitness for purpose' test (FAIRMODE) in a leave-one-out fashion, where the ratio of the modeled root mean square error (RMSE) vs. the measurement uncertainty (U) is calculated for each excluded station, and used to compare the two methods. An improvement in forecast quality can be observed for NO₂ and PM_{2.5} with an RMSE:U ratio of 1.35 and 0.92 using INLA-SPDE versus 1.53 and 1.01 using RIO (respectively), whereas O₃ and PM₁₀ do not show any improvement with an RMSE:U ratio of 0.45 and 0.99 using INLA-SPDE versus 0.42 and 0.88 using RIO, respectively. Further improvement is to be done with hyperoptimization of additional effects (e.g. station bias as a random effect) and a better choice of improvement metrics, which do not handle outliers well.



Oral presentation

Darko Mekterović, Marija Čargonja, Domagoj Mateljak, Boris Mifka, Robert Pleše

CONDITIONAL PROBABILITY FUNCTION WITH UNCERTAINTY ESTIMATES IN AIR POLLUTION RESEARCH

Keywords: *binomial ratio, bootstrapping CBPF, CPF, validation*

The conditional probability function (CPF) and the conditional bivariate probability function (CBPF) are widely used (on average 15 articles per year) and useful tools that aid in identifying pollution sources in atmospheric research. CPF is defined as conditional probability of obtaining pollutant concentration above given threshold (usually defined as 75th or 90th percentile) if wind is coming from a given direction interval. Definition of CBPF is the same except that the condition is set on two variables, wind direction and, usually, wind speed. These probabilities are estimated as ratio of the number of concentration measurements above threshold and the total number of concentration measurements in a given direction interval. If for a particular direction the obtained values are high, that supports the conclusion that the wind from that direction increases pollutant concentrations, which can be very useful in identifying pollution sources. However, for this conclusion to be reliable, the observed increase (or decrease) must be established as statistically significant. Our literature search has shown that this is never done. Even more, we found that the majority of published analyses calculate CPF and CBPF from a relatively small number of measurements when the statistical fluctuations are large. The combination of these two facts is dangerous because it can drastically increase the likelihood of incorrect conclusion. To resolve this important issue, we have developed two independent methods for estimating the significance of the CPF and CBPF results. The methods, called binomial ratio and bootstrapping, are based on the construction of confidence intervals. The methods were validated on large and real data sets. We found them to be in a very good agreement and to have good coverage properties, which is the main criterion for the validity of confidence interval construction. For calculation and visualization of CPF, CBPF and the associated confidence intervals we have developed "CPFU", freely available open-source software written in R. We also freely provide software that facilitates the (otherwise difficult) extraction of data files from the US-EPA website.



Oral presentation

Velimir Milić, Vesna Gugec, Darijo Brzoja

ESTIMATION OF DUST, FOREST FIRE AND SEA SALT CONTRIBUTIONS TO SURFACE CONCENTRATIONS OF PM_{10} IN CROATIA

Keywords: *ambient air quality directive, natural contributions, PM_{10}*

Directive (EU) 2024/2881 on ambient air quality and cleaner air for Europe states that contributions from natural sources can be assessed but are beyond the control of human activity. Where natural contributions can be determined with sufficient certainty, Member States should be able to subtract those natural contributions when assessing compliance with limit values. This however does not prevent Member States from taking actions to reduce their health impact. Contributions from natural sources are the emissions of pollutants not caused directly or indirectly by human activities, like volcanic eruptions, wild-land fires, sea sprays and transport of dust from dry (arid, desert) regions. This becomes especially relevant for assessing the number of exceedances of the daily limit values of PM_{10} . Due to the geographic location and climate characteristics, Croatia usually has a few desert dust events annually, along with local resuspension of natural dust that is mostly during summer in dry conditions. Forest fires are also a constant factor, especially along the Adriatic coast. Wind blown sea salt can also significantly increase local concentrations of PM_{10} . All the natural sources mentioned above have the potential impact to increase the number of exceedances beyond limit value. Accurately estimating all those naturally occurring contributions is important, and not just because it can then be used to improve compliance with the Directive, but because it provides a better insight into air quality that leads to formulation of more adequate action plans and better air quality management. Estimation of contribution of natural sources to PM_{10} is based on measurements (chemical speciation) and on modelling applications. We will focus on the challenges of using modelling results. Open model results (CAMS) are freely available that can help with the estimation of natural contributions. Since models are not without errors, main challenge is in correctly estimating and eliminating model bias from the result. We will present the estimation of natural source contributions in Croatia for 2024. Despite the fact that several episodes of naturally occurring PM_{10} episodes are present, they can explain only a small portion of the total exceedances.



Poster presentation

Stipica Šarčević, Velimir Milić, Vedrana Džaja Grgičin, Marina Skender, Darijo Brzoja, Vesna Gugec, Valentina Jagić, Marko Kvakić

LOTOS-EUROS CHEMICAL TRANSPORT MODEL-BASED ASSESSMENT OF THE SPATIAL REPRESENTATIVENESS IN THE CROATIAN AIR QUALITY MONITORING NETWORK

Keywords: *Croatian Network for Continuous Air Quality Monitoring, FAIRMODE, LOTOS-EUROS, spatial representativeness*

Accurate interpretation of air quality measurements requires a clear understanding of the spatial representativeness of monitoring stations. In line with the obligations of the Croatian Meteorological and Hydrological Service (DHMZ), as defined by the national Air Protection Act, DHMZ is responsible for the development and application of air quality models to support monitoring, assessment, and reporting. This includes the evaluation of the spatial representativeness area (SRA) of stations within the State Network for Continuous Air Quality Monitoring.

The revised Ambient Air Quality Directive (EU) 2024/2881 requires that the spatial representativeness of each sampling point be explicitly defined, especially when used to assess population exposure, inform network design, or support model validation. According to FAIRMODE (Forum for Air Quality Modelling) guidance, the SRA is the area in which modelled concentrations deviate less than $\pm 15\%$ from the concentration observed at the station, using annual averages as the reference metric. These areas, which may be non-contiguous and constrained by zone borders, represent zones of similar pollution levels and are crucial for data interpretation and regulatory reporting.

In this work, we present the estimation of the spatial representativeness areas for selected stations in the Croatian national network, using the LOTOS-EUROS chemical transport model for the pollutants PM_{10} , $PM_{2.5}$, NO_2 , and O_3 . The model was applied at a resolution and configuration suitable for national-scale applications, ensuring that model bias at station locations was minimized, as required by the FAIRMODE approach. Modelled concentrations at the station locations were used to derive similarity fields and delineate SRA for each site.

The results provide new insight into the effective spatial coverage of each monitoring station and support ongoing efforts to optimize the monitoring network, enhance model validation procedures, and improve air quality communication strategies. The methodology, while technically robust, also aligns with current EU guidance and anticipates future reporting requirements as Implementing Provisions are updated. This work contributes to harmonizing air quality assessment practices in Croatia with evolving EU standards and provides a foundation for improved public health protection and environmental policymaking.

DEVELOPING AND TESTING MEASURING METHODS





Poster presentation

Darijo Brzoja¹, Bram Verbeek², Marko Kvakić¹, Vesna Gugec¹, Danica Kraljević¹, Velimir Milić¹,
Valentina Jagić¹, Stipica Šarčević¹

EVALUATING LOW-COST AIR QUALITY SENSORS IN URBAN ENVIRONMENTS: INSIGHTS FROM THE LIFE CityTRAQ PROJECT

Keywords: *LIFE City TRAQ, low-cost sensors, urban air quality, Zagreb*

Air quality remains one of the key environmental issues today, with the World Health Organization estimating around 7 million premature deaths globally each year due to polluted air. Effective monitoring and management are vital in reducing the health and environmental risks associated with air pollution, including respiratory and cardiovascular illnesses, ecosystem degradation, and impacts on the climate.

The LIFE CityTRAQ project, financed by the European Commission through the LIFE programme and coordinated by the Flanders Environment Agency (VMM), aims to support cities in tackling air quality challenges. By combining measurements and air quality modelling tools, the project provides decision-makers with instruments to identify pollution hotspots, simulate the impact of mitigation measures, and design optimized local air quality plans. Within the project, participating cities explore specific use cases, focusing particularly on traffic emissions and urban mobility, and develop transferable methodologies for broader application across the EU. In Croatia, these approaches are being piloted in the City of Zagreb.

As part of its national contribution, the Croatian Meteorological and Hydrological Service (DHMZ) acquired and tested eight low-cost sensor boxes capable of measuring particulate matter, nitrogen oxides, and ozone. These sensors were co-located with reference-grade analyzers at the Zagreb-1 urban traffic monitoring station to evaluate their precision and reliability. Parallel data collection over two months enabled comparative analysis under different meteorological conditions, including temperature and humidity variations.

The study assessed both the internal consistency of the sensor devices and their alignment with certified instruments. Results provided insight into the sensors' performance capabilities, highlighting both their potential to enhance existing air quality networks and the challenges in ensuring data quality and standardization.

¹Croatian Meteorological and Hydrological Service, Ravnice 48, 10000 Zagreb, Croatia

²Vlaamse Milieumaatschappij, Dokter De Moorstraat 24-26 -9300 Aalst, Belgium



Oral presentation

Mihriban Civan¹, Demet Arslanbaş¹, Abdulmounem Alchekh Wis¹, Hilal Yılmaz²,
Ubaidullah Habibi¹ and Serpil Yenisoğlu³

A MODIFIED DIGESTION-EXTRACTION PROTOCOL FOR MICRO(NANO)PLASTIC DETECTION IN ENVIRONMENTAL AND FOOD MATRICES

Keywords: *environmental-food matrix, method validation, micro and nano plastics, MNPs, pyrolysis-gas chromatography/mass spectrometry, Py-GC/MS*

Plastic pollution has significantly increased in agricultural environments due to the extensive use of plastic mulches, the application of treated wastewater for irrigation, and the widespread use of synthetic fertilizers and pesticides. The detection and quantification of plastic contaminants in edible crops, which form the base of the human food pyramid, is a critical aspect of environmental and public health monitoring. Among these pollutants, micro- and nanoplastics (MNPs) are of particular concern due to their ability to penetrate plant tissues and accumulate in the edible portions of crops, thereby posing a potential risk to human health. The present study proposes a modified digestion-extraction and quantification protocol for MNPs. The protocol is initially applied to tomato samples; subsequent modifications are then applied to other matrices, including water, soil and air samples.

Tetramethylammonium hydroxide (TMAH, 25%) and hydrogen peroxide (H₂O₂, 30%) were employed for alkaline oxidative digestion of organic matter. Soxhlet extraction was carried out using dichloromethane solvent, while ultrasonic treatment facilitated the release of embedded plastic particles. Quantification and polymer identification were performed via pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS), targeting specific polymers such as polyvinyl chloride (PVC), polystyrene (PS), low-density polyethylene (LDPE) and polyethylene terephthalate (PET). The pyrolysis temperature was optimized at 600°C. Recovery efficiencies for spiked tomato samples (50–500 µg/g) were obtained acceptable levels for target polymers. The method that has been developed and validated demonstrates promising potential for reliable MNP detection in food and environmental matrices. Further refinement of the method will allow for broader applications, thus contributing to risk assessment and the regulation of food safety and air quality.

Acknowledgment: *This study was supported by the Scientific and Technological Research Council of Türkiye (TÜBİTAK) under the grant number of 124Y107. The authors gratefully acknowledge TÜBİTAK for its financial support.*

¹Department of Environmental Engineering, Kocaeli University, Umuttepe Campus, 41380 Kocaeli, Türkiye

²Department of Environmental Engineering, Gebze Technical University, 41400 Gebze, Türkiye

³Department of Chemistry, Bolu Abant İzzet Baysal University, Gölköy Campus, 14030, Bolu, Türkiye



Oral presentation

Silvije Davila, Marija Jelena Lovrić Štefiček, Ivan Bešlić

FIELD CALIBRATION OF SENSORS FOR PARTICULATE MATTER

Keywords: *calibration, equivalence, PM, sensor units*

Sensors for measuring air quality are more widespread and are being installed in increasing numbers in cities to monitor air quality. Their data reliability remains low and their measurement accuracy still cannot be qualitatively compared with that of the reference air quality stations. Despite this, many studies show that the accuracy of the data can be influenced by sensor calibration.

During 2024, at the automatic station for measuring air quality, located at the Institute for Medical Research and Occupational Health, Zagreb, Croatia, comparative measurements of sensors for measuring particulate matter (PM) with reference, gravimetric method (EN 12341:2023) were carried out. Three sensor units (from SmartSense company) were placed around the air quality monitoring station: two of them next to each other at a height of 3 meters above ground, close to the automatic monitoring station inlet, and the third unit close to the particulate matter samplers, at a height of 1.5 m above ground near the inlet of the gravimetric samplers. The sensor units were left to work for a year in parallel with the gravimetric method.

The paper presents a comparison of the results obtained by sensor units and by gravimetric method. Furthermore, the calibration method using equivalence will also be presented, as well as the results of measurements after sensor calibration. Calibrations were made for all four seasons separately, as well as an annual calibration.

Acknowledgment: *The results of this research were obtained using the facilities and equipment funded within the ERDF project KK.01.1.1.02.0007 and were funded by EnvironPollutHealth – European Union – Next Generation EU (Class: 643-02/23-01/00016) project.*



Oral presentation

Ranka Godec, Helena Prskalo, Marija Jelena Lovrić Štefiček, Krešimir Šega, Gordana Pehnec

COMPARING BLACK CARBON AND ELEMENTAL CARBON MASS CONCENTRATIONS: METHODOLOGICAL SIMILARITIES AND DIFFERENCES

Keywords: *aethalometer, black smoke index, reflectometer, TOT method*

Black Carbon (BC) and Elemental Carbon (EC) are often used interchangeably, but they differ in both their definitions and measurement methods. BC is an aerosol component of soot that absorbs light and is produced by the incomplete combustion of fossil fuels, biomass, and biofuels. It is typically measured using optical methods, such as an aethalometer. EC, on the other hand, is a form of carbon distinct from organic compounds, and is quantified through thermo-optical analysis. While both are related, EC represents a stable, chemically defined carbon fraction, whereas BC refers to an optically measured particle with strong light-absorbing properties.

Over 50 days, measurements were conducted at an urban background air quality monitoring station. EC was determined using 24-hour filter-based sampling and the laboratory thermo-optical transmittance (TOT) method, while BC was determined every minute with an aethalometer to capture daily variations in carbonaceous aerosol concentrations. Additionally, the black smoke index (BSI) was determined as an indirect measure of light-absorbing carbonaceous particles, and BSI values were further utilized to estimate EC mass concentrations through computational methods. This multi-method approach enabled a thorough comparison of measurement techniques, providing a comprehensive evaluation of the consistency and reliability of BC and EC data across various time scales and methodologies.

This study aimed to evaluate the comparability, accuracy, and reliability of different techniques for measuring carbonaceous aerosols, specifically BC and EC, in an urban setting. It focused on comparing traditional filter-based sampling methods, and BSI in terms of their ability to consistently and accurately measure carbonaceous particles. By analysing these methods, the study identified any discrepancies, quantified sources of error, and assessed their strengths and limitations in real-world urban conditions.

The findings provide valuable insights into how each technique responds to temporal and environmental variations in pollutant concentrations, thereby enhancing our understanding of carbonaceous aerosols in urban air. Furthermore, the study demonstrates the potential for integrating these methods into regulatory frameworks, assisting in the development of standardized procedures for assessing carbonaceous aerosol pollution at local, regional, and global levels.

Acknowledgment: *This research was conducted using facilities and equipment funded by the European Regional Development Fund project KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health", and funded by the European Union – Next Generation EU (Program Contract of 8 December 2023, Class: 643-02/23-01/00016, Reg. no. 533-03-23-0006) - EnvironPollutHealth. Measurements of PM_{2.5}, OC, and EC in PM_{2.5} were conducted within the national air quality monitoring program and were funded by the Croatian Environmental Protection and Energy Efficiency Fund.*



Oral presentation

Predrag Hercog, Mario Šantolić, Mirela Poljanac, Vedran Vadić

SOME IMPORTANT DIFFERENCES BETWEEN OLD AND NEW CROATIAN STANDARDS FOR AMBIENT AIR QUALITY

Keywords: *air quality, combined standard uncertainty, new standards, quality control, type approval*

At the beginning of 2025, the Croatian Standards Institute issued new Croatian standards HRN EN 14626, 14211, 14212 and 14625 to replace their equivalents from 2012. The aim of this paper is to describe some of the most important changes between these new and old standards for CO, NO/NO_x, SO₂ and O₃ in ambient air, with emphasis on the chapters dedicated to testing laboratories. Furthermore, this paper provides suggestions considering what testing and calibration laboratories should do to implement changes in their documentation and work. In chapters, 1–7 there are no important changes. In the type approval testing (Chapter 8/Annex E), some performance criteria, referent materials for tests specifications and test procedures have changed. In addition, there are some changes in interference tests in the same chapter. This raises the question of whether equipment manufacturers will have to redo certain type-approval tests. If so, how will this apply to testing laboratories considering uncertainties on limit value calculations as part of the data quality objectives set by the CAFE Directive 2008/50/EC? Changes to Chapter 9 Field operation and ongoing quality control have also been made. This is of upmost relevance for testing and/or calibration laboratories. For example, there are new requirements for calibration gases, the maximum allowed residence time in a sample manifold has changed; additional performance criteria and tests have been introduced for repeatability at zero and span levels as well as some changes at frequency of tests. A formula for calculating the detection limit of an analyzer has been introduced. Information about its applications on data averaging and reporting has been added. For the calculation of uncertainty due to repeatability test in the NO/NO₂ standard, an explanation that test results are to be multiplied by 2 to account for the NO and NO_x channels of the analyzer (Annex E and F) has been given. This is very important in the calculation of the uncertainties on limit values, as well as for reporting result uncertainties in proficiency tests for both testing and calibration laboratories. Finally, it is strongly suggested that, due to some relevant changes, all laboratories should consider carefully reading and comparing old and new versions of the above-mentioned standards for air quality. In addition, they should contact the analyzer manufacturers to see if they will conduct additional tests for type approval, due to changes in standards. After that, they should implement changes where necessary in their documentation and work.



Poster presentation

Branko Petrinec^{1,2}, Tomislav Meštrović¹, Luka Pavelić¹, Dinko Babić¹

DEVELOPMENT AND IMPLEMENTATION OF HYBRID GAMMA-RAY SPECTROMETRY METHODS FOR ENHANCING THE CAPACITY OF ENVIRONMENTAL RADIOLOGICAL MONITORING AROUND NUCLEAR POWER PLANTS

Keywords: *ambient dose equivalent, ¹³⁷Cs, in-situ gamma spectrometry, Monte Carlo simulations, radioactivity*

The RAINSTORM project — Development and Implementation of Hybrid Gamma-Ray Spectrometry Methods for Enhancing the Capacity of Environmental Radiological Monitoring Around Nuclear Power Plants — has demonstrated substantial progress over multiple years of research and development. It addresses key challenges in environmental radiological monitoring by integrating conventional in-situ high-resolution gamma spectrometry with advanced approaches for rapid ambient dose equivalent mapping, providing a flexible and robust monitoring capability, especially around nuclear facilities.

A major achievement of the project is the design and validation of a hybrid measurement system combining:

- Monte Carlo simulations (Geant4) for accurate modeling of detector efficiency, energy response, and conversion factors
- Dedicated software tools (InSiCal, GUM Workbench, and custom Python scripts) for uncertainty analysis and in-situ calibration
- A network of monitoring stations that synchronously record meteorological and radiological data for improved data correction and interpretation
- The FRAS (Fast Radiological Area Scanner) system for rapid field mapping to pinpoint radiological hotspots, optimize resources, and guide detailed HPGe measurements.

Field campaigns were conducted at representative research sites, and depth distribution analyses for key radionuclides, especially ¹³⁷Cs, were validated using laboratory and in-situ methods. Despite challenges such as equipment failures and supply constraints, redundant solutions and operational flexibility ensured uninterrupted data acquisition and robust results.

The RAINSTORM project successfully integrated ambient dose equivalent rate data obtained from direct measurements in air with data measured in soil. The integrated RAINSTORM methodology significantly improves the speed, accuracy, and resilience of environmental radiological monitoring and offers strong potential for further development, including integration with UAV platforms and real-time decision support systems for routine surveillance and emergency response.

Acknowledgment: *This research was conducted using facilities and equipment funded by the European Regional Development Fund project KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health".*

¹Division of Radiation Protection, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

²Josip Juraj Strossmayer University of Osijek, Faculty of Dental Medicine and Health, Crkvena ul. 21, 31000 Osijek, Croatia

HEALTH IMPACTS OF AIR POLLUTION





Poster presentation

Katja Kološa¹, Tim Ravnjak^{1,2}, Eva Kanalec¹, Sonja Žabkar¹, Luka Kazensky³, Goran Gajski³,
Bojana Žegura^{1,2}

GENOTOXIC POTENTIAL OF BENZO[a]PYRENE (B[a]P) AND DIBENZO[a,h]ANTHRACENE (D[a,h]A) IN HUMAN HEPATOCELLULAR SPHEROID MODEL

Keywords: DNA damage, genotoxicity, PAHs, polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a widespread class of environmental contaminants, primarily produced through the incomplete combustion of organic material. Major sources include traffic emissions, industrial processes, and residential combustion activities. While much attention has been given to outdoor air pollution, PAHs are also prevalent indoors, particularly in environments where combustion processes such as cooking, heating, or tobacco smoking occur. These compounds are a significant concern due to their persistence in the environment and their potential harmful effects on human health. Among them, benzo[a]pyrene (B[a]P) and dibenzo[a,h]anthracene (D[a,h]A) are recognized as highly potent carcinogens. While the genotoxic mechanisms of B[a]P have been extensively studied and are well characterized, limited data exist on D[a,h]A mechanism of genotoxicity. This lack of data is critical, as D[a,h]A may be similarly widespread and potentially harmful. To address this knowledge gap, we aimed to evaluate and compare the genotoxic potential of D[a,h]A and B[a]P in a physiologically relevant three-dimensional (3D) human hepatocellular carcinoma (HepG2) spheroid model. Cytotoxicity (ATP assay) and genotoxicity (comet assay, flow cytometry for γ -H2AX, pH3, and p21) of both compounds were evaluated after 24-hour (short-term) and 96-hour (long-term) exposures, while targeted gene expression analysis was conducted to assess their mechanisms of action. At non-cytotoxic concentrations (5 μ M and 0.25 μ M for 24 and 96 hours, respectively), dose-dependent DNA damage was detected at both time points for both compounds. Flow cytometric analysis confirmed increased levels of DNA damage-associated markers, such as γ -H2AX, while gene expression profiling revealed upregulation of key genes involved in metabolism (encoding phase I and II enzymes), DNA damage response, and oxidative stress, further confirming the genotoxic mechanisms of action for both compounds. These consistent findings across multiple independent endpoints suggest that D[a,h]A exhibits genotoxic potency comparable to that of B[a]P, highlighting the need for further mechanistic studies to elucidate its adverse effects on human health. Understanding the full scope of D[a,h]A's genotoxic effects is essential for accurately assessing its risk and implementing effective public health measures.

Acknowledgment: Supported by HEU EDIAQI (101057497), HEU CutCancer (101079113), Slovenian Research Agency (P1-0245), HRZZ HUMNap (1192) and EU BioMolTox (533-03-23-0006).

¹National Institute of Biology, Department of Genetic Toxicology and Cancer Biology, Večna pot 121, 1000 Ljubljana, Slovenia

²Jozef Stefan International Postgraduate School, Jamova cesta 39, 1000 Ljubljana, Slovenia

³Division of Toxicology, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia



Poster presentation

Matjaž Novak¹, Martina Štampar¹, Alja Štern¹, Michael J. Burgum², Gillian E. Conway², Goran Gajski³, Shareen H. Doak², **Bojana Žegura¹**

ASSESSMENT OF GENOTOXIC AND INFLAMMATORY RESPONSES TO BENZO[b]FLUORANTHENE AND BENZO[g,h,i]PERYLENE IN A CO-CULTURE LUNG MODEL AT THE PSEUDO-AIR-LIQUID INTERFACE

Keywords: *indoor air, PAHs, polycyclic aromatic hydrocarbons*

Indoor air pollution (IAP) is closely linked to respiratory infections, chronic diseases as well as cancer and therefore poses a serious threat to human health. Polycyclic aromatic hydrocarbons (PAHs) are considered as one of the most hazardous air pollutants. These include benzo[b]fluoranthene (B[b]F) and benzo[g,h,i]perylene (B[ghi]P), which, together with 14 other PAHs are classified as priority pollutants due to their widespread presence and high toxicity. Since inhalation is the primary route of exposure, it is crucial to investigate the effects of these PAHs on the respiratory tract. In the study, we investigated the genotoxic and inflammatory effects induced by B[b]F and B[ghi]P using an *in vitro* co-culture system consisting of human differentiated human macrophage-like cells (d.THP-1) and alveolar epithelial cells (A549) at the pseudo-air-liquid interface. At non-cytotoxic concentrations (B[b]F ≤ 39.6 μM; B[ghi]P ≤ 18.1 μM), neither B[b]F nor B[ghi]P showed clastogenic or aneugenic potential. They did not induce DNA double-strand breaks (γH2AX) or mitotic cells (p-H3 positive events), nor did they increase micronuclei frequency in the cytokinesis-blocked micronucleus assay (CBMN) after 24 h of exposure. The selected PAHs did not alter cell cycle distribution or affect cell proliferation (Ki67) as determined by flow cytometry. However, both compounds induced an inflammatory response. B[b]F increased the percentage of cells expressing IL-6, IFN-γ and TNF-α (flow cytometry), while B[ghi]P increased IL-6 secretion and the percentage of cells expressing IL-6, IL-1β and TNF-α (ELISA, flow cytometry). Gene expression analysis showed that neither B[b]F nor B[ghi]P deregulated genes involved in DNA damage response pathways, except for *CDKN1A*. In contrast, both compounds upregulated inflammation-related genes, including *IL-6*, *TNF-α*, *IL-17d*, *IL-10*, *IL-8* and *IL-1β*. The study demonstrated that B[b]F and B[ghi]P have the potential to cause respiratory inflammation. The lack of genotoxic effects could be attributed to the low metabolic activity of A549 cells, which limits their ability to convert B[b]F and B[ghi]P into genotoxic metabolites. The increase in proinflammatory cytokines and the upregulation of related genes suggest that these PAHs could contribute to chronic airway inflammation and associated respiratory diseases. Further research is needed to assess their long-term health effects and relevance to IAP.

Acknowledgment: *Supported by HEU CutCancer (101079113), HEU EDIAQI (101057497), ARIS (P1-0245), HRZZ HUMNap (1192) and EU BioMolTox (533-03-23-0006).*

¹Department of Genetic Toxicology and Cancer Biology, National Institute of Biology, Večna pot 121, 1000 Ljubljana, Slovenia

²In Vitro Toxicology Group, Faculty of Medicine, Health and Life Sciences, Swansea University Medical School, Swansea University, Singleton Park, Swansea, Wales, UK

³Division of Toxicology, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia



Oral presentation

Gordana Pehnec¹, Ivana Jakovljević¹, Zdravka Sever Štrukil¹, Silvije Davila¹, Marko Gerić², Katarina Matković², Mandica Sanković³, Antun Šumanovac^{4,5}, Goran Gajski²

GENOTOXIC POTENTIAL OF PAHs BOUND TO PARTICULATE MATTER IN AMBIENT AIR AT DIFFERENT LOCATIONS IN CROATIA

Keywords: *air pollution, carcinogenic potential, genotoxic equivalency factors, PM₁₀*

Polycyclic aromatic hydrocarbons (PAHs) are a group of compounds well-known for their harmful effects on human health. They originate from the incomplete combustion or pyrolysis of organic matter and therefore have many natural and anthropogenic sources. In ambient air, PAHs are common constituents of particulate matter (PM). The carcinogenic potential of PAHs bound to PM can be assessed based on Toxic Equivalency Factors (TEFs) from the literature. Several TEF schemes are available, among which the most commonly used is the one proposed by Nisbet and LaGoy in 1992 ([https://doi.org/10.1016/0273-2300\(92\)90009-X](https://doi.org/10.1016/0273-2300(92)90009-X)). However, these TEFs are available for a relatively limited number of PAHs, which implies the need for further research, considering recent scientific evidence and a wider range of PAHs. For example, in 2020, Tomasetig *et al.* (<https://doi.org/10.1016/j.toxlet.2020.03.007>) proposed Genotoxic Equivalency Factors (GEFs) for 27 PAHs, based on *in vitro* research on three human cell lines.

In this study we aimed to assess the total carcinogenic and genotoxic potency of PAHs bound to the PM₁₀ fraction of particulate matter at four locations in different parts of continental Croatia, characterised by varying levels of population density, traffic, and industrial activity. The dataset included 24-h mass concentrations of eleven PAHs in PM₁₀, measured during the cold (23 Dec 2021-21 Mar 2022) and warm (13 May-17 Jul 2022) periods of the year at two locations in Zagreb, one in Slavonski Brod and one in Vinkovci. In parallel, measurements of NO₂, O₃ and meteorological parameters were carried out as well. The results show that the harmful potential of PM₁₀-bound PAHs is much higher during the colder period, compared to the warmer period of the year. Average total carcinogenic potency for the overall period, calculated using TEFs, was the highest at the location burdened by industry (5.462 µg/m³), and the lowest at the urban residential site (2.545 µg/m³). The application of GEFs at all four locations resulted in a higher calculated total potency of PAHs, indicating a possible underestimation of health risks as well as the need to review or upgrade existing factor schemes. Furthermore, the relationship between total carcinogenic/genotoxic potency and other pollutants and meteorological parameters was studied. Overall, a negative correlation with ozone and temperature and a positive correlation with PM₁₀ and NO₂ were found, although the significance of correlations varied depending on the location and season.

Acknowledgment: *This research was funded by the HRZZ HUMNap project #1192 and supported by the Foundation of the HAZU, the ERDF (project ReC-IMI, KK.01.1.1.02.0007) and Next Generation EU (Reg. no. 533-03-23-0006, projects BioMolTox and EnvironPollutHealth).*

¹Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

²Division of Toxicology, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

³Department of Physical Planning, Construction and Environmental Protection, Kralja Zvonimira 1, 32100 Vinkovci, Croatia

⁴Faculty of Medicine, J. J. Strossmayer University of Osijek, Josipa Huttlara 4, 31000 Osijek, Croatia

⁵County General Hospital Vinkovci, Zvonarska 57, 32100 Vinkovci, Croatia



Oral presentation

Jasmina Rinkovec, Silva Žužul, Magdalena Vincetić, Gordana Pehnec

HEALTH RISK ASSESSMENT OF HEAVY METALS EXPOSURE IN THE AMBIENT AIR OF ZAGREB, CROATIA

Keywords: *hazard quotient, lifetime cancer risk, PM₁₀*

In recent years, air quality has become a global topic of interest. Exposure to airborne particulate matter (PM) can be harmful to human health. These particles often carry toxic substances, including heavy metal(oid)s such as nickel (Ni), arsenic (As), cadmium (Cd), and lead (Pb), which are known for their carcinogenic, neurotoxic, and immunotoxic effects. Chronic inhalation of PM-bound metals has been associated with increased risks of cardiovascular and respiratory diseases, developmental disorders, and various forms of cancer. The health impact is especially severe in urban and industrial areas, where emissions from traffic, combustion, and industrial processes contribute to elevated PM concentrations. The aim of this study was to determine the mass concentrations of Ni, As, Cd, and Pb in PM₁₀ and their potential health risk via inhalation to the residents of Zagreb, Croatia. Daily samples of PM₁₀ were collected in 2022 at three monitoring stations with different classifications. Samples were prepared in acid by high pressure and high temperature microwave digestion system and metals were analysed by inductively coupled plasma mass spectrometry. The health risk assessment was based on an analysis of Ni, As, Cd and Pb according to the method developed by the US EPA. Hazard quotient (HQ) was used to assess non-carcinogenic risk and lifetime cancer risk (LCR) was used to assess carcinogenic risk. Annual average values for Ni, As, Cd, and Pb were below the limit values set by Croatian and EU legislation. The HQs for Ni, As and Cd were below one at all monitoring stations indicating that the non-carcinogenic risk for human exposure to the aforementioned metals was considered acceptable. The LCR values for Ni, As and Cd were $\leq 1 \times 10^{-6}$ indicating very low carcinogenic risks, whereas the LCR value for Pb was $10^{-6} \leq \text{LCR} < 10^{-4}$ suggesting low carcinogenic risk from the inhalation of these metals through PM₁₀. The estimated hazard quotient showed no risk to residents in the vicinity of monitoring stations due to the inhalation of particle-bound metals. Also, the estimated lifetime carcinogenic risk was low, indicating minimal or no carcinogenic risk from inhalation exposure to these metals near the monitoring stations.

Acknowledgement: *measurements of metals in PM₁₀ were carried out within local air quality monitoring network and were funded by the City of Zagreb. The results of this research were obtained using the facilities and equipment funded within the ERDF project KK.01.1.1.02.0007 and supported by EnvironPollutHealth – European Union – Next Generation EU (Class: 643-02/23-01/00016) project.*

INDOOR AIR QUALITY, ENERGY EFFICIENCY AND HEALTHY BUILDINGS





Oral presentation

Daniela Dejaco and Heimo Gursch

DATA QUALITY AND INDOOR AIR QUALITY TOOLS FOR CROSS-EUROPEAN COMPARISON

Keywords: *air quality comparison, data quality, indoor air quality, outlier detection*

The EDIAQI project conducts pilots and campaigns in European cities to understand the sources, routes of exposure, and health effects of indoor air pollution. Each measurement site has between 15 and 100 different measurement locations, where between 4 and 14 physical properties are measured resulting in a total of over 2000 data streams. The data is first collected in local databases, which can either send the data directly to the central database of the project or require manual uploading. The central database assures that all the data is stored in a uniform and efficient way with its metadata organised according to the SensorThings API standard.

The complexity of the de-centralised data collection makes it unavoidable that data errors occur, due to sensors issues, transmission outages or incorrect sensor handling. However, the data quality is highly important for any subsequent AI application, as it directly affects all achieved result. Furthermore, the distributed measurement sites make it hard to select meaningful datasets for comparison and benchmarking the air quality at the various locations. Therefore, the Data Troubleshooting and indoor air quality (IAQ) Comparison Tool was developed, providing two functions:

- The Data Troubleshooting component is designed to detect data transmission (e.g., missing or duplicated values), data quality (e.g., unfitting quantisation) and measurement value (e.g., implausible values or outliers).
- The IAQ Comparison is the next step after the issues in the data have been sufficiently reduced. This tool can quickly calculate KPIs of the IAQ at the measurement sites. These KPIs can be compared across the different measurement sites to detect local or national characteristics.

The Data Troubleshooting and IAQ Comparison Tool is part of the data infrastructure in the EDIAQI project. The tool is implemented as a web application, so that the project partners can easily access it. This is important, as the data troubleshooting requires the collaboration across partners to find the root causes and eliminate them. Similarly, also the IAQ Comparison invites partners to benchmark and compare their results. The extensive metadata enables an IAQ comparison based on metadata properties, e.g., comparison between classrooms with similar sizes during the morning lessons. This makes it a powerful tool to quickly selected interesting datasets, which are then investigated in more detail.

Acknowledgment: *This work was funded by the European Union's Horizon Europe research and innovation programme under grant agreement No. 101057497 (EDIAQI).*



Oral presentation

Jose Fermoso¹, Alicia Aguado¹, Sandra Rodríguez-Sufuentes¹, Rubèn González-Colom², Josep Roca², Alba Gómez-López², Benigno Sánchez³, Alberto Rodríguez López³, María Figols⁴, Manel Sanz⁵, Felipe López⁵

HOSPITAL IAQ ASSESSMENT USING A HYBRID MONITORING STRATEGY: CONTINUOUS LOW-COST SENSING AND TARGETED SAMPLING AT HOSPITAL CLÍNIC DE BARCELONA. K-HEALTHinAIR PROJECT

Keywords: CO₂, formaldehyde, GO AQS, hospitals, indoor air quality, particulate matter, ventilation, VOC

A hospital-wide indoor air quality (IAQ) assessment was conducted at Hospital Clínic de Barcelona to characterise conditions in representative spaces and to derive operational recommendations. The information sources comprised a network of calibrated, low-cost monitors installed in main entrance and waiting areas, inpatient wards, intensive care units (ICUs), consultation rooms and technical laboratories. Continuous measurements included CO₂, PM_{2.5}/PM₁₀, total volatile organic compounds (tVOC), formaldehyde, temperature and relative humidity. Time series were processed into Global Open Air Quality Standards (GOAQS) summary indicators to harmonise interpretation across areas and pollutants.

Data integration followed a twostep process. First, each zone's time series were aggregated into the share of time spent in performance categories (good, moderate concern, needs intervention), yielding a comparable view of ventilation effectiveness, particulate events and chemical loads. Second, arealevel dashboards were used to contrast spatial patterns and to identify shortlived events against background conditions. This framework enabled concise, actionable messages for facility management without resorting to complex statistics.

Results showed marked heterogeneity across the hospital. ICUs maintained consistently excellent IAQ under regulated mechanical ventilation, with stable CO₂ and very low particulate levels and only minimal tVOC and trace formaldehyde. In contrast, consultation rooms and waiting areas exhibited the most frequent CO₂ elevations, indicating a mismatch between realworld occupancy and air renewal during busy periods. Inpatient wards generally presented lowtomoderate particulate matter with occasional bursts linked to cleaning or movement, whereas laboratories displayed higher and more variable VOC burdens, sometimes accompanied by localised formaldehyde peaks. Overall, indoor-outdoor coupling appeared limited, supporting the interpretation that most observed peaks were locally generated.

The combined evidence supports targeted improvements. Ventilation control should be aligned with actual occupancy in consultation and waiting areas, using CO₂ guided or occupancybased strategies. Selection and timing of cleaning and disinfection products should be optimised to reduce VOC spikes and to avoid unnecessary exposure. Finally, continuous IAQ tracking should be maintained in strategic spaces for early detection and response, with ICU good practices replicated where feasible.

¹ CARTIF Technology Center, 47151 Boecillo, Valladolid. Spain

² Hospital Clínic de Barcelona, 08036 Barcelona, Spain

³ CIEMAT, 28040 Madrid. Spain

⁴ INBIOT, 31192 Mutilva, Navarra. Spain

⁵ Department of Infrastructures, Hospital Clínic de Barcelona. Barcelona, Spain



Oral presentation

Tajana Horvat, Ivana Jakovljević, Gordana Pehnec

TOLUENE AS A COMMON VOLATILE ORGANIC COMPOUND IN HOMES: THE ZAGREB CITY AREA DURING TWO SEASONS

Keywords: *ambient air, households, indoor air pollution*

Indoor air quality is a crucial aspect of human health, particularly as people spend a significant portion of their time indoors, especially at home. The quality of indoor air can be severely affected by pollutants, such as volatile organic compounds (VOCs). These compounds are important because, when they react with nitrogen oxides (NO_x) in the presence of sunlight they produce ozone (O₃), a potent oxidising agent in the atmosphere. Among the different VOCs, toluene is often found to be the most common indoor pollutant, posing a possible health risk. Sources of toluene in indoor air include infiltration of polluted ambient air from motor vehicle exhausts, as well as emissions from various products used in paints and varnishes during renovations, adhesives, and personal care items. The concentration of toluene in households largely depends on ventilation and the season of the year. Previous studies have indicated that toluene levels indoors are higher than those outdoors. In the European Union, regulations on the maximum allowed concentrations of toluene in indoor and outdoor air do not exist; instead, guidelines are in place in some countries.

This study aims to present levels and behaviour of toluene in two different months, May (spring) and October (autumn). These months are at the transition between the warm and cold seasons, and are therefore characterized by various influences and air pollution sources, as well as different patterns of human behaviour. Samples of indoor and outdoor air were collected in May and October 2024 from 20 homes in the city of Zagreb, Croatia. This study presents the first simultaneous measurements of toluene in indoor and ambient air in the Zagreb area, providing insights into their levels and seasonal variations trends. The median concentrations of toluene were 11.2 µg/m³ indoors and 23.9 µg/m³ outdoors during spring. In autumn, the median concentrations of toluene were 8.1 µg/m³ and 6.8 µg/m³ for indoor and outdoor environments, respectively. Results showed that toluene levels were higher in spring than in autumn, possibly due to higher temperatures and better ventilation during this period, as a significant factors associated with air pollution episodes.

Acknowledgment: *Funded by the European Union's Horizon Europe research and innovation programme under grant agreement No. 101057497 (EDIAQI) and supported by program contract European Union—Next Generation EU No. 533-03-23-0006 (EnvironPollutHealth). This study was performed using the facilities and equipment funded by the European Regional Development Fund project KK.01.1.1.02.0007 (ReC-IMI).*



Oral presentation

Stavroula Katsikari¹, Vassiliki Vassilatou¹, Konstantinos Granakis¹, Raquel Pimenta², Ketlyn Oliveira², Susana Marta Almeida², Drew Henderson³, Robert Ferguson³, Heidi Salonen^{4,5}, Konstantinos Eleftheriadis¹, Evangelia Diapoulis¹

CHARACTERIZATION OF ULTRAFINE PARTICLE NUMBER CONCENTRATION AND SIZE DISTRIBUTION IN MICROENVIRONMENTS CRITICAL TO CHILDREN'S EXPOSURE ACROSS DIFFERENT EUROPEAN COUNTRIES

Keywords: indoor air quality, size distribution, ultrafine particles, children exposure

Air pollution is associated with significant human health effects, with children and adolescents being especially vulnerable. Among atmospheric pollutants, ultrafine particles (UFPs) are of particular concern, due to their ability to penetrate deeply into the human body, passing into the blood stream and reaching different organs.

Within the InChildHealth project, intensive monitoring campaigns were conducted at elementary schools and homes in seven European cities, during September 2023-February 2025, in order to characterize indoor air quality and the exposure of children to air pollutants, and especially airborne particulate matter. The present work focuses on three cities; Athens (Greece), Lisbon (Portugal) and Essex (United Kingdom), where real-time monitoring of UFP number concentration and aerosol size distribution was performed inside five classrooms and homes in each city, by the use of compact nanoparticle detectors (Partector 2 Pro, NANEOS Particle Solutions). Concurrent outdoor measurements were also conducted. The study aimed to evaluate children's exposure to UFPs in various microenvironments, and identify the main factors affecting the levels and size distributions.

The initial results of UFP number concentration indicated a strong correlation with outdoor UFP levels, especially in schools during school hours when windows remain open. The indoor-to-outdoor (I/O) particle number (PN) concentration ratio varied under different conditions. The mean I/O ratio during school hours was calculated as 1.05 ± 0.31 , suggesting impact also by indoor activities, whereas after school hours it decreased to 0.40 ± 0.14 . The I/O ratio was consistent across different countries, with a mean value of 0.99 ± 0.30 when calculated over the entire sampling period. The mean I/O ratio in homes was 2.17 ± 1.92 during the warm period and 2.44 ± 2.36 during the cold period. The I/O ratio in homes varied significantly across locations and cities, being strongly influenced by indoor activities. Analysis of indoor and outdoor UFP concentrations and size distributions, across different microenvironments and under various indoor conditions, may provide insight into outdoor particle infiltration and indoor sources contributing to children's exposure.

Acknowledgment: InChildHealth is receiving funding from the European Union's Horizon Europe research under grant agreement 101056883. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Health and Digital Executive Agency (HaDEA). Neither the European Union nor the granting authority can be held responsible for them. InChildHealth is also receiving funding from the Swiss State Secretariat for Education, Research and Innovation (SERI grant agreement 22.00324), from the United Kingdom Research and Innovation (UKRI grant agreement 10040524), and from the Australian National Health & Medical Research Council (NHMRC grant agreements APP2017786 and APP2008813).

¹INRASTES, National Centre for Scientific Research "Demokritos", Athens, Greece

²Instituto Superior Técnico, Universidade de Lisboa, Lisbon, Portugal

³School of Life Sciences, The University of Essex, Colchester, Essex, UK

⁴Department of Civil Engineering, Aalto University, Espoo, 02150, Finland

⁵ILAQH, Queensland University of Technology, Brisbane, 4001, Australia



Oral presentation

Marija Jelena Lovrić Štefiček¹, Silvije Davila¹, Gordana Pehnek¹, Goran Gajski², Ivan Bešlić¹, Luka Kazensky², Ivana Banić³, Mirjana Turkalj^{3,4,5}

A COMPARATIVE STATISTICAL ASSESSMENT OF PM₁ MASS CONCENTRATION VARIATION IN RESIDENTIAL ENVIRONMENTS IN ZAGREB, CROATIA

Keywords: *indoor air quality, particulate matter, statistical analysis*

In recent years, indoor air quality has gained significant attention within the scientific community, primarily due to the high proportion of time people spend within enclosed environments, particularly residential settings. Among the various indoor air pollutants, fine particulate matter (PM), specifically particles with an aerodynamic diameter of less than 1 micrometer (PM₁), has been identified as an important indicator for assessing the potential health risks associated with indoor air pollution. Household air pollution results from a multifaceted interplay of sources leading to substantial variability in PM₁ concentrations across different residential settings, thereby rendering the indoor environment a complex and dynamic context for air quality assessment.

For this study, 93 households were selected from a pilot study conducted in Zagreb, Croatia, as part of the project Evidence Driven Indoor Air Quality Improvement (EDIAQI). These households were chosen based on the availability of both indoor and outdoor weekly samples, which were analyzed gravimetrically to determine PM₁ mass concentrations across both heating and non-heating seasons. During the data preprocessing phase, it was determined that most features did not follow a normal distribution, prompting the use of non-parametric methods. Principal Component Analysis (PCA) combined with clustering techniques produced a meaningful segmentation of the dataset into defined clusters. The Kruskal-Wallis test, a non-parametric alternative to ANOVA, was used to assess statistical differences between clusters. The analysis revealed that indoor and outdoor PM₁ concentrations, seasonal measurement indicators, and the proximity of households to traffic were among the most significant contributors to cluster separation. Additional features related to potential pollutant sources such as type of household and heating source during colder periods as well as type of stove also played a notable role, suggesting that both environmental conditions and household characteristics influenced the underlying structure of the data.

All data analyses were done using the Python programming language and relevant libraries. Further research with detailed chemometric and machine learning analysis is planned and will be conducted through the EDIAQI project.

Acknowledgment: *This research was funded by the Horizon Europe (EDIAQI project #101057497) and partially carried out using the equipment and facilities from the European Regional Development Fund project KK.01.1.1.02.0007 (ReC-IMI).*

¹Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

²Division of Toxicology, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

³Srebrnjak Children's Hospital, Srebrnjak 100, 10000 Zagreb, Croatia

⁴The School of Medicine, Catholic University of Croatia, Illica 224, 10000 Zagreb, Croatia

⁵Faculty of Medicine, University of J. J. Strossmayer Osijek, Josipa Huttlara 4, 31000 Osijek, Croatia



Invited lecture

Ivan Notardonato¹, Mario Lovrić^{2,3}, Alessandro Battaglia⁴, Piergiorgio Cipriano⁵, Pasquale Avino^{1,6}

VOLATILE ORGANIC COMPOUNDS AND ALDEHYDIC COMPOUNDS: INDOOR/OUTDOOR COMPARISON ACROSS DIFFERENT LIVING ENVIRONMENTS

Keywords: aldehydes, emerging pollutants, indoor air quality, low-cost sensors, passive sampling, volatile organic compounds

Residential indoor air quality (IAQ) has garnered increasing attention from the scientific community in recent years, as reflected in the rising number of studies and publications dedicated to this topic. It is now widely recognized that exposure to clean, pollutant-free air significantly enhances human health and contributes to longer life expectancy. Given that individuals spend at least 80 % of their time indoors, IAQ understanding and monitoring have become a critical public health concern even if European regulations concerning IAQ remain fragmented and lack harmonization across Member States. In response to this gap, the *Evidence Driven Indoor Air Quality Improvement* (EDIAQI) project was established to improve the knowledges on residential IAQ by collecting analytical data across various indoors in multiple European cities (i.e., Ferrara, Seville, Tallin, Vilnius, Zagreb). This paper presents findings from the study carried out in Ferrara as Italian pilot. The study focused on volatile organic compounds (VOCs) and aldehydes. These compounds were sampled using passive Radiello® samplers. A comparative analysis of indoor and outdoor concentrations is provided for various microenvironments, each characterized by specific exposure scenarios. To better reflect real-world conditions, data were collected under varying environmental and climatic settings. The results highlight significant differences among the various investigated indoor environments and suggest possible strategies for IAQ improvement. Furthermore, this study includes the detection of other indoor pollutants such as submicron particles, microplastics, and black carbon, which currently do not have standardized regulatory thresholds.

¹Department of Agricultural, Environmental and Food Sciences, University of Molise, Via Francesco De Sanctis, 86100 Campobasso, Italy²Department for Applied Bioanthropology, Institute for Anthropological Research, Gajeva 32, 10000 Zagreb, Croatia³The Lisbon Council, Rue de la Loi 155, 1040 Brussels, Belgium⁴Labservice Analytica srl, Via Emilia 5/C, 40011 Anzola Dell'Emilia, Italy⁵Dedagroup Public Services, Via Emilio Lepido 178, 40132 Bologna, Italy⁶Institute of Atmospheric Pollution Research, National Research Council, Rome, Italy



Poster presentation

Ivan Pavičić

DETECTION OF ASBESTOS IN THE SHIP'S INTERIOR

Keywords: *air quality, fibers, polarized light microscopy*

In the past, asbestos was used in a wide range of products. Three types of asbestos have found wide commercial use. Chrysotile was used in shipbuilding for fire protection, heat insulation and sound insulation. Amosite was used as fire protection and in thermal insulation products. Crocidolite was used as fire protection and in thermal insulation and chemical insulation products, and was particularly important for the production of high-pressure asbestos-cement pipes for the delivery of potable water. Qualitative determination of asbestos in was performed by method Air Quality ISO 22262-1. Fifteen samples were delivered and analyzed for presence of asbestos. Samples were collected ta different points. It were sampled at reception, coffee shop, cabin, kitchen, control room, tank and pilot room. Type of materials were mostly isolation of walls, panels, pipes, concrete floors and floors. Samples has been inspected at stereomicroscope, and fibers were collected and were proceed for further analysis under a microscope with polarization light (PLM). The PLM analysis found that the form fifteen analyzed samples, five were positive on asbestos. Detected asbestos by type was chrysotile.

Although the production, commercial sale and trade of asbestos has been banned for more than twenty years, asbestos can still can be found in the human environment. In a case of inadequate care, untreated asbestos-containing materials can pose a potential public health problem.

Acknowledgment: *This research was conducted using facilities and equipment funded by the European Regional Development Fund project KK.01.1.1.02.0007 "Research and Education Centre of Environmental Health and Radiation Protection – Reconstruction and Expansion of the Institute for Medical Research and Occupational Health" and and supported by program contract European Union—Next Generation EU No. 533-03-23-0006 Ecological, biological and dosimetric aspects of ionizing radiation: exposure and protection (EBDIZ).*



Oral presentation

Pedro Pena^{1,2}, Renata Cervantes^{1,2}, Carla Viegas^{1,2}

PRELIMINARY ASSESSMENT OF MICROBIAL CONTAMINATION FROM WINTER SAMPLING CAMPAIGN IN PORTUGUESE ELEMENTARY SCHOOL

Keywords: *active sampling, indoor air quality, passive sampling, settled dust*

While active microbial air sampling (e.g., MAS-100 impaction) is the regulatory gold standard for indoor air quality, its reliance on short-term, equipment-intensive sampling limits its scope. This study evaluates the complementary role of passive sampling, such as settled dust (SD), which integrates microbial deposition over time. We compared both methods within school classrooms (N=10) in a winter sampling campaign using culture-dependent methods for fungal and bacterial contamination. Although the active method provided load snapshots, SD allows a broader spectrum of microbial contamination and reflects cumulative exposure. Our results demonstrate that SD is not merely a low-cost alternative but a complement to active sampling. The reliance on active methods in current frameworks overlooks critical long-term exposure data. Consequently, passive sampling represents a complementary tool that could enhance future regulatory monitoring frameworks. Its consideration would contribute to a more comprehensive and practical approach to managing infection risks in indoor settings, such as schools.

Acknowledgment: *InChildHealth is receiving funding from the European Union's Horizon Europe research under grant agreement 101056883, from the Swiss State Secretariat for Education, Research and Innovation (SERI grant agreement 22.00324), from the United Kingdom Research and Innovation (UKRI grant agreement 10040524), and from the Australian National Health & Medical Research Council (NHMRC grant agreements APP2017786 and APP2008813).*

¹H&TRC—Health & Technology Research Center, ESTeSL—Escola Superior de Tecnologia e Saúde, Instituto Politécnico de Lisboa, 1990-096 Lisbon, Portugal;

²NOVA National School of Public Health, Public Health Research Centre, Comprehensive Health Research Center, CHRC, REAL, CCAL, NOVA University Lisbon, Lisbon, Portugal



Oral presentation

Grigoris Protopsaltis, Chris Mountzouris, John Gialelis

REINFORCEMENT LEARNING-BASED AIR PURIFICATION CONTROL FOR ENHANCED INDOOR AIR QUALITY

Keywords: *energy efficiency, HVAC control, indoor air quality, Reinforcement Learning, Proximal Policy Optimization*

Maintaining healthy indoor environments requires effective control of air pollutants and thermal comfort, particularly in dynamically changing conditions. Traditional rule-based control (RBC) systems often fail to adapt optimally to fluctuations in outdoor conditions, indoor emissions and energy pricing. This study presents a Reinforcement Learning (RL) approach based on the Proximal Policy Optimization (PPO) algorithm for integrated control of heating, cooling, and air purification systems. The method aims to achieve high indoor air quality (IAQ), stable thermal comfort, and reduced energy consumption.

The control task was formulated as a Markov Decision Process (MDP), where the agent interacted with a simulated indoor environment every five minutes, forming 24-hour episodes. The simulation environment, developed using the Gym framework, incorporated the thermodynamic and particulate dynamics of indoor spaces. State variables included indoor and outdoor temperature, $PM_{2.5}$ concentrations, internal generation rates, ventilation rates, electricity price and time of day. The action space comprised discrete levels of heating, cooling, and purifier operation, while the reward function balanced comfort, IAQ, and energy efficiency by penalizing deviations from target ranges and excessive power consumption.

The PPO agent was trained using the Stable-Baselines3 library, utilizing real outdoor temperature and $PM_{2.5}$ data from Open-Meteo and electricity price data from ENTSO-E. Results demonstrated that the RL agent effectively maintained indoor $PM_{2.5}$ concentration and indoor temperature on acceptable levels, despite external fluctuations. Compared to an RBC baseline, the RL controller achieved smoother behavior, a reduction in total energy consumption, and significantly lower operational costs under dynamic pricing conditions.

This work highlights the potential of reinforcement learning for adaptive, energy-aware HVAC and air purification control. By learning optimal strategies through interaction with environmental dynamics, the proposed PPO-based controller provides a robust framework for achieving sustainable IAQ management and improved occupant well-being in modern buildings.



Oral presentation

Valentino Petrić^{1,2}, Dejan Strbad^{1,2}, Nikolina Račić^{2,3}, Francesco Mureddu², Mario Lovrić^{2,4}

HYBRID DIGITAL TWIN FRAMEWORK FOR REAL-TIME INDOOR AIR QUALITY MONITORING AND FILTRATION OPTIMIZATION

Keywords: *Computational Fluid Dynamics (CFD), hybrid modelling, low-cost sensors, machine learning, smart buildings*

This study presents a hybrid digital twin framework designed for real-time indoor air quality (IAQ) monitoring and filtration optimization within a residential environment. Using low-cost sensor networks, physics-based simulations, and machine learning models, the system dynamically replicates the indoor environment to support continuous assessment and control of main pollutants, including particulate matter (PM), volatile organic compounds (VOCs), and carbon dioxide (CO₂). The architecture integrates mass balance and decay physical models, computational fluid dynamics (CFD) simulations, regression, and neural network algorithms, evaluated under both filtering and non-filtering conditions. A graphical user interface (GUI) provides users with an interactive platform to test air purifier placements and visualize air quality dynamics. The entire solution is containerized and deployed via Kubernetes, supporting scalability and real-world deployment. Results show that simple models like linear regression outperform more complex architectures under data-limited conditions, while the hybrid modelling approach improves interpretability and robustness. This digital twin framework contributes to smart building management by offering a scalable, interpretable, and cost-effective tool for proactive IAQ control and personalized decision-making.

Acknowledgment: *This work was funded by the European Union's Horizon Europe research and innovation programme under grant agreement No. 101057497 (EDIAQI).*

¹Ascalia d.o.o., Ul. Trate 16, 40000 Čakovec, Croatia

²The Lisbon Council, Rue de la Loi 155, 1040 Brussels, Belgium

³Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

⁴Institute for Anthropological Research, Gajeva 32, 10000 Zagreb, Croatia



Oral presentation

Iva Šunić¹, Dubravka Havaš Auguštin¹, Jelena Šarac^{1,2}, Kristina Michl³, Rasmus Riemer Jakobsen⁴,
Mario Lovrić^{1,2,5}

MICROBIAL COMPOSITION OF HOUSEHOLD DUST IN CROATIAN HOMES: FINDINGS FROM EDIAQI PROJECT

Keywords: 16S, dust microbiome, indoor air, ITS, metagenomics

Indoor dust harbours a complex microbial ecosystem shaped by both human activity and environmental inputs, with its composition increasingly recognized as a key component of indoor air quality. Despite the commonness of dust in residential settings, comprehensive assessments of its microbial communities remain limited, particularly in Southeast Europe. This presentation, conducted within the European EDIAQI (Evidence driven indoor air quality improvement) project, applied high-throughput sequencing and bioinformatic approaches to characterize bacterial and fungal assemblages in household dust collected from Croatian homes.

Sequencing of samples from 90 households produced over 6 million bacterial and 3.2 million fungal reads. The bacterial fraction was dominated by Firmicutes and Actinobacteria, with *Staphylococcus*, *Corynebacterium*, and *Streptococcus* as major contributors, reflecting strong human-associated inputs. Fungal communities showed greater variability and stronger influence of outdoor sources, with *Malassezia*, *Aspergillus*, *Penicillium*, and *Alternaria* among the most prevalent taxa. Relative abundance analyses highlighted marked differences across households, revealing both highly abundant genera and taxa present only sporadically in the indoor environment.

Environmental factors such as the presence of pets, number of children, and housing characteristics contributed significantly to variation in community composition, underlining the dynamic and context-dependent nature of the dust microbiome. Comparative analyses with international cohorts revealed both globally widespread microbial signatures and unique regional patterns, emphasizing the importance of local environmental and cultural influences.

This study provides the first comprehensive metagenomic characterization of household dust in Croatia. By detailing bacterial and fungal diversity, taxonomic structure, and relative abundance patterns, it contributes valuable insights into the composition and variability of indoor microbial ecosystems. The findings establish a baseline for future investigations of dust microbiomes and their implications for indoor environmental quality.

Acknowledgment: This work was funded by the European Union's Horizon Europe research and innovation programme under grant agreement No. 101057497 (EDIAQI).

¹ Centre for Applied Bioanthropology, Institute for Anthropological Research, Gajeva 32, 10000 Zagreb, Croatia;

² Faculty of Biotechnology and Drug Development, University of Rijeka, Radmile Matejčić 2, 51000 Rijeka, Croatia;

³ Institute of Environmental Biotechnology, Graz university of Technology, Petersgasse 12/i, 8010 Graz, Austria;

⁴ University of Copenhagen, Nørregade 10, 1165 Copenhagen, Denmark;

⁵ Lisbon Council, Rue de la Loi 155, 1040 Bruxelles, Belgium



Oral presentation

Silva Žužul, Marija Jelena Lovrić Štefiček, Gordana Pehnek, Ivan Bešlić

MICROPLASTICS IN THE INDOOR AIR OF ZAGREB HOUSEHOLDS

Keywords: *air sampling, LDIR imaging, microplastics analysis*

Microplastics is a term used for polymer particles smaller than 5 mm. They are widely distributed in the environment both as primary particles, generated in different industrial processes, or as secondary particles, formed in the atmosphere through the degradation and weathering of plastic residues. There is great interest from the general public and scientist about the effects of microplastics on human health as well as a lack of knowledge about the levels, sources, distribution and exposition routes for humans. Consuming water and contaminated food are the ingestion routes, while airborne microplastics enter the body through inhalation. Air quality monitoring in the EU and Croatia is primarily focused on outdoor air quality. However, indoor air quality is more important for risk assessments because of the amount of time spent indoors. The EDIAQI project (Evidence Driven Indoor Air Quality Improvement) is currently being carried out under the Horizon Europe programme and its main focus is indoor air pollution in European cities. As part of the project, a pilot study is being conducted in households in Zagreb, Croatia. This paper presents the first results of the characterization and quantification of microplastics collected from fourteen living rooms during the heating season in 2024. The analyses were conducted using IR spectroscopy with quantum cascade laser imaging (LDIR system). Various sampling times for active pumping of indoor air were tried and different reflective surfaces were tested for the sampling, including aluminium and gold filters. Particles ranging from 10 µm to 500 µm in diameter were determined using a built-in library of spectra for microplastics from the manufacturer (Clarity software ver. 1.6.83). The most common type of polymers found in indoor air was polyamide. The remaining identified species included polyurethane, rubber, polyethylene terephthalate, polypropylene, polyethylene, polyvinyl chloride, acrylonitrile butadiene styrene, polycarbonate and polystyrene.

Acknowledgment: *This work was funded by the European Union's Horizon Europe research and innovation programme under grant agreement No. 101057497 (EDIAQI).*

CLIMATE AND ENVIRONMENTAL IMPACTS OF AIR POLLUTION





Oral presentation

Ana Alebić-Juretić

IMPACTS OF CLIMATE CHANGE IN THE CITY OF RIJEKA, CROATIA

Keywords: *desert dust deposition, impact on human health, precipitation, temperature*

Global warming is undoubtedly present, with maximum temperature values reached in the last 20 years. Climate change is reflected in the environment and human life through effects such as soil and coastal flooding, changes in river flows, shifts in agricultural production, and increased frequency of floods and erosion. Since the mid-1970s (1978–2023), there has been a consistent rise in the average annual temperature in Rijeka, with an increase of approximately 1.5°C. The largest increase was recorded in the maximum daily temperature — by as much as 10°C — and a smaller increase was noted in the minimum daily temperature. Alongside a slight rise in the average relative humidity, the same period saw an increase in the number of rainy days by more than 30, while the total annual precipitation remained practically unchanged (around 1500 mm per year). The obtained parameters were compared with historical data from the late 19th century, measured in Rijeka.

During the same period, an increase was observed in the frequency of so-called “yellow rains” (from 7–35%), which deposit desert sand. The increased frequency correlates with the rise in temperature, indicating that the increased inflow of air masses from the south is also responsible for the temperature rise in this region. Recent studies have shown that the source of desert sand in precipitation and airborne particles is not exclusively the Sahara, but also other Central Asian deserts, such as the Syrian or Azov deserts.

Global warming results in more frequent coastal flooding and rising sea levels, although there is no solid evidence for either phenomenon in Rijeka. Plants and agricultural crops are more susceptible to climate change, but apart from oral statements from farmers, there is no reliable data on this. The temperature increase has led to the introduction of allochthonous (non-native) species, such as the Asian mosquito, which was recorded in Croatia as early as 2003, as well as a rise in infectious gastrointestinal and allergy-induced respiratory diseases. However, over more than 20 years of monitoring these diseases, no correlation with rising temperatures has been found, although excess mortality resulted applying the British model to ozone and PM data during the heat wave in August 2003.



Poster presentation

Želimira Cvetković¹, Ivana Ćosić², Ksenija Kuna², Danijel Grgec¹, Marko Marić¹, Jadranka Škevin-Sović², Jasna Bošnjir^{1,3}

THE INFLUENCE OF INORGANIC COMPOUNDS IN PRECIPITATION ON TOTAL DEPOSITED MATTER – A CASE STUDY FROM ZAGREB, CROATIA

Keywords: *air pollution, background station, heavy metals, precipitation chemistry, traffic emissions, urban station*

This study presents the results of atmospheric deposition monitoring conducted in the Zagreb area, Croatia, during 2023 and 2024. Precipitation samples were collected daily at the Puntijarka station, a background site on Medvednica Mountain, while total deposited matter (TDM) was measured at an urban site, specifically in the courtyard of the Teaching Institute of Public Health "Dr Andrija Štampar", located at Mirogojska cesta 16, Zagreb.

The study aimed to explore the relationship between inorganic ions and selected heavy metals in precipitation and their contribution to TDM. Precipitation samples were analysed for major anions and cations (Cl^- , NO_3^- , SO_4^{2-} , Na^+ , NH_4^+ , K^+ , Mg^{2+} , Ca^{2+}), pH, and heavy metals: lead (Pb), cadmium (Cd), arsenic (As), and nickel (Ni). TDM samples were analysed for mass deposition and concentrations of sulphate, calcium, and the same metals.

The average concentrations of heavy metals in precipitation ($\mu\text{g/L}$) showed minimal variation between 2023 and 2024. In 2023, concentrations were: Pb – 0.130, Cd – 0.015, As – 0.074, Ni – 0.322, while in 2024 they were: Pb – 0.153, Cd – 0.014, As – 0.072, Ni – 0.314. The most abundant ions in both years were Ca^{2+} , NH_4^+ and Cl^- , showing a consistent chemical pattern. The average pH was 6.09 in 2023 and 6.17 in 2024, indicating predominantly non-acidic precipitation with values above the threshold of pH 5.6.

TDM loads during 2023 and 2024, sampled using the Bergerhoff method, ranged from 13.0 to 117.2 $\text{mg/m}^2\text{d}^1$. Pb and Ni were consistently present in measurable amounts, with maxima of 6.75 and 3.8 $\mu\text{g/m}^2\text{d}^1$. Cd and As were mostly below detection limits. TDM peaks often coincided with periods of elevated concentrations of Ca^{2+} and SO_4^{2-} in precipitation, suggesting anthropogenic sources of pollution. Noticeably higher concentrations of Pb and Ni were observed in the examined urban area of Zagreb. In contrast, concentrations of these metals at the Puntijarka background site were lower and more constant, reflecting the site's remoteness from direct emission sources.

The results show a strong link between precipitation chemistry and total deposited matter. Pb and Ni were the most persistent pollutants across both media, pointing to local emission sources. Coordinated monitoring of atmospheric deposition is essential for understanding pollutant dynamics and supporting air quality management in urban areas.

¹Teaching Institute for Public Health "Dr. Andrija Štampar", Mirogojska cesta 16, 10000 Zagreb, Croatia

²Croatian Meteorological and Hydrological Service, Ravnice 48, 10000 Zagreb, Croatia

³University of Applied Health Sciences, Mlinarska cesta 38, 10000 Zagreb, Croatia



Poster presentation

Gordana Sinčić Modrić, Tamara Cirković, Goran Crvelin

TOTAL DEPOSITED MATTER AS AN INDICATOR OF AIR QUALITY: MONITORING RESULTS IN THE CITY OF RIJEKA, CROATIA, IN 2024

Keywords: *atmospheric deposition, environmental monitoring, ICP-MS analysis, heavy metals*

Total deposited matter (TDM) includes all particles and compounds that are deposited on the ground from the atmosphere by gravity or precipitation and are not part of the natural air composition. Systematic monitoring of TDM is crucial for the assessment of air pollution and is used as an indicator of environmental and public health conditions. According to the Regulation on Air Quality Monitoring, TDM is a reference parameter for the assessment of air quality, particularly in urban and industrial areas. In addition to the total mass of deposited particles, the content of priority heavy metals is also analyzed due to their toxicity and potential for bioaccumulation.

As part of the Environment Health Protection Program 2024, and on the basis of a contract with the Primorje-Gorski Kotar County, monitoring of TDM and metals was carried out in the area of the City of Rijeka. Samples were taken from 12 monitoring stations, with the results from the Mlaka and Zavod stations presented in this study. Mlaka is located in a residential and industrial area, while Zavod is located near the Port of Rijeka.

Sampling was carried out using the Bergerhoff method (VDI 4320 Part 2:2012) with equipment built according to German standards. The sampling lasted 30 ± 2 days. The metals Pb, Cd, As, and Ni were analyzed by ICP-MS according to the HRN EN 15841:2010 standard, while Tl, Fe, Cu and Zn were determined by validated internal methods using the same technique.

The average annual amount of TDM was $131 \text{ mg/m}^2\text{d}^1$ at the Mlaka station and $77 \text{ mg/m}^2\text{d}^1$ at Zavod. The following average values were measured at Mlaka: Pb – $2.127 \text{ }\mu\text{g/m}^2\text{d}^1$, As – $0.351 \text{ }\mu\text{g/m}^2\text{d}^1$, Ni – $1.687 \text{ }\mu\text{g/m}^2\text{d}^1$, Cd – $0.058 \text{ }\mu\text{g/m}^2\text{d}^1$, Tl – $0.020 \text{ }\mu\text{g/m}^2\text{d}^1$. The values measured in Zavod were: Pb – $9.691 \text{ }\mu\text{g/m}^2\text{d}^1$, As – $0.616 \text{ }\mu\text{g/m}^2\text{d}^1$, Ni – $5.577 \text{ }\mu\text{g/m}^2\text{d}^1$, Cd – $0.205 \text{ }\mu\text{g/m}^2\text{d}^1$, Fe – $3141 \text{ }\mu\text{g/m}^2\text{d}^1$. The higher values in Zavod are related to the handling of metal waste in the Port of Rijeka.

The annual TDM amounts and metal concentrations did not exceed the limits set by the Regulation on Air Pollutant Levels (Official Gazette 77/2020), indicating a satisfactory level of air quality at the monitored sites in 2024. The results underline the need for continuous monitoring of particulate matter, especially near industrial and port areas, in order to identify potential risks to the environment and public health risks and to ensure effective air quality management in urban areas.



Oral presentation

Anita Vucić¹, Predrag Ilić², Sonja Kralj³, Danijela Peroš- Pucar¹, Katarina Bukša¹, Sanja Bajić²,
Silvana Račić Milišić², Kasim Agović³

AllerShield: STRENGTHENING CROSSBORDER SOLUTIONS FOR MANAGING ALLERGENIC PLANTS AND ENHANCING CLIMATE RESILIENCE

Keywords: *air quality, allergenic pollen, IAS*

The main goals of the "AllerShield" project are reducing the impact of climate change and the health challenges that we face every day due to the increased allergenic pollen in the air, improvement of the protection and preservation of nature, biodiversity, and green infrastructure and reducing all forms of pollution by creating a green and resilient shared environment.

This project aims on improvement of environmental conditions in the cross-border area of Zadar County, the City of Banja Luka and the City of Podgorica, through the establishment and expansion of pollen monitoring and prevention of the further spread of allergenic plants, raising awareness on invasive alien species (IAS) spread and impact on biodiversity, agriculture and health by delivering real-time air quality data to citizens and creating joint solutions/data management of air monitoring.

Allergenic pollen distribution, air quality and IAS spread does not depend on national borders, and transnational and intersectoral cooperation is necessary to collect air quality data, exchange successful practices, initiatives, and methodologies from different countries using available synergies. Invasive species control and suppression requires cross-border and international approach because among other, it depends on the rate of climate change.

Based on monitoring results, conferences, exchanges of good practices and workshops, and synthesis of different methodologies between partners, each partner contribute to creation of common Action Plan for local decision makers on strategies for invasive species control management. The Action Plan will be used by other stakeholders after the implementation of the project to lead to gradual improvement of air quality policies.

The AllerShield project will improve the cross-border monitoring systems for allergenic pollen in the air, develop tools for assessing the time-spatial spread and occurrence of new species, and the impact of allergenic pollen on outdoor air quality indicators and indicators within the health system. Through the implementation of project activities, the project addresses and implements the planning of actions to raise public awareness and strengthen the capacity health and other sectors dealing with issues of general climate adaptation.

Acknowledgment: *The AllerShield project is co-financed as part of the implementation of the Interreg VI-A IPA Programme Croatia - Bosnia and Herzegovina - Montenegro 2021-2027 with a share of 85%. The total value of the project is 807.816,00 Euros. Duration of the project is 36 months (01 July 2024 - 30 June 2027).*

¹Institute of Public Health Zadar, Croatia, Ljudevita Posavskog 7A, 23 000 Zadar, Croatia

²PSRI Institute for Protection and Ecology of the Republic of Srpska, Vidovdanska 43, 78 000 Banja Luka, Republic of Srpska, Bosnia and Herzegovina

³Environment protection Agency of Montenegro, Ulica 4. Proleterske Brigade, 81 000 Podgorica, Montenegro



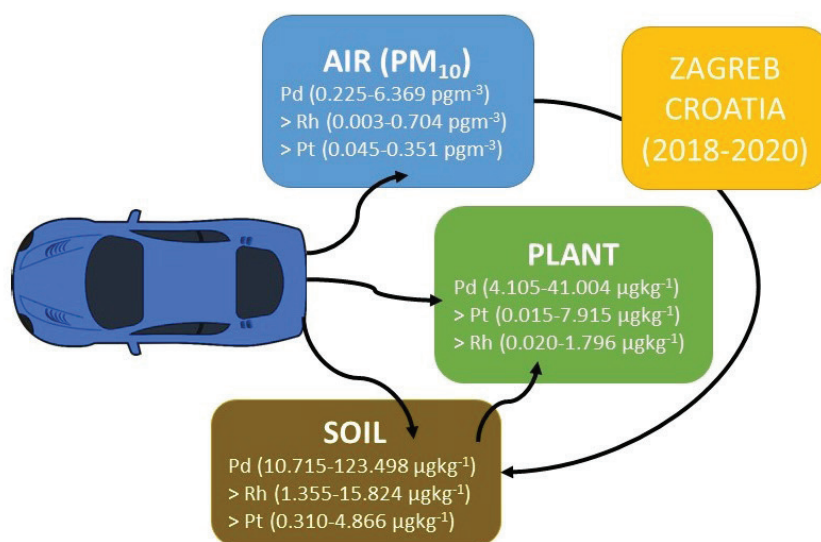
Oral presentation

Željka Zgorelec¹, Gordana Pehneć², Aleksandra Perčin¹, Marija Galić¹, Iva Hrelja¹,
Jasmina Rinkovec²

PLATINUM GROUP ELEMENTS IN THE URBAN ENVIRONMENT (SOIL, PLANTS AND AIR) OF ZAGREB, CROATIA

Keywords: *auto catalyst*, *Dactylis glomerata* L., Pd, PGE, *Plantago Lanceolata* L., Pt, Rh

The platinum group of elements (PGE) includes platinum (Pt), palladium (Pd) and rhodium (Rh). The objectives of this study were to: (i) develop and adapt a method for determining PGE; (ii) sample environmental components (air, soil and plants) and measure the PGE concentrations in them; (iii) determine the seasonal (spring and fall) and spatial (three urban sites) differences in PGE concentrations in each environmental component and the relationships between them (soil, plants, air). Samples were taken from three locations in differently polluted parts of Zagreb. Over three years (2018-2020), vegetation and soil samples were collected twice a year (in spring and fall). Each year, two samples of plant material (*Plantago Lanceolata* L. and *Dactylis glomerata* L.) and two soil samples (at depths of 0-5 cm and 5-10 cm) were collected from each site, along with suspended particulate matter with an aerodynamic diameter of less than 10 µm (fraction PM₁₀ – weekly sampling throughout the year). The results showed significantly higher concentrations of Pd in soil, air, and vegetation compared to Rh and Pt. *Plantago Lanceolata* L. had a much higher PGE content than *Dactylis glomerata* L. The concentrations in soil and air were in the order Pd > Rh > Pt, whereas in plants, the order was Pd > Pt > Rh. The PGE concentration in air was highest in the south of the city, and in plants and soil, it was highest in the city centre.



Graphical abstract

¹Faculty of Agriculture, University of Zagreb, Svetosimunska street 25, 10000 Zagreb, Croatia

²Division of Environmental Hygiene, Institute for Medical Research and Occupational Health, Ksaverska c. 2, 10000 Zagreb, Croatia

EFCA SESSION: "METHANE TIME"





Invited lecture

Andrzej Jagusiewicz

TARGETING METHANE

Keywords: *climate forcer, short-lived climate pollutant, tropospheric ozone*

Methane characteristics, particularly its role as a short-lived climate pollutant (SLCP) and as climate forcer (CF) par excellence, and its negative effects on our health, climate and ecosystems will be presented. In particular, its role as a precursor of tropospheric ozone formation - together with nitrogen oxides and other volatile organic compounds - will be emphasized. Furthermore, the most up-to-date data will be given with respect to methane emissions, globally, regionally and in the European Union and attributed to its main emission sources like agriculture, fossil fuels mining and processing and wastes generation and utilization.

Targeting methane suits ideally to EFCA (European Federation of Clean Air and Environmental Protection Associations) and IUAPPA (International Union of Air Pollution Prevention and Environmental Protection Associations) "ONE ATMOSPHERE" approach, integrating action for cleaner air and climate protection. Acting at all levels, from global to local, to reduce methane emissions provides multiple benefits: slowing climate change, improving human health and increasing crop yields.

Finally, the author will inform about the state-of-play with respect to methane abatement at all levels, focusing in particular at United Nations Economic Commission for Europe (UNECE) level in the ongoing revision of the Amended Gothenburg Protocol, taking into account the last outcome of the negotiation process, the 63rd session of the Working Group of Strategies and Review under the Air Convention (LRTAP Convention).



Invited lecture

Goran Kiš

METHANE EMISSIONS FROM LIVESTOCK: SOURCES, IMPACT, AND MITIGATION STRATEGIES

Keywords: *climate, enteric fermentation, livestock, methane*

Methane (CH₄) from livestock contributes significantly to global greenhouse gas emissions and plays an important role in climate change. The main source of methane in livestock is enteric fermentation, a microbial digestive process in ruminants—including cattle, buffalo, sheep, and goats—in which plant fibres in the rumen are broken down by archaea that produce methane as a by-product. This methane is mainly released through belching and accounts for 90–95% of methane emissions from livestock. A second source is methane produced during the anaerobic decomposition of manure, especially in liquid stores under oxygen-deficient conditions.

Globally, livestock contribute about 115–130 million tonnes of methane annually, accounting for between 32 and 40% of anthropogenic methane emissions. Enteric fermentation is responsible for 75–80% of this, with cattle producing the largest proportion due to their global population and high methane output per animal. There are regional differences, with higher methane emissions occurring in developing regions where low-quality feed is prevalent, while relatively lower but still significant emissions occur in high-income countries that benefit from improved nutrition and management practices.

Methane is a potent greenhouse gas with a global warming potential 27–30 times higher than that of CO₂ over 100 years and 81–83 times higher over a 20-year period, despite remaining in the atmosphere for about 12 years. This strong, short-lived nature makes reducing methane one of the fastest ways to mitigate near-term global warming.

Mitigation strategies include nutritional measures such as feed additives (e.g., 3-nitrooxypropanol, 3-NOP, which inhibits methanogenesis by 25–30%; algae species such as *Asparagopsis taxiformis*, which reduce emissions by up to 80%), improving feed composition (more fats, starch, and tannins), and genetic selection for animals with low methane emissions. Methane emissions from manure can be reduced by capturing biogas in anaerobic digesters and through improved manure management practices. Systemic changes, such as reducing overconsumption of ruminant meat and dairy products in high-demand markets and promoting alternative protein sources, complement on-farm measures.

Globally coordinated initiatives such as the Global Methane Pledge and regulatory frameworks such as the EU Methane Strategy promote reduction through policy, technology deployment, and monitoring. These combined efforts represent a viable pathway to significantly reduce methane emissions from livestock, contributing to the goals of the Paris Agreement and improving the sustainability of food systems.



Invited lecture

Martin Poulsen

VENTILATION AIR METHANE TREATMENT FOR UNDERGROUND COAL MINES

Keywords: *coal mines, methane treatment technologies, VAM*

Ways how to treat methane will be presented, especially from ventilation air ("VAM") of underground coal mines. Focus will be on technical concept, related total cost approach in relation to climate effect, safety relevant provisions and operational experience. The presentation will include different technologies for VAM treatment including options for combining the technology with heat recovery systems. Example projects from globally installed plants will be shared at executed systems in China, Australia, Poland and United States of America.



Invited lecture

Iva Prgomet Ernst, Tatjana Obučina, Nino Malešić

METHANE EMISSIONS AND NATIONAL INVENTORY REPORTING

Keywords: *agriculture sector, emissions, greenhouse gas, waste sector*

Methane (CH₄), as a potent greenhouse gas, is the second most significant anthropogenic greenhouse gas after carbon dioxide (CO₂), with a global warming potential more than 28 times greater than CO₂ over a 100-year period. It is a key driver of short-term climate change due to its strong but relatively short-lived atmospheric presence.

The European Union has implemented several policies to reduce methane emissions, including the EU Methane Strategy adopted in 2020, which targets key sectors: energy, agriculture, and waste. In Croatia, national legislation is aligned with EU climate policies, including obligations under the Effort Sharing Regulation and the National Energy and Climate Plan (NECP).

According to data from EU greenhouse gas inventories, methane emissions in the EU have been steadily declining, mainly due to improvements in waste management and energy systems. The agriculture sector remains the largest source of methane emissions, followed by the waste and energy sectors.

Data from the Croatian Greenhouse Gas Inventory for the period 1990 – 2023 indicate that the waste sector is currently the largest contributor to methane emissions within the country. This includes emissions from solid waste disposal on land (particularly unmanaged landfills), biological treatment of waste, and wastewater handling. The agriculture sector is the second largest source of methane emissions, the primary sources within this sector are enteric fermentation (a natural digestive process in ruminant animals like cattle) and manure management. The energy sector, particularly fugitive emissions from fossil fuels, ranks third. These emissions primarily come from the extraction, transport, and distribution of oil and natural gas.

Key challenges in reducing methane include implementing best practices in agriculture, transitioning to renewable energy, and improving waste treatment infrastructure as well as improving monitoring systems. Effective stakeholder engagement, adequate financial support, and increased public awareness of methane's climate impact will be essential for ensuring long-term progress. International collaboration through initiatives such as the Global Methane Pledge remains essential to facilitate coordinated global efforts and achieve substantial reductions in methane emissions worldwide.



Invited lecture

Jacek Skiba^{1,2,3}

PREVENTING METHANE EMISSIONS FROM UNDERGROUND COAL MINES

Keywords: *CMM, coal mine methane, mining industry*

The problem of coal mine methane (CMM) emissions, their effective mitigation through capture, and effective utilisation will be presented.

The presentation will be based on practical experience from the mining industry and international research and pilot demonstration projects carried out over more than two decades by Mining Aerology Department of Central Mining Institute-National Research Institute of Katowice GIG-PIB (Poland) as a coordinator and developer in underground hard coal mines.

¹Deputy Chair of the United Nations Economic Commission for Europe Group of Experts on Coal Mine Methane and Just Transition (GoE-CMMJT), Palis de Nations, CH-1211 Geneva 10; Switzerland

²Mining Aerology Department of Central Mining Institute-National Research Institute of Katowice (GIG-PIB), Plac Gwarków 1, 40-166 Katowice, Poland

³Secretary General of World Mining Congress organisation

IUAPPA SESSION





Invited lecture

Sohyun Jeon, Seoyeon Moon, Jihu Lee, **Young Sunwoo**

AN AIR POLLUTION POLICY DILEMMA - OZONE CONCENTRATION CHANGES UNDER AIR QUALITY POLICY IMPLEMENTATION BASED ON NATIONAL CLIMATE CHANGE PROJECTIONS IN KOREA

Keywords: *air pollution modeling, AQ policy integration, urban ozone*

This study aims to quantitatively assess the impact of temperature rise caused by climate change on the effectiveness of air quality policies. To this end, we applied two scenarios to Seoul, South Korea: a 1.5°C temperature increase scenario based on SSP5-8.5, and an emission reduction scenario incorporating the reduction rates of air pollutants (PM_{2.5}, VOCs, SO_x, NO_x, NH₃) presented in the 3rd Comprehensive Air Quality Improvement Plan (2023–2032) of Korea. The goal was to evaluate whether the current air quality policy remains effective under climate change conditions involving temperature rise.

Under the temperature rise scenario (TempUp scenario), the average ozone concentration increased by approximately 1 ppb, while the maximum concentration rose by more than 10 ppb, and the number of exceedances of the 1-hour ozone standard increased by about 75%. In the combined temperature rise and emission reduction scenario (TempUp & EmRed scenario), the average ozone concentration increased by 8.6 ppb, the maximum by 33 ppb, and the number of 1-hour exceedances rose by approximately 2.85 times. In addition, the daily maximum 8-hour average ozone concentration increased from 38.7 ppb to 52.8 ppb, and the number of exceedance days rose from 7 to 12, compared to the base scenario. Notably, the average ozone concentration on exceedance days increased from 72.1 ppb to 77.2 ppb, indicating a heightened risk of exposure to high ozone levels.

A comparison under the same emission reduction conditions showed that the presence of temperature rise leads to increases in average and peak ozone concentrations, as well as exceedance frequency, suggesting that warming may partially offset the effectiveness of current policies.

While this study has limitations such as the undisclosed details of policy implementation, spatial constraints of the study area, and a relatively conservative temperature increase assumption it holds significance in providing a scientific basis for future integrated climate-air quality policy design by quantitatively analyzing the interactions between climate change scenarios and air quality policy.

Acknowledgement: *This study was funded in part by SETI (Social Eco-Tech Institute) of Konkuk University.*

SUPPORTED BY





**INSTITUTE FOR MEDICAL
RESEARCH AND
OCCUPATIONAL HEALTH**

Ksaverska cesta 2,
HR-10000 ZAGREB /
+385 1 46 82 500 /
[http:// www.imi.hr](http://www.imi.hr)



RESEARCH

**PROFESSIONAL
SERVICES**

ACADEMIA

PUBLISHING

UNITS

Division of Environmental Hygiene

Division of Occupational and Environmental Health

Division of Radiation Protection

Division of Toxicology

Animal Breeding Unit

Poison Control Centre

Research Area "Šumbar"

DIVISION OF ENVIRONMENTAL HYGIENE

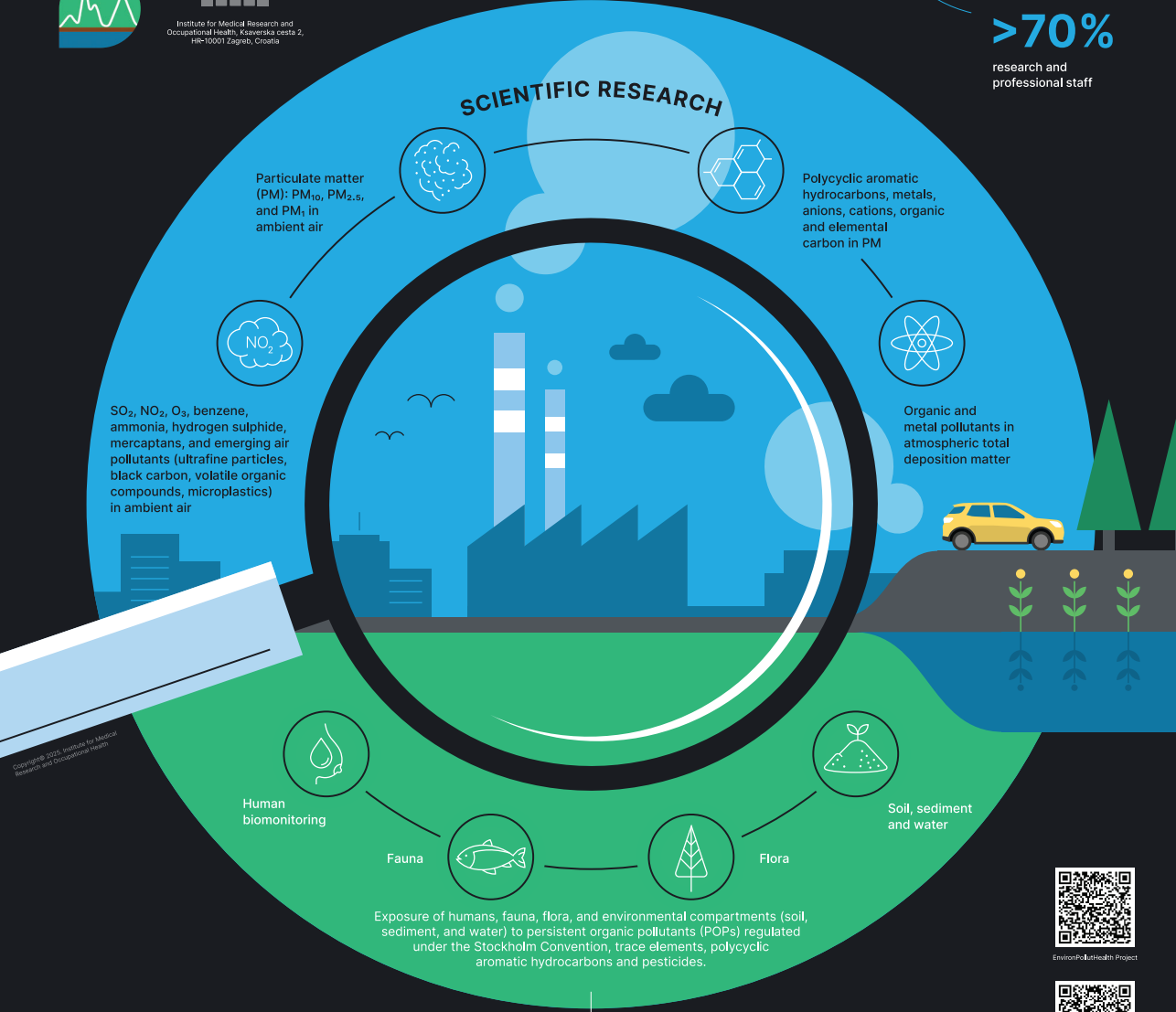


imi
Institute for Medical Research and
Occupational Health, Kašperska cesta 2,
HR-10001 Zagreb, Croatia

MAIN ACTIVITY: Monitoring
and study of pollutants in
environmental and biological
samples, as well as the
development and validation
of analytical methods for
their determination.

>30
staff members

>70%
research and
professional staff



Basic and applied scientific research in the fields of biomedicine and health, biotechnical sciences and natural sciences is carried out within scientific research projects financed by European and national funds and government bodies.



Environmental Health Project



Division of Environmental Hygiene website

PROFESSIONAL SERVICES:

1960 - TODAY
Air quality measurements at the stations of monitoring network of the City of Zagreb

2003 - TODAY
Particulate matter measurements at some of the stations of National Network for Continuous Air Quality Monitoring

2014 - TODAY
National reference laboratory for the determination of particulate matter and its chemical composition

1960

2003

2014

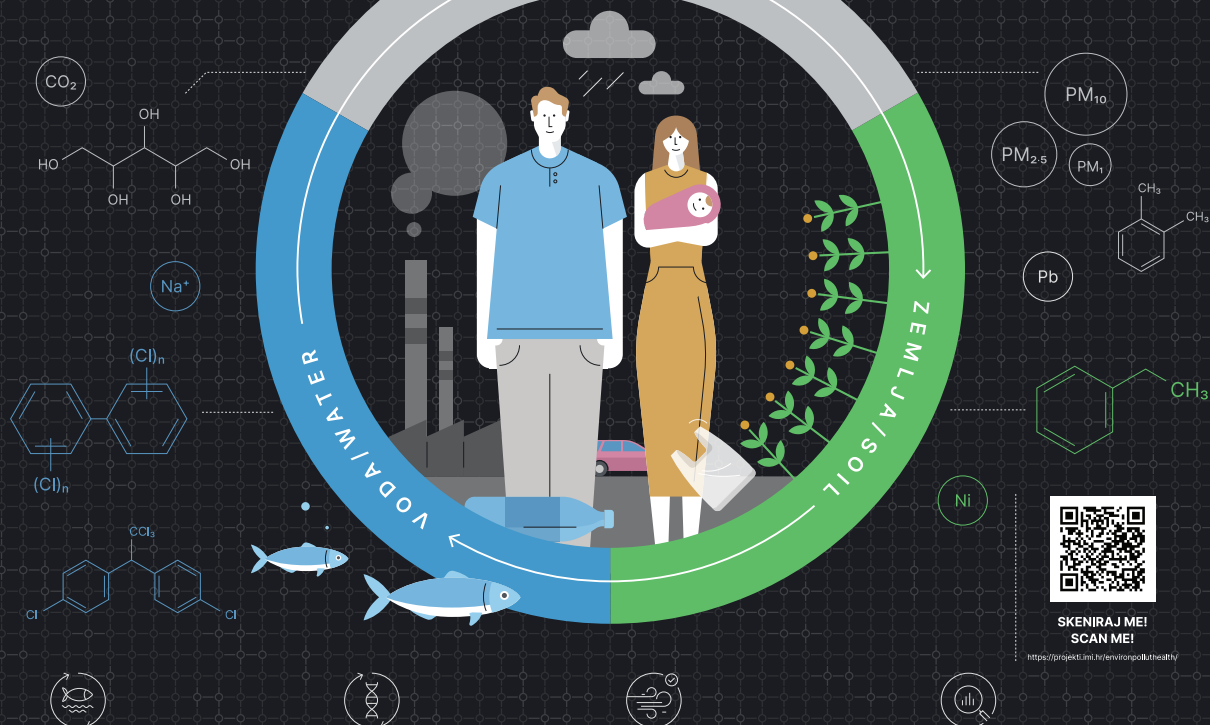
TODAY

The Division is an accredited testing laboratory according to the HRN EN ISO/IEC 17025 standard by the Croatian Accreditation Agency (HAA) in the area described in the annex to the Accreditation Certificate No 1288.

Onečišćenje okoliša i ljudsko zdravlje

Fizikalno-kemijska analiza, toksičnost
i modeli strojnog učenja

Istraživanje onečišćenja zraka i ostalih dijelova okoliša u Hrvatskoj najznačajnijim zagađivačima: policiklički aromatski ugljikovodici, postojana organska zagađivača, pesticidi, teški metali, ljetljivi organski spojevi, dušikov oksidi, sumporov dioksid, ozon, lebdeće čestice aerodinamičkog promjera manjeg od 10; 2,5 i 1 μm (PM_{10} ; $\text{PM}_{2.5}$; PM_1) i njihov sastav; te utjecaja onečišćenja na okoliš i ljudsko zdravlje.



Istraživanje vodenog ekosustava

Slatkovodni okoliš:

Ekotoksikološko modeliranje (in silico) i prostorna raspodjela onečišćenja u riječnom sedimentu jadranskog i dunavskog sljeva
Prostorna raspodjela onečišćenja u različitim ribljim vrstama jadranskog i dunavskog sljeva

Morski okoliš:

Onečišćenje mora i riblje vrste iz akvakulture
Procjena rizika po ljudsko zdravlje usljed konzumacije slatkovodnih i morskih riba

Aquatic Ecosystem Research

Freshwater environment:

- Ecotoxicological modeling (in silico) and spatial distribution of pollution in river sediments of the Adriatic and Danube basins
- Spatial distribution of pollutants in various fish species from the Adriatic and Danube basins

Marine environment:

Marine pollution and aquaculture fish species
Health risk assessment from consuming freshwater and marine fish

Humani biomonitoring

Određivanje zagađivača u ljudskom mlijeku i procjena izloženosti ljudi
Procjena rizika za zdravlje dojenčadi
Određivanje međusobnog odnosa zagađivača u ljudskom mlijeku i njihove ovisnosti o drugim varijablima (dob i broj poroda) metodom strojnog učenja

Human Biomonitoring

Determination of pollutants in human milk and assessment of human exposure
Health risk assessment for infants
Determining the interrelationship of pollutants in human milk and their dependence on other variables (age and number of births) using machine learning methods

Kvaliteta zraka

Lebdeće čestice u zraku i njihov fizikalno-kemijski sastav
Utjecaj različitih klimatskih i meteoroloških ekstrema, pustinjske prašine te požara na onečišćenje zraka i ljudsko zdravlje
Kvaliteta unutarnjeg zraka
Kruženje onečišćujućih tvari u zraku, ukupnoj taložnoj tvari i tlu
Određivanje glavnih izvora onečišćenja, čimbenika rizika i predviđanja koncentracija primjenom modela strojnog učenja

Air Quality

Airborne particulate matter and their physicochemical composition
The impact of various climate and weather extremes, desert dust, and wildfires on air pollution and human health
Indoor air quality
Cycling of pollutants in the air, total deposited matter, and soil
Identifying major pollution sources, risk factors, and predicting concentration levels through machine learning methods

Analitičke metode i primijenjena istraživanja

Razvoj novih analitičkih metoda za nedovoljno istražene tvari kao što su ultrafine čestice (promjera < 100 nm), crni ugljik, mikroplastika, specifični ljetljivi organski spojevi i derivati policikličkih aromatskih ugljikovodika
Primijenjena istraživanja: senzori za kvalitetu zraka, agroekologija

Analytical Methods and Applied Research

Development of new analytical methods for insufficiently studied substances such as ultrafine particles (diameter < 100 nm), black carbon, microplastics, specific volatile organic compounds, and derivatives of polycyclic aromatic hydrocarbons
Applied research: air quality sensors; agroecology

PARTNERI PROJEKTA / PROJECT PARTNERS:

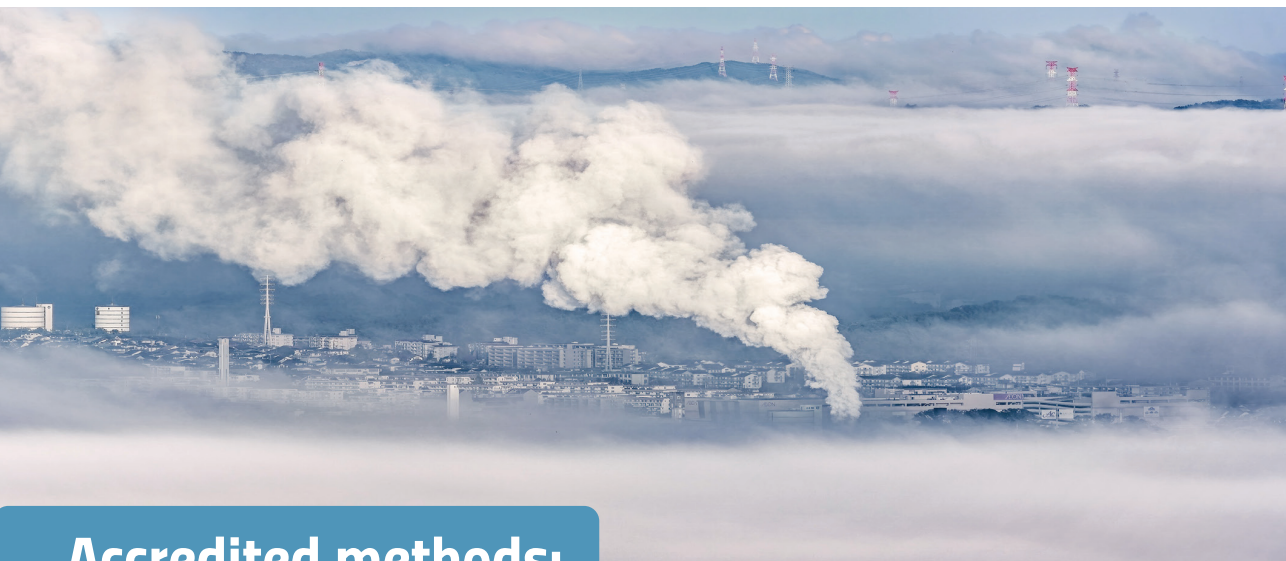
Division of Environmental Hygiene



Monitoring and study of pollutants in environmental and biological samples and the development and validation of analytical methods for their determination.

Activities related to air quality:

- Air quality measurements
- Development and testing of measuring methods
- Modeling of exposure and risk levels
- Assistance in the preparation and elaboration of legal regulations and norms
- Testing laboratory licensed by the Ministry of Economy and Sustainable Development for performing air quality monitoring activities
- Reference laboratory for determining the mass concentration and chemical content of PM_{10} and $PM_{2.5}$ fractions of particulate matter



Accredited methods:

- HRN EN 12341:2023
- HRN EN 14212:2025
- HRN EN 14625:2025
- HRN EN 14211:2025
- HRN EN 14626:2025
- HRN EN 14902:2007; HRN EN 14902/ AC:2007
- HRN EN 16909:2017
- HRN EN 15549:2008
- HRI – CEN/TR 16269:2017
- VDI 4320 Part 2:2012
- HRS CEN/TS 16645:2016
- HRN EN 15841:2010
- In-house method OP-610-UTT-TI
- HRN EN 16913:2017



INSTITUTE FOR MEDICAL RESEARCH AND OCCUPATIONAL HEALTH
Ksaverska cesta 2, HR-10000 ZAGREB / +385 1 46 82 500 / [http:// www.imi.hr](http://www.imi.hr)



DRŽAVNI HIDROMETEOROLOŠKI ZAVOD
CROATIAN METEOROLOGICAL AND HYDROLOGICAL SERVICE

ADVANCING LIVES THROUGH THE POWER OF SCIENCE

since 1947

- ✓ Meteorology
- ✓ Hydrology
- ✓ Air Quality
- ✓ Scientific research

Reliable data at your fingertips!
Scan to explore meteo.hr





TD100-xr – PFAS pod kontrolom

TD100-xr donosi slobodu i produktivnost u vaš laboratorij. Automatizirani sustav za termalnu desorpciju omogućuje analizu do 100 uzoraka bez prekida te pouzdani rad i dok vi niste u laboratoriju. Zahvaljujući prekoncentraciji hlapljivih i poluhlapljivih organskih spojeva (VOC i SVOC), TD100-xr idealan je za praćenje kvalitete zraka, emisija iz materijala i okolišnih uzoraka, uključujući i detekciju PFAS spojeva u zraku.

Kriogen-free tehnologija električnog hlađenja skraćuje cikluse i uklanja rizik začepljenja, dok podrška za helij, dušik ili vodik štiti od nestašica plina i smanjuje troškove. Od tragova u ppt do visokih koncentracija, VOC-ovi i SVOC-ovi (C3–C44) detektiraju se s vrhunskom preciznošću, uz automatsku re-kolekciju te integriranu provjeru curenja za maksimalnu sigurnost i pouzdanost rezultata.



MARKES
international

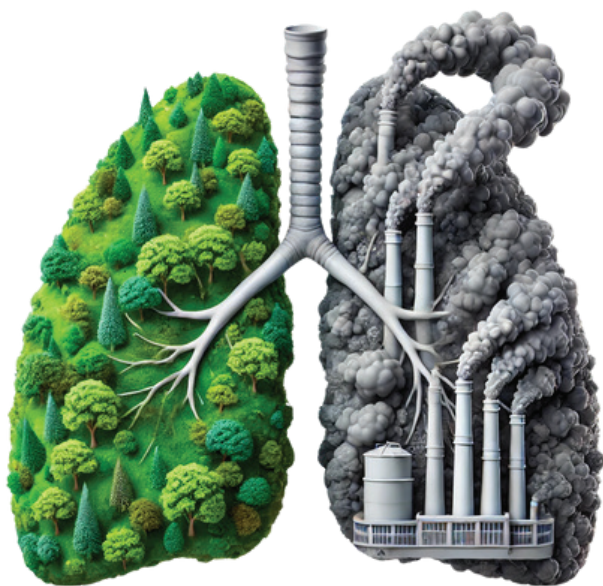
Altium International d.o.o.

Karlovačka cesta 24, Blato
HR-10000 Zagreb, Croatia

info.hr@altium.net

prodaja.hr@altium.net

www.altium.net | www.alphachrom.hr



Airanalysis

TECHNOLOGY TOOLBOX



Za čišći zrak i zdraviju budućnost

S ponosom podržavamo konferenciju

Zaštita zraka 2025

i zajednički radimo na boljoj kvaliteti zraka za sve.

Inovacije – Održivost – Pouzdanost

www.kobis.hr | info@kobis.hr | 01 6545 742

sensees

Sustav za praćenje
kvalitete vanjskog zraka

From sensing to truly seeing environmental data.



 **smartsense**

smart-sense.hr

mysensees.com

T +385 1 34 57 969 | labomar@labomar.hr | www.labomar.hr



- Air sampling pumps
- Sorbent tubes
- Sampling heads
- Particulate monitors
- Filters & cassettes
- Passive samplers
- Gas sample bags
- Calibrators
- Gas detection tubes
- Environmental sampling



- Portable gas detectors
- Personal gas detectors
- Fixed gas detectors
- Semi-portable gas detectors
- Calibration



- Low volume / medium Volume sampler EN 12341
- Automatic sequential sampling system PNS T-DM EN 12341
- Air pollution monitor
- Manual weighing system for the gravimetric assessment of sampling filters
- Automatic weighing system for the gravimetric assessment of sampling filters

METTLER TOLEDO



Laboratorijske vage serije MX

Pametne značajke za najzahtjevnije primjene

Ugrađene funkcije za osiguranje kvalitete jamče stalnu dostupnost i valjanost vaših rezultata te pomažu zadovoljiti veće zahtjeve za točnošću, sukladnošću i učinkovitošću.

► www.mt.com/new-lab-balances



Sve za Vaš laboratorij na jednom mjestu!

BIOVIT d.o.o. distribuira visokokvalitetne proizvode renomiranih proizvođača namijenjenih za upotrebu u medicini, laboratorijskoj dijagnostici, industriji i znanstveno-istraživačkim ustanovama.

- Kemikalije i reagensi za različite laboratorijske primjene
- Laboratorijski potrošni pribor
- Laboratorijska oprema
- Osobna zaštitna oprema

MERCK

Honeywell

fisher scientific
part of Thermo Fisher Scientific

BLDpharm

ROTH
CARL

LGC





EKONERG

Institut za energetiku i zaštitu okoliša

Ispitni laboratoriji:

- laboratorij za praćenje kvalitete zraka
- laboratorij za mjerenje emisija

Umjerni laboratorij:

- analizatori za kvalitetu zraka i emisije u zrak

Laboratorij za ispitivanje sposobnosti:

- ispitivanja kvalitete zraka i emisija u zrak

Referentni laboratorij RH za plinovite onečišćujuće tvari



www.ekonerg-laboratorij.com



PUBLISHER



CROATIAN AIR POLLUTION PREVENTION ASSOCIATION
Ksaverska cesta 2, Zagreb