4th Symposium

Air Quality and Health
Book of Abstracts

Wrocław, 03-05.07.2023

ORGANIZERS

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The Project "Do you know what you breathe?" – educational and information campaign for cleaner air LIFE-MAPPINGAIR/PL is financed with means of the European Union under the LIFE Financial instrument and co-financed by National Fund for Environmental Protection and Water Management

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Editors:
Magdalena Korzystka-Muskała, Joanna Kubicka,
Tymoteusz Sawiński, Anetta Drzeniecka-Osiadacz

University of Wrocław, 2023

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Preface

In recent years, air pollution has been recognized as one of the most important environmental threats. It is not surprising, because it turns out that about 7 million people die prematurely every year in the world from illnesses attributable to them. It should also be remembered that the deterioration of air quality causes a reduction in biodiversity, as well as the degradation of other environmental values, and many compounds identified as key airborne pollutants affecting the climate of our planet.

Despite the seriousness of the problem, recently the fight against air pollution in our country has been very difficult. First, the COVID-19 pandemic putted it aside, further weakening the health and immunity of the society. Then, the war in Ukraine and the resulting disturbances on the energy carrier markets caused many unfavourable phenomena that could directly and indirectly affect air quality. The increase in fuel prices and the resulting sense of threat became a pretext for a temporary liberalization of the energy market, for example by allowing low-quality fuels to be traded. The provisions of some anti-smog resolutions have also undergone unfavourable changes.

However, the current situation can be treated as an opportunity, as changes in the fuel market in the last heating season have clearly shown that relying on traditional energy carriers will not ensure our permanent security. Meanwhile, ecological solutions can help to successfully face real problems and provide warmth in our homes.

In these circumstances, the fourth edition of the Scientific Conference "Air Quality and Health" is being organized, carried out as part of the Project "Do you know what you breathe?" – educational and information campaign for cleaner air, LIFE-MAPPINGAIR/PL. The conference is organized jointly by the University of Wrocław, the Wrocław University of Technology and the City of Bydgoszcz - partners of the LIFE-MAPPINGAIR/PL project together with the Medical University in Wrocław, the Institute for Territorial Development and the European Clean Air Centre foundation.

Traditionally, our conference has been conceived as a platform for the exchange of experiences, connecting the scientific community, institutions dealing with air quality issues, national, regional and local authorities, non-governmental organizations and environmental educators.

As in previous editions, the conference will cover issues related to air pollution - their emission, dispersion and deposition, as well as the impact on human health and life, environmental education and legal aspects of activities related to improving air quality. This year, the main topic of the conference also included issues related to bioaerosol - very important from the social perspective, especially in the conditions of intensifying climate change.

The issues presented above were reflected in the presentations submitted to the conference, including 51 oral presentations and 32 posters. I am pleased to invite you to read their summaries, collected in this volume.

Tymoteusz Sawiński
Chair of Organizing Committee
Of the Conference

Part I
Oral presentations

Impact of air pollutants on aeroallergens

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KEY WORDS: pollution, allergy, pollen grains, fungal spores, allergens

Air pollution is a significant global health risk factor. Exposure to air pollution is associated with the development and exacerbation of allergic respiratory disease (Brandt et al., 2015). Various air pollutants, including sulfur dioxide (SO_2), nitrogen oxides (NO_x), and ozone (O_3), can directly or indirectly impact human health by modifying allergy triggers, such as aeroallergens (inhalant allergens). The combined exposure to air pollutants and aeroallergens can synergistically affect allergic reactions (Anenberg et al., 2020).

Pollen-producing plants and fungal spores serve as the primary sources of outdoor aeroallergens. These airborne particles carry allergenic proteins that are released upon contact with mucosa or due to rupture in the ambient air (Suanno et al., 2022). The qualitative and quantitative characteristics of allergens can be altered by the presence of air pollutants. Studies have demonstrated that air pollutants can modify allergen structure through processes such as nitrosylation, oligomerization, oxidation, and acidification (Senechal et al. 2015). Exposure to ozone and nitrogen dioxide can alter the molecular structure of certain allergens and change the IgE-binding affinity of these allergens. Moreover, pollen exposed to high levels of pollution has shown increased expression of allergenic proteins, particularly from the pathogenesis-related protein family, resulting in elevated amounts of allergens and increased allergenicity of pollen (Midoro-Horiuti et al., 2001). Apart from directly affecting aeroallergens, air pollutants may also impact plant and pollen development (Senechal et al. 2015).

Overall, air pollution exerts a detrimental impact on aeroallergens and consequently contributes to the prevalence of allergic respiratory diseases. To enhance allergy management strategies, these factors should be integrated into a unified system of air quality monitoring, which simultaneously measures anthropogenic air pollutants and aeroallergens.

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Institute Environmental Protection – National Research Institute role in supporting activities for Health Impact Assessment

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KEY WORDS: air quality, climate change, health, risk, assessment

Since air pollution and climate change are now one of the most significant health hazards, there is a sufficient scientific basis to justify developing approaches to incorporate epidemiological assessment into the health-related risk. **H**ealth **I**mpact **A**ssessment (HIA) and **H**ealth **R**isk **A**ssessment (HRA) concepts and **D**riving force – **P**ressure – **S**tate – **E**xposure – **E**ffect - **A**ction (DPSEEA) framework are the basis of a practical approach adopted by Institute of Environmental Protection – National Research Institute (IEP-NRI) to judge the potential health effects of a policy, programme or project focused on a general population and vulnerable groups. Both concepts and DPSEEA framework shows the link between exposures (e.g, to air pollution or phenomena and climate threats) and health effects as determined by many different factors operating through a chain of events, and clearly shows the many entry points for interventions (WHO, 9199, 2001, 2021; Hambling et al. 2011; Tavoos et el. 2021).

Within this framework, the **driving forces** refers to the factors which motivate and push the environmental processes involved like population growth, technological and economic development and policy intervention. The driving forces result in the generation of **pressures on the environment** (e.g. air pollutants emission including greenhouse gases). These are normally expressed through human occupation or exploitation of the environment, and may be generated by all sectors of economic activity, including mining and quarrying, energy production, manufacturing, service industries, transport, agriculture and forestry. Identification of driving forces and estimation of pressure volume takes place in National Centre for Emissions Management (KOBiZE) operating in the IEP-NRI.

In response to these pressures, the **state of the environment** is often modified. The changes involved are complex and far-reaching, affecting almost all aspects of the environment. Many changes are intense and localised and often concentrated close to the source of pressure (e.g. urban air pollution). Many others are more widespread, contributing to regional and global environmental change (e.g. climate change). When people are exposed to these environmental hazards, then risks to health may occur. Environment ambient population **exposure** refers to the quantity of the pollutant or climate risk at the interface between the recipient and the environment and is measured based on combination monitoring and different modelling techniques. The amount of any given pollutant that is absorbed is often termed the absorbed dose, and may be dependent on the duration and intensity of the exposure. Environmental assessment and level of exposure takes place in many IEP-NRI unites, mainly in Integrated Environmental Research and Sustainable Development Centres.

Exposure to environmental hazards, in turn, leads to a wide range of health **effects**. These may vary in type, intensity and magnitude depending upon the type of hazard to which people have been exposed, the level of exposure and the number of people involved.

Therefore, in order to correctly quantify and qualitatively assess the health effects associated with exposure to environmental stressors, in particular related to air quality and climate change, high-quality and spatial resolution data developed in the IEP-NRI in the chain Driving force - Pressure - State - Exposure framework are of key importance.

Based on developed and adapted to Polish conditions statistical methods and advanced models in IEP-NRI, is possible preparing science based knowledge recommendations and measures proposals for decision-makers and stakeholders, with the aim of maximizing positive health effects and minimizing environmental negative impact on health.

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Relationship between concentrations of selected gaseous air pollutants and quality of life in patients with bronchial asthma

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INTRODUCTION:

It is generally known that one of the adverse effects that air pollution causes in asthmatic patients is the decrease of health related quality of life (HRQoL), nevertheless the results of the actual measurement clarifying the interaction between air pollution and HRQoL are still scarce. This knowledge gap has a negative impact on air quality management, especially in the case of vulnerable groups whose well-being should be protected by air quality standards.

AIM OF STUDY:

The aim of the study was to estimate the potential impact of selected gaseous air pollutants (NO, NO_2, NOx, SO_2, CO) on HRQoL of asthma patients.

MATERIALS AND METHODS:

The study was conducted in Krakow, one of the cities in Europe where air quality standards, especially in winter, are most often exceeded.). The group of 300 individuals with partially controlled asthma was recruited by medical doctor and the data from the fixed-site monitors were used to assessed their exposure level in the place of residence. As a standardised tool to measure the health related quality of life we used the Asthma Quality of Life Questionnaire (AQLQ).

RESULTS:

The statistically significant adverse effect on HRQoL was found in the case of nitrogen oxides (NO, NO_2, NOx) of which the concentrations exceeded the values that could be seen as an moderate level of exposure. Most of these affect all domains of AQLQ (symptoms, emotional function, environmental stimuli, activity limitation). For gases with concentrations that do not usually exceed the values set as air quality standards (SO2, CO), the results are inconclusive.

CONCLUSIONS:

Our studies have shown that concentrations of gaseous air pollutants, which tend to exceed air quality standards, negatively affect not only the respiratory function of people with asthma, but also their quality of life. This should be taken into account when developing environmental health policies, aimed at protecting the health of vulnerable groups.

This research was financed by the grant of the Polish National Science Centre no. DEC-2011/03/BNZ7/00644

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The association between the concentration of particulate pollutants ($PM_{2.5}$ and PM_{10}) in the air and health outcomes relevant to asthma control

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INTRODUCTION:

Particulate matter (PM) has the most damaging effects on human health among all air pollutants. This is especially true for members of vulnerable groups. It seems that health of people with asthma should be strongly effected, however, the results of previous studies on the association of air concentrations of particulate matter (PM) with health outcomes, such as impaired pulmonary function, symptom frequency, and medication use are inconsistent.

AIM OF STUDY:

The goal of our study was to increase knowledge about the relationship between these health effects, that are important for asthma self-management or control, and recent concentrations of fine ($PM_{2.5}$) and coarse (PM_{10}) particles in the air.

MATERIALS AND METHODS:

We conducted our study in one of the most polluted cities in Europe. The novelty of this study was the inclusion of a homogeneous group of patients with diagnosed and controlled asthma. Patients recorded their symptoms, inhaler use, and peak expiratory flow (PEF) measurements in a diary for two weeks. Data on particulate air pollution were obtained from stationary monitoring stations.

RESULTS:

We have shown that particulate pollutants, both PM_{10} and $PM_{2.5}$, significantly affect the deterioration of respiratory function (PEF), the frequency of early asthma symptoms, as well as the asthma quick-relief inhaler use. Moreover, these effects are observed not only on the day of exposure, but also on the following day.

CONCLUSIONS:

Negative effect of air pollution is observed during the day of exposure and during the following day. However, the air quality from two days ago does not seem to affect asthma patients anymore. Easily obtainable information on local real-time levels and forecasts of particulate matter air pollution are crucial for proper asthma self-management.

This research was financed by the grant of the Polish National Science Centre no. DEC-2011/03/BNZ7/00644

The influence of COVID-19 pandemic on deposited dose of outdoor particulate matter in human respiratory tract: a case study from Krakow, Southern Poland

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ABSTRACT

High air pollution is still observed in many Polish cities especially during wintertime. The PM_{10} concentration in Krakow was lowering by about 50% during the last decade. The restrictions in the activity connected to COVID-19 pandemic also has influence on the level of particulate matter pollution. The aim of this study was to present the hourly variations of mass concentrations of different size fractions of airborne particulate matter (APM) as well as the hourly deposited dose of particles in human respiratory tract (HRT). The main point of the presented results was to show assessments of dose for the year 2019 (before pandemic) and 2022 (during pandemic) in Krakow, Poland. Hourly particle mass data of 10 size fractions of APM were collected in 2019 and 2022. Hourly deposited dose for particle mass was determined by dosimetry model ExDoM2 for male adults. Three peaks of particle mass hourly deposited doses were observed in the morning (6-9) at noon (12-14) and in the evening (17-21) for fine and coarse fractions. The hourly deposited dose in human adult male respiratory tract was in the range of 0.4 to 3.5 µg for fine fraction. The main difference in hourly dose in the tracheobronchial region and in the alveolar–interstitial region calculated for 2019 and 2022 was in the morning (6-9). For the year 2022 hourly dose was higher than for 2019. Hourly dose of coarse mass was higher in extra thoracic airways in 2022 than 2019, specially during higher activity. It was in the range 2-10 µg. Higher hourly deposited dose in mass were in the year 2022, compared to 2019 for fine fraction. Lower value of dose was in 2022 than in 2019 for coarse fraction. The total dose received by male adults was lower in 2022 than in 2019, especially in the morning, noon and in the evening.

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Ultrafine particles (UFP) – recent trends and regulatory activities

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KEY WORDS: Ultrafine Particles, Particle Number Concentration, Particle Size Distribution, Monitoring

For many years, mass-based particulate matter PM2.5 and PM10 measurements have been standardized (DIN EN 12341:2014) for the regulatory quantification and monitoring of particles in ambient air. However, recent studies reported that ultrafine particles, which are defined as particles equal or smaller than 0.1 µm, seem to be a better indicator of harmful air pollution in urban areas. Therefore, the measurement of the particle number concentration (PNC), which is most representative of ultrafine particles (UFP) has gained much interest and importance.

Reports such as Leipzig Environmental Zone from 2017 focusing on UFP and their harmful effects that have been made publicly available helped spread the word on the relevance of UFP monitoring. In 2019, a team of experts summarized the current knowledge on UFPs in a white paper on ambient ultrafine particles (Cassee et al., 2019). This report has been cited by the World Health Organization in the WHO Global Air Quality Guidelines published in September 2021. For the first time, these guidelines mention the need to expand the common air quality monitoring networks by integrating UFP measurements. It recommends to include size-segregated particle size distributions (PSD) and real-time PNC measurements in addition to simultaneous measurements with other airborne pollutants and characteristics of PM.

In order to harmonize and standardize these measurements, the European Committee for Standardization (CEN) has published the technical specification CEN/TS 16976:2016 for PNC measurements in ambient air using a Condensation Particle Counter (CPC). Based on it, a German standard DIN EN 16976 'Ambient air Determination of the particle number concentration of atmospheric aerosol' is currently being finalized. In addition, the CEN/TS 17434 technical specification for measuring the particle size distribution of ambient air by Scanning Mobility Particle Sizers (SMPS, or 'Mobility Particle Sizer Spectrometer', MPSS, in regulatory terms) was published in 2019.

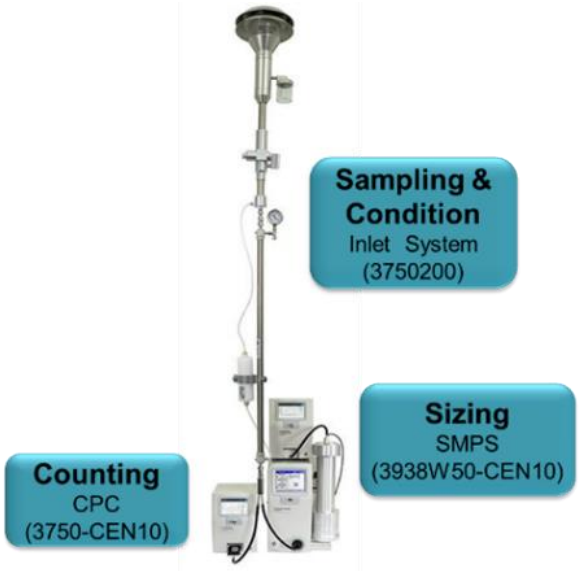

Fig. 1 CEN-compliant solution for UFP measurements of PSD and PNC including the dedicated sampling system.

Finally, the proposal for a Directive of the EU Parliament and of the Council on ambient air quality and cleaner air for Europe (COM/2022/542 final) was published in October 2022. The intention of this document is to align EU air quality standards much more closely with WHO the aforementioned recommendations.

Against the background of all these regulatory activities, we present the technical solution for reproducible sampling, conditioning and measurement of UFP as well as the necessary data handling. The complete measurement solution from TSI (see Fig. 1) is compliant with the aforementioned CEN technical specifications and it meets requirements of the ACTRIS European Research Infrastructure Consortium.

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Dane satelitarne w monitorowaniu składu chemicznego atmosfery – szacowanie emisji NO_x ze źródeł punktowych

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KEY WORDS: nitrogen oxides, emission variability, emission inventory, TROPOMI

ABSTRACT

Satellite data play an important role in monitoring the atmosphere by providing information on its chemical composition on a regional and global scale. Suffice it to mention the contribution of satellite data to the discovery and monitoring of the ozone hole phenomenon. However, the poor spatial resolution of these data has significantly limited the possibility of using them to detect and inventory sources of gas emissions, including greenhouse gases and/or sources of atmospheric pollution. Operational availability of Sentinel-5P/TROPOMI level-2 products provided an unique opportunity to study atmospheric composition with spatial resolution of 3.5x7km (3.5x5.6km since August 2019). This allows for better detection and estimation of NO_2 emission from point emitters using satellite data.

Sentinel-5P/TROPOMI NO_2 tropospheric column content data were used to estimate the NO_x life time and the emission from selected large point sources (power plants) located in Poland applying two developed methods: background 5 percentile (BM5) and search streak (SSM) ones.

The calculations were performed for five selected power plant point emitters for selected meteorological conditions (temperature, cloudiness, wind and circulation type), what enabled to decrease the influence of long-distance transport as well as the emission from other sources. The satellite derived NOx emission values were compared with E-PRTR data and the measurements performed at the power plants using infrared absorption method.

Moreover, the error analysis for both methods was performed. The obtained results indicated that the actual emission from point emitters is overestimated by satellite derived one and the accuracy of the SSM method was slightly better for almost all analysed emitters.

The methodologies as well as the obtained results will be presented and discussed.

Spatial differentiation of air pollution with particulate matter PM_{10} in winter in the area of Krakow against the background of atmospheric circulation conditions

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KEY WORDS: particulate matter PM10, Kraków area, atmospheric circulation

The main aims of the research are: 1) understanding the spatial diversity of air pollution with PM10 in winter in the area of Krakow, 2) indicating baric situations in which high PM10 values occur. The average daily values of particulate matter in the period from December to February at eight measuring stations located in Krakow in 2016-2022 (2017-2022 for Wadów, 2019-2022 for Swoszowice) were analyzed. Measurement data was taken from the GIOŚ website. The following were examined: average value of particulate matter during winter, average number of days with a value of > 50 µg/m^3, number of days for the alert level (> 150 µg/m^3). The dependencies of the average value of PM10 and values above the norm on the relative height of the measuring point, its distance from the city center and the direction of location relative to the center were analyzed.

Mean PM10 concentration during the winter period ranges from 47 µg/m^3 (Swoszowice, Wadów) to 66 µg/m^3 (al. Krasińskiego). The maximum values exceeded 300 µg/m^3. The number of days with values above the average daily norm ranged from 31 in Wadów (at the station located the furthest from the center) to 47 at al. Krasińskiego (in the center of Krakow). Three stations recorded values exceeding the norm for more than 35 days during the winter. The alert level was recorded on average for 2-4 winter days, with a maximum at Krasińskiego Avenue and Bujak Street, south of the city center. The longest sequence of alarm values was recorded on 27.01.2017. to 3.02.2017. (8 days). The average PM10 value for winter and the number of days with PM10 > 50 µg/m^3 show a negligible inverse relationship with the distance from the city centre (r = -0.67; n=8) and the relative height of the measuring point (r= -0.45; n=8). No dependence of the PM10 value on the direction of station location relative to the center was found. 86% of cases with PM10 alarm values occurred in an anticyclone situation. 63% of these cases occurred when a high-pressure wedge or anticyclone with an advection from the southwest or west over southern Poland were observed.

There is a fairly significant variation in the values of PM10 particulate matter in winter in the area of Krakow. However, the dependencies of PM10 characteristics on the distance from the city center and the relative height of the measuring point are weak.

Preliminary studies on the emission of selected atmospheric pollutants from self-heating coal waste landfills

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KEY WORDS: self-heating, coal waste dumps, atmospheric pollutants

Hard coal mining landfills are an inevitable element of the landscape of highly industrialized regions, such as Upper Silesia. The stored rocks, due to the content of organic carbon, are reactive and undergo several transformations over time. Among them, the process of spontaneous heating of waste is particularly dangerous (e.g. Drenda et al. 2007; Misz-Kennan, Fabiańska, 2010; Fabiańska et al., 2017, Różański, 2018).

Emission of a wide range of substances into the atmosphere as a result of self-heating has only recently begun to be recognized as a significant environmental and health problem (e.g. Fabiańska et al., 2018; Munawer, 2018; Li et al., 2021). Research to date has focused mainly on gases (e.g. Fabiańska et al., 2013; Kruszewski et al., 2018, 2020; Wasilewski, 2020). Little is known about the extent of the composition and migration of volatile organic compounds and substances adsorbed on dust, and the transformations they may undergo during such migration, and hence our knowledge of their impact on the environment is limited.

Three measurement campaigns were carried out at the landfill in the north-western part of the city of Bytom, taking into account: concentrations of particulate matter (PM_{10}, $PM_{2.5}$, PM_1), selected gases (e.g. CO_2, H_2S, TVOC, etc.), samples of nanoparticles were taken and their amounts in the environment were determined. Suspended particulate matter samples were collected for further testing in stationary laboratories. After a preliminary analysis of the results, it was found that the concentrations of suspended particulate matter were significantly exceeded. The recorded values are on average 10224 µg/m³ for PM_{10}, 1930 µg/m³ for $PM_{2.5}$, and 5590 µg/m³ for PM_1. The highest measured value was 152492 µg/m³ for PM_{10}, exceeding the standard more than 150 times. According to the Air Quality Index, air quality is very bad and harms health (GIOŚ, 2023).

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Waste fires in Poland – magnitude and range of impact on atmosphere

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KEY WORDS: landfill fire, atmospheric dispersion, range of impact, environmental impact assessment

Pollutants emitted into the atmosphere during fires are a threat of special concern since they can be transported over a long distance. Mechanisms in the atmosphere can dilute or concentrate pollutants. In general, models of atmospheric dispersion are based on long-term measurements of meteorological parameters; however, fire, as a spontaneous phenomenon does not obey "average" meteorological conditions, and dispersion needs to be modeled with more specific data. Analysis of the data shows that landfill fires constitute a significant share of the largest fires in Poland (Bihałowicz et al. 2021a, Bihałowicz 2022a). The study provides spatial analyses performed using geographic information system (GIS) software on the landfill fires in 2018 in Poland. The composition and amount of substances emitted in landfill fires are site-specific, while during all waste fires, particulate matter is emitted (Bihałowicz et al. 2021a). Hence the study copresence simulations of PM10 dispersion in atmospheric air from the 79 biggest waste fires that took place in 2018 in Poland. The dispersion of PM was evaluated using HYSPLIT simulations based on meteorological data observed during the fire. The total emission was evaluated based on the data of the State Fire Service in Poland (KG PSP 2020) according to the methodology provided by (Bihałowicz et al. 2021a). During the simulations, the range and area of impact of each fire were determined after processing HYSPLIT results in GIS software as described in (Bihałowicz et al. 2021b, Bihałowicz 2022b). The range and area are related by elemental mathematical functions only for low concentrations; hence both of them are required to evaluate the impact of fire on the atmosphere. The result of 79 simulations showed that pollutants from waste fires are typically transported in a different direction from the usual direction of winds in Poland (usually opposite direction). The results also showed that waste fires contribute to the transboundary transport of pollutants and cause increases in concentration on the European scale (Bihałowicz et al. 2021b, Bihałowicz 2021c).

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Application of field olfactometry in the identification of fugitive odour emission sources in municipal waste management facilities

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KEY WORDS: odour emission sources, field olfactometry, IDW

INTRODUCTION

Waste treatment processes are one of the major sources of odorous emissions into the air. Due to the very often, unorganized, and variable and dependent on meteorological conditions and the fractional composition of waste, the nature of emissions, field olfactometry is considered as an optimal odour concentration measurement method, both for economic reasons and allowing rapid assessment of the variability of odour concentrations in time and space, for the complex profile of odour emissions. (Byliński et al., 2016, Pawnuk et al., 2023). The odour concentration values obtained from measurements using field olfactometry can also be used to analyse the time and spatial distribution of the odor impact range.

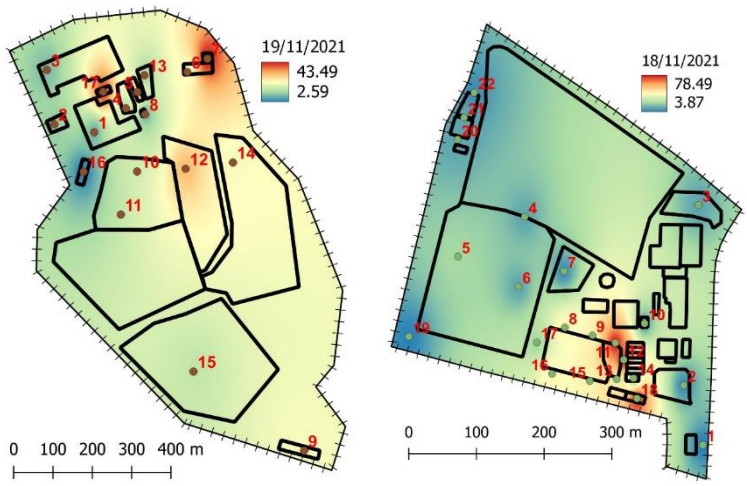

Figure 1. Examples of spatial distribution of odour concentrations (ou/m3) for WMP1 (Fig 1 a – on the left) and WMP2 (Fig 1 b – on the right).

RESEARCH AREA AND PRELIMINARY RESULTS ANALYSIS

Studies using field olfactometry were conducted in two waste management facilities (WMPs) located in the Pomeranian (WMP1) and Lower Silesian (WMP2) provinces. During the measurements conducted, we identified, respectively, composting piles (WMP1) and aerobic stabilisation area (WMP2) as dominant sources of odour emissions. In WMP1, the highest odour concentrations were recorded in composting piles in the range of 22.27 up to 43.49 ou/m^3. Odour concentrations at 4 points located around the aerobic stabilisation area (WMP2) valued at 43.49 ou/m^3. In addition, the use of the inverted weighted distance (IDW) method allowed spatial visualisation of the distribution of emission sources and determination of the variability of odour concentrations in the area of the analysed plants - selected examples of distributions for WMP1 and WMP2 (Fig. 1). The obtained results indicate the existence of clear trends in the measured concentrations of odours, e.g., increased concentrations occur in places where there is a large concentration of organic waste.

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Distinct differences in atmospheric aerosol optical properties within boundary layer in Polish cities

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KEY WORDS: atmospheric boundary layer, air pollution, atmospheric aerosol, Mie-Raman lidar

In general, the atmospheric boundary layer (ABL) being the closest to the Earth surface is regarded as containing the majority of air pollution, which can spread across the entire layer. *In situ* measurements with instruments localized close to the ground surface in a dense web of devices give the 2-dimensional structure of horizontal pollutants dispersion. Information about the vertical structure of the ABL in terms of pollutant distribution can be obtained using the high spatial and temporal resolution of active remote sensing measurements (Stachlewska, 2021).

We present the results of the lidar data analysis in terms of the vertical structure of air pollution within ABL. The data were collected during the POLIMOS SMOG Campaigns conducted in winter season in Wrocław (2022), Kraków (2022), and Zabrze (2021) with the ESA Mobile Raman Lidar (EMORAL). The gradient method was used to obtain the height of ABL for 24 hours of measurements during similar meteorological conditions in each city (Figure 1). The synergistic Lidar, Radar, Microwave Radiometer algorithm (LiRaMi) was used to estimate the abundance of aerosol in ABL, their size and shape. The *quasi* scattering ratio $^{quasi}SR$, color ratio $^{quasi}CR$, and particle depolarization ratio $^{quasi}\delta_p$ at 532 nm were used respectively (Wang et al., 2020).

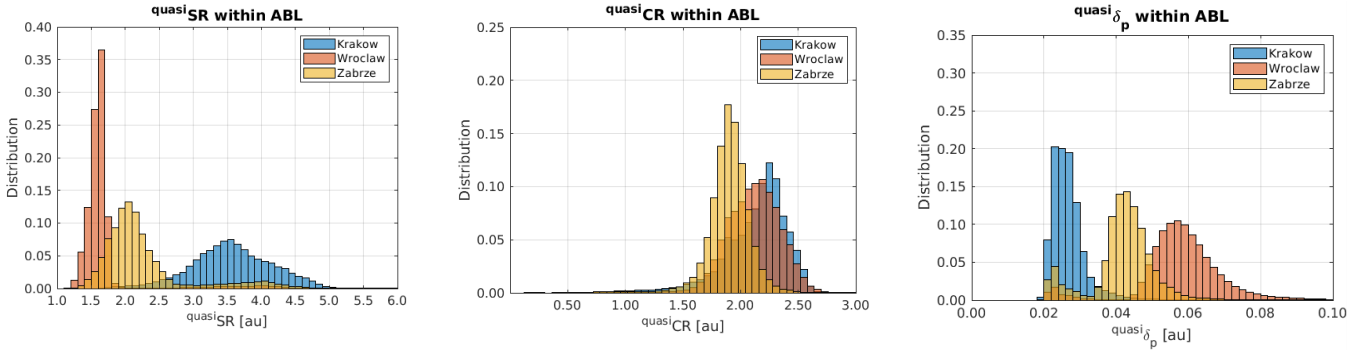

Fig. 1. Daily distribution of quasi scattering ratio (A), color ratio (B), and particle depolarization ratio (C) within the ABL in Zabrze, Krakow and Wroclaw

The analysis shows significant differences between the values of $^{quasi}SR$ and $^{quasi}\delta_p$ and their distribution within the ABL at each location with a higher abundance of less depolarizing spherical particles in Kraków and a lower amount of slightly depolarizing spherical particles in Wrocław. In addition, the analysis shows that the influence of the daily transformation cycle of the ABL on its optical properties is of importance.

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Role of long-range transport in source apportionment of black carbon at the urban background and urban polluted sites

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KEYWORDS: black carbon apportionment, air mass transport, urban environment, air quality

Our work was aimed at answering the question how the local near-surface air quality in terms of the black carbon (BC) can be affected by long-range transport. Is the air transported over a particular site able to ventilate the pollution or, contrary, to significantly increase it? And if yes, what is the spatial scale of such an effect? Can two urban sites see this as a correlated measurable effect? Would this be different at background and polluted urban site? Would it depend on the black carbon source?

The black carbon source apportionment method (Minderytė et al., 2022) was used to categorize sources into biomass burning (BB) and fossil fuel (FF) combustion based on the diurnal cycle aethalometer measurements and a pre-defined source-specific absorption Ångström exponent (AAE) for an urban background site in Vilnius, Lithuania and urban polluted site in Warsaw, Poland for data collected in May-August 2022.

We propose a new approach to analyze the air-mass backward trajectories at both locations: the obtained 72h trajectories, one set per day at 12 UTC (Minderytė et al., 2023), were inspected in terms of their spatio-temporal uniformity and assigned to predefined categories based on thresholds. In category A, a similar aerosol particles source was possible due to similar/overlapping transport pathways arriving at both sites (~50% of data). For category B, trajectories had strictly differing source origin and pathways (only in ~20% of data). The remaining days were not classified.

Both sites had similar contributions, significantly lower for BCBB (13-19 %) than for BCFF (81-87 %). The BC values were in general higher for the more polluted site in Warsaw. As expected, there were no patterns of similarities in the diurnal cycles at each site for the data classified in category B regardless of which apportionment one compares (BCFF or BCBB). For category A, patterns of similarities (both due to the ventilation process (decrease of BC) or boost of pollution (an increase of BC) were obtained, whereby they were more significant for the BC_{FF} than for the BC_{BB}. This indicates that biomass burning from long-range transport was not as important as that from local sources, e.g. 1st May in Warsaw in relation to the May Days (Majówka) and 24th June in Vilnius in relation to Midsummer (Sobótka). For biomass burning the similarities were in ventilation/decrease. For fossil fuel combustion is affected by long-range pollution both in ventilation and pollution boost.

Such study is reported for the first time for the two sites and is relevant for in this region of Europe there is a very limited number of observations of this kind, yes this is the region regarded as problematic in terms of air quality.

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The impact of a foehn wind on PM_{10} concentrations in Kraków area, Poland

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KEY WORDS: UBL dynamics, PM10, AROME model

Kraków, Poland, is a city located in the large Wisła (Vistula) valley. During the cold season (which is also the heating season), air quality in Kraków is often poor, due to several reasons, and the most problematic air pollution is particulate matter delivered mainly by burning fossil fuels in small heating facilities. The city has unfavourable natural ventilation conditions and the present paper explores the effect of a foehn wind from the Tatra Mountains (the local wind name in Polish: *halny*) on PM_{10} concentrations. Air temperature inversions occur often in Kraków and enhance the air pollution problems. Strong foehn winds were supposed to improve PM dispersion conditions. In order to verify that hypothesis, 14 long episodes of *halny* from the periods Sep 2017 - Apr 2018 and Sep 2018 - Apr 2019 were analyzed. They represent cold season when *halny* occurs the most often. Data used included measurements of PM_{10} concentrations in seven points in Kraków, and in terms of meteorological elements, air temperature and/or relative humidity were measured at 15 ground stations and at a mast up to 100 m a.g.l., while wind speed and direction was measured at seven ground stations only. Additionally, model analysis results were used. A non-operational configuration of the AROME CMC (the Application of Research to Operations at Mesoscale canonical model configuration) 1 km x 1 km was applied. A conceptual model concerning the impact of *halny* on urban air pollution was developed. The occurrence of a particular effect of *halny* on the PM_{10} spatial-temporal pattern depends on its mode of transfer through the city: a. *halny* flows above the valley where a strong cold air pool and a return flow can be found; b. *halny* enters the valley from the eastern, wider part or from the valley top and destroys the cold air pool; c. gravity waves generated by *halny* are strong enough to enter the western narrower part of the valley and cause large spatial differences in turbulence parameters within the city. The first transfer mode worsens air pollution dispersion conditions throughout the city and leads to large increases in PM_{10} levels (from below 50 to 150-200 $\mu g \cdot m^{-3}$), the second mode improves dispersion and leads to large decreases in PM_{10} levels (from 150-200 to below 50 $\mu g \cdot m^{-3}$) throughout the city, and the third generates large spatial differences in PM_{10} levels (50- 70 $\mu g \cdot m^{-3}$) within the city. There is no single effect of *halny* on air pollution dispersion conditions.

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Stable isotopic signatures of methane from solid waste treatment facilities

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KEY WORDS: methane, carbon isotopes, landfills, waste management

INTRODUCTION

Methane (CH_4) is the second most important anthropogenic greenhouse gas (GHG) after carbon dioxide (CO_2) emitted from a variety of anthropogenic sources (Friedlingstein et al., 2020; Saunois et al., 2020). The waste sector represents the third-largest source of anthropogenic methane emissions in Poland, responsible for around 8.4 % of the total CH_4 in 2021, which makes it a considerable contributor of GHGs in the atmosphere (Poland's National Inventory Report, 2023). In particular, landfill methane emission categories are spatially not well allocated and relative proportions by specific source types are not well distinguished. Thus, a more detailed waste sources apportionment, primarily based on isotopic signatures ($\delta^{13}C$) of CH_4, can provide information on the processes responsible for CH_4 production and its evolution, necessary for accomplishing methane reduction targets in landfills.

RESEARCH AREA AND METHODS

The aim of this study was to identify sources of GHG emissions across the municipal solid waste treatment plant (MSWTP) and estimate methane excess from the landfill site and its distribution in MSWTP surroundings. Ambient GHG measurements were based on multiple surveys using ground-based detection of CH_4 and CO_2 hotspots across the landfill site and samples collected directly from determined emission sources. To assess seasonal variation in methane, sampling was performed in several measurement campaigns: in autumn (November), winter (December and January), and summer (June) during the 2021–2022 season. The applied equipment included LGR- ICOS™ M-GGA-918 Analyzer mobile system for detailed real-time measurements of CH_4, CO_2 mole fractions and a laboratory-based Picarro Cavity Ring-Down Spectroscopy Analyzer (Model G2201-i) for characterization of carbon isotopic signatures ($\delta^{13}C$) of CH_4 waste sources.

RESULTS

The results of the ground-based measurements revealed the dominance of several specific individual sources of CH_4 within the waste treatment facility. The landfill active quarter and its surroundings, in particular uncovered operational areas and side slopes of waste dump, leaking wells of biogas collection network, as well as modules of aerobic stabilization of fermented waste, including open-air composting area and leachate tanks, are the major sources of methane emissions from the MSWTP. The excess of CH_4 measured at close distance (~10 – 20 m) from the selected sources inside the MSWTP reached up to 46.1 – 56.3 ppm. In most cases, however, it was not observed significant variation in atmospheric CH_4 concentration in the vicinity of the waste landfill site. The higher concentration of atmospheric CH_4 above background, which ranged from 2.1 to 3.1 ppm, during the studied period, was only found near the facility fence line. The active zones (specific individual sources) of the waste treatment plant showed distinct carbon isotopic signatures of methane, $\delta^{13}C$-CH_4 values of –58.3 ± 1.1 ‰ and –62.7 ± 0.7 ‰ for gas extraction wells in the landfill quarter, and biogas produced in composting facilities, respectively. Methane escaping from active zones into the atmosphere (at 1.5 m AGL) was more depleted in ^{13}C than in the surrounding sites. Spatial differences in $\delta^{13}C$ of atmospheric CH_4, in the range between −49.7 and −55.1 ‰, were also observed during the winter and summer surveys. Overall, as compared to measurements performed in other landfills, this analysis demonstrates that elevated CH_4

comes only from active zones of the MSWTP and have no meaningful site impact on the air quality in the surrounding atmosphere.

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Using meteorological normalization to identify the effects of reducing air pollution emissions in Krakow

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KEY WORDS: particulate matter, meteorological normalization, air concentration trends, machine learning

Air quality depends on many factors, including emissions, meteorological conditions, and terrain. The first two variables are unstable because they change over time and space. For this reason, identifying the effects of individual variables on air quality is difficult and requires appropriate methods (Oleniacz et al. 2016). Meteorological normalization can be used to identify effects resulting only from changes in air pollutant emissions. Meteorological normalization allows us to obtain air pollutant concentrations equivalent to averaged meteorological conditions (Grange, Carslaw 2019). The result is a time series of air pollutant concentrations that depend only on emissions.

The purpose of the study was to identify the effects of the corrective actions carried out in Krakow to reduce particulate matter emissions in the period 2011-2018. As part of the study, receptor models of PM_{10} and $PM_{2.5}$ concentrations were developed for individual air quality monitoring stations (MpKrakAlKras, MpKrakBujaka, MpKrakBulwar). Models were developed using the "Random Forest" ensemble learning method (Breiman 2001). The developed models were used to make 400 predictions of PM_{10} and $PM_{2.5}$ concentrations at each time point under random meteorological conditions (resampling). The resulting 400 forecasts for each time step were averaged. Time series of PM_{10} and $PM_{2.5}$ concentrations were obtained for the average meteorological conditions. Trends in PM_{10} and $PM_{2.5}$ trends were calculated using the simple non-parametric linear regression method "Theil-Sen estimator" (Kunsch 1989).

Elimination or replacement of more than 32,000 low emission sources in the period 2011 to 2018 resulted in a significant reduction in the concentrations of PM_{10} (17-27 %) and $PM_{2.5}$ (11-26 %) in Krakow. The estimated trends decreased and were 1.16-2.16 µg/m^3 and 0.51-1.39 µg/m^3 for PM_{10} and $PM_{2.5}$, respectively. Elimination of low-emission sources of 1 MW power resulted in a reduction of PM_{10} and $PM_{2.5}$ concentrations by 0.067-0.116 µg/m^3 and 0.031-0.074 µg/m^3, respectively. Analysis of the time series of particulate matter concentrations suggested that the effects of lowering air pollution concentrations in Krakow were also due to changes in industrial activities.

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Cyanobacteria and microalgae in atmospheric aerosols in the coastal zone of the Gulf of Gdańsk

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Apart from viruses and bacteria, cyanobacteria and microalgae present in the atmosphere may pose a threat to the human health by inducing illnesses and diseases. Thus the main goal of the present study was the determination of the daily and seasonal qualitative and quantitative variabilities of these microorganisms in the air of the Gulf of Gdańsk coastal zone. Bioaerosols were collected during vegetative and non-vegetative seasons, between January and December 2020 using Tisch six-stage microbiological impactor, which can be treated as a substitute for the respiratory tract. A total of 296 samples were collected during the day and 276 samples during the night. In addition the qualitative and quantitative analyses of cyanobacteria and microalgae in rain samples collected during the summer phytoplankton bloom season (May–September 2019) was performed. Rain was sampled with bulk collector with the funnel of 0.314 m^2 area. In total, 20 rainwater samples were collected. Quantitation of Microcystin-LR equivalents were performed in all samples using a colorimetric MC-LR, enzyme-linked immunosorbent assay (ELISA) kit (Abnova, Taipei, Taiwan).

The results showed that cyanobacteria and microalgae were present in the air of the southern Baltic Sea region all year round. The most abundant phylum was cyanobacteria, which constituted 63% of all detected phyla, while picocyanobacteria Synechococcus sp. dominated. The significant percentage of green algae in the taxonomic composition was also noted (34%). The increase in cyanobacteria and microalgae number and taxonomic diversity in the air occurred during periods of intense phytoplankton blooms in the Baltic Sea. The maximum abundance of these microorganisms was noted in July (1685 cells m^{-3}). The most effective meteorological factor that leads to the removal of up to 87% of cyanobacteria and microalgae from the atmosphere was rainfall.

Several harmful taxa were noted in bioaerosols and rain samples collected in the Gulf of Gdansk region. Among the harmful organisms present in aerosols, including Amphora sp. Bracteacoccus sp., Chlorococcum sp., Chlorosarcinopsis sp., Oocystis sp., Stichococcus sp., Nodularia sp., Nostocsp., Synechocystis sp., Chrysochromulina sp., and Gymnodinium sp. approximately 30.0% were recorded in particles small enough to reach secondary bronchi (<2.1 µm).The study confirmed also the ability of these microorganisms to produce the toxin microcystin-LR (MC-LR), which has a high potential negative impact on human health.

The highest concentrations of MC-LR were recorded in airborne Synechococcus sp. CCAA 46 (Wiśniewska et al. 2022 a, b).

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Stability of Sudeten forest ecosystems in the context of the ecological disaster and contemporary climate change

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KEY WORDS: forest ecosystems, ecological disaster, climate change, Sudetes

INTRODUCTION

Forest ecosystems of the Sudetes have undergone enormous transformations under the influence of anthropogenic factors over the past several hundred years. In the lower subalpine forest zone, primeval forests were cut down in the 17th and 18th centuries and replaced with spruce monocultures. It was revealed in a particular way during the ecological disaster caused by "acid deposition", the efficiency of which in the Western Sudetes reached levels not found anywhere else in the world. Between 1980-1990, deforestation and areas affected by severe negative changes covered more than 50% of forest areas in this region. The remedial action taken, e.g. the reduction of industrial emission and the redefining the spruce monocultures in terms of species and structure yielded quick results and improved the condition of ecosystems. Finally, the last three decades of instrumental measurements clearly document the progressing process of global warming. In the mountainous regions of central Europe, the following phenomena can be observed: unprecedented scale of warming, a downward trend in precipitation totals in spring, decreasing snowiness of winters and constantly growing threat of drought.

The main task that the authors of the project set themselves is not only to describe the impact of climate change on the stability of spruce ecosystems as a whole. Their primary objective is to highlight the differences in incremental response separately: in natural stands, monoculture stands of foreign origin and in stands with various degrees of degradation in the period of the ecological disaster.

MATERIAL AND METHODS

The data come from 71 meteorological stations located in the Sudetes and covers the 60-year period 1961–2020 (IMGW, CHMU and DWD measurement network). The database consists of mean monthly air temperatures (25 stations) and monthly precipitation totals (71 stations). It was used to calculate indices for 1-, 3- and 6-monthly timescales to determine the occurrence of drought: SPI (Standardized Precipitation Index), RPI (Relative Precipitation Index) and SPEI (Standardized Precipitation Evapotranspiration Index). In order to estimate the impact of drought on the Norway spruce (*Picea abies*), the following indices of forest drought were calculated for each station: EQ (Ellenberg index), FAI (Forestry Aridity Index) and AI (De Martonne Aridy Index).

All 166 core samples, used in the present study, were collected in 16 locations in October 2022. To ensure proper quality and to eliminate the age factor in the gathered data, the measured tree-ring width values were transformed through quality checking with COFECHA software as well as the ARSTAN program. The measurement series were individually detrended using a cubic smoothing spline with a 50% frequency response cutoff equalling 67% of the series length.

RESULTS

The risk of atmospheric drought has increased in the study area, which is mainly caused by air temperature rise. Precipitation based indices show only minor changes in drought occurrence. SPEI index, based on both air temperature and precipitation indicate that the frequency of dry months increased a lot in the last decade, all over the study area. At some stations, it was more than triple in comparison to previous decades. SPI (indicator based only on precipitation) calculated for the 3-monthly timescale points to statistically significant negative trends for the Western Sudetes, although Sen's slope values are as low as -0.02 for several stations. Therefore, the risk of atmospheric drought in the Western Sudetes increases dangerously and is the highest in spring and early summer.

Preliminary analysis of tree cores showed that a progressing rise in air temperature contributes to improving the condition of forest ecosystems in the upper subalpine forest (2000-2017), especially along the tree-line zone. These dependencies are reversed in the lower parts (group B) and clearly visible in the case of foothills (group A), where the thermal conditions are increasingly difficult for the development of spruce and in the abnormally warm and dry years even oppressive. In the last decade, the growth response of spruce for group A has fallen below the level observed during the ecological disaster (1980-1995), while group B ecosystems are approaching this level. It is also worth emphasizing that the ecological disaster (intense deposition of atmospheric pollutants) of the 80s of the 20th century first started in the upper subalpine forest and was the most intense there, while the contemporary decline in the growth reaction of spruce is the earliest and most intense in the foothills and the lower montane.

Phytoremediation as a passive tool to improve air quality

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KEY WORDS: phytoremediation, urban ecosystem services, particulate matter, passive design methods, Computational Fluid Dynamics model

Phytoremediation is an example of biological-based biotechnology that uses plants to remove contaminants from different environments: soil, water, and atmosphere (Lee et al., 2020). Vegetation introduced into urban areas has a passive, positive impact by activating phytoremediation, becoming a tool for air pollution control, noise reduction, mitigation of the urban heat island phenomenon, and ensuring the desired biodiversity.

This paper aims to present a methodical design of a small-scale urban green area with increased phytoremediation potential. The applied compilation-based method to intensify the regenerative potential of the shaped green area, determining both the quantitative potential of improving air quality and simultaneously identifying qualitative aesthetic features, comes out of recognition of the psychophysical nature of air pollution impacts on human health.

In the study, we discuss the aspects of the phytoremediation processes concerning traffic-related particulate matter by assessing the spatial variability of PM2.5 concentration for different greenery scenarios. A potentially appropriate selection of vegetation has the purpose of optimizing the air phytomelioration processes in urban areas. The design of the specific structure of greenery allows for synchronously activating dispersion and deposition processes to develop a multidirectional interaction between plant barriers and the plume of pollutants. The proposed design solutions were checked by multi-criteria evaluation of scenarios with different variable values (vegetation parameters and environmental parameters) using the CFD model (ENVI-met software). In the pilot facility, the concentration of PM2.5 in the most favorable arrangement of vegetation (GI scenario) reached a 7-8% reduction of concentration compared to the initial situation in a baseline scenario.

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Ambrosia pollen concentrations in south-east Poland – does the spatial differentiation exist?

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KEY WORDS: *Ambrosia*, back-trajectory model, pollen concentration

The main aim of current study was to try verify the hypothesis about existence of the spatial differentiation of Ambrosia pollen concentrations between stations located several dozen kilometers one from the other as well as between the stations located at two different height. We also tried to verify if the source of pollen inflow in two sites in south-east Poland is similar and whether discontinuous pollen monitoring is sufficient for estimation the allergic situation instead of continuous one.

The aerobiological monitoring was carried out in 2020 in Rzeszów- three stations of continuous monitoring, including two at two different height (roof and "nose" level) and in Uherce Mineralne- monitoring carried out three times a day used portable device at "nose level". The estimation of the source of *Ambrosia* pollen inflow was done using back-trajectory model HYSPLIT.

The highest concentrations of ambrosia pollen were registered at the end of August in Rzeszów and Uherce and It was noticed that they appeared few hours earlier in Uherce than in Rzeszów. The results of HYSPLIT back-trajectory model indicated similar sources of pollen inflow for both sites. The significant positive correlation existed between concentrations from four stations. It was noticed that during three days concentrations differed significantly between sites. During these days the directions of air masses incoming to Rzeszów and Uherce were different. The Wilcoxon pair-wise test indicated that there were no significant differences between concentrations from stations located in Rzeszów at two different height.

The highest concentrations of *Ambrosia* pollen grains appear in Rzeszów and Uherce at a similar time. The general similarity in the sources of pollen inflow also exists. However, some days the direction of air masses trajectory differs that results in great differences of pollen concentrations between sites despite their close range. For evaluation allergic situation, it is possible to carry out discontinuous pollen monitoring instead of continuous monitoring and it is also possible to conduct monitoring at the "nose" level because of similarity of concentration values between stations at roof and "nose" level.

The proximity of alder pollen sources in different districts of Rzeszów city- is it important for allergy risk?

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KEY WORDS: *Alnus*, pollen concentration, urban space

Whereas the allergenicity of Alnus pollen is high, the main aim of current study was to verify the hypothesis that the significant differences exist between alder pollen concentrations in the urban space and that these differences are connected with proximity and size of the pollen sources.

The preliminary study was carried out in Rzeszów in 2020 at 8 measurement points during the alder pollen season. The points differed in terms of proximity and size of the pollen sources and were located at 4 different city districts. Four of them were located close to the alder trees (calling as “with alders”) and another four were distant from alder trees 500 m at least (calling as “without alders”). The 20-minutes suction on microscopic slides had been doing in each of the points twice a day (before and after noon) at “nose level” using portable volumetric spore trap. The values of pollen grains counted under microscope were expressed as main pollen grains concentrations per hour. The results were compared with the concentrations registered by volumetric spore trap (the continuous pollen monitoring). The phonological observation were also carried out.

The nonparametric tests indicated that no significant differences exist in the concentration values between city districts and between points “with” and “without alders”. The significant differences existed only for concentrations before and after noon. The lowest concentration sum was obtained for the point with the lowest number of alder trees. At the beginning of pollen season, the higher concentrations were registered at the locations with the trees of extremely early beginning of pollination. The average pollen concentrations from the measurement days were proportional to average diurnal concentrations from the continuous monitoring.

Despite the occurring of black alder trees in clusters in few points of the city, their proximity has little importance for pollen concentrations values. However, the lowest concentrations sum is clearly visible in the points with extremely few number of trees. It is also worthy of attention that higher pollen concentrations occurred earlier at the points with the trees extremely early began the pollen release.

The occurrence of boletes spores in the air in relation to weather and land use

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KEY WORDS: basidiospores, meteorological parameters, land cover type, temperate zone

Basidiomycetes produce and release into the environment huge numbers of spores, the concentration of which in the air is variable and depends on the movement of air masses during the day and the night, as well as weather parameters and the type of land development. Although they are present in the air in considerable concentrations, they are not often the subject of aerobiological studies. The aim of the study was the spatio-temporal analysis of the concentration of Boletus type spores in the air in relation to meteorological parameters and the type of land use. The research was carried out in 2019 – 2021 years with the use of the volumetric method. The volumetric traps were located at the roof and ground level in a village and a city (SE Poland), in areas with different forests and agriculture areas covers. It was observed that the highest concentrations of Boletus type spores were in late summer and early autumn, when the forests are intensively explored by mushroom pickers. Higher concentrations of spores were usually found in the countryside, where the availability of organic matter necessary for the development of fungi is high. However, there are no significant differences between the dates of the beginning of the spore season and their maximum concentrations in the air. It has been proven that the intensity of spore release by porcini mushrooms into the air between individual years can vary significantly. The analysis of circadian cycles indicated that high concentrations of Boletus type spores may occur twice a day, at night and in the early morning. Air temperature and air humidity most strongly influenced the concentration of spores. Due to the considerable concentrations of boletes spores in the air and their allergenic potential, it is worth including information about this type of spores in messages for allergy sufferers.

Distribution of boletes spores in a beech forest

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KEY WORDS: basidiospores, aerobiology, *Boletus*

Boletes are ectosymbiotes of trees, mainly deciduous, and forests are the main source of their airborne spores occurrence. Basidiospores are mechanically launched over several milimeters after maturity, but the scale of their dispersion depends on air movement and may be greater (Halbawachs and Bässler 2015). Vertical, horizontal and turbulent air flows are vectors of sporomorphs dispersion and thanks to such mechanisms, mushroom spores can get out of the forest (Galan and Pringle, 2017, Freundorfer et al. 2019). Aerobiological monitoring was carried out at several sites in a beech forest and outside, what allowed to characterize the spatial differentiation of airborne boletes spores concentrations and to verify the thesis that a small percentage of airborne spores is observed outside the forest. Burkard portable samplers were used. The patterns of airborne spores at the sites located in the forest and at its edge were very similar but at/within? a distance of 1500 meters spores were noted for a longer time. Spores concentrations recorded in the forest were 8 times higher than outside, and at the days of very high concentrations, the hourly peaks noted outside the forest were delayed by several hours in relation to the time of maximum concentrations recorded in the forest. These findings confirm that the main source of airborne spores was the forest and anemometric conditions in the forest may hinder their long-distance dispersal (Puchalski and Prusinkiewicz 1990). During the season of mushrooms picking (www.bdl.lasy.gov.pl/portal/mapy), the bolete spore concentrations in the forest were unexpectedly high. It was noted that maximum spore concentration exceeded 16,000 in $1m^3$ of air. It is reported the allergy to *Boletus* spores (Rivera-Mariani et al. 2015), therefore it is necessary to inform people about the possibility of overexposure to these aeroallergen, which can be released in huge amount during mushroom picking, within the forest trips.

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Aerobiology in forensic science – prospects and perspective

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KEY WORDS: fungi, postmortem interval, spores, forensic mycology

In this presentation we will mainly focus on the use of fungi (colonies, thallus fragments, and spores).

Aerobiology can contribute to a variety of forensic investigations, including psychoactive substances and toxins, determination of postmortem intervals from mould growth on corpses, hazards from mould growth in buildings, providing trace evidence linking people and objects with places using aiborne spores.

Research is starting to be undertaken to explore the use of molecular data on fungi in the characterisation of soils. In addition, where there are health concerns possibly associated with mould growth in buildings, publicly available and universal rules for sampling and data interpretation should be developed. In order to avoid valuable information being overlooked, there is a need for investigating officers and those involved in forensic medicine, especially pathologists and toxicologists, to be aware of the evidential value of fungi and spores.

Pollen grains and fungal spores are valuable as evidence because they are invisible to naked eyes, it's impossible to get rid of them all from clothing, footwear, vehicles. They are resistant to acids and hydroxide, so it's impossible to destroy them. They are commonly in air and soil, but most of them are falling relatively near from its maternal plant or fungus. Spores and pollen grains from every genus has its unique shapes, sizes and structures, which allow us to assign them to specific taxa.

In particular, they should not overlook opportunities to recover spores from human remains, to examine any mould colonies growing on corpses, and to analyse respiratory tract and selected organ (stomach, intestines) contents for fungal material and spores. Fungal spores and pollen might be valuable source of information geographical origin and what route drugs and people have travelled. This kind of evidences might be useful in connecting suspects with crime scene and weapons or disprove this connection. Palynological evidence might be crucial in finding location of burried cadavers, but also verifying whether the murder was committed at a particular location or the corpse was store and moved. Using knowledge and methods of forensic mycology, we are also able to determine time of death with usage of mycological analysis of fungal colonies and spores and pollen grains found on remains.

The most commonly used method in forensic palynology is visual analysic to determine taxonomic affiliation, based on specific morphological characteristics, by light microscopy. Light microscopy make it possible to determine to which genus particular pollen grain/spore belongs to. Scanning electron microscopy making it possible to match it to particular species. In culture-based methods fungi and bacteria are grown under controlled conditions of temperature and humidity to form colonies. Distinct species produce morphological different colonies that allow identification through macroscopic observation based on among other things: form, size, elevation and colour of the colonies. Other methods used to identification are spectroscopic methods, immunological techniques (e.g. ELISA), PCR and its varieties, DNA sequencing.

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Dwie dekady monitoringu pyłkowego w Łodzi – implikacje dla diagnostyki i terapii

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WSTĘP

Monitorowanie stężeń pyłku roślin w powietrzu atmosferycznym ma kluczowe znaczenie dla wspomagania diagnostyki, profilaktyki, monitorowania i leczenia alergii i astmy oskrzelowej, a także oceny kierunków zmian klimatycznych. Tereny zielone są uważane za kluczowe elementy ochronne w obszarach miejskich. Mogą sprzyjać minimalizacji zanieczyszczeń, buforowaniu temperatury powietrza, hałasu i erozji gleby. Pomimo niezaprzeczalnych korzyści dla ludzi, mogą wiązać się z obawami związanymi z ekspozycją na pyłek roślin. Badania z wielu krajów wykazały, że zmiany klimatyczne wywołują wzrost produkcji pyłku i jego alergenność, co może zwiększać częstość występowania chorób alergicznych u ludzi.

Celem pracy była ocena trendów zmian ekspozycji na pyłek roślin w ciągu dwóch dekad badań, prowadzonych w centrum Łodzi w latach 2003-2022.

METODY

Badania prowadzono metodą wolumetryczną przy użyciu próbnika Lanzoni, w Łodzi (51° 46'17,5 "N, 19° 28'29" E), w latach 2003-2022. Pomiary dotyczyły analizy średnich dobowych stężeń pyłku dla 21 taksonów roślin: Corylus, Alnus, Juniperus/Taxus, Populus, Ulmus, Salix, Acer, Fraxinus, Betula, Carpinus, Quercus, Fagus, Pinaceae, Poaceae, Rumex, Plantago, Urticaceae, Chenopodiaceae, Artemisia, Ambrosia; oraz 2 taksonów zarodników grzybów mikroskopowych: Alternaria i Cladosporium. Trendy zmian stężeń pyłku były obliczane za pomocą regresji liniowej i kwadratowej w programie Statistica 13.

WYNIKI

Wśród taksonów drzew, najwyższe stężenia pyłku odnotowano dla Betula, Pinaceae i Alnus; najniższe dla Fagus, Ulmus i Corylus. Wśród roślin zielnych dominował pyłek Urtica i Poaceae. Najniższe poziomy stwierdzono dla Plantago i Chenopodiaceae. Stężenia zarodników Cladosporium były bardzo wysokie, około 40 razy wyższe niż Alternaria. Odnotowano istotny trend wzrostu stężeń Alternaria. Natomiast nie stwierdzono istotnych trendów zmian dla połączonej grupy badanych drzew. Wśród badanych taksonów drzew istotne, wzrostowe trendy stężeń uzyskano dla pyłku 5/14 pojedynczych rodzajów: Juniperus/Taxus, Acer, Fagus i Pinceae. Spośród roślin zielnych istotny wzrost stężeń uzyskano dla 2/7 taksonów: Plantago i Urtica, a malejący dla Rumex. Natomiast w odniesieniu do całego zbioru pyłku roślin zielnych nie stwierdzono istotnych zmian.

WNIOSKI

Na przestrzeni dwóch dekad badań, w powietrzu atmosferycznym Łodzi, dominowały zarodniki Cladosporium. Ogólna dystrybucja zarodników Cladosporium, sum badanych taksonów pyłku drzew i roślin zielnych była stosunkowo stabilna, nie wykazała istotnych zmian pomimo pogarszających się warunków hydrologicznych w Polsce centralnej, praktyk regularnego koszenia zieleni miejskiej i wycinania drzew. Z uwagi na wieloletnie trendy istotnie wzrastających stężeń pyłku kilku taksonów, do diagnostyki alergologicznej należałoby włączyć ekstrakty pyłku tych roślin, np. Juniperus/Taxus i Urtica.

Impact of climate change on allergenic pollen concentrations in the air in Wrocław for the years 2003-2022

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KEY WORDS: pollen, pollen season, pollen maximum, pollen minimum, pollen calendar, allergy, climate change, global warming

Climate change impacts the modern world significantly. The trend of increasing air temperature is so significant that even though all countries will meet their climate commitments, it will not be possible to avoid maintaining global warming at 1.5°C above pre-industrial levels, as shown in the latest IPCC report (IPCC, 2023). Global warming will also have a significant impact on the plant world, which includes pollen. This is especially important for people who suffer from pollen allergies. An increase in air temperature may affect the intensity and length of the pollen season, as well as the allergenicity of pollen grains, which is particularly important for allergy sufferers (Ziska i in., 2019). In the context of researching the impact of global warming on pollen counts, it is extremely important to monitor pollen concentrations in the air. The most common measurements are made using the volumetric method (Lanzoni and Burkard trap) (Weryszko-Chmielewska, 2007).

In Wrocław, measurements have been carried out since 1994, in cooperation with the Centre for Environmental Allergen Research in Warsaw. Initially, pollen monitoring was carried out with the VST-1 device, and since 2003 with the Burkard trap. The aim of this study was to characterise changes in pollen seasons (length, intensity, start and end dates) for various taxa, with particular emphasis on allergenic pollen. The analysis was carried out for the city of Wrocław for the period 2003-2022. The study also used a graphical method and developed pollen calendars for the entire study period and for four 5-year periods. The results indicate that some plant taxa were characterised by a faster onset of the pollen season in recent years compared to previous years. This was particularly visible for alder, hazel and yew, therefore trees that flower early in the year. The data also allows us to conclude that the pollen season became longer. Furtheremore the maximum daily pollen concentration was also higher for 2018-2022 compared to the previous years. For some plant species (including birch), this was up to twice as high as in the previous 5-year period. The total annual value of airborne allergenic pollen has also increased in recent years. The results confirm the negative effects of global warming on the plant pollen season, which may result in a further increase in the number and intensity of inhalant allergies.

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Sources of allergenic pollen in urban environment: detection of plane trees using open access remote sensing data

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KEY WORDS: bioaerosol, aerial images, predictive modeling

Platanus x acerifolia is a common ornamental tree in Poland, producing a large amount of wind-transported pollen, which contains proteins inducing allergy symptoms. Allergy sufferers can limit their contact with pollen by avoiding places with high pollen concentrations that are mainly restricted to the vicinity of plane trees. Creating detailed street greenery inventory is expensive and time-consuming. Fine remote sensing data gives an opportunity to detect the location of specific plants. However, acquiring high resolution spatial data of a good quality also incurs costs and requires regular updates. Therefore this study explores potential of using access free, remote sensing data to detect plane trees in highly urbanized environment of Poznań. Airborne LiDAR was used to find treetops, which part of (n = 2628) were subsequently marked as: young plane, mature plane, other trees, artifacts. Spectral and spatial variables were extracted from circular buffers (r = 1 m) around the treetops to minimize the influence of shadows and crown overlapping. Random forest machine learning algorithm was applied to assess the importance of variables and classify the treetops in three plots. The model performed well during 10-fold cross validation (OA ≈ 92%, κ ≈ 89%), however when implemented in a broader area, the best model detected more plane trees than really present in the study area. Nevertheless, modeled plane tree location and density agreed well with pollen influx in the study area. The results show that the open-access geodata in Poland, can be applied to recognize major local sources of plane pollen. We also identified some limitations, for example radial shifts in orthoimages, which cause spatial misalignment between LiDAR-derived treetops and the orthoimage pixels representing them. Finally, we proposed a spatially continuous index of airborne pollen occurrence probability.

Birch pollen concentration at the ground level: spatial variation and relation to roof data

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KEY WORDS: bioaerosol, allergen exposure, *Betula* sp.

Birch trees are common in northern and central Europe; they are also frequently planted in cities as ornamental plant because of the resistance to air pollutants and ability to grow on poor soils. A birch tree produces large quantities of allergenic pollen with 20% prevalence (and increasing) among inhalant allergy patients. Patients could reduce their symptoms by avoiding exposure to airborne birch pollen grains using pollen forecasts. However, forecasts are prepared based on the pollen data collected at the high-building roof level; but people live, work and rest on the ground level so there is a forecast-observation mismatch. Airborne birch pollen concentration is typically considered relatively uniform with low differences between roof and ground level and also between sites nearby. However, we suspect that sparse distribution of birch trees and also the presence of building will cause some differences in pollen concentrations even in a study area of ~ 200 x 200 m. We hypothesized that birch pollen concentration will differ significantly between 5 sites located within the study area including significant difference between roof and ground level. We collected the data between 18th April and 9th May 2023 using Burkard Portable Volumetric Traps placed on tripods. We changed microscopic slide every hour, then fixed with fuchsin-stained glycerin gelatin and counted pollen under the optical microscope. Interestingly, some ground sites differed between each other in concentrations but none of them was statistically different from roof concentrations. The ground/roof ratio depended greatly on the position of the groundtraps and varied from 0.53 to 1.47. Correlation between sites reached 0.82 – 0.95. Also, we detected several unusual peaks at ground level but not at roof level what may be an evidence that birch pollen concentration differ spatially and vertically.

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Immunological response to birch pollen allergens against the background of air pollution. Preliminary results

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KEY WORDS: birch, pollution, BAT, SDS-PAGE

INTRODUCTION

Abiotic pollution, as a stress factor, may affect pollen protein profile, resulting in a different immune response of individuals with birch allergy. The goal of the study is to estimate, whether the observed differentiation in physic-chemical properties of birch pollen proteins is associated with the variability of their immunoreactivity and allergenicity.

METHODS

Birch pollen material was collected in 2022, at selected sites in Kraków and at the less polluted areas, 80 km of the city. The study group contains 23 individuals with symptoms of respiratory allergy and confirmed allergy to birch pollen, while to the control group, 17 persons without birch allergy were included. The following analyses were performed in pollen samples: Bet v1 concentration (ELISA Assay); total protein content (Bradford method); sIgE concentration against the main birch allergens (Enzyme-Allergo-Sorbent-Test); Basophil Activation Test (BAT) after in vitro cells stimulation by birch pollen extracts; immunoblotting with patients sera of individual subunits of proteins separated by SDS-PAGE electrophoresis.

RESULTS

The birch pollen season in 2022 was typical in Kraków, except at Seasonal Pollen Integral (SPIn), three times as high as the mean value for 1991-2021. Total protein content ranged from 641,67 µg/ml to 2068,59 µg/ml and was significantly higher in pollen samples in Kraków vs out of Kraków (p=0,04), while for Bet v1 concentration the differences were not statistically significant. SDS-PAGE of birch pollen proteins showed general similarities of the obtained protein spectra. Only few differences in staining intensity of some, individual bands were observed. Contrary, electrophoretic patterns of immunoblotting after SDS-PAGE showed great differences in immunological response in birch allergic patients analyzing separated protein subunits and fractions. The percentage of activated basophils was significantly higher in sensitive persons compared to the control group, and after the stimulation by pollen collected in the more polluted environment.

CONCLUSION

The preliminary results confirm that air pollution emphasizes the immunological response of allergic persons to the natural pollen allergens.

Acknowledgments

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Analiza wyników testów skórnych w kontekście badań aerobiologicznych w Łodzi

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WSTĘP

Alergia jest poważną chorobą układu oddechowego. Pomimo coraz szerszego arsenału badań diagnostycznych stosowanych w opiece nad chorymi z alergią, klasyczne testy skórne (SPT), interpretowane zgodnie z objawami wywoływanymi w czasie ekspozycji na alergeny, są wciąż najczęściej wykorzystywanymi i obiektywnymi narzędziami identyfikacji czynników środowiskowych wyzwalających objawy alergii. Celem badań była analiza częstości i dystrybucji uczuleń wobec paneli ekstraktów alergenów wziewnych w odniesieniu do płci wieku i jednostek chorobowych zdiagnozowanych przez lekarzy alergologów i stopnia ekspozycji na pyłek roślin.

METODY

Przeprowadzono retrospektywną analizę wyników punktowych testów skórnych (SPT) u 1711 pacjentów (zakres wieku: 2,57 – 86,42 lat), poddanych diagnostyce w latach 2017–2020. SPT wykonywano przy użyciu zestawu firmy Allergopharma dla jedenastu ekstraktów alergenów wziewnych: roztoczy Dermatophagoides pteronyssinus i D. farinae, pyłku olszy, leszczyny, brzozy, traw (mix), żyta, bylicy, kota, psa, Alternaria. Wartości jedenastu zmiennych zależnych w postaci średnic bąbli uzyskanych w SPT zredukowano do czterech niezależnych głównych składowych przy pomocy analizy czynnikowej. Następnie składowe te wykorzystano do testowania różnic między średnimi wyróżnionych poziomów zmiennych niezależnych. Profile uczuleń oceniano w populacji wszystkich badanych, a także w podgrupach, z podziałem na płeć i podgrupy wieku badanych oraz jednostek chorobowych. W pracy korzystano też z danych zarejestrowanych w bazie stężeń pyłku Ośrodka Monitorowania Aeroalergenów Kliniki Immunologii i Alergii UM w Łodzi z lat 2003-2022.

WYNIKI

Najwyższe częstości uczuleń w testach SPT uzyskano dla ekstraktów pyłku żyta, brzozy i tymotki: odpowiednio 57,22% i 47,34% 44,8%. Następnie olszy 41,32%, leszczyny 38,34% i bylicy 31,85%. Uczulenia monowalentne stwierdzono głównie wobec pyłku traw/zbóż dla 4,97% (n=55). Za pomocą analizy czynnikowej wyodrębniono cztery niezależne główne składowe. Stwierdzono, że średnice bąbli dla traw są wyższe u mężczyzn ($p<0,0001$). Wśród wyróżnionych trzech kategorii wiekowych, dla uczuleń na pyłek drzew wykazano zależność między kolejnymi grupami wiekowymi. Istotne zróżnicowania wystąpiło między średnimi wartościami średnic bąbli drzew, a I/II grupą wiekową ($p=0,005$) oraz między I i III grupą wiekową ($p<0,0001$). W przypadku traw największa wartość średnicy bąbli była w kategorii II.

WYNIKI TESTÓW SKÓRNYCH, A ALERGIA

Szansa zachorowania na alergiczny nieżyt nosa (J30) była najwyższa, bo ponad 3 razy większa przy uczuleniu na trawy (OR = 3,24 (2,58-4,05); $p<0,000001$, ponad 2 razy wyższa na alergeny pyłku żyta, leszczyny i olszy niż u osób bez tego rodzaju uczuleń. U chorych z astmą dominowało uczulenie na alergeny psa i kota oraz roztoczy. Ryzyko zachorowania na atopowe zapalenie skóry było najwyższe u chorych uczulonych na pyłek brzozy i olszy. W odniesieniu do pozostałych jednostek chorobowych: J31, J32, J,33, R05, stwierdzono, zależności ujemne, Np. u osób z polipami nosa szansę uczulenia na trawy oszacowano jako czterokrotnie niższą niż u osób bez polipów. Dla jednostek chorobowych L50, T78 zależności były nieistotne.

WYNIKI TESTÓW SKÓRNYCH, A EKSPOZYCJA NA PYŁEK ROŚLIN

Średnie stężenia pyłku roślin było najwyższe dla brzozy, następnie dla pokrzywy, sosnowatych, olszy i dębu, jesionu i traw, ale częstość uczuleń bezpośrednio nie pokrywała się z hierarchią stężeń pyłku w powietrzu atmosferycznym w Łodzi.

WNIOSKI

Rozpoznanie uczulających alergenów – czyli ekspozycyjnych czynników ryzyka rozwoju objawów ma kluczowe znaczenie dla diagnostyki alergii. Profile uczuleń określane za pomocą podstawowego panelu testów skórnych różnicuje pacjentów w zależności od płci, grup wiekowych i poszczególnych jednostek chorobowych o podłożu alergicznym. Jednak poziom ekspozycji na pyłek nie był bezpośrednio związany z częstością wyników testów skórnych, czyli jego alergogennością.

Air quality versus health of winter rapeseed crops

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KEY WORDS: oilseed rape, *Leptosphaeria maculans, Leptosphaeria biglobosa, Plenodomus lingam*, *Plenodomus biglobosus*, SPEC system

Aeroplankton includes numerous airborne macro- and microorganisms, such as pollen grains, fungal spores, bacteria and viruses, many of which contain allergenic proteins adverse for human health. The concentration of these airborne pathogens can be determined using aerobiological methods with various levels of precision. The detection of pollen grains and airborne spores is based on air sampling with Hirst type suction traps. The detection of plant pathogens transmitted by air as spores or other propagules permits the development of forecasting methods. Decision support systems based on pathogen biology are greatly supported in all environmentally friendly policies of the European Union, such as the Green Deal. In Poland the monitoring system of airborne plant inoculum using a network of 9–10 volumetric spore samplers has been constantly operating since autumn 2004. This System for Forecasting Disease Epidemics (*in Polish:* System Prognozowania Epidemii Chorob, SPEC) has been focused on *Plenodomus lingam* (formely: *Leptosphaeria maculans*) and *P. biglobosus* (*L. biglobosa*), two pathogens of oilseed rape, responsible for the stem canker disease, which brings huge economic losses. The ascospores of both species are mostly discharged in the autumn and partially also in early spring. The latter brings less harm to plants and results with small decrease of yield, in contrast to plant infections in the autumn. In SPEC system tapes from volumetric traps are processed for spore counts followed by DNA extraction which enables the determination of pathogen species by quantitative Real-Time PCR. The presentation will show the organisation and results of the SPEC system over the last 20 years and the examples of its use in agricultural practice. The use of aerobiological data may help to undertake proper decisions in plant protection and save the environment by the reduction of unnecessary pesticide sprays.

Modeling the impact of changing the method of heating apartments in Krakow in the years 2012-2018 on the level of PM_{10} concentrations

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KEY WORDS: emissions from heating systems, air quality modeling, emissions reduction

ABSTRACT

Kraków, a large city with substantial emissions from communal, traffic, and industrial sources, faces unique environmental challenges. Its urban fabric and the land relief limit the city's ability to ventilate and remove pollutants. Notably, pollution concentration standards have frequently been exceeded, prompting the city government to ban the use of solid-fuel heating equipment within city limits starting in 2019. Economic incentives, such as subsidies for adopting new heating methods, were introduced to facilitate this change. An assessment of the effectiveness of these interventions in reducing PM10 (particulate matter) emissions was conducted utilizing data on the quantity and location of solid fuel furnaces and boiler houses from 2012, 2015, and 2018. AROME/MM5/CALMET/CALPUFF models (Scire et al., 2000a, 2000b) were deployed to estimate PM10 emissions from these heating sources for the respective years, considering meteorological data from a relatively cold year (2012) and a warm year (2018). This analysis was carried out using a 100 m resolution grid, allowing the precise calculation of daily and annual average PM10 concentrations, maximum daily PM10 concentrations, and the environmental effect, defined as the average annual PM10 concentration difference for the periods 2012-2015, 2015-2018, and 2012-2018. Emission data collected at the end of 2018 based on information on active furnaces and boiler houses were also integrated into the FAPPS air quality forecasting system, significantly improving Kraków's air quality predictions (Godłowska et al., 2022). The findings revealed a significant environmental effect due to the elimination of solid fuel heating sources between 2015 and 2018. Specifically, PM10 emissions were reduced fourfold in terms of average annual concentrations. Moreover, all daily averages fell below 27 µg/m³, and maximum daily PM10 concentrations dropped from 254 (170) µg/m³ in 2015 to 66 (44) µg/m³ in 2018 in the cold (warm) meteorological year for 10% of the city's area.

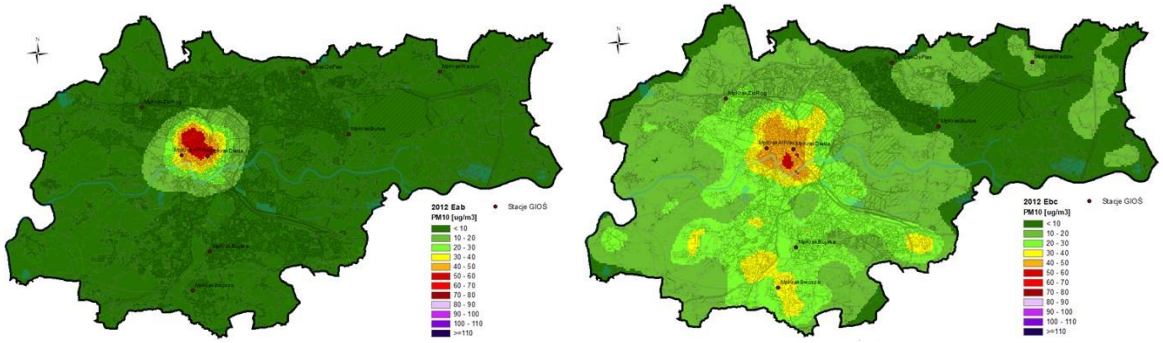

Fig.1. Maps of the environmental effects achieved by the removal of solid fuel furnaces between January 2012 and December 2015 (left) and December 2015 and December 2018 (right)

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Application of a dynamic air quality mapping system (DMJP) for monitoring and assessing the impact of odour facilities

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KEY WORDS: air quality, odour, modelling

Odour nuisance from municipal facilities is often a significant local problem faced by local authorities across the country. The lack of odour standards and complaints from people exposed to unpleasant odours make it necessary to look for methods to monitor this phenomenon. This article presents the results of a research and development project aimed at developing, on behalf of the Bydgoszcz City Hall, a local odour monitoring system for a wastewater treatment plant using low-cost sensors and modelling techniques for the dispersion of pollutants in the atmosphere. The research used the dynamic air quality mapping system (DMJP), developed as part of the NCBR-funded ISSOP project, for which experience had been gathered from previous work on air quality monitoring in urban areas for PM10 and PM2.5 pollution.

The concept for a monitoring system for odours from the Bydgoszcz municipal wastewater treatment plant assumed the use of low-cost sensors to measure two odour-forming substances characteristic of wastewater treatment plants, i.e. hydrogen sulphide (H_2S) and ammonia (NH_3). As part of the pilot study, a prototype version of the device was made, including the selection of sensors. After testing and calibration, the sensors were mounted, and the modelling (CALPUFF model) and the data presentation system for the concentrations of the analysed substances was launched. The tests were conducted for 12 months.

The developed odour monitoring system from the wastewater treatment plant can be used by the operators of the wastewater treatment plants to continuously monitor the state of air quality around the studied facility and by the local authorities to keep the residents informed about current and forecast odour pollution.

Application of ADMS-Urban for an area with a high contribution of residential heating emissions – model verification and sensitivity study for $PM_{2.5}$

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KEY WORDS: PM2.5, modelling, local scale, ADMS-Urban, Poland

ABSTRACT

Air pollution poses a significant risk to both human health and the environment in the contemporary world. Among the various pollutants, particulate matter with a diameter less than 2.5 µm (PM2.5) is regarded as the most hazardous. It has been implicated in over four million global fatalities in 2019 alone. This research paper divulges the outcomes of modeling the spatial-temporal fluctuations of PM2.5 concentrations within the confines of Wroclaw, a city situated in Poland, Central Europe. The model's output was evaluated through comparison with collected data from two government-operated monitoring stations within the city. For this study, we used the ADMS-Urban model and tested two different sources of background data (low-cost sensors and the EMEP MSC-W atmospheric chemistry transport model). The statistical analysis conducted in the paper indicates that the model reproduces the temporal variability of PM2.5. The conclusions from this research indicate that the average annual PM2.5 concentration within Wroclaw is 13.87 µg/m3, with the concentration peaking in the month of March. The spatial dispersion reveals the highest PM2.5 concentrations primarily in the southern and western zones of the city, with additional elevated concentrations observed sporadically throughout the city. The study unveils that approximately 1.28% of Wroclaw's area experiences PM2.5 concentrations exceeding the EU's annual limit of 20 µg/m3. When considered in relation to the WHO's suggested annual average level of 5 µg/m3, Wroclaw city experiences exceedances throughout. When background concentrations are excluded from the model, the annual average PM2.5 concentration across the city is noted to be reduced by more than 80%. A thorough investigation into the city's emission structure indicates that the residential sector contributes around 75% of the total annual average PM2.5 concentrations within Wroclaw, while the transportation and industrial sectors are accountable for nearly 18% and 2% respectively.

High resolution GHG dispersion modeling in urban environment – case study from Krakow

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KEY WORDS: greenhouse gases, anthropogenic emissions, biogenic emissions, hi-resolution modelling, urban atmosphere

ABSTRACT

The severity of the observed climate change during recent years is encouraging policy makers to reinforce mitigation efforts across multiple temporal and spatial scales. To ensure the effectiveness of the actions undertaken, reliable tools based on atmospheric observations are required to assess the observed changes and the primary factors driving these changes. One of the most important task within the scope of these efforts is the estimation of carbon emissions. Atmospheric transport models constitute a key element of anthropogenic emissions monitoring and verification systems. Although urban areas are responsible for significant portion of anthropogenic emissions, significant challenges and modelling and development of observation networks limited our ability to precisely assess fluxes at respective scales.

Here we present the application of a high resolution GHG (Greenhouse Gas) dispersion modelling framework based on the WRF-Chem model in the urban area of Krakow, the second largest city of Poland, located in Małopolskie voivodeship. The results demonstrate the preliminary results of the CO_2 dry mole fraction simulations obtained using the developed system and evaluate the model performance in two aspects critical for model performance for modelling of GHGs, (i) parametrisation of the urban boundary layer dynamics and (ii) spatio-temporal distribution of CO_2 emitted from the point-like strong power-generation emission source located in the vicinity of the city. The evaluation of model performance was done using vertical CO_2 profiling campaigns supported by carbon isotope analysis and application of the isotope-mass balance (Zimnoch et al. 2018), allowing to determine the urban boundary layer dynamics, and also to evaluate contribution of anthropogenic and biogenic carbon to the city atmosphere. Measurement campaigns were performed in 2021 as part of the EU-founded CoCO2 (Prototype System for Copernicus CO_2 service, Horizon 2020) research project. The preliminary results showed that the model was able to correctly represent the vertical CO_2 structure; however, the analysis of isotopic signals has indicated an underestimation of biogenic signals in the city atmosphere.

Acknowledgments

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Effect of data separation on the effectiveness of modeling NO_x concentrations in an urban agglomeration

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KEY WORDS: nitrogen oxides, machine learning, meteorological factor, data splitting

The issue of air quality modelling is widely discussed in the literature. One of the trends is the analysis of the relationship/influence of environmental factors on the concentration of pollutants in the air using various machine learning methods. The main problem of these models is their poor fit and interpretation potential (Kamińska and Turek 2020). We proposed a splitting of the data, which grouped the moments in time in a given way. The 13 variables used in the modelling were selected from 23 available by the iterative method using Random Forest (RF) (Kamińska and Kajewska-Szkudlarek 2023). They describe the characteristics of the environment such as: meteorological conditions (wind direction and speed, air temperature, atmospheric pressure, sunshine, relative humidity), traffic intensity and time variables (hour, working/week-day).

We considered two splitting methods: cluster analysis (using C&RT algorithm) and decision tree (DT). In the decision tree method, there was only one splitting variable $\mathrm{NO}_{\mathrm{x_{t-1}}}$. This means that in this method, the only splitting criterion is the last measured concentration of NOx (the value from one hour earlier). This method produced eight NOx_{t-1} intervals covering $\mathbb{R}_+$, with boundary points at 47.04, 82.1, 117.3, 162.5, 242.6, 355.4, and 526.8 μgm^{-3}. As a result of the cluster analysis, 8 clusters were also obtained. Each cluster describes different ambient conditions that most strongly influence the current concentration of NOx, taking into account traffic volume, meteorological conditions, and time of day.

For each of the two received splitting, each time into 8 subsections, we created machine learning models: Random Forest (RF), Artificial Neutral Network (ANN) and Support Vector Regression (SVR). For comparison purposes, we also built models for a full dataset without splitting. The goodness of model fit was measured by 4 popular measures summarized in Tab.1. In each case, the model based on the SVR technique was the weakest fit. ANN and RF methods show a similar level of fit. Interesting conclusions can be drawn from the analysis of the fit of individual models for each of the subsets.

The best fit in CA splitting method was obtained, for both type of models, for afternoon traffic peak periods under different ambient conditions (MAPE 14-18%). Worse fit was recorded for night times conditions (MAPE 22-25%). Models fit for C&RT splitting method was almost uniformly distributed across subsets (MAPE 16.7-20%) except one cluster contains mainly afternoon peak hours with low traffic (MAPE 22.6 and 23%).

The results show that both approaches to model specification may be effectively used to improve the quality of modelling of NOx concentrations in urban areas. The choice of approach should be determined by the purpose of the analysis. If the forecast is to be used only to provide instantaneous information, for example, to provide public warnings, then methods based on C&RT will be sufficient. However, if the goal of the analysis is to identify particular ambient conditions that favour the achievement of a particular level of air quality, with an analysis of the influence of individual factors, and the creation of scenarios for development planning or other city management actions, then models based on CA provide the possibility of obtaining such information.

Table 1. Goodness of fit measures for analysed models

	Goodness of fit measures	RF	ANN	SVR
C&RT	R^2	0.869	0.872	0.840
	$MADE$ $[\mu gm^{-3}]$	21.0	20.6	24.8
	$MAPE$ [%]	17.2	16.8	23.7
	$RMSE$ $[\mu gm^{-3}]$	33.9	34.0	38.1
CA	R^2	0.842	0.878	0.836
	$MADE$ $[\mu gm^{-3}]$	21.7	21.5	27.4
	$MAPE$ [%]	17.3	17.3	34.7
	$RMSE$ $[\mu gm^{-3}]$	40.4	34.3	39.7
Full dataset	R^2	0.852	0.856	0.678
	$MADE$ $[\mu gm^{-3}]$	21.8	22.2	42.0
	$MAPE$ [%]	17.5	18.9	91.6
	$RMSE$ $[\mu gm^{-3}]$	36.5	35.8	53.5

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A novel approach to low-stack emission management

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The aim of the study was to develop new tools for analysing air quality scenarios for the residential emission sector.

The existing databases and information have been used: The Central Register of Building Emissions (GUNB), Clean Air Programme (NFOSiGW), Report on emission factors for sources of combustion of solid fuels (Żelinski et al. 2021), sociological research amongst household owners (Pytliński et al., 2021), analysis of energy demand for households (KAPE), analysis of emission factors for ecodesign boilers (Krpec et al., 2023), efficiency of boilers from European Monitoring and Evaluation Programme guidebook (EMEP).

This robust approach allows for analysis of the impacts of different quantitative emission scenarios on the commune level (the smallest administrative unit). Authors have prepared a dataset compatible with the KOBIZE CBE (Krajowy Ośrodek Bilansowania i Zarządzania Emisjami, Centralna Baza Emisji), which is responsible for national emission inventory in Poland. Three computation tools were created to calculate specific for each commune: emission factors, energy demand, scenarios for fuel mix. 1st tool calculates average emission factors for coal and biomass, based on the local (municipal) structure of boilers and on the individual emission factors assigned to various devices, including condensable fractions of particulate matter. In the 2nd tool, in order to assess the impact of thermomodernization, the age structures of buildings in each county (higher tier then commune) were used. The energy demand reductions were assessed based on the KAPE analysis, describing heat energy consumption of houses divided into 3 thermal insulation classes and 6 age groups. Results from these two previous models provide input data for the third one, i.e. the scenario tool, that accounts: share in coal and biomass fuel mix of outdated boilers and 5 or ecodesign class, reductions in energy demand, scenario assumptions (number of replaced boilers), and conversion rate per class of boilers. The products of the scenarios include: new energy mix and emission factors per each commune. This data is further fed into KOBIZE CBE model to produce emission raster data for air quality modelling.

Four 4 scenarios have been calculated: Natural, Ambitious, Compliance and Biomass. Each had an implementation date of 2030. The main variable of each scenario was the replacement rate of outdated solid fuel boilers. The rate of exchange was based on the hitherto performance (statistics of devices replacement) of the Clean Air Programme and the quota of boilers to be replaced according to the data from The Central Register of Building Emissions.

The developed tools are at the stage of prototypes, however they have already been assessed with different KOBIZE analyses which confirm that they provide an important improvement to the existing approach, i.e. spatial differentiation, while at the same time they take into account already available public data.

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Copernicus Atmosphere Monitoring Service – implementation of National Collaboration Programme for Poland

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KEY WORDS: CAMS Service, National Collaboration Programme, national uptake, CAMS products, air quality downscaling, emissions, Sentinel 5P

Copernicus Atmosphere Monitoring Service (CAMS) is one of the thematic areas of the European Copernicus Earth Observation Programme. CAMS offers a wide range of high-quality products developed in the scope of sub-services such as air quality forecasts, emission data and satellite observations. To promote a tailored application of CAMS products the National Collaboration Programme was introduced in 2022.

The CAMS National Collaboration Programme for Poland has been launched in May 2023 and the pilot phase will last 18 months.

The primary objective of the National Collaboration Programme for Poland is to improve the uptake of CAMS products at national, regional and local levels. We aim to build and disseminate a user-driven database of ready-to-use CAMS products for Poland. Five users/stakeholder groups have been identified: public administration, researchers, secondary education, NGOs and the general public. To enhance user engagement, we will invite the interested institutions to co-design a list of applications and CAMS products that might be used in Poland in the long term.

All the activities envisaged within this project will be built around the data centre that will serve the information on air quality and emissions based on the products provided in the scope of CAMS services for the area of Poland. The project will ensure that the maximum benefit is derived from CAMS products and services. We will support the direct use of CAMS regional analysis, and pollen forecast, and facilitate the initiate uptake of Sentinel 5P observations for analysis of the atmospheric chemical composition over Poland. Downscaling methodology for CAMS regional air quality products over Poland will be developed to refine the resolution and address local problems. Also, we will promote the use of CAMS emission products in Poland and provide feedback based on local and national knowledge of the relevant CAMS services. As a part of the general society's involvement, we will design and implement educational programs and courses targeted at secondary schools.

The CAMS National Collaboration Programme gives a unique opportunity to promote the CAMS Service product and to define new applications. Our objective is to build a community of CAMS product users in Poland. The project is expected to contribute to national emission control and air quality and various air quality-related impact assessment studies, including health effects and cost-benefit analysis.

As the scientific community is an essential and competent user of CAMS products, we would like to provide a comprehensive overview of the project to initiate the discussion and to invite existing CAMS users to present their experiences at the first users workshop planned in November 2023.

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Opportunity to conduct research on atmospheric pollution using a hot air balloon

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Air quality is extremely important for the environment and human health, particularly in urban areas. That is why air quality monitoring is carried out constantly in numerous European cities. In Poland monitoring stations usually provide data on concentrations of PM10, PM2.5, and selected gases (CO, SO2,NOx, and BaP). Monitoring stations are usually located in spots representative for the urban background air pollution and do not provide information on spatial distribution of air pollutants. Nevertheless, data they collect are often the basis for modelling the emission source categories of atmospheric pollutants. There is limited information on the real-time horizontal and vertical extent of air pollutants from the emission sources. This information can be gained by using mobile research platforms.

The University of Silesia in Katowice owns the only Polish manned hot air balloon as a research platform equipped with onboard multipurpose instruments for interdisciplinary atmospheric study. During the balloon flight it is possible to do *in-situ*: measurements of solid particles concentration in the range of 10 nm to 10 µm in aerodynamic diameter, simultaneously with their sampling; analyses of various gases and their sampling into Tedlar bags for further study; measurements and collection of bioaerosols (pollen, bacteria, and fungal spores). Real-time meteorological data are also gathered during each flight. All instruments are calibrated for reliable measurements at high altitudes. Measurements and sampling can be done safely at altitudes up to 4000 m above ground level. The balloon has a large lifting capacity of up to 1200 kg that allows for additional research equipment to be uploaded if needed, e.g. for remote sensing. The advantage of hot air balloon as a research platform over the unmanned aerial vehicles (UAV) is the ability of the former to carry out different measurements and sampling simultaneously and continuously for up to 4 hours. There are no propellers that disturb air movement. The balloon flies alongside the flow of air masses, which enables tracing the spatial and temporal dispersion of air pollutants at different altitudes. This capability of the balloon platform has been confirmed during recent research flights over Upper Silesia, Warsaw and Wroclaw. Data obtained with help of the hot air balloon can serve to both creating and verifying numerical models of vertical and horizontal dispersion of airborne pollutants.

Application of field olfactometry and gas sensors in odorous samples analyzes

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KEY WORDS: odor nuissance, odor concentration, field olfactometry, gas sensors, volatile organic compounds

Odors emitted from Waste Management Plants raise social concerns regarding the well-being of employees working at these facilities and residents of nearby areas (Pawnuk et al., 2022). Therefore, reduction of unpleasant odors is a priority for this branch of industry. It is also necessary to provide verification of the effectiveness of these efforts. Olfactometry (*i.e.* dynamic and field olfactormetry) is the most popular method of odorous samples investigations. It allows to determine the concentration, intensity and hedonic quality of the analyzed odor, but information on its chemical composition cannot be obtained in this way. Analytical methods (*e.g.* GC-MS, gas sensors), in turn, allow to measure the concentration of individual odorants, but this does not tell us much about the odor impact. Therefore, sensory and analytical methods should not be treated as competitive techniques but rather used simultaneously as complementary approaches to odorous samples investigations (Jońca et al., 2022). Such strategy was employed for the investigation of three Waste Management Plants (WMP1, WMP2 and WMP3) in terms of odor and odorants concentration using field olfactometry and gas sensors, respectively. The measurements were taken during autumn (WMP1, WMP2 and WMP3), winter (WMP1) and spring (WMP1) seasons and therefore, gave the possibility to compare the odor and odorants concentrations at these three sites (autumn measurements) and to investigate the seasonal variability of these parameters at the WMP1 site.

The highest D/T that can be measured with the field olfactometer (Nasal Ranger) used in this study was 60 which corresponds to odor concentration of 78.49 ou/m^3 (Pawnuk et al., 2023). During autumn investigations, such high odor concentrations (*i.e.* 78.49 ou/m^3 and above) were recorded at 13 out of 36 measurement points (36.1%) for the WMP1. This parameter was significantly higher for the WMP2, *i.e.* 15 out of 26 measurement points (57.7%) and slightly lower for the WMP3, *i.e.* 6 out of 21 measurement points (26.6%). For the WMP1, the highest odor concentrations were observed inside the aerobic bioreactors and the waste aerobic stabilization area; for the WMP2 – at the sorting facility, the composting yard and the waste storage yard; and for the WMP3 – at the sorting facility, the composting hall and waste reception hall for anaerobic treatment. The seasonal investigations at the WMP1 revealed that, the odor and odorants concentration are generally lower during winter than for the rest of the year. This is in accordance with our previous results (Pawnuk et al., 2023).

Measurements with the specific sensors revealed that the volatile organic compounds (VOCs) are mainly responsible for the perceived odors. Indeed, as the VOCs concentration increases, the odor concentration increases as well. Various correlation coefficients (Pearson's, Spearman's, and Kendall's) were analyzed while searching for the relationships between VOCs and odor concentration. The Spearman's tests gave the highest correlation coefficient for all investigated facilities, *i.e.* 0.696 (WMP1), 0.741 (WMP2) and 0,973 (WMP3). Strong correlation coefficient was also achieved with the Kendall's tests, *i.e.* 0.568 (WMP1), 0.606 (WMP2) and 0.924 (WMP3). The weakest correlation coefficient was obtained with the Pearson's tests, *i.e.* 0.495 (WMP1), 0.536 (WMP2) and 0.588 (WMP3). The correlation coefficients may be further improved by the application of a field olfactometer with the higher D/T range. Indeed, at VOCs concentration of around 0.6 ppm, the measured D/T was often at its maximal value of 60. Meanwhile, much higher VOCs concentrations (up to 10 ppm) were frequently recorded with the PID (photo-ionization detector) sensor and especially at the WMP2.

In summary, the obtained results revealed significant diversification of odor and VOCs concentrations that depended on the waste treatment processes, the meteorological parameters, and the technological regime. Importantly, the correlation tests indicated that VOCs and odor concentration are correlated but the relationship between those parameters is not linear. Therefore, although the PID sensor can not replace well established olfactometry measurements, the VOCs measurements could be a useful tool to verify the effectiveness of odor nuisance minimization procedures put in place at the site of interest.

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Measurement of particulate matter gaseous compounds and odor identification based on the experience of Atut Ltd.

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Particulate matter measurement is carried out in the PM1, PM2.5, PM4, PM10 fractions using TSI construction solutions. We offer DustTrak Enviromental Monitor EDTDRX™ with MCERT certification, portable versions DRX ™ model 8533, 8533EP, 8534, personal aerosol analyzer SIDEPAK™ model AM520i with DATALOGGER WITH LOCAL WEB INTERFACE AND INTERNET ACCESS TO THE CLOUD Atut Smart City-D and BlueSky Air QualityMonitor 8145 and 8143.

We present the highly advanced gas pollutant measurement technology on the example of OPSIS design solutions using the DOAS method.

We measure odor compounds from installations that are highly harmful to the environment based on our own designs of APFinder and SmartCity measuring devices using VOC sum detectors (PID sensors).

Full separation of odor-generating compounds is obtained using the Z-Nose gas chromatograph /electronic nose/.

zNose chromatographs are a family of gas chromatographs equipped with modern SAW (Surface Acoustic Wave) detectors operating based on the surface acoustic wave phenomenon. Both laboratory models and fully adapted to work in the field are available.

Are the government's air quality improvement programs having a measurable effect? – Air quality changes in Warsaw and surrounding areas

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KEY WORDS: air quality, smog, analysis

With growing awareness of the dangerous effects of high concentrations of air pollutants, the Ministry of Climate and Environment, alongside local governments, has taken measures to improve air quality. To this end, several programs have been launched, such as "Czyste Powietrze", "Stop Smog", "Mój prąd", "Energia Plus", "Ciepłownictwo Powiatowe" or "GreenEvo", aimed at municipalities and counties, especially residents of single-family homes and contractors. In addition, more provincial dietines are adopting Anti-Smog Resolutions. However, are these measures producing measurable effects? This work presents the results of an analysis of open-access data from selected air quality monitoring stations of the Chief Inspectorate of Environmental Protection (https://powietrze.gios.gov.pl/) in both urban and suburban background areas of Warsaw.

The analysis carried out covers winter periods (December-February) over the years 2016-2021 for seven measurement stations - an urban traffic station (Warszawa, Aleja Niepodległości), two urban background areas (Warszawa Kondratowicza and Wokalna) and four suburban areas located north (Legionowo), east (Otwock), south (Konstancin Jeziorna) and west (Piastów) of Warsaw. A selection of the occurrence of smog in Warsaw is supplying this study. For those episodes, an analysis of the prevailing meteorological conditions was carried out, along with verification of the directions of air mass inflows in the lowest layers of the atmosphere based on the backward trajectory HYSPLIT model. The analysis indicates an improvement in the air quality both in urban and suburban areas in terms of particulate matter PM_{10} and $PM_{2.5}$. However, for some pollutants (e.g. benzo(a)pyrene), the concentrations remain at high levels. Over the years, the number of smog episode occurrences decreased, and their presence is related to temperature inversions and lack of wind.

Acknowledgments

Measurement data from air quality monitoring stations of the CIEP was analyzed. Meteorological data from the IMGW - PIB stations, were used. The HYSPLIT transport and dispersion model from NOAA Air Resources Laboratory (ARL) via the READY portal (http://www.ready.noaa.gov) was applied to determine the potential directions of air mass inflows.

Air quality and health effects related to pollution as an indicator of the progress of energy transformation

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Most countries in the world are undergoing energy transformation, moving away from the emission sources based on fossil fuels and developing zero-emission sources, such as renewable energy. The European Union is aspiring to be a leader in taking climate change actions by implementing very ambitious plan to reduce greenhouse gas emissions by 55% by 2030 in relation to 1990 and trying to reach a target of net zero emissions by 2050. The AGH University of Science and Technology is launching the project "Energy Transformation Observatory as an instrument to support the socio-economic development of Poland" under the GOSPOSTRATEG' program "Social and economic development of Poland in the conditions of globalizing markets". The aim of the project is to develop unique tools and models for assessing the energy transformation in the following areas: economic, climate and environmental, social and technical.

A detailed database of energy conversion technologies will be developed for various sectors, such as: energy, households, transport, industry, agriculture. This database will be developed based on literature review and the measurements of such an emission factors as particulate matter, sulfur oxides, nitrogen oxides, carbon dioxide and methane.

Simulations of the pollutant's dispersion in the atmosphere will be carried out using the Polyphemus air quality system. The simulation area will cover Poland with high resolution and will include an analysis of pollutant concentrations resulting from emissions from individual sectors (e.g. households). Calculated concentrations, dose-response functions, methodology of health effects assessment developed by the EPA and WHO, and the population will be used to assess the health effects (years of life lost, restricted activity day, cases of various diseases, hospital admissions) related to a given sector. The obtained results will allow to determine the health effects and the resulting concentrations per emission unit.

The health effects will be evaluated and the total external costs for the use of individual technologies in Poland will be developed. Based on the obtained results of external effects and costs for the Polish population and emissions of individual energy technologies, unit external costs for individual technologies will be calculated (external costs per unit of energy (input and/or output) and per person).

What will be the low emission zone in Wrocław?

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KEY WORDS: low emission zone

The amendment to the Act on electromobility and alternative fuels in 2021 gave local governments the opportunity to use another tool to improve the quality of air, which are low emission zones (LEZ). Cities and municipalities in Poland have gained greater freedom in making decisions regarding the creation and operation of low emission zones. The city of Wroclaw also decided to take advantage of this opportunity. In June 2022, measurements of exhaust emissions from road transport in the city center were commissioned and a report was commissioned, which contains recommendations regarding the implementation of the clean transport zone in the capital of Lower Silesia. The most dangerous pollutants emitted by vehicles are nitrogen oxides (NOx) and particulate matter (PM10 and PM2.5). According to the research, the most pollutants of this type are emitted by old petrol and diesel vehicles, manufactured before 2005.

In December 2022, a document was presented: Low emission zone in Wroclaw. Vehicle exhaust emission test report and recommendations for the establishment of CTZ. It presents three proposals for clean transport zone areas. Each of the variants presented the area of the zone and the criteria for entering it. According to the assumptions of the above-mentioned document, the clean transport zone in Wroclaw should come into force in 2025, and its criteria should be tightened in 2028 and 2032. Currently, consultations with residents are being conducted on the recommendations presented in the Report.

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Part II
Poster session

Exposure of inhabitants of Silesia to B[a]P and volatility of $PM_{2.5}$ and PM_{10} concentrations

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KEY WORDS: benzo[a]piren, air pollution, risk assessment

ABSTRACT

Air pollution is the most serious environmental health threat in the modern world. This is a major cause of various diseases and premature deaths. In 2016, it was estimated that air pollution was the cause of 4.2 million premature deaths caused by cardiovascular diseases, i.e., heart diseases and strokes, as well as respiratory diseases, predominantly lung diseases and lung cancer. The pollutants with the most serious impacts on human health are particulate matter (PM), PM10-bound benzo[a]pyrene (B[a]P), nitrogen dioxide and ground-level ozone. Both particulate matter and benzo[a]pyrene are classified by the International Agency for Research on Cancer (IARC) as carcinogenic to humans (Group 1). B[a]P has been recognized as a good and sufficient indicator of human exposure to priority polycyclic aromatic hydrocarbons (PAHs) present in the air, for many years.

Negative health effects are more frequently observed in of European countries characterized by significant pollution. Exceedances of the daily limit value recommended by the EU for PM10 (50 $\mu g \cdot m^{-3}$) occur throughout the continent. However, the highest concentrations are observed in Northern Italy, Croatia, Bulgaria, Serbia, Kosovo, Turkey, Bosnia and Herzegovina, North Macedonia and Poland. Poland is considered to be a country with some of the severest problems related to air pollution in the EU, mainly due to such pollutants as PM2.5, PM10 and benzo[a]pyrene pollutants. According to the ranking pre-pared by the World Health Organization (WHO), 36 out of 50 cities with the worst air quality in the EU are located in Poland, most of them in Upper Silesia.

The aim of this study was to examine the variability in the PM and PM10-bound B[a]P concentrations at 11 monitoring stations and to analyze the risk of developing cancer resulting from inhalation exposure to B[a]P among the inhabitants of Upper Silesia.

In many Silesian cities, the average annual concentrations of PM10, PM2.5 and B[a]P were much higher than those recorded in other European countries. At each station, the average daily PM10 concentrations were exceeded on 12 to 126 days a year. Taking into account the WHO recommendation for PM2.5, the highest recorded average daily concentration exceeded the permissible level by almost 40 times.

In the Silesian Voivodeship, in in recent years the average annual concentration of PM10-bound B[a]P ranged from 2.48 to 13.18 $ng \cdot m^{-3}$. The highest B[a]P concentrations were recorded in Rybnik, which exceeded the limit value by 109 times recommended by the WHO of 0.12 $ng \cdot m^{-3}$.

The lifetime cancer risk (LCR) of inhalation exposure was estimated on the basis of the concentration of PM10-bound B[a]P in the atmospheric air in the Silesian Voivodeship. The LCR values were calculated for three scenarios: (a) annual, (b) the heating season and (c) the non-heating season. In the area of the Silesian Voivodeship, the LCR of the inhalation exposure to B[a]P was at an acceptable level. The calculated lifetime cancer risk (LCR) associated with the exposure to B[a]P in the Silesian Voivodeship suggested 30–429 cases per 1 million people in the heating sea-son depending on the scenario used for the calculations (IRIS, EPA or WHO).

Preliminary assessment of the influence of meteorological conditions on the variability of concentrations and composition of particulate matter in indoor and outdoor air in the area of a selected health resort

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KEY WORDS: air quality, meteorological conditions, health resorts

INTRODUCTION

Air quality is one of the major environmental hazards in the world and is the cause of an increased incidence of cardiovascular and respiratory diseases and an increased risk of cancer and premature death (WHO 2006). These factors should be considered in terms of 28 both outdoor air quality (Act of July 28th, 2005) and indoor air quality particularly in resort areas, where the adequate quality of the environment, including climatic conditions and ambient air quality, is crucial in providing comprehensive health care (Sówka et al. 2019). In both in indoor and outdoor air, meteorological conditions play a key role in the distribution of pollutants, including particulate matter.

RESEARCH AREA AND METHODS

Air quality assessment was carried out at Szczawno-Zdroj Health Resort based on measurements made during three measurement campaigns (two winter: 2021, 2022 and one summer: 2021). Particulate matter sampling was carried out according to PN-EN 12341 (PN-EC 12341, 2014-07), while the concentrations of the measured elements were quantified by energy-dispersive X-ray fluorescence (EDXRF). Ion concentrations were determined by isocratic ion chromatography using an ICS-1100 instrument (Thermo Scientific, Sunnyvale, USA). The air quality measurements were complemented by measurements of the air temperature indoors and outdoors. As supplementary data, data from SEM and meteorological data from the nearest foothill stations of the Institute of Meteorology and Water Management (Jelenia Góra and Klodzko) and wind direction data, illustrating the main direction of advection, from the IMWM observatory on Śnieżka were used. Furthermore, the results of the back trajectory simulations for selected days, developed based on the HYSPLIT model in the online version (Stein et al. 2015), were used for the analyses.

PRELIMINARY RESULTS

The study shows that the highest indoor particulate matter concentrations were recorded in winter 2021 for PM_{10} 49.8 μgm^{-3} for $PM_{2.5}$ 42.2 μgm^{-3} and for PM_1 23.1 μgm^{-3}, outdoors the maximum value for PM_1 was 39.9 μgm^{-3}, and that S, Fe, Zn, Si, and Pb, as well as SO42-, Cl-, NO2-, Ca+, K+ were predominant in the PM_{10} fraction and Cl in the PM_1 fraction in indoor air for the winter measurement campaign. The concentrations of individual dust fractions in the 2 winter seasons in indoor and outdoor air indicated a very strong correlation with each other, indicating the presence of the stack effect during winter and the infiltration of pollutants into the building. The greatest influence on air quality during the winter season was the wind speed (both as a daily average and maximum value), as well as the minimum temperature during the day.

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Polycyclic aromatic hydrocarbons in particulate matter of a rescue and firefighting unit as a source of health hazard for firefighters

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KEY WORDS: polycyclic aromatic hydrocarbons (PAHs); particulate matter (PM); occupational exposure

Among the many different chemicals in the air, polycyclic aromatic hydrocarbons (PAHs) pose a serious threat to human health. The carcinogenicity of PAHs in humans has been evidenced in cases of colon, skin, lung, bladder and kidney cancer (Hwang et al. 2021). Firefighters are exposed to them both during fire suppression and in fire vehicles and fire stations due to inhalation of the fumes from contaminated clothing and personal protective equipment.

This study aimed to estimate the concentrations of different PM fractions and PAHs air pollution in a fire station unit (FSU) garage as well as to evaluate the associated firefighters' carcinogenic risk. The health risk assessment was performed based on the 15 PAHs listed as priority by the US EPA (Keith 2015). To evaluate the toxicity and assess the risks of a mixture of chemicals, the toxic equivalent (TEQ), the incremental lifetime cancer risk (ILCR) and the non-cancerogenic hazard quotient index (HQ) from PAH inhalation over the period of professional activity were calculated (Zhao et al. 2020).

Air samples were collected for 4 months in a garage of the FSU in a small town, located in an urban–rural area. PM sampling was performed using optical and gravimetric methods, while PAH concentrations were measured using the gas chromatography method with mass spectrometry (GC/MS).

The concentration of PM4 and TSP in the fire station garage was 7 and 9 times higher than outside, respectively. The calculated values of health hazard risks associated with the exposure to PAHs in PM4 and TSP were: TEQ up to 10.36 and 23.33, ILCR up to 3.45 and 4.65 and HQ up to 0.42 and 0.57, respectively. Results indicated that firefighters are a professional group with very high health risk, especially to neoplastic diseases and different kinds of cancers caused by inhalation of toxic PAHs.

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The role of fine particles in urban air pollution

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KEY WORDS: particulate matter, fine particles, particle number concentration, high pollution periods

Despite extensive activities in the area of reducing emissions related to industrial and household activities, the problem of exceeding the limit values for particulate matter (PM) applies to almost all zones in the country (Błaszczak et al. 2020). The harmfulness of aerosols depends not only on its chemistry but also on the size distribution. In this context, the smallest particles of PM, with a diameter of 2.5 µm and smaller ($PM_{2.5}$, PM_1), are particularly dangerous, because they are able to persist in the air for a long time, can penetrate the lower respiratory tract, and constitute a carrier of various potentially toxic substances (Landkocz et al. 2017, Masiol et al. 2017).

This paper presents the results of research conducted at the urban background station in Zabrze, using Fidas®200 S optical aerosol spectrometer. Based on the measurement of light scattered at an angle of 90° on individual particles, the device calculates and records continuously the concentrations of PM_1, $PM_{2.5}$, PM_4, PM_{10} and TSP as well as the particle number concentration C_n. The study devoted much attention to the analysis of episodes of increased PM concentration, which were identified on the basis of the authors' previous experience (Błaszczak et al. 2020) – as cases with daily $PM_{2.5}$ concentration > 50 $\mu g \cdot m^{-3}$, lasting for at least 3 consecutive days.

It was found that the average concentration of $PM_{2.5}$ for the annual measurement period (Jun 2022 – May 2023) was 24.19 $\mu g \cdot m^{-3}$, which means that the limit value for the average annual concentration (20 $\mu g \cdot m^{-3}$) was not met (Directive 2008/50/EC). During the campaign, a total of 42 cases of exceeding the level of 50 $\mu g \cdot m^{-3}$ (~12% of the measurement time) were identified. Among them, 7 periods of increased PM concentration were distinguished, the longest of which was in the second half of Nov 2022. Regardless of the averaging period, $PM_{2.5}$ – especially PM_1 – constituted the dominant part of the total suspended particulates (TSP). The shares of these fractions were particularly high in the winter months and in episodes (~83% and ~80%, respectively for $PM_{2.5}$ and PM_1), when the particle number concentration was also very high.

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Differences between variability patterns of pollutants concentrations measured at traffic and urban backgrund stations in Warsaw

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KEY WORDS: air pollution, traffic emissions, transport sector, air quality monitoring

Air pollution is one of the greatest health and environmental challenges of modern society. In particular, NO2, PM10 and PM2.5 often exceed permissible standards in urban areas. The accumulation of emission sources in Polish cities, including the municipal, transport, industrial and service sectors, results in significantly higher pollutant concentrations compared to rural areas. This is particularly noticeable in the Warsaw agglomeration, where the suburbs of the Polish capital are characterised by high pollutant concentrations, especially in winter. Air quality is also affected by individual heating in this area, while urban heat islands in the city centre can prevent a strong accumulation of pollutants.

Given the large population in the Warsaw conurbation, it is important to assess the impact of the transport sector on mortality and morbidity. Studies suggest that traffic congestion is a significant health risk and that additional urban traffic may increase the risk, depending on the type of roads and other factors.

Presented analyses focuses on the air pollutants variability in Warsaw agglomeration and possible impact of transport sector.

The aim of this study is to compare temporal variability od concentration based on the observation from national air quality monitoring network for the period 2016-2021. The comparison of diurnal, weekly and monthly averages at traffic station and urban background stations let to identify possible contribution from the traffic sector. For NO2 temporal profile is clearly related to traffic intensity, while for PM10 the diurnal variability is weaker and suggest the importance of resuspension. While NO2 and PM10 concentrations are systematically higher at traffic station that at urban background stations, PM2.5 levels are comparable. The results will help to define the emission variability profile for local air quality modelling as well as the expected contribution from non-exhaust traffic emissions.

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Radon-health hazard gas and tool to evaluate GHG flux

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KEY WORDS: radon, GHG, RTM model

Radon is an inert, odourless and tasteless radioactive invisible gas that is a constant component of the air. Its presence in the atmosphere is linked to its concentration in the soil. The concentration of radon in the soil depends on the level of radium, uranium and thorium in the soil or bedrock, which serve as the parent elements of radon. However, the relationship between these parameters is not straightforward due to the influence of air and soil temperature, pressure, humidity, and precipitation on radon movement in the ground and its release into the atmosphere.

Radon poses a health hazard, from a radiation protection perspective. Elevated levels of radon concentration present a health risk for humans. Radon is considered the second leading cause of lung cancer among individuals who smoke cigarettes and the primary cause of lung cancer among non-smokers (Darby et al., 2005; Bochicchio et al., 2013).

Radon gas can be utilized as a tracer to estimate regional greenhouse gas (GHG) emissions using Radon Tracer Method (RTM). If the radon flux from the soil is known, the correlated increase of radon and GHG concentration can be used to estimate the GHG flux. The Radon Tracer Method has been employed for greenhouse and other gas emission and sink estimates by Gaury et al. (1990); Levin et al. (1999); Biraud et al. (2000). In all these studies, the Rn-222 flux from the soil was assumed to be spatially homogeneous with only slight variations on a seasonal timescale. However, recent research has revealed significant spatial variability in radon gas (Szeregavy et al., 2009, Lopez-Coto et al., 2013; Tchorz-Trzeciakiewicz D.E., Rysiukiewicz M., 2021). Therefore, there is a need for improvement and further development of the Radon Tracer Method with a particular emphasis
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The cleaning effect of rainfall – Results of long term measurements of wet deposition in polluted urban environment

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KEY WORDS: particulate matter, atmospheric precipitation, wet deposition, chemical composition

Precipitation is an important process as a result of which many air pollutants are removed from the atmosphere and deposited onto the ground surface (Michalski, Pecyna-Utylska 2022). Among the many different substances identified in rainwater, sulphates, nitrates and other acidic compounds can have a detrimental effect on vegetation, and can also accelerate the process of soil acidification or corrosion of building structures (Meng et al. 2019). On the other hand, water soluble organic carbon (WSOC) participates in the formation of cloud condensation nuclei and may play an important role in the formation of secondary organic aerosol (SOA) (Aswini et al. 2019).

Systematic studies of wet deposition at the urban background site in Zabrze were initiated in Feb 2020 and continued in subsequent years. The aim of the research was to determine the wet loading of particulate pollutants and, additionally, to analyze the chemical composition of rainwater and suspension collected on the filter – in terms of ionic compounds and carbonaceous matter.

It was found that the sum of atmospheric precipitation clearly decreased in subsequent years, remaining at the following levels: 587.17 nm (2022), 739.23 mm (2021) and 805.71 nm (Feb-Dec 2020). Even greater differences were observed in the wet deposition of dust (D_w), which was 9.87, 24.67 and 33.11 kg·ha^{-1}, respectively. In general, seasonal variability of Dw shows an opposite tendency compared to the PM concentrations, with higher values in the summer months (June-August) and lower values in the autumn-winter period (October-December). However, it was also stated that there is no strong and clear relationship between the sum of precipitation and PM concentration. This allows to conclude that there are other factors – apart from the intensity of precipitation – that determine the stream of wet deposition and the most important include atmospheric transformation processes and variable activity of local emission sources.

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Improvement of $PM_{2.5}$ concentration modelling using the Random Forest algorithm

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KEY WORDS: air pollution modelling, PM2.5 prediction models, machine learning for air quality

The recorded concentrations of PM2.5 in Poland are among the highest in the EU countries (EEA 2020). The recommended annual concentration by WHO of 5 µg*m^{-3} for PM2.5 in 2021 was consistently exceeded throughout the country, causing negative health effects and ongoing concerns for residents (GIOŚ 2021; WHO 2021).

In this study, the Random Forest algorithm in R language was used to improve modelling results of PM2.5 concentrations by the EMEP4PL chemical transport model for monitoring stations in Poland. Data from 2016-2019 for 71 stations were used to train the models. Three approaches were tested, differing in terms of the selected explanatory variables or the number of models used. Each approach underwent 5-fold cross-validation. In the first case, the EMEP4PL model results, along with variables like month, station ID, season, and year, were used as predictors. The second approach added meteorological predictors from the WRF model for the current and previous two days. The third approach utilized all previous predictors and developed 12 separate models for each month. The errors of all models were summarized using the coefficient of determination (R^2), root mean square error (RMSE), and normalized mean bias (NMB). Variable importance rankings were also obtained for each case.

Results indicated the significance of meteorological predictors related to air temperature, wind speed, atmospheric pressure, and planetary boundary layer height. All three RF outperformed the EMEP4PL model's prediction alone. When considering both EMEP4PL and meteorology, R^2 exceeded 0.7, and when modelling was divided into individual months, it reached 0.75 *(Fig. 1)*. R^2 values for individual stations in the second and third approaches often exceeded 0.5 and occasionally surpassed 0.8. An important result is the elimination of the underestimation of observed concentrations, which was a limitation of EMEP4PL due to e.g., uncertainties in emission estimates.

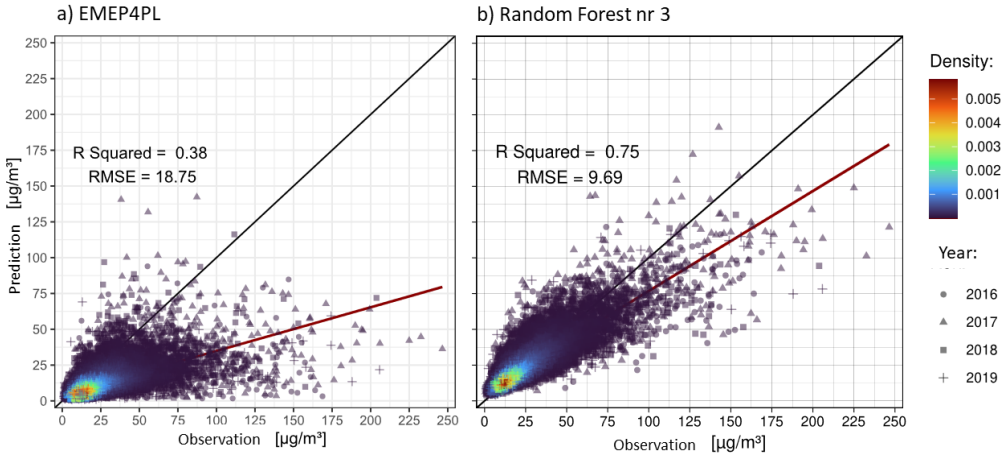

Figure 1. Results for Random Forest modelling – third approach (b) compared to EMEP4PL model (a)

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TROPOMI NO_2 tropospheric column assimilation – a hybrid ensemble-variational approach (4DVar)

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INTRODUCTION

TROPOMI aboard Sentinel-5P is the first representative of the new generation of satellites capable of delivering high resolution (3.5x7.0km) tropospheric NO2 column concentration with a revisit time of one day. Regional CTM models suffer from uncertainty and bias originating from the emission data and errors in meteorological field reproduction.

The idea of data assimilation is to use the observed (satellite-borne) observation to improve the modelling results. There are two main approaches to data assimilation: sequential and variational. In the sequential approach model, trajectories (state variables) are shifted towards the observed ones. An ensemble of models is run to avoid shifting into non-physical values, and the new state variables are chosen among the ensemble results. In contrast, in the variational approach, optimisation is run (minimisation) on a cost function, which describes the bias between the model results and the observation. Based on this minimisation, new model parameters are chosen. This process can occur on a single concentration field (3DVar) or within a temporal assimilation window (4DVar). Both cases require the calculation of gradient (adjoint function), which is not straightforward for large spatiotemporal scale models.

DATA AND METHODS

Our work aimed to apply a hybrid approach – 4DEnVar (Yarce et al., 2021). We run an ensemble of 14 parallel GEM-AQ model runs, differentiating emission data. Within a 48h assimilation window, we minimise the difference between the TROPOMI tropospheric column and the one resulting from the model. We chose new emission data based on this minimisation and used it for subsequent simulation days.

We used the GEM-AQ model (Kaminski et al., 2008) – an online chemical transport model (CTM) with a 10 km resolution and CAMS regional domain. Calculations cover the period from the 2nd to the 22nd of April 2020. Thus, ten subsequent assimilation windows were used (each lasting 48 hours).

RESULTS

We present a spatial comparison with reference simulation (run without assimilation) and a comparison with surface NO2 concentration observation time series for selected locations. Both surface and satellite-borne observation revealed an underestimation of NO2 concentration. The 4DEnVar assimilation scheme tried to compensate for the underestimation and partially succeeded.

CONCLUSIONS

Within 20 days of simulation, we have shown that TROPOMI's tropospheric vertical column density can serve as an independent source of observations for NO2 concentration on a regional scale. However, the 4DEnVar assimilation process has introduced some artefacts. Thus, the algorithm should be implemented robustly. The underestimated concentration is likely due to underestimated emissions in the CAMS emission inventory. The 4DEnVar was revealed to be capable of correcting the concentration magnitude, but it does not affect the dynamics, which are driven by the meteorological component of the modelling system.

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Social factor in assessing the olfactory impact of odour-emitting facilities

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KEY WORDS: odour nuisance, field research, social studies

INTRODUCTION

The odour impact of odour-emitting objects can affect the perception of odour nuisance by nearby residents. The perception of an odour nuisance can be influenced by many factors, such as individual factors (health condition, age, life activity), as well as the type of odour and its intensity, time of day, and frequency of odour situations/episodes, or characteristics of the area where the odour occurs and odour dispersion processes in air. The range and degree of odour impact can be determined by assessing the intensity and frequency of occurrence of identified odours outside the facility boundaries or by comparing the odour concentration at the receptor points with the established limit values. Research to determine the olfactory impact of odour-emitting objects can be divided into emission and immission measurements.

SELECTED ODOUR IMPACT ASSESSMENT METHODS

Emission measurements include classical analytical methods (GC-MS) and sensory methods (dynamic olfactometry) to determine the concentration of individual odorants in the emitted gases and the odour concentration, respectively. Based on the calculated value of pollutant emissions and analyses using mathematical modelling by obtaining the odour concentrations at the receptor points, it is possible to determine the extent of the facility's impact and to confirm compliance with the standards. Determining the odour impact is also possible by performing immission measurements, for example, by measuring the concentration of selected odour compounds at receptor points using analytical, sensor or field research methods (field measurements, field olfactometry and sociological research, in which questionnaires and odour observation logs are used). It should be noted that the latter are particularly important in determining the actual degree of odour nuisance in a given area.

THE IMPORTANCE OF THE SOCIAL FACTOR IN EVALUATING AND SELECTING A METHOD TO REDUCE ODOUR IMPACTS

In the case of repeated complaints from residents that odorous air quality causes discomfort and is a nuisance, measures aimed at social dialogue are very important. Communication with residents in such cases should be supported by expert knowledge and the results of scientific research, both in the context of identifying and characterising odour emission sources, as well as methods minimising odour nuisance. Involving the local community in monitoring the odour situation and providing information in this regard (e.g., through surveys, mobile applications, observation logs) and communicating the results obtained (e.g., during working group meetings or open meetings) allows one to highlight the existing problem. Therefore, eco-mediations are an important element in socially difficult cases and allow the solution of ecological problems and the making of compromises with respect to all aspects of sustainable development: social, economic, and environmental protection.

Confronting the results of the emission, field and sociological research with the complaints of the residents allows us to show and understand the fullness of the issue. It is important that sociological and field research be preceded by the identification of odour sources based primarily on a thorough field reconnaissance. The research carried out during the reconnaissance makes it possible to specify the dominant types of odour and include them both in the odour observation logs and in field research, and to design a measurement grid. Such a comprehensive approach, combined with statistical and geospatial analyses, allows overlapping and comparing the results of mathematical modelling of odour dispersion (based on emission measurements), e.g., with the results of field research, field olfactometry, and sociological research. Involving the local community in filling out the diaries and participating in meetings of the parties to the conflict allows to verify the real social mood and the scale of the problem. The results of the analyses should be made available to the community along with an indication of specific actions to reduce the odour impact (such as plant operation outside evenings and weekends or odour masking agents during meteorological conditions conducive to the dispersion of odours toward residential buildings).

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The influence of air quality in the heating season on health residents

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KEY WORDS: air quality, low-stack emission, respiratory and cardiovascular diseases

Poland has the most polluted air among all European Union member states. The reason is, in particular, low-stack emission, i.e. emission of pollutants from the combustion of solid fuels in the municipal and residential sector, mainly in small home hearths, local central heating boiler rooms, craft plants where solid fuels are burned, especially hard coal, but also wood, peat, and sometimes even waste. The formation of low emission is a complicated process and depends on many factors, such as the type, quantity and quality of the fuel burned, the method and technology of its combustion, many meteorological factors, topography and development, the height and location of emission sources.

The paper attempts to analyze the relationship between the quality of atmospheric air and the number of people who reported to the local clinic diagnosed with respiratory and cardiovascular diseases. The analysis was performed on the example of the city of Żory in southern Poland. Żory is located in the Silesian Voivodeship, and thus the city is located in one of the most polluted voivodeships in Poland. According to the World Health Organization report from 2016, Żory was ranked 49th on the list of the most polluted cities in the European Union.

Air pollution concentrations PM 2.5; PM10; SO2 for the heating seasons was obtained from the database of the monitoring station belonging to the Chief Inspectorate of Environmental Protection. Information on the number of people who consulted a doctor and who were diagnosed with a respiratory or cardiovascular disease was obtained from the local health center.

The analysis was performed for 54 days of the heating season. The graphs show the number of patients who were diagnosed with respiratory and cardiovascular diseases on specific days, and the concentrations of pollutants such as: particulate matter PM2.5 and PM10 and SO2 in the air. In the analyzed period, there were 35 days with exceeding the limit value of PM10 suspended particulate matter in the air, which is 64.8% of the observation time. In the period from 01/11/2021 to 15/01/2022, 1,236 people came to a doctor with respiratory diseases, and 1,037 people with cardiovascular diseases. In the study period, no short-term correlations were observed between air quality in the heating season and the number of people diagnosed with respiratory and cardiovascular diseases.

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Assessment of the diversity of exposure to $PM_{2.5}$ concentrations as a result of the use of various protective face masks during the COVID-19 pandemic

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KEY WORDS: air quality, COVID-19, face masks, filtration efficiency, $PM_{2.5}$ concentration reduction

According to estimates by Msemburi at al. (2023), the COVID-19 infectious disease caused by the new type of coronavirus SARS-CoV-2 caused a significant global excess mortality of about 15 million deaths between 2020 and 2021 alone, including 4.5 million in 2020 and 10.5 million in 2021. During the period of highest risk of illness associated with the COVID-19 pandemic, most countries around the world were required to use face masks or other personal protective equipment in certain situations (Torres-Agullo 2021). This resulted in massive consumption of protective masks, reaching about 129 billion per month (Prata et al. 2020), and forced a significant increase in their production compared to before the pandemic (Aragaw 2020). In order to reduce the inhalation of viral aerosol less than 5 μm capable of penetrating the lower respiratory tract, the use of high-efficiency air-filtering face masks, such as N95 respirators, was particularly recommended (Xu et al. 2020), although non-medical face masks were also considered an effective way to reduce the transmission of respiratory viruses in the community, especially when their wearing was required or common (Howard et al. 2021).

During the COVID-19 pandemic, a great many types of protective face masks were used, such as disposable medical or non-medical masks, including surgical masks and N95 filtering respirators containing a layer of charged/electrostatic fabric (known as an electret filter, such as charged meltblown polypropylene) significantly improving particle filtration (O'Dowd et al. 2020, Kwong et al. 2021, Xu et al. 2020, Zhang et al. 2020). Much more expensive certified dust or anti-smog respirators were also used, as well as non-certified single- or multi-layer protective masks made from a variety of available materials, including homemade face masks, whose main criteria for assessing suitability by users were usually aesthetics of manufacture, ease of breathing or washability and reusability (Bagheri et al. 2021, Kwong et al. 2021, Pei et al. 2020). In addition to the primary task of reducing the transmission rate of SARS-CoV-2, wearing face masks also made it possible to capture to some extent particulate matter (PM) from the air drawn through the mask, thus reducing inhalation of $PM_{2.5}$, among other particles (Marsal et al. 2023, Pacitto et al. 2019, Su et al. 2022, Xu et al. 2020, Zhang et al. 2018). Their effectiveness in this regard depends mainly on the type and properties of the materials used (including the thickness and microstructure of the filter layer), the size of the filtered particles, the air intake velocity and humidity, but also on the way the mask is worn, the degree of wear, the method of sterilization and the number of treatment or washing cycles for reuse (Bagheri et al. 2021, Hao et al. 2021, Kwong et al. 2021, Liu et al. 2020, Xu et al. 2020).

The purpose of this study was to present the results of comprehensive measurements of the efficiency of trapping the $PM_{2.5}$ fraction (particles with aerodynamic diameter less than 2.5 μm) by filter materials used in selected face masks (including commercial masks and masks specially made during the COVID-19 pandemic), as well as to estimate the potential reduction of exposure to $PM_{2.5}$ particles by people wearing these masks, taking into account typical $PM_{2.5}$ air concentrations in Poland. The filtration efficiency was determined as a function of the mass of retained and unretained particles on a given filter material using the gravimetric method and a measurement set based on a low-flow dust collector (2.3 m^3/h flow rate) with a $PM_{2.5}$ impactor head operating in accordance with EN 12341:2014. Tested filter materials were cut into disks of about 47 mm diameter (at least 4 samples), dried at about 60°C, cooled in a desiccator, weighed and placed in the dust collector in front of a glass microfiber final filter (Whatman® GF/A) of known initial mass. The source of $PM_{2.5}$ was indoor air in a well-ventilated laboratory room with a volume of about 64 m^3, where the measurement set was run for at least 48 hours. The results obtained were related to previous preliminary studies (conducted even before the COVID-19 pandemic) using a similar methodology, but based on exposure of a dust collector in outdoor air on the roof of a four-story building (Bieniaszewski et al. 2018, 2020), as well as the results of studies conducted with other methods adapted to the needs of a given research program (using particle size analyzers), based on air with real or artificial dust (poly- or monodisperse aerosols).

The conducted tests confirmed (already known to some extent from the literature) the large variation in the effectiveness of some of the tested filter materials in terms of their ability to retain $PM_{2.5}$ particulate matter, depending on the type and number of filter layers and their grammage. These efficiencies for multilayer materials used in filters and respirators of the FFP3, FFP2 and FFP1 filter classes mostly occurred at relatively high levels (on the order of 95-99 %, 85-99 % and 82-98 %, respectively), although for some filters and respirators of the FFP2 filter class declared by the manufacturer, the average efficiency for $PM_{2.5}$ obtained by the gravimetric method fell below 85 % and even below 70 %. Of the protective masks usually classified as FFP2 class, the relatively inexpensive disposable half-mask KN-95 respirator was particularly popular during the COVID-19 pandemic. However, not all masks of this type available on the Polish market contained a double layer of Meltblown filter (despite such a declaration in the product description). This caused their average effectiveness to decrease from about 90 % (masks with a double Meltblown filter) to about 30-60 % (masks from different suppliers with a single Meltblown filter of various thicknesses). For more than 10 types of medical (including surgical) and non-medical disposable face masks with Meltblown filters tested, as well as reusable double-layer cotton masks with a possible additional replaceable Meltblown filter, their filtration efficiencies for $PM_{2.5}$ ranged from about 40 % to 85 %. The least effective (efficiencies of about 10-40 %) were protective single-, double- or triple-layer masks (of different weights) made of non-woven Wigofil (spunbond type), polyamide fabric, polyester fabric or microfiber (fiber Dryarn®). Assuming an average concentration of $PM_{2.5}$ in inhaled air of 20 $\mu g/m^3$ (a value close to the annual average in Poland for 2021), it can be concluded that face masks put on and worn in a way that guaranteed 100 % tightness during inhalation usually guaranteed a reduction of $PM_{2.5}$ concentration in inhaled air to approx. 0.4-6 $\mu g/m^3$ for filters and respirators with a declared filtration class of FFP3, FFP2 or FFP1, 3-12 $\mu g/m^3$ for medical or non-medical masks with a Meltblown filter and at least two-layer cotton masks, and 12-18 $\mu g/m^3$ for the least effective protective masks.

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Air quality in seaside resorts

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KEY WORDS: microclimate, air pollution

ABSTRACT

Many of us are convinced of the beneficial effects of the marine climate on human health. Due to the geographical location, often windy weather, and therefore larger sea waves and salinity, the Polish sea and other Northern Seas produce a greater amount of aquatic particles containing various micro and macro elements beneficial to health, such as iodine, bromine or magnesium. Water particles floating in the air make them extremely beneficial for our body. Many coastal towns, due to their unique microclimate, become health resorts, but in the air, in addition to various beneficial microelements, there may also be various dust and gas pollutants. The air we breathe should not contain impurities above the permissible concentration values, and the oxygen content should be above 19% (this value is the lower limit below which the first symptoms of hypoxia of the body may occur). Air pollution is created by dusty substances, gaseous substances and microorganisms, each of which can have harmful effects on human health. The size of the particles that make up the pollutants is very important. The type of air pollution most harmful to health is particulate matter (PM), especially finer particulate matter that can reach deeper into the lungs, such as PM2.5 (particulate diameter < 2.5 µm). Such small PM particles < 2.5 µm can also diffuse into the bloodstream and travel throughout the body, and even through the blood-brain barrier can enter the brain and further cause inflammatory changes. So you can ask the question whether seaside resorts really have such clean and healthy air? Air pollution issues are a growing public health problem, and mortality from air pollution is expected to double by 2050. For this reason, it was decided to conduct preliminary air quality tests for PM1, PM2.5 and PM10, gaseous SO_2 and H_2S, O_2 levels, as well as taking into account microclimatic parameters such as temperature, relative humidity and wind speed in one of the coastal towns on the Baltic Sea. The results obtained were compared with current standards and the obtained data were compared with scientific data from other cities. The test area included five sampling points located in close proximity to the sea not exceeding a total of 600 m. Measurements were made every day in the afternoon between 15.00-17.00 for one week. The obtained results indicate that the tested air pollution parameters, such as particulate matter (PM), SO_2, H_2S, remain at the correct level not exceeding the permissible standards. The examined parameters of the microclimate: temperature, relative humidity and air velocity did not differ from the correct (recommended) values.

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Microbiological air quality – the influence of the method on the interpretation of results in the estimation of biological hazards

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KEY WORDS: mesophilic bacteria, mould fungi, sedimentation method, impact method

People spend at least several hours a day in indoor spaces. Microbiological indoor air quality is a crucial factor that impacts their well-being and health. This type of exposure is primarily connected with the inhalation route. The selection of the appropriate method for qualitative and quantitative measurements of bioaerosols is crucial in assessing the biological hazards associated with this type of exposure.

The aim of the study was to compare the results of two bioaerosol measurement methods: sedimentation (using Petri dishes) and impaction (Air Ideal 3P impactor), in order to ascertain which method is more suitable for assessing the biological risk associated with airborne microorganisms (mesophilic bacteria (TSA - Trypticase Soy Agar, 35°C) and mold fungi (Czapek-Dox Agar, 25°C)). The research was conducted in the building of the Center of New Technologies in Gliwice (Southern Poland), including corridors and a lecture hall (spring 2023 during one day). All samples were performed in triplicate.

It was found that the results obtained using the sedimentation method significantly differed from those obtained using the impaction method. In most cases, the number of microorganisms was significantly higher (CFU/m3 of bacteria as well as fungi) when analyzed by the sedimentation method. Additionally, the values of deviations obtained from three repetitions of each analysis were, in most cases, much larger when analyzed using the sedimentation method than by impactor. The use of the impactor allowed for obtaining more reliable and repeatable results, especially in the case of fungi, which were not detected in several corridors when the sedimentation method was used. The exposure time (in the range from 12 to 20 min.) of the Petri dishes was crucial in the case of the sedimentation method as it may lead to the overinterpretation of biological hazards. The changes in the sampling air volume (in the range 100 to 200) in impaction method were a less important factor. Therefore, it can be concluded that the use of the impaction method provides a more reliable picture of the threats caused by airborne mesophilic bacteria and mould fungi in buildings.

Allergenic Potential Of Urban Green Spaces, Case Study From Poznań, Poland (Central Europe)

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KEY WORDS: pollen allergy, Poznan city center, urban green spaces

Greenery is a crucial element of the city space, influencing its general appearance, attractiveness and climate. The presence of greenery improves mental and physical health, reduces morbidity of city residents by providing mental relaxation and relieving stress. Urban greenery stimulates physical activity and reduces exposure to noise and excessive temperature (WHO 2017). Poorly planned and managed green spaces can however have a negative health impact. This problem is raised primarily in the context of allergic diseases caused by pollen grains (Carinanos and Casares-Porcel 2011). It is estimated that currently pollen allergy affects about 20-30% of the population, and the number of allergic people is the highest in urban areas (Samoliński et al. 2014). One of the reasons for this phenomenon is the increase in the number of allergenic ornamental plants in cities, and the species homogeneity of green spaces, i.e. preferring only selected plant species, leading to the biodiversity loss (Carinanos and Casares-Porcel 2011). In recent years, a similarly alarming trend in urban greenery management can be noticed in Poznań, e.g. by over-representativeness in the plantings of the London plane tree (Platanus × acerifolia) (Nowak et al. 2012). As a result, green areas, instead of having a health-promoting function, become unpleasant areas for a significant number of inhabitants. Moreover, the introduced ornamental species may contribute to the increase in the prevalence of allergic diseases. The main aim of this study is to assess of the allergenic potential of green urban spaces. Therefore, serves as a premise to test the hypothesis about the significant role of green areas in shaping the prevalence of allergic diseases in the city.

The inventory was carried out in 10 parks and all the streets and alleys of Poznań city center. Approximately 4000 trees were recorded, which belong to 68 species, 45 genera, and 26 plant families. The evaluation of species and genera in the inventory of Poznan city center shows that *Acer* genus (Maple) is the most abundant genus. The second and third common genus is *Tilia* and *Aesculus*. By the data of common species with the allergenicity, 83% of the total trees are allergenic potential with levels 1 to 5. Among that, the presence of species with high allergenic potential includes species of the genus: *Platanus*, *Betula*, *Fraxinus*, *Carpinus*, *Juniperus*, *Taxus*, *Corylus*, … By the way, we have localized areas with high concentrations of allergenic plants, areas clearly defined in the map. With these preliminary results, warnings can be given to people living around areas where is a high concentration of allergenic trees in flowering seasons.

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Applicability of DeltaPix InSight software for hazel, alder and birch pollen counting

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KEY WORDS: DeltaPix InShight, pollen, pollen allergy, volumetric method, automatic counting

Nowadays, the issue of pollen allergies is becoming a significant problem. This is related, among other things, to climate change and atmospheric air pollution. Rising air temperatures and the presence of chemical pollutants affect the timing and duration of pollen seasons, increase the number of biological particles in the air, and alter the allergenic properties of pollen. Consequently, the importance of monitoring of bioaerosols in ambient air is increasing (Dbouk T et al., 2022). The volumetric method using a Hirst-type pollen sampler is the most commonly employed technique for airborne pollen monitoring. The analysis of collected slides is a quantitative, visual method, which is done using an optical microscope. However, it is a labour-intensive and time-consuming method (Weryszko-Chmielewska, 2007). This study aims to evaluate the applicability of the DeltaPix InSight software for the automatic recognition of pollen grains of three allergenic taxa, i.e. hazel (*Corylus* sp.), alder (*Alnus* sp.), and birch (*Betula* sp.). The software works on the basis of 5 criteria; i.e.: the colour determined by three RGB ranks, the morphology of the objects searched for as a preprocessing step, and thresholds regarding the area, shape and Feret diameter for the areas designated by the software that correspond to the first two criteria. The analysis was conducted for daily data for two weeks during the 2023 season. During the first week (21.02-27.02), the predominant allergenic pollen was alder and hazel, and during the second week (18.04-24.04) - birch. The results of the automatic counting were compared with the results of the manual observation and summarised using the statistics, such as: Probabilty of detection, Succes Ratio, Bias and Critical Succes Index. The results showed that using the first four criteria provides the best results in pollen quantification. When a threshold related to Feret diameter was included, the software performed significantly worse in counting pollen grains. The results that were the closest to those of manual observation were mainly obtained during the week, when alder and hazel pollen predominated. Then, for the 4 criteria used, the program performed best. The average pollen detection rate for the tested week reached nearly 70% (POB) and also the number of false signals was low and the Succes Ratio reached about 0.65. Much poorer results were obtained in the recognition of birch due to the large number of pollen grains, including those similar to birch (e.g. oak), as well as contamination on the preparation (plant fragments), resulting in numerous false signals. Using 4 criteria also achieved the best result, the detection of birch pollen was on average 50%. However, Bias was very high and Succes Ratio reached about 0.05. The verification allowed to identify the main advantages and disadvantages of the software, and to determine when the software could be helpful in counting airborne pollen grains.

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Birch pollen allergenicity in Poznań city area

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INTRODUCTION

Birch pollen (Betula pendula) is responsible for inhalant allergy in about 20% of the human population in Europe, causing symptoms such as allergic rhinitis (AR) accompanied by asthma symptoms and oral allergy symptoms. Most people are sensitive to the main birch allergen, Bet v1. The concentration of this protein in pollen grains may change, probably due to the influence of different factors, including environmental factors and pollutants. The main objective of the research was to test the hypothesis about the influence of air pollutants, such as PM2.5 and PM10 dusts, temperature and humidity, on the amount of Bet v 1.

METHODS

Pollen grains collected in 2020 from the Betula pendula Roth birch population in Poznań and its vicinity, from 37 sites, were divided into the following categories: urban, suburban and semi-natural.

Bet v 1 was quantified using an enzyme immunoassay and pollen grains were counted using a hemocytometer. Bet v 1 content in pollen grains was expressed in pg Bet v 1/zp. The significance of differences in Bet v 1 content between populations was determined using the ANOVA method, while the impact of environmental factors (air temperature and humidity, PM2.5 and PM10 concentrations) on the Bet v 1 value was determined using correlation analysis.

RESULTS

Bet v 1 content in birch pollen grains ranged from 0.23 to 6.36 pg Bet v 1/zp.

The highest average level of Bet v 1 was observed in urban facilities, while the lowest in semi-natural areas (1.77 pg Bet v 1/zp). However, these differences were not statistically significant. A statistically significant relationship was observed between the amount of Bet v 1 in urban areas and the concentration of PM2.5 and PM10. In the case of the influence of temperature and humidity, no significant effect on the size of Bet v 1 was found.

The studies have shown that the allergenicity of birch pollen grains is clearly spatially differentiated and there is a gradient between urban and semi-natural areas, which are caused by stress factors such as dust pollution. To test this hypothesis, further analyzes using local habitat data are necessary to determine as accurately as possible the role of stress factors in the amount of Bet v 1 in birch pollen grains.

Pollen seasons of selected Cupressales species with relation to flowering phenology in Poznań during 2023

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KEY WORDS: pollen grains, allergens, *Thuja* sp., pollen calendar, ornamental species

Pollen grains released by species of the order Cupressales are a significant cause of seasonal allergies (D'Amato et al. 2007). A dramatic increase in the concentration of Cupressales pollen grains has been observed in Poznań (Western Poland) in recent years. Hypothetically, the numerous plantings of Cupressales trees in the city are responsible for this phenomenon. In the Cupressales order morphological features of the pollen grains belonging to different genera, e.g. *Taxus*, *Juniperus* and *Thuja*, are not distinct enough to allow determination by light microscopy. Therefore, the contributions of pollen released by specific genus to the total airborne pollen are unknown.

The aim of the study was to determine the flowering phenology and pollen seasons of six species from Cupressales order (*Taxus baccata, Thuja occidentalis, Thuja pilcata, Chamaecyparis lawsoniana, Juniperus sabina* and *Juniperus communis*) for Poznań, Poland in 2023. Pollination periods were estimated by phenological observations and the airborne pollen concentrations were obtained using a Hirst-type volumetric trap located at the AMU Morasko Campus in Poznań (18m a.g.l.).

The first pollen grains of Cupressales were recorded in the air already in the middle of January. The highest daily pollen concentration (308 pollen/m^3/day) was observed on 23rd of March. Cupressales pollen season has several additional smaller peaks, i.e. on 14th of March (298 pollen/m^3/day), 19th of March (210 pollen/m^3/day) and 10th April (227 pollen/m^3/day). *T. baccata* began to flower the earliest (between 16th of January and 27th of March), followed by *T. occidentalis* and *T. pilcata* (between 12th and 28th of March), then *J.sabina* (between 1st and 20th of April), *Ch. lawsoniana* (between 14th and 30th of April) and finally *J. communis* (between 26th of April and 11th of May). The highest increase in pollen concentration was observed between 12-25th of March which corresponds to the flowering of *T. baccata, T. occidentalis* and T. *pilcata*.

Based on flowering observations and airborne pollen data it may be concluded that the species contributed the most to total pollen level are *T. baccata, T. occidentalis*, and *T. pilcata*. Other species, e.g. *J. communis* has lower impact on Cupressales pollen load, although due to late flowering time, it markedly prolongs Cupressales pollen season. Likely, plantings of ornamental trees, such as *Thuja* sp., could be linked with increased levels of in airborne pollen in Poznań.

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Optimizing the ozonation process under different ventilation parameters for safe indoor bioaerosol removal

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People spend the majority of the day i.e. about 80% in indoor space and in this about 65% at home. Therefore indoor air quality is a crucial parameter that impacts their wellness and health. Especially role play bioaerosol's quality and quantity parameters resulted from the amount and diversity of bacteria, fungi and viruses. The use of an ozone generator is one of the most effective methods of disinfection of the air and surfaces.. However, indoor ozone highconcentrations are harmful to humans. In case of the presence of people in disinfected spaces very important is to select the process parameters such as ozone concentration, air exchange rate and room's ventilation what allow to protects from the exceeding the permissible concentration of ozone in the air during and after process. Therefore it is crucial to develop and optimize the efficient process of indoor air disinfection with consideration of people's safety what was the aim of presented studies.

The ozone generator was operated at an output of 0.12 g/min, measurements were taken at 1 minute intervals with an Aeroqual meter. Ventilated air exchange rates were adjustable from 0.2 to 2 h-1. The microbiological analysis included the estimation of the total number of mesophilic, psychrophilic bacteria and molds. The samples were taken by impact method (sampler Air Ideal 3P (Biomerieux)) from one point located at the front wall of the closed chamber. For bacteria and fungi growth the Trypticase Soy Agar and Sabouraud medium were used respectively. The results were presented as CFU/m3.

The efficiency of ozone disinfection at different process parameters without exceeding the permissible level was examined. An 80-90% reduction of bacteria and a 40-45% reduction of fungi was achieved during ozone disinfection. The study confirms that the duration of ozone exposure has a strong influence on disinfection results, especially for fungi.

Identifying pollen episodes using a synergy of in-situ and remote sensing measurements

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KEY WORDS: Mie-Raman polarization lidar, Hirst-type spore traps, pollen grains, fungal spores

Bioaerosols emitted into the atmosphere due to plant pollination are considered as one of the main reasons for an increase in respiratory diseases (Asher et al., 2006; Strzelczyk et al., 2020). During inhalation process airborne pollen grains and fungal spores can cause an allergic reaction that, if left untreated, may lead to asthma (e.g. Rapiejko et al., 2018). Moreover, global climate change may increase the length of pollination, so relevant in terms of allergy hazards and its impact on human health.

In our research, we focus on allergenic pollen grains and fungal spores characterization. For that we are currently conducting a dedicated 12-month measuring campaign (Jan-Dec 2023) using unique combination of remote (Mie-Raman polarization lidar) and in-situ (Hirst-type spore trap) instruments to capture the whole pollination period of different plants in Warsaw urban environment. This core measurements are backed up with a range of additional observations, e.g. meteorological conditions, air-pollution monitoring, column-integrated sunphotometer observations, Doppler wind lidar profiling, etc.

Our aim is to characterize the detected pollen in terms of its morphology including structural and ornamental aspects of the grain (symmetry, shape, size, aperture number and location) and in terms of their type and abundance close to the surface and also above it. We seek information on how pollen grains spread within the atmospheric boundary layer and what conditions are enhancing such spread.

Based on an evaluation of nearly a decade of the past Mie-Raman polarization lidar observations (2013-2021) we propose a methodology that helps to identify pollination events in lidar data. The typical case is characterized in terms of volume depolarization ratio, relative humidity, temperature, wind speed and boundary layer top maximum level. Thus, it can be used for current observations as a muster. With the use of the Hirst-type spore trap measurements, which consist of a sample collection on a tape and a manual analysis through the microscopic examination, we can both identify pollen grain types at the ground level and verify lidar measurements. Pollen grains are classified based on their morphology (Weryszko-Chmielewska et al., 2007). The concentration of different pollen taxa is quantitatively analyzed, and the start and end dates of pollen seasons are determined using the so-called 98-percentage method.

Combination of both allows us to characterize pollen type and its vertical extent and assess to what extent the synergy of using the combined approach can help in faster pollination detection.

Acknowledgments

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Application of mobile platform and geostatistical methods in the analysis of air quality in the selected area of the city of Lodz

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KEY WORDS: air quality; urban atmosphere, spatio-temporal variability, UAV, GIS

INTRODUCTION

Air pollution, in terms of particulate matter (PM_{10}, $PM_{2.5}$, $PM_{1.0}$) and gaseous pollutants (H_2S, and VOC) has serious health effects. Thus, the ability to identify sources of air pollutant emissions and quickly assess air quality in urban areas, characterized by complex emission profiles, taking into account the dynamics of air pollutants distribution becomes crucial. In this type of research, mobile platforms can be used in addition to measurements made as part of standard monitoring (Jońca et al. 2022, Cichowicz and Dobrzański, 2021). The GIS interpolation techniques, on the other hand, allow for predicting unknown values at unsampled points based on the given points with known values distributed within the study area (Bezyk et al., 2021, Li et al., 2016).

RESEARCH AREA AND METHODS

As part of the study, in-situ measurement approaches were combined with the interpolation methods in the GIS system to investigate the spatial variability of pollution levels from a specified source in the urban atmosphere and an assessment of outdoor air quality in the vicinity of a small Paintshop operating in the city of Lodz was made. Concentrations of pollutants in vertical profiles (up to 47 m a.g.l.) of ambient air were measured using a mobile platform (unmanned aerial vehicle with measuring equipment) during three survey campaigns in September 2021. The performance of two interpolation techniques (inverse distance weighting, IDW and the Ordinary Kriging methods) to analyse the spatial and temporal variability of measured pollution concentration in the vicinity to the Paintshop was compared. The interpolated surfaces were created using the ArcGIS software within the Spatial Analyst and the Geostatistical Analyst techniques in the Geostatistical Wizard extension. The sensitivity of each method to the input data characteristics with different parameters (weights of sample point structure, number of measured points of the search radius) was evaluated.

RESULTS

The vertical structure of the pollutant concentrations indicated the occurrence of different types of layers with an almost constant concentration near the land surface, strong decrease (up to ca. 10 – 15 m a.g.l.), and significant fluctuations in concentrations to higher levels (above 25 m a.g.l.). Particulate concentrations (PM_{10}, $PM_{2.5}$, $PM_{1.0}$) were not exceeded the value of 39 $\mu g\ m^{-3}$, with levels peaked on the surface. The maximum value of particulates concentration (up to 38.5 $\mu g\ m^{-3}$) in vertical profiles was recorded at ca. 35–40 m a.g.l. The average concentrations of H_2S and VOC varied between 0.07 – 0.12 ppm and 0.01 – 0.27 ppm, respectively. The highest H_2S concentrations were observed at ca. 18 – 23 m a.g.l., reaching 0.14 ppm. A rapid increase in VOC levels, which reached 0.29 ppm, was measured in vertical profiles of 20 m a.g.l. and up to about 40 m a.g.l. Based on the survey results obtained, the kriging interpolation method was well suited to generate spatially distributed pollution maps for individual measurement campaigns.

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Possibilities of using the wind profiler for air quality tests. First experiences

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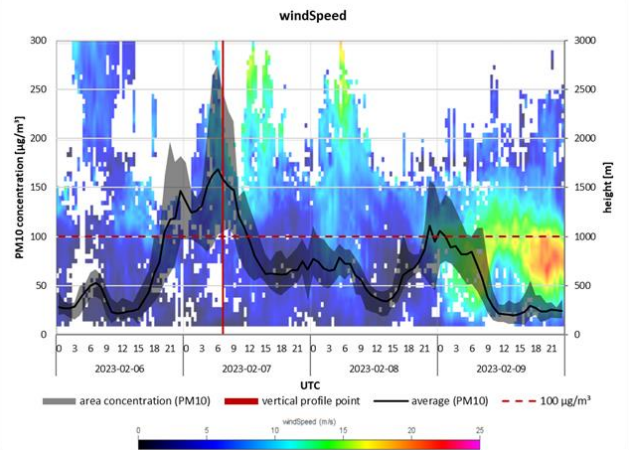
KEY WORDS: remote sensing, wind profiler, air quality

ABSTRACT

The aim of the paper is to present the possibility of using wind profiler - an automatic remote sensing device that examines the course of areological conditions in the lower troposphere to identify meteorological causes of episodes of high concentrations of air pollution. Installed at the hydrological and meteorological station in Racibórz, the Wind Profiler LAP3000 is the first radar anemometer in Poland. It functions similarly to a meteorological radar, but its task is to measure the areological conditions of the atmosphere in a vertical system. The device sends a beam of electromagnetic pulses, which is scattered and partially reflected by air particles with different turbulent properties. After technical tests, in February 2023, control measurements in winter conditions were launched, the aim of which was to obtain information about the effectiveness of the device. Among its many applications (Boming L.,et all, 2020), its suitability for assessing the impact of areological conditions on air quality during high dust concentrations was also tested. From 6-9.02.2023, an increased concentration of particulate matter was recorded in the vicinity of Racibórz. During the entire episode, the ground layer of the atmosphere was dominated by a weak wind, below 1 m/s, and the horizontal components of the wind speed up to a height of 250 m were a maximum of 4 m/s. On 7 February, when the highest values of PM10 concentration were recorded, the wind speed in the layer up to 1000 m did not exceed 5 m/s. In the entire analyzed period, the vertical components of wind speed up to a height of 1 km were close to 0 m / s or negative (up to -0.1 m/s). The wind prevailed from the northern and eastern sectors, with the exception of a section of the atmosphere layer at an altitude of about 750 m, where the wind blew from the south-western sector.



The presented results confirm the role of air ventilation factors in costing high dust concentrations, confirm the important role of WP in the diagnosis of such situations.

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Comparison of PM mass and concentration variations determined using traditional – manual weighing and robotic weighing system

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KEY WORDS: PM; mass measurements; mass variations; robotic weighing system; automated weighing, RB 2.4 Y.F.; urban background; uncertainty

Precise determination of the levels of PM in the air and reliable information about possible exceedances is of great importance. Gravimetric mass of PM continues to be an important surrogate of regulatory importance linking particulate pollution to health and environmental impacts. Studies show that exposure to PM in ambient air has been linked to a number of different health outcomes, including: lung inflammatory reactions (He et al., 2017; Jia et al., 2021), adverse effects on the cardiovascular system (Yang et al., 2021; Qu et al.,2018; Czernych et al., 2023). Several observations report a significant association between ambient concentrations of PM with COVID-19 pandemic (Copat at al., 2020). For this reason methods of PM measurement have become essential in the preparation of strategies directed to human health protection. Filter weighing is a key part of this process, since PM mass and its concentration give a measure of air quality. Next to the manual method a robotic weighing systems have been developed to catch even microgram-level PM mass. In comparison to traditional weighing these systems provide more repetitive and accurate results regarding PM mass and eliminates human factor as the reason of measurement errors, making them more cost-effective and compliant with the EN 12341:2014 standard. This paper give an evaluation of the performance of a traditional manual weighing compared to robotic weighing system by using standard deviation in the repeated measurements of mass as a comparative measure. Different PM fractions (PM_1, $PM_{2.5}$, PM_{10}) were collected using four reference samplers located in three locations differing regarding the type of emission sources. The PM mass was measured with a microbalance and a weighing robot. Most commonly used quartz fiber filters were used in this study. By evaluation of obtained results it was observed that differences in the parameters of conditioning, unstable conditioning periods when speaking about manual method as well as handling of the filters has influence on the filter weight in particular in the range of 0.008 mg to 0.220 mg, (±1.26% between manual and automatic PM mass weighing and ±1.11% between manual and automatic concentration measurements). In the nutshell, we found that robotic weighing is better able to minimize temperature and relative humidity [RH] fluctuations in the weighing environment.

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The Air Quality Monitoring System In The City Of Kielce

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KEY WORDS: air pollution, air quality monitoring, modeling the spread of PM10, environmental education

BASIC SYSTEM INFORMATION

The air quality monitoring system in the city of Kielce was created as part of the "Kielce without smog" project of the Kielce Civic Budget of 2020. The system consists of 21 devices for measuring air quality, monitoring the level of PM1, PM2,5 and PM10 suspended particulate matter, temperature, humidity and pressure. Including 20 devices were installed in various Parts of the city the facades of schools and kindergartens and on the building of the City Hall. Data from the readings of air quality measurements, from sensors included in the system, are processed and made available through a widget presenting the results on the website. The system is informative and educational. Ongoing access to measurement data provides information on the current state of air in the city of Kielce, while the analysis of data from individual measurement points will allow for locating sources of air pollution, constituting important data helpful in the fight for clean air in the city.

Environmental education

In order to obtain funds for the implementation of social education, the project was submitted to the competition under the "Regional Education Support Program Ecological". The following educational activities have been reported: part A – the guide/book "What we breathe in cities. An example of the city of Kielce"; part B – activities for children and young people; part C – education of residents interested in investments planned as part of the "Kielce Energy Cluster"; part D – education of retirees (Senior Clubs and the University of the Third Age).

Scientific aspects

1. Creation of databases on air pollution and accompanying atmospheric phenomena.
2. Improving PM10 concentration modeling tools.
3. Forecasting in the city area covered by monitoring.

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Usefulness of UAV-mounted multisensors system for in situ atmospheric measurement: a case study from Wrocław

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KEY WORDS: UAV measurements, particulate matter, vertical profiling, sodar

Air pollution, especially particulate matter (PM), is considered as a major environmental threat worldwide (WHO, 2021). Associations between ambient air pollution and adverse health effects are well documented, both for long-term and short-term health impacts (Brauer et al., 2019; Lelieveld et al. 2015, Dominici et al., 2019). Particulate matter has a serious detrimental effect on the environment, damages the crop, causes climate change and reduces visibility. High-resolution monitoring of air pollution concentration and meteorological conditions (temperature, humidity, wind, etc.) within the atmospheric boundary layer (ABL) is crucial for various environmental applications. It is important to understand the processes of surface–atmosphere interactions, which govern, e.g., high air pollution concertation events, and it is vital to measure the impacts of air pollution on human health and the environment. Information about these parameters is usually limited to a few meters above the ground; moreover, these measurements are most frequently carried out in stationary mode, and sometimes are extended with remote sensing technology (Buzdugan, Stefan, 2020; Lambey, Prasad, 2021). Thus, mobile measurement involving UAVs is an interesting supplement for ground-based measurement. Drones equipped with properly designed and constructed sensors are success-fully used in measuring air pollution, greenhouse gases, and meteorological variables, and seems to be useful for surveys in small areas (Chang et al., 2020; Madokoro et al., 2021).

The main objective of the study is to present the ability of using UAVs in simultaneous research of air pollution concentration and meteorological parameters and to deter-mine the variability of the PM concentration together with the ABL structure in the lower part of the atmosphere in various types of land use and with different emission structures.

The key issue to be solved is the appropriate design of the measurement system for comprehensive atmospheric studies (Chang et al., 2020), and in the case of using low-cost sensors, their proper calibration to obtain reliable data with high resolution. The use of miniature solutions also allows measurements to be made up to a height of 1000 m above ground level; however, it seems that from the point of view of concentration dynamics and the structure of the ABL, the lowest 300–500 m above the ground is the most important, especially in urban areas.

The solution presented in this study, utilizing simultaneous measurements of meteorological variables carried out according to the standards and air quality, allows for a detailed analysis of the influence of the structure of the ABL on air quality. It also complements remote sensing measurements, such as ABL sodar research. Thanks to the modular construction of the measuring head, in addition to basic equipment for measuring temperature, humidity, particulate matter, and ozone concentration, selected devices could be added depending on the scientific needs.

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Evaluation of the suitability of the application of selected measurement and calculation methods in the odour impact assessment of the waste management facilities – A case study

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KEY WORDS: air quality, odour impact assessment, dynamic olfactometry, field olfactometry, geostatistical methods, CALMET/ CALPUFF system

INTRODUCTION

When considering the selection of specific types of method to assess the odour impact of municipal waste management facilities, it is important to take into account the complexity of the processes involved in the management of municipal waste containing organic fractions that can generate odours, including, but not limited to. : waste unloading, the waste transfer stage at transfer stations, and waste management activities at mechanical-biological treatment (MBT) and biological waste treatment plants, including aerobic stabilisation and anaerobic stabilisation technology, in the case of mixed municipal waste processing,
as well as composting and anaerobic digestion, in the case of selectively collected biowaste thermal waste conversion in waste incinerators (Pawnuk et al., 2022, Pawnuk et al., 2023). The number and varying activity and characteristics of odour emission sources means that measurement and calculation methods can be used in parallel in odour impact assessment, which, when applied simultaneously, allows for assessment in both spatial and temporal contexts (Sówka, 2018).

RESEARCH AREA AND METHODS

The study, which included 3-series field measurements (field olfactometry, sensory evaluation in the form of field inspections), was carried out at a waste management plant located in Lower Silesia where processes and operations are carried out including mechanical-biological processing of waste, sorting of raw waste, acceptance of municipal waste, with the capacity to manage 320 thousand tons of waste per year. The results of the field survey provided an opportunity to perform analyses of the odour concentration and odour intensity distribution using the weighted inverse distance interpolation method (IDW). However, the assessment based only on measurements considers the simultaneous impact of all sources, including those adjacent to the plant (such as a sewage treatment plant or landfill quarters). The precise identification of the sources with the greatest impact was possible using modelling techniques. In this purpose, data from odour concentration measurements were used to create an emission model dedicated to this facility and perform model calculations using the CALMET/CALPUFF system and meteorological data from 2021.

EXAMPLES OF RESEARCH RESULTS

The average concentrations of odour at the site, as in the case of odour intensity, were close to the upper limit of determination. Analysis of spatial concentration distributions using the IDW method showed that the most odour generating places on the site were: the sorting room, the composting yard and the waste storage yard and model studies have clearly indicated that the greatest impact relates to the waste storage yard. However, analysis performed for the whole year (2021), shown that the impact of the facility is limited. The maximum range with exceedance of 1 ou/m^3 is about 1 km, but when we consider the intensity of the odour this range is limited only to 100 m. On the other hand, maximum impact closes within facility boundaries and it is limited to 20% hours in the year.

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Application of selected measurement and calculation methods in the analysis of particulate matter emission sources in urban areas

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KEY WORDS: particulate matter, source, urban atmosphere

INTRODUCTION

Due to the toxic properties of fine particulate matter (PM) and the frequent exceeding of acceptable standards established for the protection of human health, analyses in the field of identification emission sources and trends of changes in particulate matter in the air arouse great interest both among scientists and government and local authorities responsible for implementing programmes protection of air, or implementation of environmental policy and protection of public health (WHO 2013). Knowledge of composition of the PM and local and regional sources of air pollution emission and meteorological conditions with the use of appropriate statistical techniques allows the assessment of emission sources in the selected area. The identification of sources emission, especially in the case of the fine PM fraction, is extremely important due to the threat associated with the presence of fine particles in the atmosphere, as well as due to the fact that Poland is a specific region where PM concentrations are exceptionally high (Rogula-Kozowska i in. 2019, Sówka i in. 2018, Rawicki i in. 2018).

RESEARCH AREA AND METHODOLOGY

The research and analyses presented in the work included the results of the measurements carried out during two measurement campaings carried out in Poznań. Sampling was carried out in two 4-week measurement campaigns in thermally different seasons (25.10-22.11.2016 and 5.06-2.07.2017), and the measurement points represented the type of urban background and traffic stations. Harvard impactors were used to collect particulate matter samples of the PM_1, $PM_{2.5}$, and PM_{10} fractions. The Derenda PNS 16T-3.1 sequential impactor and MicroPNS LVS 16 type impactors from Umwelttechnik MCZ GmbH were used to collect the measurement of particulate matter concentrations within the State Environmental Monitoring. The sampling methodology was in accordance with the PN-EN 12341 standards (PN-EC 12341, 2014-07). The samples were analysed using the method ion chromatography and inductively coupled plasma – optical emission spectroscopy (ICP-OES) and OC and EC, ten water-soluble ions (Na^+, NH_4^+, K^+, Mg^{2+}, Ca^{2+}, F^-, Cl^-, NO^{3-}, PO_4^{3-}, SO_4^{2-}) and 12 trace elements (As, Br, Cd, Cr, Mn, Mo, Ni, Pb, V, Zn, Al, Fe) have been determined. As the final part of the work, receptor modelling was used, with the simultaneous use of 3 research methods: enrichment factor (EF), Principal Component Analysis (PCA) and Positive Matrix Factorization (PMF) method.

RESULTS

The research and analysis indicated four main sources in Poznań: emissions from the municipal and household sector, inflow related to combustion processes, traffic emissions (including combustion of liquid fuels in automobile engines and abrasion of road surfaces and vehicle components) and mineral dust. Research and analyses have proved that air quality in Poznań is

significantly influenced by low-stack emissions from the municipal and household sectors, but it cannot be clearly stated that only this source determines air quality in the city. In the Poznań area there are many other emission sources that can significantly affect the composition of air quality, and thus the air quality and living comfort of residents.

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Preliminary studies on the optimisation of the operating conditions of the BTF for the hydrogen sulfide removal

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KEY WORDS: odours, biological methods

INTRODUCTION

There are a number of classical methods for the removal of odorous compounds from waste gases, but biological methods (bioscrubbers, biofilters, and biotrickling filters: BTFs) are becoming increasingly applicable (Wu et al. 2020). Determining the operating parameters that affect the efficiency of hydrogen sulfide removal is crucial in making an appropriate decision regarding the selection of the optimal treatment method, suitable for the characteristics of the technological processes and the chemical composition of the emitted odorous gases (Melse et al. 2012).

RESEARCH METHODOLOGY

The test stand consisted of a vertical biotrickling filter column, a tank for the sprinkler, and a separate control and monitoring panel. The system was supplied with air from an oil-free compressor and hydrogen sulfide from a cylinder (H_2S concentration in the cylinder 50%v in nitrogen). The gases were combined in a mixer and fed countercurrent to the liquid flow to the biotrickling filter column that was filled with polyurethane foam elements inoculated with microorganisms from activated sludge. The concentration levels of the set concentration values at the inlet to the column were selected from the range of 60 - 300 ppm. The tests were carried out at a constant pH value of 3 and 4, which was automatically controlled with a pump dispensing NaOH solution. During the study, the proportions of the various groups of microorganisms (mesophilic bacteria,, psychrophilic bacteria and microscopic fungi), the loading rate (LR), the elimination capacity (EC) and the removal efficiency (RE) were determined at the residence time of the empty residence bed time (EBRT) ranging from 9.42 - 44.3 seconds. There was also continuous monitoring of process parameters such as column pressure, L/G ratio (amount of spray liquid to gas stream), liquid volume (Vliq), gas and liquid temperature (Tg, Tliq), conductivity (Con.), and oxidoreduction potential (ORP) of the spray liquid.

PRELIMINARY RESULTS

The results of the study indicated a 98.3 - 100% H_2S removal efficiency depending on the retention time and hydrogen sulfide concentration at the column inlet, variation in the proportion of group of microorganisms (*Psychrophilic Bacteria, Mesophilic Bacteria* and *Microscopic fungi*), both over time and in the vertical profile of the column. For example, before and after the biofiltration process *Mesophilic bacteria, Psychrophilic bacteria, and Microscopic fungi* in the amount of 19400000 and 6900000, 29850000 and 6900000 and 15000 and 18000 cfu/1 element of the deposit, respectively, were observed. The increase in the number of *Microscopic fungi* after the biofiltration process may be due to the fact that at the inlet to the biofilter, local drying of the bed or reduction of pH may occur, which is conducive to their development.

The publication is the result of a collaboration with Tholander Ablufttechnik GmbH.

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Gaseous air pollutants in Silesia Province – comparison between Sentinel 5P satellite data and ground measurements

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KEY WORDS: air pollution, air quality, Upper Silesian Industrial Region

Silesia is considered a region with highest concentrations of air pollutants in Poland. However, ground level measurements are performed only in a limited number of stations. In this work, we attempted to use satellite data on selected gaseous pollutants, i.e. nitrogen dioxide, sulfur dioxide and ozone to assess the relationship with ground level data and check if it is possible to calculate the surface pollutant concentrations based on Satellite data. Tropospheric vertical column densities for NO_2, O_3, SO_2 over the Silesian Province were obtained using Sentinel-5 Precursor satellite for the years 2019-2021 using Google Earth Engine. These data sets were compared with measurements made at 18 ground stations in Silesia, which were downloaded from the AirBase (The European air quality database) via saqgetr R package. Data for tropospheric columns downloaded from the satellite and those measured at ground stations correlated well for NO_2, with a correlation coefficient $r > 0.75$ for summer periods (from May to September) after removing outliers. On the other hand, the lowest correlation between the measurements appears in the autumn and winter periods. This could be due to the fact that the temperature is lower, which leads to an increase in the combustion intensity of products not intended for this purpose in obsolete furnaces and fireplaces. These practices lead to large spatial variability in the distribution of pollution that is not reflected in Sentinel 5p images. In addition, all stations located in Silesia are city stations located in densely populated cities, which significantly inflates the values measured by them. It is possible that including more remote sensing and meteorological variables could increase the correlation of surface measurements of gaseous air pollutants and satellite-derived pollution data.

The occurrence of BETX inside motor vehicles

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KEY WORDS: VOC, IAQ, diffusive samplers, cars

ABSTRACT

In the modern world, cars are an important part of people's lives, as they are a means of transportation in which people can spend from a few minutes to even dozens of hours. The drivers, as well as passengers, are exposed to many harmful substances, including volatile organic compounds (VOCs), which mainly migrate from the outside and spread inside the vehicle. Exposure to VOCs is a serious health problem causing drivers, especially professional, may be at increased risk of cancer. BTEX compounds (benzene, toluene, ethylbenzene, xylenes) are considered to be indicators of human exposure to VOCs, which in turns are recognized, along with formaldehyde, as markers of exhaust emissions from vehicle engines. This study attempts to determine the concentrations of benzene, toluene, ethylbenzene, xylenes and styrene in the cabins of passenger vehicles powered by gasoline (G), gasoline and gas (GG) and diesel (D). The test objects consisted with 11 different car models. All the cars differed in year of manufacture, type of engine and intensity of use. The research was carried out in parallel, during the winter-spring season. Measurements were carried out for a period of 5 weeks, samples were taken every 7 days. Tubes packed with Tenax GR type bed were used for passive sampling. Samples were analyzed by thermal desorption-gas chromatography with flame ionization detector (TD-GC/FID). The average concentrations of total BTEX were 28.97 μg/m^3, 20.8 μg/m^3 and 14.48 μg/m^3 for G, D and GG respectively. In each car, the highest average concentration was noticed for toluene (9.6-21.1 μg/m^3), what accounts for about 46-73% of maximum value. The average concentration of carcinogenic benzene ranged from 1.6 μg/m^3 (GG) to 3.3 μg/m^3 (D). In one of the vehicles tested, a very high benzene concentration reaching out to 31.5 μg/m^3 was recorded, after a visit to a diagnostic station. In GG and D, almost 20% were xylenes, while in G the proportion of xylenes reached the half that.

Formaldehyde in the indoor air of beauty salon – first results

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KEY WORDS: indoor air, beauty salons, VOC

Nowodays, there is a significant amount of data and publications available on indoor air quality in various types of buildings, including schools, theaters, classrooms, and libraries (Kociszewska K. et al. 2017, Chang C-J et al., 2018).

Indoor air tests conducted in Poland have so far mainly covered the mass and number of concentrations of particulate matter (Rogula-Kopiec P. et al. 2019, Rogula-Kozłowska W. et al. 2020)

Meanwhile, formaldehyde can have adverse health effects on humans. Short-term exposure to elevated formaldehyde levels causes irritation of the eyes, nose and throat, as well as respiratory symptoms such as coughing and wheezing (Tsigonia A. et al. 2010). Long-term or repeated exposure to formaldehyde is associated with respiratory problems, allergic reactions, and may even increase the risk of certain cancers (Decisioneering 2007).

Formaldehyde levels in indoor air quality (IAQ) are often measured using air quality tests, which can include passive sampling devices. Professional air quality assessments let identify formaldehyde sources and determine indoor concentration. World Health Organization (WHO) recommends a maximum residential formaldehyde exposure limit of 0.08 parts per million (ppm) (WHO 2000).

The work presents the first results from formaldehyde measurements in a selected beauty salon, located in Bytom city. The measurement was carried out with a compact microF formaldehyde analyzer from Chromatotec. It enabled continuous real-time qualification and quantification of formaldehyde (HCHO) in real time. The obtained data series was presented as the course of six-hour averages over the period 8-23.03.2023.

From the compiled results, a significant increase in concentrations of formaldehyde in the morning can be observed, lasting during the time when the salon is open and provides its services. It is clear that the highest concentrations occur during the opening and closing hours of the salon, which may indicate that its main source in the living room is most likely outdoor air 8-23.03.2023.

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Particulate matter in the indoor air in a residential house – a case study from Goczałkowice-Zdrój

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KEY WORDS: air pollution, IAQ, particulate matter, sick building syndrome

Indoor air pollution is increasingly being researched by scientists. It is estimated that about 90% of the time people spend indoors. For this reason, interest in indoor air quality (IAQ) has increased. The problem of air pollution in buildings concerns highly and poorly developed countries. However, the reasons for the worse state of the microenvironment inside are different. In addition to atmospheric air, IAQ is influenced by the activity of residents, ventilation and indoor microclimate. Pollutants include chemical compounds such as carbon monoxide, nitrogen oxides and formaldehyde as well as volatile organic compounds. In addition, they are also solid particles in the form of particulate matter. These substances can be hazardous to health and life. Exposure to pollution is mainly manifested by irritation of the upper and lower respiratory tract. It increases the risk of cardiovascular diseases and increases the likelihood of allergies. Frequent complaints from exposure to indoor pollutants can lead to Sick Building Syndrome (SBS).

In this work, a measurement module was used to study the concentration of particulate matter PM_1, $PM_{2.5}$ and PM_{10} in rooms containing potential pollution emitters. Based on the results, it was noted that the actions taken by users have a significant impact on air quality. A negative impact of tobacco smoke on the concentration of particulate matter in the air was also found.

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