3rd Symposium

Air Quality and Health
Book of Abstracts

Online conference 12-14.05.2021

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

University of Wrocław 2021

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Contents

Preface

The third edition of the scientific conference "Air quality and health", organized as a part of the LIFE-MAPPINGAIR/PL Project, is a platform for the exchange of knowledge, solutions and good practices between scientific communities, local authorities, social organizations and educators dealing with the issues of improving air quality.

As in previous editions, the subject of the conference covers issues related to air pollution - their emission, dispersion and deposition, as well as their impact on human health and life. An important element is also air quality measurements, including those carried out with the use of low-cost devices. Their rapid development, resulting in the formation of entire measurement networks open to the public, is one of the characteristic phenomena of recent years. Since the so-called anti-smog resolutions have recently been introduced in most regions of Poland, their gradual entry into force and the introduction of related restrictions has become an important element of public discourse and a challenge for local governments as well as residents. For this reason, we have decided to include social issues, such as legal aspects of activities related to air quality improvement and management in the spectrum of the conference topics. Air quality modeling is also a separate and important issue. There is no doubt that the improvement of tools and methods enabling, inter alia, better forecasts of aerosanitary conditions is one of the key factors related to universal and open access to information on air quality in the place of residence, work and study, especially in the context of protection against health risks related to poor air quality.

The issues presented above were reflected in the presentations submitted to the conference, including 47 oral presentations and 19 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

Characteristics of urban aerosols in Kraków (Poland)

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Aerosols collected on polycarbonate filters from 2019 to 2021 were analyzed using scanning electron microscopy with energy dispersive spectrometry (SEM-EDS).

Single particle analysis indicates that submicron particles strongly dominate in all samples taking into account the number of particles with the most numerous group of particles below 300-200 nm. Content of bigger particles is limited (mineral particles, bioaerosols; secondary sulphates).

Analysis of the morphology and chemical composition indicates that particles formed during fuel burning dominate. Soot occur as complex agglomerates of various morphologies, small agglomerates composed of a limited number of particles, and as single particles units composed of several particles. Most of the soot single particles are below 100 nm. Tar balls occur commonly, their size is usually between 200 nm and 1 μm. The detail determination of the sources of these particles is difficult (coal and wood burning in household heating, diesel and gasoline engines, industrial installations, and small production and service enterprises). Heath impact of soot is significant because of the small size of particles, content of organic compounds, and the common occurrence of metals. Potential health impact of tar balls type particles is also significant because of their small size and composition (aromatic compounds).

Numerous types of metal-containing particles were identified in aerosols in Kraków, differing in the content of the main and accompanying metals, and in the chemical form of occurrence. The abundance of transition metals occurring commonly in the form of oxides suggests that these particles could exert a strong and adverse health impact because of strong oxidative stress.

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Spatial Variability of Carbon Monoxide Pollution – Case Study of Bydgoszcz city

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The dynamic increase in the number of vehicles travelling on roads, which is accompanied by significantly slower development of the transportation network, has led to a noticeable drop in the average speed at which vehicles travel. This leads to several problems where the urban environment is concerned, including increased air pollution. The aim of the work was to determine the size of areas at risk of carbon monoxide pollution derived from road traffic along with determining the number of inhabitants exposed to excessive CO levels using geostatistical modelling on the example of the city of Bydgoszcz. The COPERT STREET LEVEL program was used to calculate CO emissions. Next, based on geostatistical modelling, a prediction map of CO pollution [kg] was generated, along with determining the level of CO concentration [mg/m^3]. The studies accounted for the variability of road sources as well as the spatial structure of the terrain. The results are presented for the city as well as divided into individual housing estates. The level of total carbon monoxide concentration for the city was 5.18 mg/m^3, indicating good air quality. Detailed calculation analyses showed that the level of air pollution with CO varies in the individual housing estates, ranging from 0.08 mg/m^3 to 35.70 mg/m^3. Out of the 51 studied residential estates, the permissible level was exceeded in 10, with 45 % of the population at risk of poor air quality. The carried out studies show in what way geostatistical tools from the ArcGIS package and Intergraph Geomedia program can be used to map spatial variation of air pollution in a city. The obtained spatial details can be used to improve the estimates based on interpolation between terrain observations and prediction models.

Air pollution with particulate matter in Polish health resorts, with particular emphasis on concentrations of benzo(a)pyrene

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To assess the air quality state, combined methods are used, considering measurements carried out as part of the State Environmental Monitoring, mathematical modelling of air quality as well as methods of objective estimation. The results of these studies form the basis of the analyses presenting the scale and variability of particulate matter and B(a)P pollution problems in all Polish health resorts over the last few years. They indicate an unfavourable situation in selected locations, especially in southern Poland. In 2019, the mean annual concentration (Sa) of PM_{10} and benzo(a)pyrene determined in health resorts ranged from 14.6 µg/m^3 to 30.6 µg/m^3 and from 0.5 ng/m^3 up to 4.2 ng/m^3, respectively. Modelling and measurement methods indicated that the target concentration of B(a)P (1 ng/m^3) had been exceeded in 21 health resorts, i.e. 47 % of all functioning ones. The available measurements carried out in health resorts in 2020 indicate the Sa value for PM_{10} and B(a)P ranges from 12.3 µg/m^3 3 to 35.5 µg/m^3 and from 0.5 ng/m^3 to 9 ng/m^3, respectively.

The impact of air pollution on health can be long-term and short-term. It is linked to the occurrence of high or very high concentrations episodes and often connected to unfavourable pollutant dispersion. Such situations in autumn and winter are of particular importance because of curative stays in this period. The article presents the scale of these issues, based on the available measurement data.

The influence of public transport on air pollution of polycyclic aromatic hydrocarbons

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KEY WORDS: air pollution, traffic, PAHs, OC and EC, Gdynia

The state of air quality over Gdynia is shaped by the proximity of the sea and the emission of anthropogenic pollutants. Research on the air pollution and chemical composition of aerosols in Gdynia has been carried out in recent decades. However, they have never focused directly on the influence of communication on the concentration of carbon species in aerosols, which was the aim of this study.

Aerosols were collected only during the non-heating season (July and September), in communication peak hours (from 7:00 am to 9:00 am and from 3:00 pm to 5:00 pm). Tisch Environmental high-flow multi-cascade impactor was used to collect particles in the size range from below 0.49 µm to 10 µm in diameter. In all samples the concentration of organic and elemental carbon as well as chosen PAHs (benzo(a)pyrene, fluoranthene, chrysene, pyrene, benzo(a)anthracene) was analyzed.

The research allowed to determine the impact of transport on concentration variability of organic and elemental carbon as well as chosen PAHs in particles smaller and higher than 3 µm in diameter. The highest value of the ΣPAHs (57.71 $ng \cdot m^{-3}$) and EC (0,5 $\mu g \cdot m^{-3}$) was recorded during the school period, during the morning communication peak hours. The PAHs' profile was dominated by fluoranthene- an indicator of PAH emissions from fuel combustion. The meteorological conditions played a significant role in shaping the concentration of PAHs. In the holiday season, higher air pollution resulted from lower air humidity and poor air purification with precipitation. HMW hydrocarbons showed a greater tendency to adsorb on larger aerosols. In summer, these compounds were subject to photodegradation at higher air temperatures and greater intensity of solar radiation. The role of land transport in shaping the quality of the ambient air was greatest when local to regional winds prevailed, bringing pollution from nearby schools and the beltway.

Status and trends of mercury pollution of the atmosphere and terrestrial ecosystems in Poland

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Mercury (Hg) is a contaminant introduced into the environment from natural sources, including volcanoes and forest fires, re-emission from the ocean and terrestrial surfaces, and anthropogenic activities in energy production, metallurgy, waste incineration, and other industrial processes. Human-caused emission significantly increased the global Hg pool in the environment and resulted in its elevated concentration in air, water, soil and sediments, often exceeding the geochemical background level. Given the adverse health effects of Hg, including brain damage and changes in the central nervous system, for several decades, numerous actions have been taken to reduce the anthropogenic Hg emission and to prevent its spread in the environment.

The main goal of this study was to assess the current status and trends of total mercury (THg) contamination of the atmosphere and terrestrial ecosystems in Poland. The results obtained showed that the reduction of domestic atmospheric emission of Hg by 42 % since 1990, resulted in decreased THg level in the terrestrial biotope and biosphere. This was particularly evident in plants, in which THg levels dropped by up to 10 times, and herbivorous wild animals, in which concentration of THg showed an approximately 2-fold decrease. In the tissues of livestock the average THg concentration decreased by more than twofold. This was additionally influenced by changes in feeding methods and withdrawn of the protection products based on Hg compounds from the EU market.

Considering that Poland is one of the main Hg emitters in Europe, the THg concentrations in its abiotic environment are still elevated. However, the THg level in terrestrial organisms is relatively low, which is because a large proportion of Hg deposited on land is accumulated in organic-rich soils. Regarding the THg concentration, consumption of wildlife and livestock from Poland is safe for humans. Nevertheless, the authors indicate the need for effective environmental monitoring, based on selected bioindicators, namely brown birch bolete mushroom (*Leccinumscabrum*) and herbivorous wild animals, mainly deer (*Cervidae*). This is crucial considering the slowing reduction of Hg emission combined with the consequences of the changing climate on the terrestrial environment, such as extended vegetative season.

Suspended organic carbon (WIOC) and elemental carbon (EC) introduced with precipitation into the coastal zone of the Gulf of Gdańsk in 2019/2020

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In the period from 27/10/2019 to 09/09/2020, precipitation samples were collected on the roof of the IO UG building in Gdynia in order to determine the concentration of organic carbon (OC) and elemental carbon (EC) and the load of these compounds to the coastal zone of the Gulf of Gdańsk. At the same time, meteorological data were collected throughout the period and the trajectories of the air masses were determined. After determining the volume of precipitation, their pH and conductivity, the analysis of organic and elemental carbon using the thermo-optical method (Sunset Laboratory Dual-Optical Carbonaceous Analyzer) was carried out with an accuracy of 1 µg C. For this purpose, a fragment of a quartz filter (1.5 cm^2) was used, through which the precipitation was previously filtered. The results obtained in Gdynia at the turn of 2019 and 2020 showed that in the precipitation samples the median of OC concentration was an order of magnitude higher than the median of EC concentration (4.0 □g/dm^3 and 0.3 □g/dm^3, respectively). The share of organic carbon in the total mass of carbon was higher than that of elemental carbon, regardless of the measuring period, and ranged from 89 % (non-heating period) to 92 % (heating period). However, the Mann Whitney U test did not show statistically significant differences between the concentrations of both compounds depending on the season ($p > 0.05$). The share of elemental carbon in the total mass of carbon in precipitation increased in the non-heating period, which was probably related to the increased transport activity of tourists in Pomerania during the holidays. The year 2020 was exceptional in this respect, and the higher number of tourists than in previous years is a consequence of fear of going abroad due to the spreading COVID-19 pandemic. At the turn of 2019 and 2020, the combustion of fossil fuels for heating purposes was less important than transport in shaping the concentration and load of both forms of carbon introduced into the coastal zone of the Gulf of Gdańsk. The highest concentration and load of these compounds were recorded on 3.11-4.11.2019 and 1.09-2.09.2020. In both cases, the reason can be found in the increased activity of traffic. In November it was the weekend after All Saints' Day, and in September it was the beginning of the school year.

Identification of odour emissions in agri-food sector

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The Polish agri-food sector is one of the most important sectors of the national economy. It is highly dispersed and varies in terms of odor emissions and impact on odorous air quality. The production processes causing odor emissions in this industry include: fermentation, refining of edible oils and fats, receiving and storing raw materials, sorting, selecting, dehulling or stalking, removing stalks and pruning, processing, mixing and homogenizing, removing free fatty acids, bleaching, distillation, dissolving, fermentation, sprouting, smoking, blanching, cooking and brewing, baking, roasting, frying, drying. In the case of animal husbandry and breeding, the main source of gaseous emissions are the animals' metabolisms or bacterial processes in the intestines or feces. Due to the variety of technologies used and the multitude of emission sources, facilities belonging to the food sector cannot be treated uniformly. The selection of an appropriate method of identifying the sources of odor emissions is significant in the assessment of the odorous air quality. This paper presents a classification of selected methods in terms of their applicability (and limitations) to the assessment of odor impact in relation to the agri-food sector with particular emphasis on the results obtained using dynamic olfactometry.The case study will be carried out for a selected plant producing sugar and mushroom growing medium. At the plant, odor concentrations determined at selected sources reached values of over 200,000 ou_E/m^3.

GHG'S carbon isotopes and mixing ratio from self-heating coal waste dump: geochemical interactions and environmental implications

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KEY WORDS: coal waste dump, mine tailings, self-heating, GHGs (CH_4 and CO_2), carbon isotopic composition

Coal mining activities have the significant long-term influence on the environment. Nowadays, a majority of coal mines are already closed, however, the mine waste disposal practices still cause emissions of exhaust gases to the atmosphere. High content of coal in well aerated mine tailings promotes thermal activity. Inside the coal waste dumps where self-heating occurs, the GHGs are reaching concentrations that are several orders of magnitude greater than in the atmosphere.

The aim of this work was to estimate the changes in emissions of methane (CH_4) and carbon dioxide (CO_2) from self-heating coal waste dump and their potential health and environmental impact. Air samples were collected from the coal waste dump in NowaRuda - Slupiec (NR-S), southwestern Poland, using ground surveys during spring (March 30, 2019) and winter (December 1, 2019) sampling campaigns. In order to detect the origin of the plume-emissions, stable isotopic composition ($\delta^{13}C$) of CH_4 and CO_2 was measured in the surface gases over the coal-mine dump hill and its surroundings using Picarro G2201-i cavity ring-down spectrometer (CRDS). This allowed to understand the sources of methane and carbon dioxide release from the coal waste dump to atmosphere and to estimate the magnitude of CH_4 oxidation in the cover layer.

The concentration of ambient atmospheric CH_4 in the vicinity of the NR-S coal waste dump varied from 1.936 to 1.965 ppm, the CO_2 values ranged from 412 to 421 ppm. In ambient air neighboring the dump the average carbon isotopic signatures were close to -53 ‰ for methane and -9.4 ‰ for carbon dioxide. Many gas leaks from the actively burning dump sites into the atmosphere were identified during the ground surveys. CH_4 mole fraction in the emitted gases at discrete hot-spots, varied from 3.8 to 270 ppm with an average value of 47 ppm. Most of the methane samples collected from the dump were strongly enriched in ^{13}C, varying in range from -43.5 to -26.5 ‰ with an average value of -37.1 ‰, which is characteristically more enriched than methane coming out from formerly excavated coal seams. Moreover, the CO_2 concentration from active burn dump sitesvaried from 522 to 2858 ppm with an average value of 923 ppm, and the isotopic signature of CO_2 was in a wide range from -31.5 to -12.4 ‰ with an average value of -18.0 ‰.

These results indicate that substantial amounts of methane escape from the self-ignited spots on the NR-S coal waste dump, however, the mobile surveys did not reveal the enhanced methane concentration in distance between 1-3 km from the dump. The other pollutant concentrations in the gaseous plume coming from the self-heating coal waste dump were significantly lower compared to total amount of CH_4 and CO_2. Hence, tt is difficult to determine how large the exposition of the local population to coal waste dump gases.The results highlight those changes in the fire intensity, prevailing winds, dump architecture, and surface roughness in the surrounding regions are the most important factors of air pollutant emission from complex coal mine dump system.

Magnetic fraction in atmospheric aerosols in Kraków (Poland)

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Magnetic fraction of atmospheric aerosols was collected during 9 months period (2019-2020) in Kraków. A static sampler – a matrix of solid magnets arranged to increase gradients and magnetic field strength was used. Magnetic fraction was analyzed using SEM-EDS, TEM, XRD, VSM under applied field and as a function of temperature as well as Mössbauer spectroscopy at room as well as at LN temperatures.

Fe rich particles containing small amounts of other transition metals dominate in the magnetic fraction. Fe rich particles occur as discrete forms of various size and morphology, grains attached to the surface of bigger particles or as component of aggregates. Size of those particles varies from above 20 m to nanoparticles below 100 nm. Fe rich particles are characterized by a varying oxygen content. Magnetic fraction is composed of magnetite, hematite, quartz, a-Fe, feldspars, and pyroxenes. Mossbauer spectroscopy data can be successfully fitted with four sextet (α-Fe2O3, Fe3O4, (Fe1-yXy)3O4 and metallic iron - about 75 % of the measured intensities) and two doublet components. Magnetization measurements show clearly a strong ferromagnetic signal saturating at about 0.4T.

Precise determination of the origin of magnetic particles in atmospheric aerosols is difficult however high content of particles from anthropogenic sources is evident. Fe rich particles possess different environmental impacts and adverse human health effects.

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Microplastic in urban air pollution in Kraków

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Microplastic, an emerging pollutant is defined as particles of synthetic polymers which are smaller than five millimeters. Microplastic can be of either primary origin or secondary origin (particles formed in degradation process of larger artifacts). Airborne microplastic is currently studied intensively in terms of the effects it has on human health. This research concerns microplastic presence in the air in Kraków. Samples collected from both wet and dry deposition, at the sampling site in the city, over a six months period were examined using Py-GC/MS, ATR-FT-IR spectroscopy and SEM-EDS microscopy. The microplastic particles found in the atmosphere belonged a few of the most popular polymer types: PET, PP, PS, LDPE and Nyl-66. Mainly secondary origin, fibrous type microplastic was observed, and different polymer type ratio varied between samples. Inhaled microplastic particles can pose a danger to human health, but it can also disperse from the atmosphere to the hydrosphere, sediments and soilsand enter the food chain. Preparation of standard procedures of determination of microplastic (including nanoplastic) content in the atmospheric particulate matter as well as concentration standards is an urgent matter

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Vertical distribution of PMx from residual heating in light of drone measurements – the results of research in Wrocław, SW Poland

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This study presents the results of measurements of the vertical structure of PMx, carried out since 2017 in the NE part of Wrocław, SW Poland. The authors use Matrice 600 hexacopter equipped with a prototype environmental measurement head. The UAV measurement system was developed in cooperation between the Department of Climatology and Atmosphere Protection of the University of Wrocław and the company Optimum Tymiński. The UAV-based system enables measurement of $PM_{2.5}$, PM_{10}, and PM_{100} concentration as well as air temperature and relative humidity. Furthermore, all flight parameters are recorded. The assumed data logging time resolution is 1 second. The air inlets of the measurement head are located at the top of the device, above the plane of the UAV rotors to minimize the impact of air turbulence caused by the rotors on the obtained data. The maximum flight time for the entire measurement set is 40 minutes. The measurements were carried out in areas with different land use and emission structure (old single-family house estates, compact settlement areas in the city center, suburbs with new semi-detached and terraced houses).

The main aim of the research was to analyse the variability of the concentration of particulate matter in the vertical profile up to 350 m a.g.l. To ensure the highest precision of the measurements, an ascent speed of 1 m/s was assumed. This ensured measurement profile resolution of approx. 1 m. The analysis was supplemented with detailed meteorological background data (including SODAR measurements) as well as stationary measurements of temporal variability of PM concentration at two heights. All background data were provided by the Meteorological Observatory of the University of Wrocław.

The obtained results show the great potential of drone measurements in air quality studies in urban areas. Data illustrating the vertical variability of PM concentrations in various weather conditions such as stable and unstable atmospheric equilibrium or morning and evening transition periods. Gathered data provide, i.a., additional knowledge of the processes of accumulation and dispersion of pollutants within the urban atmospheric boundary layer, and can also be used as input or verification data in air quality modeling.

The research was carried out under the Project "Do you know what you breathe?" – educational and information campaign for cleaner air LIFE-MAPPINGAIR/PL, financed by the European Union under the LIFE Financial Instrument and co-financed by the National Fund for Environmental Protection and Water Management

Air pollution in Polish health resorts – a problem for both local authorities and patients

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KEY WORDS: Polish health resorts, climatotherapy, PM_{10}, $PM_{2.5}$, B(a)P, local actions

Health resorts should be in a position to provide clean air, good enough for climatotherapy conducted in the open air. The air at health resorts resembles that elsewhere in the country (Poland is one of the Europe's most polluted country) in being affected by high concentrations of particulate matter (PM10, PM2.5) and benzo(a)pyrene. This is the effect of combustion of poor-quality coal, wood or even waste in domestic stoves.

Poland has 45 health resorts, most of them situated in the mountains. In 2018 almost 850,000 patients received spa treatment, and among them c. 40 % in winter, heating season.

In the years 2010-2018, permanent monitoring of PM_{10}s was only engaged in at 14 of Poland's spas, with just 6 having full data from 2010 on. $PM_{2.5}$ and B(a)P are monitored at even fewer stations. This paper analyses mean annual, monthly and daily concentrations of these pollutants, as well as numbers of days on which permissible levels were exceeded and seeking reasons for this state of affairs. Numbers of days with PM_{10} >5 0 $\mu g \cdot m^{-3}$ exceeded permissible levels in most of the spas and on selected days concentrations of $PM_{2.5}$ reached 300 µg m^{-3}. The worst situation applies to B(a)P which concentration at all the spas displayed 2- to 10-fold exceedances of permissible levels.

On the example of few, very polluted, health resorts: Cieplice, Szczawno-Zdrój, Szczawnica and Busko-Zdrój the paper presents more detailed the source of the problem and the actions of local governments to improve the situation. The problem is even greater because 2 of them have upper and lower respiratory tracts in their therapeutic profile, and the health resort is the main employer in the town.

Modeling the number of diagnosed respiratory system diseases with respect to the air quality

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The main goal of our work is the analysis of the impact of air pollution factors and meteorological data on the respiratory system diseases on the basis of the data with the number of ambulance calls in Wrocław in 2016. We use the Spearman correlation coefficient and the R software to create GLM (Generalized Linear Models) in several different variable selection methods with the logarithm linking function. We compare the models using the information criteria.

We show that the number of ambulance calls to the patients with the respiratory diseases could be described by the components of PM_{10} and $PM_{2.5}$ shifted by 9-15 days, the daily concentration of CO shifted by 14 days, the mean of NO_2 shifted by one day and the level of NOx by 27 days. It means that reaction of the respiratory system in the human body is delayed after exposition on the air pollutants by 9-27 days for different factors. We optimized the number of shifted days for all significant air pollution factors.

Our results could be used in hospitals, medical clinics and pharmacies to make adequate supplies of medicines. On the other hand proposed models could also be used to predict economic losses connected with air pollution in Wrocław.

Exposure to arsenic in the air and 15-F2t-isoprostane in urine in subpopulation of inhabitants of the copper smelter region

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Most studies on arsenic toxicity have been conducted among populations exposed to arsenic contained in drinking water. Relatively little research concerns effects of airborne arsenic. The aim of this study was to determine whether there is an association between urinary 15-F 2t -isoprostane (u15-F2t-IsoP) levels in relation to renal function (urinary creatinine and N-acetyl-b-D-glucosaminidase - uNAG) and urinary arsenic (uAs) in inhabitants from copper smelter impact zone.

Urinary 15-F 2t -IsoP, NAG and creatinine were measured in 967 urine samples collected from 649 adult women (51.9 ± 13.2 years old) and 318 adult men (53.8 ± 14.9 years old). Total uAs concentration was measured in 918 samples using HPLC-ICP-MS. Arsenic species such as inorganic arsenic, methylarsonic acid, dimethylarsinic acid and arsenobetaine were measured in urine collected from 255 participants with uAs exceeding the upper norm. Data were analyzed using multivariate linear regression and logistic regression models. In the studied population urinary creatinine was positively associated with uAs. A positive linear correlation ($p < 0.0000$) between lg(uAs) and u15-F 2t -IsoP was found both for normal and elevated uAs. A positive linear correlation was observed also between lg(ΣuAs) and u15-F 2t -IsoP ($p<0.0000$). In the logistic regression model, after adjustment for confounders, elevated uAs was the only predictor of increased u15-F 2t -IsoP (OR = 1.31, 95% CI 1.08 to 1.59, $p < 0.01$). Cigarette smoking was associated with renal proximal tubular dysfunction only in people with uNAG concentration above 75th quartile. Conclusions: In the studied population chronically exposed to airborne arsenic, increase in urinary arsenic is associated with renal dysfunction and systemic oxidative stress. Urinary 15-F 2t -isoprostane may be useful in the monitoring of health status in populations exposed to airborne arsenic.

Air pollution and obstructive sleep apnea

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INTRODUCTION

Obstructive sleep apnea (OSA) is a common disease caused by a collapse of the upper airways during sleep, which leads to airflow limitation, arterial blood desaturation and episodes of waking from sleep. OSA has been independently associated with cardiovascular diseases such as hypertension, stroke, ischemic heart disease, abnormal heart rhythm. Air pollution is a serious problem all over the world, especially in the winter months, when the use of non-ecological and inefficient fuels for heating leads to an increase in the air concentration of nitrogen dioxide and particulate matter.

AIM

Verification of the hypothesis about the relationship between air pollution and the obstructive sleep apnea based on available scientific research.

MATERIALS AND METHODS

Literature review performed using the PubMed database. The keywords used were "air pollution" and "sleep apnea". The time range of the analyzed studies was determined as the last 5 years.

RESULTS

23 publications were selected based on the search criteria. The results of the studies indicated that different criteria were used to diagnose the obstructive sleep apnea and to assess of the air pollution. Nevertheless, the conducted studies provide scientific evidence confirming the existence of a relationship between air pollution and OSA. Many researchers indicate a relationship between the concentration of PM_{10} dust and the severity of OSA during the dry season, in the absence of such a relationship in the rainy season.

CONCLUSIONS

Air pollution increases the severity of OSA. Reducing exposure to solid particles, which translates into better air quality in bedrooms, can reduce the severity of OSA.

Ambient Particulate Air Pollution and Daily Hospital Admissions in 35 Cities in Poland

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The aim of the studies was to derive a concentration-response function of hospitalization due to short-term exposition of PM_{10} in Poland. Two reasons of admissions (ICD-10) were analyzed: cardiovascular and respiratory.

Analyzed were carried in cities which were a compromised between the need of detailed data and confidential data of patients. Cities with population over 100 000 were chosen for analysis, because of two reasons. Every municipality with that size of population have air pollution monitoring stations , and sufficient number of daily hospital admissions for statistical purpose. To account for confounding factors weather parameters was used for each city. Database used for this research after initial completeness analysis included 35 municipalities. Period chosen for the study was 2011-2017. Generalized Additive Model (GAM) was used to determine Relative Risk (RR).

Data used for the analysis had following categories: day of the year, overall number of admission of all modes (urgent and scheduled) from cardiovascular and cardiovascular, humidity, temperature, PM_{10} concentration, selected based on statistical parameters from subsequent model runs. Air pollution data was trimmed with 5 % highest and 5 % lowest concentration. Natural spline was used for GAM with 7 degrees freedom for years, 6 for temperature and 3 for humidity. RR for 10 $\mu g/m^3$ have been calculated for each city and using random effect model a meta-analysis of Polish was conducted to produce a single result.

Relative Risk of hospital admission due to cardiovascular cause from daily increase of 10 $\mu g/m^3$ of PM_{10} is equal to 1.0077 (CI 95 % 1.0062-1.0092) and from respiratory cause 1.0218 (CI 95 % 1.0182 – 1.0253). This is probably somehow higher (taking into account that PM_{10} concentration is always higher than PM2.5) than WHO HRAPIE RR of $PM_{2.5}$ 10 $\mu g/m^3$ increase functions accordingly of causes 1.0091 (CI 95 % 1.0017–1.0166) and 1.0190 (0.9982–1.0402) since WHO refers to smaller particles.

Is chronic exposure to lead still a significant health problem? The authors' own research on the influence of lead on the cardiovascular system

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Exposure to lead is a consequence of industrial development. It takes place during the production of e.g. batteries, cables, wires, solders, bearings, typefaces, shields protecting against ionizing radiation, in the production of paints, dyes, and insecticides. Over the years, lead tetraethyl has been added to gasolines as an anti-knock agent. Disturbances resulting from chronic exposure to lead concern the hematopoietic system, the respiratory system, the nervous system, kidneys, the digestive system, and the cardiovascular system. Classically, WHO has defined chronic lead poisoning as six clinical syndromes: symptoms of increased lead absorption, initial symptoms of lead poisoning, lead-related anaemia, lead colic, lead encephalopathy and polyneuropathy, and lead nephropathy; pointing to the most strongly documented association of exposure to lead with haematopoiesis disorders, changes in the nervous system and kidney damage. The aim of the present study was to answer the question of whether chronic exposure to lead is still a significant health problem. Moreover, an attempt was made to present the current state of knowledge on the relationship between exposure to lead compounds and morphology and function of the cardiovascular system based on the authors' own research. Subsequently, the current data on the population's exposure to lead compounds is discussed; types of exposure and populations exposed to lead compounds are indicated; elementary mechanisms of lead toxicity are discussed; organ and systemic changes related to exposure to lead are presented. Further in the study, selected own research on the relationship between exposure to lead and morphology and function of the heart and vessels is presented, considering proatherosclerotic and hypertensive effects of lead. Summing up, when analysing air quality, one should not forget about the classic pollutants, an example of which is air pollution from lead.

Optimized mathematical models used to forecast the impact of air pollutants on the otolaryngological system diseases

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According to the International Agency for Research on Cancer, some pollen mixtures are carcinogens and one of the most dangerous air pollutant is BaP (benzo(a)pyrene). In 2015, BaP concentrations in Poland were the highest across Europe [European Environment Agency. Air quality in Europe — 2017 report. No. 13/2017. 2017]. Harmful are not only the components of pollen mixtures PM_{10} or $PM_{2.5}$, but above all their chemical mixture, what is proved by our data analysis.

The work will focus on modelling the number of otolaryngological cases depending on air quality indicators (e.g. $PM_{2.5}$, PM_{10}, BaA, BaP, BbF, BjF, BkF, Cd, DBaH, O_3 and CO) and basic meteorological data. We will focus on the agglomeration of Wrocław, because residents of large cities are very vulnerable to the negative impact of air pollutants.

We perform our analyses using R software proposing multimodeling method with comparing the information criterions. We fit GLM (Generalized Linear Models) and GAM (Generalized Additive Models) and use methods of smoothing data. The results of our work can be used in the organization of the schedule of doctors in first-contact clinics and in improving the availability of medicines commissioned by doctors for sick people. The analyses were carried out for 2015. Approximately, the consequences of air pollution exposure affect the otolaryngological system after about three days.

Meteorolgical conditions resulting in high PM_{10} and $PM_{2.5}$ concentrations in Northern Poland

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Particulate Matter (PMx – PM_{10} & $PM_{2.5}$) pollution is one of the most dangerous for human health in the long term and continues to significantly impact Europeans living in urban areas. Each year, episodes of high PMx concentrations are responsible for a significant number of premature deaths (primarily due to heart diseases and strokes), and according to annual EEA reports, Poland is one of the most polluted countries in Europe.

PMx concentration levels result from the combination of local emission characteristics and meteorological conditions. The research aimed to investigate the variability of PMx (PM_{10} and $PM_{2.5}$ where possible) concentrations at selected sites in northern Poland, focusing on those located in the seashore vicinity. Selected stations comprised: Szczecin (Piłsudskiego St.), Słupsk (Kniaziewicza St.), Gdynia (Wendy St.) and Gdańsk (Leczkowa St.). The temporal scope covered 10 years: 2010-2019, and the temporal resolution was 24h (daily averages). Data originated from GIOŚ database (https://powietrze.gios.gov.pl).

The analysis included statistical characteristics of PMx levels at selected locations, including the occurrence of extreme events. Random Forest model allowed identifying quantifiable relation between PMx levels and meteorological variables (air temperature, pressure, wind speed, wind vector components, precipitation totals, sunshine duration) from the closest IMGW-PIB stations and ERA5 reanalysis (e.g., boundary layer depth). Models' quality metrics were subsequently analysed in the context of possible application. Additionally, some extreme PMx concentration cases were investigated individually to show the direct influence of meteorological variables on the dispersion effectiveness. The results clearly show that PMx concentrations in northern Poland are lower than in Poland's other urbanised areas. The Machine Learning approach's application allowed the quantification of PMx concentration due to meteorological conditions in the context of absolute values and the occurrence of threshold exceedances. Additionally, we present possible adaptation strategies for municipal bodies in the context of PM concentrations and the resulting wellbeing of the citizens.

The impact of a foehn wind on air pollution in Kraków

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Kraków, southern Poland, is a city with poor air quality. It is located in the large Wisła (Vistula) valley, and affected by a foehn wind, the 'halny', from the Tatra Mountains in the Carpathians. There were 14 long episodes of the foehn analyzed from the periods Sep 2017 - Apr 2018 and Sep 2018 - Apr 2019. Data used included measurements of PM_{10} concentrations, air temperature and relative humidity, wind speed and direction from ground stations and mast measurements up to 100 m a.g.l., along with model analysis results. Non-operational configuration of the AROME CMC 1km x 1km (AROME CMC 1km) was applied. A conceptual model concerning the impact of a foehn on urban air pollution was developed. The occurrence of a particular effect of a foehn on the PM_{10} spatial-temporal pattern depends on its mode of transfer through the city and nearby: a. a foehn flows above the valley where a strong cold air pool and a return flow can be found; b. a foehn enters the valley from the eastern, wider part or from the valley top and destroys the cold air pool; c. gravity waves generated by a foehn 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, the second mode improves dispersion and leads to large decreases in PM_{10} levels throughout the city, and the third generates large spatial differences in PM_{10} levels within the city. There is no single effect of a foehn on air pollution dispersion conditions.

Characteristics of particulate matter exposure during heavy air pollution episodes in the heating season over Wrocław urban area

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KEY WORDS: particulate matter (PM_{10} and $PM_{2.5}$), PM pollution episodes, meteorological factors.

Air pollution, in terms of particulate matter (PM), has significant health challenges, particularly evident in urban areas. Despite the reported reduction in emissions of particulates, the exceedances of the daily limit value of PM_{10} concentrations usually frequently happen in the heating season for Polish cities and agglomerations. In the heating season 2020-2021, the concentrations above the PM10 daily standards (>50 $\mu g \cdot m^{-3}$) were recorded from October 2020 through March 2021, with a peak in January 2021. In many locations, the level of particles was raised significantly during heavy pollution episodes, resulting primarily from unfavorable weather conditions. The current study investigates the temporal variabilities of PM pollution episodes occurred in the city of Wroclaw and the impact of the corresponding meteorological conditions during the heating season 2020–2021.

The analysis showed that the changes of the PM_{10} concentrations across Wroclaw were dominated by anthropogenic emission and unfavorable weather conditions, such as air temperature and patterns of transport and dispersion of air pollution, including variations in the structure of Planetary Boundary Layer (PBL) and wind speeds. Besides, the advection of polluted air masses from desert regions represented one of the natural contributions to atmospheric PM during the winter season. The poor air quality episodes, exceeding the 24 h mean permissible PM_{10} concentrations (>50 $\mu g \cdot m^{-3}$), have been registered 31 times at the State Environmental Monitoring (PMŚ) background station located in Wroclaw. A number of repeatedly occurred PM episodes were related to the influence of high-pressure systems, drops in air temperature, weak wind, mixing depth limited by ground-based or elevated inversion layers. Higher energy demands under low temperatures obviously have increased domestic consumption for heat, which leads to harmful pollutants (coarse PM_{10} and fine $PM_{2.5}$ fraction) being emitted into the atmosphere. The highest hourly values of PM_{10} and $PM_{2.5}$ in the range of 116–149 $\mu g \cdot m^{-3}$ and 105–134 $\mu g \cdot m^{-3}$, respectively, were observed in Wroclaw during the extreme drop of the air temperature (below -16°C) noted on January 17–18, 2021.

Severe episodes of exceedances of the daily limit value of PM_{10} concentrations, associated with Saharan dust transportation, took place in Wroclaw during December 2020 and February 2021. The occurrence of desert dust on February 23, 2021, substantially increased the ambient level of PM_{10} (239 $\mu g \cdot m^{-3}$), while the rise in $PM_{2.5}$ concentration (67 $\mu g \cdot m^{-3}$) was not considerable. The air quality during the typical synoptic situations for early spring, with an increase in the maximum air temperature in the day and entry of heavily cooled air at night that further leads to episodes with high PM levels, were also considered in the present work.

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Deposition of airborne microalgae and cyanobacteria with rainfall over the Gulf of Gdansk area

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Airborne cyanobacteria and microalgae are commonly found in the atmospheric air, and they get there as a result of emissions from water sources as well as from soil. Their emission process depends primarily on meteorological conditions such as wind speed, temperature, and air humidity. Many studies assume that cyanobacteria and microalgae undergo the same processes in the atmosphere as particulate matter, so their removal occurs due to atmospheric deposition, washes out, and rain out. This study aims to determine the efficiency of washing out of airborne cyanobacteria and microalgae with rainfall. These studies allow to determine what and how many cyanobacteria and microalgae were in the atmosphere before, after the precipitation, as well as what and how many of these microorganisms were in the precipitation itself. This allows to assess whether the atmosphere is effectively cleaned of cyanobacteria and microalgae that have been confirmed in the air, which are hazardous to human health. Due to the innovative nature of the research, in 2019, during the rainy period, a pilot study was conducted to determine an effective method of growing cyanobacteria and microalgae washed out by rain, as well as to determine the method of cell counting. Then, at the turn of August and September 2020, after the algae bloom in the Baltic Sea, a measurement campaign was carried out, assuming sampling rain, cyanobacteria and microalgae from the atmosphere both before and after rainfall. The number of cyanobacteria and microalgae in the rain was estimated at between 350 and 342.2·103 cells L^{-1}. The greatest diversity of airborne microalgae and cyanobacteria was recorded in July 2019, despite the smallest number of those microorganisms in the rain. The highest number of airborne microalgae and cyanobacteria was detected during the highest number of phytoplankton in marine water. Days of intensive rainfall favoured the washout of these orgasms, but a short time without precipitation was enough to make the number increase again. A decrease in the amount of microalgae and cyanobacteria was noted after rain, up to 87 % compared to the measurement before rainfall. The study allows to determine the importance of the impact of washout on air quality, which is especially significant in tourist coastal areas, where toxic cyanobacteria and microalgae blooms are frequent.

Analysis of waste treatment processes in terms of the emission of odorous compounds

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Municipal solid waste management plants, due to the nature of their operating conditions, could be potential sources of odour emissions into the air. Modern waste management facilities that integrate many processes related to different waste treatmentactivities, such as, for example, mechanical and biological waste treatment, temporary waste storage or landfilling are one of the most significant sources of the emission of odorous compounds (Sonibare et al. 2019, Wiśniewska et al. 2020). The mainsource of the emission of odorous substances to the air in the case of waste management is the biological decomposition of organic fractions contained in waste (Sonibare et al. 2019), where the dominant process responsible for the emission of odorous substances is the waste fermentation process and, to a lesser extent, the composting process. Theseprocessescanoccurboth in a controlledmanner, associated with certainactivities and processes at a given site, and in an uncontrolled manner, e.g. during temporary storage of waste. One of the most common odorous substances emitted into the air from these processes are, among others, hydrogensulfide, ammonia and volatile organic compounds (Sonibare et al. 2019, Wiśniewska et al. 2020). In managing odours and preventing their emissions, it is crucial to precisely identify and characterize the processes responsible for odour generation. The paper presents the characteristics of the main processes and sources of odour emissions in waste management and discuss the results of measurements of odorous compounds from a selected waste management plant.

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Low- and medium-cost sensors for tropospheric ozone monitoring – the results from evaluation study in Wrocław, Poland

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Tropospheric ozone (O_3) is an air pollutant that affects human health, causes damages to plants and materials and contributes to climate change. In the coming decades, higher temperatures and more frequent heatwaves may lead to increased episodes of elevated O_3 concentrations. Therefore, continuous monitoring may be necessary to estimate exposure to this pollutant and sensor networks are gaining attraction in this field.

The paper presents the results of a 1.5-year evaluation study of low- and medium-cost O_3 sensors. The following sensors were tested: Sensoric O3 3E 1 (City Technology), SM50 (Aeroqual), SP3-61-00 (FIS) and MQ131 (Winsen). O3 3E 1 is an electrochemical sensor and the rest are semiconductor gas sensors. Three copies of each sensor model were enclosed in a measurement box and placed near the reference analyser MLU 400 (UV absorption analyser) on a platform at the Meteorological Observatory of Department of Climatology and Atmosphere Protection of University of Wrocław.

During the measurements, the correlations between reference analyser and sensor data were generally strong. High linear relationships were observed for SM50 devices (R^2 > 0.94 for 1-hour data), but some periodic data offsets were reported, which result in the necessity of modifying the calibration coefficients. In the case of City Technology devices, R^2 values for 1-hour data were above 0.90 for the first 6-8 months of deployment and deterioration of fitting was observed in subsequent months (R^2 = 0.63-0.69). After one year of use, a significant change in output values was observed, which can be attributed to the sensor ageing processes. Non-linear relationships (power-like functions) were identified in the case of SP3-61-00 (R^2 > 0.60) and MQ131 (R^2 = 0.4-0.7).

The study showed that sensor devices could be useful in tropospheric O_3 monitoring, but in the case of sensor networks, regular data quality checks and recalibrations may prove necessary. The results of this study can help researchers select sensors for ozone measurement systems and determine procedures for their use and calibration.

The assessment of effectiveness of SEM- EDX and ICP-MS methods in the process of determining the mineralogical and geochemical composition of particulate matter deposited on spider webs

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According to the fact that air pollution monitoring is of a big importance nowadays, many different methods are being developed for this purpose. Considering that we aimed to test and validate two different analytical techniques concerning mineralogical and geochemical analyses with the use of a new kind of passive sampler i.e. spider web. Spider web samples were collected in 2018 in the proximity of the copper smelter Głogów (Poland). Then samples were subjected to scanning electron microscopy with energy dispersive x-ray analysis (SEM-EDX) and the particles present on spider webs were identified. Apart from the information about the size and form of studied particles also their origin (anthropogenic or terrigenous) was acquired. Geochemical analysis was conducted using inductively coupled plasma mass spectrometry (ICP-MS) and provided the information about total amount of chosen, potentially toxic elements. Results obtained with the use of these two methods (ICP-MS and SEM-EDX) were compared in the terms of frequency of metal occurrence in particulate matter and then recalculated into percentage contribution. A significant correlation between mineralogical and chemical composition was found, which proved proper identification of phases and minerals with the use of SEM and their correct assign to different groups. For the major contaminants in the study area (i.e. Pb, Zn, and Cu) the validation of the method gave satisfying results and revealed the convergence of results in most of the sampling points. Eventually, the research proved the possibility to compare the results obtained by SEM-EDX analysis with quantitative results (ICP-MS analysis).

Fractional distribution measurements of particulate matter from the deck of an observation balloon in Cracow

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Despite the implementation of a series of restrictions on the emission of particulate pollution, Krakow is still facing elevated concentrations of PM pollution. The most important issue for the city authorities at the moment is to determine the main sources of the particulate matter polluting the city. There are a number of hypotheses concerning traffic sources and incoming pollution from neighbouring municipalities. As the city is located in a valley, it is extremely sensitive to both emissions within its own area and inflows from surrounding settlements.

Already several years ago, the PMŚ (State Environmental Monitoring) network in Cracow was developed, increasing the number of stations measuring PM concentrations from 3 to 8. The expansion of one of the largest networks of low-cost air quality sensors began in the city of Cracow. However, all these are near surface measurements which do not give a full picture of the entire air mass over the city.

In order to estimate the origin of pollution over the city, measurements were proposed not only on the surface but also in the vertical column. Additionally, not only one type of pollutants but their fractional distribution was studied. The fraction of particles depends on such factors as distance from the source as well as its type.

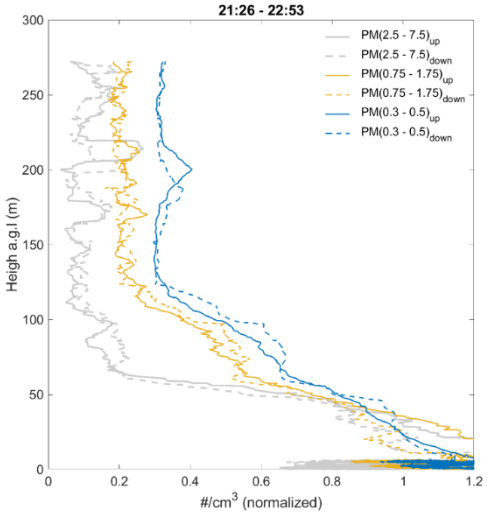

Fig. 1. Relationship of particulate matter concentration with altitude for one flight and three selected particulate matter size ranges. The flight was separated into an upward and a downward section. The particle sizes were normalized accordingly for comparison.

In this exploratory study, an observation balloon (filled with helium) was used as a mobile platform, performing several flights per day. The balloon flies up to an altitude of 280 meters and is installed permanently in the centre of Cracow. Firstly, a measuring device based on a low-cost particulate matter sensor was installed on the balloon. In late 2020 and early 2021, the balloon was equipped with an instrument (LOAC type) that allows to know the fractional distribution of aerosols. Measurement campaigns were also carried out with the use of TSI Inc. OPS3330 device, which allows to measure the concentration of particulate matter in 16 ranges of aerodynamic diameters. The preliminary data analysis allowed us to assess the dynamics of changes in the concentration of pollutants of various fractions (from 0.3 to 10 µm) in the vertical profile of the atmosphere over Cracow. As it

can be observed in Figure 1 there is a large variation between the vertical profiles for different particulate matter fraction sizes. This type of data is very difficult or even impossible to be directly interpreted. In the future, the data will also serve to verify high-resolution models of pollutants transport in Cracow, which may contribute to determining the spatial distribution of sources of dust pollution.

Accurate on-line instruments for indoor aerosol sources identification: could be emissions from 3D printing reduced by air purifier?

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INTRODUCTION

During the last years measurement of size distributions of aerosols containing nanomaterials has received increasing attention, e.g. for the investigation of possible exposure to nanoparticles used in or added to products and posing health risk. The size distribution and number concentration of nanoparticles represent key parameters in the determination of their risk, as has been identified by many health studies. One study reported a high rate of pulmonary deposition of nanoparticles, and their ability to travel from lung to systemic sites as well as their high inflammation potential (Oberdörster et al., 2005). A key parameter for their characterization is the number size distribution measurement ideally combined with number concentration measurement. Here we show an example on measuring emissions from commercial 3D printer using Fast Mobility Particle Sizer (EEPS, TSI model 3090) and Condensation particle Counter (CPC, TSI model 3776).

But the measurements of ultrafine particles from indoor sources and their on-line mass size distribution has been always a challenge (Ramisetty et al., 2018). In this work we also present measurements of real-time mass and size distributions of ultrafine and fine aerosols in an indoor environment using the Quartz Crystal Microbalance Micro-Orifice Uniform Deposit Impactor (QCM-MOUDI, TSI model 140) (Chen at al. 2016).

SCOPE

To investigate potential worker exposure to 3D printer emissions, measurements were taken object was printed. Measuring these emissions poses several challenges. Mainly because particle generation within a 3D printer is not a constant event; particles are often emitted in bursts, depending upon the feedstock composition and specific details of the object being printed. In order to accurately capture the transient nature of particle generation in 3D printing, a EEPS spectrometer with 10 Hz time resolution was employed. The EEPS spectrometer is able to measure full range of particle sizes (5.6 – 560 nm) ten times per second. This makes it ideal for measuring transient aerosol dynamics like those present in 3D printer emissions. In addition, a CPC was used to monitor total particle concentrations of particles larger than 2.5 nm (TSI APPLICATION NOTE EEPS-010).

In this work the QCM-MOUDI has been used to investigate the indoor air quality in order to show the effect of so-called air purifiers/ionizers, which are commercially available to reduce particle concentrations indoors. The scope was to investigate the effect on the indoor air's total mass concentration and mass-size distribution when using such an air ionizer.

SUMMARY

An industrial-scale 3D printer has been observed to generate high number concentrations of nanoparticles in the breathing space of a worker standing near the printer. On-line measurement of number -sized distribution show high presence of particles in the peak around 15 nm. Here we can conclude the on-line monitoring of particle size and number concentrations and s in the vicinity of 3D printers would help to identify nanoparticle exposure.

The second experiment was focused on reducing particle exposure using air purifiers. A micro-orifice cascade impactor for real-time aerosol mass distribution measurement, utilizing quartz-crystal microbalances, has been used to determine the effect of a commercially available indoor air purifier/ionizer. We could see the effect of the air ionizer/purifier on the total mass concentration of the sampled indoor air. The measurements carried out

when operating the air ionizer showed a notable decrease of the total mass concentration. The total mass measured was thus almost cut in half.

Summarizing TSI's instruments are an ideal tool for particle exposure identification by, providing accurate particle number and mass concentration together with its size measurements at high time resolution, which makes it suitable even for a dynamic process such as 3D printing is.

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Application of selected CI methods to imputation of environmental sound level

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The paper aims to present several methodologies of the imputation of the missing environmental sound level data, for several months, in noise monitoring stations located at thoroughfares. The first methodology applies the RandomForest-based model of sound level with scaling functions. To build the model, at first, the proper set of input attributes is elaborated, and the training dataset is prepared using recorded equivalent sound levels at one of the thoroughfares. Next, a computational intelligence (CI) approach, called Random Forest is applied to build the model. Then, the scaling functions are calculated, and the obtained RandomForest model is used to impute data at other locations, using these scaling functions. The next methodology uses an artificial neural network (ANN) to build the model with the use of the previously mentioned training dataset. The obtained model is then applied to impute data at one location. Then, particle swarm optimization (PSO) is used to change ANN weights to tune the model for other locations. Another methodology relies on recorded traffic intensity data which are used for calculation of environmental sound level using Nordic Prediction Model or using a simplified version of CNOSSOS-EU.

Seasonality of PM_{10} sources at traffic and urban background air monitoring stations: case study from Krakow, southern Poland

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In large urban agglomerations, car traffic is one of the main sources of particulate matter. It consists of particulate matter directly generated in the process of incomplete liquid fuel burning in vehicle engine, secondary aerosols formed from exhaust gaseous pollutants (NOx, SO_2) as well as a products of tires, brake pads and pavement abrasion. Krakow is one of the cities in Europe with the highest concentrations of particulate matter. There are several air monitoring stations in the city. The article presents the results of combined elemental, chemical and isotopic analyses of particulate matter PM_{10} at two contrasting urban environments during winter and summer seasons. Daily PM_{10} samples were collected at both stations during summer and winter seasons of 2018/2019. Mean PM_{10} concentration at traffic related station were equal to 35±7 µg/m^3 and 76±28 µg/m^3 in summer and winter, respectively. Mean PM_{10} concentration at urban background station were equal to 25.6±5.7 µg/m^3 and 51±25 µg/m^3 in summer and winter, respectively. The source attribution of analysed PM_{10} samples was carried out using two modeling approaches: (i) Positive Matrix Factorization (PMF) for elemental and chemical composition (the concentration of elements, ions, as well as organic and elemental carbon in daily PM_{10} samples), and (ii) Isotope Mass Balance (IMB) for ^{13}C and ^{14}C isotope composition of carbonaceous fraction of PM_{10}. For PMF application, five sources of particulate matter for each station were identified for each station: fossil fuel combustion, secondary inorganic aerosols, traffic exhaust, soil and the fifth source which included road dust, industry, construction work. The IMB method allowed partitioning of the total carbon reservoir of PM_{10} into carbon originating from coal combustion, from biogenic sources (natural emissions and biomass burning) and from traffic. Both apportionment methods gave consistent results.

The Polish road to climate neutrality

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During the Council of Europe meeting on December 12-13, 2020 in Brussels, the leaders of 27 member states accepted the goal of EU climate neutrality by 2050. Poland did not veto the summit conclusions, but the principle was included that "Poland will achieve climate neutrality at its own pace" (as said Prime Minister of Poland). Taking into account the arguments of the Polish side, the President of the Commission stated that "Poland needs more time", but added the remark that "the actions of the Commission will go on its own way". These quoted statements of politicians testify to the great responsibility, but also to the unprecedented degree of difficulties that Poland faced in order to meet the task of reducing greenhouse gas emissions from 40 % (adopted on October 23, 2014 in Brussels, before COP21 meeting on 12 December 2015 in Paris) to 55 %, compared to the emissions from the base year 1990.

The article presents the evolution of the global, European and Polish economy's drive to stop the increase of the Earth's temperature at a level not exceeding 1.5 °C as compared to the temperature in the pre-industrial period. The Polish energy sector, based on over 70 % of hard coal and lignite, is facing an extremely difficult restructuring.

The political decision-making process at EU and national level and the resulting economic effects have an impact on the costs of transition. In addition to the costs of the energy transformation, there are also the costs of rebuilding the economies of the EU countries after the COVID-19 pandemic and the related arrangements in the EU and Poland. The European Green Deal is a major challenge for many EU countries, and most importantly for Poland due to the dependence of the energy sector on coal. The widespread use of coal for heating causes the atmosphere to be polluted with combustion products and puts human health at risk. Political and economic decisions to reduce carbon consumption are having positive effects; improving the state of the atmosphere and health of the society.

Civil law as a tool in the struggle for clean air

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In recent years the awareness of the issue of ambient air pollution and its negative impact on health has increased significantly in the Polish society. Concerned citizens are looking for effective ways of improving air quality in their neighborhood. In addition to broadly defined activism, including launching grassroots movements, engaging in the activities of non-governmental organizations, conducting educational campaigns, participating in protests, attempts are increasingly being made at using legal tools.

Protection of ambient air against pollution is primarily the domain of public law. Unfortunately, the actions of public administration bodies in most cases are not decisive and effective enough. The possibilities for citizens to enforce effective air quality policies are limited. For example, Polish administrative courts deny citizens the right to challenge faulty, ineffective air quality plans, which is the subject of the infringement proceedings initiated by the European Commission.

For this reason, attempts are being made to use civil law instruments as a means of protecting ambient air against pollution. Increasing numbers of air quality-related civil lawsuits are brought before Polish courts.

The aim of the presentation is to provide an outline of these instruments, in particular of air quality-related civil claims against private entities (including natural persons), as well as against local government units or the state.

The presentation discusses the relationship between the protection of ambient air quality and the civil law protection of personal rights, including the concept of the right to a clean environment and ambient air as an intrinsic personal right.

The presentation concludes with an attempt to answer the question whether, and to what extent, the civil law instruments can constitute an effective tool for the society in the struggle for rapid improvement of ambient air quality in Poland.

A Comparative analysis of recently adopted air quality plans in chosen regions

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The aim of the analysis is to compare air quality plans adopted in a representative group of seven regions between themselves, as well as to formerly approved air quality plans. The analysis should help to assess whether the air quality plans developed and adopted under the new legal framework in 2020 may effectively and rapidly improve air quality.

The following analysis includes a representative group of regions (voivodeships): małopolskie, śląskie, opolskie, dolnośląskie, mazowieckie, łódzkie and wielkopolskie. Each of these regions has been reviewed at 14 areas. Raport includes: ensuring proper implementation of the anti-smog resolution, excluding coal installations from public funding, planned inspections of compliance with air quality regulations e.t.c.

All analysed air quality plans include integrated short term action plans. The purpose of short-term action plans is to implement ad hoc measures to reduce air pollution immediately when limit or target values are exceeded or at risk of being exceeded.

To avoid further infringement procedures Poland adopted an amending act to the Environmental Protection Law as well as introduced a new regulation specifying the contents of air quality plans. The aim was to increase efficiency as well as to make them more standardized in terms of form and content.

The current air quality plans are more consistent and standardized in form and content compared to previous documents. Some provisions have a chance to introduce a quick and significant improvement in air quality. Nevertheless, very rarely the corrective measures have clearly established targets, which should be obligatory fulfilled by a specific authority or entity within a given deadline. Even if such targets are described it is not fully clear whether they are obligations or just ‘expected results’, that cannot be legally enforced. The applicable law should be unified in all voivodships to facilitate compliance and enforcement of the provisions.

A dynamic air quality map as a tool to support local authorities in corrective actions in the area of atmosphere protection

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Monitoring of the air quality condition, in the context of corrective actions, resulting from air protection programs, is one of the main elements of the air quality management system. To assess air quality, the results of measurements performed at fixed measurement points are used, which can be supplemented with mathematical modelling techniques of pollution dispersion in the atmosphere. The technological advances made in recent years in the field of low-cost sensors of environmental parameters have opened new possibilities for the development of local-scale air quality modelling systems. The article presents the technical concept and existing examples of the implementation of a dynamic air quality map, in which the integration of air quality information from fixed measurement points, dispersion modelling and sensor networks was applied. The basic functions of the map in terms of historical analysis, nowcasting and air quality forecast were presented. The most important features of the hardware and information technologies used were described. The goals and scope of the ISSOP research and development project, which resulted in a dynamic air quality map system, were also discussed.

An interactive tool for informing residents about air quality

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In the period December 2018 - March 2020, the Dynamic Air Quality Map was put into use for the residents of Bydgoszcz. The project was financed by the City, NFOŚiGW and WFOŚiGW-Toruń as part of the KAWKA II program. The service provider was Atmoterm.

The map was the result of modelling the dispersion of pollutants, which presented the current state of air pollution with particulate matter: PM_{10}, $PM_{2.5}$. The air quality model used allowed to determine the spatial distribution of PM_{10} and $PM_{2.5}$ concentrations based on data from the emission inventory, mechanisms of chemical and physical processes taking place in the atmosphere and a set of meteorological data. The results obtained from the simulation provided information on air quality at any point in the city, indicating the share of the type of emission sources in the concentration of PM_{10} and $PM_{2.5}$. The map worked in three modes: current, historical and forecast (for the next 36 hours).

The air quality modelling system used, inter alia, emission data, meteorological data, PMŚ data and data obtained from supplementary measurement (low-cost sensors).

Air quality modelling made it possible to forecast air quality for 2 consecutive days, which is of great importance for residents in the context of reducing exposure in the event of expected episodes of high concentrations. Thanks to the animations, city residents could observe the variability of air quality in the city space over the next hours, plan outdoor activities, checking the air quality in their immediate and further surroundings, e.g. around educational institutions.

Modelling showed differences in air quality in individual urban units. It has been observed that the concentration of pollutants is not linear to the emissions and depends on many factors, including the topography, nature of buildings, environmental conditions and meteorological conditions.

Realization of the LIFE Project: Implementation of the air quality management system in the local governments of the Opole Voivodeship LIFE19 GIE/PL/000398 LIFE_AQP_Opolskie_2019.PL

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As it is well known air pollution has negative impacts on human health, the environment and the climate. According to the European Commission data, every year 44 000 people in Poland die prematurely due to air pollution. Opole Voivodeship is no exception.

Assessment of ambient air quality from previous years show that PM_{10}, $PM_{2.5}$ and target levels of benzo[a]pyrene are exceeded in the Opole Voivodeship. The problem of poor air quality is the main environmental problem in the Opole Voivodeship that effect directly the largest percentage of the population of the Voivodeship. This problem occurs most intensively in cities.

As the main source of exceedances of PM_{10}, $PM_{2.5}$ and BaP is individual household heating, and taking into account that by 2026 emissions from this sector have to be reduced by 1350 Mg / year compared to 31/12/2017, which is an organizational and competence challenge for local governments, Opolskie Voivodeship decide to introduce the LIFE Project orientated on the implementation of the air quality management system in the local governments.

Conclusions from implementation of previous AQPs points to lack of a management system, i.e. appropriate tools and competences in local governments as the reason for the insufficient effectiveness of AQP implementation. Mainly cos the activities undertaken by local governments aren't consistent, based on different methods, and depends of individual organizational capabilities.

In this case one of the main objectives of the project is to increase the capacity and quality of public administration of the Opole Voivodeship at all levels in relation to the remedial actions from AQP. By systematization of the AQP management at all levels of the structure in the mode of the holistic management system. This means ensuring simultaneously functioning components that enable consistency, stability, appropriate dynamics, stability, predictability of the obtained results to achieve the objectives more efficiently.

Dostęp do danych z urządzeń Internetu Rzeczy (IoT) dla celów monitorowania jakości powietrza

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Szacuje się, że do końca 2021 roku liczba aktywnych urządzeń Internetu Rzeczy osiągnie 25 miliardów. Jednocześnie około 60 % rozwiązań będzie wykorzystywanych przez konsumentów lub na ich rzecz. Pojęcie IoT obejmuje tak różne kategorie przedmiotów jak samochody, smart-domy, wyroby medyczne (rozruszniki serca, pompy insulinowe czy inhalatory do leczenia astmy), czy też zabawki i gadżety reklamowe. Już teraz wskazuje się, że urządzenia te są wszechobecne.

Cechą immamentną urządzeń IoT jest zbieranie przez nie danych. Ocenia się, że do 2025 roku ogólna liczba danych generowanych będzie wynosiła 175 zettabajtów. Za ten wzrost w dużej mierze odpowiedzialne są urządzenia IoT, których działanie generuje dane osobowe i nieosobowe. Ma to ogromne znaczenie dla rozwoju gospodarki opartej na wiedzy, a w szczególności tworzenia i trenowania algorytmów sztucznej inteligencji. Dane mogą być też podstawą do lepszego zarządzania miastem, w tym efektywniejszej organizacji usług społecznych jak transport publiczny czy edukacja, badania jakości powietrza w mikroskali czy inwestowania środków finansowych w celu uzyskania lepszej jakości powietrza.

W UE wykorzystywanie danych wygenerowanych przez organy administracji publicznej do celów komercyjnych i niekomercyjnych jest uregulowane przepisami dyrektywy 2003/98/WE w sprawie ponownego wykorzystywania informacji sektora publicznego. Jednocześnie, zdecydowana większość danych jest generowana przez urządzenia IoT należące do podmiotów prywatnych, tym samym pozostające poza zakresem normowania tego aktu. W mojej prezentacji przybliżę istniejące i planowane rozwiązania prawne w tym zakresie, które nakierowane są na zapewnienie szerszego dostępu do danych w celu wykorzystania ich dla dobra publicznego.

Pollutant emissions from road transport

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This talk explains how growing concerns about traffic pollution have led to increasingly stringent standards for vehicle exhaust emissions. However for diesel cars and vans, promoted because of lower CO_2 emissions, these standards have been widely exceeded including the deployment of cheat devices, although real-world testing has since led to much improved emissions. Looking to the future electric cars and vans and hydrogen trucks are not “zero emissions” as is frequently claimed. Non-exhaust emissions from tyres, brakes and road abrasion are difficult to tackle except by reducing vehicle use.

A UK and Global analysis of the 2018 atmospheric nitrogen pollution with the EMEP-WRF model

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Atmospheric reactive nitrogen (Nr) is a key pollutant that through its various forms has a large effect on ecosystems and human health. Emissions of Nr are mainly directly anthropogenic or derived indirectly from human activities. For example, in the UK, oxidised nitrogen compounds (NOx) are primarily emitted by combustion activities such as transportation and energy production, while ammonia (NH_3), another Nr pollutant important for air-quality, is mainly emitted by agricultural activities, such as livestock and fertilization of crops. The gas and phase-transfer reactions between Nr compounds and other pollutants, such as sulphur dioxide (SO_2) and volatile organic compounds (VOCs), lead to the formation of secondary pollutants, such as ozone and fine particulate matter ($PM_{2.5}$). The complex $PM_{2.5}$ composition and dynamics (primary + secondary + sizes + thermodynamic equilibrium) make models the best way to evaluate the outcome of emissions policy analysis as they are able to represent the non-linear processes occurring in the atmosphere. The EMEP MSC-W model coupled with the WRF model is applied to the UK and to a global scale to investigate the sensitivity of near-surface $PM_{2.5}$. The implications of model resolution are briefly discusse.

Particular Matter chemical composition: measurements and model evaluation

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The adverse effects of particular matter ($PM_{2.5}$) on human health and climate have seen PM-related air pollution move rapidly up the political agenda. The focus is on cities, and with an increasing global population, on megacities. Understanding the local sources and sinks affecting these environments is key to the implementation of effective air quality policies. A combination of $PM_{2.5}$ chemical composition measurements, together with models allows us to investigate the $PM_{2.5}$ sources and the processes that are involved in its transport. In this study, measurement techniques of $PM_{2.5}$ chemical composition at different time resolutions are presented. While low-cost DELTA® instruments can be deployed across large national monitoring networks to provide monthly measurements and annual trend in relation to the land use, fast-response instrumentation such as the online-IC-based MARGA and the aerosol mass spectrometer (AMS) provide a high time resolution “picture” of the daily processes or events occurring at a specific location as well as insights into synoptic transport and diurnal variations in gas-aerosol partitioning. Results of measurement campaigns in the UK, Europe and in South Asia are shown in comparison with the EMEP-MSC-W model coupled with the WRF model.

Part II
Poster session

Air pollution and its sources in Poznań

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KEY WORDS: air pollution, pollution sources, air quality measurements

The air quality in Poland is much worse compared to other countries in Europe. Air pollution affects our health and the environment we live in (Jędrak et al. 2017). Air measurements in Poland are carried out by the Chief Inspectorate for Environmental Protection. The following compounds and particulate matter are monitored: sulphur dioxide, nitrogen dioxide, carbon monoxide, nitrogen oxide, nitrogen oxides, ozone, benzene, PM_{10} and $PM_{2.5}$ suspended particulates. The permissible concentrations are regulated in the Ordinance of the Minister of the Environment of August 24, 2012 on the levels of certain substances in the air. The main source of air pollution in cities are harmful fumes generated by the transport sector and households. The emission is especially exceeded in winter (Malec, Borowski 2016).

The aim of the study is to analyze the level of air pollutants in Poznań, along with their origin on the basis of data from measurement stations in Poznań carried out by the Chief Inspectorate for Environmental Protection.

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Status and trends of mercury pollution in the marine ecosystem of the Polish part of the Baltic Sea

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The marine environment is particularly vulnerable to mercury (Hg) pollution, as it originates from many different sources. Hg inputs are considered to be atmospheric, including both dry and wet deposition, waterborne via rivers, and from direct point sources located on land and sea. Hg is a neurotoxin which accumulates in organisms, and its concentration increases with the trophic position of the organism. For that reason, the most vulnerable to the effects of Hg are organisms at the top of the trophic chain: predatory fish, mammals and birds, but also humans.

The main goal of this study was to assess the current status of the Hg pollution of the abiotic and biotic compartments of the southern Baltic Sea, and also to indicate the direction and pace of temporal trends of Hg level in the context of reduced anthropogenic emissions and changing environment.

The results showed that despite the relatively large outflow of Hg from Poland to the Baltic Sea, the Hg concentrations in both the abiotic and biotic compartments of its southern part are low and do not exceed the safe limits, above which wildlife and humans would be at risk. In the Baltic Sea, the changes in Hg emission and atmospheric deposition reflects in the decreasing Hg concentration in fish, which may indicate the exposure of the marine food web to the Hg pollution. However, the herring (Clupeaharengus) as a long-lived, accessible and widely consumed species meets the criteria to become an important bioindicator. At the land-sea interface, the feathers, blood and eggs of water birds can provide important information on Hg contamination, but they cannot be treated as bioindicators. Blood and feathers in the growth phase allow to effectively track local contamination and directly reflect the Hg load in birds. Suggestions from HELCOM to include seals in the assessment of the state of the marine environment are only realistic based on random dead individuals. This irregular access to biological material means that seals cannot be considered as very useful for monitoring in the southern Baltic. For long-term assessment of contamination in the region where the food comes from, fully developed feathers and unfertilized eggs are more useful.

Metaliczne zanieczyszczenia w $PM_{2.5}$ i PM_{10} strefy brzegowej Zatoki Gdańskiej

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Zdrowie człowieka i jakość powietrza jest ściśle powiązana z poziomem stężeń gazowych i aerozolowych zanieczyszczeń, ich strukturą biogeochemiczną i przemianami. Ocena narażenia społeczeństw na metaliczne składniki pyłu zawieszonego pochodzącego z różnych źródeł antropogenicznych jest obecnie jednym z kluczowych problemów środowiskowych.

W ramach niniejszego projektu dokonano wielopierwiastkowej analizy As, Cd, Co, Cr, Cu, Fe, Mn, Mo, Ni, Pb, Sb, V techniką ICP-OES w zmineralizowanych próbkach pyłu $PM_{2.5}$ i PM_{10} strefy brzegowej południowego Bałtyku. Do kolekcjonowania dobowych próbek aerozoli wykorzystano nisko-przepływowe urządzenia pomiarowe obsługiwane w systemie modułowym: (i) próbnik manualny z głowicą cząstek PM_{10} oraz (ii) zestaw automatyczny z głowicą $PM_{2.5}$. Wśród priorytetowych zadań w projekcie znalazły się m.in. analiza porównawcza stężeń pierwiastków śladowych w obu frakcjach aerozoli, identyfikacja lokalnych źródeł emisji zanieczyszczeń (metody statystyczne), oszacowanie strumieni depozycji metali w obu klasach wielkości cząstek atmosferycznych, ocena zróżnicowania współczynników wzbogacania EF względem Fe oraz ocena toksyczności cząstek we wdychanym powietrzu.

Stwierdzono statystycznie istotne różnice w stężeniach poszczególnych metali w pyle zawieszonym $PM_{2.5}$ i PM_{10} nad strefą brzegową Zatoki Gdańskiej. Szczegółowo przebadano wpływ różnych źródeł lokalnych na dystrybucję metalicznych zanieczyszczeń w poszczególnych sezonach pomiarowych. Na podstawie zebranych danych zawartości metali w pyle zawieszonym określono ryzyko zdrowotne występujące w grupie kobiet i mężczyzn stosując modelowe wskaźniki US EPA (2009) dla inhalowanych zanieczyszczeń tj. Dinh (daily dose for non-cancer risk), HQ (hazard index), HQ (hazard quotient), ILCR (incremental lifetime cancer risk). Nowością w prowadzonych badań było wykazanie wpływu transportu morskiego na jakość powietrza w strefie brzegowej w oparciu o współczynnik masowy V/Ni jako specyficzny marker emisji zanieczyszczeń ze statków podczas spalania olejów ciężkich.

Projekt realizowany jest ze środków na naukę przyznanych przez Narodowe Centrum Nauki (UMO-2017/27/B/ST10/01200).

Influence of the type of surroundings of academic buildings on the concentrations of particulate matter (PM_{10}, $PM_{2.5}$, $PM_{1.0}$) and gaseous pollutants (VOC, H_2S, SO_2) at different heights

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Air quality has a strong influence on human health and the health of flora and fauna. The level of air pollution in the area of people's everyday life, i.e. in towns and villages, is particularly important. The analysis of the concentration of pollutants in urbanized areas is a very complex issue, because the concentration of pollutants is influenced by, inter alia, meteorological conditions, terrain roughness, sources of pollutant emissions and the type of surroundings of the analysed area or object. Due to the so-called low and high pollutant emissions, changes in the concentration of air pollutants in relation to the height above the ground should also be taken into account. Based on the analysis of the problem, an attempt was made to investigate the influence of the type of building surroundings on the air quality around them at different heights. Two high buildings located on the campus of the university in the central part of the city were selected. The first building allows you to observe the impact of green areas and the car park, while the second building allows you to see the impact of a busy street and car park on air quality. The analysis included the concentration of particulate matter PM_{10}, $PM_{2.5}$ and $PM_{1.0}$ as well as gaseous pollutants H_2S, VOC and SO_2.

The examination of the air pollution caused by vehicle exhaust emissions in the forest ecosystem of Świętokrzyski National Park

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In the years 2019 - 2020, the research studies regarding the impact of anthropopressure on the functioning of the forest ecosystems within Świętokrzyski National Park were conducted. These research studies, to some extent, considered the process of the analysis in the range of the impact of traffic-related air pollution. It included the examination of pollutant emissions on the 2.3 km section of the district road No. 0324T from the entrance gate to the Park up to the plateau of Święty Krzyż (Holy Cross). The variation in the relative height of this section reaches 95.4 m and it is situated entirely on the western slope of Łysiec (Święty Krzyż - 594.3 m above sea level). The road is primarily used by vehicular traffic and pedestrian traffic. The specific objectives of the research studies, based on the personal research methodology, included the following aspects:

a) the fixed monitoring of concentrations of the selected gaseous and particulate compounds and heavy metals at three measuring points located at the foot of the road and in its middle and final sections,

b) periodic measurements in the range of the mobility of people, including their methods of moving,

c) the calculation of emissions (CO_2, CO, NOx, PM) generated by motor vehicles, taking into consideration their age and type structures,

d) estimations of CO concentration distribution in the cross-section of the road considering the intensity of the vehicle traffic, the distance from the centre of the road, the height above ground level, the relative height, the exposure and the gradient of the place, and the prevailing weather conditions.

The obtained research outcomes provide evidence for the significant impact of the harmful compounds contained in the exhaust fumes and other external factors of the anthropogenic kind, leading to a negative effect on the Park's forest ecosystems and people staying in this area.

The temperature and moisture sensitivity of soil GHG respiration under different urban land use

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KEY WORDS:CO_2 flux, CH_4 oxidation; chamber measurements, urban ecosystems

Climatic factors that control the activity of vegetation and soil microorganisms have a distinct impact on the rate of ecosystem GHG (CO_2 and CH_4) fluxes. In the present study, the relationship between CO_2, CH_4 respiration/uptake and soil moisture content and temperature was examined in three different types of land use (grassland, city park and arable land). The analysis was based on the field measurement campaigns at biweekly intervals over a year using a static closed chamber method in Wroclaw urban area, Poland. The sensitivity of ecosystem respiration to moisture and temperature was evaluated by using the exponential model (Q10 model) and quadratic (parabolic) function, respectively.

The observed patterns of land-atmosphere CO_2 and CH_4 exchange varied across land cover types and were strongly influenced by seasonal variations of temperature and soil water content. Emission of CO_2 from grasslands and the city park was higher than from the arable lands. The calculated CH_4 oxidation efficiency was significant under grassland and the city park site as compared to arable soils. In the vegetation season, the average ecosystem CO_2 flux (only respiration contribution to NEE) was above 4±0.5 $\mu mol \cdot m^2 \cdot s^{-1}$ in grassland, above 2±0.4 $\mu mol \cdot m^2 \cdot s^{-1}$ and 5±0.8 $\mu mol \cdot m^2 \cdot s^{-1}$ in arable land and city park, respectively.

Despite the differences in biological activities, the values of ecosystem respiration/uptake in the three land use types were primarily driven by soil temperature and moisture regimes. The obtained Q10 values ranged between 1.68 and 1.79 for respired CO_2 and from 1.26 to 1.49 for CH_4, depending on the ecosystem type. The temperature sensitivity of soil respiration decreased when the temperature was above 24.5 °C across the sufficient moisture gradient. The results suggest a complex interplay of soil temperature and water content, whereas their interaction are the controlling factors in regulating temporal variations of CO_2 and CH_4 emissions from the ecosystem to the atmosphere at a seasonal scale.

Analysis of the variability of ozone concentrations in selected Polish cities

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The 34% of the inhabitants of European cities are exposed to the ozone concentrations above EU air quality standards, and 99% of the population – to the concentrations above the World Health Organization (WHO) guidelines, according to a European Environment Agency (EEA) report (EEA 2020).

In Poland monitoring of ozone concentrations in terms of health protection is carried out by the Chief Inspectorate for Environmental Protection at 105 measuring stations. In the assessment of air pollution, two criteria are used in terms of health protection: the target level and long-term objective one. European and Polish regulations have also introduced the information threshold level (180 µg/m^3) and the alert threshold (240 µg/m^3) for one-hour average ozone concentration.

The present study analyzed the variability of ozone concentrations in selected Polish cities in 2011-2020. The analyzes included data from selected national locations: large urban agglomerations, suburban and extra-urban areas, as well as selected spa towns. A comparative analysis was carried out for various areas in Poland, then data was compared with the most densely populated cities in neighbouring countries, such as the Czech Republic and Germany. The relationships between the concentration of tropospheric ozone and meteorological conditions were also estimated. Data on concentrations of other air pollutants, in terms of health hazards, was also discussed.

The results showed a significant diversification of the risk associated with increasing O_3 concentrations at ground level in different regions and different types of areas, as well as its clear relationship with meteorological conditions.

Human health risk assessment of air pollution in the regions of unsustainable heating sources. Case study – the tourist areas of southern Poland

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Air pollution is one of the main factors affecting human health. Air quality is especially important at the tourist areas developed with facilities for outdoor activities. During the winter season of 2017/2018, the concentrations of PM_{10}, $PM_{2.5}$, PM_1, CO, O_3, and NO_2 were studied in twelve attractive tourist villages in the surroundings of the Czorsztyn Reservoir in southern Poland. Air pollutant measurements were performed continuously, using a single ground+based Alphasense air sensor. Our assessment of human health risk (HHRA), arising from inhalation exposure to air contaminants, was calculated for both local inhabitants and tourists, based on actually measured values. It was found that pollutant concentrations exceeded both permissible and recommended levels of PM_{10} and $PM_{2.5}$, respectively. The mean total noncarcinogenic risk values were equal to 9.58 (unitless) for adults and 9.68 (unitless) for children and infants, under the resident exposure scenario. However, under the tourist exposure scenario, the mean total risk was equal to 1.63 (unitless) for adults and 1.64 (unitless) for children and infants. The risk to tourists was lower than that to inhabitants due to shorter exposure times. The target noncarcinogenic value of 1, calculated for PM_{10}, $PM_{2.5}$, and NO_2, was significantly exceeded in total risk, under the residential exposure scenario, in reference to all the local subpopulations. In the majority of the investigated locations, the total risk exceeded the value of 1, under the tourist scenario, for all the subpopulations analysed. $PM_{2.5}$ was recognised to be the most important contaminant in our risk analysis, in view of its share in the total risk value.

RADON – toxic or therapeutic?

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Radon is a colorless and odorless noble gas with radioactive properties. The most important in the environment is its longest-lived isotope: Rn-222, with a half-life of 3.8 days. The inhabitants of regions whose geological structure determines the increased concentration of this isotope are particularly exposed to radon. Radon is formed in rocks (mineral grains) as a product of radioactive decay of Ra-226. In the human environment, the source of radon can be air and water (groundwaters: i.e. taken from wells, or water intended for consumption). Radon gets into the environment as a gas released directly from rocks, or as a gas dissolved in water existing in the pore space. Radon is highly soluble in water, and therefore it can be transported with groundwaters, mainly shallow circulation. At the point of outflow or intake of these waters it reaches the surface. This work presents two sides of radon. On the one hand it can be used for therapeutic treatment but on the other hand it can be also dangerous. Due to the theory of radiation hormesis, small doses of ionizing radiation can have a beneficial effect on the human body. According to Polish law, groundwaters containing at least 74 Bq/L of radon, can be used as medicinal radon water and as a source of the therapeutic gas. Radon therapy are provided in many health resort in the world (including Poland, Lower Silesia). In places where the concentration of radon may exceed the limit values (especially indoor radon) periodic monitoring and risk assessment is required. It concerns houses, facilities and other buildings. This presentation shows an overview of the law regulations and archival data on radon concentration in the human environment.

Has the COVID-19 pandemic affected the air pollution trends in Warsaw agglomeration?

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The pandemic of COVID-19 forced Polish government to introduce numerous preventive measures to manage the epidemiological situation. Since the first lockdown in Spring 2020, the closure of educational institutions, as well as the transition to home office resulted in significant traffic reduction in all Polish cities. The aim of this study is to investigate whether the administrative measures, that limited citizens mobility and economic activity, had impact on the air quality in Warsaw agglomeration. Hourly data on the particulate matter ($PM_{2.5}$) and nitrogen oxides (NOx) mass concentrations from three GIOŚ air monitoring stations (Legionowo, Niepodległości Avenue and Wokalna Street) covering last twelve months were compared with the long-term averages for years 2015-2019 and also with the weeks prior to the virus outbreak. NOx levels showed the most significant reductions in the Center of Warsaw (34.9 %), as a result of reduced vehicle movement downtown, while in Legionowo even small increase in NOx concentration was observed (3.8 %). $PM_{2.5}$ levels fell to a lesser extent and periodically varied at all stations. Significant changes in daily and weekly pollutant concentration trends were observed. NOx concentration decreased the most during morning and evening rush hours at Niepodległości Avenue (of 34 % and 38.3 % respectively). In the other locations the reduction effect in the morning was not observed, but the maximum NOx values occurred approximately an hour later than in the pre-pandemic period. During last 12 months the $PM_{2.5}$ pollution levels dropped at all stations, but the greatest decrease was observed on weekends, from Friday to Sunday. The air temperature and wind speed were also considered in the analysis as possible interfering factors, however the meteorological conditions since the beginning of the pandemic did not differ significantly from the long-term averages.

Air quality and bioclimatic conditions in Lublin (2015-2019)

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Every year, inhabitants of urbanized areas are exposed to the low air quality of the atmospheric environment, subject to increasing changes. These changes concern both the chemical and physical composition (dust), but also result from planning activities related to the reduction of biologically active areas and an increase in the share of artificially transformed areas. Due to contemporary climate changes, the latter element not only contributes to the increase in pressure related to the occurrence of heat stress, but also contributes to a further increase in air pollution.

Lublin, as the largest city located east of the Vistula River, is not free from the processes described above. It is the city with lower than average share of green areas in Poland. Each year, Lublin is in the group of cities where significantly exceeded concentrations of air pollutants that are harmful to the health of residents are recorded.

The study attempts to indicate the relationship between biometeorological conditions and selected air pollutants. The Universal Thermal Climate Index (UTCI) was used to characterize the biometeorological conditions. It takes into account the combined influence of air temperature, relative humidity, wind speed and solar radiation conditions on human heat balance. The analysis of aerosanitary conditions was based on the concentrations of the following air pollutants: NO_2, O_3, CO, SO_2, PM_{10}, $PM_{2.5}$ and benzo(a)pyrene. In addition, we analysed the episodes of the highest air pollution and the situations characterized by the highest heat load of the human body in connection with the synoptic situation in the region.

Air quality monitoring in the health resort Rabka-Zdrój

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KEY WORDS: air quality monitoring, health resorts, air quality, Rabka-Zdrój

Air quality monitoring is the first step to assess the state of air quality in a selected area and, in a further step, to identify the need to undertake appropriate corrective activities for air protection. In accordance with the applicable law in Poland, the health resort municipality shall meet the several conditions, inter alia, possess the deposits of natural healing materials with confirmed medicinal properties, have a climate with proven healing properties, and meet the environmental requirements set out in the environmental protection regulations. Therefore, the health resort areas should be a high priority to provide air quality monitoring.

The main aim of the paper is to review air quality monitoring and the assessment of ambient air quality in the Rabka-Zdrój health resort. In the area of the health resort there was no continuous monitoring of air quality, are only temporary measurements (NO_2, SO_2, PM_{10}, B(a)P) that have been carried out in the years 2004-2007, 2009, 2014, 2017 and 2020. Monitoring of air quality in terms of carcinogenic B(a)P concentration in the air showed that in 2014 and 2017 the health resort did not meet the European Union requirements for the average annual concentration at the level of 1 ng/dm^3. Furthermore, the health resort has exceeded the average daily concentration of PM_{10} (>50 µg/dm^3). In 2017, 66 days with the exceeding concentration of PM_{10} were recorded, with a limit value of 35 days in a calendar year. The analysis shows that the health resort did not exceed the limit value of the average annual concentration of PM_{10} dust - at the level of 40 µg/dm^3. In the indicated years of measurement, the health resort did not exceed the European Union limit values in terms of NO_2 and SO_2 concentration and the frequency of exceeding the limit value in year.

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Impact of meteorological conditions on the spatial distribution of PM_X concentration in the Wrocław and Bydgoszcz agglomerations in the light of mobile measuremants

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The study presents the results of mobile measurements of particulate matter (PMx) concentrations carried out during LIFE-MAPPINGAIR/PL project. These measurements have been carried out since September 2019 and continue the research started within LIFE-APIS/PL project (Drzeniecka-Osiadacz et al, 2018) in 2016.

The measurements were carried out with use of mobile research stations based on electric drive car Nissan eNV200 (within the city of Wrocław) and unleaded petrol driven cars (Renault Kangoo and Fiat Doblo) in Bydgoszcz and vicinity of Wrocław. All three cars were equipped with measurement stations, consisting of an optical dust meter DustTrak II with a heated measuring path and air inlet installed at car rooftop, at the height of approx. 2.5 m a.g.l. Additionally, a meteorological station was installed on the cars to measure the meteorological background during the transects. These data were supplemented with data obtained from the Meteorological Observatory of University of Wrocław in Wrocław (meteorological data and PMx concentrations), as well as from the Institute of Meteorology and Water Management network (meteorological data) and State Environmental Monitoring system stations (air quality parameters).

The measurements were carried out mainly in the evening hours (between 6.00 p.m. and 11.00 p.m.) and in the mornings (between 6.00 a.m. and 10.00 a.m.), during the periods of increased demand for heat at houses, resulting in increased emissions of pollutants from heating systems. The measurement transects lasted approx. 3 hours and were conducted at an average speed not exceeding 30 kph. With the assumed logging frequency of 1 sec. the results were obtained with a spatial resolution of 8 m.

The obtained results have shown that the spatial structure of PMx concentrations in the studied areas is determined by the emission level and the number of emitters, as well as concomitant weather conditions. Thus, two characteristic types of spatial distribution of concentrations have been distinguished: "hotspot pattern" and "hot area pattern".

The main features of the ‘hotspot pattern’ are low variability of the background of PMx concentrations on one hand, and the presence of single spots where PMx concentrations may even exceed the background concentrations by an order of magnitude on the other. These hot spots are formed in the close vicinity of the emitters, the PMx concentration decreases very quickly when moving away from them. Such a spatial structure occurs during dynamic weather, in which we deal with conditions favouring the removal of pollutants from the atmosphere (windy, rainy, unstable atmosphere stability). In such conditions, generally air quality depends on the number and density of active emitters in a given area.

‘Hot area pattern’ occurs in stable, rainless and windless weather conditions. It is frequently connected with frosty situations however also frost-free weather, with a developed near-ground thermal inversion would be favourable. Such conditions result in hindered dispersion of pollutants. Thus they accumulate in the vicinity of the emitters, and their impact gradually extends over an increasingly larger area. As a result, relatively large areas with clearly higher concentrations occur in the spatial structure of PMx. These may be even 2-3 times higher than the background concentrations. It should be noted that in such situations, a significant deterioration of air quality

in a given area may be affected even by a single emitter. The key factor in this case is the duration of the conditions favouring PMx accumulation.

In case of Wrocław agglomeration, it was found that the problem of decreasing air quality concerns to a much greater extent in small suburban localities. In such places high concentrations of PMx appear even in relatively warm weather (e.g. already in September or October), which, according to the authors, is related not only to the widespread use of solid fossil fuels for heating purposes, but also hot water provision. Due to the small areas of towns and the high density of emitters, the deterioration of air quality often covers the entire town, regardless of the weather type.

The research was carried out under the Project "Do you know what you breathe?" – educational and information campaign for cleaner air LIFE-MAPPINGAIR/PL, financed by the European Union under the LIFE Financial Instrument and co-financed by the National Fund for Environmental Protection and Water Management

Mapping urban ambient air pollution with a mobile sensor network

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Ambient air pollution is a substantial issue for city management and urban ecology in many parts of the fast urbanising world and also Central Europe, and Poland with increasing number of car traffic and outdated heating infrastructure. Air pollution levels in many cities in the world have been also aggravated by climate change and the urban heat island phenomenon. Numerous initiatives have been established to tackle this issue that is responsible for various human health problems such as cardiovascular diseases and excessive death rates. However, so far there are no universal and scalable means that could support decision making processes in real or near real time to mitigate short-term and long-term increased pollution levels.

In the presentation we put forward a concept of a GIS based decision support system incorporating near real time tracking of air pollution levels on the entire area of an urban agglomeration with public transport installed proprietary sensors, big data analytics, and Internet of Things infrastructure.

Results of preliminary trials conducted in Wroclaw with a self-designed and constructed laser measuring device show that the methodology can be easily and efficiently used to obtain reliable data on air pollutants distribution including analysis of their temporal and spatial variability. We have also tested interpolation functions including interpolation with barriers to assess the quality of continuous field air pollution components such as $PM_{2.5}$, PM_{10} maps from point measurement data. The proposed approach can be further extended with a supervisory system informing the local community about air quality and recommending safety precautions, as well as providing other services and proactive tasks.

Analysis of elevated $PM_{2.5}$ episodes using the campus air quality sensor network of Wrocław University of Science and Technology

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Air quality sensors have become very popular in recent years. Such devices are small and lightweight, and their prices are much lower than those of traditional instruments for air monitoring. Low-cost sensors and sensor networks may supplement the conventional regulatory systems, detect “hot-spots”, provide additional information about air pollution issues and raise public awareness on this topic.

The paper presents the application of a sensor network from the campus area of Wrocław University of Science and Technology (WUST) for analysis of elevated $PM_{2.5}$ episodes. The WUST sensor network provides the academic community and citizens of Wrocław with up-to-date information about the local air quality. In the city of Wrocław, the problems of air quality deterioration are particularly significant in the autumn-winter seasons, when $PM_{2.5}$ is emitted mainly from individual heating systems in households (combustion of fossil fuels and biomass). The WUST sensor network consists of nodes distributed on the main campus area and five peripheral campuses. Nodes contain optical PMS A003 sensors and heated inlets, which minimize the impacts of high levels of humidity.

The analysed data set spans the heating season 2020/2021 (01.11.2020-31.03.2021). During this period, the average hourly $PM_{2.5}$ concentration for the regulatory urban background monitoring station was 28.9 $\mu g/m^3$, similar to the regulatory traffic monitoring station: 28.7 $\mu g/m^3$. The sensor network nodes reported slightly lower values: 20.6-27.0 $\mu g/m^3$. Maximum hourly concentrations data contained more significant discrepancies: the highest concentration for the urban station was 145.8 $\mu g/m^3$, while the traffic station reported a 20 % lower value (115.6 $\mu g/m^3$). The range of maximum hourly $PM_{2.5}$ values for sensor nodes was 85.5-138.5 $\mu g/m^3$, which shows a considerable variation in the distribution of $PM_{2.5}$ concentrations within the city.

The article also presents the meteorological factors affecting the elevated $PM_{2.5}$ concentrations and pollutants distribution. The dominant wind direction during the measurement period was WNW. However, during the elevated $PM_{2.5}$ episodes, the dominant wind directions related to the highest concentrations were SE and ESE.

Short-term air pollution forecast as an element of air quality management in the region of the PL-CZ-SK, AIR TRITIA border. Application of artificial intelligence methods in the protection of the atmosphere

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Short-term air quality forecasts in recent years have been an important element of warning the population against episodes of high concentrations of pollutants not only in Poland. They function especially where the air quality in terms of daily and temporary standards requires urgent improvement. In most cases, methods based on pollutant dispersion models are used, which are based on emission data and the forecast field of meteorological conditions from mezo-scale models of regional laboratories. Their verifiability, provided that a complete and up-to-date emission base is taken into account, is very good. Alongside these models, statistical and artificial intelligence models are being successfully developed. Especially the latter are the favourite tools for forecasting pollutant concentrations on a local scale. The forecast using this methodology is most often made by training the model from a dense grid of data from low-cost sensors.

This presentation presents a hybrid air quality forecast model (air quality AQ) that uses both the numerical mesoscale model COSMO-LM weather forecast from the past as well as historical and current data on pollutant concentrations from the SEM / CIEP stations. In its computational layer, it uses data mining methods. This operationally used model was prepared for the needs of VIEP Katowice and was operated in a constantly improved form in 2007-2018. In its current form, it is an element of the air quality management system in the area of TRITIA (borderland PL-CZ-SK) as one of the results of the AIR TRITIA project "Uniform approach to the air pollution management system for functional urban area in Tritia Region" implemented under Interreg CE in 2017-2020.

Data mining is an analytical process, the purpose of which is to examine large data pools to find regularities and systematic correlations between the variables and to evaluate the results by applying the detected models to the new data subsets. The ultimate objective of data mining is to forecast e.g. customer behaviour, sales volume or certain physical phenomena.

The data mining process includes three fundamental stages:

- preliminary exploration,
- building a model, which includes evaluation and verification,
- implementation and use of the model for new data to acquire the predicted values or classifications.

Air quality forecasts are based on the following assumptions:

♣ Purpose of prediction (air quality forecast) – air pollution level over 72 hours (3 subsequent days);

♣ The location of prediction is a specific point (city).

Five cities have been selected for the forecast: Opava, Opole, Ostrava, Rybnik, Žilina;

¬ predictive data necessary to draw up an exploration forecast;

¬ current numerical weather forecast for the prediction location;

¬ historical weather forecast set over the course of several years (at least 5) of the prediction location;

a sequence of air pollution measurements at the dates corresponding to the historical weather forecasts, preferably close to the prediction locations.

There are many air quality indexes in the world. They have been developed since the first automatic monitoring networks were created. Currently the aim is to standardize the approach in the areas using uniform standards

Air quality is classified in the European Union by using the Common Air Quality Index (CAQI). Its formula has been defined for the purpose of comparing air quality in various European cities. The index is used by the European Environmental Agency (EEA 2010) as part of Eye On Earth system sharing information on air quality.

At this stage of forecasting, a set of output files is generated in the form of forecasted courses of suspended concentrations PM (particulate matter) with the aerodynamic fraction PM_{10} and $PM_{2.5}$ (hourly and daily values).

The model in an operational way - as an element of the AIR TRITIA project, it has been functioning since 2019. Its results can be seen at: http://air-tritia-test.herokuapp.com/pl/.

The model results are subjected to both daily and periodic verifiability analysis, which indicates its satisfactory effectiveness.

Evaluation of the effectiveness of hydrogen sulphide removal in a biotrickling filter

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Hydrogen sulphide is an air pollutant emitted as a result of the activities of municipal management facilities such as wastewater treatment plants, waste treatment plants, as well as industrial facilities - e.g. pulp and paper or sugar industries. Due to the low olfactory detection threshold and the unpleasant, irritating nature of the smell, H_2S largely contributes to the odor nuisance. Gases containing H_2S can be purified by traditional physical and chemical methods, but for economic reasons and due to the problem of secondary waste generation, it seems beneficial to use biological methods, including biotrickling filtration. The paper presents the evaluation of the effectiveness of H_2S removal on a lab-scale biotrickling filter packed with open-pore polyurethane foam inoculated with pre-thickened activated sludge from a local wastewater treatment plant, operating with counter-current flows of the air and liquid streams. After the adaptation stage of the filter bed, II measurements series were carried out, lasting 10 and 15 days, respectively, during which gases with concentrations of 59-65 ppm and 116-128 ppm of H_2S were subjected to the biotrickling filter, respectively. In each of them, the effectiveness of H_2S removal was assessed for 5 different gas retention times from 9.4 s to 44.3 s. Results indicated that even at the EBRT 9.4 s, the efficiency of H_2S removal on the biotrilckling filter was up to 98.4% and 91.4 % for the inlet H_2S concentration of 59÷65 ppm and 116÷128 ppm, respectively.

Proces control of biogas purificaion using electronic nose and gas chromatography

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Nowadays, more and more emphasis is being put on all sorts of environmental issues, with which activities aimed at minimizing the emitted pollution are inseparably connected. All types of odorogenic compounds are an example of substances harmful to the environment, as well as worsening the quality and comfort of life. Biogas produced from landfills and wastewater treatment plants is important sustainable and affordable source of energy. However impurities from biogas stream can cause a serious odour problem, especially for residents of areas immediately adjacent to production plants. Therefore, biogas pre-treatment is necessary to protect engines that convert biogas into energy and in order to increase the specific heat. There are several methods for reducing odorous substances in air stream: absorption processes, adsorption processes, thermal neutralization (combustion), non-thermal oxidation, odor compensation and biological treatment processes (Wysocka et al. 2019).

Evaluating the effectiveness of specific deodorization technologies is a complex process that requires searching for efficiency and economic tradeoffs. There are two basic techniques for assessing odour nuisance. Sensory techniques, in which the human sense of smell acts as the measuring sensor (e.g. dynamic and field olfactometry), and analytical (or instrumental) techniques, which enable analysis by means of non-selective gas sensors arrays (e-nose) or gas chromatography (Gębicki et al. 2016). Sensor arrays allow analysis of the composition of a gas mixture without the need to separate and identify its individual components. Additionally, compared to olfactometric techniques, there is a lack of olfactory adaptation and the need for trained personnel with specific olfactory perception. Furthermore, compared to chromatographic techniques sensor arrays are characterized by short analysis times and lower instrument prices (Szulczyński, Gębicki 2019).

This study presents the use of sensor arryas to evaluate the efficiency of absorption-based purification of model biogas. The gas mixtures consisted of methane, carbon dioxide and odorant: cyclohexane, toluene, propionaldehyde, 1-butanol and dimethyl disuflide. Three absorbents were used in the research: hexadecane and two deep eutectic solvents: choline chloride with urea (ChCl:U) in 1:2 molar ratio and camphor with guaiacol (C:Gu) in 1:1 molar ratio. For process efficiency monitoring the electronic nose and gas chromatography were used. The purification efficiency was calculated for each process sample . For example the toluene removal efficiency calculated from the electronic nose results was 74.6 % (hexadecane), 85.0 % (C:Gu) and 81.0 % (ChCl:U) and the results obtained by gas chromatography are as follows: 67.8% (hexadecane), 89.3 % (C:Gu) and 72.9 % (ChCl:U). Only for dimethyl disulfide, the electronic nose significantly deviates from the reference values. PE_{enose}were as follows: 27.9 % (hexadecane), 39.2% (C:Gu) and 30.9 % (ChCl:U) which is significantly lower than the PE_{GC} which are respectively: 47.9 % (hexadecane), 69.9 % (C:Gu) and 60.3 % (ChCl:U). However, the obtained results show that electronic nose can be successfully use to monitor the biogas purification process by absorption. As part of a research, the usefulness of deep eutectic solvents (DES) as a green alternative to ionic liquids, due to their environmental-friendly composition, simple synthesis, low cost, and biodegradability has also been demonstrated.

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Aerosol from waste wood fires: number and volume size distribution

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The degradation of organic materials due to thermal processes is a phased process. The number size distribution (NSD) and volume size distribution (VSD) of the particles depends whether pyrolysis or oxidation occurs in the material. We analyzed the NSD and VSD of particles from waste wood combustion using Dekati® High Temperature ELPI®+ (Electrical Low Pressure Impactor with 14 stages). In the experiment two materials were analyzed: pine wood and laminated particle board. These materials are typical for household and household waste – the majority of house construction elements and furniture are made of them. The material was prepared in small sticks and arranged in piles, according to ISO/TS 7240-9:2012, that were allowing free flow of air. The experiment was conducted in the 70 m^3 chamber. The NSD and VSD was measured at all stages of experiment: before, during the fire and after the fire. The cumulative distributions are presented in Fig. 1 and 2.

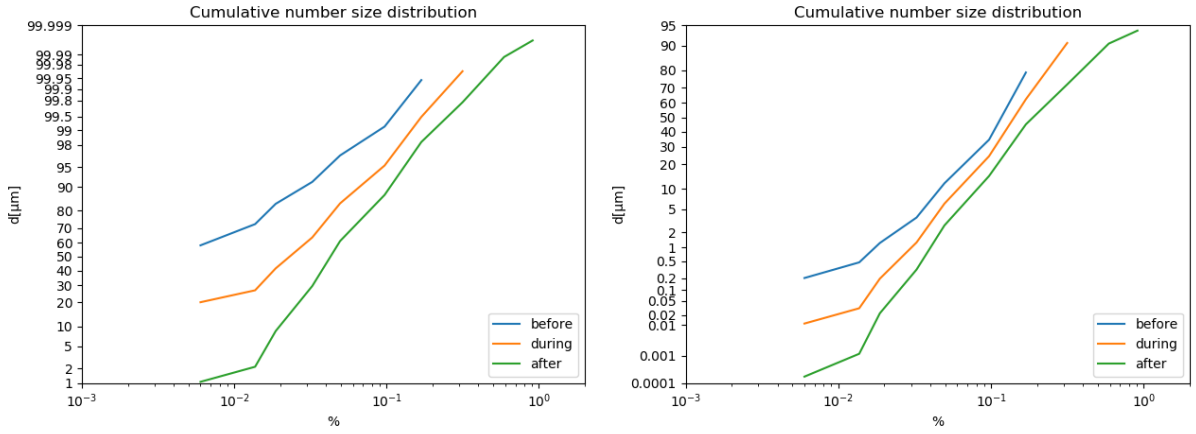

Fig. 1. Cumulative number (NSD) and volume (VSD) size distribution before, during and after fire of pine wood

The structure of cumulative NSD and VSD before, during and after fire are different for pine wood and laminated particle board, however, the general order of cumulative distributions, before≥during>after, is the same for both before, during cumulative distributions are arranged in order. As could be expected, the number concentration of particles (C) is higher during burning and much lower after the extinguishing contrary to the change in median diameters (MD). The number (NMD) and volume median diameter (VMD) are significantly increasing with the stage of experiment (before, during and after extinguishing fire). The NMD seems to be independent from burned material while VMD for pine wood is higher than for laminated particle board (Table 1).

The comparison of cumulative NSD and VSD indicates that size distribution of particles emitted from laminated particle boards are not unimodal, while distributions of particles emitted from pine wood seems to be straight lines (as for log-normal distributions) – Fig. 1 and 2. The further studies requires verification of the particle mass obtained from the volume distributions with the masses obtained from weighting particles collected at each stage of impactor. It will allow to determine correct mass size distribution of particles emitted from fire of pine

wood and laminated particle board and evaluate the density of particles in each analyzed fraction of the emitted particles.

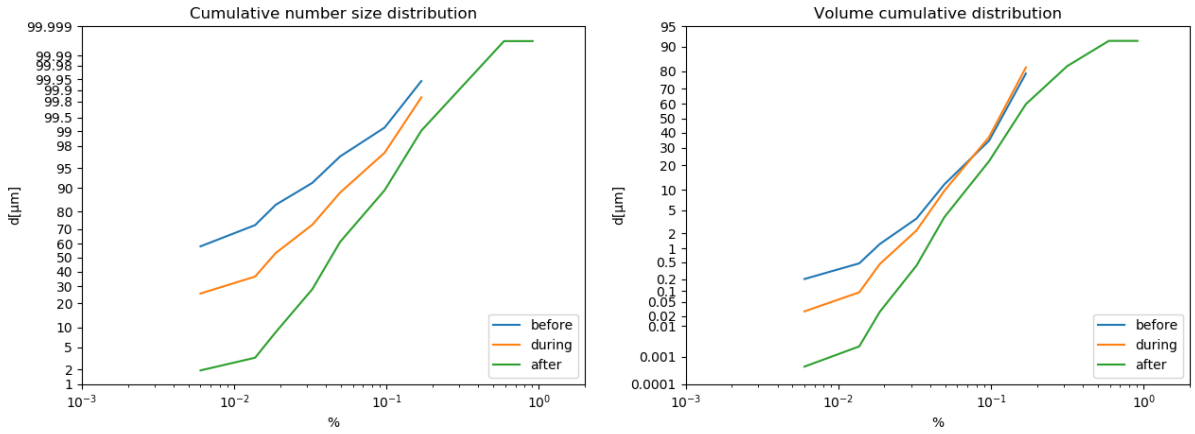

Fig. 2. Cumulative number (NSD) and volume (VSD) size distribution before, during and after fire of particle laminated board

Table 1. Comparison of particles concentration (C), number (NMD) and volume (VMD) median diameter for number (NSD) and volume (VSD) size distribution before, during and after fire of pine wood and laminated particle board.

	pine wood			laminated particle board		
	C $\left[\frac{1}{m^3}\right]$	NMD [µm]	VMD [µm]	C	NMD [µm]	VMD [µm]
before	0.014	0.015	0.194	0.014	0.015	0.194
during	11.743	0.036	0.253	9.649	0.029	0.193
after	7.346	0.077	0.367	3.478	0.076	0.303

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Transport with better air quality within cities

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Air quality greatly affects the mood and directly health, including the efficiency of the human body. Transport by means of internal combustion vehicles is disadvantageous in this sense, but so far no alternative has been introduced that would create direct competition for this type of means of transport. City logistics deals with issues related to the possibility of improving the situation, which is currently harmful to city dwellers. The purpose of the presentation is to present the current possibilities of using low-emission means of transport. Examples of proposals include public transport-related activities and innovations aimed at improving the quality of services, which has the consequence of increasing the share of this type of means of transport in relation to passenger cars. The disadvantage is the inability to take over all the features that work to the advantage of competitors, while boldly compensating for this with other benefits. In addition, in order to reduce the level of pollution, alternatives to passenger cars themselves are used, which do not have to be limited to propulsion using an internal combustion engine, and are even representatives of vehicles other than cars, e.g. scooters and bicycles. In addition, appropriate infrastructure may also reduce the harmfulness of means of transport by optimizing energy consumption. These and other various solutions can be combined with each other in order to implement the concept of greener cities. Data was collected from various sources on the solutions themselves and it's about, e.g. alternative fuels, as well as the share and possibilities of various means of transport in cities.

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