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Air pollution in Krakow – particulate matter, its characteristics and origin

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Introduction: High levels of particulate matter (PM) concentration in the atmosphere in Krakow have been a problem of great concern for many years, and while a drop in concentration of PM was observed in the final two decades of the 20th century, the problem of air pollution is still important. Since the end of the last century, the average concentration of PM has stabilized at a relatively high level, often exceeding the limits determined by EU regulations. It is possible, based on single particle analysis, to prove that primary PM originates mainly from residential heating, vehicular exhausts, industrial emissions, and natural sources. Secondary aerosol particles (e.g. sulphates and secondary organic aerosols) are also abundant.

Methods: The single particle analysis is based on the scanning electron microscopy fitted with energy dispersive spectrometry (SEM-EDS) determination of particles size, morphology and chemical composition. Various methods of sample collection and preparation for SEM-EDS analysis were applied.

Results and conclusions: High concentration of fine and ultrafine particles in aerosol in Krakow is typical. Carbonaceous particles strongly dominate in PM1. Soot of various origins occurring as discrete particles (approx. 50 nm in diameter) or aggregates containing several particles are the most commonly found in the studied material. Soot particles often constitute about 80% of the total number of particles in PM2.5. Elongated, often branched, chain-like or densely packed aggregates composed of numerous soot particles are also present. Rounded carbonaceous particles (up to 500 nm) or partly irregular particles probably represent secondary organic aerosols. Particles of this type are often seeded on soot particles. Analysis of soot from various emission sources (e.g. household heating, vehicular emissions) indicates that the distinction of their origin based on the particles' size and morphology is impossible.

Sulphates, chlorides and nitrates represent secondary aerosols. Na, Na-K, Na-K-Ca, or Ca sulphates are present as irregular granular particles or polyhedral particles with rounded edges. KCl occurs as polyhedral, partly rounded particles. Sulphates and chlorides often develop on soot aggregates. Small crystals of nitrates are scarce. Carbonates (usually Mg-Ca carbonates) were noted. Ca, Ca-K, Ca-Mg-K, and Ca-Mg-K-Fe aluminosilicate particles occur as discrete grains or as aggregates, often mixed with Na-K or Ca sulphates.

Silicate or aluminosilacte mineral components are present mainly in coarse (2.5 to 10 μm) fraction. Quartz grains are usually irregular with surfaces partly covered with attached clay minerals. Aluminosilicate spherical particles (containing Ca, Fe, Mg, Ti, K, Na, P) related to coal combustion in power plants are relatively common. Smooth spherical SiO_2 particles from 50 to 150 nm in size often form aggregates. SiO_2 fibres are observed sporadically. Irregular or spherical Fe oxides are sometimes present. TiO_2 particles (from 100 to 350 nm) form aggregates. Sometimes, particles are enriched in Cr, Ni, Zn or other metals. High diversity of bioaerosols is observed in PM samples collected in Krakow.

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Pollen allergens vs. the phenomenon of smog

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Introduction: Human health and well-being are closely related to the state of the environment. It is estimated that air pollution with particulate matter PM2.5 accounts for nearly 0.5 million premature deaths in Europe, including nearly 80% of deaths due to respiratory diseases and lung cancer. The health effects caused by particulate matter also include nervous system diseases, allergies, asthma and diabetes.

Determining correlation and forecasting the values of pollen concentrations in the case of the threat of smog occurring in the pollen season is important for patients and allergy doctors. It gives the possibility of reducing the risk of adjuvant effects of air pollution on the human body. Such an effect in the case of high exposure to pollen allergens means an additional increase in the body's immune response and the severity of pollinosis symptoms.

Methods: Analysis of the pollen concentration was performed in Szczecin in the seasons of 2008-2017. The volumetric sampler of the Hirst type is located at 21 m above the ground level, in the city centre. To assess the impact of air pollution on the severity of allergic reaction, among others PM10 was used based on data from the meteorological station on the Andrzejewskiego street in Szczecin.

Results and conclusions: The permissible daily level for PM10 is > 50 μg/m^3. In 2008-2017 (10 years period) it was exceeded 255 times, exclusively in the cold periods from November to April, that is during the heating seasons for households (waste incineration, low quality of coal and use of old furnaces). Exceeding the permissible level of PM10 was usually accompanied by low air temperature, low wind speed (or windless days) and high air humidity. These atmospheric conditions cause the air to "stand" and the impurities to accumulate. All these factors contribute to the creation of smog, although the alarm level for PM10 > 300 μg/m^3 (so-called smog alert) in the analyzed period 2008-2017 did not occur. Also, during this period, the admissible levels of other components of the so-called acid smog (SO_2) or photochemical smog (O_3, CO, NO_x) were not exceeded.

In 2008-2010, days that were particularly unfavourable for health were distinguished, in which the admissible level for PM10 was exceeded (> 50 μg/m^3) as well as the threshold number of pollen concentration necessary for the occurrence of allergy symptoms in the majority of patients (average value 50 pollen grains in 1 m^3 of air):
– for Alnus, 28 such days were recorded mainly in February and March; – for Corylus – 3 days, all in March; – for Taxaceae/Cupressaceae – 15 days (mainly in March and 3 days in April); and for Betula – 5 days in April.

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The influence of air pollution on the physiological condition of silver birch (*Betula pendula* Roth) trees – possible correlations with pollen allergenic property

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Introduction: The aim of the presented investigations was to estimate physiological conditions of *Betula pendula* Roth specimens in Kraków and Małopolska (Lesser Poland). It is assumed that the physical conditions of *B. pendula* trees are disturbed by pollution, which in turn may affect the chemical composition and metabolic activity of pollen. The physiological condition of the trees were estimated on the basis of the photochemical efficiency of the photosystem II (PSII) and on the optical properties of the leaves. Analysis of fluorescence kinetics of chlorophyll *a* (OJIP test) is a method for determining the impact of many environmental factors on the photosynthesis process. Also the measurements of the leaf reflectance are useful for the study of plants responses to various environmental stresses.

Methods: Studies have been conducted on the leaves of *Betula pendula* Roth at the turn of September and October 2017 at selected sites located in Krakow (Aleje Mickiewicza, Batowice and Ruczaj) and Małopolska (Trzebinia, Gorlice and (Brunary). The PSII photochemical efficiency was measured using a Handy-PEA fluorometer. Results were compiled in the PEA Plus program and selected parameters of chlorophyll *a* fluorescence kinetics were analyzed: F_V/F_M, F_V/F_0, Area, PI, RC/ABS, TR_0/RC, ET_0/RC, and DI_0/RC. The leaf reflectance was measured using a CID Bio-Science CI-710 spectrometer. The reflectance spectra in the 400-1000 nm range were recorded using the SpectraSnap software. Then reflectance coefficients were calculated: ARI (anthocyanin content); CRI (carotenoid content); SIPI (carotenoid to chlorophyll *a* ratio); FRI (flavonoid contents); PRI (an alternative form of assessment of photosynthesis quantum yield and PSII efficiency); WBI (degree of hydration of the leaf tissue).

Results: The values of parameters describing the photochemical efficiency of PSII in tree leaves growing in all analyzed sites are similar, except for those growing at Brunary. In addition, all OJIP curves except those obtained for the tree growing at Brunary, have characteristic inflection points indicating the correct functioning of the energy flow within PSII. However, the measurements of the reflection of the solar radiation from the leaves indicate the differentiation of the physiological state of the leaves at individual sites. The highest reflection of the radiation was observed in birches growing at two sites in Kraków (Batowice and Ruczaj) and in Brunary. The lowest reflection was shown by birch leaves in Gorlice.

Conclusions: Contrary to expectations, trees in areas of a large urban agglomeration do not show a significant stress response. It cannot therefore be ruled out that trees growing in an environment exposed to pollution have adapted to difficult environmental conditions.

Lack of clear differences between the physiological state of the leaves of trees growing in urban areas and areas with a smaller degree of urbanization can also be the result of the strong air pollution occurring more often in these, so far, "clear" areas.

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Electrophoresis of proteins in birch pollen extracts collected from locations of different pollution levels

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Introduction: The epidemiological data indicate, that the patients manifest the pollen allergy symptoms more frequently in polluted regions, than in the areas of a potential pollution free air. It is thought, that the main reason for this situation is the influence of pollutants on plant pollen by their deposition on the pollen surface, morphological changes of pollen wall and the interference into the allergenic protein structures. The aim of the study was to determine the protein composition in *Betula pendula* pollen collected at the 20 sites in the Lesser Poland region.

Methods: Pollen material was collected from 60 *B. pendula* specimens growing in more or less contaminated environments in Lesser Poland in April, 2017. Protein composition was analyzed by SDS-PAGE.

Results: The results of electrophoretic images indicate the complex structure of the analyzed proteins. Among the over a dozen fractions and protein subunits separated by SDS-PAGE, 11 proteins were carried out by a detailed densitometry analysis, because these corresponding bands were characterized by the highest quality in terms of the sharpness and the intensity of their staining. The estimation of molecular masses of individual protein fractions compared to standard proteins (HMW and LMW of wheat glutenin), showed a wide range of variation (from a dozen to over 150 kDa). The comparison of obtained results with the research of other authors allowed us to identify protein bands corresponding to the main allergens of birch pollen. They are: protein of MW=17 kDa, probably Bet v1; protein of MW=14 kDa, probably Bet v2; proten of MW=33 kDa, probably Bet v6 and protein of MW=20 kDa, probably Bet v7.

The analyzed samples were characterized by an almost identical pattern on electrophoretic images. However, a clear differences in the intensity in staining of individual fractions were observed for both samples collected within one environment, as well as for those coming from different environments, as estimated on the basis of densitometry analysis. This proves a significant variation in the protein content concerned in the subunits. The largest differences were observed in case of HMW proteins, in particular for 100 kDa and 150 kDa proteins (samples collected in Nowa Huta), which differed two and three times, respectively. A one year research result suggests that the differences in electrophoretic images can be conditioned by both genetic and environmental factors.

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Application of the allergenicity index to assess the impact of urban greenery on sensitized people

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Introduction: One of the factors positively affecting the quality of life of urban residents is the green infrastructure. However, more and more often the negative impact of urban greenery is pointed out, inter alia, through the excessive exposure to allergenic pollen of plants. Until recently, this effect was indirectly assessed comparing pollen concentrations in the air to the urban vegetation as well as by examining the allergic flora of a given region. Cariñanos et al. (2014) proposed the Index of Allergenicity of Urban Green Spaces (I_{UGZA}) that considers biological features of plants and biometric parameters of tree crowns and the volume of turf. Index describes the potential risk for allergenic people posed by the vegetation. The biological parameters: type of pollination and its duration, allergenicity of pollen are expressed on a scale from 0 to 3. The crown volume is calculated using the standard mathematical formulas taking into account the height of the crown, two perpendicular diameters, and the shape of the crown. Assuming turf height to be 0.25m, its volume is calculated.

Methods: The assessment of the impact of urban parks was carried out in Rzeszów, in the warm temperate climate zone, in parks of various types: a downtown park, a landscape-like park, and a peripheral park.

Results: The following trees were most frequently found: *Betula pendula*, *Quercus rubra*, *Fraxinus excelsior*, *Acer platanoides*, *Picea pungens,* and *Tilia cordata*. The first three are characterized by a high allergenicity potential. Parks clearly differ in allergenic potential. The value of I_{UGZA} is strongly influenced by the number of oaks and silver birch trees and the volume of their crowns. The value of the index negatively correlates with the surface of alleys, lawns and shrubs. The volume of ash and maple crowns, the number of trees and the volume of turf are weakly related to the I_{UGZA} value. It was found that the landscape-like park does not pose a serious threat to their visitors.

Conclusion: The research on the park vegetation for the potential production of allergenic pollen of plants should be taken into account in planning the urban greenery. It is necessary to pay special attention to the plants growing near playgrounds, pergolas, i.e. where people stay for a long time.

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Comparison of the content of sporomorphs in the soil surface sample with the Tauber type trap collected in 2007 and 2017, at the Gronostajowa street site in Krakow

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Introduction: In 2007 on a test site on the Gronostajowa street modern pollen rain to soil and to the Tauber type trap was examined. In 2017, the research was resumed on the same site. The aim of the work was to compare modern pollen rain to soil and to traps, quality and quantity comparison of sporomorphs and their reference to flora on the examined area. The test site is located in artificial forest sites (oak, larch, maple, young ash), and meadow (*Impatiens,* grasses, *Sanguisorba officinalis, Solidago*). Along the watercourse grows *Phragmites.*

Methods: In 2007 and 2017, surface samples of the soil were taken only (from to top layer, 5 cm in diameter and capacity 1 cm^3). In the same years, on the same site the Tauber type traps collecting annual (from early spring to late autumn) pollen were placed. The material from soil and traps was subjected to acetolysis. The list of flora was made near examined sites during examined years.

Results: In each of examined samples, percentage of wind-pollinated taxa (*Pinus* and Poaceae) dominated. In 2017, pollen of *Ambrosia* attracts attention, only 0.66 and 0.7% (in the soil sample) but according to its strong allergic features, it is a relevant ingredient of pollen rain. It was not registered in 2007, maybe the plant grows around Krakow. The sample from the trap taken in 2017 is clearly different from the others by the highest percentage of *Fraxinus* pollen. Only young ash trees grow in the closest area.

Conclusions: Soil samples and a trap sample in 2007 are statistically similar. The sample from the trap taken in 2017is clearly different from the others. Wind-pollinated taxa are present the most but there are also present taxa growing in the area closest to the site.

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The pollination pattern in central Poland has not been changes during fifteen years of observations

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Introduction: The pollen monitoring is crucial for the prevention and precise diagnosis of pollen allergy and also important for the adequate treatment with immunotherapy. Many authors suggest that the climate change has an important impact on human health via changes in the allergenic magnitude and earlier flowering, prolongation of pollen seasons, rise of pollen concentrations in the air and plants and the pollen distribution by the long-range transport phenomenon. The aim of the study was to produce a summary of a fifteen year pollen concentration variability of twenty taxa: *Corylus*, *Alnus*, *Juniperus*, *Taxus*, *Populus*, *Ulmus*, *Salix*, *Acer*, *Fraxinus*, *Betula*, *Carpinus*, *Quercus*, *Fagus,* Pinaceae, Poaceae, *Rumex*, *Plantago*, *Urtica*, Chenopodiaceae, *Artemisia*, *Ambrosia*.

Methods: This study presents fifteen years of the pollen monitoring (2003-17) in the city centre of Łódź (51°46'17.5" N, 19°28'29"E).

Results: Our findings indicate a lack of the significant qualitative and quantitative changes in the pollen concentrations for most analyzed taxa, including the mean annual, length of the pollen season and daily pollen concentrations. Significant changes in the concentration of pollen were found only for the taxa with a generally low share in total pollen count. The exposure to tree pollen of examined taxa was twice higher than that to herbaceous pollen. Among tree taxa, the highest share was of *Betula* pollen (33%, mean 119), followed by Pinaceae (16%) and *Alnus* pollen (13%), but we did not observe any significant changes in their trends. *Urtica* and Poaceae pollen was dominant among pollen of herbaceous , respectively 52 % and 24% of total herbaceous pollen concentrations but also without any significant trend changes.

Conclusion: We did not find any evidence of a clear tendency towards an increase in most important atmospheric pollen, so we do not confirm observations from many Western countries where rising trends are attributed to global warming.