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Evaluation of the impact of meteorological conditions on the amount of air pollution in Krakow

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Abstract. The publication presents an assessment of the impact of meteorological conditions on air quality in a given location. The subject matter of the work is related to problem-review issues in the field of environmental protection and energy management. The publication draws attention to the fact that despite several decades of ecological monitoring of air pollution, only in recent years attention has been paid to the scale of air pollution problem. The study examined the relationship between meteorological elements (wind velocity, relative humidity on the amount of air pollution immissions. Significant impact of precipitation, atmospheric pressure and thermal braking layer was indicated. The possibilities of air quality improvement were presented based on the measurement data concerning the immission of impurities.

1 Introduction

An important objective of almost all countries in Europe is an improvement of air quality. Today, more than 80% of Europeans city dwellers breathe in a contaminated air. The main source of an air pollution is connected with a combustion of solid fuels in heating or in power-producing plants, from a transportation sector and industry. A purification of air is one of the key elements of the EU's environmental strategy [1]. The main sources of air pollution are different for diverse regions. About 3.5 million people in the world and about 44 thousand in Poland die because of poor air quality every year. About half of the 50 most polluted cities in Europe are in Poland. One of the main causes of poor quality of air is the combustion of poor quality solid fuels in heating installations. The number of passenger of vehicles per 1000 inhabitants is systematically growing and another reason for the very poor air quality is pollution originated in transport [2].

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The city of Krakow is known not only for beautiful architecture and monuments, but also for very dangerous air pollution. All causes of the air pollution are accumulated in Krakow. The main reason is low emission from heating. Krakow is in the top ten of Europe's most polluted cities and in the top five of the most overcrowded place cities in Poland, as well. This results in a longer travel time, and thus in an increase in exhaust emissions of about 35%. In addition, some vehicles do not meet the strict emission standards. The unfavorable location of Kraków in the Vistula basin contributes to the limitation of natural ventilation. Moreover, about 30% of the days are windless, and in another 30-40% of the time, the wind does not exceed the speed of 2 m/s.

Another problem faced by Krakow is a gradual accumulation of pollutions from adjacent villages where the fossil fuel is a main source of heating. An industry with the impact of pollution from combined heat and power plants has an impact on the air quality. The rise of a dust on streets by an air turbulence caused by moving vehicles is also of great importance. The amount of impurities from street surfaces rising into the air in the main communication arteries can increase more than 50%. The number of days during the year in which the permissible contamination is exceeded is also significant. Krakow is the worst in this statistic [8].

In addition to the activities undertaken by individuals to protect air, it is worth paying attention to universal education in this area [1, 4].

2 Ambient Air Quality Monitoring Systems

There were 286 air quality measurement stations in Poland in 2017. The automatic air monitoring system in the Lesser Poland, established in 1991, consisted of 24 air quality measurement stations located in the province, while 7 of them are situated in Krakow. The stations are equipped with measuring systems from: Thermo Environmental Instruments, Andersen, FAG, Rupprecht & Patashnick, and French: Environment S.A, ISECO, DIGITEL [3]. They collect atmospheric air samples and analyse them. The data obtained in this way are stored in the computer's memory at the stations and then sent via a computer network to the headquarters of the Provincial Environmental Protection Inspectorate in Krakow. The obtained data is subjected to verification and archiving there. The stations carry out continuous measurements of concentrations of air pollutants, such as sulphur dioxide, nitrogen oxides, carbon monoxide, ozone, PM10. Repeatedly, every five days for 24 hours, particulate matter PM10 and PM2.5 are collected and send to the laboratory, where there are analysed for the content of heavy metals. Measuring devices of the Institute of Meteorology and Water Management additionally provide meteorological data, such as wind speed and direction, the amount and type of precipitation, air temperature, pressure, and occurrence of inversion phenomena, as well [5].

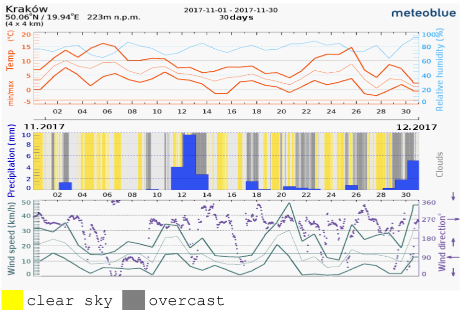

Fig. 1. Course of temperature, relative humidity, precipitation, cloud cover, wind speed and direction in November 2017 [6].

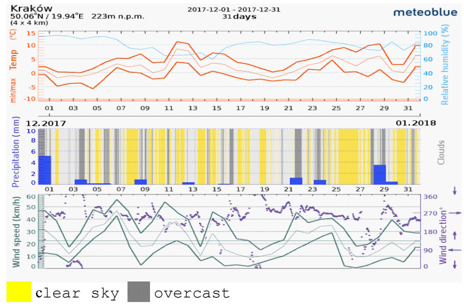

Fig. 2. Course of temperature, relative humidity, precipitation, cloud cover, wind speed and direction in December 2017 [6]

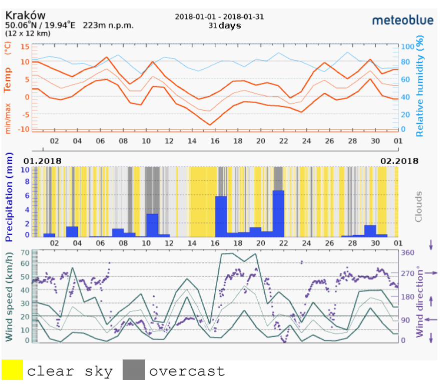

Fig. 3. Course of temperature, relative humidity, precipitation, cloud cover, wind speed and direction in January 2018 [6]

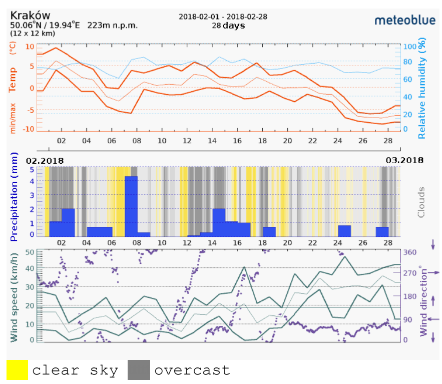

Fig. 4. Course of temperature, relative humidity, precipitation, cloud cover, wind speed and direction in February 2018 [6]

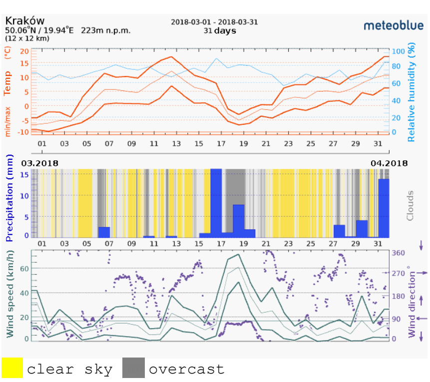

Fig. 5. Course of temperature, relative humidity, precipitation, cloud cover, wind speed and direction in March 2018 [6]

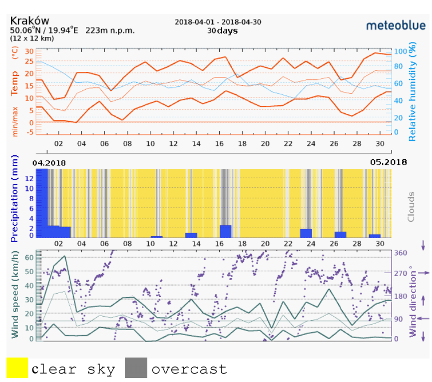

Fig. 6. Course of temperature, relative humidity, precipitation, cloud cover, wind speed and direction in April 2018 [6]

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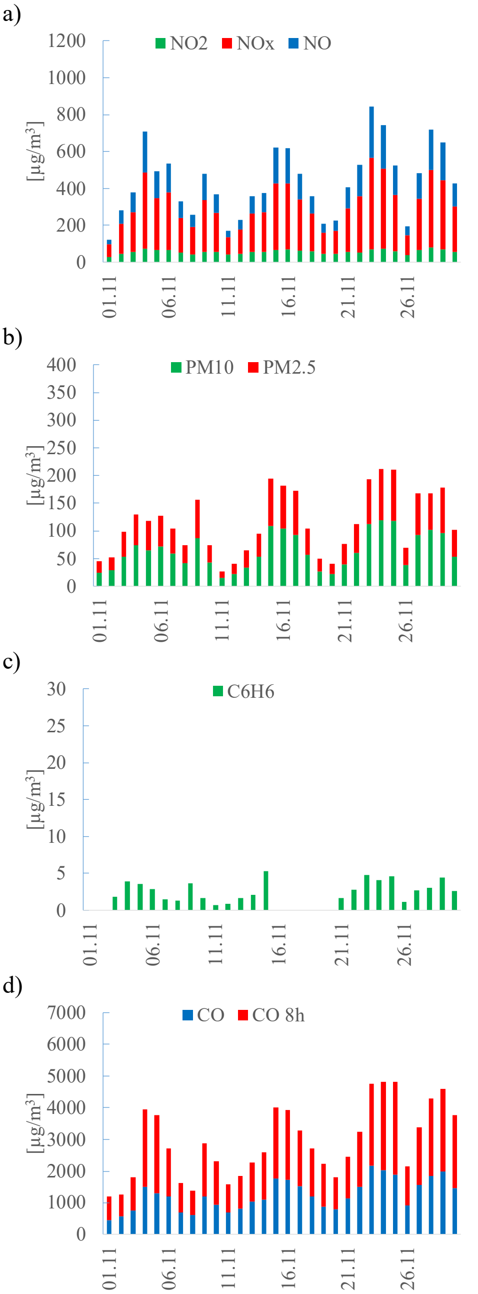

Fig. 7. Concentration of a) nitrogen oxides, b) Particulate Matter (PM10) and (PM2.5), c) benzene and d) carbon monoxide in November 2017 [7]

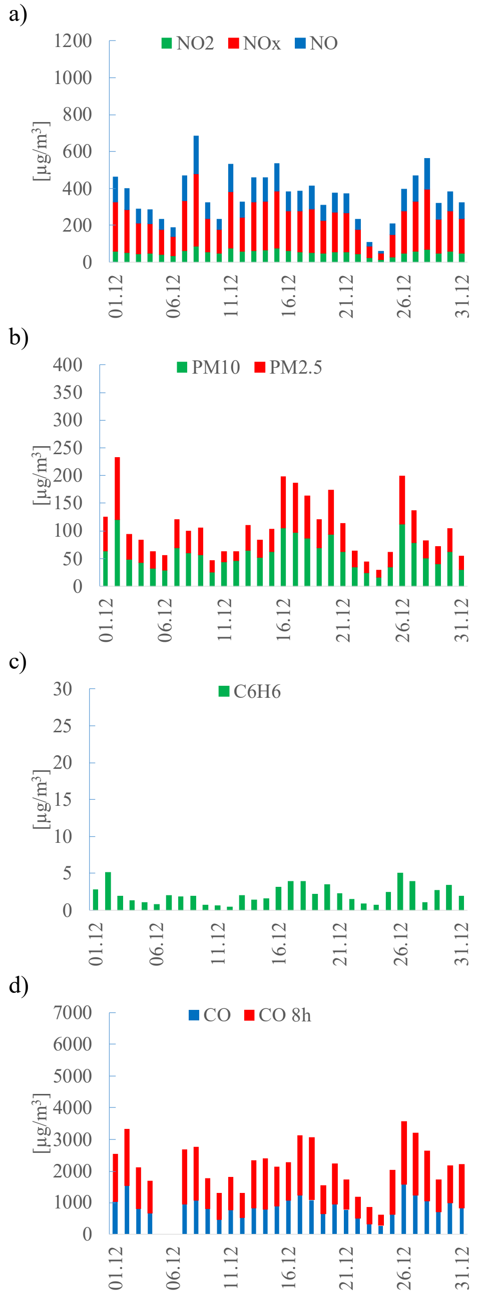

Fig. 8. Concentration of a) nitrogen oxides, b) Particulate Matter (PM10) and (PM2.5), c) benzene and d) carbon monoxide in December 2017 [7].

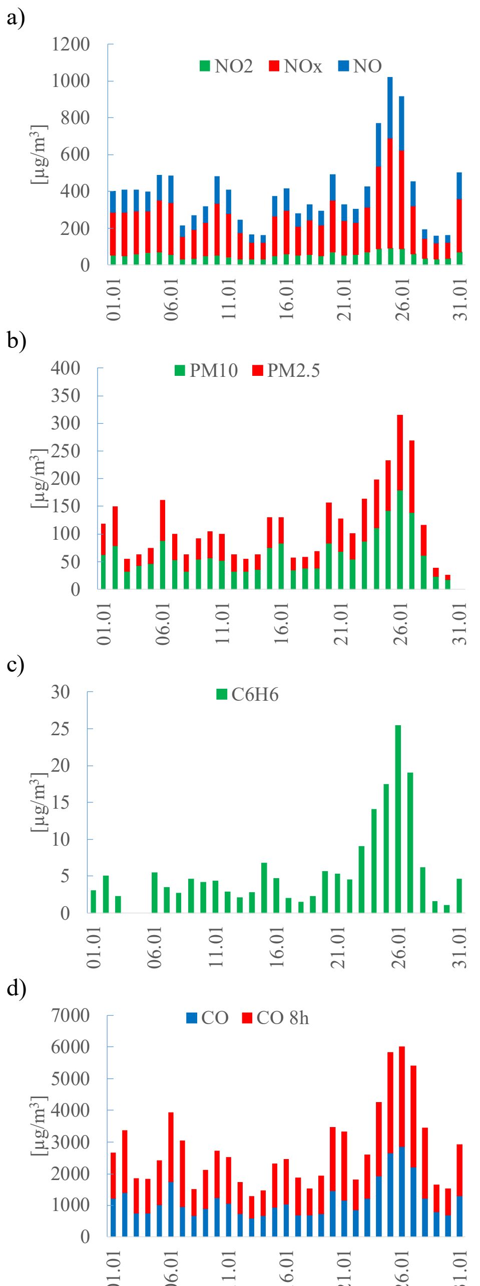

Fig. 9. Concentration of a) nitrogen oxides, b) Particulate Matter (PM10) and (PM2.5), c) benzene and d) carbon monoxide in January 2018 [7]

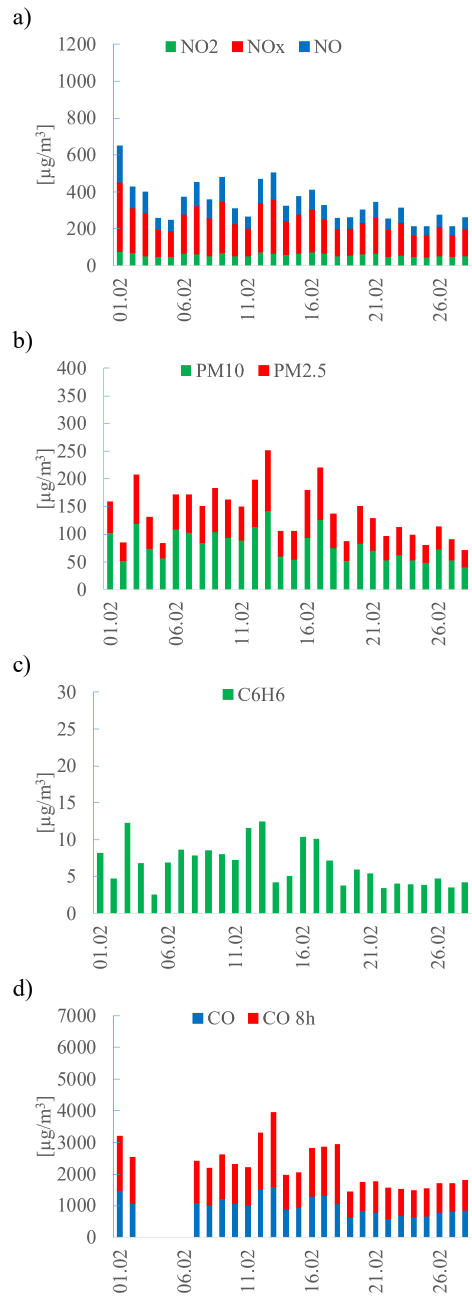

Fig. 10. Concentration of a) nitrogen oxides, b) Particulate Matter (PM10) and (PM2.5), c) benzene and) carbon monoxide in February 2018 [7]

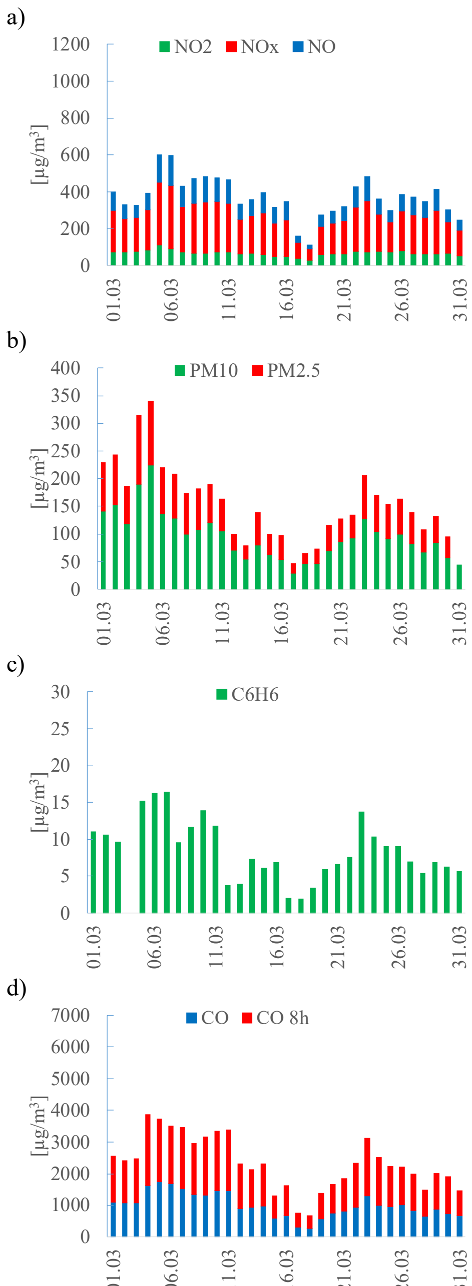

Fig. 11. Concentration of a) nitrogen oxides, b) Particulate Matter (PM10) and (PM2.5), c) benzene and d) carbon monoxide in March 2018 [7]

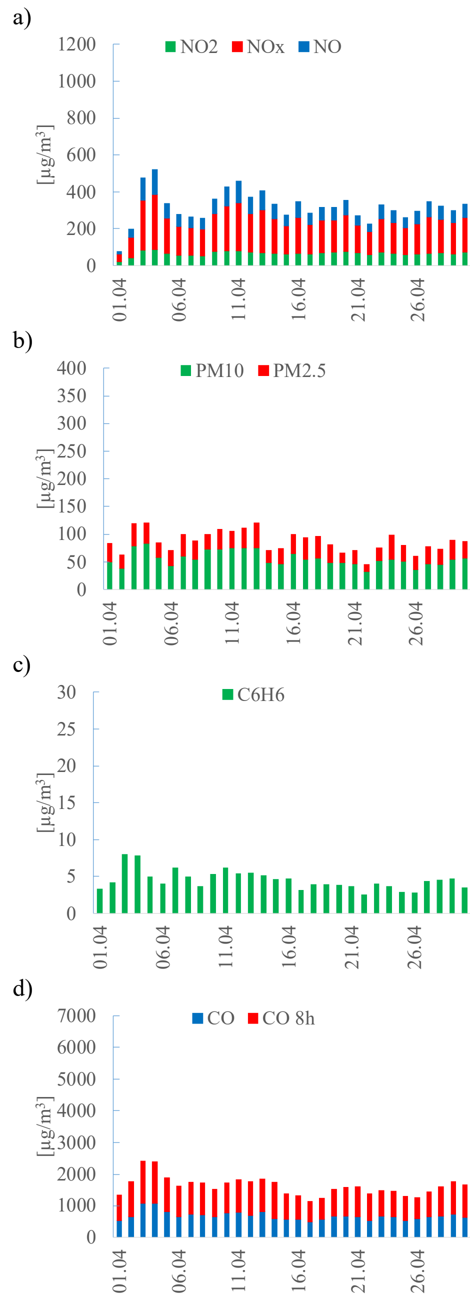

Fig. 12. Concentration of e) nitrogen oxides, f) Particulate Matter (PM10) and (PM2.5), g) benzene and h) carbon monoxide in April 2018 [7].

3 Analysis of the impact of meteorological conditions on air pollution

Figures 1 – 6 show the temperature, relative humidity, precipitation, wind speed and direction, measured in Krakow - Balice from November 2017 to April 2018 . The concentrations of NOx, PM10 and PM2.5, benzene and CO measured at the selected monitoring point at very high contaminated communication route in Krakow are shown on figures 7 – 12.

A close relationship can be noticed when analysing the meteorological conditions in Figure 1 and the corresponding values of contamination concentrations in Figure 7. On November 2, 12, 13, 21 and 26, improvement in air quality is observed and it is the result of rainfall, increase in relative humidity and wind speed. A similar analogy can be seen in Figures 2 and 8. In this case, the lower concentrations of pollutants are primarily the result of high wind speeds on December 7, 11, 12 and 25.

The following charts show the impact of meteorological conditions on the air pollution. Precipitation, higher relative humidity and often associated with them increase of wind speed showed in Figure 3, can cause improvement of air quality on January 8, 10, 16, 19 and 29, which is shown in Figure 9. In the first two decades of February (days: 2, 5, 15, 16) lower concentrations of pollution is associated with the occurrence of rainfall, which is shown in Figures 4 and 10. However, after February 19, the wind speed increases and causes air purification. It can be seen a decrease in pollution concentrations caused by an increase in rainfall, relative humidity and strong wind from March 7 to 19 and from March 26 to 31, showed in Figures 5 and 11.

Figures 6 and 12 show a similar situation at the beginning of April. In the following days, a wind speed decreases, and only a rainfall causes leaching of pollutants from the air, and thus improvement of air quality, on April 16 and 24. The increase in temperature in the considered part of the year involves a reduction in heat demand in households, which in turn results in a lower pollutant emission.

4 Summary

Based on the air pollutants concentrations analysis, it is possible to determine the high impact of wind speed and rainfall on the air quality in Krakow. Unfortunately, due to the unfavourable location of the city in the basin of the Vistula river and blocked of air corridors, there are only few days with high wind speed. The location is additionally unfavourable for the crowded communication road. Old vehicles that do not meet emission standards can cause high air pollution all year round. This threat to air quality is additionally intensified by traffic jams. It is also worth emphasizing the large role of dust rising in the streets by air turbulence caused by moving vehicles. This can cause dust concentrations to increase by up to 50% at the most crowded avenues in Krakow. The end of the heating season affects the improvement of air quality in Krakow. The problem of low and inflow emissions from outskirts of the city is minimized then [8 – 10].

The urban air is polluted almost everywhere, there are no places in the world free from air pollution. Currently the leader of a global air pollution with 15 out of the 20 most polluted cities in the world is India. The levels of air pollution are even four times higher than in the most polluted cities in Europe. Simultaneously, no country in the EU meets the World Health Organization guidelines, the closest are Estonia, Finland and Sweden.

References

1. J. Depešová, H. Noga, P. Migo, TEM Journal, **7** (2), 250-254 (2018)
2. A. Graczyk, I. Wielewska, M. Piaskowska-Silarska, *Rozwój odnawialnych źródeł energii w Polsce. Problemy bezpieczeństwa energetycznego i lokalnego wykorzystania zasobów*, Monografia (2017)
3. W. Hudy, K. Jaracz, Przegląd Elektrotechniczny, **5**, 279-281 (2011)
4. H. Noga, Information Technologies and Technical Education, **1**, **2**, 165-169 (2009)
5. www.krakow.pios.gov.pl
6. www.meteoblue.com
7. www.monitoring.krakow.pios.gov.pl
8. K. Pytel, W. Hudy, H. Noga, W. Kulinowski, International Carpathian Control Conference **17,** 401–406 (2016)
9. K. Pytel, W. Hudy, H. Noga, W. Kulinowski, International Carpathian Control Conference **17,** 407–412 (2016)
10. K. Pytel, K. Jaracz, S. Gumula, International Carpathian Control Conference **13,** 592–595 (2012)