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Air Quality Matters: assessment of air quality in typical public places

Abstract. *The article presents an experimental analysis of the level of PM10, MP2.5 and PM1 suspended particulate matter in various environments in Poland. The results were compared to national and WHO recommended levels. The obtained results illustrate that not only such well-known sources of pollution as heavy traffic or smoking classic cigarettes can be harmful, but also the kitchen environment and smoking electronic cigarettes. Under these conditions, temporary pollution levels may even exceed the alarm values adopted in Poland.*

Streszczenie*. W artykule przedstawiono analizę eksperymentalną poziomu pyłów zawieszonych PM10, MP2,5 i PM1 w różnym środowisku na terenie Polski. Wyniki porównano do zalecanych poziomów krajowych i WHO. Uzyskane wyniki ilustrują, że szkodliwe mogą być nie tylko tak dobrze znane źródła zanieczyszczeń jak duży ruch samochodowy czy palenie klasycznych papierosów, ale również środowisko kuchenne i palenie papierosów elektronicznych. W tych warunkach chwilowe poziomy zanieczyszczeń mogą przekraczać nawet przyjęte w Polsce wartości alarmowania. (**Air Quality Matters: ocena jakości powietrza w typowych miejscach publicznych**)*

Keywords: air quality, suspended dusts, BBair, Raspberry Pi.
Słowa kluczowe: jakość powietrza, pyły zawieszone, BBair, Raspberry Pi.

Introduction

The issue of air quality as one of the important factors affecting human health has been discussed in medical scientific studies for years (e.g. [1-4]). One of the important negative factors is the so-called suspended particulate matter (e.g. [5-6]), the content of which in the air is assessed on an ongoing basis in various parts of the world, being an important indicator of this quality. Among them, the most frequently assessed are dusts marked as PM1, PM2.5 and PM10. These dusts penetrate into the human body mainly through the respiratory system, causing a long-term increased (heart and respiratory diseases; difficult to assess) number of premature deaths. The main sources of these pollutants are: smoke, dust, pollen, motor vehicle exhaust, cigarette fumes. The importance of this problem resulted in the adoption in the European Union of a number of regulations specifying dust content standards and methods of measurement [e.g. 7-9]. The problem is also noticed in Poland, as evidenced by, for example, the signing of the anti-smog act by the President of the Republic of Poland in 2015, granting local governments the power to adopt their own regulations to improve air quality, the National Air Protection Program, the Clean Air program or the educational campaign entitled Stop Smog.

Nevertheless, electronic systems for measuring the intensity of these dusts, installed in large numbers in the European Union, unfortunately clearly indicate significantly worse air quality in Poland than in Western European countries.

It should also be noted that publicly installed measurement systems often do not provide answers to questions about the level of particulate matter in places such as public transport, private utility rooms, etc. Recently, there has been a lot of discussion regarding the harmfulness of the so-called electronic cigarettes. In the further part of this article, we will try to give a partial answer to these questions. The following chapters describe the design of the measurement system, the measurement methodology and the results and their evaluation.

Measuring station

To assess the level of particulate matter in selected scenarios, a measuring system based on a Raspberry Pi microcomputer ((RPi), [10]) and a combined, precise air quality sensor BBair [11] were used, measuring temperature, humidity and the level of particulate matter PM1, PM2.5 and PM10. The device performs dust measurements based on the PMS7003 module with an accuracy of 1μm/m3 and measurement of temperature in the range from -40 to +125^{0}C with precision 0.01^{0}C and humidity in the range from 0% to 100% with precision 1% RH (Relative Humidity) based on the SHT20 module. Communication with the outside world takes place via the BLE bluetooth module (Fig. 1).

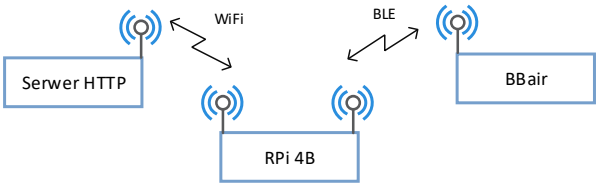

Fig. 1. Measuring station connection diagram

The BBair has been adapted to work with the RPi and enables measurements in two modes:

- on demand - at any time, after establishing a Bluetooth connection, the sensor performs the measurement, sending the results to a mobile device,
- automatic – performed cyclically (every 15 minutes, every 1 hour or every 3 hours) with sending the results to the computer collecting and processing the data.

Results can be stored in the RPi's memory and/or sent to an external instance. Starting the system for cooperation with the RPi is an activity consisting in the installation of appropriate drivers and the BBair_SMOG_logger application in accordance with the procedure prepared by the manufacturer. In order to conveniently analyze the results, an external http server was launched to collect the measurement results, communicating with the RPi via a WiFi link. Supervision over the implementation of a series of measurements in individual scenarios is taken over by a dedicated application running on the RPi.

In order to check the accuracy and correctness of the measurements carried out by the launched electronic system, comparisons of a series of measurements with the results indicated by an operating nearby, commercial sensor were made [12]. Measurements were made at a temperature close to 0^{0}C and relative humidity of about

70% for all 3 assessed indicators on March 11, 2023. The results are presented in Fig.2.

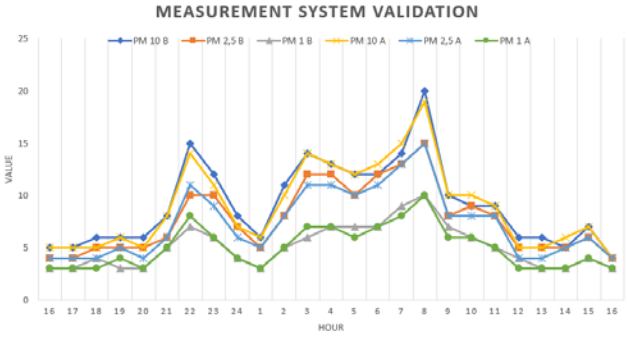

Fig. 2. Measurement system validation based on comparison with a nearby Airly sensor. The letter B denotes the results for the BBair system and the letter A denotes the results for the Airly sensor.

Taking into account the declared precision of the system (1µm/m^3), the test confirms a very good convergence of results, with differences not exceeding 1µm/m^3 in pairs for individual types of dust.

Scenarious

Measurements of suspended particulate matter were carried out for various scenarios reflecting typical life situations. This set includes scenarios for (Table 1):

- High traffic roads
- Housing estate road
- Rural area
- Restaurant kitchen
- An e-cigarette smoked indoors
- A standard cigarette smoked in a smoking room (semi-open environment)

The choice of measurement conditions was guided by the possibility of comparing the results, and for outdoor scenarios, comparable atmospheric conditions such as temperature, humidity and wind were taken into account.

Table 1. Measurement scenarios

Lp	Scenario	Data	Place	The main source of pollution	Ambient conditions (Temperature [^{0}C] /Humidity [%] /Wind [km/h])	Start time	End time
1	High traffic road	16.03.2023	City of Bydgoszcz Rondo Jagiellonów	Car exhaust	8,2/70,6/19,8	13.00	18.00
2	Housing estate road	17.03.2023	City of Bydgoszcz, 81 Glinki Street	Car exhaust	9,8/71/18,8	13.00	18.00
3	Rural area	02.04.2023	Łochowo village, 7 Pieczarkowa Street	Furnace fumes	7,2/60,6/26,2	16.00	16.00
4	Restaurant kitchen	04.04.2023	A classic restaurant in Bydgoszcz City	Frying and cooking	-	12.00	22.00
5	E-cigarette	01.04.2023	A room in a student dormitory	Nicotine fumes	-	7.00	15.30
6	Cigarette	31.03.2023	Semi-open smoking room	Nicotine fumes	11/73,5/13,8	7.00	15.30

It is worth noting here that according to the recommendations of the World Health Organization (WHO) regarding the maximum daily concentrations for PM 10 and PM 2.5, these values should not exceed 45 and 15 µg/m3, respectively [13]. The average annual concentration should not be higher than 15 and 5 µg/m3, respectively. At the same time, it should be noted that the information and alert levels currently in force in Poland are many times higher than the guidelines of the World Health Organization [14], Table 2.

Table 2. Pollution standards in selected European Union countries [15], [16]

Country	Information level	Alert level
Poland	100 µg/m^3	200 µg/m^3
Belgium	No data	70 µg/m3
The czech republic	No data	100 µg/m3
Finland	50 µg/m3	No data
France	No data	80 µg/m3
Macedonia	50 µg/m^3	50 µg/m^3
Slovakia	100 µg/m3	150 µg/m3
Switzerland	75 µg/m3	100 µg/m3
Hungary	75 µg/m3	100 µg/m3
Italy	50 µg/m3	75 µg/m3
Great Britain	101 µg/m^3	No data

Results

Figures 3 to 8 show the measurement results for the scenarios in the order presented in Table 1.

In addition, the levels of maximum concentrations for PM10 and PM2.5 were marked in accordance with WHO recommendations, as well as the information and alert levels adopted in Poland. Contamination levels are expressed each time in µg/m^3.

It can be expected that the level of suspended particulate matter on a heavily trafficked road (Fig. 3) significantly exceeds the values recommended by the WHO. It is worth realizing that this level may be within the limits of informing and alarm in accordance with the values adopted in Poland and continuous staying in such places can be very harmful to health. It can therefore be concluded that residents of large cities, depending on where they live, should consider how to clean the air in them. The situation at the housing estate road (Fig. 4) looks completely different (better) where the level of the above-mentioned particulate matter may be mostly below the values recommended by the WHO. It could also be expected that in rural areas (Fig. 5), where there are no main sources of this type of pollution (vehicle traffic), the level of particulate matter is the lowest. It may come as a surprise in a kitchen environment where products of combustion and baking can cause a temporary increase in pollutants around alert levels. From the above, it can be concluded that effective ventilation systems in such places are of great importance. This also applies to home scenarios.

The next figure (Fig. 7) shows the level of pollutants emitted by e-cigarettes in a closed room. It is worth noting that temporary concentrations of the tested dust may highly exceed the alarm level. This means that the vapors emitted from this type of cigarette, although less harmful than a classic cigarette (Fig. 8), can be still very dangerous. In conclusion, it is worth noting that smoking or even being

near smokers of classic cigarettes (even in a semi-open space) will expose us to inhalation of pollutants many times exceeding the alarm levels.

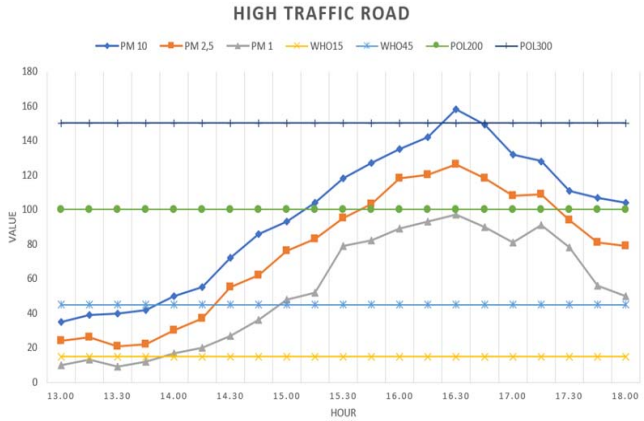

Fig. 3. Particulate matter levels for a road with heavy traffic

Fig. 4. Particulate matter levels for a residential road

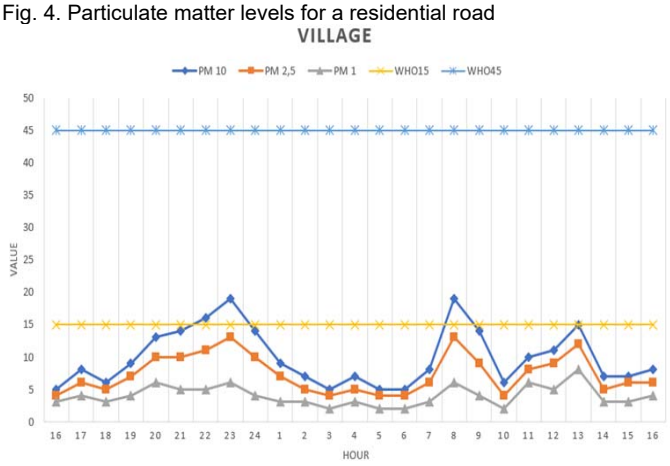

Fig. 5. Particulate matter levels in rural areas

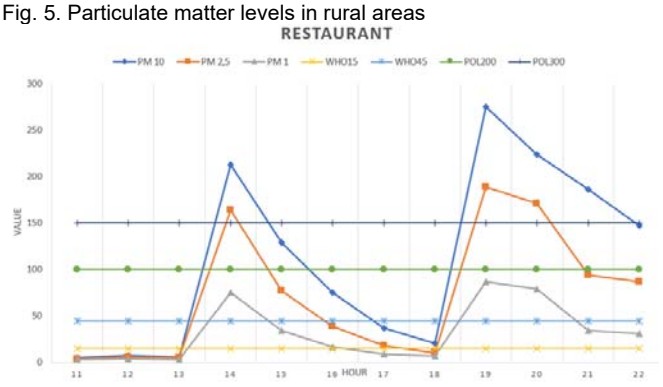

Fig. 6. Particulate matter levels in a restaurant kitchen

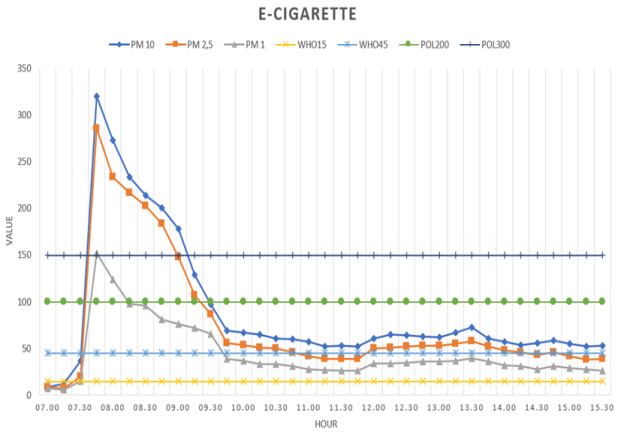

Fig. 7. E-cigarette particulate matter levels

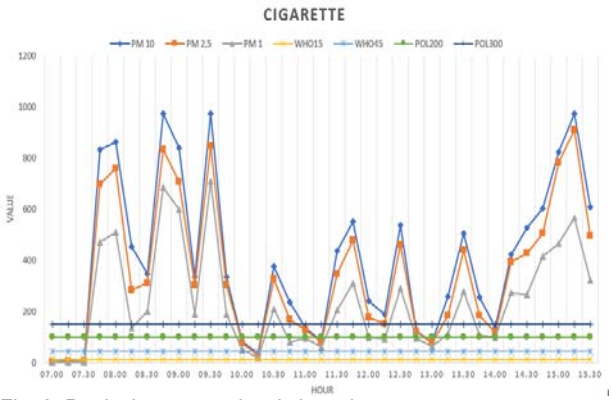

Fig. 8. Particulate matter levels in a cigarette

Conclusions

The article presents the assessment of the level of PM10, PM2.5 and PM1 for several test scenarios in comparison to the levels recommended by the WHO and Polish standardization institutions. As a result, the high harmfulness of urban environments and cigarette smoking was confirmed, and attention was drawn to the less noticeable fact of the potential harmfulness of the kitchen environment and being near people smoking e-cigarettes. In the last two cases, temporary levels of suspended particulate matter may exceed the alarm values adopted in Poland at a high level of 200 μg/m^3.

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