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Examination of PM10 and PM2.5 Concentration in an Apartment in a Multifamily Building †

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Abstract: The purpose of this article is to analyze the level of air pollution by particulate matter PM10 and PM2.5 in an apartment in a multifamily building. Also, there is a comparison between pollution level caused by particulate matters in indoor and outdoor air at the same time. An attempt was made to define a correlation between concentration of PM10 and PM2.5 in indoor and atmospheric air.

Keywords: particulate matter; air quality; indoor environment; air pollutants; ventilation

1. Introduction

The quality of indoor environment is an important issue because people spend a significant part of the day inside buildings and are often not aware of implications to their health and well-being. Currently, while a healthy lifestyle is very popular with people practicing sports and eatingclean products, there is also a need to pay attention to what we breathe [1].

The quality of the internal environment is largely dependent on the quality of indoor air. As we live in a moderate climate zone, we spend most of our time indoors. Therefore, the indoor environment and its microclimate has the strongest effect on human well-being, health and productivity [2,3].

Internal air has high concentrations of harmful compounds and chemicals, so it is hard to define the precise amount and concentration. Moreover, the influence of many of them on the human organism is still unknown. Common pollutants that have the most significant impact on the dilution of air quality include: particulate matter (especially PM2.5), carbon monoxide and dioxide, nitrogen oxides, ozone, volatile organic compounds, formaldehyde, radon, tobacco smoke and microorganisms [3,4].

High concentrations and long-term exposure to some pollutants cause diseases, and some of the substances, for example carbon dioxide, affect the comfort of work and use of the rooms. Due to this, air exchange rate should be provided to ensure the safety and health of people [5,6].

According to researchers, particulate matter PM2.5 and PM10 are contaminants responsible for the greatest burden of disease from poor indoor air quality in Europe—about 78%. The most frequently occurring disease entities are asthma, lung cancer, allergies, skin irritation. Therefore, there is a need to monitor concentrations of PM10 and PM2.5 to ensure room users comfort [7,8].

The purpose of this article is to analyze the level of air pollution by particulate matter PM10 and PM2.5 in an apartment in a multifamily building. Also, there is a comparison between pollution level caused by particulate matters in indoor and outdoor air at the same time. An attempt was made to define a correlation between concentration of PM10 and PM2.5 in indoor and atmospheric air.

The aim of this comparison is also to show how the concentration of pollutants in the outside air affects the quality of indoor air, and thus the quality of life. Currently, the quality of air, especially in terms of particulate matters, is not on a high level. This is caused by the duration of the heating period, during which the increased PM10 and PM2.5 dust emission is observed.

2. Materials and Methods

Measurements were carried out with the Aeroqual Series 500 Portable Indoor Air Quality Monitor with a sensor dedicated to particulate matter measurements with a relative humidity correction. In the Aeroqual portable monitor, there is a laser particle counter (LPC) for its small size and portability. It is accurate for indoor measurements and works automatically. The measuring range is between 0 and 1.000 mg/m^3. The sensor uses optimized signal processing and algorithms to correct for interferences, e.g., humidity.

The air quality test was carried out on 14 and 15 January 2019 in an apartment in a multifamily building at Zwierzyniecka Street in Białystok. At that time, the flat was used by one person. The measuring device was programmed for continuous measurement around the clock every 1 min. Measuring station was located in a hall, because of air mixing from all rooms. During the test, all windows were closed.

An apartment with a cubature of 84 m^3 wasequipped with gravity ventilation in the bathroom and kitchen, as well as window ventilators.

In addition, the PM10 and PM2.5 concentration data have been analyzed for external air, registered at the nearest measurement stations at Waszyngtona Street (distance about 900 m) and Warszawska Street (2000 m), which belong to the Voivodship Inspectorate of Environmental Protection.At the measuring stations of the Provincial Inspectorate for Environmental Protection, two methods wereused: automatic measurement to measure PM2.5 concentrations and manual measurement used to monitor the PM10 level. The station at Waszyngtona Street wasequipped with PM2.5 MetOne BAM 1020 suspended dust analyzer and PM10 Comde-Derenda PM18T dust collector. The measuring station at Warszawska Street has a PM2.5 suspended dust collector MCZ MicroPNS LVS16, and PM10 TEOM 1405F suspended dust analyzer.

In order to assess the connection of PM10 and PM2.5 particle concentrations between indoor and outdoor air, the Pearson's linear correlation coefficient was used. The formula is as follows (1) [9]:

$$r_{XY}=\frac{C(X,Y)}{\sqrt{S_X{}^2\cdot S_Y{}^2}}=\frac{\sum_{i=1}^{n}(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2\cdot\sum_{i=1}^{n}(y_i-\bar{y})^2}}=\frac{C(X,Y)}{S_X\cdot S_Y} \quad (1)$$

where:

C(X,Y) – covariance between the characteristics of X and Y,

Sx^2 –variance of the X trait,

Sy^2 – variance of the Y trait,

Sx – standard deviation of the X trait,

Sy – standard deviation of the Y trait.

The interpretation of the correlation coefficient is presented below:

- $|r_{XY}| < 0.2$—there is no linear relation between the features,
- $0.2<|r_{XY}| < 0.4$—low (poor) linear relation,
- $0.4<|r_{XY}| < 0.7$—moderate (average) correlation dependence,
- $0.7<|r_{XY}| < 0.9$—significant (strong) linear relation,
- $|r_{XY}| > 0.9$—very strong linear relation,
- $|r_{XY}| = 1.0$—functional dependence (1—increasing linear function, −1—linear decreasing function),
- $|r_{XY}| = 0$—lack of any dependence between features.

3. Results

The results of measurements are shown at the pictures below (Figures 1 and 2).

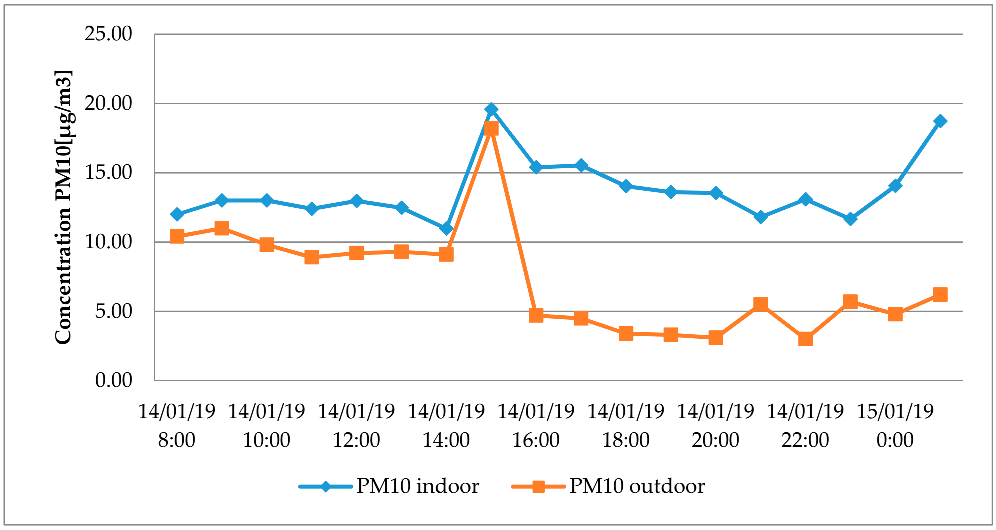

Figure 1. Concentration of PM10 (µg/m³) in an apartment in multifamily building (PM10 indoor) and in outdoor air.

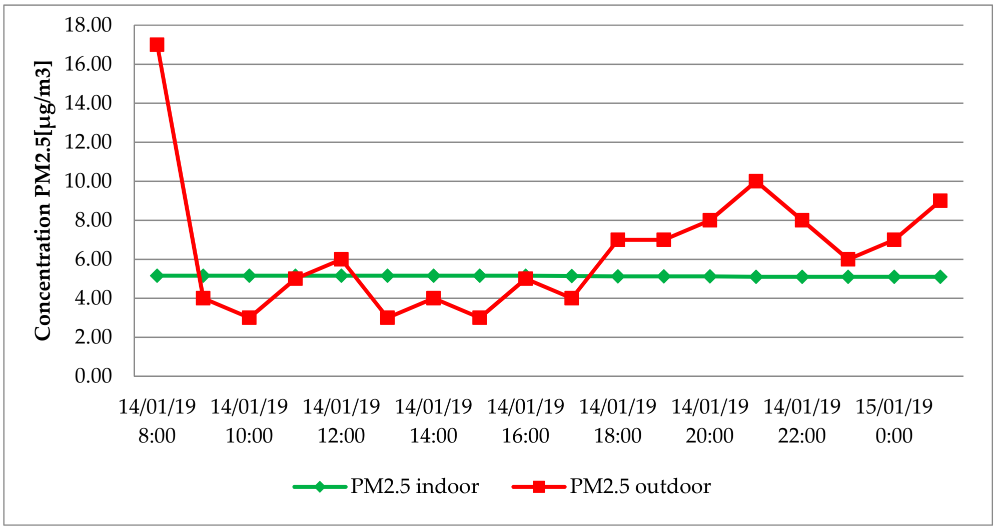

Figure 2. Concentration of PM2.5 (µg/m³) in an apartment in multifamily building (PM2.5 indoor) and in outdoor air.

The results of the research showed that the concentration of PM10 and PM2.5 was at an appropriate level in relation to the standards. According to World Health Organisation recommendations, the concentration of PM10 should be below 50 µg/m³ per day in the outdoor air. PM2.5 concentration should be within the limit of 25 µg/m³ per day. These limits are included in the WHO Air Quality Guidelines and can also be applied to indoor air [10]. The average daily PM10 was below 20 µg/m³ (Figure 1), while in the case of PM2.5, below 10 µg/m³ (Figure 2). The concentration of dust increased twice during the presence of other person in the apartment. It follows that the human body is an emitter of pollutants, also particulate matters.

The results of calculations of Pearson's linear correlation coefficient are: $r_{XY(PM10)} = 0.2433$ and $r_{XY(PM2.5)} = -0.3127$. Both results are within the range of $(0.2 < |r_{XY}| < 0.4)$0.2<|r, which means a low correlation between PM10 and PM2.5 concentration measurements inside the room and outside the building.

In the case of PM10 particles, the relationoccurs in the same direction because the result of the coefficient is positive. This means that an increase in the concentration of PM10 in atmospheric air is associated with an increase in the concentration of PM10 inside the building. In the case of PM2.5, the relationship is reversed, as the correlation coefficient is negative. This means that the concentration inside the room decreases if the concentration of pollutants on the outside increases.

4. Conclusions

The concentrations of PM10 and PM2.5 in indoor and outdoor air connects low correlation dependence. It may be a result from inaccuracy of measurements, a large distance between measuring points, terrain obstacles (e.g., high buildings) and strong wind, which can cause large spatial diversity of dust pollution concentrations. Also, it is also possible that the high tightness of the window joinery significantly reduces infiltration of dust pollutants into the building.

According to the WHO Air Quality Guidelines recommendations, the concentration of PM10 should be below 50 μg m^3 per day and for PM2.5 below 25 μg/m^3 per day in the outdoor and indoor environment. The concentration of particulate matter does not exceed the WHO recommendations, but the air quality in terms of PM10 and PM2.5 can be improved. Residents did not use any methods of air purification. It is anticipated that methodsof improving air quality, such as filtration by air purifier, will remove excess particulate matter and improve the comfort of the users.

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Conflicts of Interest: The author declares no conflict of interest.

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