

Particulate matter PM10 air pollution in Katowice

1. Introduction

Nowadays, air pollution is a growing problem on a global scale. It has a negative impact not only on the widely understood environment and living organisms but also on the quality of human life and health. Their sources can be natural or anthropogenic. Natural sources include, for example, dust that got into the atmosphere as a result of volcanic eruptions, natural forest fires or sand storms. The anthropogenic sources are mainly related to the processes of fuel combustion and production processes. Pollution related to human activity includes energy, communication and communal sources. According to a 2018 report by the World Health Organisation 36 of the 50 most polluted cities in Europe are located in Poland. In our country, one of the regions with very high concentrations of pollutants in the Silesian Voivodeship, where the permissible standards are often exceeded, especially during the heating season. One of the reasons for this is the high industrialisation and high population density of this region. Currently, the biggest source of air pollution is low emission, which comes from the combustion of fuels and releases several pollutants into the atmosphere, mainly from local boiler houses and domestic heat sources. The sources of low emissions are located at an altitude of no more than 40 m. Low emissions contribute mainly to the formation of smog. An example of an area where significant exceedances of pollution standards are recorded is Katowice.

One of the pollutants whose value is most often exceeded is PM₁₀ particulate matter. Particulate matter is a mixture of solid particles and liquid droplets remaining in the air. These particles contain various components such as sulfur, organic compounds, heavy metals and allergens (such as pollen and fungal spores). PM₁₀ dust contains particles smaller than 10 µm in diameter.

2. Research area

The research area of this work is Katowice. It is situated in the central part of the Silesian Voivodeship. The city is located in the centre of the Upper Silesian Industrial District, therefore there is a lot of industrialization and transport traffic there. Katowice is characterized by flat terrain located at a height of 240-260 m above sea level.

3. Objective

The purpose of this research work is to characterize air pollution with PM10 particulate matter in Katowice in 2015-2019.

4. Source materials

The main source material for the study is the daily data on PM10 particulate matter collected from the Chief Inspectorate for Environmental Protection (GIOŚ) for the period of five years (2015-2019) for Katowice. The station is located at Kossutha Street 6 ($50^{\circ} 26'$, $18^{\circ} 98'$), in the northwest part of Katowice (Fig. 1). Based on these data, statistical analyzes were performed. The study distinguishes two seasons per year: heating - covering the months from October to March, and summer - from April to September.

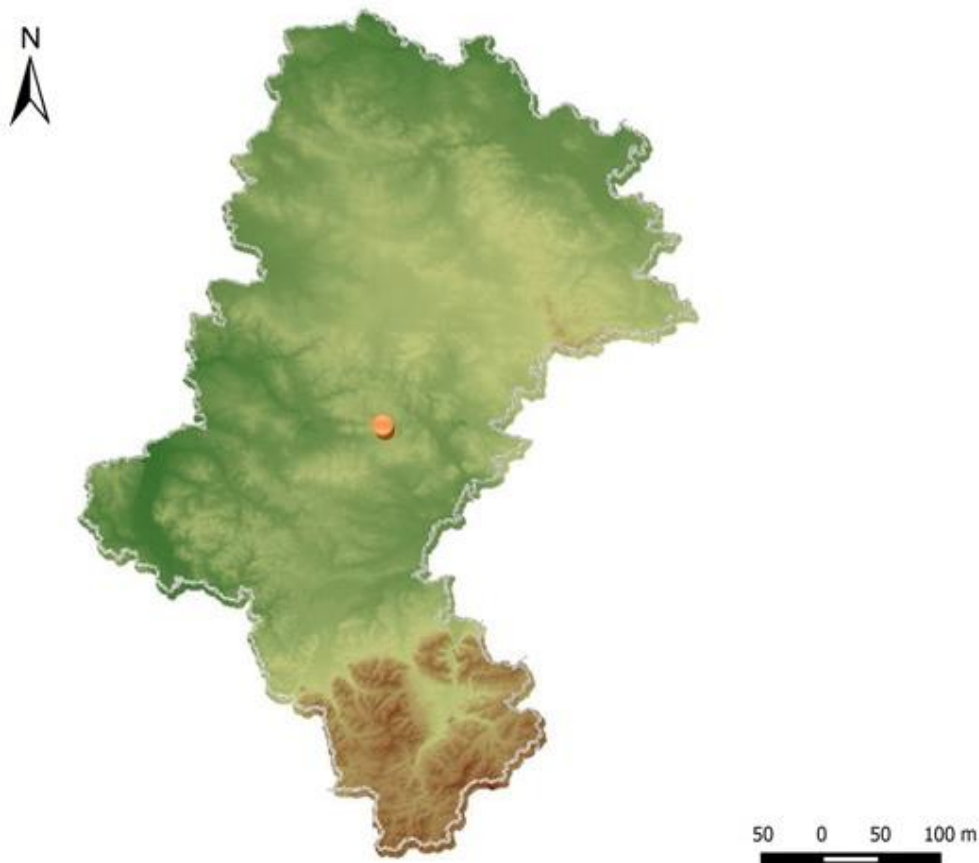


Fig. 1. Location of the GIOŚ station in Katowice

To determine whether a given value of pollutants is within the normal limits, it should be compared to the permissible level of dust in the air (Table 1). The acceptable daily level of PM10 suspended dust throughout the year is 50 $\mu\text{g}/\text{m}^3$. The acceptable level for a calendar year means the average value of all days in a year and it amounts to 40 $\mu\text{g}/\text{m}^3$. The permissible number of days when these values may be exceeded is 35.

Acceptable level [$\mu\text{g}/\text{m}^3$]		Permissible frequency of crossing in the calendar year of the limit level
24 hours	50	
calendar year	40	35 times

5. Research results

The highest concentration of PM10 suspended dust was recorded in 2017 (41 $\mu\text{g}/\text{m}^3$), while the lowest in 2019 (32,1 $\mu\text{g}/\text{m}^3$). Among the analyzed years, the permissible PM10 concentration in the air was exceeded twice, in 2017 and 2018 (Fig. 2). In last year understudy, a significant decrease in dust concentration can be observed, which indicates an improvement in air quality in Katowice.

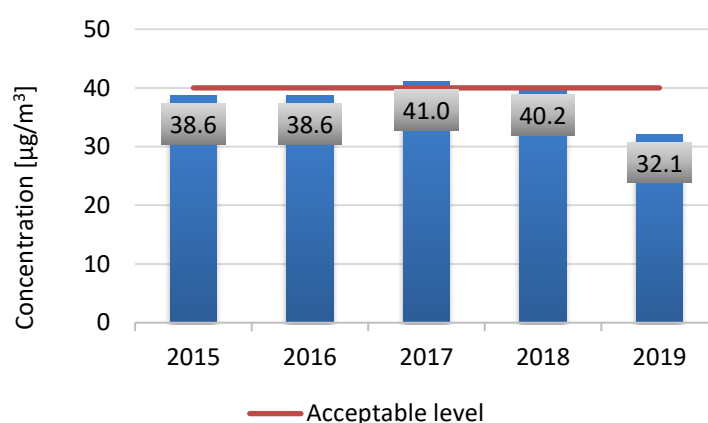


Fig. 2 Annual average values of PM10 concentrations [$\mu\text{g}/\text{m}^3$] in 2015-2019 in Katowice

A certain regularity can be noticed in the chart below, presenting the monthly average PM10 in the studied five-year period (Fig. 3). In the autumn-winter period, much higher concentrations are recorded, which are even almost three times higher than in the summer months. The highest average value was recorded in January (63,8 $\mu\text{g}/\text{m}^3$), while the lowest in July (21,5 $\mu\text{g}/\text{m}^3$).

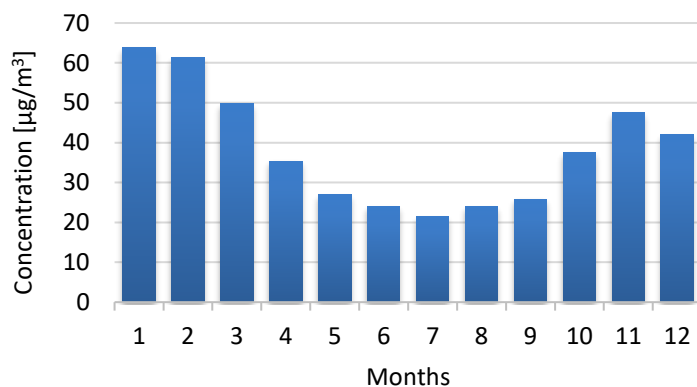


Fig. 3 Average monthly values of PM10 concentrations [$\mu\text{g}/\text{m}^3$] in 2015-2019 in Katowice

When analyzing the maximum values of PM10 concentrations in the given months, it can be noticed that the highest value was recorded in January (362,6 $\mu\text{g}/\text{m}^3$) on January 9, 2017 (Fig. 4). In the autumn and winter months, the maximum concentrations are much higher than in the spring and summer months.

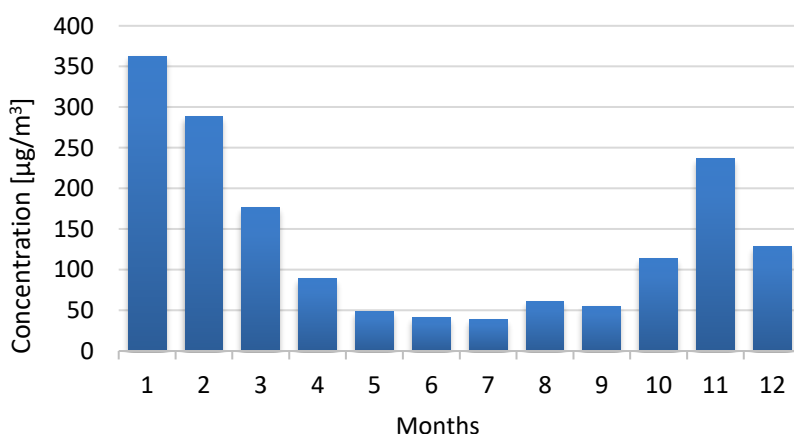


Fig. 4 Maximum values of PM10 concentrations [$\mu\text{g}/\text{m}^3$] in individual months in 2015-2019 in Katowice

In the heating season, PM10 dust concentrations significantly exceed those in the summer season (Fig. 5). The highest average pollution during the heating season took place in 2017 (59,1 $\mu\text{g}/\text{m}^3$) when the concentrations were almost three times higher than in the summer season (22,7 $\mu\text{g}/\text{m}^3$). This year is the most discrepant between these seasons. In the last analyzed year, the lowest average dust concentration took place during the heating season. It can also be noticed that in each of the heating seasons the permissible standard in the calendar year (40 $\mu\text{g}/\text{m}^3$) was exceeded. In the summer season, this value was not exceeded even once.

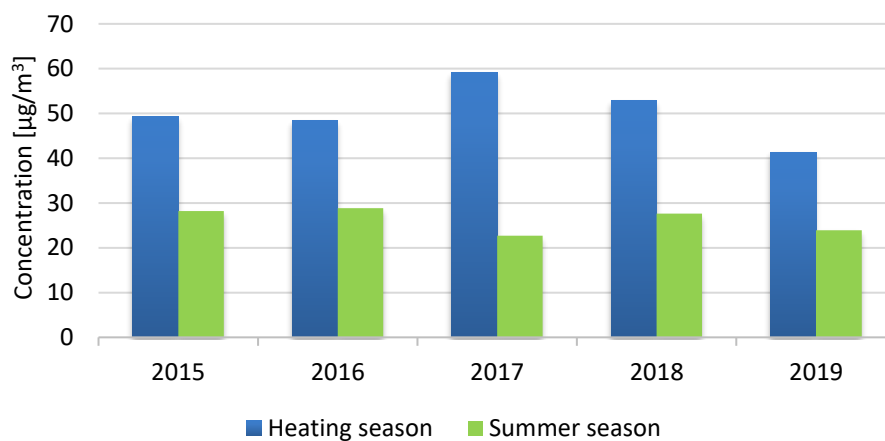


Fig. 5 Average concentration of PM10 [$\mu\text{g}/\text{m}^3$] in the heating and summer season in 2015-2019 in Katowice

The chart below presents the daily course of PM10 in Katowice (Fig. 6). There is a noticeable increase in concentrations in the evening hours, which is related to the increase in human activity by heating residential buildings. Concentrations decrease in the midday hours. The highest average value is recorded at 10 p.m., and the lowest at 3 p.m. The graph shows very well, that anthropogenic activity increases the concentration of pollutants in the ground layer of the atmosphere, which is associated with low emissions.

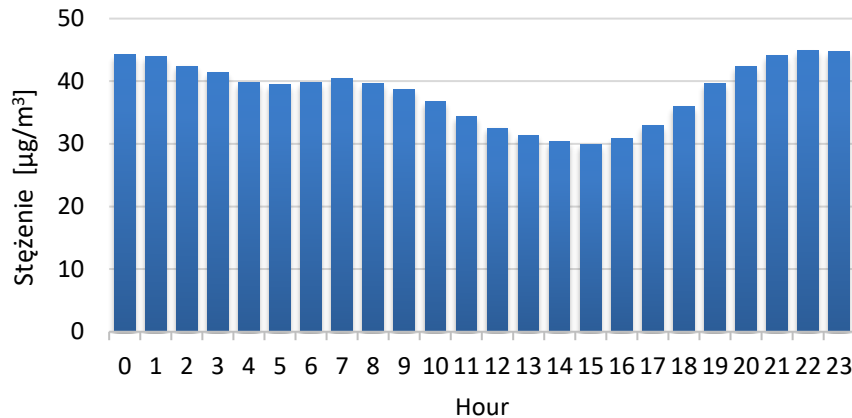


Fig. 6 Average hourly PM10 concentrations [$\mu\text{g}/\text{m}^3$] in 2015-2019 in Katowice

The graph below shows the hourly values of PM10 suspended dust concentrations in the air for five years, both in the heating and summer season (Fig. 7). The basic conclusion that can be drawn from the chart below is the fact that in the heating season the concentrations of suspended dust are higher, and the course of changes during the day is more pronounced. From 6 p.m. to about 1 a.m., there is a significant increase in the concentration values, which is related to human activity in heating houses. The highest concentration was recorded at 10 p.m. ($61,2 \mu\text{g}/\text{m}^3$), and the lowest at 3 p.m. ($38,6 \mu\text{g}/\text{m}^3$) when there is no need for intensive heating. In the summer season during the day, the concentrations are similar to the differences between the evening hours and in the afternoon they are small. At the same time in the heating season, the concentrations reach even twice as high as in the summer season, which indicates more intense human activity, e.g. in the winter months.

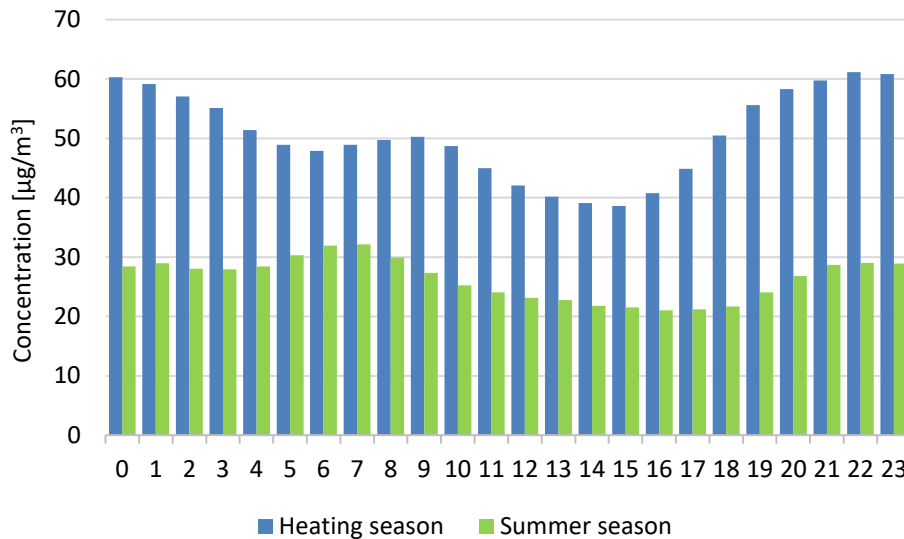


Fig. 7 Average hourly PM10 concentrations [$\mu\text{g}/\text{m}^3$] in the heating season and winter in 2015-2019 in Katowice

The chart below shows that in each of the analyzed years in Katowice, the permissible number of days was exceeded when the permissible dust concentration was exceeded (Fig. 8). The largest number of them took place in 2018 when this value was exceeded more than twice. The lowest number of days with exceedance took place in the last examined year.

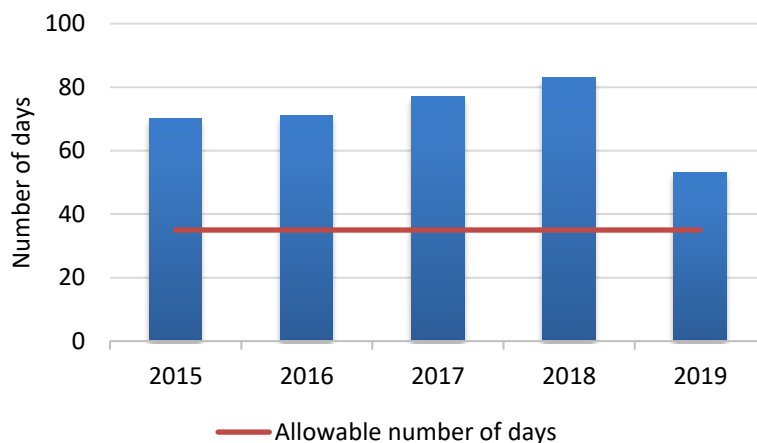


Fig. 8 Number of days with exceeding the concentration of PM10 [$\mu\text{g}/\text{m}^3$] in 2015-2019 in Katowice

According to the latest standards for the concentration of particulate matter PM10 within the five studied years (2015-2019), the number of days when the dust concentration exceeded 100 µg/m³, and thus exceeded the information level, is 44 days (Table 2). At the same time, the number of days when the concentration level has exceeded the alarm level (150 µg/m³) was 23 days, which is approximately half as much as for the information level.

Tab. 2 Permissible level and alarm level of PM10 suspended particulates in the air

Standards for the concentration of PM10 dust in the air	Number of days
Information level =>100 µg/m³	44
Alarm level =>150 µg/m³	23

6. Summary

Due to Katowice's location in a highly urbanized area and industrialized and the activities of numerous industrial plants, it is an area where the problem of air pollution is significant and cannot be underestimated. In the analyzed period of 2015-2019, the number of days when the PM10 dust concentration may be exceeded was sometimes even more than twice the limit (35 days). The average monthly values are much higher (even almost three times) in the months included in the heating season, i.e. from October to March. The average concentration in the last year under examination is the lowest, which may indicate an improvement in air quality in Katowice. In the studied years, it is visible that in the same season the concentration values fluctuate significantly depending on the hour, and therefore on human activity related to heating residential buildings.

7. Conclusions

1. In the heating season, concentrations of PM10 suspended dust are higher than in the summer season.
2. The diurnal course of PM10 concentrations indicates an increase in air pollutants in the evening hours, while in the noon hours the concentrations decrease.
3. High values in the heating season prove the dominant influence of low emission pollution sources.
4. The lowest concentration was recorded in 2019 and therefore it can be concluded on improving air quality in Katowice.
5. In the five years under study, the permissible number of days was exceeded in each year, in which the permissible dust concentration was exceeded.