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Environmental & Socio-economic Studies

DOI: 10.2478/environ-2024-0014

Environ. Socio.-econ. Stud., **2024, 12, 2: 83-93**

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Original article

Selected legal instruments for air protection against low emissions in Poland

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ABSTRACT

A fundamental problem during the heating season is the above-normal concentrations of pollutants, especially particulate matter, which are often exceeded. Currently, the main source of air pollution in Poland is low emissions, which consists of from the inefficient burning of fossil fuels in single-family homes and road transportation. This article discusses the permissible particulate matter standards and identifies the anti-smog resolution as a legal instrument to reduce low emissions. For the purpose of this research, field measurements of particulate matter of various fractions were carried out using the specialist equipment of the University Laboratories for Atmosphere Control of the University of Silesia in Katowice. Field measurements were carried out in early 2023 using the Overhead Mobile Laboratory and the Field Mobile Laboratory in selected districts of Katowice. When conducting the study, attention was paid to the type of development, which determines the specifics of heating and the proximity of roads, which are a source of traffic pollution. Due to the high variability of atmospheric conditions and other components, such as current traffic, the data should be treated as indicative. The results of the study depend primarily on the conditions found and reflect the situation at a particular place and time. The occurrence of low emissions was confirmed by the results of the study, which showed very high concentrations of particulate matter in the southern districts of Katowice, where single-family old buildings predominate and building heating is unsuitable. An impact of automobile traffic on air quality was found.

KEY WORDS: air pollution, low emissions, air protection, anti-smog resolution, particulate matter

ARTICLE HISTORY: received 21 February 2024; received in revised form 4 June 2024; accepted 6 June 2024

1. Introduction

Atmospheric air pollution is one of the most important environmental problems globally. The state of air quality in Poland deviates from accepted standards in the European Union. Currently, the largest source of pollution is low emissions from single-family houses as a result of burning fuels as a source of heating during the cold season. Existing exceedances and their very large scale indicate the lack of effectiveness of public authorities' previous actions in the sphere of air pollution protection (NAJWYŻSZA IZBA KONTROLI, 2018). An estimated 400.000 citizens of the European Union die prematurely each year as a result of above-normal concentrations of pollution (EUROPEJSKI TRYBUNAŁ OBRACHUNKOWY, 2018), including about 45.000 Polish residents (NAJWYŻSZA IZBA KONTROLI, 2014). Despite the reduction in air pollution over the past few decades, the country's air quality remains a huge challenge (NAJWYŻSZA IZBA KONTROLI, 2018). The European Commission's decision of 10th December 2015 referred Poland to the Court of Justice of the European Union due to persistently high concentrations of particulate matter in the air, and thus causing a serious threat to public health. The justification indicated that of the 46 monitored air quality zones in Poland, as many as 35 zones had exceeded daily limit values for PM_{10} particulate matter exceeded for

at least five years (HAJDYS, 2008). The European Commission's decision of 22nd February 2018 stated that Poland infringed the EU law related to compliance with European air quality standards, with limit values for PM_{10} concentrations being exceeded continuously (WYROK TRYBUNAŁU, 2018). The European Commission has concluded that administrative and legislative actions to date to reduce air pollution are insufficient (SOBOLEWSKI, 2016).

In the Polish legal system, there is a very diverse catalogue of legal acts. The fundamental piece of legislation in the European Union regarding air quality standards is the CAFE Directive (Dz. U. UE L 2008.152.1). The basic elements of air protection found in the Directive specifically address the risks of particulate matter and human exposure to pollution. The national legal act that comprehensively regulates air quality protection is the Environmental Protection Law Act of 27 April 2001 (Dz. U. 2024 poz. 54).

The most important goal of air quality protection is to reduce the emissions of pollutants in such a way as to improve air quality and meet the standards set by law. An important step leading to the reduction of pollutants is the implementation of effective legal instruments that will improve air quality and ensure their standards. The Polish air protection system distinguishes between legal instruments, such as air quality standards, remedial programs to comply with them, as well as measures to control and prevent pollutant emissions (DUBOWSKA, 2015).

Air quality protection in Poland is implemented in large part by local government units. Statutory delegation in this regard is set forth in the Environmental Protection Law, based on which provincial assemblies have the authority to enact air protection programs (Article 91), short-term action plans (Article 92) and adopt anti-smog resolutions (Article 96). In the current state of the law, anti-smog resolutions are considered a key legal instrument to prevent low emissions.

2. Purpose of the research and methods

The first objective of this research is to check the functioning of selected legal instruments for air protection against low emissions based on PM_{10} particulate matter data from the Chief Inspectorate of Environmental Protection (GIOŚ) from two available air monitoring stations in Katowice for the period 2011–2023. One of the stations is located at 6 Kossutha Street, surrounded by modern multi-family residential buildings. The other station is located near the A4 highway at Górnośląska Avenue, where there is a lot of car traffic. The second objective is to conduct experimental short-term measurements in different districts of Katowice to obtain actual measurements of particulate matter. The results depend primarily on the actual conditions found. On the measurement days, PM_{10} data from air monitoring stations (GIOŚ) and selected meteorological conditions from the synoptic station in Katowice (IMGW) were presented.

This article focuses on the study of particulate pollution. It is known that one of the main components of air pollution caused by low emissions is benzo(a)pyrene, whose standards are often exceeded, but this component has not been subject to analysis. Field measurements of particulate matter concentrations of individual fractions: $PM_{0.5}$; PM_1; $PM_{2.5}$; PM_5; PM_{10} and TSP (Total Suspended Particles) were carried out using the Overhead Mobile Laboratory – a hot-air balloon with measuring equipment during a balloon flight (14.02.2023) and by using the Field Mobile Laboratory – an off-road vehicle equipped with measuring equipment (22.03.2023 and 31.03.2023) in Katowice. The optical devices used in the research are particle concentration analyzers (GrayWolf PC-3500, GrayWolf PC-4000), which provide data on the concentration and number of particles of a given diameter. The devices have the relevant certificates and were calibrated. The settings of the devices were the same for the reliability of the measurements, which were very close to each other, so they were averaged.

3. Particulate matter

Particulate matter is understood to be a mixture of solid and liquid particles suspended in the air (REIZER, 2016). Dusts, and fine particles of solid or liquid matter, when emitted into the atmosphere, remain suspended in the atmosphere and form aerosols with different properties, depending on the fraction, surface area, morphology, shape and chemical composition of the particles (HYS ET AL., 2018). Dust grain size is one of the most important parameters characterizing dust properties (REIZER, 2016). The most studied dust fraction is PM_{10} (particles with an aerodynamic diameter of 10 μm or less) and $PM_{2.5}$ (particles with an aerodynamic diameter of 2.5 μm or less). The aerodynamic diameter of a particle is defined as that of a sphere, whose density is 1 g/cm^3, which settles in still air at the same velocity as the particle in question. Dust fractions differ in origin, physicochemical properties, chemical composition,

as well as their effects on human health. Particles with an aerodynamic diameter of more than 2.5 μm are referred to as coarse dust. They are formed mechanically, as a result of abrasion or crushing of various materials of natural origin (mineral dust), as well as anthropogenic origin (such as brake and tyre abrasion). These particles have high falling speeds and are easily removed from the atmosphere by precipitation. Their residence time in the atmosphere is short, ranging from minutes to days. They can be carried over considerable distances (REIZER, 2016). Particles smaller than 2.5 μm are referred to as fine dust. They mainly consist of soot, formed as a result of incomplete fuel combustion due to home heating and transportation (EUROPEJSKI TRYBUNAŁ OBRACHUNKOWY, 2018). Particulate matter can contain toxic substances such as carcinogenic benzo(a)pyrene, which belongs to the group of polycyclic aromatic hydrocarbons, heavy metals, dioxins and furans, among others. PM_{10} is absorbed in the upper respiratory tract. $PM_{2.5}$ particles due to their smaller fraction, are much more dangerous. They penetrate from the alveoli into the blood vessels and enter various organs and tissues (SOBOLEWSKI, 2016). A factor that affects the health effects of dusts is the ability and effectiveness of particles to retain toxic substances on their surface (ROGULA-KOZŁOWSKA, 2016). The sorption surface area of dust is one of the properties resulting from the degree of fineness, and its size is inversely proportional to the diameter of the particles. A significantly developed surface area allows the absorption of additional pollutants, often of greater toxicity (JABŁOŃSKA, 2003).

The manner and rate of dispersion of pollutants is mainly influenced by meteorological conditions, topography, emission conditions and volumes, as well as the physical and chemical properties of pollutants (PACIOREK & TRAPP, 2016). The variability of dust concentrations in the atmosphere is the result of physical and chemical processes that occur under the influence of a number of meteorological factors (KRAJNY & OŚRÓDKA, 2016). Low air temperatures and negligible wind speeds are considered the primary meteorological factors co-responsible for high particulate matter concentrations. As temperatures drop, there is an increase in particulate emissions into the air due to the heating of buildings (KUCHCIK & MILEWSKI, 2018). Wind is a major dispersion factor. Higher wind speeds can contribute to the ventilation of an area, which serves an important function especially during the heating months, when pollutants are concentrated due to fuel combustion in individual emission sources (OLENIACZ ET AL., 2016). Low temperatures can also lead to significantly higher PM emissions of combustion engines (SUAREZ-BERTOA & ASTORGA, 2018). As a result of meteorological conditions that impede the dispersion of pollutants, they may linger longer, especially in valley areas that favor the accumulation of pollution.

4. The problem of low emissions

The main cause of inadequate air quality in the country, especially during the heating season, is low emissions (SADLOK, 2014), by which is meant emissions of dust and gases introduced into the atmosphere as a result of emitters located at heights of up to 40 meters, but the most common ceiling is up to 10 meters. This concept does not have a legal definition, which means that it is not regulated by law. As indicated in the doctrine, it is considered to be a non-legal concept (DOBROWOLSKI, 2000). Low emissions are shaped primarily by the municipal sector as a result of improper heating of single-family houses, local boiler houses, as well as through combustion transport. As a result of fuel combustion in automobile engines, tyre abrasion and resuspension, there is an increase in pollution near the ground surface.

The problem of protection against low emissions mainly concerns old and scattered buildings, where the basic problem is the use of outdated and inefficient heating equipment and the combustion of fuels of poor quality or waste, which are a source of emissions of significant amounts of toxic and substances hazardous to health. For economic reasons, solid fuels are commonly used for heat production, the inefficient combustion of which is associated with the occurrence of above-normal concentrations of pollutants, especially particulate matter and benzo(a)pyrene. The most commonly used fuel is coal, its derivatives and post-coal waste, especially fines, silt, post-coal flotsam, which not only have low energy values, but also contain significant amounts of sulphur and ash. Due to the low height of chimneys in single-family homes, there is an accumulation of pollutants in the ground layer of the atmosphere, which is particularly harmful to humans due to the direct inhalation of polluted air.

The most noticeable result of low emissions is smog, which is characteristic of the autumn and winter seasons, when the inefficient combustion of various types of low-quality fuels occurs due to low air temperatures. This mixture includes pollutants such as particulate matter, benzo(a)pyrene, sulphur

dioxide, carbon oxides and soot. The concepts of low emissions and smog are not the same and should not be confused with one another. Smog is a noticeable phenomenon, which is a confirmation of the presence of low emissions in an area. In the event that smog is not visible, this does not mean that low emissions do not occur.

5. Air quality standards

All permissible standards for individual pollutants are regulated by the Regulation by the Minister of the Environment of 24 August 2012 on the levels of certain substances in the air (Dz. U. 2021 poz. 845). With regard to PM_{10}, the annual average concentration standard during the calendar year is 40 μg/m^3, while the 24-hour average concentration level is 50 μg/m^3. It is noted that the permissible frequency of exceedance of this level during a calendar year must not exceed 35 days.

In Poland, there is a problem of high PM_{10} concentrations for the information and alert levels, the standards of which are much higher than in other European Union countries. As an information level is defined as the concentration of a substance in the air, above which, as a result of short-term exposure to pollution, there is a threat to health. The alert level is defined as such a concentration of a substance in the air, above which there is a threat to health with even a short exposure to pollution. Polish legislation for a very long time had acceptable standards from the 2012 Regulation. When the daily concentration of PM_{10} dust reached 300 μg/m^3 at a station an alert level was announced, while at 200 μg/m^3, only then was the public informed of the danger. Due to such high concentrations, in 2019 the levels have been reduced twice from those previously in effect. According to the new regulations, the information level is 100 μg/m^3, while the alert level is 150 μg/m^3. The lowering of the standards was aimed at informing residents more frequently about the threat posed by air pollution. In many countries of the European Union, the information and alert levels are more stringent. While a given concentration in a country is considered hazardous to health, it is acceptable under Polish legislation. For example, in France, when the daily concentration of PM_{10} is 50 μg/m^3, an information level is announced, while in Poland it is an acceptable daily norm, and air quality is considered good. In contrast, an alert level is announced at 80 μg/m^3. In Poland, at such concentrations, air quality is described as moderate. The lowest alert level is found in Finland and Germany (50 μg/m^3), which is three times lower than in Poland (POLSKI ALARM SMOGOWY, 2019).

6. Anti-smog resolutions

Anti-smog resolutions have been adopted in most provinces in Poland and are considered the only instrument likely to mandate the use of appropriate types of fuels of the right quality for heating purposes (PRZYBOJEWSKA, 2017). Resolutions are intended to impose orders or bans, concerning the operation of heating systems in residential buildings. These restrictions can apply to the required standards for the boilers used for combustion, but also to the types of fuel that are prohibited for use in a given province. Resolutions mandate the replacement of old boilers, stoves and fireplaces with modern ones, and impose a total, or partial, ban on burning coal or wood at different times, depending on the province. They may set the requirements for fuel combustion facilities by indicating their permissible parameters and technical solutions or emission parameters.

The anti-smog resolution obligatory specifies:

1) The boundaries of the area where restrictions or prohibitions are implemented,
2) The types of entities or installations for which restrictions or prohibitions are implemented,
3) The types or quality of fuels approved for use, or fuels the use of which is prohibited in the area, or technical parameters or technical solutions or emission parameters of the fuel combustion installations, approved for use in this area.

In order to strengthen compliance with the area's applicable regulations contained in the anti-smog resolution, the Environmental Protection Law provides for criminal liability. According to the law, anyone failing to comply with restrictions, orders or prohibitions set forth in the resolution is subject to a fine, which can be up to PLN 5.000. Compliance with the regulations should be controlled both in terms of the heating equipment owned and the types of fuel used. Local government authorities have the right to inspect the provisions of the Resolution and, if violations are noted, to impose a fine. The municipal or communal police, the municipal office, and in the case of business entities, the Provincial Inspectorate for Environmental Protection are authorized to carry out inspections of compliance with the regulations. Inspections may be carried out by the Police if there is suspicion of a violation.

The anti-smog resolution for the Silesia Voivodship has been effective since 1 September 2017 and prohibits combustion of the following products in installations:

1) lignite and fuels produced with its use,
2) sludge and floto-concentrates as well as mixtures produced with their use,
3) coal fuels with a mass fraction of less than 3 mm exceeding 15%,
4) biomass with a humidity in the working condition over 20%.

According to the Resolution, non-compliant installations whose operation began before 1 September 2017, should be replaced according to the dates indicated in the Resolution (Dz. Urz. Woj. Śląskiego, poz. 2642).

In order to implement the measures contained in the anti-smog resolutions, funding is needed to support the replacement of obsolete installations, to educate residents on the need to implement these measures, and to systematically inspect compliance with the implementation of the regulations. These funds can be found in government programs (e.g. Clean Air, Stop Smog), regional operational programs, EU projects (e.g. LIFE) and municipalities' own funds (RAPORT UN GLOBAL COMPACT NETWORK POLAND, 2022).

7. Results of PM_{10} from air monitoring stations

The graph in Fig. 1 shows the values of average annual PM_{10} concentrations based on data from air monitoring stations in Katowice for the period 2011–2023. The values of PM_{10} concentrations indicate a decrease in dust pollution in the city. The lowest average PM_{10} concentration was recorded in 2023 at both stations. The highest average PM_{10} concentration were observed at the station in Górnośląska Avenue in 2017 (52 µg/m³), and at the station at 6 Kossutha Street in 2011 (50 µg/m³). On a multi-year basis, the permissible level of average annual PM_{10} concentrations at 6 Kossutha Street was exceeded six times, while at Górnośląska Avenue as many as nine times. Comparing the concentrations from these two stations, much higher values were found at Górnośląska Avenue, which is due to the location of the station next to the A4 highway, where there is increased car traffic. In 2020–2023, the permissible level of the average annual concentration was not exceeded at any of the stations, which may suggest an improvement in air quality in Katowice.

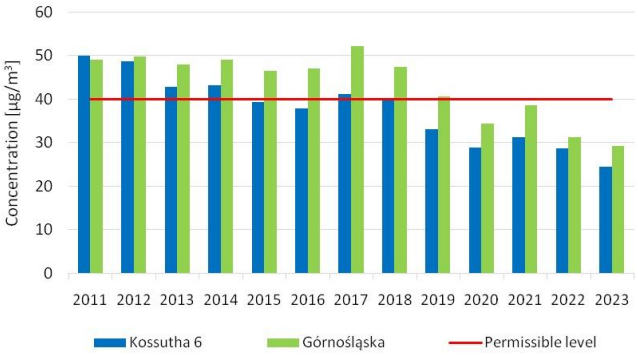

Fig. 1. Annual average values of PM_{10} concentrations [µg/m³] at stations located at 6 Kossutha Street and Górnośląska Avenue in Katowice in 2011-2023 (Source of data: powietrze.gios.gov.pl)

8. Field surveys of particulate matter

During the research balloon flight (14.02.2023), dust pollution concentrations were measured over Katowice in different districts (Osiedle Witosa, Załęska Hałda-Brynów, Brynów–Osiedle Zgrzebnioka, Piotrowice-Ochojec, Kostuchna, Murcki) at different altitudes (321–1501 m a.s.l.). The course of the research flight route is shown in Fig. 2.



Fig. 2. Balloon flight route on 14.02.2023 over Katowice (blue line)

The daily PM_{10} concentration on 14.02.2023 was slightly higher at 6 Kossutha Street station (32.3 µg/m³) than at Górnośląska Avenue (28.5 µg/m³). At the time of the field measurements, PM_{10} concentrations at the first station ranged from 24.9 to 27.3 µg/m³, and was 25.5–28.9 µg/m³ at the second station. On that day, Poland was within a high-pressure system, as

evidenced by records of very high pressure (1036.5 hPa). Air temperature (3.6°C) and wind speed (1.3 m/s) were the lowest of the days analyzed. The predominant wind direction appeared to be westerly, with north-westerly winds occurring to a lesser extent (Fig. 3). During the measurements, the air temperature in Katowice was between 4.4–4.6°C, and the wind Speer was between 1–2 m/s.

The results of the measurements are displayed in Table 1. At the highest altitudes, the concentration turned out to be negligible, while the closer to the ground the pollution was higher. In the Piotrowice-Ochojec and Murcki districts, measurements were made directly over the forest, while in the other districts they were mostly over built-up areas. The lowest concentrations were recorded in the Piotrowice-Ochojec district, which may be due to reaching the highest altitudes during the flight. In the districts of Załęska Hałda-Brynów and Brynów-Osiedle Zgrzebnioka, concentrations turned out to be very comparable, and the flight took place at relatively low altitudes, close to buildings.

Measurements of particulate matter by the Field Mobile Laboratory were carried out twice (22.03.2023 and 31.03.2023) at the same points in order to compare the variability of dust concentrations in Katowice over time. The research route included 11 measurement points, which were selected due to the variation in the type of development in different districts of the city (Fig. 4). The characteristics of each measurement point are shown in Table 2.

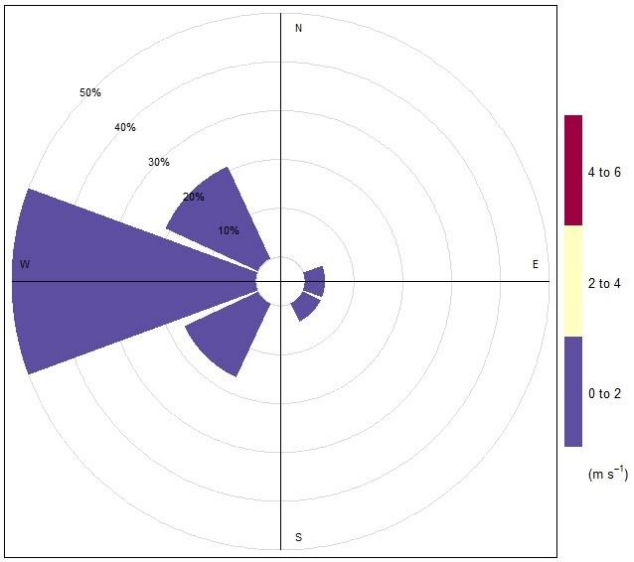

Fig. 3. Frequency of counts by wind direction (%) in Katowice on 14.02.2023

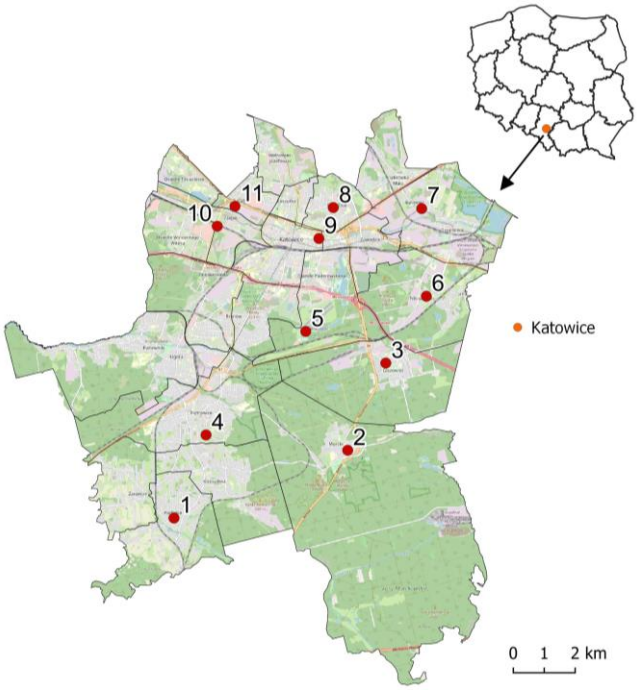

Fig. 4. Location of measurement points on the research route (1-11) in Katowice (red points)

Single-family residential development areas are concentrated mainly in the western and southern districts of Katowice, and thus are areas where low emissions, mainly from individual heating systems, have a significant impact on air quality. Heating of these buildings, which are not connected to the municipal heating network, may be done in an improper way, such as with a coal stove, which consequently contributes to the release of pollutants into the atmosphere. Due to the valley terrain, the conditions for the dispersion of pollutants for measurement sites number 1 (Podlesie) and 7 (Szopienice-Burowiec) are particularly unfavourable. Multi-family housing dominates in the downtown and northern districts. The multifamily buildings described can include both modern and older buildings. An air monitoring station is located at 6 Kossutha Street surrounded by modern multi-family housing, which is connected to the district heating network. Therefore, low emissions from home heating do not occur in this area.

The daily concentration of PM_{10} on 22.03.2023 at both stations were the highest of all analyzed days (6 Kossutha Street – 38.4 μg/m^3, Górnośląska Avenue – 44.6 μg/m^3), however, the permissible level was not exceeded. The atmospheric pressure on that day was 1014 hPa, the air temperature 10°C, and the wind speed 2.5 m/s. The dominant wind direction was southerly, and the highest frequency was between 2 and 4 m/s (Fig. 5).

Table 1. Measurement results of particulate matter concentrations [μg/m^3] on 14.02.2023 in individual districts in Katowice

$PM_{0.5}$						
Parameters	Osiedle Witosa	Załęska Hałda-Brynów	Brynów- Osiedle Zgrzebnioka	Piotrowice-Ochojec	Kostuchna	Murcki
Average	0.7	3.5	3.8	0.8	1.8	1.9
Minimum	0.5	0.7	3.2	0.0	0.0	1.4
Maximum	0.9	4.5	4.2	3.5	3.1	2.6
PM_1						
Parameters	Osiedle Witosa	Załęska Hałda-Brynów	Brynów- Osiedle Zgrzebnioka	Piotrowice-Ochojec	Kostuchna	Murcki
Average	1.6	6.5	7.0	1.5	3.3	3.4
Minimum	1.1	1.3	5.9	0.1	0.1	2.5
Maximum	2.5	8.3	7.8	6.4	5.5	4.7
$PM_{2.5}$						
Parameters	Osiedle Witosa	Załęska Hałda-Brynów	Brynów- Osiedle Zgrzebnioka	Piotrowice-Ochojec	Kostuchna	Murcki
Average	5.2	11.2	11.7	3.1	6.0	6.4
Minimum	3.1	4.3	10.2	0.5	0.4	4.9
Maximum	7.8	13.4	12.8	11.3	10.2	8.5
PM_{10}						
Parameters	Osiedle Witosa	Załęska Hałda-Brynów	Brynów- Osiedle Zgrzebnioka	Piotrowice-Ochojec	Kostuchna	Murcki
Average	30.1	18.9	18.5	5.5	10.2	12.4
Minimum	13.6	9.9	15.3	0.5	0.6	8.0
Maximum	55.2	33.1	23.6	20.2	28.1	17.9

Table 2. Characteristics of measurement points in Katowice

Measurement point	District	Latitude (N)	Longitude (E)	Altitude [m a.s.l.]
1	Podlesie	50° 10' 43.445''	18° 58' 6.431''	265
2	Murcki	50° 11' 54.448''	19° 2' 49.599''	325
3	Giszowiec	50° 13' 25.796''	19° 3' 51.778''	283
4	Piotrowice-Ochojec	50° 12' 10.555''	18° 58' 58.634''	293
5	Osiedle Paderewskiego-Muchowiec	50° 13' 59.05''	19° 1' 41.257''	274
6	Janów-Nikiszowiec	50° 14' 35.779''	19° 4' 58.128''	279
7	Szopienice-Burowiec	50° 16' 7.671''	19° 4' 50.615''	258
8	Bogucice	50° 16' 8.767''	19° 2' 26.358''	280
9	Śródmieście	50° 15' 36.39''	19° 2' 2.812''	262
10	Załęże	50° 15' 49.256''	18° 59' 16.906''	269
11	Dąb	50° 16' 10.141''	18° 59' 45.735''	268

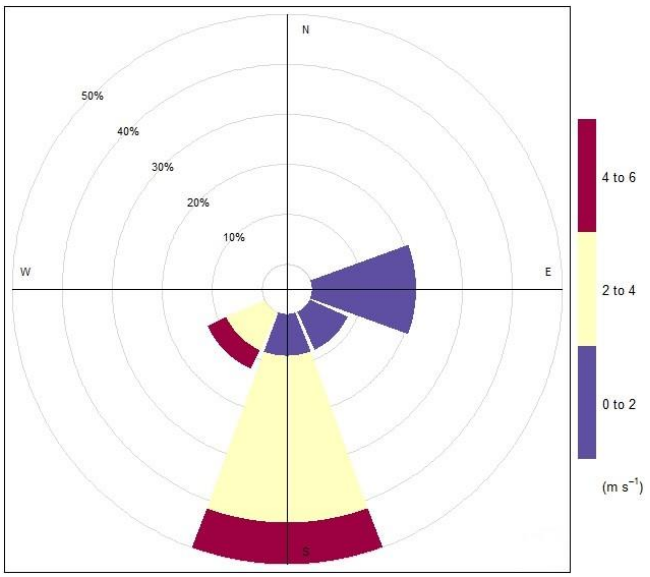

Fig. 5. Frequency of counts by wind direction (%) in Katowice on 22.03.2023

The results of the field survey clearly indicate that at survey point number 1 – Podlesie, the concentration of particulate matter of individual fractions turned out to be very high (Table 3). Among all the sites, the highest concentration of fine particulate matter is noted here, which may be due to the processes of burning solid fuels because of heating buildings. Relatively high concentrations of dust are recorded at the site located in Murcki, where both emissions from single-family homes and road transport may have contributed to the pollution. In the hours preceding the measurements, the air temperature turned out to be relatively low, with the lowest value recorded at 4:00 am (2.3°C). Due to heating processes, there was an excessive concentration of pollutants from the chimneys of single-family houses. At that time, wind speeds had very low values (up to 1 m/s), as a result of which the ventilation of the area was difficult, especially in valley areas. During the field measurements, the air temperature gradually increased (11.8–16.6°C) and increased wind speeds (4–5 m/s) were recorded, which may have contributed to lower PM_{10} in the following hours. During the measurement time, concentrations ranged from 19.3 to 42.3 μg/m^3 at the station at 6 Kossutha Street, and 29.9–49.6 μg/m^3 at Górnośląska Avenue. The obtained results indicate the problem of low emissions in the studied area, which is closely related to the inappropriate heating of residential buildings (Podlesie, Murcki).

Table 3. Average measurements of concentrations of particulate matter [μg/m^3] on 23.03.2023 at individual measurement points in Katowice

Measurement point	$PM_{0.5}$	PM_1	$PM_{2.5}$	PM_5	PM_{10}	TSP
1	31.6	56.5	67.9	80.7	112.8	177.5
2	20.5	34.1	41.0	51.1	82.3	158.5
3	19.3	31.6	38.5	47.4	61.2	84.0
4	15.9	25.5	34.0	48.5	76.9	118.9
5	13.7	21.6	27.5	39.6	64.5	115.0
6	9.7	14.3	18.8	27.3	43.5	68.9
7	8.5	13.3	21.4	56.5	161.8	296.9
8	12.5	17.5	23.6	38.6	69.0	109.9
9	6.8	9.9	14.1	24.1	43.2	77.4
10	6.7	9.8	13.0	23.5	39.2	65.9
11	5.2	7.5	9.9	16.0	26.9	47.5

The influence of linear emissions on the measurements obtained depends on the proximity of roads and the volume of traffic at a given time. When the measurement point was located directly next to a road with heavy traffic, dust concentrations were found to be higher. An example is measurement point number 7 in the Szopienice – Burowiec district, where higher concentrations of both PM_{10} and TSP dust were recorded. Given the recording of high concentrations of coarse dust (above 2.5 μm), it can be inferred that a resuspension process may have occurred as a result of passing vehicles. Local pollutants may be involved in coarse dust concentrations.

On 31.03.2023, daily PM_{10} concentrations at both stations were at very low levels (6 Kossutha Street – 18 μg/m^3, Górnośląska Avenue – 25 μg/m^3). On this day, Poland was subjected to a low-pressure system, so there were increased wind speeds. Of all the

measurement days, the atmospheric pressure on the day turned out to be the lowest (1004.3 hPa), while the wind speed (4.4 m/s) and air temperature (10.4°C) were the highest. Advection of air masses took place from the southern sector, and the prevailing direction turned out to be the southwest, with velocities of 4–6 m/s having the highest frequency (Fig. 6). During the measurement hours, concentrations at the station at 6 Kossutha Street ranged from 10.6 to14.5 µg/m^3, and at Górnośląska Avenue 21.6–40.4 µg/m^3.

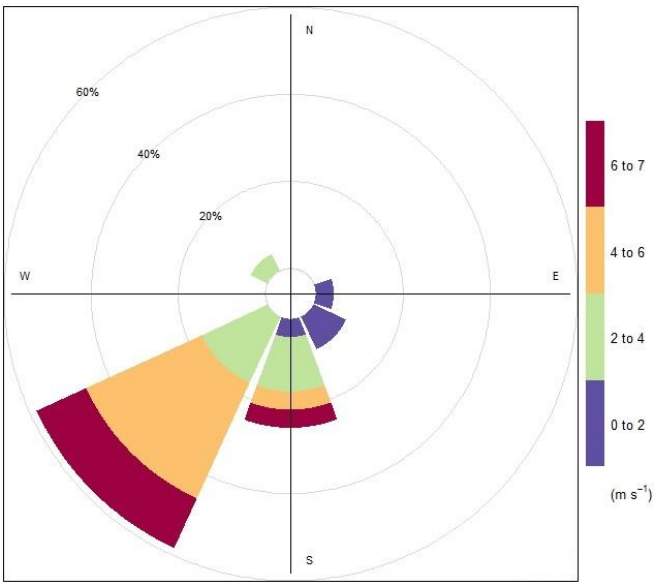

Fig. 6. Frequency of counts by wind direction (%) in Katowice on 31.03.2023

Field measurements showed that on 31.03.2023 the concentrations of each fraction of particulate matter appeared to be lower at almost all measurement sites compared to 22.03.2023 (Table 4). It is also noted that there is little variation in concentrations between measurement points on 31.03.2023. It is worth noting the low concentrations of fine dust at each site. In the hours before and during the measurements, increased wind speeds (up to 7 m/s) were recorded in Katowice, which may have directly contributed to the dispersion of pollutants in the city. Comparing dust concentrations on the analyzed days, it is possible to note the significantly lower values on 31.03.2023 in the southern districts of Katowice, where there are single-family buildings in close proximity to the measurement point. It is likely that there may have been lower atmospheric emissions of pollutants from the combustion of fossil fuels on that day, as a result of the relatively higher air temperature on the earlier day and high wind speeds were a determining factor in the dispersion of pollutants. The main factor responsible for the low concentrations on the day was high wind speeds. The day before, the average wind speed was 5 m/s, and there were gusts of 5–7 m/s when the field measurements were conducted. The air temperature at the time oscillated between 11.9–14.6°C. The highest concentrations on that day were recorded at sites where road transport may have played an important role in shaping air quality, including the Szopienice–Burowiec, Bogucice district. In the Dąb district, dust concentrations turned out to be higher than on 22.03.2023, which may be due to increased car traffic at the time.

Table 4. Average measurements of concentrations of particulate matter [µg/m^3] on 31.03.2023 at individual measurement points in Katowice

Measurement point	$PM_{0.5}$	PM_1	$PM_{2.5}$	PM_5	PM_{10}	TSP
1	9.1	14.6	21.1	33.1	44.8	57.1
2	6.1	10.2	16.0	25.8	33.4	41.0
3	4.8	8.6	14.5	25.5	35.3	53.0
4	3.7	6.7	13.2	25.5	40.5	68.2
5	3.1	5.3	10.4	20.1	29.6	43.5
6	2.9	5.0	10.1	21.6	36.3	63.3
7	2.5	4.7	10.6	24.6	48.9	83.4
8	4.3	7.4	13.9	28.7	53.2	87.0
9	3.1	5.9	11.9	23.9	38.1	60.9
10	2.5	4.4	10.5	24.3	40.0	65.9
11	2.4	4.2	10.3	23.0	35.1	75.5

9. Discussion and conclusions

Reducing low emissions is key to meeting air quality standards set by law. Based on long-term data, there has been a decrease in PM_{10} pollution in Katowice, indicating an improvement in the city's air quality. In recent years the permissible annual level of PM_{10} has not been exceeded. However, there are only two monitoring stations in Katowice. One of them is located in the surroundings of modern multifamily housing, where low emissions do not occur. The other station is located next to a highway, where pollution mainly comes from road transport. Katowice is highly diverse in terms of both development and terrain, so data from only two monitoring stations do not reflect the actual conditions in the city, and thus these stations are not representative of the entire area. In order to obtain actual measurements of particulate matter in individual neighborhoods, an experiment was conducted. Preliminary incidental results indicate a wide variation in concentrations in individual neighbourhoods, which is determined by the type of development, terrain and proximity of roads to the point. The most predisposed region for low emissions are the southern districts of Katowice, where single-family housing of old buildings prevails and the method of heating is unsuitable. On a day of unfavourable meteorological conditions, dust concentrations were high in the area. Road transport also has an impact on air quality. At the point located directly next to the road (Szopienice-Burowiec), where there was increased car traffic at the time, dust concentrations were also found to be high. Comparing data from monitoring stations, higher concentrations were found next to the highway than in the vicinity of multi-family housing. The measurements obtained represent conditions at a specific place and time. The results of field studies indicate that meteorological factors affecting the accumulation of pollutants are low air temperatures, resulting in the burning of fossil fuels in homes, and low wind speed. KRAJNY & OŚRÓDKA (2016) confirmed that air temperature has an inversely proportional effect on the amount of particulate matter concentration, which is associated with an increase in particulate matter emissions into the atmosphere in the process of home heating. Significant wind speeds contribute to the dispersion of pollutants, which favour the ventilation of the area (OLENIACZ ET AL., 2016).

There are large differences in dust concentrations between hourly data from monitoring stations and actual measurements at measurement points. Daily PM_{10} concentrations at monitoring stations on the analyzed days did not exceed the permissible level. If the stations were located in areas where low emissions are a major problem, it is likely that the concentrations would have turned out to be much higher. Conclusions about improvements in air quality can be drawn from monitoring data, but they do not reflect the real situation of air pollution in the city. To check whether air quality is actually improving, the number of monitoring stations would need to be increased, especially in neighbourhoods where single-family housing is prevalent. More densely distributed stations in places where emissions from household furnaces can actually be measured would make it possible to know whether the implementation of the anti-smog resolution is having the desired effect. The Resolution aims to eliminate sources of pollution from the residential sector and use good-quality fuels with certain parameters. In order for the regulations to bring the expected results, it is necessary to increase the effectiveness of control activities and raise awareness among citizens.

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