Polish Political Science Yearbook, vol. 51(3) (2022), pp. 19–38
DOI: https://doi.org/10.15804/ppsy202231 PL ISSN 0208-7375
www.czasopisma.marszalek.com.pl/10-15804/ppsy

Katarzyna Świerszcz
The Military University of Technology (Poland)
ORCID: 0000-0002-1819-6705
e-mail: katarzyna.swierszcz@wat.edu.pl

Air Pollution as an Indicator of Local Environmental Safety Based on the Example of the Town of Barlinek

Abstract: This article aims to present the state of air quality treated as a measure of the state of quality of local environmental safety, based on the research conducted in the town of Barlinek. This information is necessary to identify the areas that require action to improve air quality (to reduce the concentration of pollutants). The main factors that inspired the author to address this issue are, first of all, the continuous high level of air pollution, despite the actions taken to reduce it; secondly, the lack of precise, clear indicators and measures of such deprivation that applies to a major part of the territory of Poland that would take into account the individual national context; thirdly, the need to identify the main factors that determine this phenomenon in the specific context of Poland. Other factors include the need to consider the requirement for Poland as a member state of the EU to participate in reducing air pollution to an appropriate extent; and, finally, the need to develop and implement integrated 10-year National Energy and Climate Plans (NECP) for the years 2021–2030 with a long-term perspective to the year 2050, as well as long-term renovation strategies to improve the accuracy of eliminating air pollution. The research problem focuses on three issues: presenting the current national and European criteria of ecological safety for air pollution, identifying the indicators and measures that enable the determination of air pollution levels, and presenting the local air pollution level based on the selected example. The research problem discussed in the article is empirical. Analytical/synthetic, qualitative and quantitative methods were used to provide a more in-depth analysis of the problem, and conclusions were drawn.

Keywords: *ecological safety, air pollution indicators, air pollution measures, low emission, heat poverty*

Introduction

The analysis of the existing studies on assessing air quality in Poland reveals that its condition is constantly improving. The share of specific sources that affect air quality has also changed. Initially, the sectors that had the strongest influence on air quality were the power generation and industrial sectors, while transport and the municipal and household sector had a smaller share. However, due to the application of technical and technological solutions, the influence of the industrial sector on the air pollution level has decreased significantly. Unfortunately, it has been replaced by households, which have become the main source of the emission of combustion gases in the last few years. It is confirmed by the results of annual air quality assessments conducted by the Main Inspectorate for Environmental Protection. They reveal that Poland's main phenomenon responsible for improper air quality is the so-called low emissions generated in the municipal and household sector. It is shown in Fig. 1 and 2.

Considering that, public authorities, in particular the Ministry of Climate and the Environment, the Ministry of State Assets, and the Ministry of Family and Social Policy defined the priority actions to be taken by 2030 and then by 2050 to eliminate this phenomenon, considering, in particular, continuous analysis and monitoring of its causes. These actions aim to achieve the desired air quality standards and maintain them on a level specified in the European Union, the national legislation, and the World Health Organisation (WHO) regulations. In order to achieve the defined goals and for the effective realisation of the actions that are necessary on the voivodeship and local levels, it is required, among others, to increase the priority given to the air quality issue by consolidating activities on the national level and establishing a "wide Partnership for the improvement of air quality". Then, it is required to develop a legal framework that will foster the realisation of effective actions aimed at improving air quality; involve the community in activities aimed at improving air

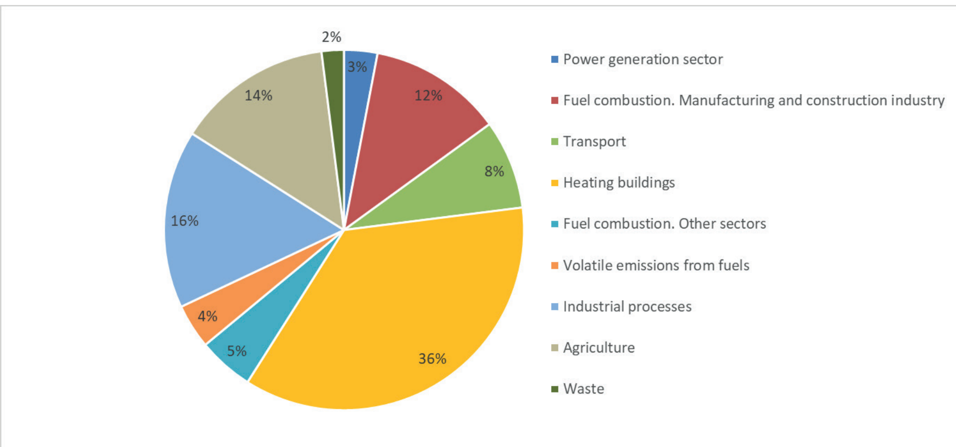

Figure 1. The percentage share of important sectors in the emission of PM_{10} particles in Poland in 2020.

Source: Main Inspectorate for Environmental Protection. Air quality in Poland in 2020 in light of the measurements conducted as part of the State Environmental Monitoring, The National Fund for Environmental Protection and Water Management, Warsaw 2021, p. 161.

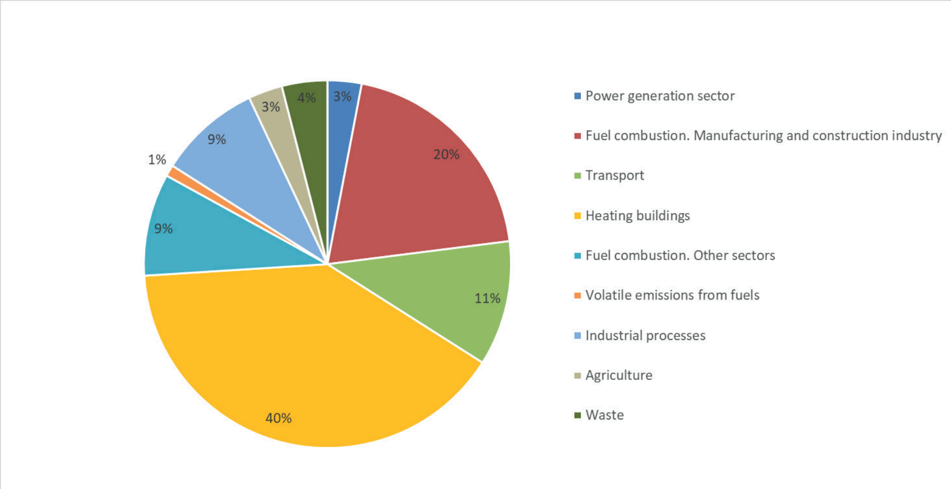

Figure 2. Percentage share of specific sectors in the emission of $PM_{2.5}$ dust in Poland in 2020.

Source: Main Inspectorate for Environmental Protection. Air quality in Poland in 2020 in the light of the results of the measurements conducted as part of the State Environmental Monitoring, The National Fund for Environmental Protection and Water Management, Warsaw 2021, p. 188.

quality by increasing social awareness and creating permanent platforms for dialogue with civil organisations; develop and popularise technologies that contribute to the improvement in air quality; develop mechanisms to control low emission sources to foster the improvement of air quality; and, finally, popularise financial inducements that contribute to the improvement of air quality (National…, 2015; Assessment…, 2021).

This article aims to present air quality treated as a measure of the state of quality of local ecological safety, based on the research conducted in the town of Barlinek. The research problem presented here focuses on the question: What is the level of air pollution caused by low emissions from households in the town of Barlinek? The research hypothesis assumes that air quality significantly influences ecological safety, and households are an important source of this. The research problem discussed in the article is empirical. Analytical/synthetic, qualitative and quantitative methods were used to provide a more in-depth analysis of the problem, and conclusions were drawn.

Existing Ecological Safety Criteria Related to Air Pollution

The presentation of acceptable air pollution level criteria requires clarifying certain terms, including air pollution, level, assessment, the related acceptable values, and the target value. Air pollution should be understood as the release to the atmosphere of solid, liquid, or gaseous substances that do not exist naturally in the air or natural substances at rates that exceed the natural amounts and may be detrimental to human health, the climate, vegetation, fauna, water, and soil, i.e., the environment as a whole (Directive, 2008). The pollution level is the concentration of a pollutant in ambient air or the deposition thereof on surfaces in a given time (Directive, 2008). Assessment is any method used to measure, calculate, predict or estimate levels (Directive, 2008; Jagusiak & Stochaj, 2017). The limit value shall mean a level fixed based on scientific knowledge, intending to avoid, prevent, or reduce harmful effects on human health or the environment as a whole, to be attained within a given period and not to be exceeded once attained (Directive, 2008; Directive, 2004).

Finally, target value means a level fixed to avoid, prevent, or reduce harmful effects on human health or the environment, to be attained where possible over a given period (Directive, 2008; Air quality in Europe, 2021). Air pollution originates both from anthropogenic (artificial) and natural sources. In this case, the subjects of analysis are the sources of pollution, households, referred to as low emissions (Świerszcz, 2021a; Świerszcz et al., 2019; Tan et al., 2022).

Usually, air pollution in Europe and Poland is assessed based on qualitative criteria. These criteria have been specified in European and national legislation, based on the recommendations of the World Health Organisation (WHO), which, in turn, are based on numerous scientific studies that determine the effects of various air pollutants on human health (Directive, 2008; Main…, 2021) The current recommendations of the WHO are more restrictive towards six particularly harmful substances, which are: carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and suspended particle matter, in two sizes ($PM_{2.5}$ and PM_{10}). These recommendations take the form of acceptable levels (limit values) of pollutants for specific time intervals, which are presented in Table 1.

Table 1. Limit values of air pollutant concentrations according to the recommendations of WHO

Period of air pollutant concentration µg /m3	**$PM_{2.5}$**	**PM_{10}**	**O_3**	**NO_2**	**SO_2**
Mean annual concentration	5	15		10	
Mean daily concentration	15	45		25	40
Mean eight-hour period concentration			60		

Source: Ambient (outdoor) air pollution, downloaded from: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Apart from the air pollutants, other commonly found pollutants are hydrocarbons (often so-called ozone precursors, i.e., pollutants that contribute to increased ozone concentration in the air) and carbon oxides. The most harmful air pollutants include heavy metals and strongly acidic or alkaline compounds, such as benzene, hydrogen chloride, hydrogen sulphide, and ammonia. Although the WHO has not provided any recommendations for these pollutants, they are assessed based on national or European regulations (Świerszcz et al., 2019).

Currently, the main legal act for the assessment of air quality on the scale of the European Union is Directive 2008/50/EC of the European Parliament and the Council of May 21, 2008, on ambient air quality and cleaner air for Europe (Directive, 2008; Świerszcz & Grenda, 2019), often referred to as the CAFÉ (Clean Air for Europeans) Directive. It presents a set of legal tools that the EU Member States must use to achieve the appropriate target values of reducing the concentration of selected pollutants in the air. These target values are expressed as limit values of pollutant concentration for defined time ranges and the number of acceptable excessions per year, as shown in Table 2.

Another document that establishes the criteria for air pollution, which became effective in 2004, is the separate "Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004, relating to arsenic, cadmium, mercury, nickel, and polycyclic aromatic hydrocarbons in ambient air". This document defines the limit values of the concentration of those metals and benzo(a)pyrene in the air, which were to be achieved on December 31, 2012. These levels are presented in Table 3.

Table 2. Limit values of air pollutant concentrations according to the legislation of the European Union (the CAFÉ Directive)

Substance	Period of averaged measurement results	Limit value $\mu g/m^3$	Acceptable frequency of excessed limit value per calendar year
Sulphur dioxide (SO_2)	1 hour.	350	24 times
	1 day	125	3 times
Nitrogen dioxide (NO_2)	1 hour.	200	18 times
	Calendar year	40	-
Benzene (C_6H_6)	Calendar year	5	-
Carbon monoxide (CO)	1 day	10	-
Lead (Pb)	Calendar year	0,5	-
$PM_{2.5\ particles}$	1 day	25	-
	Calendar year	20	-
PM_{10}	1 day	50	35 times
	Calendar year	40	-

Source: Directive 2008/50/EC of the European Parliament and the Council of May 21, 2008 on ambient air quality and cleaner air for Europe (Official Journal. L 152 of the 11.6.2008), download: https://eur-lex.europa.eu/legal-content/PL/TXT/PDF/?uri=CELEX:32008L0050&from=PL, pp. 41-42.

Table 3. Limit values of the substances: arsenic, cadmium, nickel, and benzo(a)pyrene in the air

Type of pollutant	Target value (1)
Arsenic	6 ng/m^3
Cadmium	5 ng/m^3
Nickel	20 ng/m^3
Benzo(a)pyrene	1 ng/m^3

(1) For the total content of the PM_{10} fraction, averaged for the calendar year.
Source: Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air, download: https://powietrze.gios.gov.pl/pjp/publications/card/3079, p. 8.

In Poland, both directives are in force, along with the limit values of pollutants and the periods for their achievement. It was confirmed by implementing the provisions of the directives to the Polish legal system by introducing two legal acts: The Act of April 27, 2001 – Environmental Protection Law (Journal of Laws of 2013, item 1232, incl. further amendments) and the Act of October 3, 2008, on the release of information about the environment and its protection, participation of the public in the environmental protection and assessments of the environmental impact (Journal of Laws of 2013, item 1235, incl. further amendments). These acts are accompanied by several ordinances, of which the most important one implements the European targets concerning the limited values of air pollution to the Polish law. It is "The Ordinance of the Minister of the Environment of August 24, 2012, on the levels of certain substances in the air" (Journal of Laws of 2012, item 1031). These values are identical to those specified in EU legislation presented in Table 2.

The approach to assessing the concentration of carbon dioxide in the air is slightly different. This chemical compound is a natural element of the ambient air, where it accounts for approx. 0.03%. Thus, pollution may exist only in the case of drastic differences between the local concentration and the average global concentration. Carbon dioxide at the existing concentration levels in various places of the world is not harmful to the health of humans, plants, or animals, so its limit values are not defined. However, WHO issued recommendations on the concentration of this compound on premises. According to this organisation, it should not exceed 1,000 ppm. The limit value of carbon dioxide concentration in Poland workplaces is 9,000 ppm (Directive, 2008; Jagusiak & Stochaj, 2018).

Measures and Indicators of Air Pollution Levels

The indicators determining air pollution levels include technical, social, and economic indicators. The first type (technical indicators) include the type of heating devices used in the municipal and households sector; the type of boilers or furnaces, and the quality of coal used by households; the technologies of solid fuel (coal and biomass) combustion in heating devices; the energy efficiency level of buildings; the type and quality of heating fuel preferred by households; the level of adaptation of the flue pipes of multi-family buildings to the type of heating and the ventilation system used in the given household (Świerszcz, 2021b; Men et al., 2021). The second type of indicator (economic indicators) is the amount and type of financial instruments allocated to activities in the municipal and household sector; the amount of funds spent on the corrective actions specified in air protection programmes and the liquidity of their realisation; the level of incentives and financial support for the application of modern solutions and clean energy, e.g. from Renewable Energy Sources (RES) in adapted equipment, which may guarantee the fulfilment of the relevant requirements of EU legislation; support for co-generation that enables reconstructing old heating plants into combined heat and power (CHP) facilities and replacing the depreciated property of existing CHP plants; the excise tax policy of the state applied to fuel prices that takes into account environmental aspects; financial support other than from local government budget for the realisation of shield programmes that guarantee the durability of the environmental effect, addressed to households that change the way of heating and use environmentally-friendly fuel furnaces; co-financing and co-realisation of pro-efficiency, pro-environmental activities by third parties as part of a wide range of public-private partnership solutions (Rao et al., 2021). The third type of indicator (social indicators) refers to the choice of the heating solutions based on investment and operational costs; social awareness of the effects of poor air quality and environmentally friendly behaviour that includes the way of burning solid fuels, including coal and wood in boilers and fireplaces, as well as the awareness of the effects of the combustion of waste in devices that are not fit for this purpose (National…, 2015; Rosario, Urrutia-Pereira et al., 2021; Shen et al., 2021).

The measures of air pollution are various types of concentrations of pollutants that are present in the air, e.g., suspended particles of two-particle diameter sizes: up to 2.5 micrometres ($PM_{2.5}$) and to 10 micrometres (PM_{10}), carbon dioxide (CO_2), lead (Pb), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) or benzo(a)pyrene.

Local Air Pollution in the Town of Barlinek

The heating network in the town of Barlinek is supplied from the source operated by the SEC Region Company, which is part of the holding Szczecińska Energetyka Cieplna that operates heating plants in Szczecin and several nearby towns. The heating network belongs to the same company. In Barlinek, the company operates a coal heating plant. In 2015–2019, the heat sold was practically constant, at 82,000 GJ per year. Only in 2015 it was 10,000 GJ lower. It probably resulted from the decreasing number of heat recipients, as the production was also lower. It is presented in Figure 3.

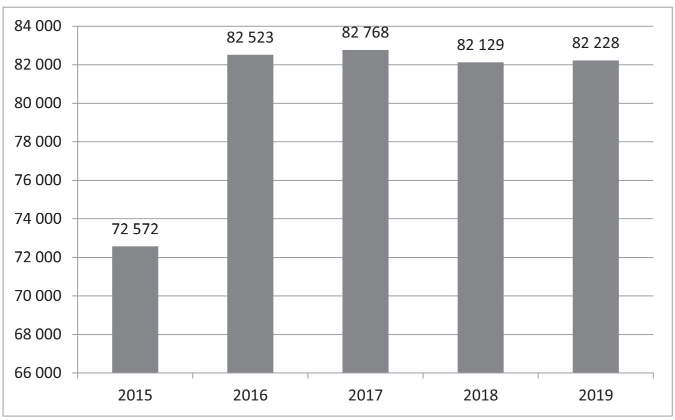

Figure 3. Changes in the network heat production in Barlinek in 2015–2019

Source: own study based on information from the SEC Region Company.

The structure of heat recipients in town refers to the year 2018, and, according to the statements of the Company, it has not changed in subsequent years. The main recipients of heat are multi-family houses owned by housing co-operatives (43%) or communities of residents (20%). Public facilities (from the budget sector) also had a significant share (21%). It is shown in Figure 4.

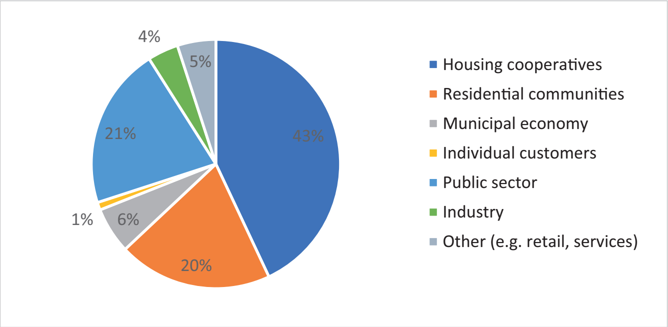

Figure 4. Structure of network heat recipients in Barlinek (2018).
Source: own study based on information from the SEC Region Company.

The price of heat (considering all fees) fell from 67.69 PLN/GJ in 2015 to 63.71 PLN/GJ in 2019. However, in 2017, the price decreased to the lowest level of 61.29 PLN/GJ, then increased again. It is presented in Figure 5. The higher price of heat in 2015 may have resulted from the lower number of recipients and the need to allocate the same fixed costs to the company. However, this is only a supposition, as such information was not confirmed in the survey.

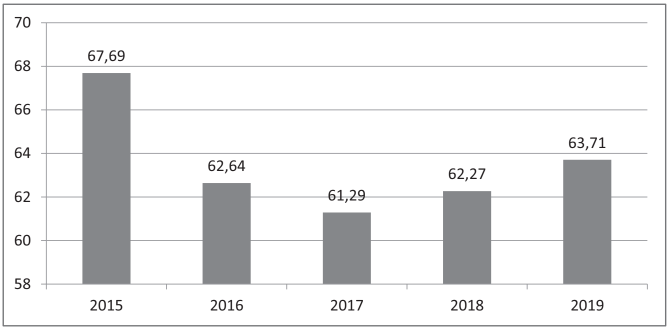

Figure 5. Changes in heat prices in Barlinek (PLN/GJ) in 2015–2019.
Source: own study based on information from the SEC Region Company.

In Barlinek, no air pollution measurement station belongs to the national measurement network. The local heat producer did not provide information about the emissions to the air either. It is why the author conducted her own air pollution measurements for research purposes, with the use of special equipment. The measurements focused on the following factors: suspended particles (PM $_{2.5}$ and PM_{10}) and carbon dioxide (CO_2).

The author's measurements of the concentration of PM10 in Barlinek reveal that the air quality level is insufficient. These results are presented in Table 4.

Table 4. Results of PM_{10} concentration measurements in Barlinek.

PM_{10}	Height (m)	p1	p2	p3	p4	p5	p6	p7	P8	Average
Barlinek	1.5	7.77	**97.43**	**150.8**	**169.7**	**46.2**	5.57	4.24	5.02	60.83875
	3	38.87	**102**	**106.1**	**109.8**	**61**	4.74	9.18	4.63	54.5375
	5	15.76	**88.34**	**83.76**	**64.8**	**61.49**	4.35	4.81	3.83	40.8925

Source: own study.

Research demonstrates that the annual limit value for the concentration of PM_{10} was exceeded several times at each height. The average for specific heights is higher than the expected limit values specified in national and European regulations. The maximum measured concentration of PM_{10} is more than two times higher than the expected limit value for daily values. This pollution, measured at specific heights – 1.5m, 3m, and 5m – is shown in Figures 6, 7, and 8.

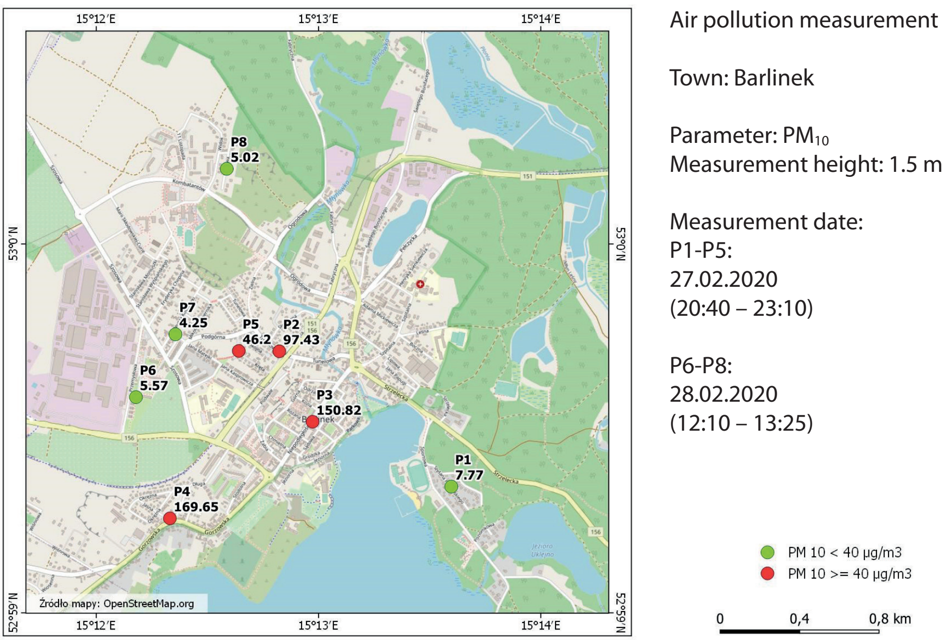

Figure 6. Measurement of air pollution with PM_{10} at the height of 1.5 m in Barlinek.
Source: own study.

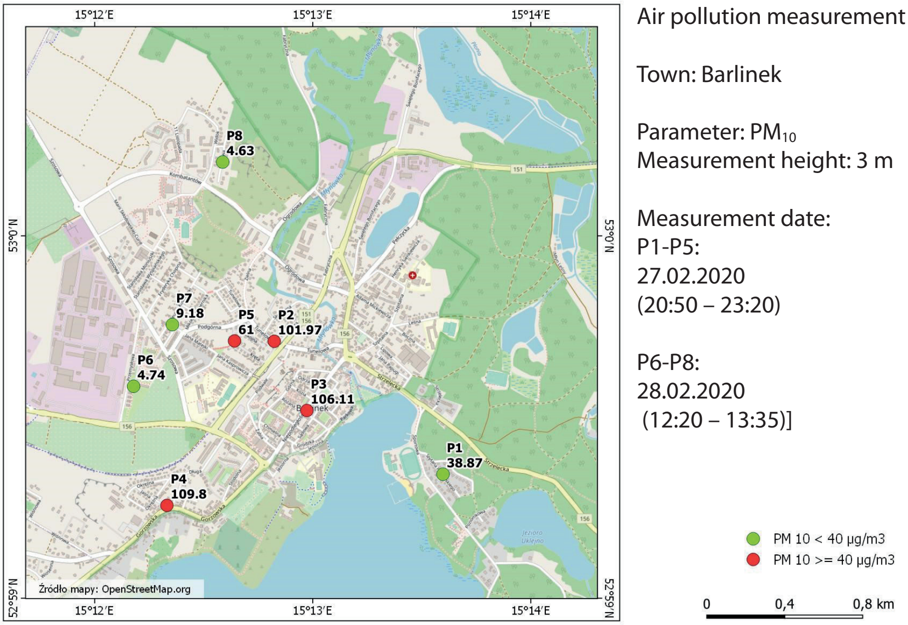

Figure 7. Measurement of air pollution with PM_{10} at the height of 3 m in Barlinek.
Source: own study.

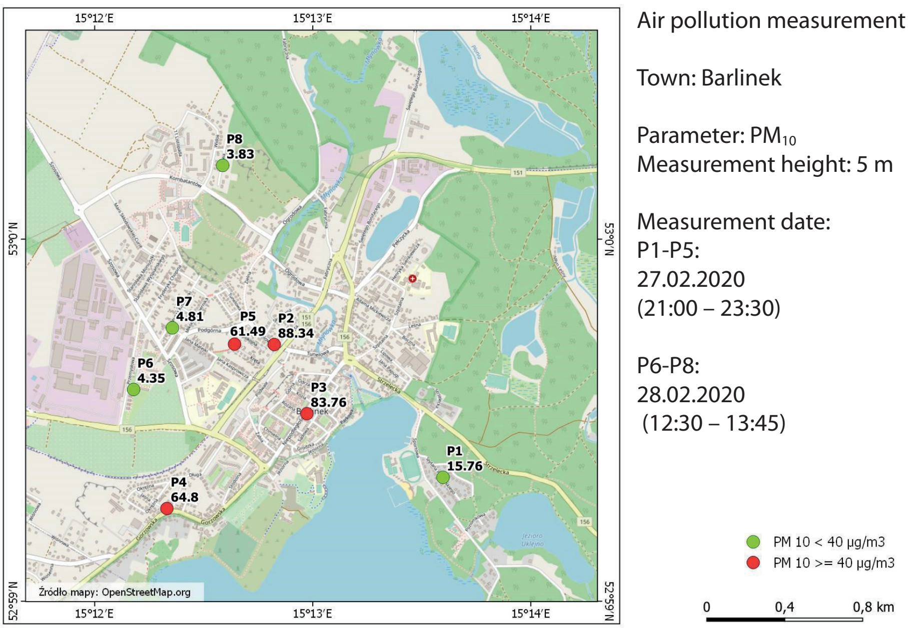

Figure 8. Measurement of air pollution with PM_{10} at the height of 5 m in Barlinek.
Source: own study.

The measurements of the concentration of $PM_{2.5}$ for Barlinek also demonstrate an insufficient level of air quality in town. The average concentration of $PM_{2.5}$ in Barlinek is higher than the expected limit values, averaged for the year, specified in national and European legislation. This level was exceeded at several points in the city at various heights. Some of the noted values exceeded the annual limit value several times. These results are presented in Table 5 and Figures 9, 10, and 11.

Table 5. Results of $PM_{2.5}$ concentration measurements in Barlinek.

$PM_{2.5}$	Height (m)	p1	p2	p3	p4	p5	p6	p7	P8	Average
Barlinek	1.5	5.94	**61.84**	**91.01**	**86.75**	**30.23**	3.32	2.78	2.54	35.55125
	3	**30.22**	**66.59**	**64.97**	**60.75**	**37**	2.84	5.62	1.87	33.7325
	5	12.79	**58.25**	**51.2**	**37.74**	**37.68**	2.71	3.31	1.7	25.6725

Source: own study.

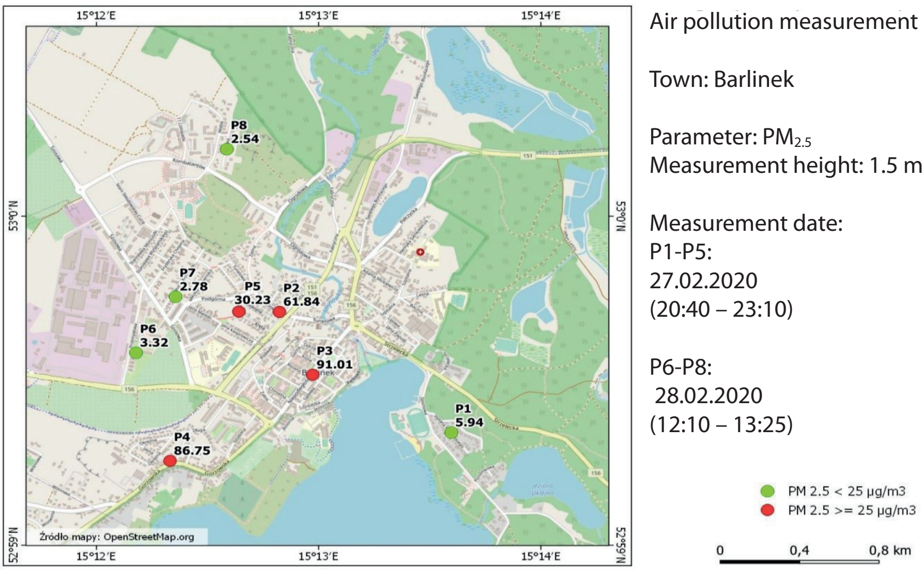

Figure 9. Measurement of air pollution with $PM_{2.5}$ at the height of 1.5 m in Barlinek.
Source: own study.

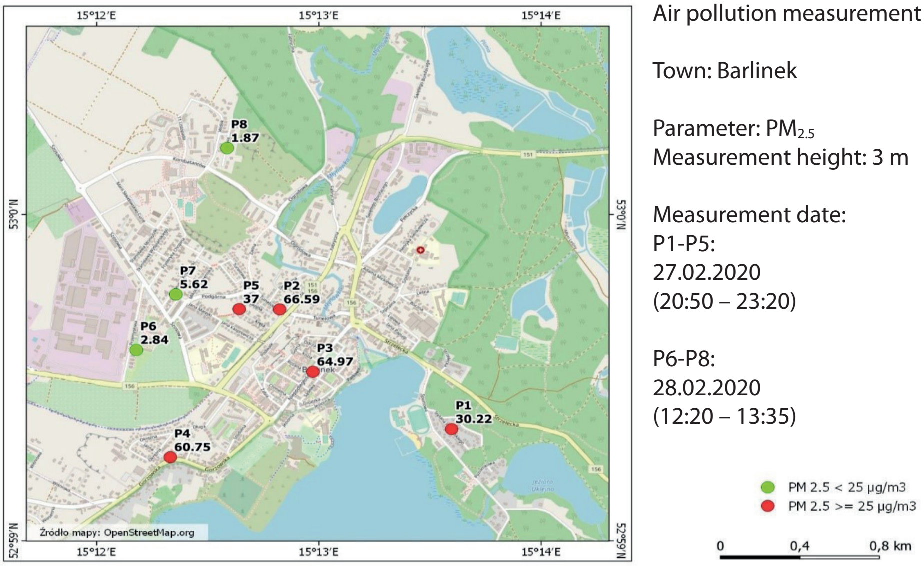

Figure 10. Measurement of air pollution with $PM_{2.5}$ at the height of 3 m in Barlinek.
Source: own study.

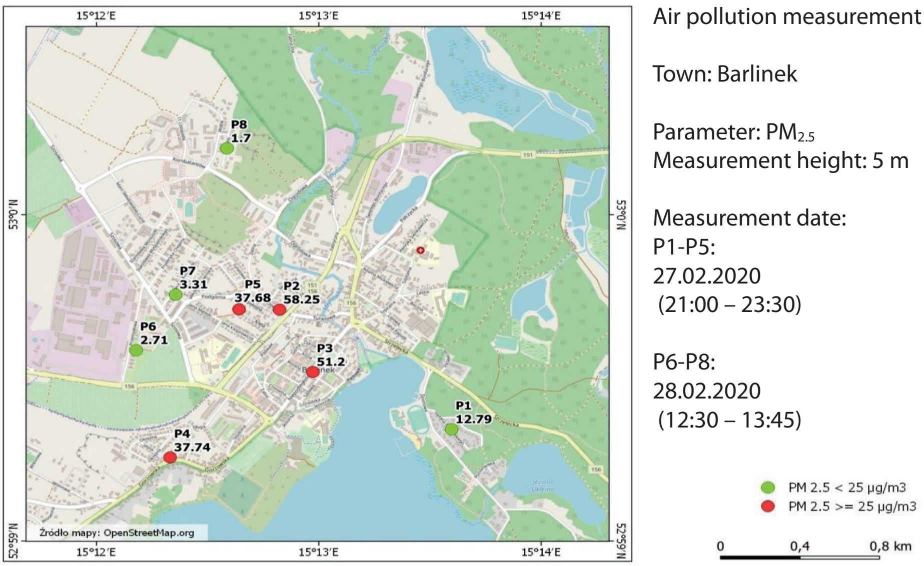

Figure 11. Measurement of air pollution with $PM_{2.5}$ at the height of 5 m in Barlinek.
Source: own study.

The measurements of another type of pollutant (CO_2) in Barlinek, conducted by the author, also point, without any exceptions, to high concentrations in reference to the global average (410 ppm). The measurement results are presented in Table 6 and Figures 12, 13, and 14.

Table 6. Results of CO_2 concentration measurements in Barlinek.

CO_2	Height (m)	p1	p2	p3	p4	p5	p6	p7	P8	Average
Barlinek	1.5	**500.59**	**572.31**	**643.17**	**722.58**	**643.17**	**1130.0**	**1248.9**	**912.82**	769.8113
	3	**500.59**	**572.31**	**664.1**	**722.58**	**643.17**	**1130.9**	**1248.9**	**912.82**	799.4275
	5	**480.15**	**508.99**	**494.69**	**727.63**	**475.14**	**818.33**	**934.16**	**689.14**	641.0288

Source: own study.

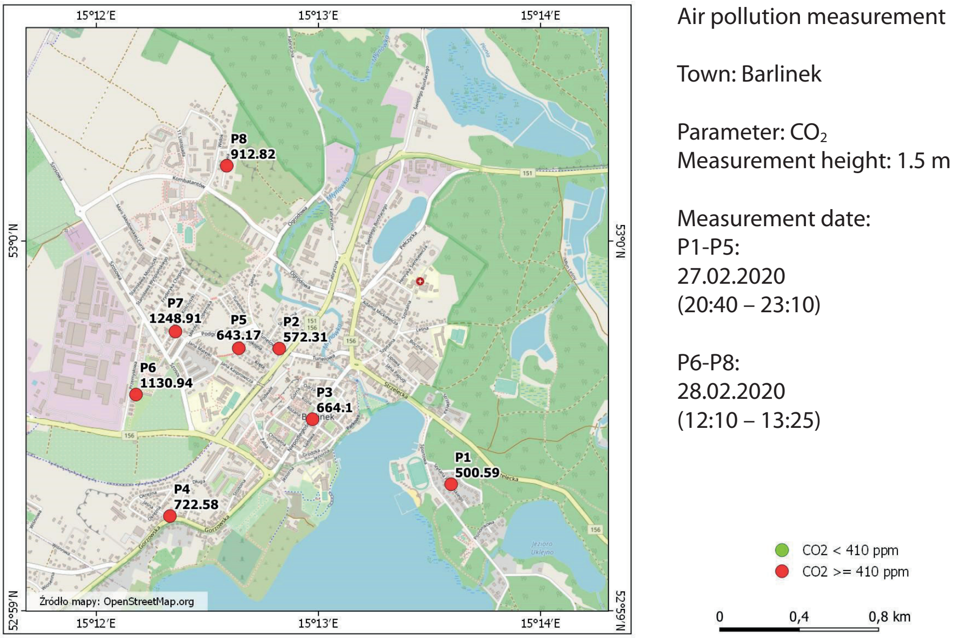

Figure 12. Measurement of air pollution with CO_2 at the height of 1.5 m in Barlinek.
Source: own study.

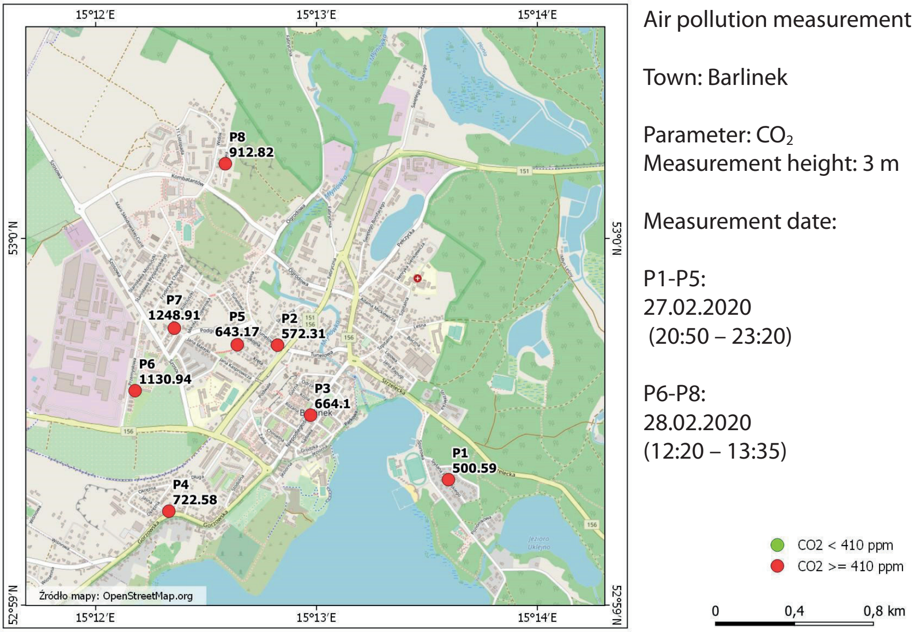

Figure 13. Measurement of air pollution with CO_2 at the height of 3 m in Barlinek.
Source: own study.

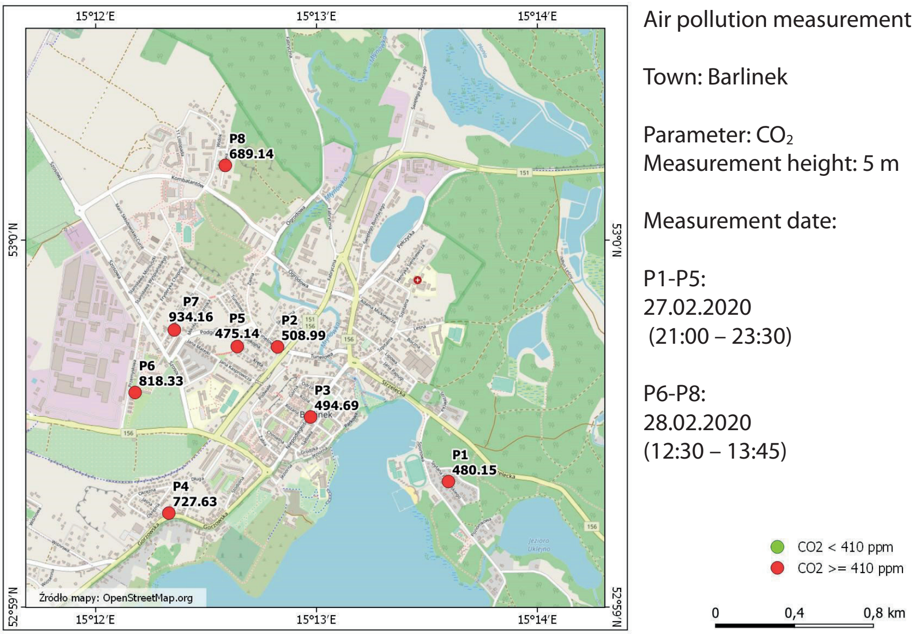

Figure 14. Measurement of air pollution with CO_2 at the height of 5 m in Barlinek.
Source: own study.

Discussion

The research on air pollution in the town of Barlinek reveals that residents perceive the phenomenon as a rather serious or very serious problem that they experience in their place of residence and the neighbourhood (according to 37% of the respondents). It is shown in Figure 15.

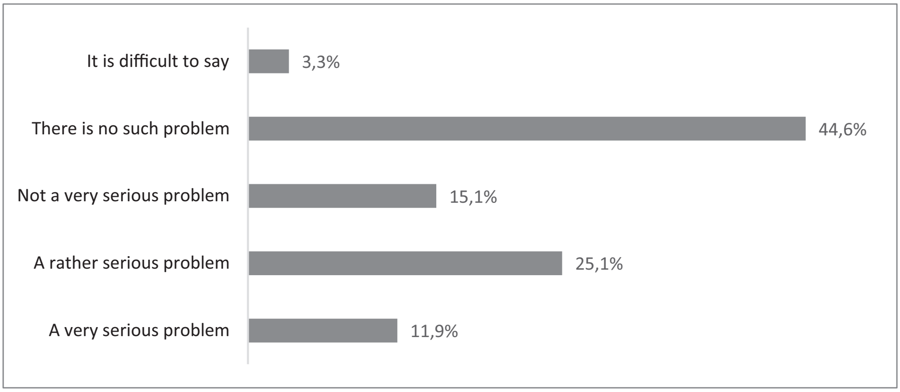

Figure 15. The problem of poor air quality at the place of residence/in the vicinity of the town Barlinek, N=1222
Source: own study.

Considering the results of the empirical air quality analysis, the survey results among residents are not surprising. The noticeable and severe pollution in the town of Barlinek was confirmed not only by the opinions of residents but also among territorial self-government units. They pointed to the existing correlation between low emissions and the phenomenon of heat poverty in households in their town. It was proven by their answers to the following question: What investment or activity realised by the town as part of counteracting heat poverty in the last five years would you describe as a model? In their answers, the respondents stated that these were the same activities as those aimed at preventing low emissions. The most often mentioned activities were thermal modernisation (thermal insulation, replacement of window and door frames and roof sheathing), development of the heating network (expansion, connecting to the heating network and closing of local heating facilities), and the replacement of individual furnaces and boilers.

Considering that, one may conclude that the circumstances that contribute to the air pollution level are also barriers to counteracting heat poverty. The three most frequently mentioned barriers were: high bureaucracy, lack of funds, and the passive attitude of persons at risk of heat poverty. The complexity of the applications, obscure instructions, vague language, and the excessive number of documents discourage the beneficiaries from completing and filing the applications for subsidies. Residents and public offices suffer from a lack of funds for realising investments. The lack of possibility to cover their own contributions by beneficiaries of the programmes of subsidies for the replacement of furnaces or thermal modernisation was mentioned multiple times. This aspect makes government programmes inaccessible to people with low income. Apart from the inability to afford to benefit from subsidies, those who are at risk of heat and energy poverty often are unwilling to accept changes and show a passive attitude.

One should note that, on the European scale, air pollution is analysed based on several different sources of pollutants, according to the main sectors of the economy. In 2021, the European Environment Agency presented the structure of emissions of various air pollutants from those sectors in its report. It also pointed to the two main sources of dust emissions, which are residential and commercial buildings. For $PM_{2.5}$, this source was responsible for 54% of the emissions, while for PM_{10} for 41% of the emissions from residential buildings. The industry is the second-largest sector responsible for this type of pollution (18% and 22%, respectively). It is shown in Figure 16.

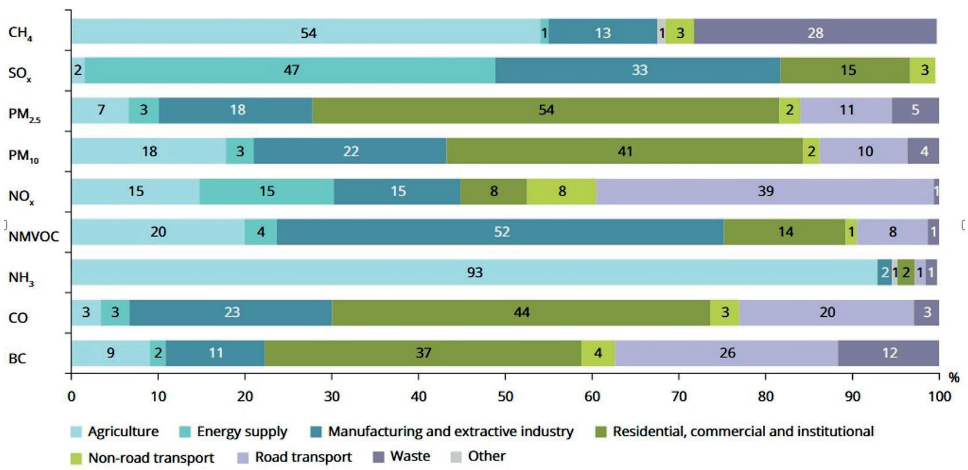

Figure 16. Europe's Contribution to EU-28 emissions from the main source sectors in 2020 of CH_4, SO_x, NO_x, primary PM_{10}, primary $PM_{2.5}$, NH_3, NMVOCs, CO and BC

Source: Air quality in Europe – 2021 Report, European Environment Agency (EEA). https://www.eea.europa.eu/publications/air-quality-in-europe-2021/health-impacts-of-air-pollutionEEA, 2021.

In Poland, the residential sector is the main source of dust emissions. In 95% of the zones subject to the assessment of PM_{10} pollution, the source of emissions exceeding the limit values is the municipal housing sector. The remaining 5% are caused by road traffic. As far as zones excessively polluted with $PM_{2.5}$ is concerned, the reason was, in 100% of cases, the emission from municipal and household sector (buildings). According to the European Environment Agency (EEA), in Poland, the housing sector is responsible for 44% of the $PM_{2.5}$

emission, while 10% of emissions are caused by transport. The remaining share is divided among power generation, industry, agriculture, and mining sectors.

According to the summary report on the assessment of air quality in zones in Poland in 2020, prepared by the General Inspectorate for Environmental Protection (GIOŚ) (Assessment…, 2021), the main cause of exceeded values of $PM_{2.5}$ and PM_{10} dust concentrations, together with the benzo(a)pyrene contained in this dust, are emissions from the municipal and housing sector and road transport. The concentrations of benzo(a)pyrene B(a)P that exceed the standard values result mainly from emissions from individual heating systems in apartments and single-family houses that use sold fuels, particularly in the winter. The common use of furnaces for the combustion of solid fuels, which are often of very poor quality, lower efficiency, and large pollution emission, in many regions of Poland, also influences the air quality (frequency of excessive values).

In the opinion of the respondents in this quantitative research, the most common reason for air pollution in their place of residence or the neighbourhood where the residents function is the combustion of waste/garbage. One-third of the respondents (respectively 32.9 and 31.2%) mentioned burning poor quality coal and using faulty, outdated equipment, i.e., the main factors listed in the report by the GDEP. It is shown in Figure 17.

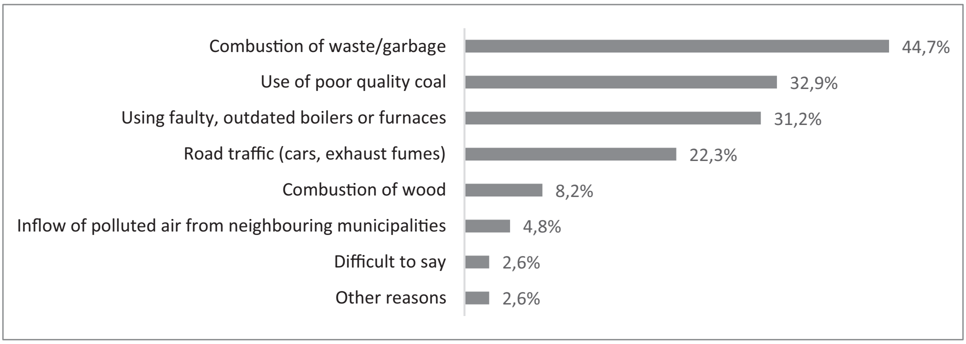

Figure 17. Reasons for air pollution in the place of residence/neighbourhood where the respondents live, N=1222

Source: own study.

The analysis shows that the least frequently mentioned reasons for air pollution are the inflow of poor-quality air from the neighbouring municipality or the combustion of wood by residents.

Summary

The research conducted in the town of Barlinek concerning the phenomenon of air pollution understood as a measure of local environmental safety pointed to a series of related limitations. They refer first of all to the systemic, technical, economic, social, and organisational actions and solutions. These limitations have a direct and indirect influence on the air quality and thus on the state and quality of local environmental safety. The main systemic barrier is the lack of a systematic and comprehensive approach to activities aimed at improving air quality, as defined in the relevant sector policies. The technical barriers include the use of high-emission heating devices in the municipal and housing sector; the use of low-quality heating sources by households that use individual boilers or furnaces that are not equipped with measures to reduce the emission of pollutants; the use of faulty and outdated heating equipment and living in houses of low energy efficiency. The economic barrier is the fact that local government units do not have sufficient funds for corrective actions in the municipal and housing sector; supporting households in the participation in programmes and the related corrective actions specified in air protection programmes and the connected delays in their realisation; insufficient level of financial incentives (support) to use modern solutions and clean energy, e.g. from Renewable Energy Sources, in suitable equipment; lack of support for co-generation that enables reconstructing old heating plants into combined heat and power (CHP) facilities and replacing the depreciated property of existing CHP plants; absence of the excise tax policy of the state applied to fuel prices that takes into account environmental aspects; as well as the lack of financial support from sources other than local government budget for the realisation of shielding programmes (that guarantee the durability of environmental effects) for persons who change the manner of heating and use boilers that combust environmentally friendly fuels. Social barriers include the choice of the cheapest way of heating that results from the investment and operating costs borne by households; low social awareness of the influence of poor air quality on the health and the condition of the environment; and low social awareness of pro-environmental behaviour, such as proper combustion of solid fuels, including coal, wood in boilers and fireplaces and the effects of the combustion of waste in equipment that is not fit for this purpose. Finally, the organisational barriers are insufficient human resources among Territorial Self-Government Units that are responsible for the realisation and control of corrective measures concerning air quality and thus the environmental safety of the town.

Considering that, the research results presented in this paper are valuable both from the point of view of Poland as a member state of the European Union obliged to ensure environmental safety and the related energy safety in the national aspect, Territorial Self-Government Units, and other entities and enterprises obliged to ensure environmental safety and the related energy safety in the local aspect. It is also vital for households responsible for implementing actions to increase ecological awareness and related energy efficiency.

References:

Act of April 27, 2001 – Environmental Protection Law (Journal of Laws of 2013, item 1232, incl. amendments). https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20010620627/U/D20010627Lj.pdf

Act of October 3, 2008 on the release of information about environment and its protection, participation of the public in the environmental protection and assessments of the environmental impact (Journal of Laws of 2013, item 1235, incl. amendments). http://www.przepisy.gofin.pl/przepisy,3,29,164,992,328945,20211223,art-8-28-udostepnianie-informacji-o-srodowisku-i-jego.html

Directive 2004/107/EC of the European Parliament and of the Council of 15 December 2004 relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air. https://powietrze.gios.gov.pl/pjp/publications/card/3079

Directive 2008/50/EC of the European Parliament and the Council of May 21, 2008, on ambient air quality and cleaner air for Europe (Official Journal of the EU L 152 of the 11.6.2008). https://sip.lex.pl/akty-prawne/dzienniki-UE/dyrektywa-2008-50-we-w-sprawie-jakosci-powietrza-i-czystszego-powietrza-dla-67775294

European Environment Agency. (2021). Air quality in Europe – 2021 Report. https://www.eea.europa.eu/publications/air-quality-in-europe-2021/health-impacts-of-air-pollution

Główny Inspektorat Ochrony Środowiska. (2021). *Jakość powietrza w Polsce w roku 2020 w świetle wyników pomiarów prowadzonych w ramach Państwowego Monitoringu Środowiska*. NFOŚiGW.

Jagusiak B., & Stochaj J. (2018). Wyzwania z zakresu zagwarantowania bezpieczeństwa ludności cywilnej. In B. Jagusiak (Ed.), *Systemy bezpieczeństwa w teorii i praktyce* (pp. 169–180). WAT.

Jagusiak, B., & Stochaj, J. (2017). Praktyczne uwarunkowania bezpieczeństwa europejskiego – wymiar społeczny. In B. Jagusiak & K. Karski (Eds.), *Praktyczne uwarunkowania bezpieczeństwa europejskiego* (pp. 211–232). WAT.

Men, Y. T., Li, J. P., et al. (2021). Contributions of internal emissions to peaks and incremental indoor PM (2.5) in rural coal use households. *Environmental Pollution, 288*, Article Number 117753. DOI: 10.1016/j.envpol.2021.117753

MŚiDOP. (2015). *National Air Protection Programme until 2020 (planned until 2030)*.

NFOŚiGW. (2021). *Ocena jakości powietrza w strefach w Polsce za rok 2020. Zbiorczy raport krajowy z rocznej oceny jakości powietrza w strefach wykonanej przez GIOŚ według zasad określonych w art. 89 ustawy - Prawo ochrony środowiska*.

Ordinance of the Minister of the Environment of August 24, 2012, on the levels of certain substances in ambient air (Journal of Laws of 2012, item 1031).

Rao, N. D., Kiesewetter, G., et al. (2021). Household contributions to and impacts from air pollution in India. *Nature Sustainability, 4*(10), 859. DOI: 10.1038/s41893-021-00744-0

Rosario, N. A., et al. (2021). Air pollution and indoor settings. *World Allergy Organization Journal, 14*(1). DOI: 10.1016/j.waojou.2020.100499

Shen, G. F., Xiong, R., Cheng, H. F., & Tao, S. (2021). Rural residential energy carrier structure and primary PM2.5 emissions from the Qinghai-Tibet Plateau. *Chinese Science Bulletin-Chinese, 66*(15), 1900–1911. DOI: 10.1360/TB-2020-0408

Świerszcz, K. (2021). Current Challenges in Sustainable Management of Local Energy Security in Reducing Heat Poverty - A Case Study of a Selected Region of Poland. In K. S. Soliman (Ed.), *Proceedings of the 37th International Business Information Management Association Conference (IBIMA), Innovation Management and information Technology impact on Global Economy in the Era of Pandemic*. (pp. 192–202). IBIMA.

Świerszcz, K. (2021). *Stan bezpieczeństwa energii cieplnej w Polsce na tle Europy*. WAT.

Świerszcz, K., & Grenda, B. (2019). Geothermal Energy as Near-Ground Emissions Reduction Potential in the Energy and Climate Security Policy Strategy as Illustrated by the Podhale Region. *Proceedings of the 4th International Conference on Power and Renewable Energy (ICPRE2019)* (pp. 110–116). IEEE PRESS.

Świerszcz, K., Szczurek, T., Mitkow, S., Zalewski, J., & Ćwik, B. (2019). Knowledge of the Problem of Fuel Poverty Among Local Government Authorities – in the Aspect of Local Energy Security. *Journal of Eastern Europe Research in Business and Economics (JEERBE), 2019*. DOI: 10.5171/2019.780276

Świerszcz, K., Szczurek, T., Mitkow, Sz., Zalewski, J. & Ćwik, B. (2019). Level of Local Government's Awareness of Heat Energy Poverty in Households as an Indicator of the Degree of Energy Security at the Local Level. In K. S. Soliman (Ed.), *Proceedings of the 33rd International Business Information Management Association Conference (IBIMA)* (pp. 588–599). IBIMA.

Tan, Y. T., Keh, C. G., Tang, S. E., & Gan, P. T. (2022). Evaluating the COVID-19 response policy's impact on carbon dioxide emissions in the top four CO2 emission countries. *Management of Environmental Quality*. DOI 10.1108/MEQ-08-2021-0183.