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AIR QUALITY ASSESSMENT IN THE MUNICIPALITY OF WADOWICE

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Abstract

The article presents an analysis of pro-ecological activities in the municipality of Wadowice in the field of air quality protection against the effects of low emission. Research conducted by the Provincial Inspectorate for Environmental Protection in Krakow indicated that in the town of Wadowice, the capital of the municipality, in the period from October till March, the permissible level of particulate matter (PM10) was exceeded on average approximately 16 times within one month. The municipality of Wadowice is one of the most polluted municipalities of the Małopolska voivodeship. The elaborated municipal Low-Emission Economy Plan, updated in 2017, is coherent with the climate and energy package and implements the guidelines of the new European Union 2020 strategy for economic and social development. Until 2015, the municipality had implemented the KAWKA program, which led to liquidation of 11 coal-fired boiler rooms and installation of 11 new boiler rooms. The continuation of the system in 2016 enabled the closure of further 31 coal-fired boiler rooms and the assembly of new boiler rooms and 10 solar panel installations in order to reduce emissions in the local fuel-fired heat source.

Keywords: low emission, boilers, pollution, PM10 particulate matter

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INTRODUCTION

Currently, municipalities are struggling with numerous problems of air quality protection and countermeasures against the multiple effects of low emission in the economic, social and natural spheres. More and more attention at the international, national and local level is also being drawn to irrational economy of natural resources, uncontrolled spread of buildings, the growth of space chaos, and disproportion in the standard of living of urban communities (Ogrodnik 2017). The idea of sustainable development (Ogrodnik 2017) begins to play an important role in contemporary urban planning. According to Mierzejewska (2009), „the sustainable development of the city will be such a socio-cultural development that will reduce the pressure on the natural environment as well as ensure the improvement of the life standard of both current and future residents". Air quality is connected with the idea of sustainable development.

Air protection against pollutants is an important element of the European environmental policy. This is confirmed, inter alia, in the provisions of the CAFE Directive on Reduction of Low Emission (Directive 2008/50/We of 21 May 2008 of the European Parliament and European Council on air quality and cleaner air for Europe). The Directive is the main legal instrument at the EU level in the field of air pollution and apart from introducing new mechanisms for air quality assessment and management, including in particular PM2.5 particulate matter suspended in the air, it also verifies and consolidates existing the European Union legislation relating to this issue (NIK 2014).

At the national level, the definition of *emission and pollution* was introduced in the Act of 27 April 2001 on Environmental Protection Law (Journal of Laws No. 62, item 627, as amended). *Emission* is understood as „the introduction, directly or indirectly, into air, water, soil or earth: a substance, energy such as heat, noise, vibrations or electromagnetic field as a result of human activity „. *Pollution* is defined as „emission that is harmful to human health or the environment, causes damage to tangible goods, worsens the aesthetic values of the environment or interferes with other, justified methods of using the environment."

Sources of air pollution are divided into natural and man-made. The first results from the natural activity of the nature itself, without human engagement. e.g. inorganic and organic air pollutants and gas pollutants mainly in the form of carbon and sulfur compounds. Man-made sources, also called anthropogenic ones, are associated with human activity. Low emission sources should mostly belong to the latter group (Nadziakiewicz 2005).

Pollutants get into the air from **point sources** in an organized manner (Table 1), i.e. through individual chimneys or set of chimneys, which is mainly typical of industrial emission. **Surface sources** introduce pollutants into the air from a given surface. These include, inter alia, individual emitters in the munic-

ipal sector, located in close proximity to each other (e.g. local chimneys from individual house furnaces). **Linear sources of pollution** created by emitters located along a specific line, determined, for example, by the road route can also be distinguished. Heavy traffic transport routes and chimneys located linearly, close to each other are often such emission sources (Pałysz 2016).

Table. 1. Basic sources of pollutant emissions into the atmospheric air (Pałasz 2016)

The source of emission	The main types of pollutants
point	Particulate matter, SO_2, NO_x, CO_x, heavy metals (As, Pb, Cd, Ni, Hg)
surface	Particulate matter, SO_2, CO_x,
linear	NO_x, CO_x, heavy metals (mainly Pb)

Source: Author's own elaboration

According to Pałasz (2016), low emission is not legal in nature. It is usually understood as pollutants created in the municipal and household sector, inter alia, due to ineffective combustion process of fuels, mainly coal in household furnaces and as so-called transport emission.

Stelmach et al. (2017) explains that low emission mainly results from inefficient combustion of solid fuels that are used to heat houses in the autumn and winter seasons. In their research, Pałasz (2016) and Czajkowska-Matosiuk et al. (2017) prove that the creation of low emission is a complicated process, depending on the type, quantity and quality of the fuel burned, the method and technology of its combustion, numerous meteorological factors, the topography and development of the area, the height and location of the emission sources.

According to the National Inventory Report, in 2016, carbon dioxide (81.65%) played a dominant role in domestic emission in Poland, while the share of methane and nitrous oxide was much smaller and amounted to 10.9% and 5.2% respectively (National Report Inventory 2016). According to CSO data (GUS) published in 2017, in Poland in 2016, hard coal consumption reached the level of 74.2 million tons (excluding heating consumption in entities which belong to the section D "Production and demand for electricity, gas, steam, hot water and air for conditioning systems"). The energy sector accounted for 59% of consumption, and nearly 24% for industry and construction, including own consumption of mines and consumption for the input for transformation activities in coking plants. Households (14%) were the major consumer of coal. In the classification of provinces the highest consumption occurred in the following voivodeships: Śląskie, Mazowieckie and Opolskie, and the smallest in Lubuskie, Podlaskie and Warmia-Mazury. The Śląskie province was characterized by the highest consumption (28.3%) both in the energy sector and in industry and con-

struction. In the Śląskie and Opolskie provinces, the volume of consumption in industry and construction was largely influenced by the location of coking plants in these provinces (CSO 2017).

Analyzing the structure of energy consumption in households in Poland in 2016, solid fuels, mainly hard coal (which is an exception in the EU) and firewood played a significant role. The consumption of natural gas (excluding consumption for technological needs of the gas sector) amounted to 592.1 PJ. The highest consumption of natural gas occurred in the Mazowieckie voivodeship (20.6% of the consumption in the country), whereas the smallest in the Podlaskie voivodeship (0.8%). Natural gas consumption in industry and construction, including the consumption for the input for transformation activities in coking plants and refineries accounted for 47.5% of total consumption, 11.9% in the energy sector, 3.1% in transport, and 37.6% in the small consumer sector (CSO 2017). The use of natural gas in households, industry and construction is a good alternative to hard coal and a way to counteract low emission.

The Małopolska voivodeship is at the forefront of the regions with the largest amounts of air pollution in the country. In the Małopolska, the problem of low emission from hard coal combustion in local boiler plants and individual furnaces, transport and pollution coming from neighboring areas is evident (Klojzy-Karczmarczyk, Mazurek 2009). In order to counteract this problem, the share of emission sources from the outside of the province started to be considered, taking into account all sources of emission in the area of 50 km from its borders (CSO 2017). In this respect, sources of emission were located in the Śląskie, Podkarpackie, Opolskie and Świętokrzyskie provinces (CSO 2017). From outside of the Małopolska voivodeship, the sources located in Slovakia and part of the Czech Republic (CSO 2017) were also considered.

AIM, MATERIAL AND METHOD

The purpose of the article is analysis of pro-ecological activities in the municipality of Wadowice in the field of air quality protection against the effects of low emission. The following study evaluates pro-ecological activities in the municipality of Wadowice regarding the protection of air quality against the effects of low emission. Data referring to the PM10 particulate matter level was obtained from the air quality monitoring station, which in January 2017 had been installed in the city center. The analyzed data for the period 2011-2015, concerning the number of days with exceedances of 24-hour permissible concentrations of PM10 particulate matter, came from the Air Protection Program called *"Małopolska in a healthy atmosphere" (Małopolska w zdrowej atmosferze)* for the Małopolska province.

CHARACTERISTICS OF THE RESEARCH AREA

The municipality of Wadowice is one of the municipalities with the highest degree of low emission pollution in the Małopolska voivodeship. Research carried out by the Provincial Inspectorate for Environmental Protection in Krakow indicated that in the town of Wadowice, the capital of the municipality, between October and March, the permissible level of PM10particulate matter was exceeded, on average, around 16 times within one month. The municipality of Wadowice is therefore one of the most polluted communes of the Małopolska.

The municipality of Wadowice is characterized by considerable population (Table 2) and favorable geographical location in the Skawa valley, at the intersection of important transportation routes, between Silesia and Podhale and between Krakow and Cieszyn (the Development Strategy of the Municipality of Wadowice for the years 2014-2020).

Table 2. Number of inhabitants in the municipality and town of Wadowice

Municipality/Town	Permanent and temporary residence	Permanent residence
municipality of Wadowice	38282	37494
town of Wadowice	19117	18516

Source: Author's own elaboration based on data from the Wadowice Municipal Civil Affairs

The town of Wadowice, the capital of the municipality, has been the largest economic center in the Wadowice administrative district for many years and has a very large development potential, resulting from many conditions. Both prospects and previous actions place Wadowice very high in the ranking of towns in terms of the dynamics of development. The municipality of Wadowice is the leader in terms of the number of companies operating in its area, both in the public and private sectors. The dominant role here is played by companies falling into the sector of small and medium-sized enterprises. The woodwork and footwear industry, the production tycoons of the food and machine industry are the economic hallmark of the local entrepreneurship (the Development Strategy of the Municipality of Wadowice for the years 2014-2020).

Sucha Beskidzka, which is a neighbor of Wadowice, also struggles with the problem of air quality. In 2014, the mean annual PM10 particulate matter concentration in the municipality amounted to 46.9 $\mu g/m^3$ and exceeded the permissible concentration level as recommended by CIEP (GIOŚ). The amount of pollution reduction was feasible due to the liquidation of the coal boilers. In the years 2014-2016, 1055 boilers were dismantled and 103 buildings underwent thermal modernization. Only in 2016 itself, RES (solar installations) were installed in 402 buildings. Sucha Beskidzka is one of the two towns in the entire

Małopolska, which fully implemented the Air Protection Program planned for the years 2013 – 2015 (Petryk 2017).

RESEARCH RESULTS AND DISCUSSION

According to the Air Protection Program for the Małopolska called "*Małopolska in a healthy atmosphere*", the average daily concentrations of PM10 particulate matter can exceed the value of 50 $\mu g \cdot m^{-3}$ only 35 days a year. In Wadowice at the measurement station, the value of daily-average concentrations was exceeded for a greater number of days. These concentrations were exceeded even for 104 days in 2013 (Table 3).

Table 3. Number of days with exceedances of 24-hour permissible concentrations of PM10 particulate matter at the measurement station in Wadowice in the years 2011-2015

Location of the station	Number of days with occurrence of 24-hour PM10 particulate matter concentrations above 50 $\mu g \cdot m^{-3}$, Permissible number of days (since 2005): 35				
	2011	2012	2013	2014	2015
Wadowice	94	101	104	90	-

Source: Author's own elaboration based on the Air Protection Program for the Małopolska

The smallest number of days with exceedances at measurement stations occurred in 2014. The number of days with exceedances in individual years is variable and is largely related to weather conditions and variable temperature.

The Low Emission Reduction Program for the municipality of Wadowice was adopted by the resolution of the Town Council of December 12, 2012. The municipality systematically made corrections to the Low Emission Reduction Program in 2014, 2015 and 2017. The main goal of Low-carbon Economy Plan was to improve the air quality and comfort of inhabitants by reducing air pollutants, including CO_2, and reducing final energy consumption in all sectors. The following were identified as the priority objectives: (Low-emission Economy Plan with elements of mobility 2017):

- reduction of final energy consumption by 19071.54 MWh, or by 0.22%
- CO_2 emission reduction by 6148.22 Mg/year, i.e. by 0.10%
- increase in the share of energy from RES by 120 MWh/year, or to 0.18%
- PM10 particulate matter emission reduction by 27.91 Mg/year that is by 13.44%
- reduction of PM2.5 particulate matter by 28.85 Mg/year that is by 17.08%
- benzo[a]pyrene emission reduction by 15.3 kg/year that is by 0.84%

- SO_2 emission reduction by 51.62 Mg/year that is by 0.92%

The most important task of the Low Emission Reduction Program (PONE) is the elimination of old low-efficiency heating devices as part of the subsidy system for exchanging heating sources being implemented by the municipality. The funds are allocated to residents and entities covered by the program. The subsidies are to bring specific benefits in the form of the ecological effect of air pollution reduction (Table 4).

Table 4. The required environmental effect of pollutant emission reduction for the municipality of Wadowice in the years 2012-2015 and assumed until 2023

Wadowice	In 2013-2015 [Mg/year]					till 2023 [Mg/year]				
	PM10	PM2,5	BaP	SO_2	CO_2	PM10	PM2,5	BaP	SO_2	CO_2
	6.60	6.75	0.004	15.05	1054.35	29.69	29.56	0.02	67.74	4744.59

Source: Author's own elaboration based on the Low-emission Economy Plan with elements of mobility for the municipality of Wadowice. Annex to Resolution No. XXXIII/252/2017 of the Town Council in Wadowice dated March 10, 2017.

Thanks to the cooperation of the mayor of Wadowice with the Krakow Smog Alert, in January 2017 a permanent air quality monitoring station was installed, which enables continuous measurement of the PM10 suspended particulate matter level and the carcinogenic benzo[a]pyrene. The measurement results showed a poor state of air quality. The values of average PM10 particulate matter concentration in 2017 at the monitoring station showed the exceedance of PM10 particulate matter level in the winter months. In January, a record-breaking value of 108.3 $\mu g \cdot m^{-3}$, exceeding twice the permissible level (Table 5), was recorded.

Table 5. The value of mean PM10 particulate matter concentrations in 2017 at the air quality monitoring station in Wadowice

Wadowice Market Square Station	02/2017	03/2017	04/2017	05/2017	06/2017	07/2017	08/2017	09/2017	10/2017	11/2017	12/2017
PM10 [$\mu g/m^3$]	108.3	58.5	33.3	28.1	21.2	17.2	22.7	21.8	35.0	65.9	62.7
Permissible level (since 2005):40 $\mu g/m^3$											

Source: Author's own elaboration based on data provided by the Municipal Office in Wadowice; measurement data for 2017

The actions of the municipality consisting in co-financing boiler replacement result in the intended effects, which can be clearly seen when comparing 2017 with 2018. In February 2018 PM10 level was lower (88.8 $\mu g \cdot m^{-3}$) than at

the same time in 2017, when it amounted to as much as 108.3 $\mu g \cdot m^{-3}$. March 2018 was worse, when the pollution was almost three times higher than in 2017 and reached the level of 89.5 $\mu g \cdot m^{-3}$ (Table 6).

Table 6. The value of mean PM10 particulate matter concentrations in 2018 at the air quality monitoring station in Wadowice

Wadowice Market Square Station	01/2018	02/2018	03/2018	04/2018	05/2018
PM10 [$\mu g \cdot m^{-3}$]	65.1	88.8	89.5	40.01	20.05

Source: Author's own elaboration based on data provided by the Municipal Office in Wadowice; measurement data for the period of January to May 2017

In the municipality of Wadowice, a company *"TERMOWAD" Energetyka Cieplna* operates which generates 95% of thermal energy distributed to the municipality (Table 7). In order to acquire new customers, the company systematically carries out renovations using funds acquired in 2010 as part of co-financing for the implementation of the project "Modernization of the District Heating Station in Wadowice" so as to improve the quality of heat production and reduce particulate matter pollutants emitted into the air.

Table 7. Final recipients of *THERMOWAD* as per 31 January 2016

No.	Type of final recipient	Number of recipients
1	Housing cooperatives	1
2	Housing communities	23
3	Industrial plants	2
4	Public utility buildings	31
5	Individual recipients	98

Source: Author's own elaboration based on letter correspondence as per 09 June 2017

Since 2014, the local government has been aiming at replacing heat sources and utilizing renewable energy sources and, as a consequence, connecting residents from the center of Wadowice to the heating network. Municipal authorities and companies consider the possibility of connecting buildings that can be connected to the network due to the convenient location and availability of the network. As part of the implementation of the PONE (Low Emission Reduction Programme) and KAWKA programs, in the years 2015-2016, 107 old coal-fired boiler rooms were liquidated and the following were installed:

- 58 – gas condensing boilers
- 43 – class 5 solid fuel fired boilers
- 3 – class 5 pellet boilers

- 3 – connections to the City Heating Network
- 10 – solar installations for hot utility water

Only in 2016, PLN 13,888.82 was paid from the own funds of the municipality so as to liquidate two coal-fired boiler rooms and to assemble gas boilers. In 2017, subsidies from own funds of the municipality covered a total of PLN 16,000.00.

An overview of the pro-ecological actions of the local government for the improvement of air quality in the municipality of Wadowice in the period from 2009 to 2017 is presented in Table 8.

Table 8. Activities in the municipality of Wadowice for clean air in the years 2009-2017

Year	Type of action	The final effect of the action
2009	Application submission with the Association of Municipalities of the Lower Raba River as the project coordinator for the Swiss program for co-financing the purchase and installation of solar panels	The project was on the reserve list.
2010-2013	Preparation of a project and application for the MROP – Improvement of air quality in the municipality of Wadowice by installing a solar installation and a heat recovery installation from rinsing water and gray sewage in the indoor swimming pool „Delfin"	Co-financing received: PLN 1 289 183.38
2011	Development of the Low Emission Reduction Program for the Municipality of Wadowice	
Since 2011	Educational campaigns conducted by the foundation of *„ARKA – You love children do not burn rubbish"* through distribution of posters and dissemination of information on the harmfulness of waste incineration in heating furnaces.	
2014	Elaboration of the Low-Emission Economy Plan for the Municipality of Wadowice	
2014	Involvement in the preparation and implementation of the integrated project as part of the LIFE financial instrument *„Implementation of the Air Protection Program for the Małopolska province – Małopolska in a healthy atmosphere"*.	Implementation of the system called Eco-advisers for air protection in municipalities.
2014	Preparation of an application for Provincial Fund for Environmental Protection and Water Management (WFOŚiGW) as part of the KAWKA program. The application covered the liquidation of 42 coal-fired boiler rooms and the installation of new ones as well as the purchase and installation of 41 solar panels with a total power of 184.5 kW.	Applicable subsidy amount PLN 734,500.00. Co-financing granted by the resolution of the WFOŚiGW Management Board as per February 2, 2015.

Year	Type of action	The final effect of the action
2014	Preparation of an application for Provincial Fund for Environmental Protection and Water Management (WFOŚiGW) as part of the implementation of the Low Emissions Program (PONE) in the Małopolska province	Applicable subsidy amount PLN 167,160.00. Co-financing granted by the resolution of the WFOŚiGW Management Board as per November 19, 2014.
2015	Implementation of the KAWKA program	11 coal-fired boiler rooms were closed down and 11 new gas boiler rooms were installed; co-financing obtained: PLN 118.4311,36
2016	Implementation of the KAWKA program	31 coal-fired boilers were closed down and new 26 gas boiler rooms as well as 3 connections to the heating network were installed and 10 solar collector installations were assembled; co-financing amounted to PLN 127,919.81
2017	Preparation of an application for Provincial Fund for Environmental Protection and Water Management (WFOŚiGW) as part of the implementation of the Low Emissions Program Stage III in the Małopolska province	The application included the liquidation of 122 coal-fired boiler rooms and the assembly of new ones. The subsidy applied for was PLN 486,000.00. Co-financing granted by the resolution of the WFOŚiGW Management Board as per July 27, 2017
2017	Preparation of an application for the ROP Sub-measure 4.4.2 Reducing the low emission level (replacement for gas-fired boiler). Liquidation of 79 low-efficiency coal-fired boiler rooms; installation of 74 new gas boiler rooms; installation of 1 new biomass boiler rooms; installation of 1 heat pump; execution of 3 new connections to the heating network.	Co-financing amount PLN 1 143 863.39
2017	Preparation of an application for the ROP Sub-measure 4.4.3. Reducing the low emission level (replacement for solid fuel fired boiler). Liquidation of 266 low-efficiency coal-fired boiler rooms; installation of 1 heat pump; execution of 3 new connections to the heating network.	Co-financing amount PLN 2 471 066.55

Source: Author's own elaboration based on data obtained from the Town Council of Wadowice

Two national transit routes run through the municipality of Wadowice (No. 28 and No. 52). Unfortunately, the possibilities to reduce emissions in this sec-

tor are small. One of the few opportunities is the construction of the planned Beskidzka Integration Road, for which local governments lined along the national road no. 52, including the municipality of Wadowice, compete. Emission from transport is mainly connected with a substantial share of lorries and passenger cars that emit the largest amount of CO_2.

Infrastructure in the municipality of Wadowice has a high energy intensity, which manifests itself, for example, in the use of obsolete lighting in public buildings or energy-consuming road lighting lamps. The prospect of exploiting renewable energy sources is significantly limited. The creation of integrated urban transport in the town of Wadowice through the construction of interchange, Park & Ride car parks, pedestrian and bicycle routes, and maintenance of roads in order to reduce the secondary emission of pollutants. The municipality conducts systematic thermo-modernization of public utility buildings. In the coming years 2018-2019 significant energy modernization of 4 public utility buildings is planned: Public School Complex in Wysoka, Public School Complex No. 2 in Wadowice, municipal building in Barwałd Dolny No. 64 acting as a school and municipal building in Stanisław Górny No. 132b also acting as a school and a kindergarten.

Residents of the municipality present a low level of interest in the offer of local government actions limiting low emission. This problem may result from the lack of knowledge about the harmfulness of low emission, the possibility and manner of introducing changes in the household, and the scope of the municipality's activities aimed at improving the state of air quality. The local government takes initiatives to disseminate knowledge and shape pro-ecological attitudes. The municipality cooperates with the ARKA organization as part of the project *"You love children, do not burn rubbish"* (Kochasz dzieci nie pal śmieci). Employees of the Greenery and Environmental Protection Department of the Town Council participate in regular talks, on average once a year, with pupils of primary schools, junior high schools and kindergartens, as well as residents of the municipality at meetings of village and district councils.

CONCLUSIONS

The research results obtained allowed to put forward the following conclusions:

- Low emission in the municipality of Wadowice is mainly generated by boiler rooms in individual buildings using outdated solid fuel furnaces.
- The Low-Emission Economy Plan, being in force in the municipality of Wadowice, is consistent with the climate and energy package and implements the guidelines of the new strategy for economic and social development of the European Union 2020.

- Since 2009, the local government has significantly increased the scope of activities improving air quality in the area of the municipality of Wadowice, which concerns in particular the modernization of the infrastructure of public buildings and the development of the municipal heating system.
- The local government has been intensifying systematic cooperation with external parties (e.g. Krakow Smog Alarm), which resulted in the installation of a mobile air quality measurement station in the town of Wadowice, which other communes of the Wadowice poviat (e.g. the municipality of Kalwaria Zebrzydowska) did not decide to go in for.
- The share of funds obtained by the municipality of Wadowice from Regional Inspectorate for Environmental Protection (WIOŚ) is systematically growing.
- The local government conducts a social campaign for the formation of pro-ecological attitudes of residents of the municipality towards the issue of low emission generated by households.

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