Air Quality Plan for the Malopolska Region

Malopolska in a healthy atmosphere

Attachment 2

Resolution No. XXV/373/20 of the Assembly of the Małopolskie Voivodeship of September 28, 2020.

Marshal Office of the Malopolska Region

MAŁOPOLSKA IN A HEALTHY ATMOSPHERE

eko MAŁOPOLSKA

Completed in accordance with the Agreement of November 4, 2019 upon the commission of the Marshal Office of the Malopolska Region

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*The Plan was modified and its content was being changed by the contracting authority.

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I. DESCRIPTIVE PART

1. PURPOSE, SCOPE AND LEGAL BASIS FOR THE PLAN

In accordance with the Regulation of the Minister of Environment of 6 June 2018 on the scope and method for reporting air pollution information[1], the Plan code is assigned: **PL12PM10adPM2.5aBaPaNO2a_2018.**

This Air Quality Plan for the Malopolska Region (hereinafter AQP or Plan) was developed as a result of exceeded air quality standards noted in the Malopolska Region in 2018. It was developed in accordance with the requirements of the Regulation of the Minister of Environment of 14 June 2019 on air quality plans and short-term action plans.[2] An integral part of the Plan is a short-term action plan (hereinafter referred to as Short-term Action Plan or Plan). The program includes three air quality assessment zones:

- **Krakow Agglomeration zone** (code PL1201) - subject to air quality assessment for the protection of human health,
- **Tarnow city zone** (code PL1202) - subject to air quality assessment for the protection of human health,
- **Malopolska zone** (code PL1203) - subject to air quality assessment for the protection of human health and plant protection.

The purpose of the Air Quality Plan is to indicate the reasons for exceeding the permissible and target levels of PM10, PM2.5, nitrogen dioxide and benzo(a)pyrene, and to determine corrective measures to help improve the air quality. For the analyses necessary under the Air Quality Plan, data for 2018 as the base year, was used. All planned tasks have been analysed and selected to ensure the highest possible effect of improving the air quality using the available financial means. The tasks are scheduled to be completed by 2023.

The currently proposed corrective measures focus on supporting the implementation of the provisions of anti-smog resolutions and the use of funds under the government programs: Clean Air, Stop Smog and thermo-modernization tax relief. These programs require greater involvement of municipal governments by launching information points, providing assistance of Eco-managers and organizing educational campaigns. In addition, construction of the Central Building Emissions Register requires inventory and inspection of heating sources in buildings.

1.1. New possibilities and conditions for the implementation of the Plan

During the work on the Plan, the conditions for implementing actions to improve air quality have changed. On both national and European scale, new opportunities have emerged that will facilitate the implementation of the Plan's assumptions. They are the result of decisions taken at the governmental level, as well as at the level of the European Union. In view of the new opportunities that can support the process of improving air quality, the Plan sets out corrective actions that focus on the effective use of available tools that can accelerate the implementation of actions to reduce emissions of harmful substances. The basis for the full implementation of the Plan's objectives is ensuring the coherence of the regional policy with higher-level policies.

[1] Journal of Laws of 2018, item 1120
[2] Journal of Laws of 2019, item 1159

Changes in the Clean Air Priority Program

On May 15, 2020, the National Fund for Environmental Protection and Water Management announced a simplification of the rules for the selection of applications for co-financing from the Clean Air Programme. The current amendment to the Program is the result of several months of consultations, findings and analyses. It also results from the need to accelerate the pace of the Program implementation. The new version of the Clean Air Program introduces a number of changes, including:

- change and simplification of income criteria,
- simplification of the grant application,
- the possibility of submitting online applications,
- shortening the time of processing applications for co-financing – from 90 to 30 days,
- strengthening cooperation with municipalities,
- integration of the Clean Air Program with the "My Electricity" Program,
- inclusion of the Banking Sector in the implementation of Program, which will enable a source of complementary and bridge funding,
- enabling the combination of co-financing offered by the Program with co-financing from municipal low-stack emission reduction programs – municipalities gain the possibility to create their own programs supplementing the financing received from the Clean Air Program.

In addition, the introduced changes are planned to be reinforced in the future by creating an internet platform with a list and information on devices, materials and services that are eligible for co-financing under the Clean Air Program. This is to simplify the entire process on the applicant's side as much as possible.

Changes to the Program are to encourage municipalities to establish Clean Air information points. There are currently 58 of them in the Malopolska Region, including:

- 1 at the office of the Regional Fund for Environmental Protection and Water Management in Krakow,
- 4 in the Fund's branch offices (Miechow, Oswiecim, Nowy Sacz, Tarnow)
- 53 in the municipalities of the Malopolska Region, which signed cooperation agreements under the Clean Air Program.

Effective use of available funds until 2029 is therefore both an opportunity and a challenge. Active involvement of municipalities in increasing the Program’s availability is crucial in the process of reaching for funds.

Draft Act on the Central Building Emission Register

The Ministry of Climate has prepared a draft amendment to the Act on *supporting thermo-modernization and renovation* as well as the Act *on the Inspection for Environmental Protection*, which will result, among others, in the launch of the Central Building Emission Register (CEEB)[3].

The database, which is a kind of **inventory of heating sources**, is aimed at creating the basis for planning corrective actions and improving housing conditions of the society. The CEEB is to support the implementation of other activities such as improving energy efficiency, improving air quality and combating energy poverty. Inventory carried out as part of the Base will allow to diagnose low-stack emission sources, which will be implemented by collecting uniform and coherent data across the country regarding buildings and the sources of emissions.

[3]Source:https://bip.kprm.gov.pl/kpr/bip-rady-ministrow/prace-legislacyjne-rm-i/prace-legislacyjne-rady/wykaz-prac-legislacyjny/r1273188465185,Projekt-ustawy-o-zmianie-ustawy-o-wspieraniu-termomodernizacji-i-remontow-oraz-u.pdf

In practice, the designed base will constitute an IT system. The draft act defines individual system users, including data providers and those responsible for their systematic update. The system will enter key information on emission sources in the municipal and housing sector, which will be obtained through a nationwide general inventory with the accuracy of each residential building in Poland. This information will also be embedded in data about the existing and planned heating and gas networks. The creation of a database and inventory of emission sources is a key step leading to the diagnosis of the air quality problem and a reliable determination of the actions necessary to be taken in order to achieve the permissible and target pollutant concentration levels.

Renovation Wave as part of the European Green Deal

In March 2020, the European Commission presented a new draft regulation on the decarbonisation of the economy and achieving climate neutrality. The European Green Deal[4] was created in order to present the possibilities of implementing solutions serving the pursuit of climate neutrality by European Community countries. The European Green Agreement suggests "*renovation wave*" of public and private buildings. Construction accounts for 36% of Europe's total greenhouse gas emissions – building renovation can bring significant benefits in terms of energy efficiency, affordability, lower energy bills and support for small and medium-sized enterprises and jobs. *The Clean Energy for all Europeans Package* offers the opportunity to accelerate the energy transformation in Europe – with a significant improvement in the energy efficiency of buildings.

Despite the delay in implementing climate and environmental actions which results from the epidemic, Minister of Climate Michal Kurtyka emphasizes that *"(...) the slump, caused in the economy by the coronavirus pandemic, causes the need to mobilize large funds to revive the economy. The flywheel here can be just changing energy sector, which must continue its transformation*." In Poland such means are, among others, the Clean Air Priority Program or My Electricity Program, which in the coming years will be the driver for investments in renewable energy sources and improvement of energy efficiency in the municipal and household sector. Despite the difficulties caused by the pandemic, these activities should be even more intense.

Just Transition Mechanism

One of the instruments for implementing the assumptions of *the European Green Deal* is the Just Transition Fund[5]. It is one of the three pillars of the Just Transition Mechanism, which is to provide a comprehensive solution to support the ability of Member States to finance activities related to energy transformation. The purpose of the Fund is to provide subsidies to regions most affected by the effects of climate transformation, in particular regions in which energy is based on solid fuels such as hard coal. All Member States can apply for support, while the distribution of funds will be proportional to the needs resulting from the energy transformation. In order to receive financing, Member States are required to prepare at least one territorial just transition plan that is a part of the national plan of the state's transformation by 2030.

At present, 6 regions from Poland will apply for the Fund. The European Commission plans to allocate a total of EUR 17,5 billion to the needs of the fund, of which EUR 3,5 billion (the largest part of the fund) would be allocated to Poland. **In order to accelerate the implementation of climate, energy and environmental measures, the Malopolska Region is also applying for available funds.** They will make it possible to implement the assumptions not only in accordance with the strategy of air protection, but also of the climate and broadly understood sustainable energy development.

[4]Source: Commission announcement, The European Green Deal https://eur-lex.europa.eu/legal-content/PL/TXT/HTML/?uri=CELEX:52019DC0640&from=EN

[5]Source: Regulation of the European Parliament and of the Council establishing a Just Transition Fund https://eur-lex.europa.eu/legal-content/PL/TXT/HTML/?uri=CELEX:52020PC0022&from=EN

Activities of the Provincial Fund for Environmental Protection and Water Management

By 31 December 2023, the Regional Fund for Environmental Protection and Water Management in Krakow is implementing a project called "*A nationwide system of advisory support for the public, housing and industry sectors in the field of energy efficiency and renewable energy*" (PDE), which supports the achievement of the objectives set in the Air Quality Plan for the Malopolska Region.

The project is implemented under Sub-measure 1.3.3 OPI & E 2014-2020 in cooperation with the National Fund for Environmental Protection and Water Management and 16 Partners at the voivodship level – 15 regional funds for environmental protection and water management and the Lubelskie Voivodship, what ensures complementarity of actions taken in Malopolska with actions taken all over the country. In addition, preparations are underway for the continuation of the nationwide Energy Consultancy project in the next financial perspective of the European Union.

1.2. Legal bases

The development of the Air Quality Plan results from **Article 91 of the Act of 27 April 2001, Environmental Protection Law**[6] (hereinafter: EPL Act), which imposes such an obligation on the regional management in the event of exceeding the permissible or target levels of substances specified in the Regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air[7]. Necessity to develop the Air Quality Plan for the base year 2018 within the set deadline in 2020 results from Art. 7 of the Act – Environmental Protection Law and the Act on Crisis Management (Journal of Laws of 2019, item 1211). Currently developed Plan does not constitute an update of the Plan in accordance with applicable regulations, but it is a new document, independent of the previously adopted.

The documentation for the Air Quality Plan for the Malopolska Region was prepared on the basis of the following legal acts:

- Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on air quality and cleaner air for Europe (Journal of Laws EU.L.2015.226.4)
- 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
- Commission Regulation (EU) No 1272/2009 of 11 December 2009 laying down common detailed rules for implementing Council Regulation (EC) No 1234/2007 as regards buying-in and selling of agricultural products under public intervention (OJ EU L .2017.171.113)
- Commission Regulation (EU) 2015/1189 of 28 April 2015 on the implementation of Directive 2009/125 /EC of the European Parliament and of the Council with regard to eco-design requirements for solid fuel boilers (Journal of Laws EU.L.2016.346.51)
- Directive 2010/75/EU of the European Parliament and of the Council of November 24, 2010 on industrial emissions (integrated pollution prevention and control) (Journal of Laws EU.L.2012.158.25)
- Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters
- Directive (EU) 2015/2193 of the European Parliament and of the Council of 25 November 2015 on the limitation of emissions of certain pollutants into the air from medium combustion plants
- Act of 20 February 2015 on renewable energy sources (consolidated text, Journal of Laws of 2020, item 261)

[6] Consolidated text: Journal of Laws of 2020, item 1219, as amended.
[7] Journal of Laws of 2012, item 1031 as amended.

- Act of 27 April 2001 – Environmental Protection Law (consolidated text, Journal of Laws of 2020, item 1219)
- Act of 3 October 2008 on sharing information about the environment and its protection, public participation in environmental protection and on environmental impact assessments (consolidated text, Journal of Laws of 2020, item 283)
- Act of 14 December 2012 on waste (consolidated text, Journal of Laws of 2020, item 797)
- Act of 29 August 1997 on communal guards (consolidated text, Journal of Laws of 2019, item 1795)
- Act of 23 April 1964 Civil Code (consolidated text, Journal of Laws of 2019, item 1145)
- Act of June 6 1997 Penal Code (consolidated text, Journal of Laws of 2019, item 1950)
- Act of 10 April 1997 Energy Law (consolidated text, Journal of Laws of 2020, item 833)
- Act of 20 May 2016 on energy efficiency (consolidated text, Journal of Laws of 2020, item 264)
- Act of 7 July 1994 Construction Law (consolidated text, Journal of Laws of 2020, item 1333)
- Act of 20 June 1997 Road Traffic Law (consolidated text, Journal of Laws of 2020, item 110)
- Act of 26 April 2007 on crisis management (consolidated text, Journal of Laws of 2019, item 1398)
- Act of 20 July 1991 on the Environmental Protection Inspection (consolidated text, Journal of Laws of 2020, item 995)
- Act of 27 March 2003 on spatial planning and development (consolidated text, Journal of Laws of 2020, item 293)
- Regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air (Journal of Laws of 2019, item 1931)
- Regulation of the Minister of Environment of 14 June 2019 on air quality plans and short-term action plans (Journal of Laws of 2019, item 1159)
- Regulation of the Minister of Environment of 2 August 2012 regarding zones in which air quality is assessed (Journal of Laws of 2012, item 914)
- Regulation of the Minister of Environment of June 6 2018 on the scope and method for reporting air pollution information (Journal of Laws of 2018, item 1120)
- Regulation of the Minister of Environment of June 8 2018 regarding assessment of levels of substances in the air (Journal of Laws of 2018, item 1119)
- Regulation of the Minister of Entrepreneurship and Technology of 21cFebruary 2019 amending the ordinance on requirements for solid fuel boilers (Journal of Laws of 2019, item 363)
- Regulation of the Minister of Energy of 27 September 2018 on quality requirements for solid fuels (Journal of Laws of 2018, item 1890)
- Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions to be met by buildings and their location (consolidated text, Journal of Laws of 2019, item 1065)
- Regulation of the Minister of Environment of October 8, 2019 amending the ordinance on the levels of certain substances in the air (Journal of Laws of 2019, item 1931)

2. DESCRIPTION OF ZONES COVERED BY THE PLAN

This Plan has been prepared for the zones of the Malopolska Region, i.e. the Krakow Agglomeration, the Tarnow city zone – city with a population of above 100,000, and the Malopolska zone, i.e. the remaining area of the voivodeship, as defined in the Regulation of the Minister of Environment of 2 August 2012 regarding zones in which air quality is assessed.[8] In 2018, air quality assessment was carried out for each of the aforementioned zones regarding health protection, and for the Malopolska zone also regarding plant protection.

In the *Annual air quality assessment in the Malopolska Region for 2018*, the zones of the region were classified as class C due to exceeded standards of the following substances:

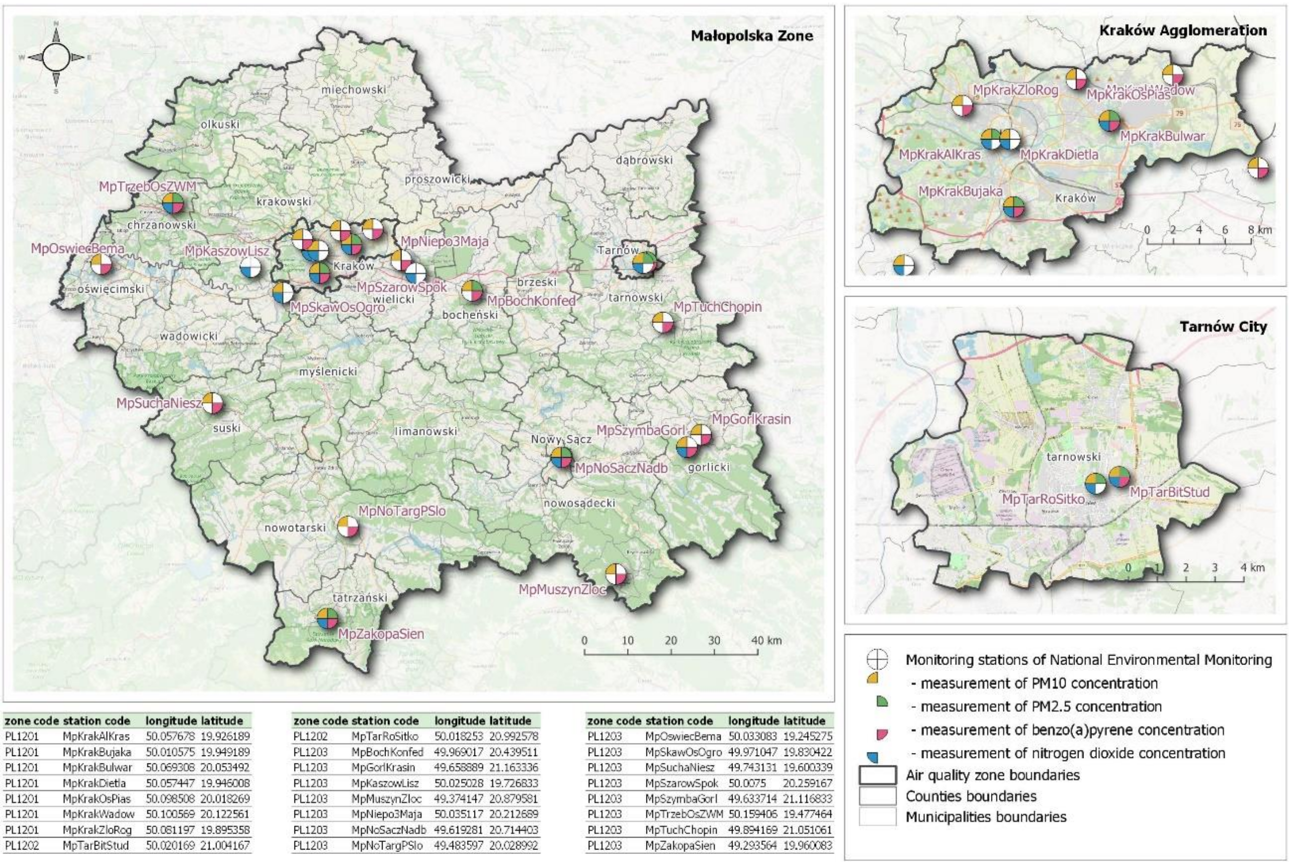
- **Krakow Agglomeration zone** – particular matter PM10, PM2.5, benzo(a)pyrene, NO_2;
- **Tarnow city zone** – particulate matter PM10, PM2.5 (phase II) and benzo(a)pyrene;
- **Malopolska zone** – particulate matter PM10, PM2.5 and benzo(a)pyrene.

Table 1. Area and demographic data of the zones of the Malopolska Region in 2018 [9]

Zone name	Zone code	Zone type	Surface	Population			Population density		
				total by place of residence	total by age 0-4 years	total by age ≥ 65 years	total	total by age 0-4 years	total by age ≥ 65 years
			[km²]	[person]			[people/km²]		
Krakow Agglomeration	PL1201	agglomeration	327	771 069	43 491	151 285	2 358	133	462
Tarnow city	PL1202	a city with a population of over 100,000	72	109 062	4 526	22 555	1 514	62	313
Malopolska zone	PL1203	remaining area of the region	14 784	2 516 807	183 155	564 515	224	12	37

[8] Source: Journal of Law from 2012, item 914
[9] Source: Central Statistical Office (GUS) Local Data Bank for 2018

The figure below shows the zones of the Malopolska Region.



zone code	station code	longitude	latitude
PL1201	MpKrakAlKras	50.057678	19.926189
PL1201	MpKrakBujaka	50.010575	19.949189
PL1201	MpKrakBulwar	50.069308	20.053492
PL1201	MpKrakDietla	50.057447	19.946008
PL1201	MpKrakOsPias	50.098508	20.018269
PL1201	MpKrakWadow	50.100569	20.122561
PL1201	MpKrakZloRog	50.081197	19.895358
PL1202	MpTarBitStud	50.020169	21.004167

zone code	station code	longitude	latitude
PL1202	MpTarRoSitko	50.018253	20.992578
PL1203	MpBochKonfed	49.969017	20.439511
PL1203	MpGorlKrasin	49.658889	21.163336
PL1203	MpKaszowLisz	50.025028	19.726833
PL1203	MpMuszynZloc	49.374147	20.879581
PL1203	MpNiepo3Maja	50.035117	20.212689
PL1203	MpNoSaczNadb	49.619281	20.714403
PL1203	MpNoTargPSlo	49.483597	20.028992

zone code	station code	longitude	latitude
PL1203	MpOswiecBema	50.033083	19.245275
PL1203	MpSkawOsOgro	49.971047	19.830422
PL1203	MpSuchaNiesz	49.743131	19.600339
PL1203	MpSzarowSpok	50.0075	20.259167
PL1203	MpSzymbaGorl	49.633714	21.116833
PL1203	MpTrzebOsZWM	50.159406	19.477464
PL1203	MpTuchChopin	49.894169	21.051061
PL1203	MpZakopaSien	49.293564	19.960083

Figure 1. Air quality assessment zones in the Malopolska Region with locations of the stations used in Annual air quality assessment for 2018 [10]

An important factor, which determines the level of concentrations of air pollution, are meteorological conditions, in particular:

- air temperature, which affects the amount of heat energy demand, the production of which generates emissions of pollutants into the air as a result of burning fuels,
- wind speed, which determines the way of dispersion of pollutants released into the air,
- wind direction, which determines where the pollutants transported by the air masses originate,
- the equilibrium state of the atmosphere and the height of the mixing layer, which indirectly affect the accumulation or dispersion of pollutants introduced into the air,
- air humidity,
- atmospheric precipitation, which causes elution of pollutants from the air

The factor affecting the level of air pollution is also the terrain, in which areas with a specific climate, microclimate and meteorological conditions may occur. The most favourable conditions for the spread of pollutants are in flat areas that characterize with: a large number of days with sunshine, good thermal conditions, and high air masses velocities (good ventilation). In valleys and basins, the exchange of air masses is obstructed, therefore the topographic and climatic conditions of such areas favour the accumulation of pollutants, which in turn results in the occurrence of high concentrations of pollutants.

[10] Source: based on data from the State Environmental Monitoring network, (Chief Inspectorate of Environmental Protection) CIEP

The analysis of meteorological data shows that adverse weather conditions (e.g. low wind speed, low air temperatures, low pressure gradients – anti-cyclonal circulation) determine the appearance of elevated concentrations of particulate pollutants. An improvement in air quality is observed, when wind speed increases and precipitation occurs. Such conditions lead to a rapid and significant improvement in air quality.

2.1. Location, topographic data, and demography

The Malopolska Region with the capital in Krakow is located in the south-eastern part of Poland, and covers an area of 15 183 km^2. In terms of area, it ranks 12th out of all the voivodeships of the country. It is inhabited by over 3,400,000 inhabitants[11], 48.3% of which live in the cities.

The voivodeship is divided into 19 land districts, 3 urban districts (counties), and 182 municipalities. It includes 61 cities among which 3 have county rights - Krakow, Tarnow, and Nowy Sacz.

The Malopolska Region borders with the following voivodeships:

- from the north with the Swietokrzyskie voivodeship,
- from the east with the Podkarpackie voivodeship,
- from the west with the Slaskie voivodeship.

From the south the Malopolska Region borders with Slovakia.

The region covers the following physiographic regions:

- Silesian-Krakow Upland,
- Outer Western Carpathians,
- Central Western Carpathians,
- Malopolska Upland,
- and Northern Subcarpathian region.[12]

The natural border between the mountains and the lowland is the Vistula valley.

The Malopolska Region characterize with varied natural conditions. The described terrain has mountain and upland areas. The relief of the terrain is extremely varied: from the high post-glacial High Tatras, through the post-glacial high-mountain carving of the Western Tatras, the mid-mountain Beskid, foothill and karst highlands, to the lowlands of the Podkarpacka Basin.

In terms of climate, three major climate regions are distinguished within the voivodeship: the Central Polish uplands, the Podkarpackie Valleys and the Carpathian Mountains themselves. A large weather variations and seasonal fluctuations occur in subsequent years.

The winds from the western, southern and south-eastern sectors dominate in Malopolska. Average annual temperature ranges from 5°C to 8°C and the average annual rainfall reaches approximately 800 mm. Annual multi-annual precipitation amounts value from 550 mm in the Malopolska Upland to 1200-1400 mm in the Carpathian Mountains.

Surface sources from the communal and municipal sector, and in the case of nitrogen dioxide traffic sources, i.e. transport, are the main factors responsible for air emissions in the Malopolska Region. Linear sources from national, voivodship's, municipal, and local roads also have a significant contribution in emissions. Point sources from industrial emitters and other from agriculture or fugitive sources account for a small fraction

[11] Central Statistical Office GUS Data for 2018
[12] Source: J. Kondracki, 2002, Geografia regionalna Polski, Ed. PWN, Warsaw.

of total emissions. Industrial emissions mainly originate in the steel, metallurgy, energy, and chemical industries (especially in Krakow and Skawina).[13]

The Malopolska area is interesting in terms of nature and landscape. Legally protected areas span on a total of 804,400 ha (representing 53.0% of the total area of the region and 7.9% of protected area in Poland). This includes 6 national parks, 11 landscape parks, 84 nature reserves and 2,189 natural monuments in the region.

The Malopolska Region is a region of high investment prospects. The territory includes areas of five industrial zones: Krakowski, Tarnowski, Skawinski, Jaworznicko-Chrzanowski, and Karpacki. Special economic zones that have the greatest impact on socio-economic development in the region are: Krakow Special Economic Zone with subzones in Krakow, Tarnow, Nowy Sacz, Skawina, Zabierzow, Niepolomice, and Dobczyce, Special Economic Zone EURO-PARK MIELEC with subzone in Gorlice, Tarnobrzeg Special Economic Zone with a subzone in Wojnicz, and the Katowice Special Economic Zone with a subzone in Myslenice.

The leading branches of the Malopolska economy are the high technology, banking, and consumable goods industry sectors, including the tobacco industry. The economy basis include also traditional branches, such as metallurgy, mining, chemical, and metal industries. In recent years, development of services has been observed, including consulting, advisory, design, publishing, as well as tourism and spa services.

Krakow Agglomeration

Krakow Agglomeration spans over the entire city of Krakow. It is located in the southern part of the Malopolska Region in the Vistula Valley, at the junction of four geographical regions. From the north it borders with the Krakow-Czestochowa Upland, from the south with the Wieliczka Foothills, from the east with the Sandomierz Basin, and from the west with the Oswiecim Basin.

Krakow Agglomeration zone was populated by 771 069 people in 2018.[14] The area of the zone is 327 km^2 (the second largest city in Poland).

The city of Krakow has a climate with a clear impact of the continental climate. Summers happen to be hot and winters cold. The climate of Krakow characterize with long-lasting heavy rainfall, lasting up to several days, which is typical for the mountains. There local precipitation reaches up to 100 mm per day. In 2018, the average annual air temperature was 10.6°C. The weak winds from the western sector dominate the zone. The prevailing wind conditions and frequent temperature inversions are the cause of poor ventilation of the city, which worsens the state of the natural environment through the accumulation of traffic pollution, low-stack emissions, and industry-related emissions. The specific climate of Krakow is the result of the city's location in the Vistula River valley, which limits ventilation capacity of the city.

Krakow in a strategic communication nod, connecting the main tourist and transit routes. The second highest traffic airport in Poland, the John Paul II International Airport Krakow-Balice is located nearby (11 km west of the city centre).

[13] Source: Annual air quality assessment in the Malopolska Region. Report for 2018, Krakow, April 2019
[14] Source: Annual air quality assessment in the Malopolska Region. Report for 2018, Krakow, April 2019

Tarnow city zone

Tarnow is a city located in the eastern part of the Malopolska Region, on the Bia and Dunajec rivers. Tarnow city zone was inhabited by 109,062 people in 2018.[15] The area of the zone is 72 km^2.

Tarnow is considered heat focal point of Poland. This area belongs to the warmest regions of Poland. It characterized with relatively high annual temperatures (the highest in July). The city's area climate is described as the foothill climate zone, which manifests by a relatively large precipitation. January is considered the coldest month.

Tarnow is an important, large industrial and economic centre. The city hosts specialized chemical, machine, food, building materials, textile, and glass industry.

The city is located at the intersection of important European trade routes, which makes it a strategic communication location. The presence of international road E40 and national road No. 73 is important for transport accessibility. The distance between Tarnow and the John Paul II International Airport Krakow-Balice equals approximately 100 km.

Malopolska zone

Malopolska zone covers the area of the Malopolska Region, excluding the zones of the Krakow Agglomeration and the city of Tarnow. The Malopolska zone was inhabited by 2,516,807 people in 2018.[16] The area of the zone is 14 784 km^2.

The location of the Malopolska zone in different geographical regions results in a significant environmental diversity. The largest Polish voivodeship vertical span of the area of approximately 2,300 meters is the reason for the stacked diversity of climatic, hydrological, soil, and plant occurrence conditions. The region is characterized by the presence of 7 elevational zones, numerous mountain microclimates, including spa resorts, and the highest annual rainfall sum in Poland, which are a source of rich water reservoir of the west-Carpathian area of the country.

About 30% of the region's area lies above 500 m a.s.l., reaching a height of 2,499 m a.s.l. The highest peak of Poland – Rysy and the most attractive high-mountain massif – the Tatra Mountains are located in this area. Its distinctive feature is the occurrence of various landforms such as mountains and foothills, from low through medium to high.

Malopolska zone, as a part of the voivodeship, administrates a very well-developed transport infrastructure. Its area is the longest in Poland, 672 km long, the A4 motorway and the main transit corridor from Western Europe to Ukraine – CORRIDOR III.

Malopolska zone is among the very attractive areas for tourism, which increases the number of vehicles traveling on the roads, as well as the need to provide accommodation facilities to a much greater extent than while maintaining a constant number of inhabitants of the region. In 2018, Malopolska (of which the Malopolska zone is a significant part) broke the tourist movement record. The region was visited by a total of 16.78 million people, which was an increase of 5.14% as compared to 2017. Both the number of visitors from Poland (13.28 million people) and from abroad (3.5 million people) increased, and the increase in the number of tourists from within the country was slightly higher (by 5.31%) than the number of visiting foreigners (by 4.48%).

[15] Source: Annual air quality assessment in the Malopolska Region. Report for 2018, Krakow, April 2019
[16] Source: Annual air quality assessment in the Malopolska Region. Report for 2018, Krakow, April 2019

3. DESCRIPTION OF THE AIR QUALITY IN THE ZONES

3.1. Classification of air quality assessment zones in the Malopolska Region

According to the *Annual air quality assessment in the Malopolska Region for 2018*, conducted by the Chief Inspectorate of Environmental Protection (Regional Department of Environmental Monitoring in Krakow), for each substance assessed, the zones were assigned to the appropriate air quality class. The classification is based on the following guidelines:

- **class A** - if the pollutant concentration in the zone did not exceed the permissible levels, target levels, long-term goal levels;
- **class C** – if the pollutant concentration in the zone exceeded the permissible or target levels;
- **class C1** – if PM2.5 concentrations in the zone exceeded the permissible level, applicable from 1 January 2020.

Table 2. Characteristics of the Malopolska Region by zone.[17]

Zone name	Zone code	Zone type	Zone area [km^2]	Zone population	Classification by health care criteria [yes/no]	Classification plant protection criteria [yes/no]
Krakow Agglomeration	PL1201	agglomeration	327	769 498	yes	no
Tarnow City	PL1202	a city with a population of above 100,000	72	109 358	yes	no
Malopolska zone	PL1203	remaining area of the voivodeship	14 784	2 516 807	yes	yes

3.1.1. *METHODS USED TO ASSESS LEVELS OF SUBSTANCES IN THE AIR*

It the annual assessment it was indicated that several methods were used to assess the air quality in 2018:

- results of measurements carried out at permanent monitoring stations under the State Environmental Monitoring (using reference methodologies), which include:
  - continuous measurements (with automatic meters),
  - manual measurements – taken daily,
- results of indicative measurements (include measurements conducted as part of the State Environmental Monitoring, for which the requirements for data quality purposes are not as strict as for intensive measurements),
- objective estimation methods based on:
  - analysis of information on emissions and its sources, land development, topographic and climatic conditions of the areas under consideration,
  - results from modelling of the Institute of Environmental Protection – National Research Institute (methodology supplementary to measurements of air pollution, and in specific cases replacing them)

[17] Source: Annual air quality assessment in the Malopolska Region. Report for 2018, Krakow, April 2019

Objective estimates were made using, e.g.:

- mathematical methods of calculating concentrations from values obtained from measurements at other places or at another time, based on knowledge of concentration distributions and emissions in a given area,
- applying analogy to concentrations measured in another area,
- applying an analogy to concentrations measured in a given area in another period,
- calculation of exposure diagnostics based on reanalysis and identification of areas with exceedances.

A detailed description of the pollutant dispersion modelling methods used in the analyses is presented in Chapter 17.2.

3.2. List of substances covered by the Plan

The air quality analysis in the Air Quality Plan was performed for substances for which areas of exceedance of permissible or target concentrations were indicated in 2018. Limit and target values are indicated in the table below.

Table 3. Limit and target levels for substances covered by the Program[18]

Level	Results averaging period	unit	PM10	PM2.5	B(a)P	NO_2
levels acceptable for health protection	average annual concentration	[µg/m³]	40	25		40
	average annual concentration (since 01.01.2020)	[µg/m³]		20		
	daily concentration (24 h)	[µg/m³]	50			
	permissible number of days with exceedance of the daily level	[days]	35			
	hourly concentration	[µg/m³]				200
	permissible number of hours with exceedance of the daily level	[hours]				18
level of public information	24-hour concentration	[µg/m³]	200			
	24-hour concentration (from 11.10.2019 r.)	[µg/m³]	100			
alert level	24-hour concentration	[µg/m³]	300			
	24-hour concentration (from 11.10.2019 r.)	[µg/m³]	150			
	1-hour concentration	[µg/m³]				400
target levels for health protection	annual concentration	[ng/m³]			1	
exposure concentration obligation	average of three years	[µg/m³]		20		

Particulate matter PM10 and PM2.5

Particulate matter PM10 and PM2.5 is an air pollution consisting of a mixture of fine solid and liquid particles. Pollutants can come from natural or anthropogenic sources. The amount of PM10 and PM2.5 in the air may result from direct emissions (primary dust) or may be result of a reaction between substances in the atmosphere (secondary dust). Secondary dust precursors are primarily sulphur oxides, nitrogen oxides, volatile organic compounds and ammonia. Particulate matter may contain toxic substances, such as polycyclic aromatic hydrocarbons (including benzo(a)pyrene), heavy metals, dioxins and furans.

[18] Source: prepared by Atmoterm S.A. based on the Regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air (Journal of Laws of 2012, item 1031 as amended)

In the Malopolska Region, the largest share fraction PM2.5 of the particulate matter in total dust (TSP) is observed in dust emitted from the municipal and household sector. The smallest amounts of PM2.5 in dust come from extraction and processing of minerals, where mainly larger fractions dust is emitted. Much of the PM10 and PM2.5 emissions from road transport come from processes other than fuel combustion. These processes include abrasion of car linings (e.g. tyres and brakes), abrasion of road surfaces and pollutants re-floated off road surface.

Benzo(a)pyrene

Benzo(a)pyrene represents polycyclic aromatic hydrocarbons (PAHs). The source of B(a)P is the combustion of solid fuels at low temperatures between 300°C and 600°C in low-efficiency devices, waste incineration in non-dedicated installations, numerous industrial processes (e.g. coke production, road surface production), and also processes, such as forest fires, tobacco smoking and all processes of thermal decomposition of organic compounds in low temperature. B(a)P occurs in smoke during incomplete combustion, incl. tobacco smoke (smoke from 1 cigarette contains 0.16 µg of this substance). It is also found in coal tar (0.65% by weight), crude oil, engine oils (new – up to 0.27 mg/kg, used – up to 35 mg/kg). Due to its presence of smoke, B(a)P gets into food when smoking. The carrier of B(a)P in the air is dust, therefore its harmful effect is closely related to the impact of dust and its specific physical and chemical properties.

Nitrogen dioxide

An inorganic chemical compound from the group of nitrogen oxides in which nitrogen occurs in oxidation state IV. At room temperature, it is a brown, highly toxic gas with a pungent odor similar to chlorine gas. Even brief contact with the substance causes irritation of the respiratory system and eyes, as well as coughing. This gas also occurs in air polluted by transport and industry, and gives smog its characteristic colour. People who live in polluted cities may experience breathing problems and lung disease.

3.3. Meteorological conditions in the Malopolska Region in 2018

Meteorological conditions play a key role in shaping the air quality in the Malopolska Region. The voivodeship is a specific area where significant differences in meteorological conditions occur due to several climatic regions: mountain climate, the climate of the Carpathian Foothills, the climate of foothill basins and the climate of the uplands.

The meteorological conditions for 2018 were analysed on the basis of the observation and measurement data of the National Research Institute of Meteorology and Water Management (*the IMWM)* and *the Annual air quality assessment in the Malopolska Region Report for 2018*.

There are two synoptic stations in the Malopolska Region, the results of which are used in the analysis: in Krakow and at Kasprowy Wierch in Zakopane.

The base year 2018 was an extremely warm year, which affected the air quality in the voivodeship. The average temperature recorded at the stations in Krakow was 10.6^{o}C and was 2^{o}C higher than the average for the multi-year period of 1971-2000.

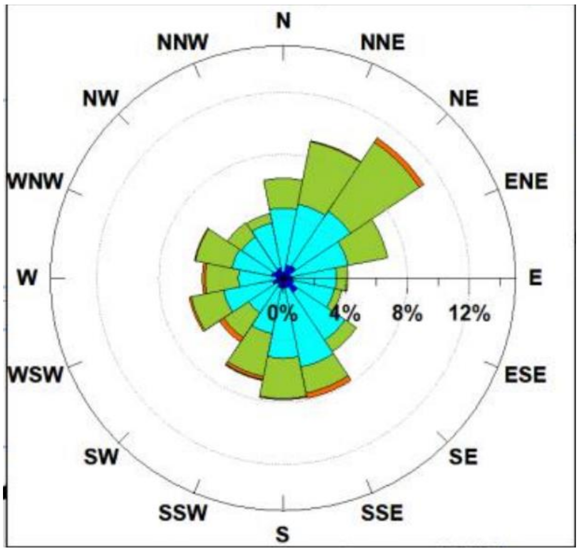


Figure 2. Wind direction and speed at points representative of the IMWM monitoring network for the south-eastern part of the country[19]

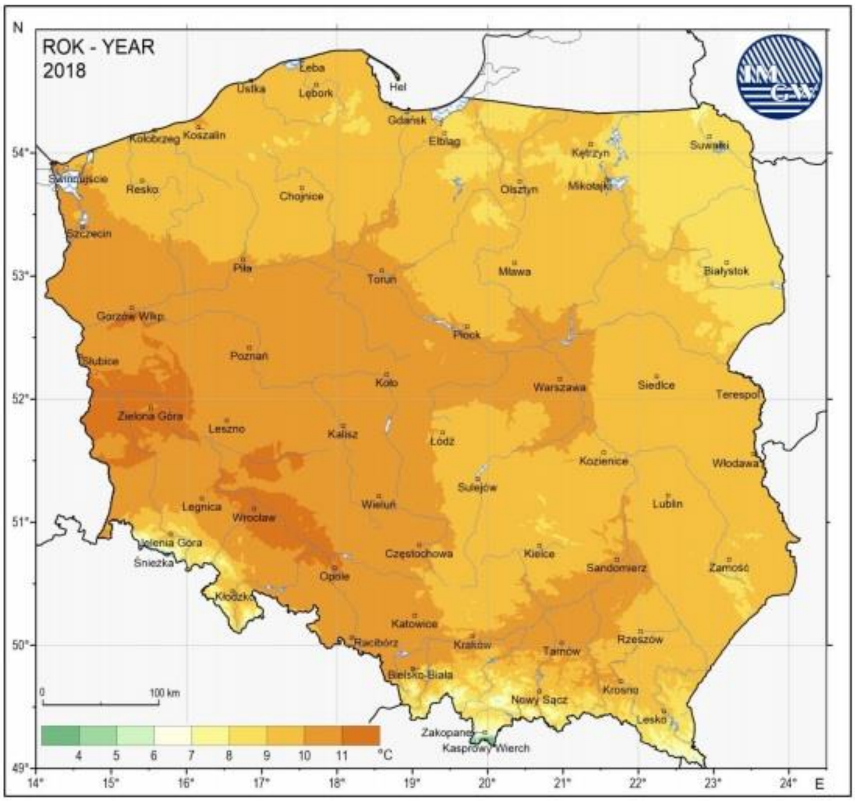


Figure 3. Average annual air temperature in 2018[20]

[19] Source: Climate Monitoring Bulletin 2018, The National Research Institute of Meteorology and Water Management
[20] Source: Climate Monitoring Bulletin 2018, The National Research Institute of Meteorology and Water Management

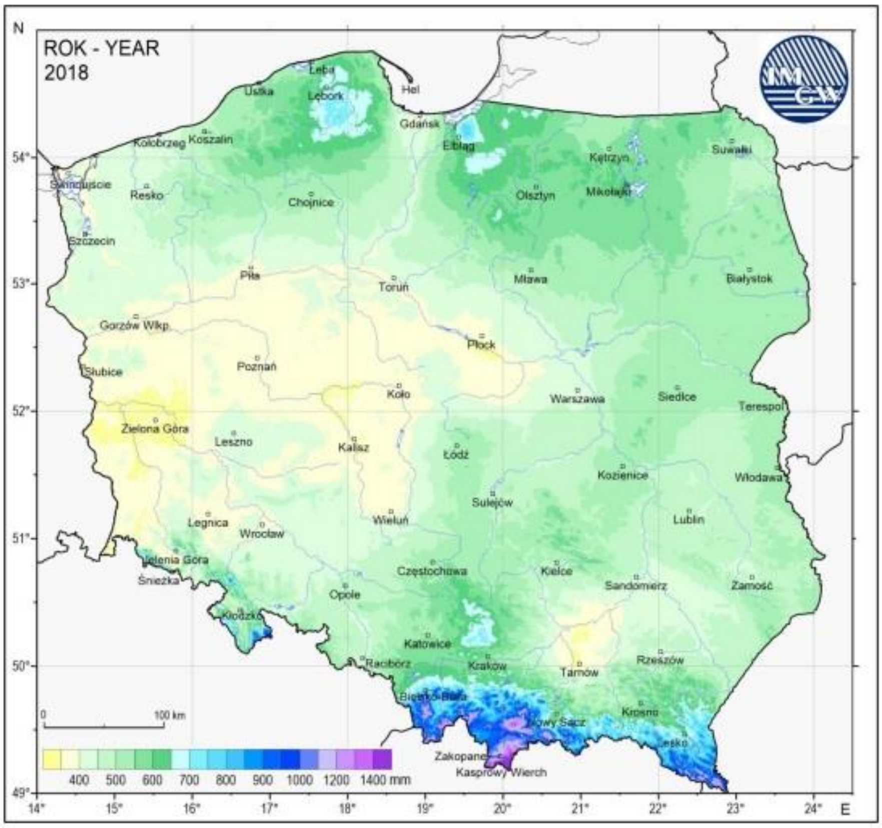


Figure 4. Annual precipitation totals in 2018[21]

In the first three months of 2018, there were specific meteorological conditions conductive to the occurrence of episodes of high concentrations, related to freezing temperatures and the frequency of inversion. This resulted in 5 cases of exceeding the level of notifying the population about pollution with PM10 particulate matter.

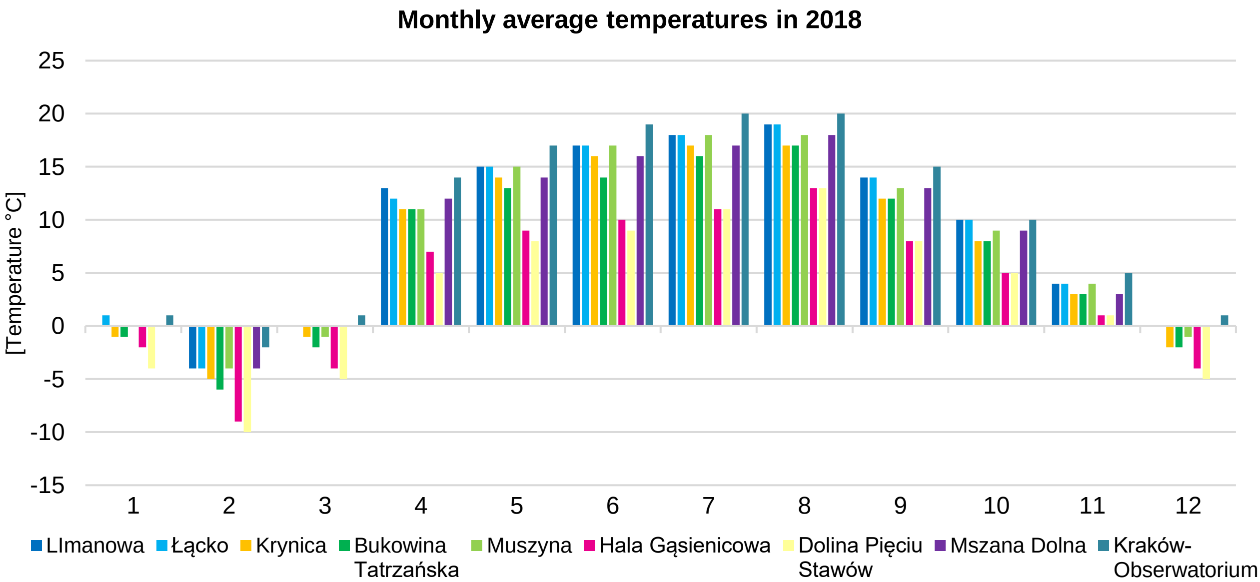


Figure 5. Monthly average temperatures at stations, based on IMGW measurements[22]

[21] Climate Monitoring Bulletin 2018, The National Research Institute of Meteorology and Water Management
[22] https://dane.imgw.pl/data

According to the data of the Institute of Meteorology and Water Management, in 2018 there were 7 episodes of the influx of tropical air (from the region of North Africa) over the territory of Poland, lasting a total of 28 calendar days. In the event of such episodes, there is a possibility that fine dusts raised above dry areas will be able to generate exceedances of the daily average at stations conducting PM10 measurements.

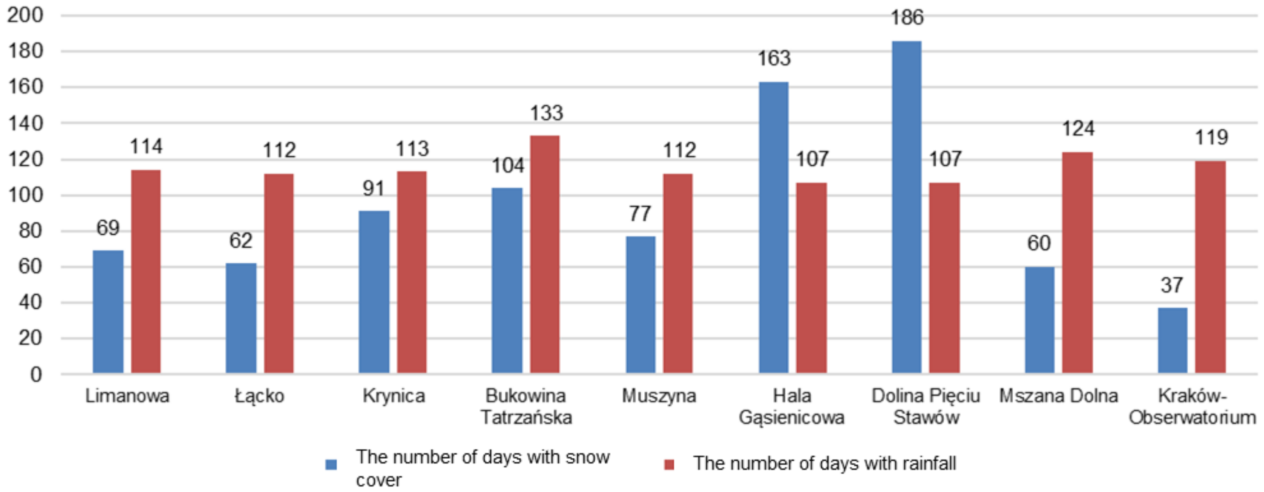


Figure 6. Days with snow cover and days with rainfall in the Malopolska Region, based on IMWM measurements[23]

The air quality analyses for the forecast years used the same meteorological data as for the base year 2018 due to the need to maintain consistency in the calibration of the model with the base year. This allowed for the best possible comparison of the achieved effects of the implementation of corrective actions.

3.4. The results of air quality measurements in the zones in 2013-2018

3.4.1. *KRAKOW AGGLOMERATION*

The results of air quality measurements carried out in the Krakow Agglomeration for pollution encompassed by the Plan in 2018, and in the previous years, i.e. 2013–2017, are presented below.

All results were based on the air quality measurements obtained from the monitoring stations located in the zone. In 2018, there were 7 monitoring stations in the Krakow Agglomeration zone, indicated below. At some stations, measurements are carried out automatically (al. Krasinskiego and ul. Dietla), while at other stations– manually or with a mixed method (ul. Bulwarowa).

Table 4. List of State Environmental Monitoring monitoring stations performing air quality measurements in 2018 in Krakow Agglomeration.[24]

Item	Monitoring station code	Monitoring station name	Station Address	Latitude	Longitude	Area Type	Station type
1	MpKrakAlKras	Krakow, Al. Krasinskiego	Al. Krasinskiego	50.057678	19.926189	urban	traffic
2	MpKrakBujaka	Krakow, ul. Bujaka	ul. Bujaka	50.010575	19.949189	urban	background
3	MpKrakBulwar	Krakow, ul. Bulwarowa	ul. Bulwarowa	50.069308	20.053492	urban	Industrial
4	MpKrakDietla	Krakow, ul. Dietla	ul. Dietla	50.057447	19.946008	urban	traffic

[23] https://dane.imgw.pl/data

[24] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

Item	Monitoring station code	Monitoring station name	Station Address	Latitude	Longitude	Area Type	Station type
5	MpKrakOsPias	Krakow, os. Piastow	os. Piastow	50.098508	20.018269	urban	background
6	MpKrakWadow	Krakow, os. Wadow	Wadow	50.100569	20.122561	urban	traffic
7	MpKrakZloRog	Krakow, ul. Zloty Rog	Zloty Rog	50.081197	19.895358	urban	background

Nitrogen dioxide

The permissible level for the average annual concentration is 40 µg/m³ for nitrogen dioxide. Exceedances of this level occurred in 2018 only in the Krakow Agglomeration. At the monitoring station, al. Krasinskiego in Krakow, every year since 2013, there were exceedances of the average annual permissible level. Analysis of data from the previous 5 years shows that the average annual concentrations were higher than in 2018, when the average annual concentration was 60,8 µg/m³. At other monitoring stations in the zone, the concentration level does not exceed 75% of the norm.

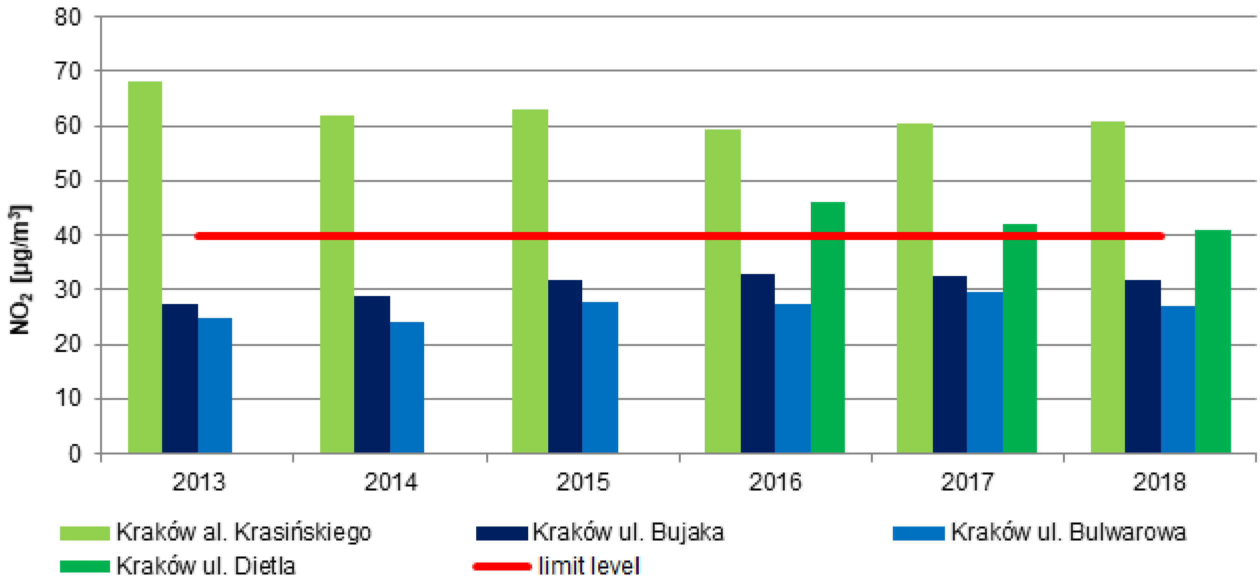


Figure 7. Average annual concentrations of nitrogen dioxide – NO_2 in the Krakow Agglomeration zone[25]

[25] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

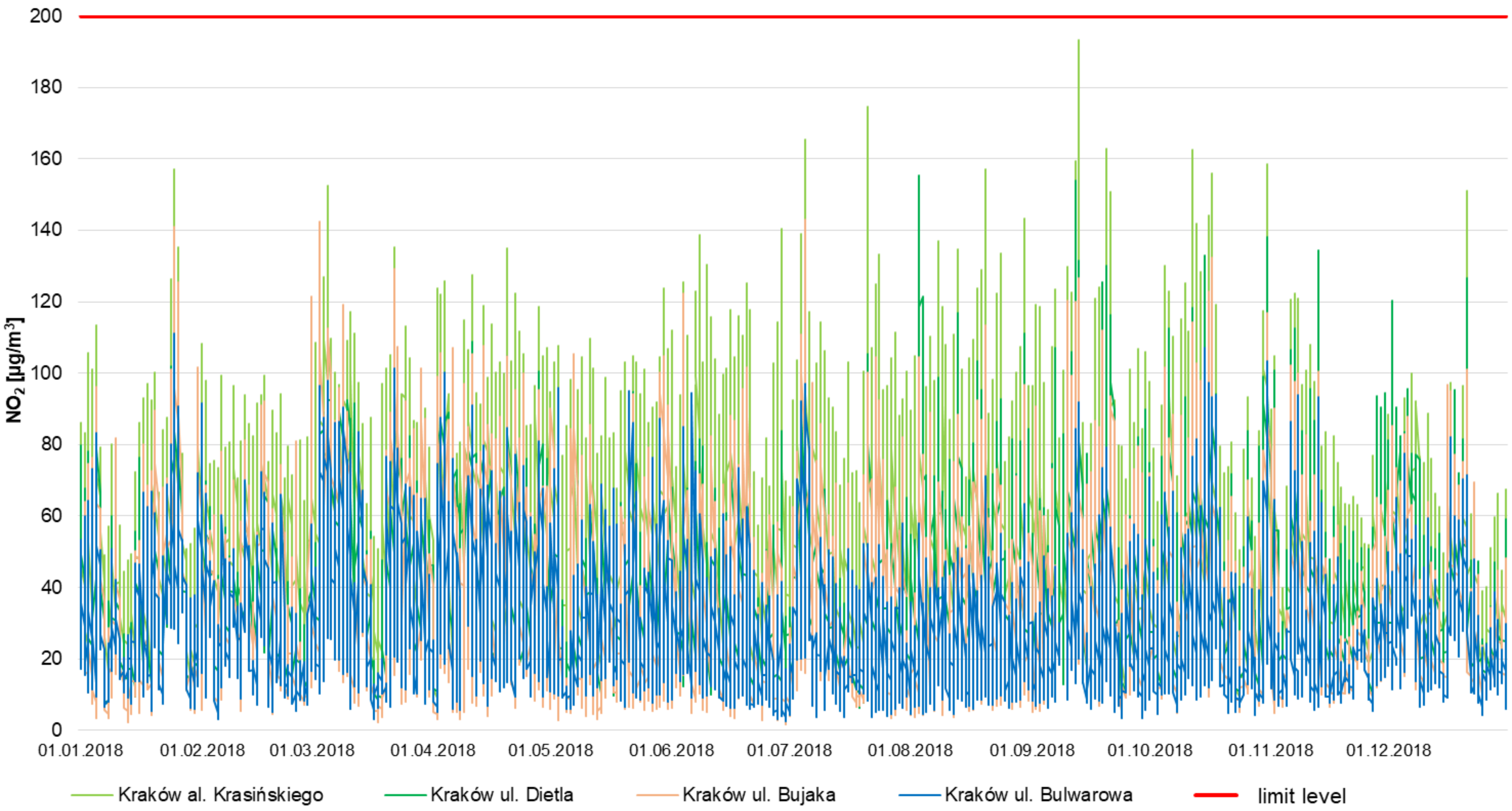


Figure 8. Distribution of 1-hour NO_2 concentrations in 2018 at monitoring stations in the Krakow Agglomeration zone[26]

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[26] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

In 2013-2018, exceedances of the average annual nitrogen dioxide norm were registered every year. However, there is a noticeable decrease in the level of average annual concentrations at the traffic station al. Krasinskiego in Krakow. Exceedances of the NO_2, hourly norm, which for the area of the country, for the protection of human health, is 200 μg/m³, occurred in 2013–2015. From 2016 to 2018, the hourly norm was not exceeded. The analysis of hourly concentrations on an annual basis does not indicate significant seasonal weather-dependent variation. However, analyzes of the concentrations by hour, show a visible change of nitrogen dioxide concentrations. These changes depend on the change in traffic, which is particularly evident at traffic stations.

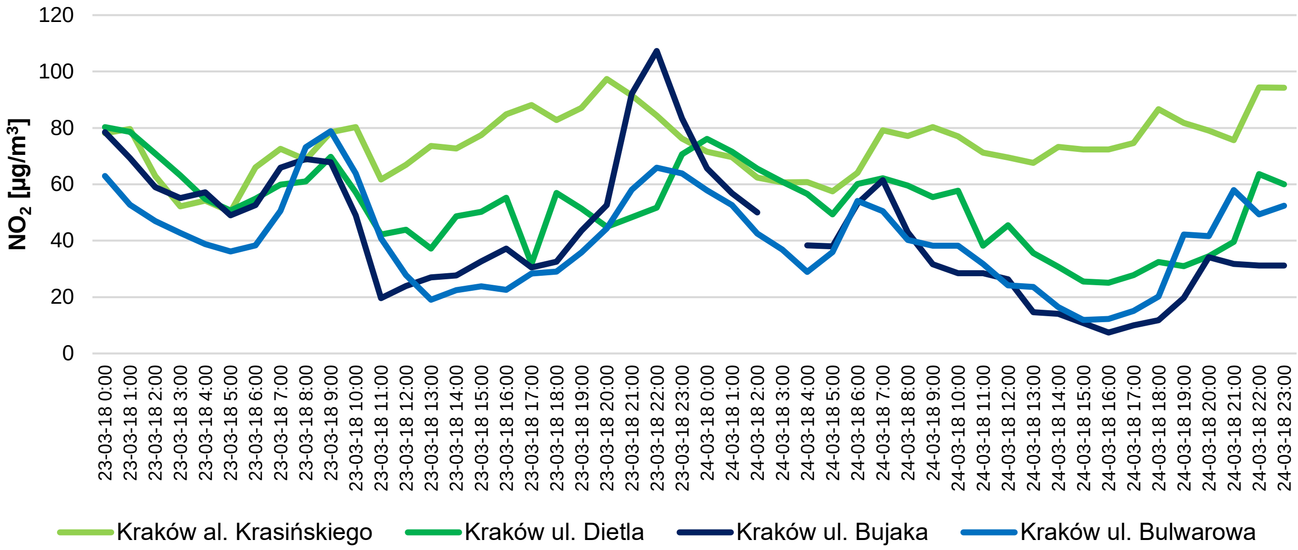


Figure 9. Distribution of 1-hour NO_2 concentrations at monitoring stations on 23-24 March 2018 in the Krakow Agglomeration zone[27]

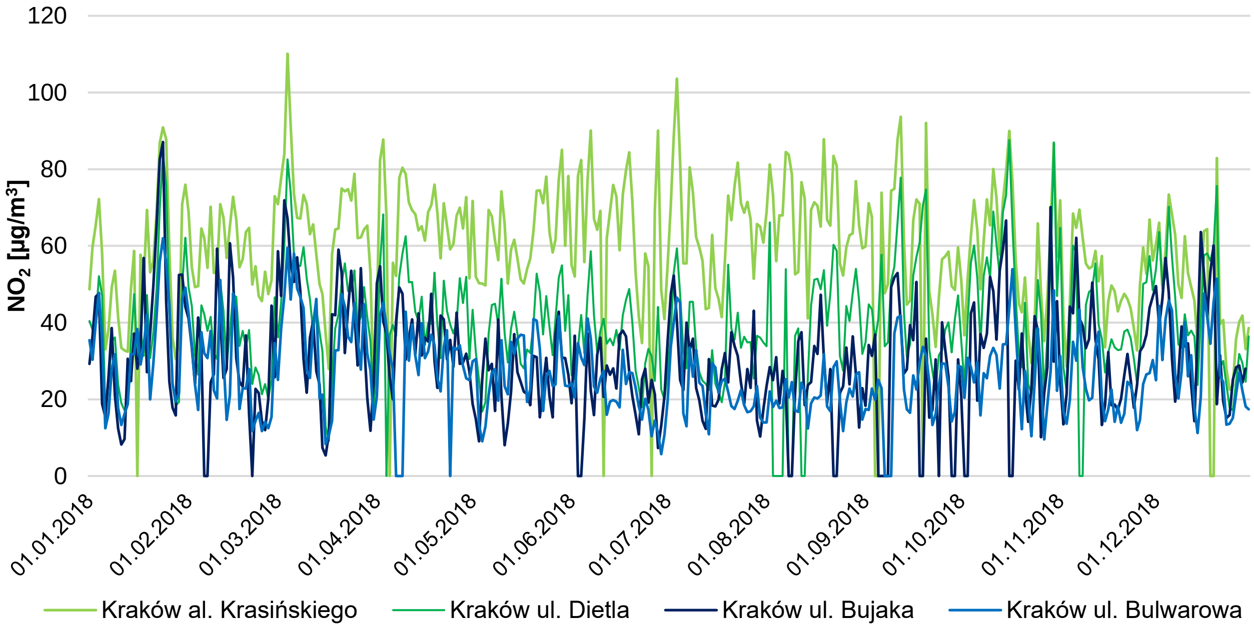


Figure 10. Distribution of 24-hour NO_2 concentrations in 2018 at monitoring stations in the Krakow Agglomeration zone[28]

[27] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region
[28] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

The graph (Figure 10) presents the distribution of 24-hour concentrations of nitrogen dioxide throughout 2018 at stations in Krakow. The measurement results show significantly lower concentrations in built-up areas at urban background stations and, at the same time, significantly higher concentrations at traffic stations. In addition, the concentrations decrease slightly in winter, and in summer the concentrations at traffic stations are higher.

Particulate matter PM10

The Regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air[29] introduces the following norms for PM10: daily of 50 µg/m³ and annual – 40 µg/m³. The number of days in a calendar year with daily exceedances (over 50 µg/m³) should not be greater than 35. In addition, the amendment to the Regulation of the Minister of Environment of 8 October 2019 on levels of certain substances in ambient air changed the information and the alert levels of PM10 concentrations. After the changes, the smog alarm is announced on the exceedance of the daily average value of 150 µg/m³ for PM10 (previously 300 µg/m³) and the 100 µg/m³ information level (previously 200 µg/m³).

According to *the Annual air quality assessment in the Malopolska Region for 2018*, the annual norm for particulate matter PM10 was not met in the Krakow Agglomeration. This is visible in the graph below which compares the average annual PM10 concentrations at the stations in Krakow. Intensive corrective measures taken in the region contribute to the improvement of air quality. However, despite this, the permissible levels of air pollutants are still exceeded. In recent years, the average annual concentrations recorded at stations reached the lowest value in 2016, with exceedances only at traffic stations – al. Krasinskiego (56 µg/m³) and ul. Dietla (47 µg/m³). In 2017, concentrations increased at an industrial station – ul. Bulwarowa (44 µg/m³), Zloty Rog (45 µg/m³) and at the station in ul. Bujaka (42 µg/m³). In 2018, there was a decrease in concentrations at the station in ul. Bulwarowa and Zloty Rog, where, despite the decrease in concentration, the annual norm (42 µg/m³). Both at the station in ul. Bujaka, and in os. Piastow concentrations increased, and in 2018 they exceeded the permissible values.

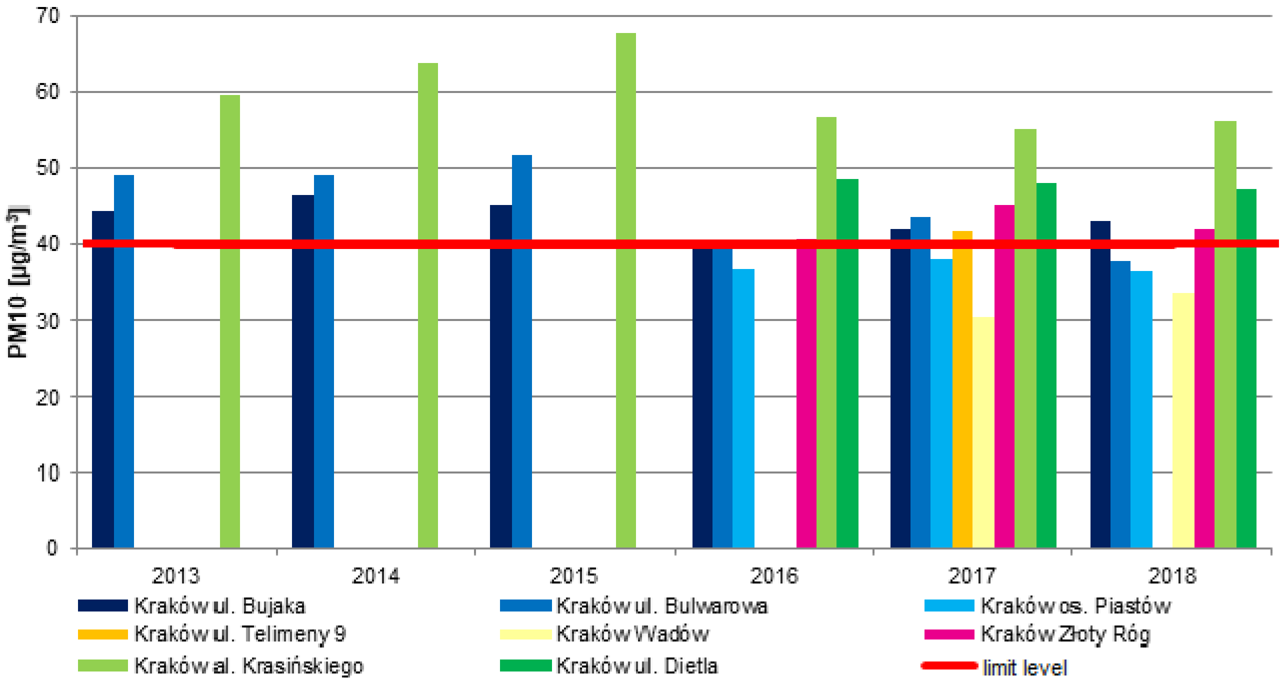


Figure 11. Average annual PM10 concentrations in the Krakow Agglomeration zone[30]

[29] Source: Journal of Laws of 2012, item 1031with changes
[30] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

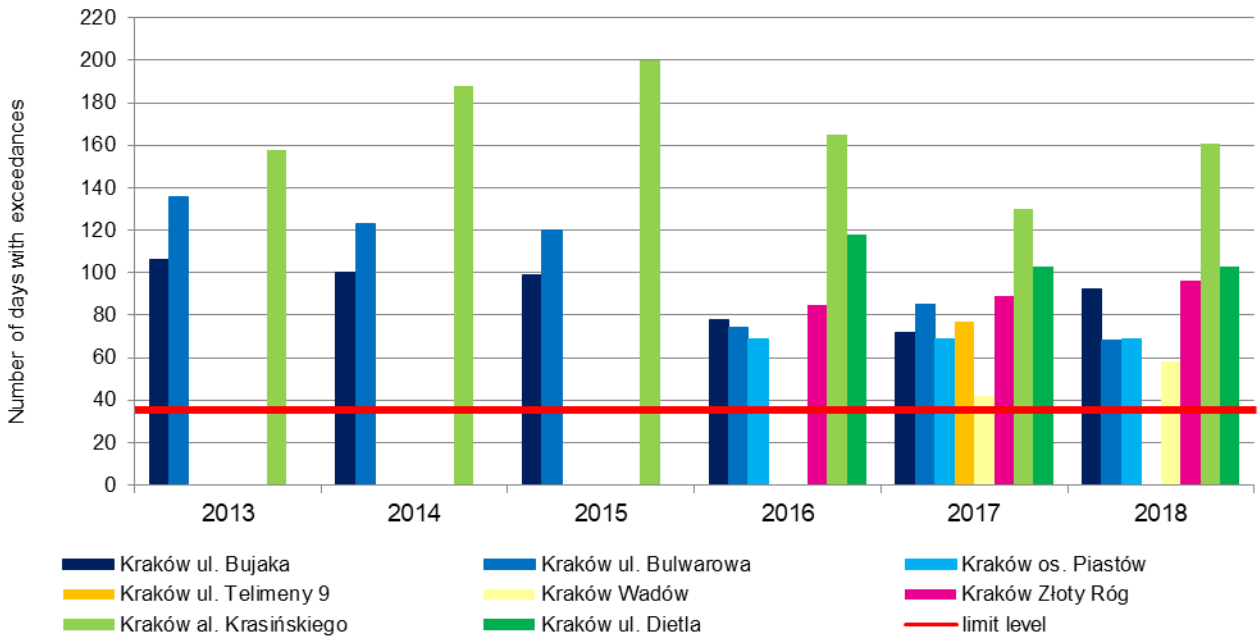


Figure 12. Number of days with exceedances of 24-hour PM10 concentration in the Krakow Agglomeration zone[31].

In 2018, all stations registered more than 35 days with exceedance of the daily norm for PM10 (50 µg/m^3). Most days on which the daily concentration value was above 50 µg/m^3, occurred at traffic stations in al. Krasinskiego – 161 days, and in ul. Dietla –103 days. The fewest exceedances were recorded at the Wadow station – 58 days.

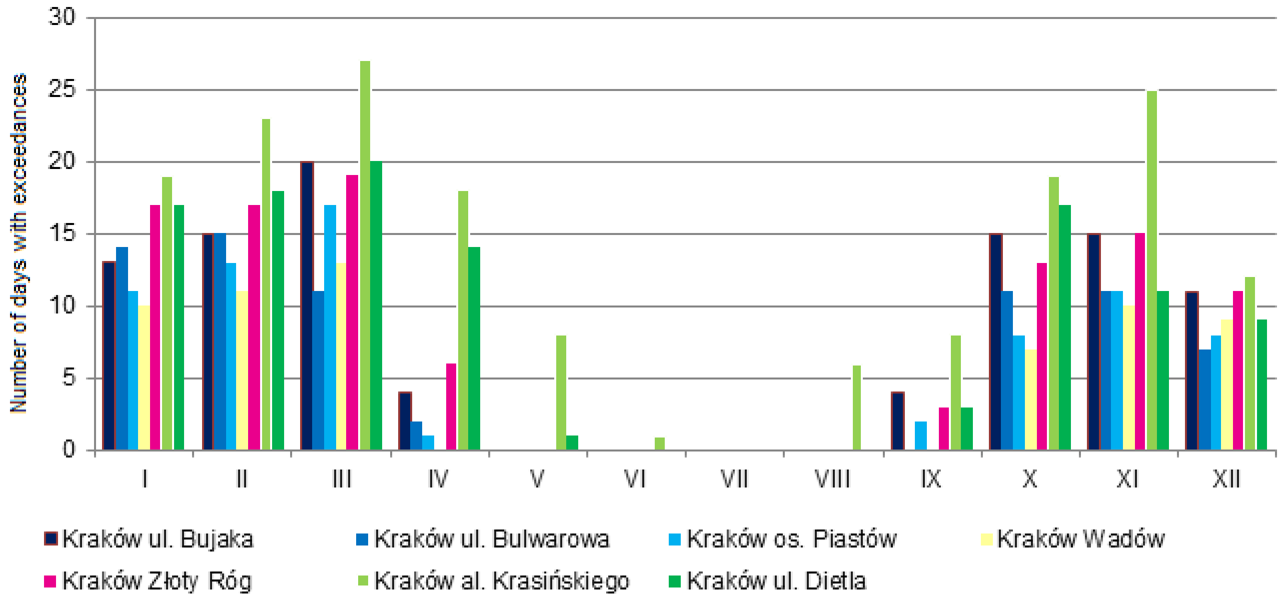


Figure 13. Number of days with exceedance of 24-hour limit value for PM10 in the Krakow Agglomeration zone in 2018[32]

Analysing the changes in the number of days with exceeded PM10 daily norm in 2018 on a monthly basis, the highest number of these days was observed in March 2018. At the station al. Krasinskiego on 27 out of 31 days, daily concentrations exceeded the allowable value. At 5 out of 7 stations, the air quality did not meet the norm for more than half a month. The only month when the daily norms were not exceeded at any station was

[31] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

[32] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

July. In May, June and August, the exceedances occurred only at traffic stations, which clearly indicates the impact of low-stack emission on the occurrence of exceedances.

The distribution of the number of days with exceedances of the daily norm during the year also indicates a variation in air quality between the first and the second half of the year. The beginning of the year was not favourable for the ventilation of the city, which is why there were many more days with exceedances than in the second half of the year, i.e. at the beginning of the heating season.

The differences in the number of days with exceedances in months perfectly illustrate the importance of meteorological conditions in the analysis of air quality, determining the occurrence of smog and exceedances of PM10 limits. This is also demonstrated by the results of daily PM10 concentrations in 2018 recorded at monitoring stations. The vast majority of days with exceedances of the daily norm occurred in the heating season, which indicates the dominant impact of the municipal and household sector on high levels of PM10. Outside the heating season, exceedances of the permissible level were recorded only at an increased frequency of traffic at the traffic station – Al. Krasinskiego.

In addition to exceedances of daily norms, both in 2018 and in the years before it, exceedances of the information and the alert level were observed. Based on the levels biding in 2018 (information level – 200 μg/m^3, alert level – 300 μg/m^3) no exceedances occurred. The largest number of days with the concentration of PM10 above the alert level in previous years occurred in 2017. Similarly, the most days with exceeding the information level were recorded in 2017. However, referring the recorded concentrations to the currently-biding norms (information level – 100 μg/m^3, alert level – 150 μg/m^3), both values were exceeded, which can be seen in figure 14.

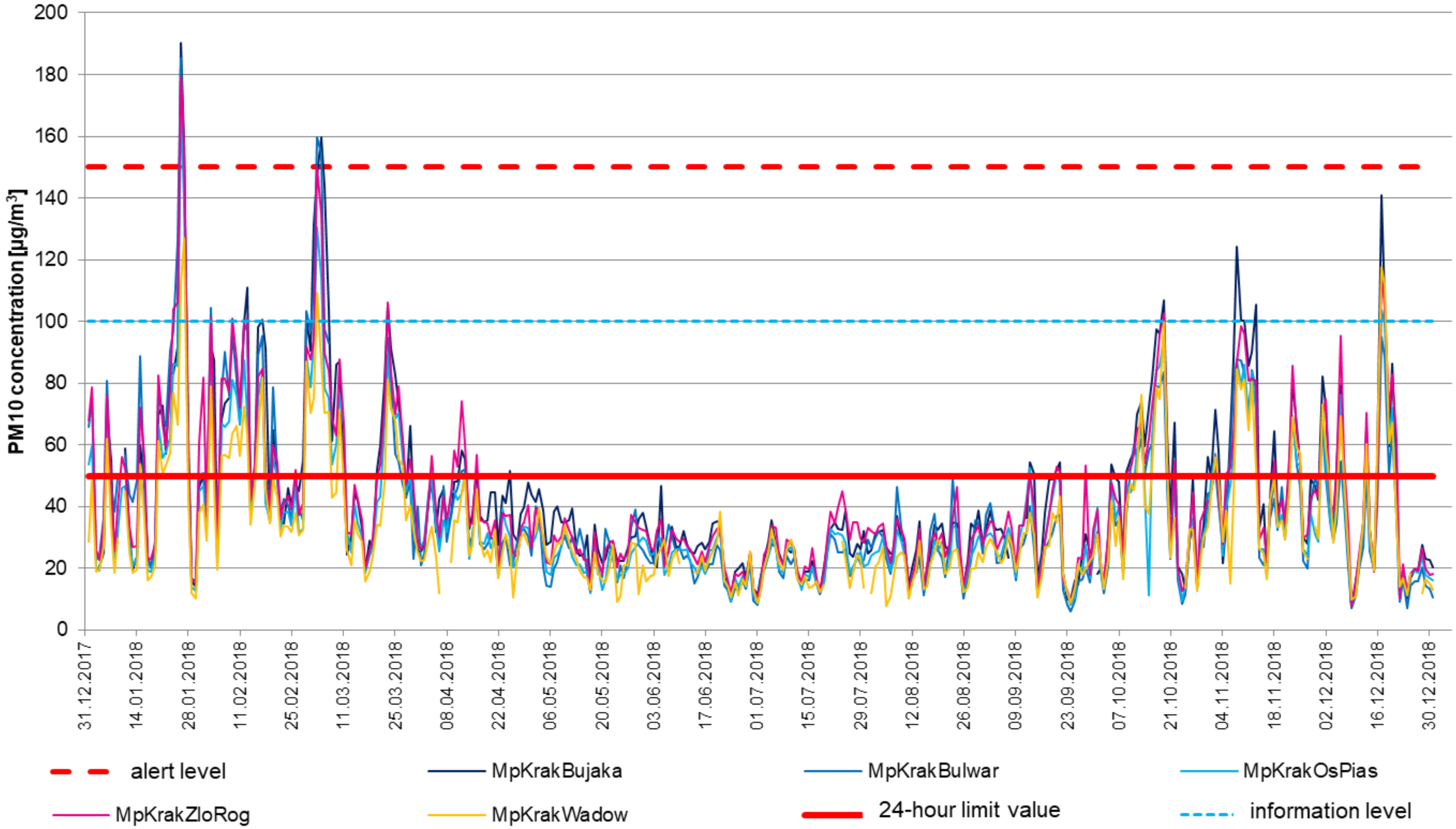


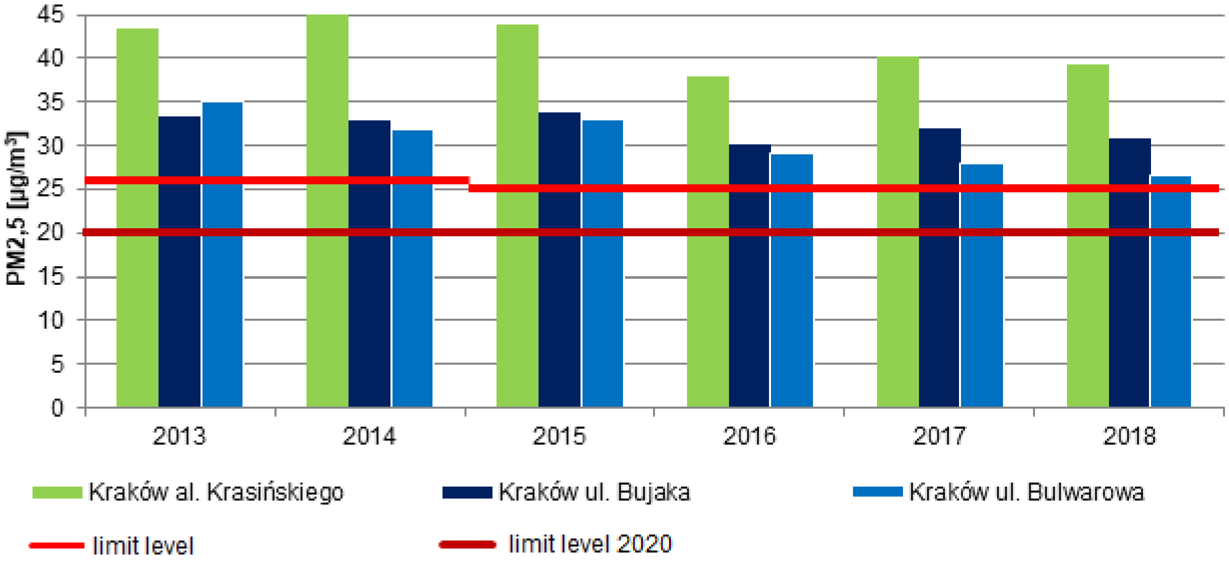
Figure 14. Pattern of changes in 24–hour concentration of PM10 at urban background stations in the Krakow Agglomeration in 2018.[33]

[33] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

Particulate matter PM2.5

According to the Regulation on levels of certain substances in ambient air[34] from 2020 the norm for the average annual concentration of PM2.5 is 20 µg/m³. The Regulation required achieving the average annual PM2.5 concentration of 25 µg/m³ in I phase, i.e. until 2015, from 2020 (phase II) the average annual PM2.5 concentration must stay at 20 µg/m³. In 2018, the Krakow Agglomeration observed exceeded concentrations of average annual PM2.5 for phases I and II.

The data presented below (

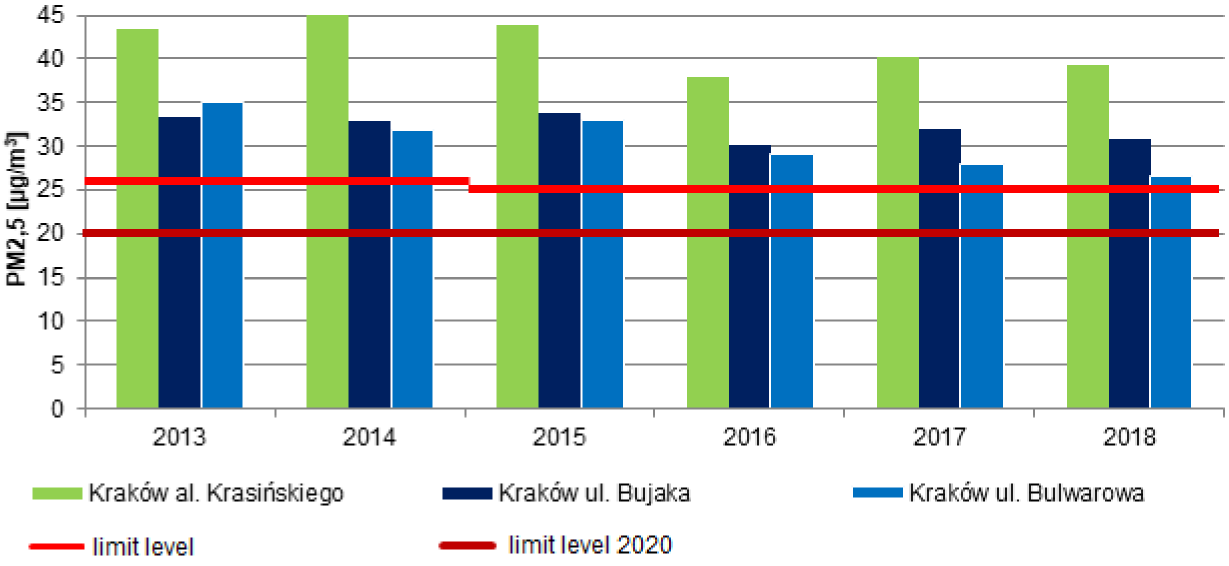


*the permissible level of the annual average PM2,5 between 2013 and 2014 was 26 µg/m³, between 2015 and 2019 it was 25 µg/m³, since 2020 permissible level is 20 µg/m³

Figure 15. Average annual PM2.5 concentration in the Krakow Agglomeration.

) show that, from 2013 to 2018, in Krakow, the permissible level of PM2.5 was exceeded at all monitoring stations. Comparing measurements from recent years, a decrease in the concentration of the air pollution of this type was visible since 2013. The highest average annual concentrations occurred in 2018 at Al. Krasinskiego station, with average annual of 39,3 µg/m³. The lowest concentration occurred at the station in ul. Bulwarowa.

[34] Source: Journal of Laws of 2012 item 1031



**the permissible level of the annual average PM2,5 between 2013 and 2014 was 26 µg/m³, between 2015 and 2019 it was 25 µg/m³, since 2020 permissible level is 20 µg/m³*

Figure 15. Average annual PM2.5 concentration in the Krakow Agglomeration.[35]

Due to the negative impact of fine dust PM2.5 on people's health and lives, an additional indicator for urban background areas – *the average exposure indicator* – was introduced. This indicator is calculated for cities with more than 100,000 inhabitants and for agglomerations. For these areas, the permissible value for PM2.5 in the air was determined, which was called the exposure concentration ceiling, calculated on the basis of the average exposure indicator. Based on this indicator, the national average exposure indicator is also calculated, which is currently 22 µg/m³. It is the basis for calculating the national exposure reduction target. The value of the indicator for the Krakow Agglomeration in 2018 was 31 µg/m³. Compared to previous years, a decrease in the value of the above indicator for Krakow – in 2015 it was 33 µg/m³.

[35] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

Benzo(a)pyrene

Pursuant to the Regulation of the Minister of Environment on levels of certain substances in ambient air, the concentration norm for the average annual target level for benzo(a)pyrene is 1 ng/m^3. The mentioned pollution for many years exceeded the norm specified in the abovementioned Regulation. The average annual concentrations of benzo(a)pyrene at stations located in the Krakow Agglomeration are presented below.

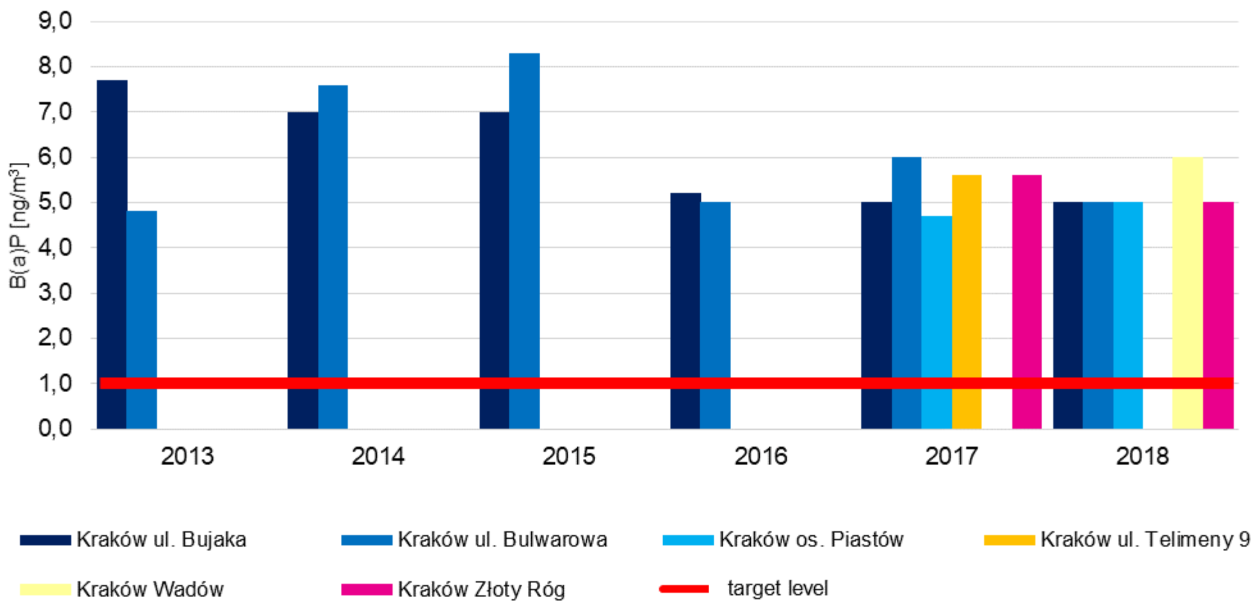


Figure 16. Average annual concentrations of benzo(a)pyrene in 2018 in the Krakow Agglomeration zone[36]

The average annual concentrations of benzo(a)pyrene in 2018 several times exceeded the target level at all monitoring stations. In Krakow, the average concentration value was 5 ng/m^3, which is 500% of the target value. Such high exceedances are mainly due to B(a)P emissions in coal combustion processes in the municipal and household sector. In comparison to last years, values of benzo(a)pyrene concentrations in Krakow have decreased.

3.4.2. TARNOW CITY ZONE

All the results of the air quality assessment for Tarnow were based on the results of air quality measurements at the monitoring stations. In 2018, there were 2 monitoring stations in the city of Tarnow zone, indicated below.

Table 5. List of the State Environmental Monitoring monitoring stations performing air quality measurements in 2018 in Tarnow.[37]

Item	Monitoring station code	Monitoring station name	Station Address	Latitude	Longitude	Area Type	Station type
1	MpTarBitStud	Tarnow, ul. Bitwy pod Studziankami	ul. Bitwy pod Studziankami	50.020169	21.004167	urban	background
2	MpTarRoSitko	Tarnow, ul. Ks. Romana Sitko	ul. Ks. Romana Sitko	50.018253	20.992578	urban	traffic

[36] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

[37] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

Particulate matter PM10

In recent years, PM10 levels in has remained at a similar level in recent years and have not exceeded the average annual norm. The highest concentration - 38 μg/m³ was noticed in 2017.

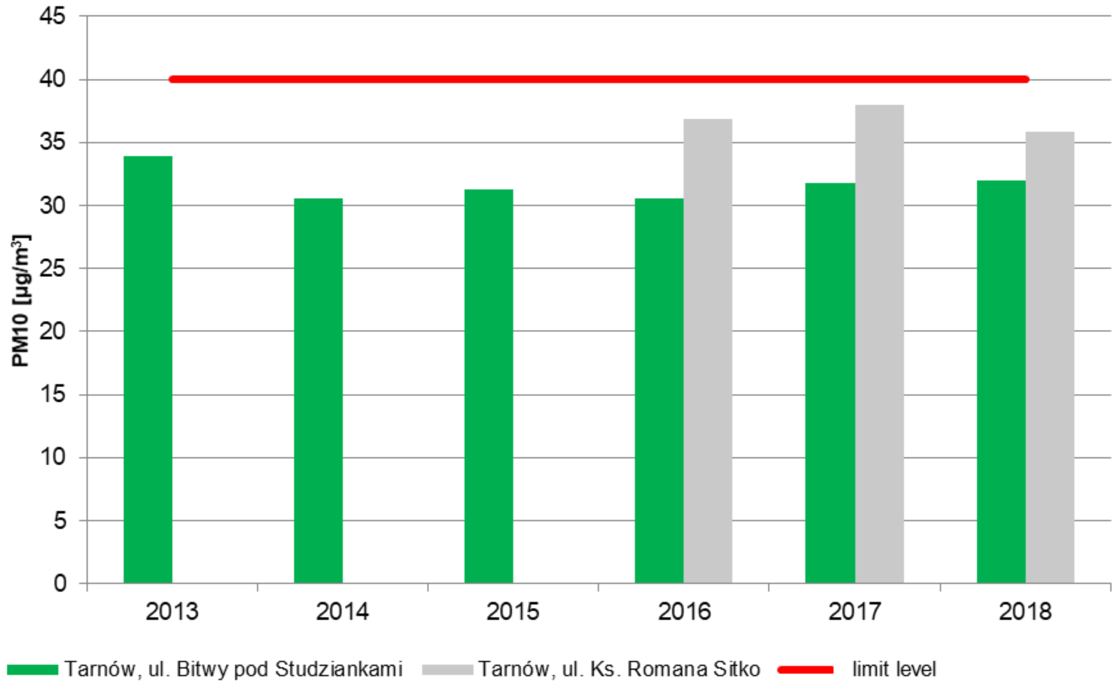


Figure 17. Average annual concentration of PM10 in the Tarnow city zone[38]*.*

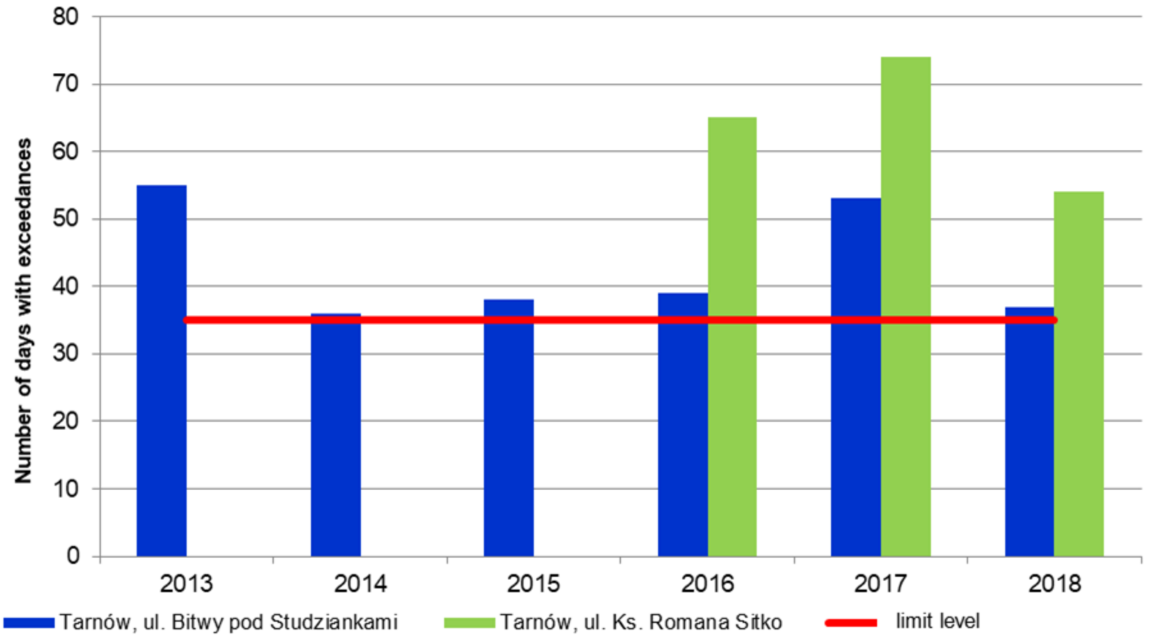


Figure 18. Number of days with exceeded 24-hour PM10 concentration in the city of Tarnow[39]

[38] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

[39] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

In the city of Tarnow zone, in 2018, the average annual PM10 concentration was not exceeded at any of the station (**Błąd! Nie można odnaleźć źródła odwołania.**), while the number of days with exceedances of 50 μg/m^3 (daily norm) was 37 days at the station in ul. Bitwy pod Studzianki and 54 days in ul. Ks. Romana Sitko. Measurement data indicate a decrease in both the average annual concentration and the number of days with exceedances of daily norms for PM10 in recent years. Established in 2016, the station in ul. Ks. Romana Sitko shows significantly higher concentrations than the station operating to date in the city.

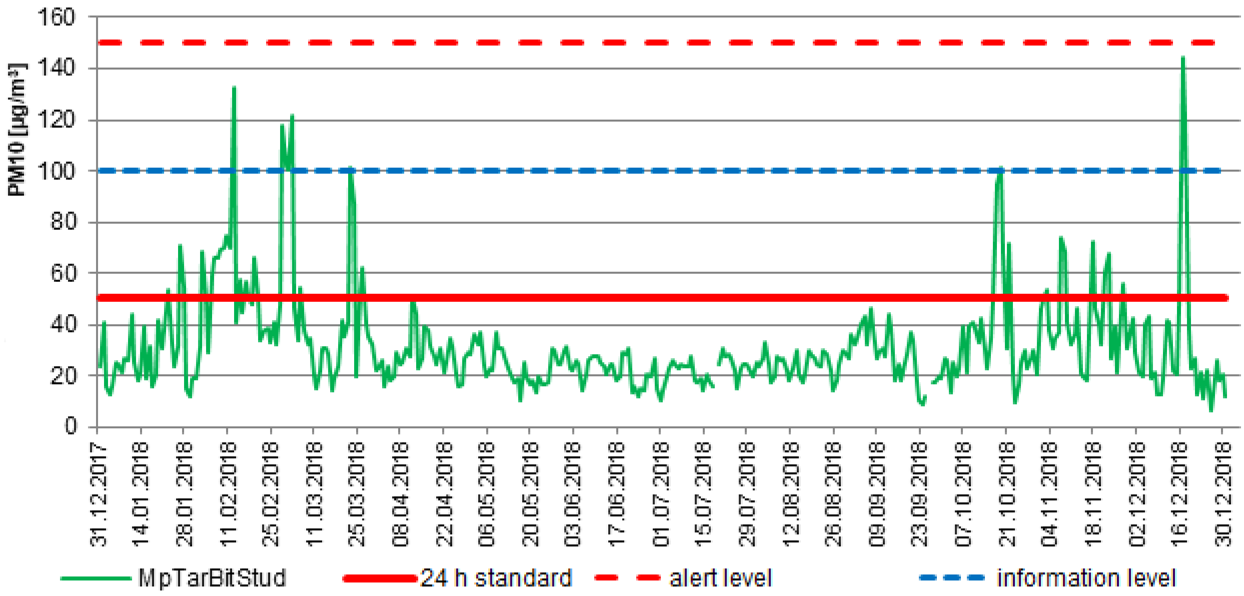


Figure 19. Pattern of changes of 24-hour PM10 concentrations in Tarnow in 2018[40]

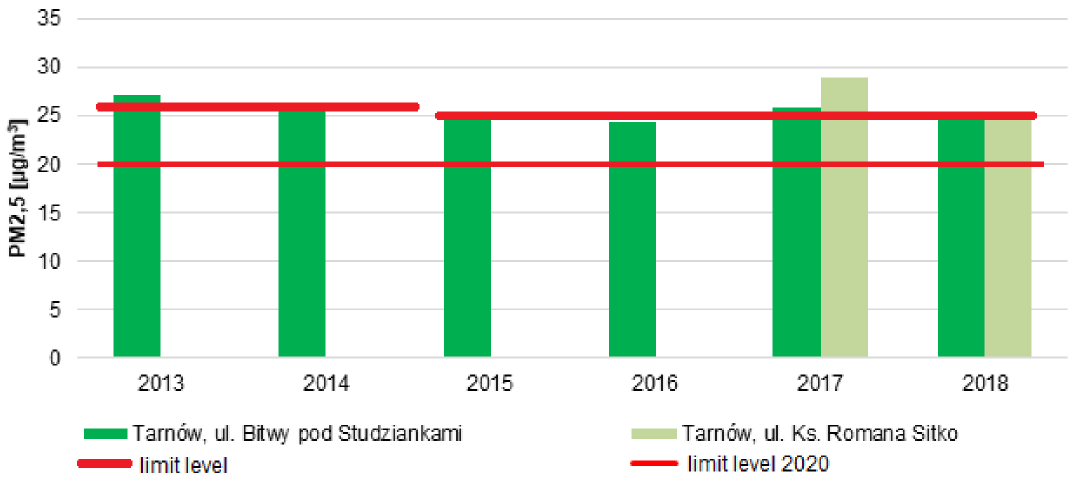
Analysing the pattern, it can be seen that exceeding the permissible level (50 μg/m^3) occurs only in the heating season.

In Tarnow, the alert level was not exceeded even once (according to the new Regulation from 2019), and the daily norms were exceeded only in winter, in the heating season. Exceeding the information level would occur several times if compared with the value applicable from 2019 (100 μg/m^3). According to the levels biding in 2018, there were no exceedances of the public information level.

Particulate matter PM2.5

In the city of Tarnow, in 2018, PM2.5 concentrations did not exceed the limit value of the air quality biding in the year. Yet, the permissible level of phase II for PM2.5, which will apply from 2020 (20 μg/m^3), has been exceeded.

[40] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region



**the permissible level of the annual average PM2,5 between 2013 and 2014 was 26 µg/m³, between 2015 and 2019 it was 25 µg/m³, since 2020 permissible level is 20 µg/m³*

Figure 20. Average annual PM2.5 concentration in the Tarnow city zone[41]

The analysis of the data presented in the above chart shows that since 2013 the annual PM2.5 concentration norms have not been exceeded. The exception was 2017, when, at the station in ul. Ks. Romana Sitko, the annual norm was exceeded by 4 µg/m³. The average annual PM2.5 concentration recorded in Tarnow (24,8 µg/m³) did not exceed the norm biding in 2018. Since 2020, the average annual PM2.5 concentration may not exceed 20 µg/m³.

The value of the average exposure indicator for Tarnow, which is determined in relation to the PM2.5 concentration, was 25 µg/m³. The national average exposure indicator is 22 µg/m³. Compared to previous years, a decrease in the value of the above indicator is observed (in 2015 it was 26 µg/m³ for Tarnow).

Benzo(a)pyrene

Measurements of benzo(a)pyrene concentration indicate several-fold exceedance of the target value. This is a nationwide problem because in virtually all regions the average annual target value of 1 ng/m³ is exceeded. Since 2013, the concentration of benzo(a)pyrene in Tarnow has been stable at around 4 ng/m³, which exceeds the target value four times.

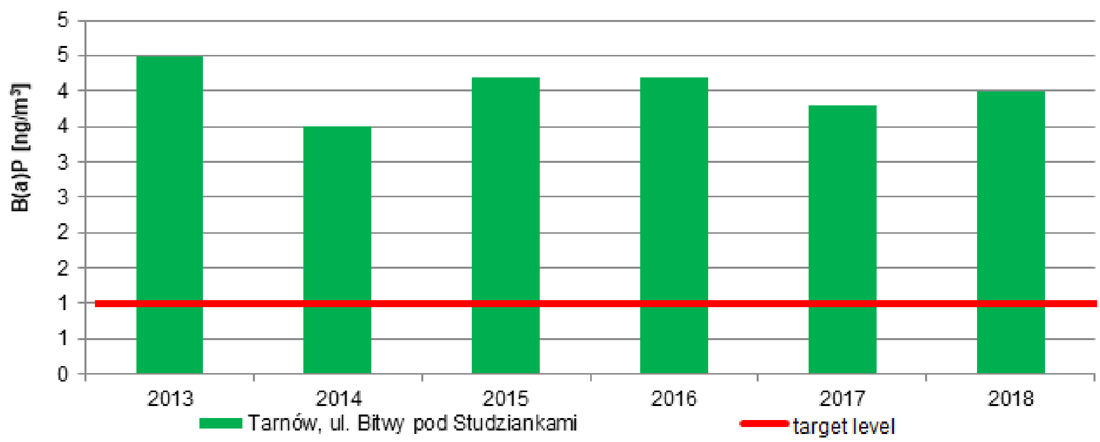


Figure 21. Average annual benzo(a)pyrene concentrations in the Tarnow city zone42

[41] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

[42] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

3.4.3. MALOPOLSKA ZONE

The air quality analysis in the Malopolska zone was based on results from monitoring stations, with manual (referential) and automatic measurements. The list of monitoring stations used in the air quality assessment for 2018 is shown in the table below.

Table 6. List of the State Environmental Monitoring monitoring stations performing air quality measurements in 2018 in the Malopolska zone. [43]

Item	Monitoring station code	Monitoring station name	Station Address	Latitude	Longitude	Area Type	Station type
1	MpBochKonfed	Bochnia, ul. Konfederatow Barskich	ul. Konfederatow Barskich	49.969017	20.439511	urban	background
2	MpGorlKrasin	Gorlice, ul. Krasinskiego	ul. Krasinskiego	49.658889	21.163336	urban	background
3	MpKaszowLisz	Kaszow	Bory	50.025028	19.726833	suburban	background
4	MpMuszynZloc	Muszyna Zlockie	Zlockie 79	49.374147	20.879581	non-urban	background
5	MpNiepo3Maja	Niepolomice, ul. 3 Maja	ul. 3 Maja	50.035117	20.212689	urban	background
6	MpNoSaczNadb	Nowy Sacz, ul. Nadbrzezna	ul. Nadbrzezna	49.619281	20.714403	urban	background
7	MpNoTargPSlo	Nowy Targ, Plac Slowackiego	Plac Slowackiego	49.483597	20.028992	urban	background
8	MpOswiecBema	Oswiecim, ul. J. Bema	J. Bema	50.033083	19.245275	urban	background
9	MpSkawOsOgro	Skawina, os. Ogrody	os. Ogrody	49.971047	19.830422	urban	background
10	MpSuchaNiesz	Sucha Beskidzka, ul. Nieszczynskiej	ul. Nieszczynskiej	49.743131	19.600339	urban	background
11	MpSzarowSpok	Szarow, ul. Spokojna	ul. Spokojna	50.007500	20.259167	suburban	background
12	MpSzymbaGorl	Szymbark	MpSzymbaGorl	49.633714	21.116833	non-urban	background
13	MpTrzebOsZWM	Trzebinia, os. Zwiazku Walki Mlodych	os. Zwiazku Walki Mlodych	50.159406	19.477464	urban	background
14	MpTuchChopin	Tuchow, ul. Chopina	ul. Chopina	49.894169	21.051061	urban	background
15	MpZakopaSien	Zakopane, ul. Sienkiewicza	ul. Sienkiewicza	49.293564	19.960083	urban	background

Particulate matter PM10

The annual norm for particulate matter PM10 in the Malopolska Region zone was not met throughout the analysed period, i.e. 2013-2018. Graphs for all monitoring stations showing the average annual concentrations of PM10 are presented below.

[43] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

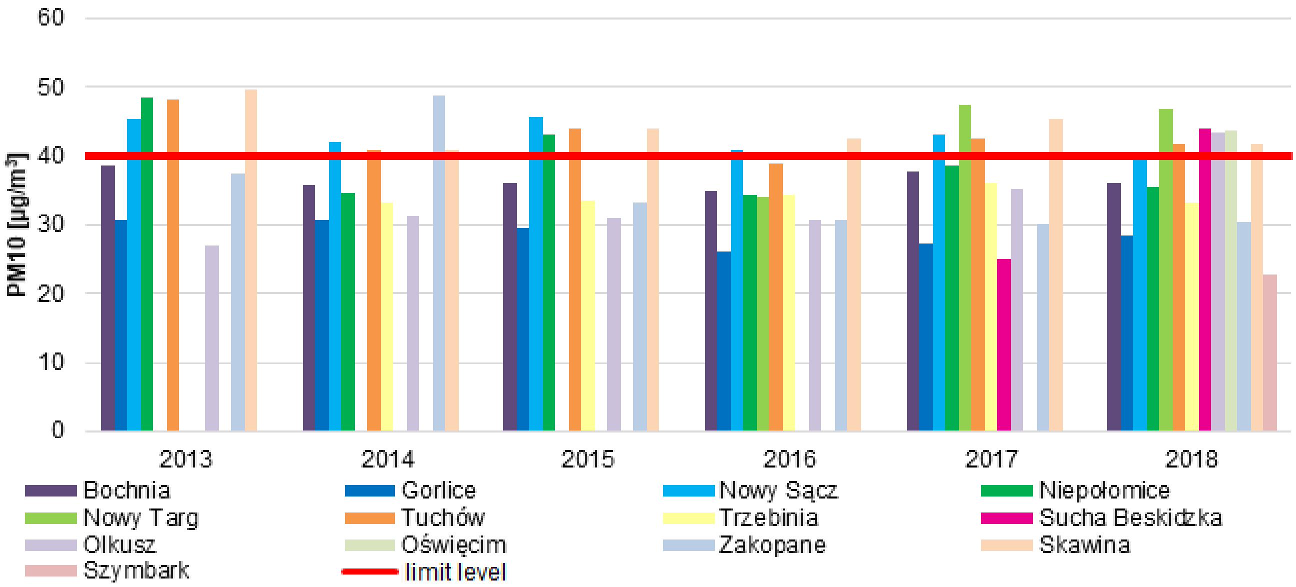


Figure 22. Average annual concentration of PM10 in the Malopolska zone44

The largest exceedances occurred in 2018 at the stations in Nowy Targ (46 µg/m^3), Oswiecim (43 µg/m^3), Sucha Beskidzka (43 µg/m^3) and Tuchow (41 µg/m^3). Concentrations at other stations were not higher than the permissible value of 40 µg/m^3. The average annual concentration in Nowy Sacz fell below the limit value. The lowest average annual concentrations were recorded at the stations in Gorlice (28 µg/m^3) and Zakopane (30 µg/m^3).

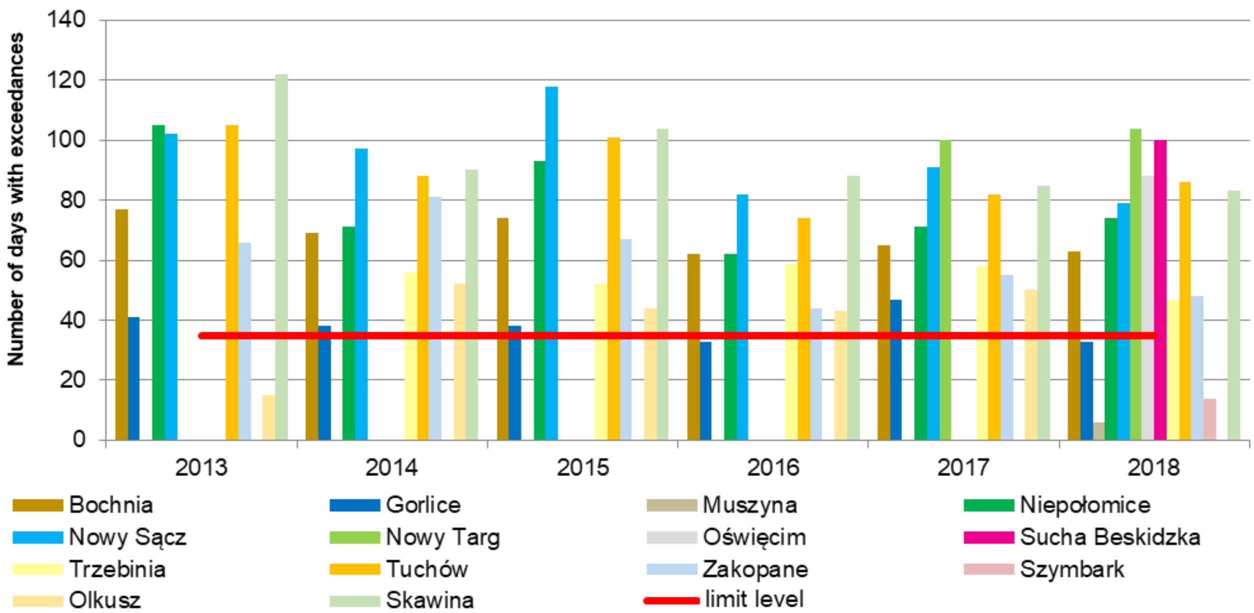


Figure 23. Number of days with exceeded 24-hour concentration of PM10 in the Malopolska zone[45]

In Nowy Targ and Sucha Beskidzka, the daily norm of PM10 was exceeded on more than 100 days a year. In 2018, the fewest days with exceedances occurred in Muszyna. Since 2015, the number of stations measuring air quality increased from 9 to 13 in 2018. This allows better diagnosis of areas with high concentrations of substances.

[44] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

[45] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

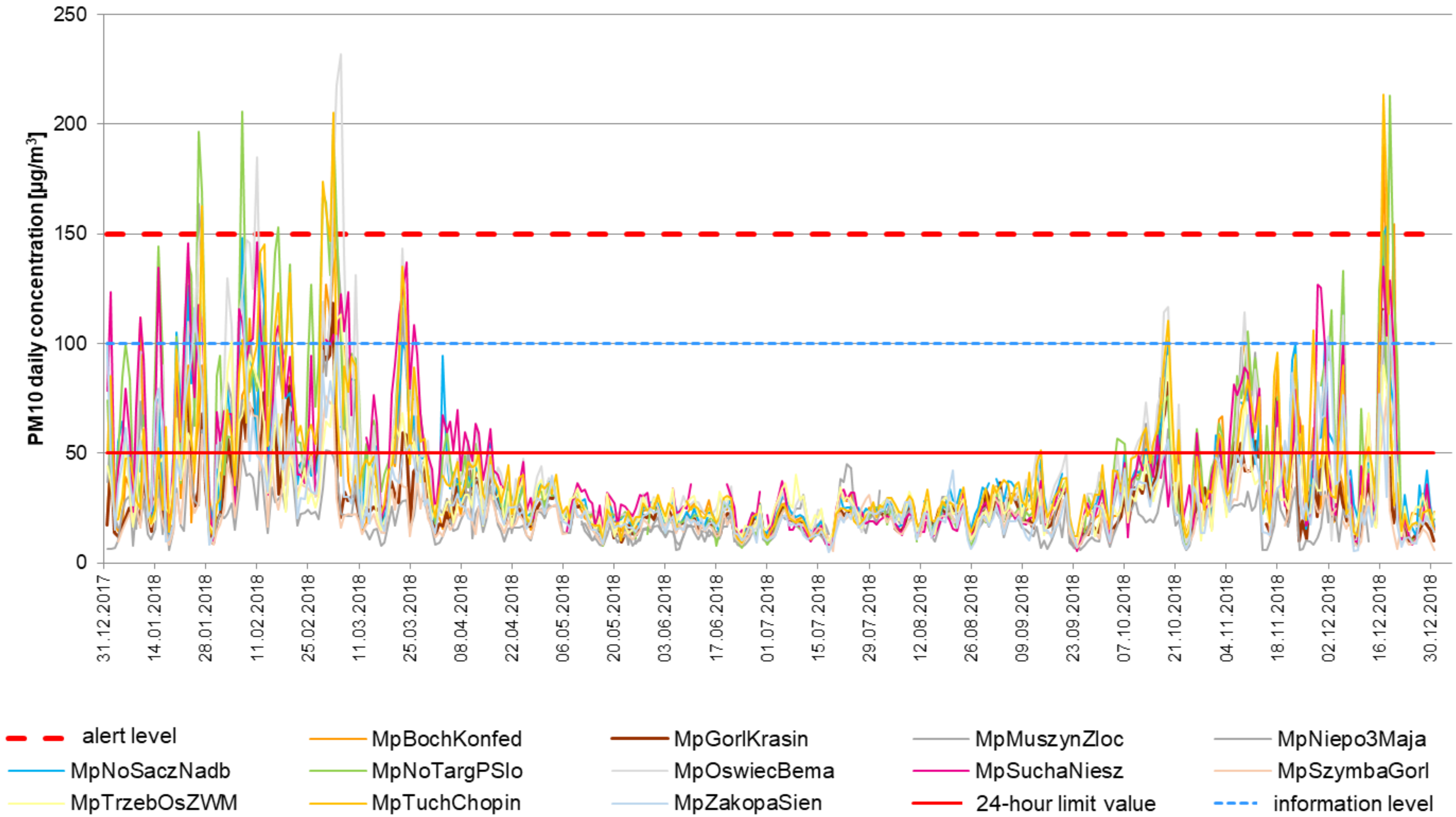


Figure 24. Pattern of changes of 24-hour concentrations of particulate matter PM10 in the Malopolska zone[46]

[46] Source: Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

Exceedances of the 24-hour PM10 norm are recorded primarily in the periods from January to April and from October to December. Such high values were affected by meteorological conditions, in particular the occurrence of thermal inversion, very weak wind and low temperatures. In periods of low temperatures, heating processes intensify – burning of energy resources in individual furnaces at the time of thermal inversion blocks the upward movement of pollutants. This problem appears mainly in towns located in mountain valleys, and thus affects a significant part of Malopolska Region.

Particulate matter PM2.5

According to the Regulation on levels of certain substances in ambient air[47] from 2020, the norm for the average annual PM2.5 concentration has been reduced from 25 µg/m³ (phase I) to 20 µg/m³ (phase II). In 2018, there were exceedances for both phase I and phase II of the average annual PM2.5 concentration.

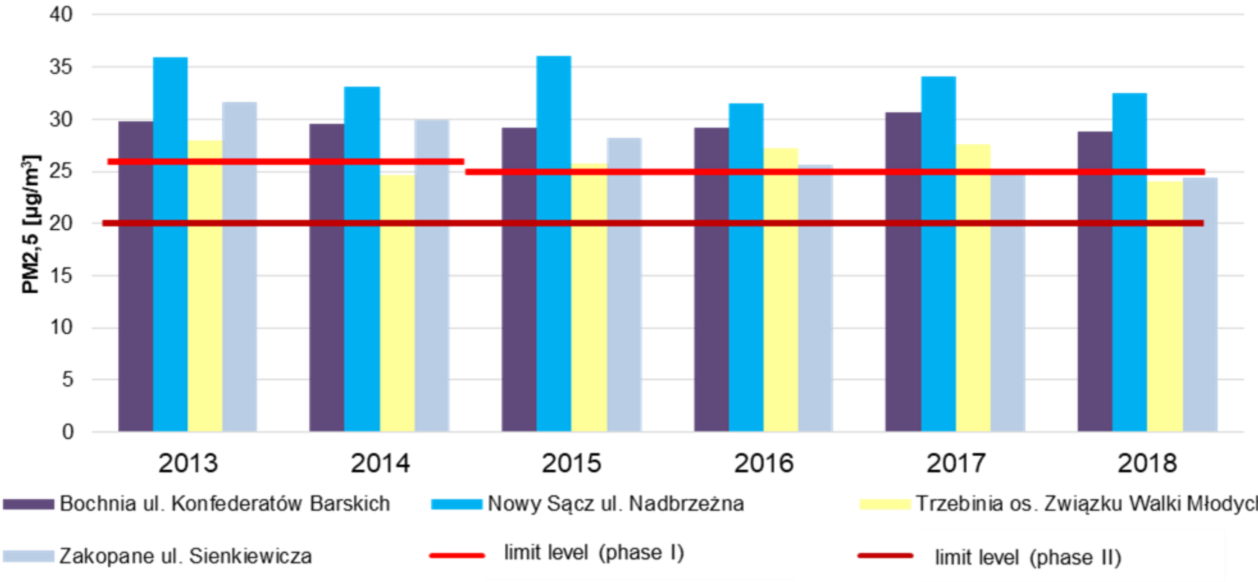


Figure 25. Average annual concentrations of PM2.5 in the Malopolska zone[48]

The results of the measurements show that in the Malopolska zone in the period from 2013 to 2018, at the majority of stations exceeded permissible levels were observed. At the same time, there is a downward trend in PM2.5 concentrations. In 2018, at two of four stations – in Trzebinia and Zakopane – the permissible level of 25 µg/m³ was not exceeded. However, the level set for phase II (20 µg/m³) was exceeded at all stations.

Benzo(a)pyrene

For many years, this pollution has exceeded the norm specified in the Regulation on levels of certain substances in ambient air. The average annual concentrations of benzo(a)pyrene at stations located in the Malopolska zone are presented below.

There are very high exceedances of the benzo(a)pyrene target value throughout the whole Malopolska zone. The highest recorded exceedances occur in Nowy Targ (18 ng/m³) and in Nowy Sacz (10 ng/m³). These values are several times greater than the designated norm. Most monitoring stations show a downward trend or average annual concentrations remaining at a similar level in recent years. Only in Nowy Targ the concentration of B(a)P clearly increases. Pollution with carcinogenic benzo(a)pyrene is currently the biggest problem in terms of air quality in Malopolska.

[47] Source: Journal of Laws of 2012 item 1031

[48] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

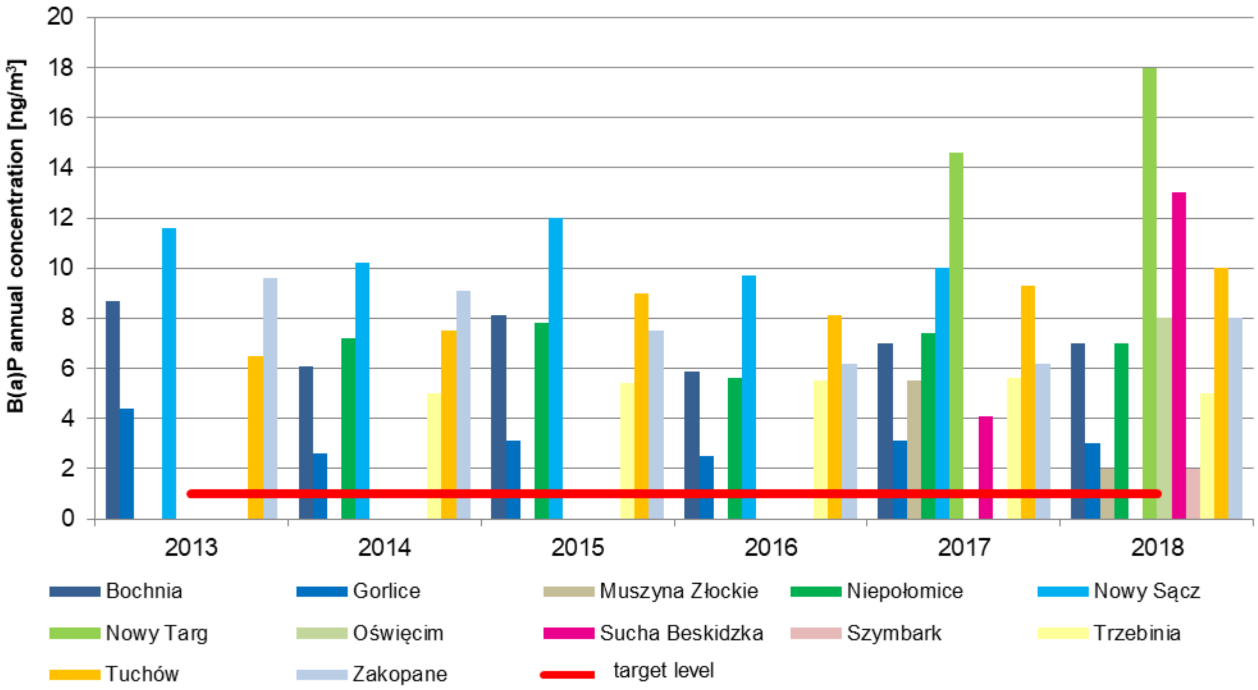


Figure 26. Average annual concentrations of benzo(a)pyrene in the Malopolska zone[49]

3.5. The results of the annual air quality assessment in 2018

3.5.1. *Areas of exceedances in the Malopolska Region*

Areas of exceedances in the Malopolska Region were indicated in *the Annual Air Quality Assessment in the Malopolska Region for 2018*[50]. The analysis presents the areas where the substance concentration was exceeded and significant information of the area with exceedance.

On the indicated maps, each identified area with exceedances was marked with a number and then characterized in the table with the number of exposed population, size of the area and its location. For each area, the number of vulnerable groups of the population exposed to poor air quality in the area and the number of places where these people may stay are also indicated, i.e. schools, kindergartens, nurseries, day care centres, educational centres, care centres, health resorts and hospitals. Each area had a code of exceedance situation assigned, in accordance with the guidelines in the Regulation.

Krakow Agglomeration

The area with exceedance of the daily PM10 permissible level, the average annual PM2.5 permissible level and the average annual benzo(a)pyrene target level is equivalent to the entire city of Krakow. All residents are exposed to excessive content of the substances in the air. The area with exceedance of the average annual PM10 concentration covers 40.9% of the city – the place of residence of 54% of the population.

The area with exceedances of the permissible average annual nitrogen dioxide concentrations covers the following districts: Stare Miasto, Krowodrza, Zwierzyniec, Debniki, Bronowice, Pradnik Bialy, Grzegorzki, Podgorze, which is about 10% of the city's area. Approximately 29% of the city's population live in this area, as it is a densely built-up residential area in the city centre, mostly with multi-family housing.

[49] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring and data from annual reports on air quality in the Malopolska Region

[50] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

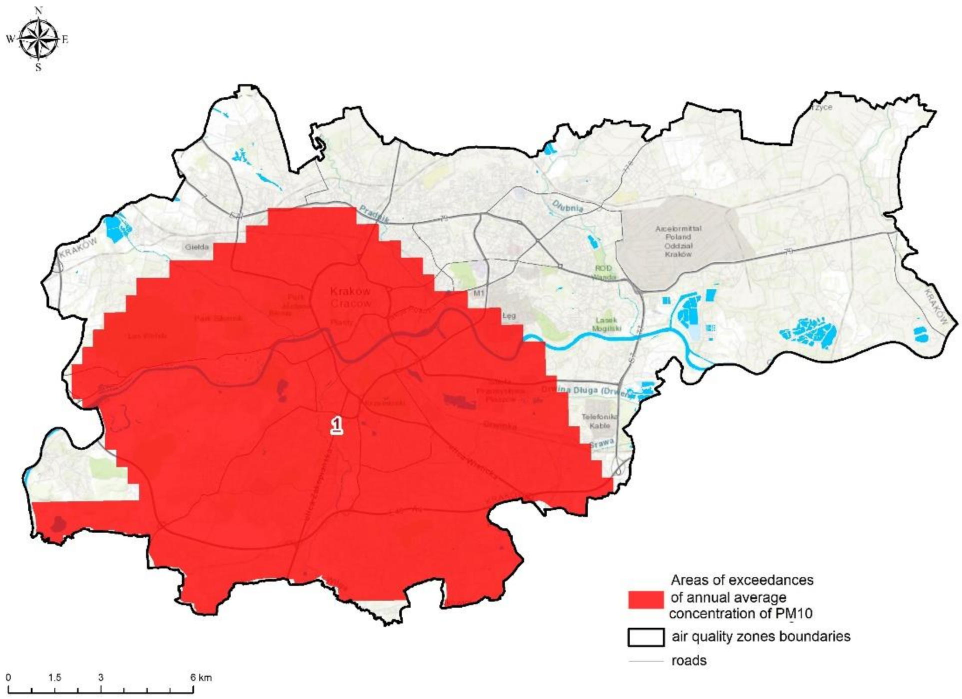


Figure 27. Areas with exceedances of average annual PM10 concentrations in the Krakow Agglomeration based on Annual air quality assessment for 2018 for the Malopolska Region with the assigned number of the exceedance area[51].

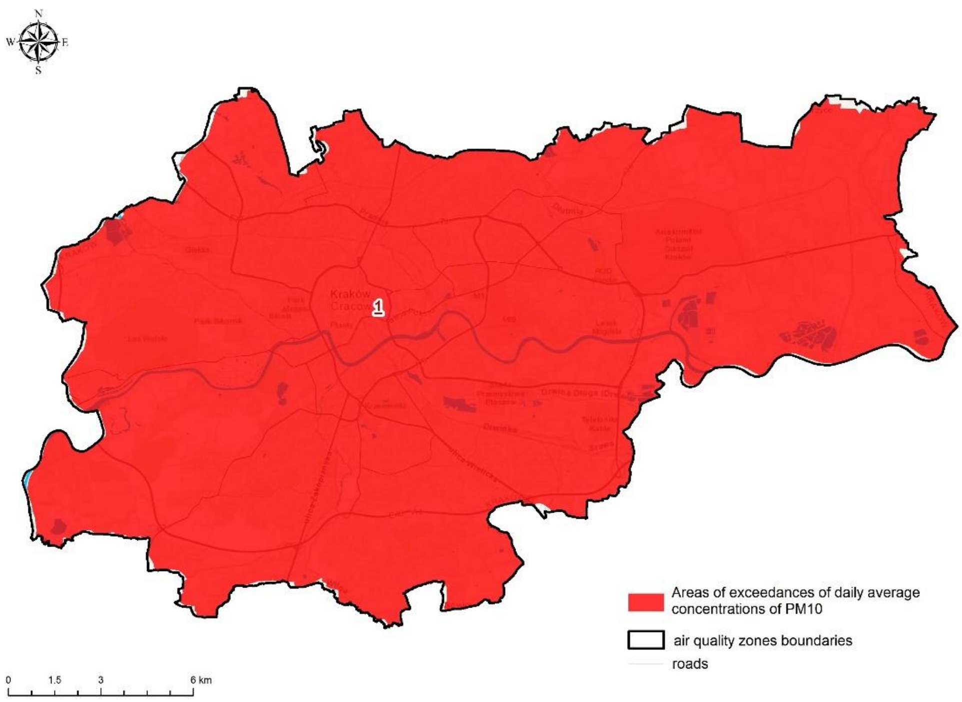


Figure 28. Areas with exceedances of 24-hour PM10 concentrations in the Krakow Agglomeration based on Annual air quality assessment for 2018 for the Malopolska Region with the assigned number of exceedance area[52]

[51] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

[52] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

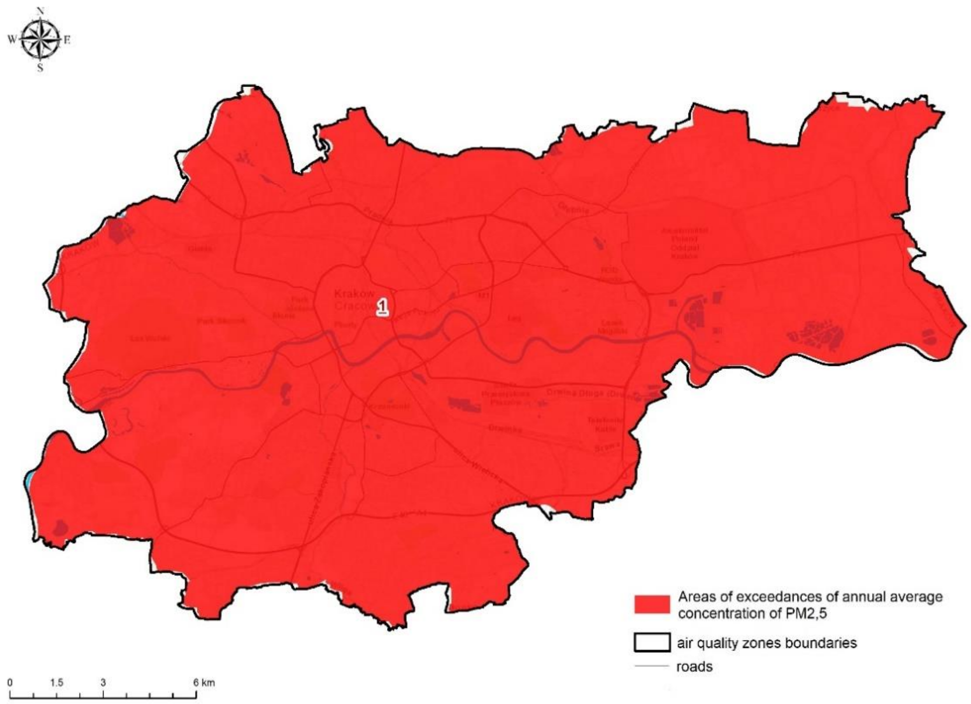


Figure 29. Areas with exceedances of average annual PM2.5 concentrations in the Krakow Agglomeration based on Annual air quality assessment for 2018 for the Malopolska Region with the assigned number of the exceedance area[53]

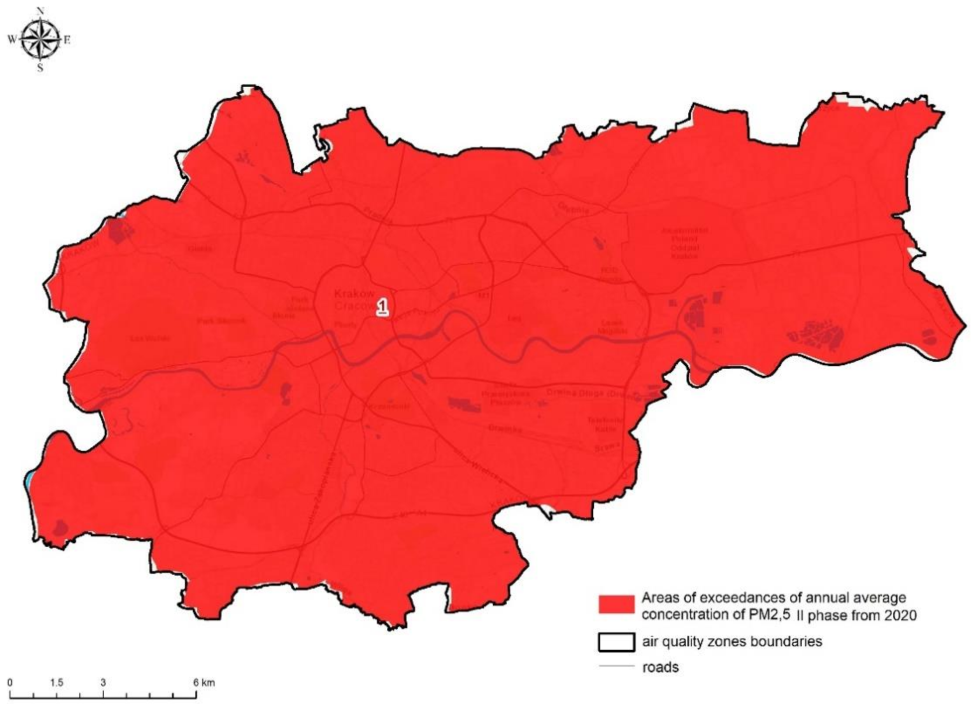


Figure 30. Areas with exceedances of average annual concentrations of PM2.5 of Phase II since 2020 in the Krakow Agglomeration based on Annual air quality assessment for 2018 for the Malopolska Region with the assigned number of the exceedance area[54].

[53] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

[54] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

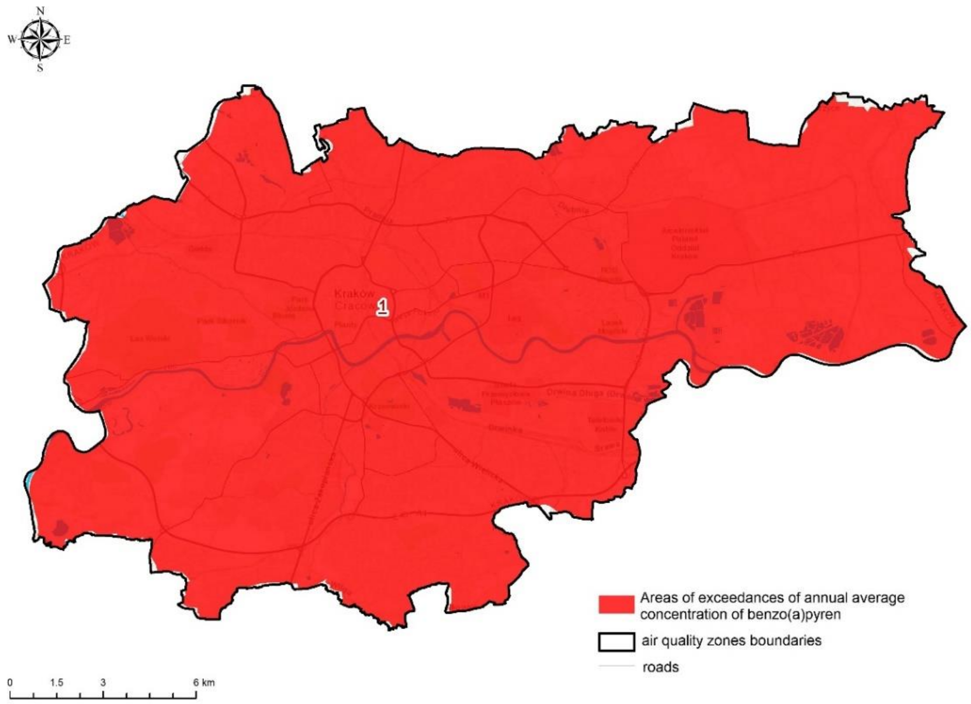


Figure 31. Areas with exceedances of average annual concentrations of benzo(a)pyrene in the Krakow Agglomeration on the basis of Annual air quality assessment for 2018 for the Malopolska Region with the assigned number of the exceedance area[55]

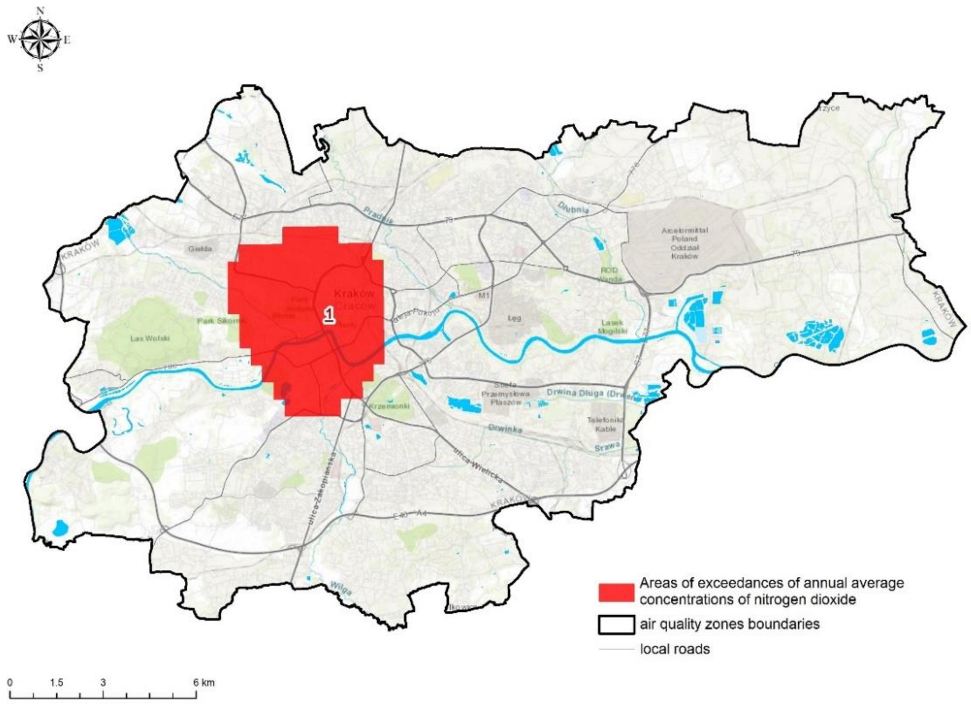


Figure 32. Areas with exceedances of average annual nitrogen dioxide concentration in the Krakow Agglomeration based on Annual air quality assessment for 2018 for the Malopolska Region with the assigned number of the exceedance area[56]

[55] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

[56] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

Table 7. List of areas with exceedances for all substances in the Krakow Agglomeration in 2018[57]

Item	Exceedance area code	Location (county, municipality)	Area with exceedances	Area classification	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
			[km^2]		total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
The average daily concentration of PM10										
1	Mp18AKrPM10d01	city of Krakow	327	urban	767 348	43 491	151 401	1 855	71	2 400,83
The average annual concentration of PM10										
1	Mp18AKrPM10a01	city of Krakow	149	urban	493 259	20 819	72 475	845	33	1 394,88
The average annual concentration of PM2.5 Phase I										
1	Mp18AKrPM2.5a01	city of Krakow	327	urban	767 348	43 491	151 401	1 855	71	2 400,83
The average annual concentration of PM2.5 Phase II										
1	Mp18AKrPM2.5a01	city of Krakow	327	urban	767 348	43 491	151 401	1 855	71	2 400,83
The average annual concentration of benzo(a)pyrene										
1	Mp18AKrBaPa01	city of Krakow	327	urban	767 348	43 412	151 124	1 855	71	2 400,83
The annual concentration of nitrogen dioxide										
1	Mp18AKrNO2a01	city of Krakow	23,9	urban	220 230	3 179	11 066	130	7	328,00

[57] Source: Annual air quality assessment in the Malopolska Region. Report for 2018., Regional Department of Environmental Monitoring CIEP

The city of Tarnow

The area with exceedances in the city of Tarnow refers to exceedances of permissible daily concentrations of PM10 and target average annual concentrations of benzo(a)pyrene. In addition, the area with exceeded permissible PM2.5 average annual concentration was defined according to the level for phase II (from 2020 the permissible level of PM 2.5 is 20 μg/m^3). Exceedances of the norm applicable to PM2.5 in phase I (until 2019 - 25 μg/m^3) were not exceeded in 2018. The assessment of air quality made for 2018 by Regional Department of Environmental Monitoring in Krakow indicates the emission sources from individual buildings heating as the main reason for the occurrence of exceeded concentration levels.

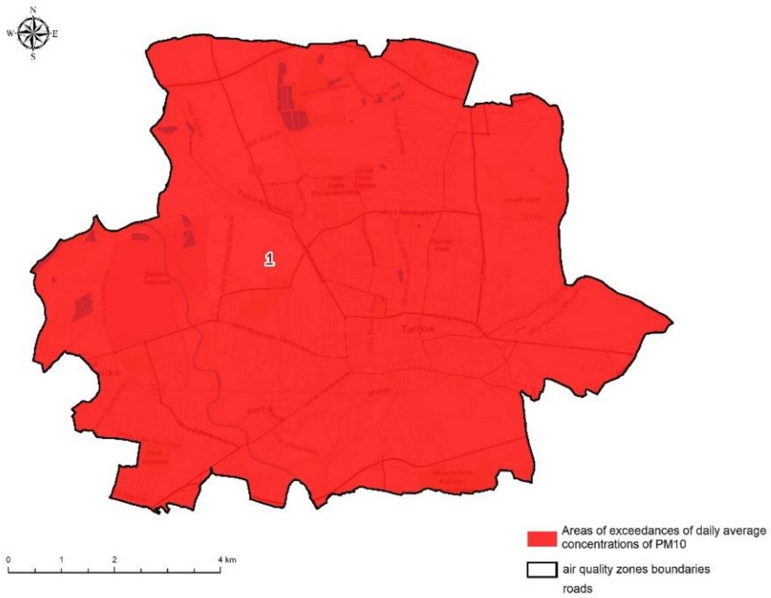


Figure 33. Area with exceedances of 24-hour PM10 concentrations in the city of Tarnow in 2018 with the assigned number of the exceedance area.[58]

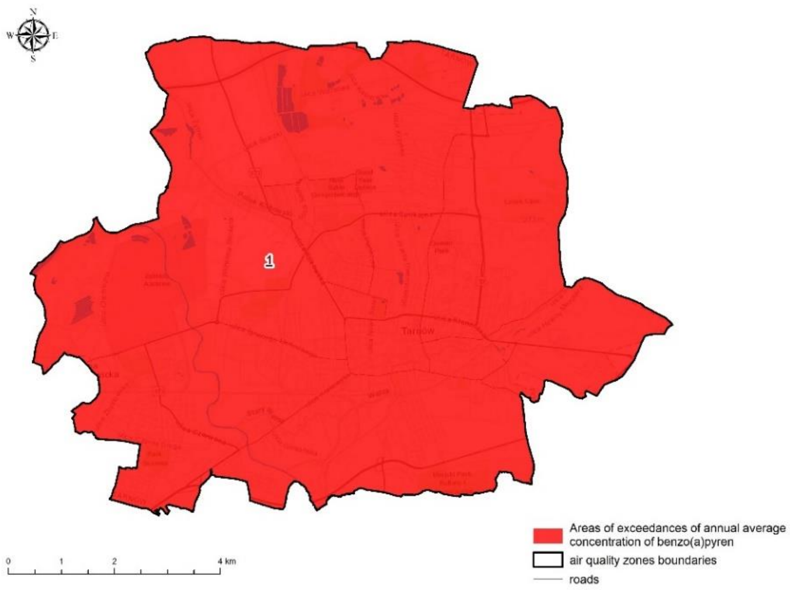


Figure 34. Area with exceedances of average annual concentrations of benzo(a)pyrene in the city of Tarnow in 2018 with the assigned number of the exceedance area. [59]

[58] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

[59] Source: Annual air quality assessment for the Malopolska Region report for 2018, Regional Department of Environmental Monitoring CIEP

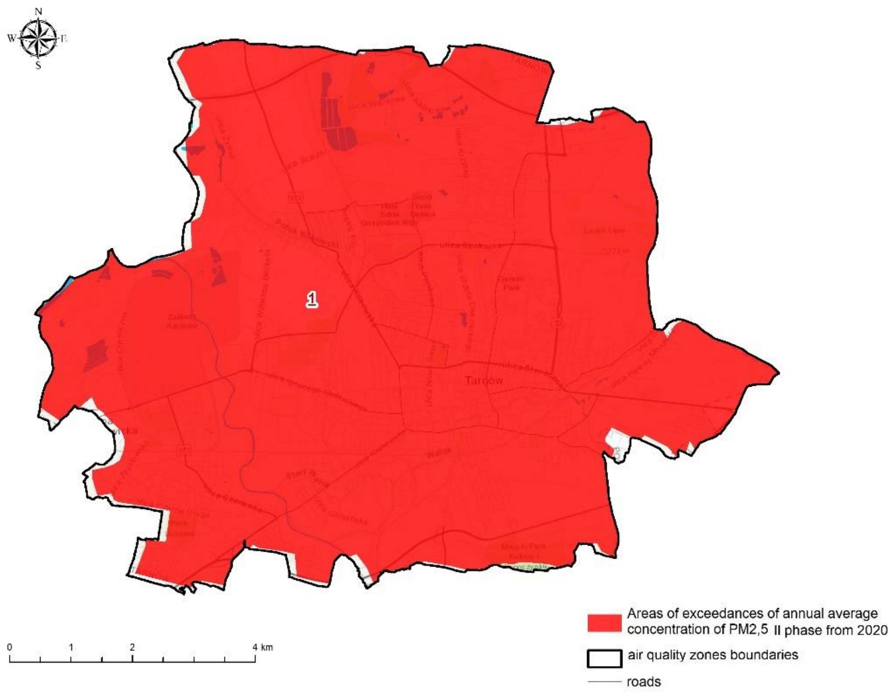


Figure 35. Area with exceedances of average annual PM2.5 concentrations according to phase II in the city of Tarnow in 2018 with the assigned number of the exceedance area. [60]

Table 8. List of areas with exceedances for all substances in the city of Tarnow in 2018 [61]

Item	Exceedance area code	Area with exceedances	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
		[km²]	total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
24-hours concentration of PM10								
1	Mp18TarPM10d01	72	109 080	4 536	22 608	251	10	446,50
The average annual concentration of benzo(a)pyrene								
1	Mp18TarBaPa01	72	109 650	4 536	22 608	251	10	446,50
The average annual concentration of PM2.5 Phase II								
1	Mp18TarPM2.5a01	72	109 650	4 536	22 608	251	10	446,50

Malopolska zone

Areas with exceedances in the Malopolska zone were indicated in *the Annual air quality assessment for the Malopolska Region for 2018*.

In the Malopolska zone, the exceedance areas have different ranges and characteristics. Substances whose limit and target levels are exceeded in the Malopolska zone include particulate matter PM10 and PM2.5 (levels for phase I and II) and benzo(a)pyrene. Benzo(a)pyrene has the largest exceedances area. Its target level of 1 ng/m^3, is exceeded in the area covering **98% of the Region**.

[60] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

[61] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Particulate matter PM10

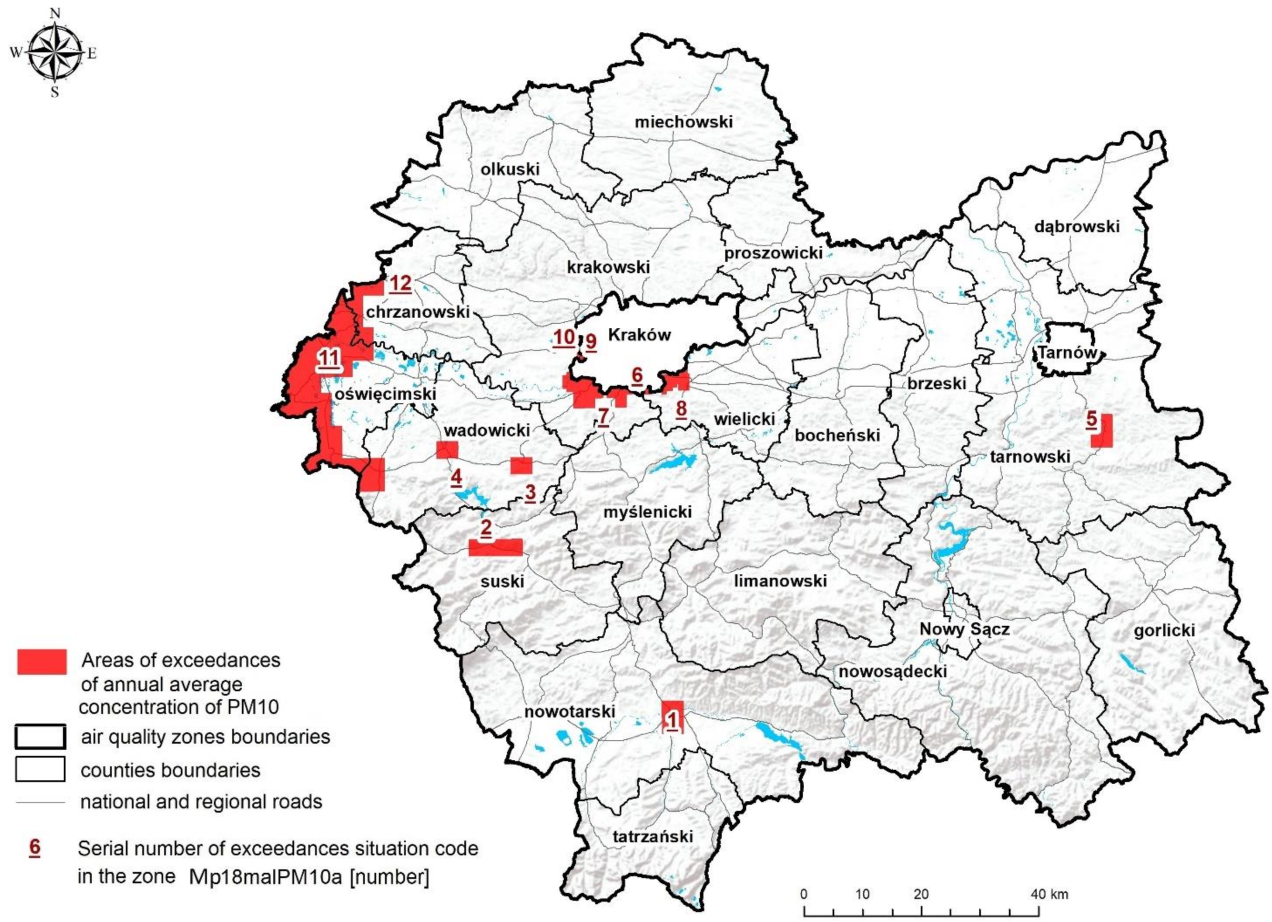


Figure 36. Areas with exceedances of average annual concentrations of PM10 in the Malopolska Region zone in 2018 with the assigned numbers of the exceedance area.[62]

[62] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Table 9. Areas with exceedances of the average annual PM10 concentrations in the Malopolska zone in 2018.[63]

Item	Exceedance area code	Location (county, municipality)	Area with exceedances	Area classification	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
			[km^2]		total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
1	Mp18malPM10a01	Nowy Targ, Szaflary	20,13	urban	13 183	665	2 335	28	2	106,23
2	Mp18malPM10a02	Part of Suski county, municipalities: Sucha Beskidzka, Makow Podhalanski, Budzow and Stryszawa	25,02	rural – regional	8 207	401	1 477	19	2	74,03
3	Mp18malPM10a03	Part of Wadowice county, municipalities: Kalwaria Zebrzydowska, Stryszow, Lanckorona	9,98	rural – near the city	2 476	140	390	6	1	41,72
4	Mp18malPM10a04	municipality Wadowice	9,98	urban	17 032	799	3 413	39	2	73,38
5	Mp18malPM10a05	municipality Tuchow	14,97	urban	5 555	270	899	12	1	44,60
6	Mp18malPM10a06	municipality Wieliczka – rural area	1,31	rural – near the city	544	29	74	2	0	6,45
7	Mp18malPM10a07	Part of Krakow county – municipalities: Skawina, Liszki, Mogilany	35,34	urban	43 074	2 227	7 880	94	4	150,82
8	Mp18malPM10a08	municipality Wieliczka - city	12,55	urban	22 595	1 482	3 754	59	3	104,63
9	Mp18malPM10a09	municipality Liszki rural	1,43	rural – near the city	346	21	48	1	0	7,70
10	Mp18malPM10a10	municipality Liszki rural	0,36	rural – near the city	88	6	12	0	0	0,46
11	Mp18malPM10a11	Part of Oswiecimski, Chrzanowski, Wadowicki counties	244,55	rural – regional	60 161	2 691	9 783	125	4	930,83
12	Mp18malPM10a12	municipality Chrzanow – city	0,0004	urban	0	0	0	0	0	0,00

[63] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

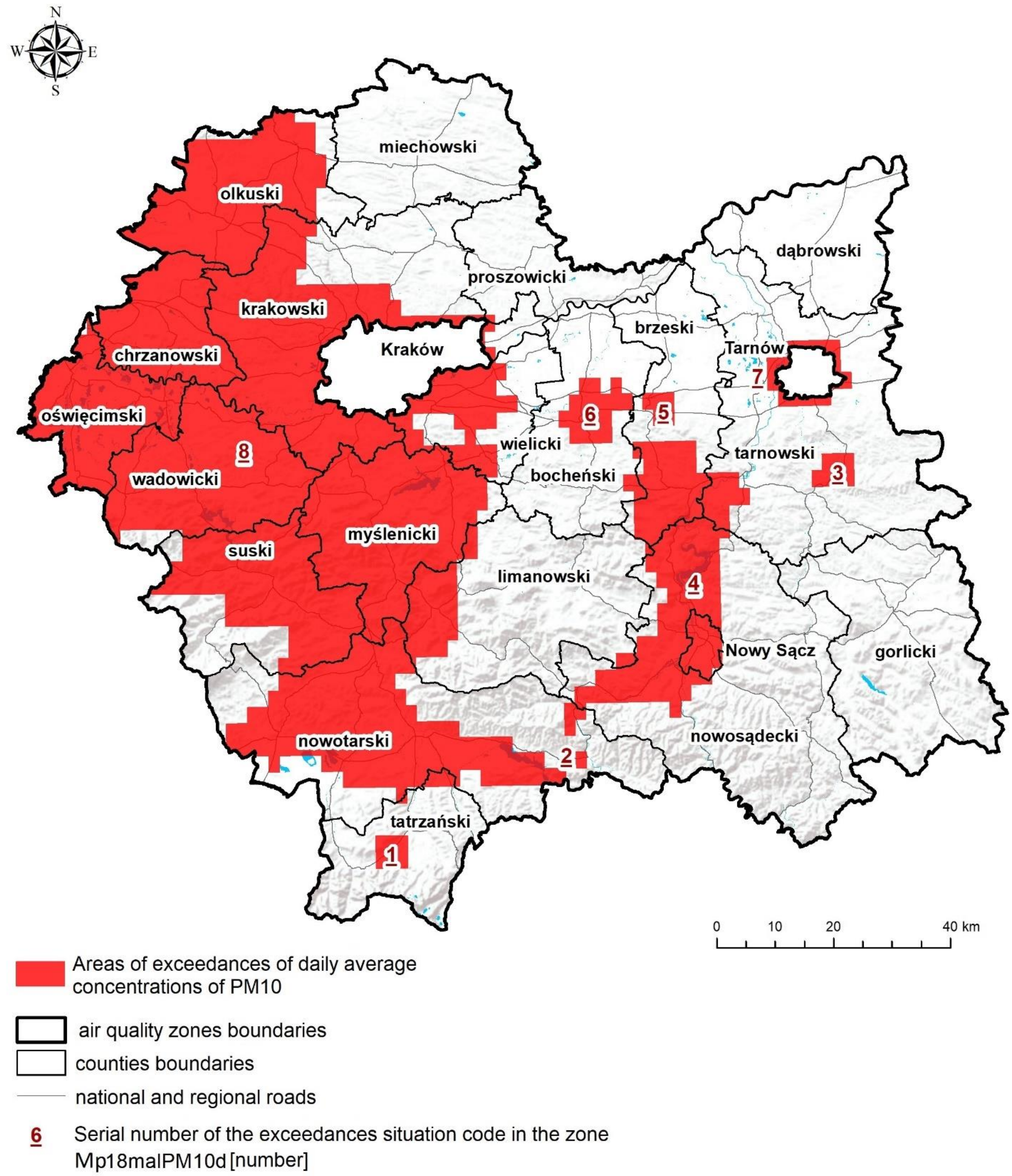


Figure 37. Areas with exceedances of 24-hour PM10 concentrations in the Malopolska zone in 2018 with the assigned numbers of the exceedance area. [64]

[64] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Table 10. List of areas with exceedances of 24-hour PM10 concentrations in the Malopolska zone in 2018 [65].

Item	Exceedance area code	Location (county, municipality)	Area with exceedances	Area classification	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
			[km²]		total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
1	Mp18malPM10d01	Zakopane, part of Poronin	30,29	urban	9 816	455	2 030	21	2	152,58
2	Mp18malPM10d02	municipality Kroscienko nad Dunajcem rural area	5,03	rural – distant	605	36	96	1	0	4,82
3	Mp18malPM10d03	municipality Tuchow, part of municipality Gromnik	34,94	rural – near the city	4 858	280	734	11	1	84,46
4	Mp18malPM10d04	counties: Brzeski, Bochenski, Limanowski, Nowosadecki, Nowy Sacz, Nowotarski, Tarnowski	661,10	rural – regional	169 243	10 578	19 172	435	15	1 483,05
5	Mp18malPM10d05	Brzesko	24,90	urban	5 355	274	748	14	1	102,60
6	Mp18malPM10d06	part of Bochenski county	89,66	urban	89 483	4 753	16 050	231	4	266,89
7	Mp18malPM10d07	part of Tarnowski county	52,06	rural – distant	16 349	782	2 344	37	2	168,74
8	Mp18malPM10d08	Area of counties: Chrzanowski, Krakowski, Limanowski, Myslenicki, Nowotarski, Olkuski, Oswiecimski, Proszowicki, Suski, Tatrzanski, Wadowicki and Wielicki	4 918,90	rural – regional	570 594	34 433	78 703	1 355	54	10 402,40

[65] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Particulate matter PM2.5

The area with exceedance of the average annual PM2.5 concentrations in the Malopolska zone covers partially or completely the area of 14 counties. In the case of phase II of the PM2.5 norm, the exceedance area is much larger and covers the area of 19 counties.

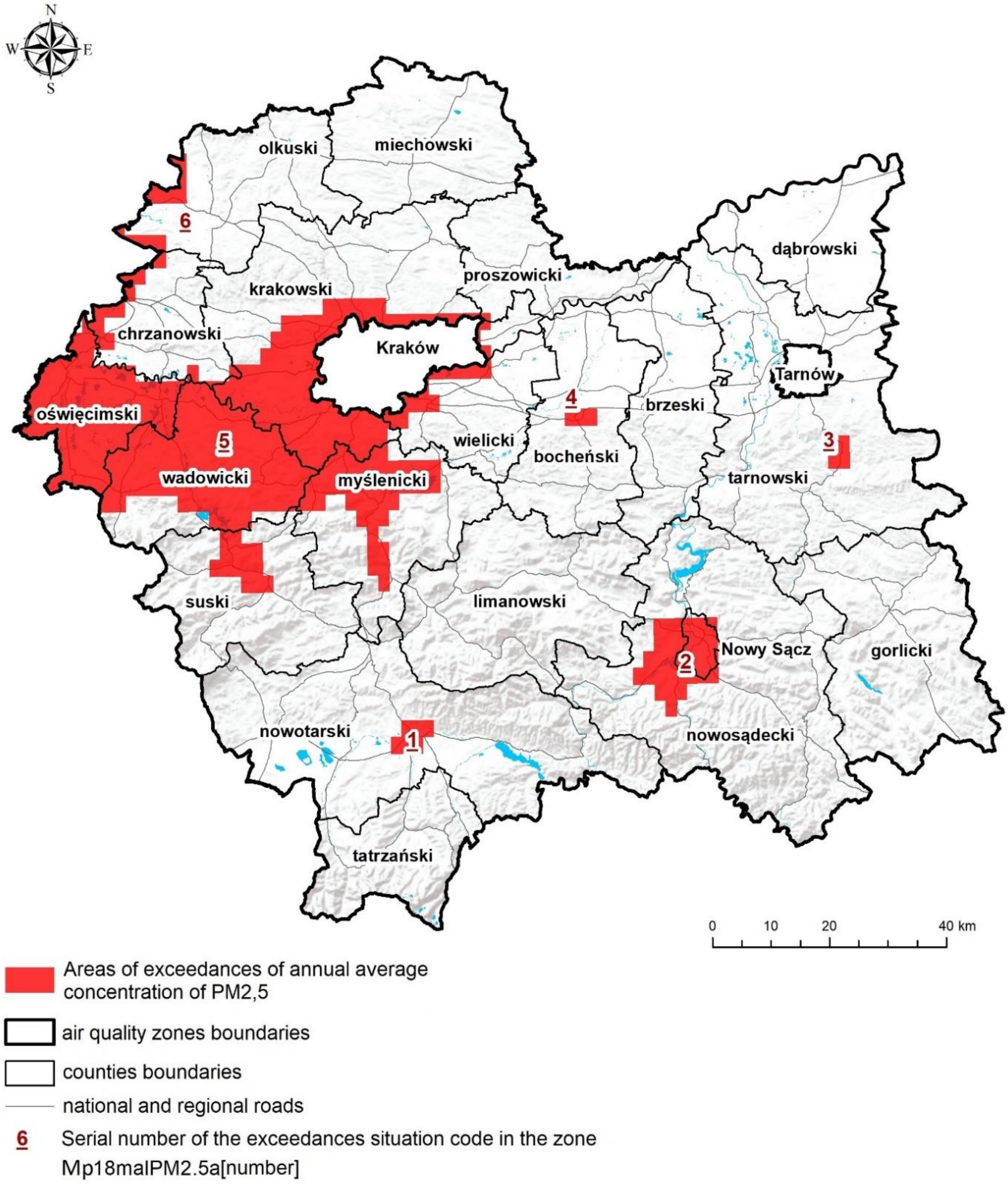


Figure 38. Area with exceedances of average annual PM2.5 concentrations in the Malopolska zone in 2018 with the assigned numbers of the exceedance area.[66]

[66] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

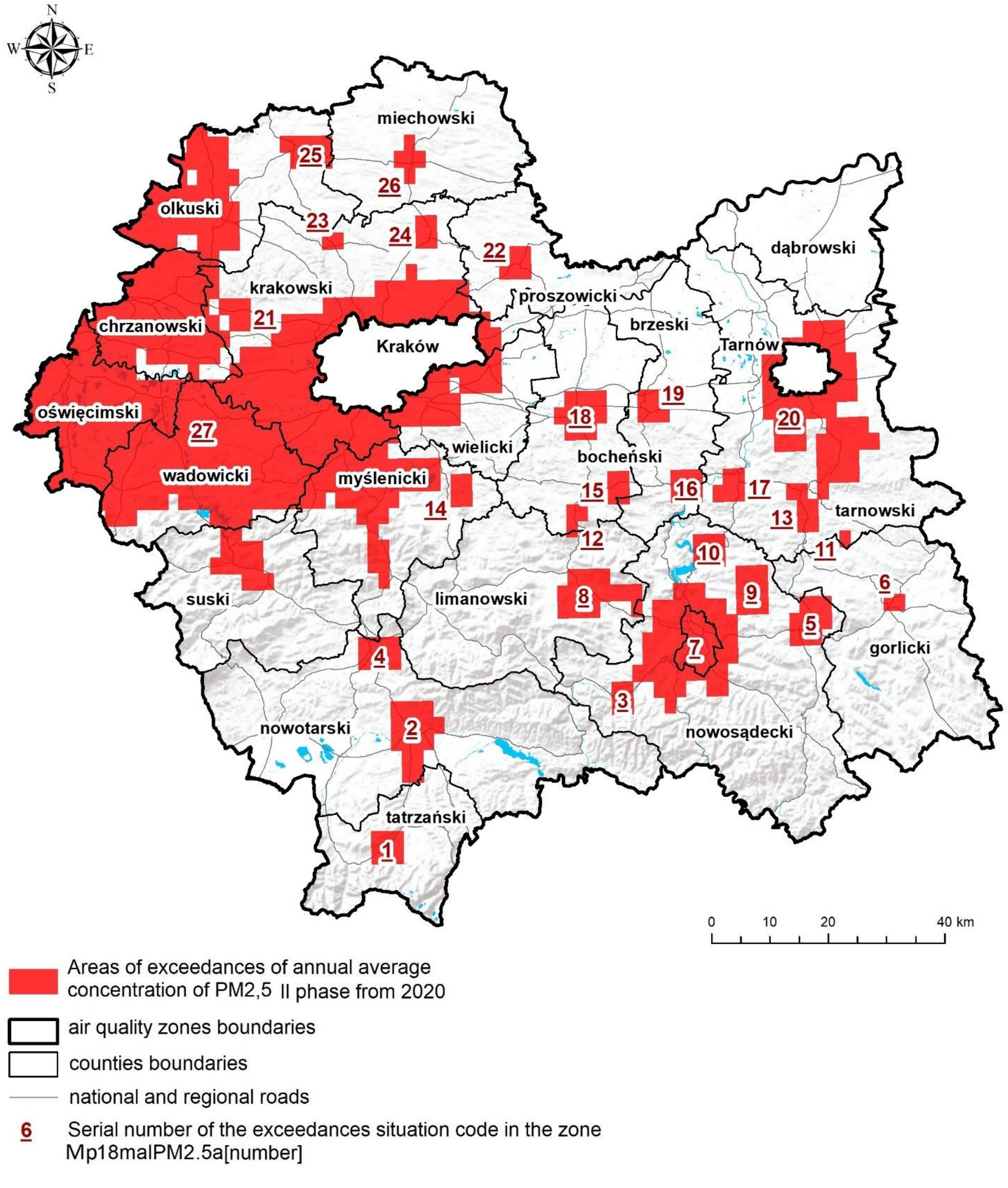


Figure 39. Area with exceedances of average annual concentrations of PM2.5 dust according to phase II of the norm in the Malopolska zone in 2018 with the assigned numbers of the exceedance area.[67]

[67] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Table 11. Areas with exceedances of the average annual PM2.5 concentrations in phase I and II of the norm in the Malopolska zone in 2018[68].

Item	Exceedance area code	Location (county, municipality)	Area with exceedances	Area classification	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
			[km^2]		total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
The average annual concentration of PM2.5 Phase I										
1	Mp18malPM2.5a01	municipality Nowy Targ, part of munucipality Szaflary	30,19	urban	19 774	997	3 502	52	2	136,36
2	Mp18malPM2.5a02	Nowosadecki county, municipality Nowy Sacz	155,65	urban	21 792	1 401	2 802	52	2	651,68
3	Mp18malPM2.5a03	Municipality Tuchow – urban area	14,97	urban	5 555	270	899	12	1	44,60
4	Mp18malPM2.5a04	Municipality Bochnia	14,95	urban	14 918	793	2 676	38	1	83,84
5	Mp18malPM2.5a05	Contess: Chrzanowski, Krakowski, Myslenicki, Olkuski, Oswiecimski, Proszowicki, Suski, Wielicki, Wadowicki	1763,05	rural – near the city	320 875	14 105	61 707	736	29	4 734,77
6	Mp18malPM2.5a06	municipality Boleslaw rural area, Klucze	26,32	rural – distant	4 792	211	922	10	0	44,90
The average annual concentration of PM2.5 Phase II										
1	Mp18malPM2.5a01	Zakopane, part of municipality Poronin	30,29	urban	9 816	455	2 030	21	2	152,58
2	Mp18malPM2.5a02	Part of county Nowotarski: Nowy Targ, Szaflary and Bukowina Tatrzanska	85,53	urban, rural – near the city	11 120	599	1 711	29	1	235,56
3	Mp18malPM2.5a03	municipality Lacko rural area	20,10	rural – distant	2 514	181	302	6	0	34,44
4	MP18malPM2.5a04	Part of counties: Nowotarski, Myslenicki and Limanowski.	40,14	urban, rural suburban	5 220	282	803	11	2	183,29
5	MP18malPM2.5a05	Grybow city and rural area	50,16	rural suburban	8 328	603	1 004	20	1	107,27
6	MP18malPM2.5a06	The city of Gorlice	10,02	urban	11 534	482	2 277	32	1	93,64

[68] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Item	Exceedance area code	Location (county, municipality)	Area with exceedances	Area classification	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
			[km²]		total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
7	Mp18malPM2.5a07	Nowy Sacz and Nowosadecki county	255,98	urban, rural suburban	33 279	1 792	5 120	99	4	880,71
8	Mp18malPM2.5a08	Limanowski county - part	85,18	rural – regional	11 841	767	1 619	33	2	166,24
9	Mp18malPM2.5a09	Municipalities: Korzenna rural area, Grybow rural area	45,10	rural – distant	6 134	406	722	14	0	61,85
10	MP18malPM2.5a10	Municipalities: Grodek nad Dunajcem, Lososina Dolna	30,02	rural – distant	3 153	181	421	8	1	56,79
11	Mp18malPM2.5a11	Rzepiennik Strzyzewski rural area	5,00	rural – distant	476	31	76	0	0	10,02
12	Mp18malPM2.5a12	Municipalities: Zegocina rural area, Laskowa	14,99	rural – distant	2 385	180	315	6	0	29,74
13	Mp18malPM2.5a13	Tarnowski county - part	29,99	rural – distant	4 289	240	660	10	1	69,78
14	Mp18malPM2.5a14	Municipalities: Raciechowice rural area, Dobczyce	19,97	rural – distant	2 098	140	300	4	0	34,51
15	Mp18malPM2.5a15	Municipalities Lipnica Murowana rural area, Iwkowa	19,97	rural – near the city	1 898	140	260	5	0	24,38
16	Mp18malPM2.5a16	Brzeski county – part	29,96	rural – near the city	4 735	270	720	12	1	72,16
17	Mp18malPM2.5a17	Zakliczyn – rural area	24,97	rural – near the city	2 298	150	350	4	0	61,85
18	Mp18malPM2.5a18	Bochenski county – part	59,78	urban, rural suburban	9 865	598	1 495	25	1	196,82
19	Mp18malPM2.5a19	Brzesko – rural area	24,90	rural – near the city	5 356	274	748	14	1	114,86
20	Mp18malPM2.5a20	Tarnowski county – part	271,35	rural – distant	38 805	2 171	5 970	88	4	602,32
21	Mp18malPM2.5a21	Krzeszowice – rural area	24,82	rural – near the city	4 568	224	795	10	1	130,52

Item	Exceedance area code	Location (county, municipality)	Area with exceedances	Area classification	Estimated population exposed to air pollution			Infrastructure for the elderly and children		Estimated road length
			[km²]		total	number of children under 5 years of age	number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
22	Mp18malPM2.5a22	Proszowice – rural area	24,78	rural – near the city	2 752	149	472	6	1	64,93
23	Mp18malPM2.5a23	Skala – rural area	9,90	rural – near the city	932	50	149	0	0	28,99
24	Mp18malPM2.5a24	Slomniki - rural area	19,80	rural – near the city	1 684	100	278	3	0	55,14
25	Mp18malPM2.5a25	Wolbrom - rural area	44,45	rural – near the city	4 668	223	845	9	0	98,95
26	Mp18malPM2.5a26	Miechow - city	24,70	urban	19 195	865	4 052	42	4	78,43
27	Mp18malPM2.5a27	Counties: Chrzanowski, Krakowski, Myslenicki, Olkuski, Oswiecimski, Proszowicki, Suski, Wadowicki and Wielicki	2 531,30	rural – near the city	477 971	21 896	95 792	1135	46	6 756,16

Benzo(a)pyrene

The area with exceedances of benzo(a)pyrene covers almost the entire Malopolska Region, excluding a small part of the counties of Gorlice and Tatra. The excluded areas include parts of the municipalities: Sekowa, Uscie Gorlickie, Koscielisko, Zakopane, Bukowina Tatrzanska and Poronin. The area with the exceedances is 14 547,7 km^2. 2,474,139 inhabitants of the Region are exposed to the exceeded average annual concentrations of benzo(a)pyrene, of which 130,93k are children under 5 years of age, while 378.2k are persons over 65 years of age.

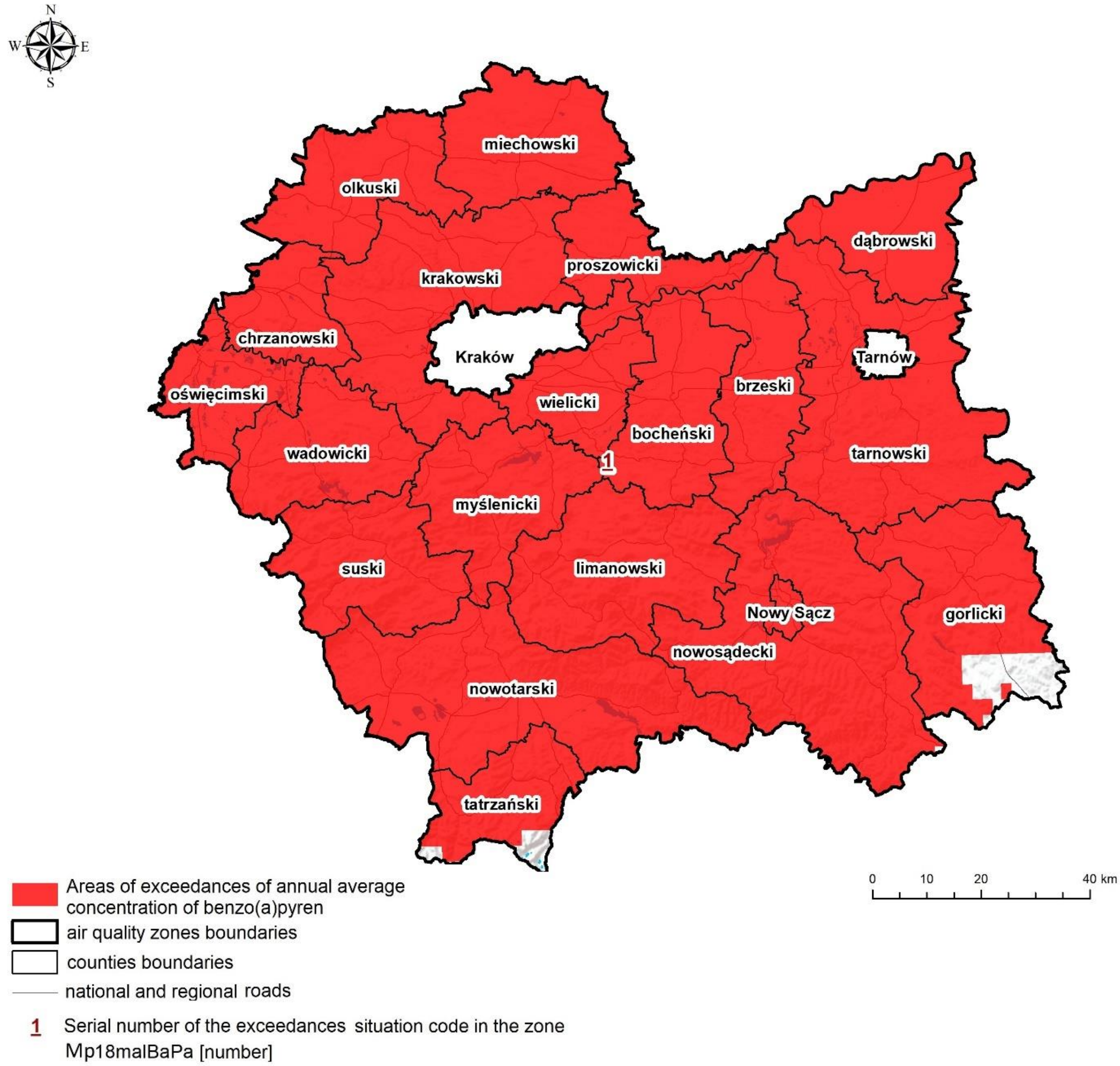


Figure 40. Area with exceedances of average annual concentrations of benzo(a)pyrene in the Malopolska zone in 2018 with the assigned number of the exceedance area. [69]

[69] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

Table 12. List of areas with exceedances of average annual concentrations of benzo(a)pyrene in the Malopolska zone [70]

Item	Exceedance area code	Area with exceedances	Area classification	Estimated population exposed to air pollution [thousand]			Infrastructure for the elderly and children		Estimated road length
		[km²]		total	number of children under 5 years of age	Number of people older > 65 years of age	number of centres for children	number of centres for the elderly	[km]
The average annual concentration of benzo(a)pyrene									
1	Mp18malBaPa01	14 547,7	urban, rural suburban, rural – near the city, rural – regional	2 474	130	378	8 132	334	24 589

The air quality assessment conducted by the Regional Department of Environmental Monitoring in Krakow, as the main reason for the occurrence of bezo(a)pyrene exceedances in the zones of the Malopolska Region, indicates the impact of emissions from individual buildings heating.

4. EMISSION BALANCE SHEET OF POLLUTANTS PUT INTO THE AIR IN ZONES IN THE BASE YEAR

Data on sources of air pollutant emissions are collected by The National Centre for Emissions Management (KOBIZE). The emission inventory operated by KOBIZE enabled determining the load size of the analysed pollutants released into the air in 2018 from the zones of the Malopolska Region. The total amount of emissions of individual pollutants is the sum of emissions from various categories of sources:

- **point sources** – industry and energetics SNAP1,3,4,
- **linear** – road transport SNAP7,
- **surface** – municipal and household sources from buildings' heating sources SNAP2,
- **from agriculture** – breeding and cultivation SNAP10,
- **other vehicles**–agricultural tractors working in fields, railways, airports SNAP8,
- **fugitive** – heaps, excavations SNAP5,
- **from waste storage** SNAP9,
- **natural** – forest areas, lands SNAP11.

Below is the balance of substances covered by the Plan released into the air from the zones of the Malopolska Region, from data about emissions presented in Annual air quality assessment in the Malopolska Region. Report for 2018.

In order to conduct a detailed air quality analysis for the year of the forecast (after the implementation of corrective measures), a detailed inventory including linear emissions as well as emissions from agriculture and surface emissions from the municipal and housing sector was prepared. It was based on data entered by all municipalities into the inventory database of heating sources in the Malopolska Region (Building heating

[70] Source: Annual air quality assessment for the Malopolska Region. Report for 2018, Regional Department of Environmental Monitoring CIEP

inventory database in Malopolska). As part of the inventory, emissions were estimated taking into account detailed data broken down into buildings level in municipalities. The emission inventory used for modelling for the scenarios was verified with the data from the inventory of heating sources (Building heating inventory database in Malopolska) and high data consistency was achieved in the case of counties with the highest level of completeness of the data entered by municipalities. The emission values estimated within the inventory created for the purpose of scenarios modelling are therefore very close to the emissions from the Building heating inventory database in Malopolska.

In the case of traffic emissions, a road database was used using the traffic volume and the structure of vehicles traveling on the roads of the Malopolska Region in 2018. In the case of transport sector, the amount of non-flue gas emissions and secondary emissions of dust pollutants were also determined in the database prepared for the needs of the Air Quality Plan.

The Central Emission Inventory provided by KOBIZE for the purposes of the Air Quality Plan was used for modelling in terms of other emission sources: other vehicles such as railways, heaps and workings, as well as landfills, forests and land, fires, airports, and point emissions.

Due to the fact that a different database was used for the estimation of the exceedance areas (Central Emission Inventory KOBIZE for all emission sources) than for the Air Quality Plan, the emission values from all three emission databases are presented below, in order to compare the values presented in them.

Table 13. Summary of the volume of the emissions of the substances, in the zones of the Malopolska Region in 2018[71]

Nitrogen oxides NOx [kg/year]					
Zone Name	**Surface emission SNAP2**	**Road transport SNAP7**	**Industry and energetics SNAP1,3,4**	**Other SNAP5,8,910,11**	**Total**
Emission inventory used for the purpose of *Annual air quality assessment for the Malopolska Region in 2018*					
Krakow Agglomeration	286 226	1 971 206	3 810 346	298 973	**6 366 751**
Tarnow city	135 974	322 306	5 395 324	16 488	**5 870 092**
Malopolska zone	7 090 465	21 209 669	5 880 156	6 830 171	**41 010 461**
Malopolska region	7 512 665	23 503 181	15 085 826	7 145 632	**53 247 304**
KOBIZE Central Emission Inventory for 2018					
Krakow Agglomeration	373 286	2 074 995	3 736 067	220 073	**6 404 420**
Tarnow city	90 096	397 018	5 387 517	7 585	**5 882 216**
Malopolska zone	6 818 041	20 733 596	5 675 593	1 441 231	**34 668 462**
Malopolska region	7 281 423	23 205 609	14 799 176	1 668 889	**46 955 097**
Emission inventory prepared for the purpose of the Air Quality Plan for the Malopolska Region					
Krakow Agglomeration	543 139	1 164 807	3 736 067	390 837	**5 834 850**
Tarnow city	121 485	182 401	5 387 517	9 292	**5 700 694**
Malopolska zone	4 302 169	6 915 490	5 675 593	1 665 014	**18 558 266**
Malopolska region	4 966 792	8 262 698	14 799 176	2 065 143	**30 093 810**

[71] Based on the Central Emission Base used for Annual air quality assessment for the Malopolska Region in 2018.

Particulate matter PM10 [kg/year]					
Zone Name	**Surface emission SNAP2**	**Road transport SNAP7**	**Industry and energetics SNAP1,3,4**	**Other SNAP5,8,910,11**	**Total**
Emission inventory used for the purpose of *Annual air quality assessment for the Malopolska Region in 2018*					
Krakow Agglomeration	574 890	131 227	219 358	133 039	**1 058 514**
Tarnow city	444 527	21 592	232 562	25 129	**723 810**
Malopolska zone	24 265 356	1 438 745	665 546	4 481 270	**30 850 917**
Malopolska region	25 284 773	1 591 564	1 117 466	4 639 438	**32 633 241**
KOBIZE Central Emission Inventory for 2018					
Krakow Agglomeration	720 592	137 204	490 216	239 758	**1 587 770**
Tarnow city	288 384	25 667	272 681	31 097	**617 830**
Malopolska zone	23 311 159	1 408 990	671 754	4 384 758	**29 776 662**
Malopolska region	24 320 135	1 571 862	1 434 652	4 655 613	**31 982 261**
Emission inventory prepared for the purpose of the Air Quality Plan for the Malopolska Region					
Krakow Agglomeration	596 201	900 377	490 216	125 668	**2 112 462**
Tarnow city	278 694	90 647	272 681	50 993	**693 015**
Malopolska zone	11 076 795	3 402 238	671 754	4 536 560	**19 687 347**
Malopolska region	11 951 689	4 393 261	1 434 652	4 713 222	**22 492 824**

Particulate matter PM2.5 [kg/year]					
Zone Name	**Surface emission SNAP2**	**Road transport SNAP7**	**Industry and energetics SNAP1,3,4**	**Other SNAP5,8,910,11**	**Total**
Emission inventory used for the purpose of *Annual air quality assessment for the Malopolska Region in 2018*					
Krakow Agglomeration	564 923	102 868	169 851	37 504	**875 146**
Tarnow city	437 297	16 809	153 115	5 594	**612 815**
Malopolska zone	23 890 668	1 117 924	405 324	1 329 810	**26 743 726**
Malopolska region	24 893 888	1 237 601	728 290	1 372 908	**28 231 687**
KOBIZE Central Emission Inventory for 2018					
Krakow Agglomeration	708 018	107 722	490 216	44 064	**1 350 020**
Tarnow city	283 665	20 163	272 681	6 944	**583 453**
Malopolska zone	22 951 367	1 094 329	182 315	1 334 983	**25 562 994**
Malopolska region	23 943 049	1 222 214	945 213	1 385 991	**27 496 466**
Emission inventory prepared for the purpose of the Air Quality Plan for the Malopolska Region					
Krakow Agglomeration	548 359	302 446	490 216	37 873	**1 378 894**
Tarnow city	257 491	32 858	272 681	6 668	**569 698**
Malopolska zone	10 690 251	1 209 897	182 315	654 700	**12 737 163**
Malopolska region	11 496 101	1 545 200	945 213	699 241	**14 685 754**

Benzo(a)pyrene [kg/year]					
Zone Name	Surface emission SNAP2	Road transport SNAP7	Industry and energetics SNAP1,3,4	Other SNAP5,8,910,11	Total
Emission inventory used for the purpose of *Annual air quality assessment for the Malopolska Region in 2018*					
Krakow Agglomeration	272,1	1,9	8,2	0	**282,2**
Tarnow city	229,9	0,3	34,7	0	**264,9**
Malopolska zone	13 282,5	21,4	326,8	14,5	**13 645,2**
Malopolska region	13 784,5	23,6	369,7	14,5	**14 192,3**
KOBIZE Central Emission Inventory for 2018					
Krakow Agglomeration	340,9	2,0	5,3	0,0	**348,2**
Tarnow city	148,4	0,4	34,5	0,0	**183,2**
Malopolska zone	12 776,2	20,9	280,7	14,5	**13 092,3**
Malopolska region	13 265,5	23,3	320,4	14,5	**13 623,6**
Emission inventory prepared for the purpose of the Air Quality Plan for the Malopolska Region					
Krakow Agglomeration	244,2	2,7	5,3	0,1	**252,2**
Tarnow city	111,9	0,3	34,5	0,0	**146,7**
Malopolska zone	5 478,1	11,1	280,7	14,5	**5 784,3**
Malopolska region	5 834,2	14,0	320,4	14,6	**6 183,2**

The differences in the amount of emissions may particularly result from the use of different input data to calculate emissions and also partially from other emission factors. The KOBIZE Central Emission Inventory does not contain input data or emission factors (but only information about the resulting emissions) to enable comparison and determination of differences in the emission calculation methodology, therefore it could not be applied to corrective action scenarios. Input data for calculating emissions of pollutants are necessary to introduce changes resulting from a given scenario, e.g. changes in the structure of heating sources, replacement of non-class boilers with ecological boilers, etc. The changed data for calculating the emissions allow, in turn, to determine changes in pollutant concentrations.

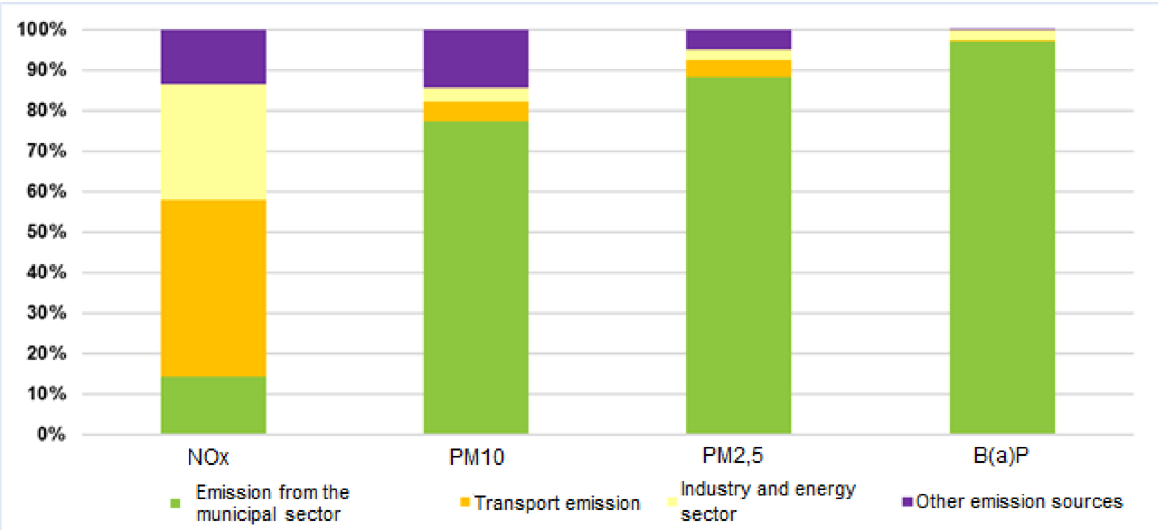


Figure 41. The volume of the pollutant emissions in the Malopolska Region in 2018.[72]

[72] Source: Prepared by ATMOTERM S.A. on the basis of Central Emission Inventory – KOBIZE, calculated as the total of emissions from transport sector, point sources, agriculture, residential sector and fugitive emissions

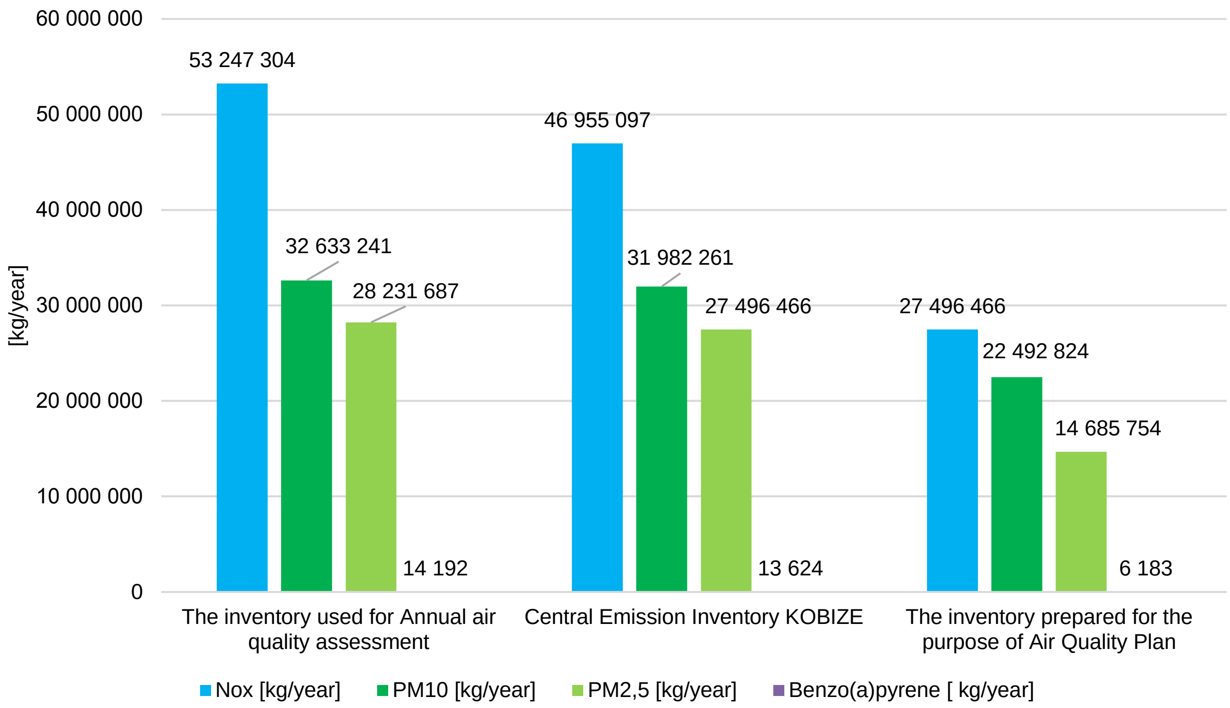


Figure 42. Summary of emissions in balances from various inventories used in the Air Quality Plan.

The emission factors used for the inventory prepared for the purposes of this Air Quality Plan are presented in the tables below. They were used to calculate the ecological effect resulting from the implementation of corrective measures in the municipal and housing sector and in the transport sector.

Table 14. Emission factors by heating sources used in the inventory prepared for the use of Air Quality Plan

Fuel type	Device type	Feeding method	Pollutants emission factors														
			PM10	PM2,5	B(a)P	SO_2	NO_x	CO	NMLZO	NH_3	C_6H_6	CH_4	CO_2	As	Hg	Cd	Pb
			[g/GJ]	[g/GJ]	[mg/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[mg/GJ]	[mg/GJ]	[mg/GJ]	[g/GJ]
Fuel	***Device***	***Method***	*PM10*	*PM2.5*	*BaP*	*SO_2*	*NOx*	*CO*	*NMLZO*	*NH_3*	*C_6H_6*	*CH_4*	*CO_2*	*As*	*Hg*	*Cd*	*Pb*
District heating			0	0	0	0	0	0	0	0	0		94 678	0	0	0	0
Electric heating			0	0	0	0	0	0	0	0	0		215 506	0	0	0	0
Photovoltaic installation, heat pumps, solar collectors			0	0	0	0	0	0	0	0	0		0	0	0	0	0
Natural gas			1,2	1,2	0,000562	0,3	51	31	1,9	0	0,0006		56 100				
Fuel oil			1,9	1,9	0,08	70	51	46	0,69	0	0,121		77 400				
Biomass fuelled devices	**Classified as OLD, non-class**	**M/A**	760	740	0,121	11	80	4 000	600	70	16,4		94 678				
	Boiler class 3	**manual**	108	102,6	0,02	10	80	2 850					94 678				
	Boiler class 4	**manual**	49,5	47,03	0,069	10	110	592					94 678				
	Boiler class 5	**manual**	36	34,2	0,05	10	130	440					94 678				
	Boiler Ecodesing	**manual**	36	34,2	0,05	10	130	440					94 678				
	Boiler class 3	**automatic**	49,5	47,03	0,038	20	115	670					94 678				
	Boiler class 4	**automatic**	23,68	23,33	0,0074	20	341	493					94 678				
	Boiler class 5	**automatic**	18	17,1	0,005	0	100	247					94 678				
	Boiler Ecodesing	**automatic**	18	17,1	0,005	0	100	247					94 678				
	stoves, local space heaters, kitchen stoves	**without emission reduction**	672	168	0,13	20	60	5 250					94 678				
	stoves, local space heaters, kitchen stoves	**with emission reduction**	168	42	0,13	20	60	5 250					94 678				
	stoves, local space heaters, kitchen stoves	**Ecodesign**	20	5	0,013	0	75	950					94 678				
	Classified as NEW	**M/A**	18	13,8	0,023	5	92,8	250	15	0,15	0		94 678	2	5,05	1,25	
Coal fuelled devices	**Classified as OLD**	**M/A**	404	398	200	400	110	4 600	484	0,3	6,1		94 678				
	non-class	**manual**	404	398	0,23	400	110	4 600					94 678				
	non-class	**automatic**	240	220	0,15	282,8	150	2 000					94 678				
	Boiler class 3	**manual**	200	150	0,2	400	110	2 467					94 678				
	Boiler class 4	**manual**	49,5	47,03	0,084	200	110	860					94 678				
	Boiler class 5	**manual**	23,68	23,33	0,045	0	202	345					94 678				

Fuel type	Device type	Feeding method	Pollutants emission factors														
			PM10	PM2,5	B(a)P	SO_2	NO_x	CO	NMLZO	NH_3	C_6H_6	CH_4	CO_2	As	Hg	Cd	Pb
			[g/GJ]	[g/GJ]	[mg/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[g/GJ]	[mg/GJ]	[mg/GJ]	[mg/GJ]	[g/GJ]
Fuel	*Device*	*Method*	*PM10*	*PM2.5*	*BaP*	*SO_2*	*NOx*	*CO*	*NMLZO*	*NH_3*	*C_6H_6*	*CH_4*	*CO_2*	*As*	*Hg*	*Cd*	*Pb*
	Boiler Ecodesing	**manual**	23,68	23,33	0,045	0	202	345					94 678				
	Boiler class 3	**automatic**	49,34	48,6	0,075	282,8	340	1 140					94 678				
	Boiler class 4	**automatic**	23,68	23,33	0,045	200	340	670					94 678				
	Boiler class 5	**automatic**	15,79	15,55	0,011	0	190	247					94 678				
	Boiler Ecodesing	**automatic**	15,79	15,55	0,011	0	190	247					94 678				
	stoves, local space heaters, kitchen stoves	**without emission reduction**	424	106	0,26	450	100	5 250					94 678				
	stoves, local space heaters, kitchen stoves	**with emission reduction**	106	26,5	0,26	450	100	5 250					94 678				
	stoves, local space heaters, kitchen stoves	**Ecodesign**	17,6	4,4	0,011	0	170	830					94 678				
	Classified as NEW	**M/A**	19,8	15,4	0,0296	241,4	175	270	12,335	0,15	0		94 678	2	5,05	1,25	

Table 15. Emission factors connected with transport sector used in the inventory prepared for the use of Air Quality Plan.

Vehicles speed	Type of emission	Vehicle type	Pollutants emission factors [g/km/vehicle]															
[km/h]			TSP	PM10	PM2,5	B(a)P	SO_2	NO_x	CO	NMLZO	NH_3	C_6H_6	CH_4	CO_2	As	Hg	Cd	Pb
-	non-exhaust emissions from tyre and brake wear	passenger cars	0,0262	0,0195	0,0107													
-	non-exhaust emissions from tyre and brake wear	light vehicles	0,0362	0,0272	0,0148													
-	non-exhaust emissions from tyre and brake wear	heavy duty trucks	0,1318	0,095	0,095													
-	non-exhaust emissions from tyre and brake wear	buses	0,1318	0,095	0,054													
-	non-exhaust emissions from road wear and tear	passenger cars	0,0203	0,0101	0,0055													
-	non-exhaust emissions from road wear and tear	light vehicles	0,0203	0,0101	0,0055													
-	non-exhaust emissions from road wear and tear	heavy duty trucks	0,1026	0,0513	0,0277													
-	non-exhaust emissions from road wear and tear	buses	0,1026	0,0513	0,0277													
-	resuspension	passenger cars	0,7507	0,144	0,03456													
-	resuspension	light vehicles	0,7507	0,144	0,03456													
-	resuspension	heavy duty trucks	0,7507	0,144	0,03456													
-	resuspension	buses	0,7507	0,144	0,03456													
30	exhaust emissions	passenger cars	0,00323	0,00307	0,0029	0,00000048	0,00507	0,1228	0,90066	0,04278		0,00158		139,32				
30	exhaust emissions	light vehicles	0,01919	0,01823	0,01722	0,00000048	0,00654	0,3857	0,27233	0,04042		0,00067		283,22				
30	exhaust emissions	heavy duty trucks	0,05206	0,04946	0,04674	0,00000090	0,01613	1,58673	0,55563	0,85326		0,00783		827,64				

Vehicles speed	Type of emission	Vehicle type	Pollutants emission factors [g/km/vehicle]															
[km/h]			TSP	PM10	PM2,5	B(a)P	SO_2	NO_x	CO	NMLZO	NH_3	C_6H_6	CH_4	CO_2	As	Hg	Cd	Pb
30	exhaust emissions	buses	0,05206	0,04946	0,04674	0,00000090	0,01613	1,58673	0,55563	0,85326		0,00783		744,91				
40	exhaust emissions	passenger cars	0,00359	0,00341	0,00323	0,00000048	0,00462	0,10674	0,72897	0,03609		0,00158		139,32				
40	exhaust emissions	light vehicles	0,02053	0,01951	0,01843	0,00000048	0,00572	0,3336	0,25789	0,03533		0,00067		283,22				
40	exhaust emissions	heavy duty trucks	0,04355	0,04137	0,0391	0,00000090	0,01375	1,3605	0,476	0,68801		0,00783		827,64				
40	exhaust emissions	buses	0,04355	0,04137	0,0391	0,00000090	0,01375	1,3605	0,476	0,68801		0,00783		744,91				
50	exhaust emissions	passenger cars	0,00364	0,00346	0,00327	0,00000048	0,00434	0,09603	0,64959	0,03266		0,00158		139,32				
50	exhaust emissions	light vehicles	0,02193	0,02084	0,01969	0,00000048	0,00519	0,30621	0,25523	0,03149		0,00067		283,22				
50	exhaust emissions	heavy duty trucks	0,03647	0,03464	0,03274	0,00000090	0,01176	1,38462	0,4101	0,52788		0,00783		827,64				
50	exhaust emissions	buses	0,03647	0,03464	0,03274	0,00000090	0,01176	1,38462	0,4101	0,52788		0,00783		744,91				
60	exhaust emissions	passenger cars	0,00324	0,00308	0,00291	0,00000048	0,00394	0,09124	0,58398	0,02883		0,00158		139,32				
60	exhaust emissions	light vehicles	0,02119	0,02013	0,01902	0,00000048	0,00488	0,29896	0,22976	0,02704		0,00067		283,22				
60	exhaust emissions	heavy duty trucks	0,03286	0,03122	0,0295	0,00000090	0,01167	1,43941	0,37334	0,42268		0,00783		827,64				
60	exhaust emissions	buses	0,03286	0,03122	0,0295	0,00000090	0,01167	1,43941	0,37334	0,42268		0,00783		744,91				
70	exhaust emissions	passenger cars	0,00267	0,00254	0,0024	0,00000048	0,00348	0,09288	0,51479	0,02453		0,00158		139,32				
70	exhaust emissions	light vehicles	0,01883	0,01789	0,01691	0,00000048	0,0048	0,30728	0,19524	0,02304		0,00067		283,22				
70	exhaust emissions	heavy duty trucks	0,03308	0,03142	0,0297	0,00000090	0,01334	1,42684	0,3744	0,39341		0,00783		827,64				
70	exhaust emissions	buses	0,03308	0,03142	0,0297	0,00000090	0,01334	1,42684	0,3744	0,39341		0,00783		744,91				
80	exhaust emissions	passenger cars	0,00231	0,0022	0,00208	0,00000048	0,00312	0,10134	0,4592	0,02116		0,00158		139,32				
80	exhaust emissions	light vehicles	0,01704	0,01619	0,0153	0,00000048	0,00499	0,32661	0,18512	0,02074		0,00067		283,22				
80	exhaust emissions	heavy duty trucks	0,0323	0,03069	0,029	0,00000090	0,01455	1,37051	0,37077	0,35624		0,00783		827,64				
80	exhaust emissions	buses	0,0323	0,03069	0,029	0,00000090	0,01455	1,37051	0,37077	0,35624		0,00783		744,91				
90	exhaust emissions	passenger cars	0,00244	0,00232	0,00219	0,00000048	0,00303	0,11692	0,45005	0,02018		0,00158		139,32				
90	exhaust emissions	light vehicles	0,01841	0,01749	0,01653	0,00000048	0,00547	0,3524	0,232	0,02023		0,00067		283,22				
90	exhaust emissions	heavy duty trucks	0,02705	0,0257	0,02428	0,00000090	0,01384	1,41562	0,31712	0,23703		0,00783		827,64				
90	exhaust emissions	buses	0,02705	0,0257	0,02428	0,00000090	0,01384	1,41562	0,31712	0,23703		0,00783		744,91				
100	exhaust emissions	passenger cars	0,00315	0,00299	0,00283	0,00000048	0,00328	0,13984	0,52484	0,02222		0,00158		139,32				
100	exhaust emissions	light vehicles	0,02457	0,02334	0,02205	0,00000048	0,00621	0,38008	0,35546	0,02031		0,00067		283,22				
100	exhaust emissions	heavy duty trucks	0,03157	0,02999	0,02834	0,00000090	0,01663	1,82901	0,30659	0,27631		0,00783		827,64				
100	exhaust emissions	buses	0,03157	0,02999	0,02834	0,00000090	0,01663	1,82901	0,30659	0,27631		0,00783		744,91				
110	exhaust emissions	passenger cars	0,00426	0,00405	0,00383	0,00000048	0,00381	0,1702	0,72247	0,02696		0,00158		139,32				
110	exhaust emissions	light vehicles	0,03455	0,03282	0,03102	0,00000048	0,00707	0,40507	0,55788	0,01989		0,00067		283,22				
110	exhaust emissions	heavy duty trucks	0,10422	0,09901	0,09356	0,00000090	0,04461	2,99913	0,80514	1,52477		0,00783		827,64				
110	exhaust emissions	buses	0,10422	0,09901	0,09356	0,00000090	0,04461	2,99913	0,80514	1,52477		0,00783		744,91				

4.1. The balance of pollutant emissions covered by the Plan 30 km around the zones

In order to determine the size of the regional background broken-down by the natural, trans-boundary and national background, mathematical modelling of pollutant dispersion for the base year 2018 was carried out.

The modelling parameters are described in chapter 17.2. of this Plan. The modelling takes into account the emissions from the neighbouring voivodeships and from Slovakia. Below is the estimated amount of pollutant emissions covered by the Plan outside the zones of the Malopolska Region in the 30 km circumference around each zone.

Table 16. Estimated amount of pollutant emissions covered by the Plan in 2018 from the 30 km perimeter around the zones of the Malopolska Region [73]

	PM10 [Mg/year]	PM2.5 [Mg/year]	Benzo(a)pyrene [Mg/year]	Nitrogen dioxide [Mg/year]
Podkarpackie Voivodeship	5 982,7	4 718,8	2,3	9 053,3
Silesian Voivodeship	24 849,6	21 636,4	9,4	26 460,6
Swietokrzyskie Voivodeship	9 973,1	7 212,7	3,3	14 306,4
Slovakia	4 600,0	3 600,0	0,2	13 300,0

The analysis with the use of mathematical modelling clearly shows that the emission from the Silesian Voivodeship has the highest share in the incoming emissions (from the area outside the voivodeship). The emissions from the areas adjacent to the zones of the Krakow Agglomeration and the city of Tarnow were also taken into account in the inflow emissions to the zones. The amount of this emission was also estimated in the zone of 30 km from the zone border. The amount of emissions is set out in the table below.

Table 17. Estimated emissions of pollutants covered by the Plan in 2018 from the 30 km belt around the zone Krakow Agglomeration and the city of Tarnow [74]

	PM10 [Mg/year]	PM2,5 [Mg/year]	Benzo(a)pyrene [Mg/year]	Nitrogen dioxide [Mg/year]
Krakow				
Podkarpackie Voivodeship	-	-	-	-
Silesian Voivodeship	-	-	-	-
Swietokrzyskie Voivodeship	306,48	272,94	0,13	573,63
Slovakia	10 336,11	9 604,99	4,95	19 886,63
City of Tarnow				
Podkarpackie Voivodeship	1 031,60	887,57	0,42	2 016,50
Silesian Voivodeship	-	-	-	-
Swietokrzyskie Voivodeship	122,14	102,57	0,05	308,42
Malopolskie Voivodeship	3 781,43	3 470,15	1,74	6 709,33

[73] Source: Prepared by ATMOTERM S.A. on the basis of Central Emission Inventory – KOBIZE, calculated as the total of emissions from transport sector, point sources, agriculture, residential sector and fugitive emissions

[74] Source: Prepared by ATMOTERM S.A. on the basis of Central Emission Inventory – KOBIZE, calculated as the total of emissions from transport sector, point sources, agriculture, residential sector and fugitive emissions

5. AIR QUALITY ANALYSYS

5.1. Estimated level of regional pollution background in the base year 2018

Apart from the sources located in the zone of the Malopolska Region, the quality of air in the region is also influenced by sources of emissions from neighbouring zones. The level of regional background was determined basing on the results of pollution dispersion modelling taking into account emission sources (anthropogenic and natural) from outside the zones covered by the Plan. The table below presents data that describe the regional background for the Malopolska Region. It contains the range and the average values in the areas of the analysed zones. The regional background was also presented similarly broken down into trans-boundary, national, and natural backgrounds.

Table 18. Range of regional background concentrations in the Malopolska Region in 2018 [75]

Zone code	Zone name	Pollutant	Regional background	
			Range	Average
PL1201	Krakow Agglomeration	PM10	13,04-13,98	13,32
PL1201	Krakow Agglomeration	PM2.5	10,25-10,73	10,44
PL1201	Krakow Agglomeration	B(a)P	0,77-0,9	0,82
PL1201	Krakow Agglomeration	NO_2	4,69-5,35	5,10
PL1202	Tarnow city	PM10	13,47-14,74	13,86
PL1202	Tarnow city	PM2.5	10,63-11,24	10,86
PL1202	Tarnow city	B(a)P	0,92-1,1	0,99
PL1203	Malopolska zone	PM10	11,3-25,72	13,83
PL1203	Malopolska zone	PM2.5	9,12-22,15	10,75
PL1203	Malopolska zone	B(a)P	0,58-4,2	0,94

Data on the regional background ranges indicate that in the case of PM10 the values take average value from 13,32 µg/m^3 to 13,86 µg/m^3, which is about 30% of the PM10 standard, and 60% of the recommended WHO guideline (20 µg/m^3).

In the case of PM2.5, the average values range between 10,44 µg/m^3, and 10,86 µg/m^3, which is 50% of the phase II permissible limit (20 µg/m^3). These values exceed the level recommended by the WHO, which is 10 µg/m^3.

The regional background value of benzo(a)pyrene ranges between 0,82 ng/m^3 and 0,99 ng/m^3, which equals almost 100% of the target level concentration of 1 ng/m^3. The national background for benzo(a)pyrene accounts for over 60-70% of the target value, which is why corrective measures should also include the range of supra-regional activities that affect the level of benzo(a)pyrene.

Breakdown of regional background by trans-boundary, national and natural background indicates, that the national background has greatest influence on the concentration level (up to 40% of the permissible level of PM2.5). This means, that in order to achieve a significant improvement in air quality, it is necessary to introduce measures not only locally but also throughout the country.

[75] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Table 19. The range of regional background concentrations in the Malopolska Region in 2018 divided into different types of background[76]

Zone code	Zone name	Pollutant	Range of regional background concentrations within zones					
			trans-boundary		national		natural	
			range	average	range	average	range	average
PL1201	Krakow Agglomeration	PM10	2,93-2,99	2,96	9,32-9,83	9,53	0,64-1,41	0,83
PL1201	Krakow Agglomeration	PM2.5	2,33-2,36	2,34	7,86-8,31	8,05	0,04-0,07	0,05
PL1201	Krakow Agglomeration	B(a)P	0,13-0,14	0,14	0,63-0,76	0,68	0-0	0,00
PL1201	Krakow Agglomeration	NO_2	0,9-1,01	0,96	3,79-4,34	4,14	0-0	0,00
PL1202	Tarnow city	PM10	2,95-2,97	2,96	9,62-10,27	9,88	0,81-1,53	1,02
PL1202	Tarnow city	PM2.5	2,36-2,38	2,37	8,2-8,79	8,44	0,05-0,08	0,06
PL1202	Tarnow city	B(a)P	0,15-0,16	0,15	0,76-0,95	0,83	0-0	0,00
PL1203	Malopolska zone	PM10	2,87-5,68	3,03	7,87-21,94	9,72	0,42-1,93	1,08
PL1203	Malopolska zone	PM2.5	2,32-4,89	2,42	6,63-19,64	8,26	0,03-0,09	0,06
PL1203	Malopolska zone	B(a)P	0,12-1,43	0,17	0,37-4,07	0,76	0-0	0,00

5.2. Estimated urban and local background increment in the base year 2018 grouped by emission sources

In order to determine the measures aimed at improving air quality by reducing the emission of air pollutants, it is necessary to determine the causes of exceedances of each of the analysed substances – to indicate sources most responsible for the exceedances. To this end, modelling of pollutant dispersion was carried out for the exceedances areas, which allowed for a detailed determination of the share of each emission type in concentrations. The results of pollutants dispersion modelling with the CALPUFF model were analysed for each type of emission source included in the inventory. This allowed the determination of local background increment for each area of exceedance attributed to individual emission sources.

The average annual concentration generated by different types of sources was determined for each point where the monitoring station is located, basing on the modelling results. Information for each area where standards were exceeded (PM10, PM2.5, NO_2, and B(a)P) are presented in the charts.

The table below shows the emission sources that were indicated in the analyses along with their assignment to the SNAP category.

Table 20. Division of emission sources by SNAP categories

Type of emission sources indicated in the analyzes	Category	Emission sources
Heat and electricity production industry	SNAP 01	Combustion processes in the energy production and transformation sector
	SNAP 03	Combustion processes in industry
	SNAP 04	Production processes
Commercial and housing sector, services, crafts	SNAP 02	Combustion processes in the municipal and housing sector
Fugitive	SNAP 05	Extraction and distribution of fossil fuels
Road transport	SNAP 07	Road transport
Off-road mobile machinery	SNAP 08	Other vehicles and devices
Agriculture	SNAP 10	Agriculture

[76] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

5.2.1. KRAKOW AGGLOMERATION

The analysis of the sources shares in average annual concentrations was divided into types of sources identified in the framework of the estimated regional background, urban background increment, and local background increment.

Particulate matter PM10

Table 21. Estimated regional background level, urban background increment, and local pollution background increment at PM10 monitoring station points in Krakow Agglomeration. [77]

Background or background increment	Type of sources	PM10 monitoring station codes							
		MpKrakAlKras	MpKrakBujaka	MpKrakBulwar	MpKrakDietla	MpKrakOsPias	MpKrakTelime	MpKrakWadow	MpKrakZloRog
Estimated regional background level for PM10 [μg/m^3]	Trans-boundary	2,97	2,96	2,95	2,96	2,96	2,95	2,94	2,98
	National	9,58	9,43	9,50	9,54	9,64	9,40	9,59	9,68
	Natural	0,65	0,68	0,77	0,64	0,79	0,71	1,19	0,75
Estimated urban background increment for PM10 [μg/m^3]	Other voivodeship zones	5,02	5,02	5,02	5,02	5,02	5,02	5,02	5,02
	SNAP 10 agriculture	0,20	0,20	0,20	0,20	0,20	0,20	0,20	0,20
	SNAP 1 heat and electricity production industry	0,69	0,69	0,69	0,69	0,69	0,69	0,69	0,69
	SNAP 5 fugitive	0,28	0,28	0,28	0,28	0,28	0,28	0,28	0,28
	SNAP 7 road transport	6,87	6,87	6,87	6,87	6,87	6,87	6,87	6,87
	SNAP 2 commercial and housing sector, services, crafts	6,63	6,63	6,63	6,63	6,63	6,63	6,63	6,63
Estimated local background increment for PM10 [μg/m^3]	SNAP 7 road transport	11,24	2,50	0,92	3,59	0,00	0,00	0,00	3,90
	SNAP 2 commercial and housing sector, services, crafts	8,27	4,77	4,07	6,77	0,39	7,87	0,08	7,37

The constant value of the urban background increment, understood as the average concentration from the urban area, constitutes 70% of the permissible value of PM10. The increase in concentration values from local sources is particularly visible for the station at Al. Krasinskiego, where emissions from the transport sector account for a significant share of concentration. The contribution of transport related emissions is also notable for the monitoring stations at Dietla Street and the Zloty Rog. The transport is the major factor in the urban background increment, which indicates that it poses a source of PM10 pollution in the area of urban fabric.

[77] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

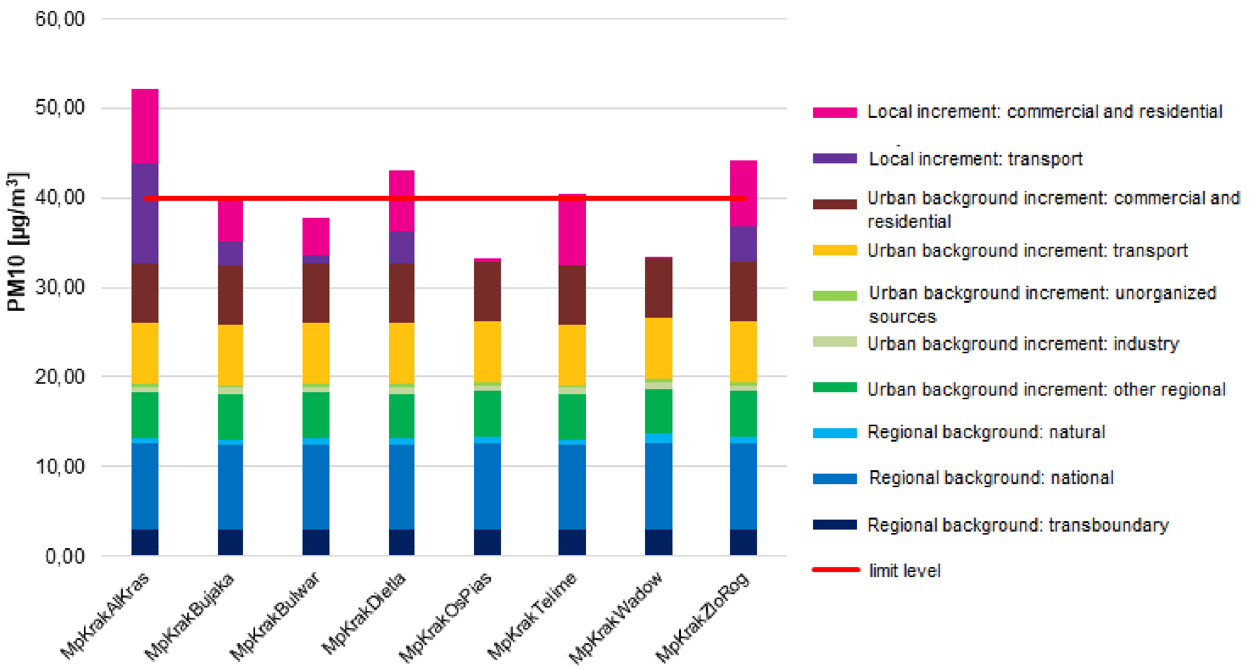


Figure 43. The picture of regional background levels, urban background increment, and local PM10 background increment for monitoring stations in the Krakow Agglomeration in 2018 [78]

Particulate matter PM2.5

The analysis of the shares of individual types of sources in the average annual PM2.5 concentrations for the monitoring stations in Krakow indicates which sources have the greatest impact on the occurrence of the exceedances. Apart from regional and urban background sources, the concentration levels are predominantly affected by the transport sources and the municipal sector.

Table 22. Estimated regional background level, urban background increment and local background increment at PM2.5 dust monitoring station points in Krakow Agglomeration. [79]

Background or background increment	Type of sources	PM2.5 monitoring station codes							
		MpKrakAlKras	MpKrakBujaka	MpKrakBulwar	MpKrakDietla	MpKrakOsPias	MpKrakTelime	MpKrakWadow	MpKrakZloRog
Estimated regional background level for PM2.5 [µg/m³]	Trans-boundary	2,35	2,34	2,34	2,34	2,34	2,34	2,33	2,35
	National	8,09	7,96	8,03	8,06	8,14	7,93	8,11	8,19
	Natural	0,04	0,04	0,05	0,04	0,05	0,04	0,06	0,05

[78] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.
[79] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Background or background increment	Type of sources	PM2.5 monitoring station codes							
		MpKrakAlKras	MpKrakBujaka	MpKrakBulwar	MpKrakDietla	MpKrakOsPias	MpKrakTelime	MpKrakWadow	MpKrakZloRog
Estimated urban background increment for PM2.5 [μg/m³]	Other voivodeship zones	3,45	3,45	3,45	3,45	3,45	3,45	3,45	3,45
	SNAP 10 agriculture	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01
	SNAP 1 heat and electricity production industry	0,45	0,45	0,45	0,45	0,45	0,45	0,45	0,45
	SNAP 5 fugitive	0,07	0,07	0,07	0,07	0,07	0,07	0,07	0,07
	SNAP 7 road transport	1,97	1,97	1,97	1,97	1,97	1,97	1,97	1,97
	SNAP 2 commercial and housing sector, services, crafts	5,40	5,40	5,40	5,40	5,40	5,40	5,40	5,40
Estimated local background increment for PM2.5 [μg/m³]	SNAP 7 road transport	3,94	1,08	0,58	1,39	0,00	0,00	0,00	1,47
	SNAP 2 commercial and housing sector, services, crafts	8,75	5,46	4,04	7,35	1,26	5,66	0,26	7,15

In the case of annual average PM2.5 concentrations, the contribution of local transport sources decreases in respect to their contribution in PM10. Municipal sector sources are the main contributors to local background increment for monitoring stations. Only at the Al. Krasinskiego station, contribution of transport emission sources is visible. National sources, which determine the regional background, account for the largest share of PM2.5 concentrations. Other emission sources do not contribute to the local background increment, therefore they are not included in the list.

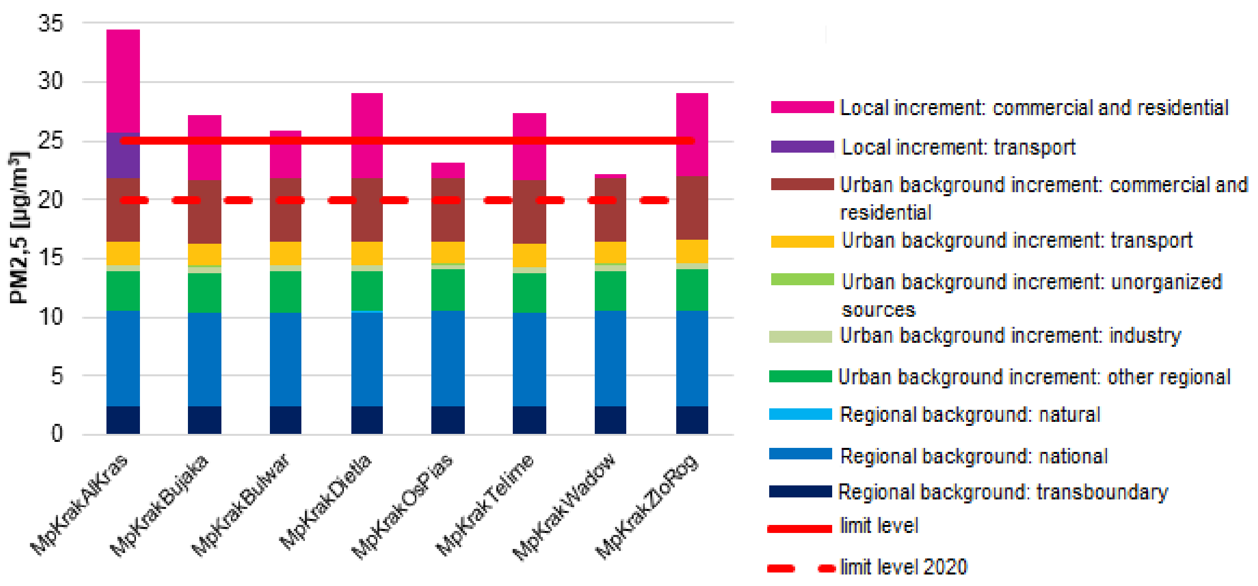


Figure 44. The picture of regional background levels, urban background increment, and local background increment for PM2.5 at monitoring stations in the Krakow Agglomeration in 2018 [80]

Reduction of the urban background, i.e. average concentrations generated by individual sources, can lead to an improvement in air quality and a decrease in PM2.5 concentrations to the level required by regulations. The analysis also signalized the need to reduce the level of national background, which, together with the trans-boundary background, is equal to the value of the concentration level recommended by WHO for PM2.5. Such a significant share of the regional background allows to conclude that the total reduction of emissions in the Krakow Agglomeration will not lead to reaching the level recommended by WHO, because the volume of the inflow from outside of the zone exceeds the WHO guideline level.

In the case of PM2.5, pollution from outside the Krakow Agglomeration has a varying impact on the average annual concentrations. In the area of exceeded standards, they generate concentrations at a relatively constant level of 10,32-10,58 µg/m^3, which is about 50% of phase II of the permissible level. The national background sources equal 7,93-8,19 µg/m^3 are apparently high. In turn, pollutants from the local background generate concentrations of 0,26-12,69 µg/m^3 while the urban background is responsible for concentrations of 11,34 µg/m^3.

Benzo(a)pyrene

Benzo(a)pyrene is a pollution whose concentration in the air is strongly dependent not only on the level of emissions from local fuel combustion sources, but also on the inflow from other areas of the voivodeship and the country.

[80] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Table 23. Estimated level of regional background, urban background increment and local background increment for B(a)P at monitoring stations in Krakow Agglomeration. [81]

Background or background increment	Type of sources	B(a)P monitoring station codes							
		MpKrakAlKras	MpKrakBujaka	MpKrakBulwar	MpKrakDietla	MpKrakOsPias	MpKrakTelime	MpKrakWadow	MpKrakZloRog
Estimated regional background level for B(a)P [ng/m³]	Trans-boundary	0,13	0,14	0,14	0,13	0,13	0,14	0,14	0,13
	National	0,69	0,65	0,69	0,68	0,72	0,65	0,73	0,71
	Natural	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Estimated urban background increment for B(a)P [ng/m³]	Other voivodeship zones	1,17	1,17	1,17	1,17	1,17	1,17	1,17	1,17
	SNAP 10 agriculture	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	SNAP 1 heat and electricity production industry	0,03	0,03	0,03	0,03	0,03	0,03	0,03	0,03
	SNAP 5 fugitive	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	SNAP 7 road transport	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
	SNAP 2 commercial and housing sector, services, crafts	2,01	2,01	2,01	2,01	2,01	2,01	2,01	2,01
Estimated local background increment for B(a)P [ng/m³]	SNAP 7 road transport	0,00	0,00	0,01	0,00	0,01	0,01	0,02	0,00
	SNAP 2 commercial and housing sector, services, crafts	1,81	1,16	0,88	1,41	0,06	1,11	0,16	1,53

The municipal sector sources are responsible for the majority of annual average concentrations of benzo(a)pyrene. The contribution of sources from outside the county is equal to the contribution of local sources for points where monitoring stations are located. However, the impact of urban background sources is predominant.

The inflow of emissions from outside the zone accounts for 70-80% of the target concentration value, which means that a total reduction of emissions from local sources will not help to achieve the target level. The local, regional, and national action simultaneously is required to reduce emissions from the municipal and housing sector. It is necessary to reduce emissions by up to about 30% on a national scale, which, together with regional activities, will allow to reach the long-term target.

Additionally, industrial sources and transport contribute slightly in benzo(a)pyrene concentrations, but this level is much lower than for other sources. Analysis of the participation of individual emission sources for the excessive concentration of benzo(a)pyrene in the Krakow Agglomeration area indicates that the values of regional concentration are between 0,74 and 0,86 ng/m^3, which translates into over 80% of the target level. The individual heating sources, which generate concentrations at the level of 0,06-1,81 ng/m^3, bear the greatest responsibility for the increment in the local background of benzo(a)pyrene concentrations in Krakow.

[81] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

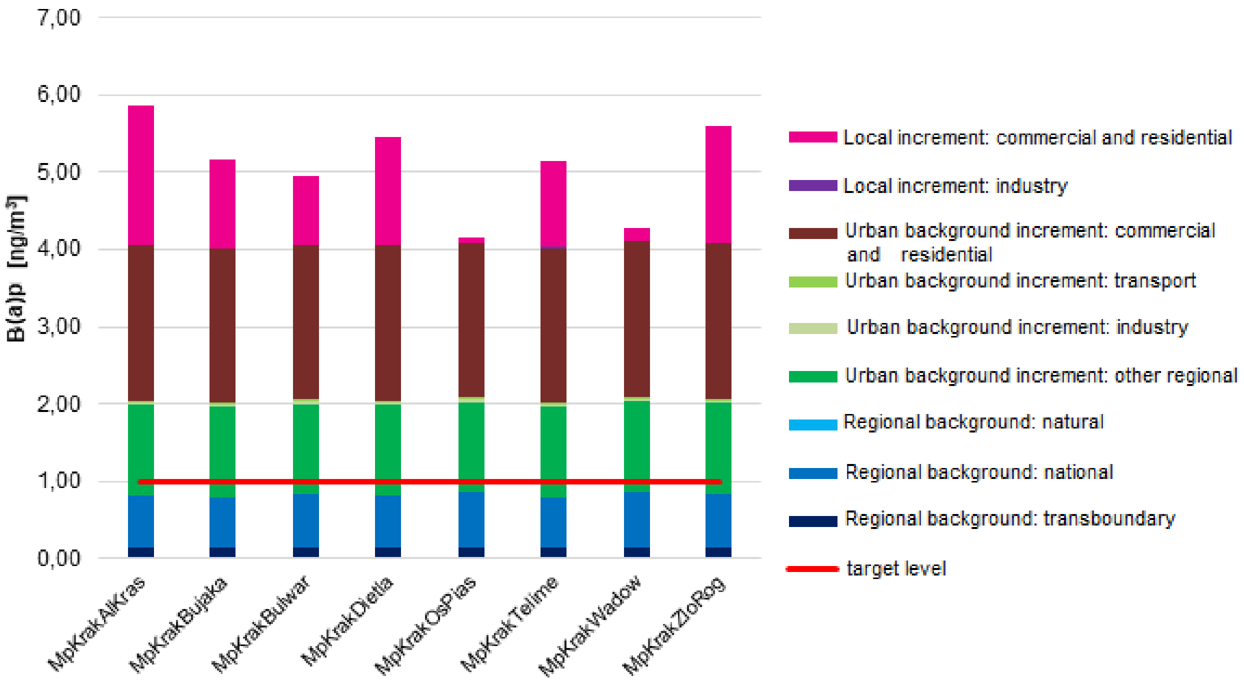


Figure 45. Regional background levels, urban background increment, and local background increment for benzo(a)pyrene at monitoring stations in the Krakow Agglomeration in 2018[82]

Nitrogen dioxide

The analysis of the shares of sources in average annual nitrogen dioxide concentrations indicates a particular impact of transport in terms of both urban and local background. The impact of transport is particularly visible at traffic stations.

The concentration of nitrogen dioxide from sources outside the voivodeship range from 5,02 to 5,30 µg/m³. Transport sources located in the city make the average annual concentration higher by about 15,38 µg/m³. The inflow of emissions from other counties causes the increment in average annual concentrations by about 6,39 µg/m³. However, local transport has the largest contribution to the local background increment, causing a concentration increase at a highly varying level ranging from 0,35 to 26,35 µg/m³. The maximum concentration value from local transport equal to 26,35 µg/m³ at the traffic station – Al. Krasinskiego.

Table 24. Estimated level of regional background, urban background increment, and local background increment for nitrogen dioxide at monitoring stations in Krakow Agglomeration[83]*.*

Background or background increment	Type of sources	NO_2 monitoring station codes							
		MpKrakAlKras	MpKrakBujaka	MpKrakBulwar	MpKrakDietla	MpKrakOsPias	MpKrakTelime	MpKrakWadow	MpKrakZloRog
Estimated regional background level for NO_2 [µg/m³]	Trans-boundary	0,99	0,96	0,97	1,00	0,98	0,97	0,94	0,96
	National	4,27	4,06	4,17	4,30	4,25	4,08	4,09	4,21

[82] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.
[83] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Background or background increment	Type of sources	NO_2 monitoring station codes							
		MpKrakAlKras	MpKrakBujaka	MpKrakBulwar	MpKrakDietla	MpKrakOsPias	MpKrakTelime	MpKrakWadow	MpKrakZloRog
	Natural	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Estimated urban background increment for NO_2 [µg/m^3]	Other voivodeship zones	6,39	6,39	6,39	6,39	6,39	6,39	6,39	6,39
	SNAP 10 agriculture	0,12	0,12	0,12	0,12	0,12	0,12	0,12	0,12
	SNAP 1 heat and electricity production industry	0,86	0,86	0,86	0,86	0,86	0,86	0,86	0,86
	SNAP 5 fugitive	15,38	15,38	15,38	15,38	15,38	15,38	15,38	15,38
	SNAP 7 road transport	1,68	1,68	1,68	1,68	1,68	1,68	1,68	1,68
Estimated local background increment for NO_2 [µg/m^3]	SNAP 2 commercial and housing sector, services, crafts	0,00	0,00	1,12	0,00	0,00	0,00	0,47	0,00
	SNAP 7 road transport	26,35	9,92	4,65	12,74	0,35	1,92	0,00	13,80
	SNAP 2 commercial and housing sector, services, crafts	2,06	1,61	0,47	1,82	0,65	0,58	0,00	3,68

The figure below pictures the constituents of average annual concentrations recorded by the monitoring stations in relation to the annual standard. It can be applied in order to determine the areas where it is possible to take measures aiming in reduction of the nitrogen dioxide concentrations.

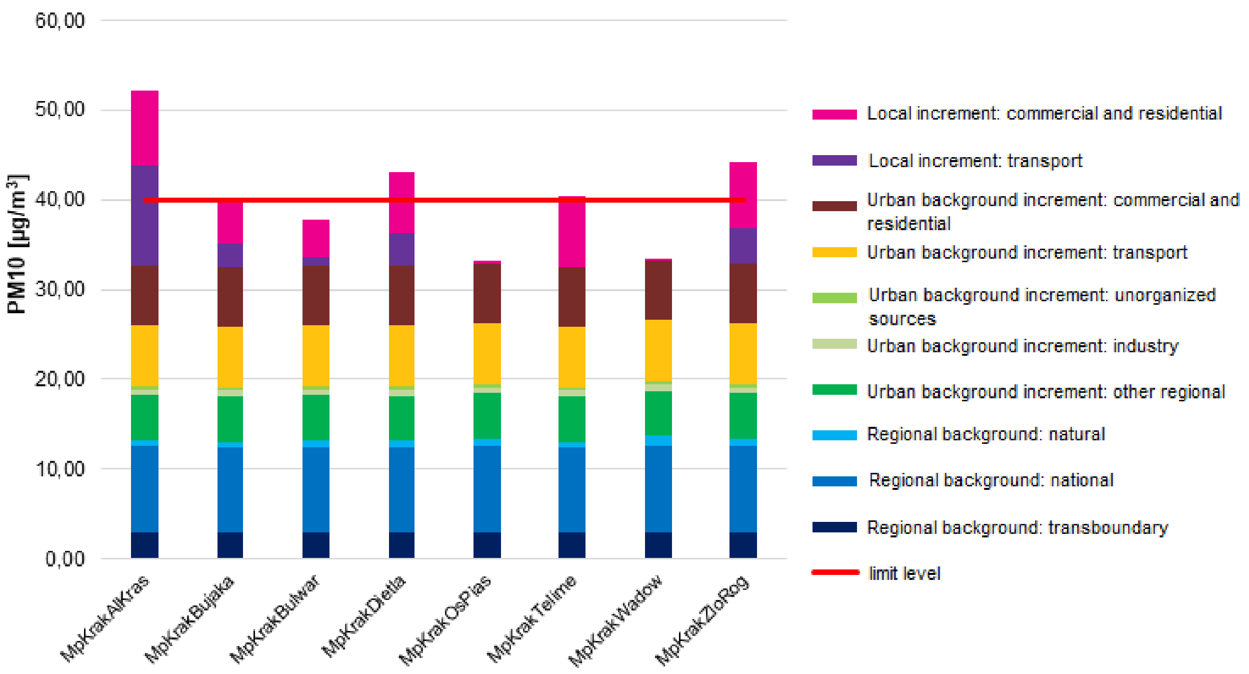


Figure 46. The picture of regional background levels, urban background increment, and local background increment for nitrogen dioxide at monitoring stations in the Krakow Agglomeration zone in 2018.[84]

5.2.2. TARNOW CITY ZONE

The analysis of the sources shares in average annual concentrations in the Tarnow city zone was divided into types of sources identified in the framework of the estimated regional background, urban background increment, and local background increment.

The analysis was performed for the monitoring stations used for the *Annual air quality assessment for the Malopolska Region in 2018.*

Particulate matter PM10

The average annual concentrations of PM10 in Tarnow depend to a large extent on the regional background. The analysed concentration contributions in both monitoring stations indicate which of the sources predominantly form the average annual concentrations. At the stations in Tarnow, the level of permissible average annual PM10 concentration was within allowed standard, while the daily concentrations were at times excessive.

Table 25. Estimated regional background level, urban background increment, and local pollution background increment for PM10 at monitoring stations in Tarnow city zone [85]*.*

Background or background increment	Type of sources	PM10 monitoring station codes	
		MpTarBitStud	MpTarRoSitko
Estimated regional background level for PM10 [µg/m³]	Trans-boundary	2,97	2,96
	National	10,00	9,92
	Natural	0,86	0,82

[84] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.
[85] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Background or background increment	Type of sources	PM10 monitoring station codes	
		MpTarBitStud	MpTarRoSitko
Estimated urban background increment for PM10 [μg/m³]	Other voivodeship zones	5,56	5,56
	SNAP 10 agriculture	0,46	0,46
	SNAP 1 heat and electricity production industry	0,70	0,70
	SNAP 5 fugitive	0,10	0,10
	SNAP 7 road transport	3,28	3,28
	SNAP 2 commercial and housing sector, services, crafts	4,47	4,47
Estimated local background increment for PM10 [μg/m³]	SNAP 7 road transport	2,41	1,67
	SNAP 2 commercial and housing sector, services, crafts	1,26	4,83

Pollutants coming from outside the Tarnow city zone (mainly regional background) affect the level of average annual PM10 concentrations in a divergent way. In the exceedances areas, they generate concentrations of 13,70 – 13,8 μg/m³, i.e. approximately 32% of the permissible level. A high contribution of domestic sources is visible in regional background concentrations. They are responsible for concentrations ranging from 9,92 μg/m³ to 10,0 μg/m³. Concentrations generated by trans-boundary sources ranged between 2,96 μg/m³, and 2,97 μg/m³. The natural background level was between 0,82 μg/m³ to 0,86 μg/m³. The increment in urban background includes emissions from road transport translating into a concentration of 6,87 μg/m³ and emissions from the municipal sector remaining at 3,28 μg/m³ level.

The level of local background increment depends on, among other factors, emissions from municipal sources, while the increment varies in different areas in the range of 1,26 to 4,83 μg/m³. The impact of emissions from individual heating sources of buildings has a local character. There is no significant contribution of traffic emissions in PM10 concentrations at the transport station in Tarnow. The figure below presents PM10 concentrations generated by various types of sources for each monitoring station.

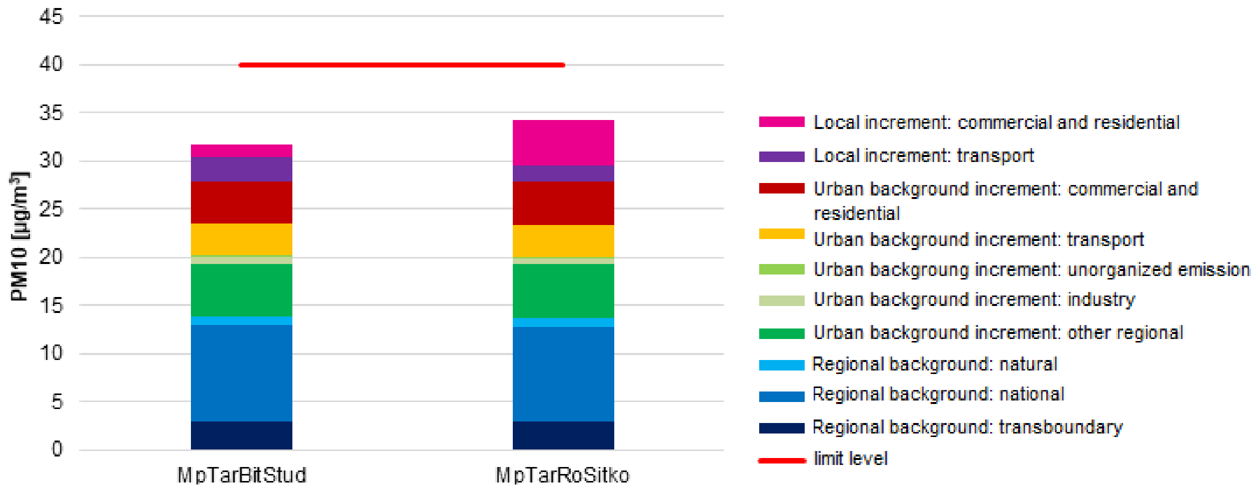


Figure 47. The picture of regional background levels, urban background increment, and local background increment for PM10 at monitoring stations in the Tarnow city zone in 2018[86].

[86] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Particulate matter PM2.5

The contribution of individual sources of pollutant emissions in average annual concentrations of PM2.5 particulate matter is similar to that of PM10. Detailed contributions are presented in the table below.

Table 26. Estimated regional background level, urban background increment and local background increment of PM2.5 pollution at the monitoring stations in Tarnow city zone[87].

Background or background increment	Type of sources	PM2.5 monitoring station codes	
		MpTarBitStud	MpTarRoSitko
Estimated regional background level for PM2.5 [μg/m³]	Trans-boundary	2,37	2,37
	National	8,55	8,47
	Natural	0,05	0,05
Estimated urban background increment for PM2.5 [μg/m³]	Other voivodeship zones	3,59	3,59
	SNAP 10 agriculture	0,01	0,01
	SNAP 1 heat and electricity production industry	0,59	0,59
	SNAP 5 fugitive	0,02	0,02
	SNAP 7 road transport	1,12	1,12
	SNAP 2 commercial and housing sector, services, crafts	4,20	4,20
Estimated local background increment for PM2.5 [μg/m³]	SNAP 7 road transport	0,82	0,53
	SNAP 2 commercial and housing sector, services, crafts	1,32	4,67

Pollutants from outside the city of Tarnow generate concentrations at the level of 10,89-10,97 μg/m³, which is about 50% of PM2.5 phase II permissible the level. In the area of exceedance of the permissible level, a high contribution of national background sources, which equals 8,47-8,55 μg/m³ is visible.

[87] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

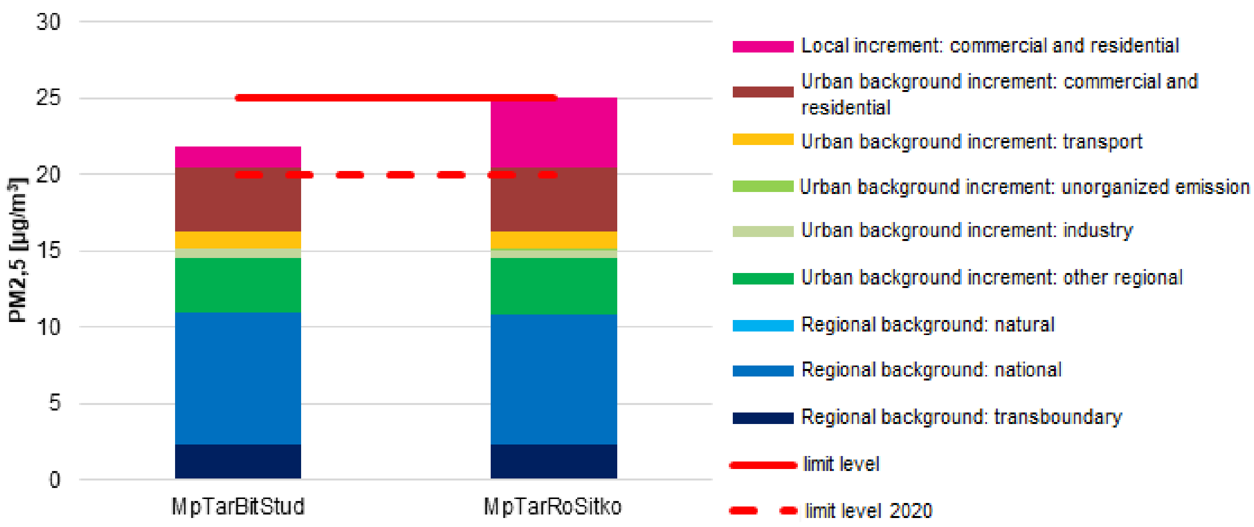


Figure 48. The picture of regional background levels, urban background increment, and local background increment for PM2.5 at monitoring stations in the Tarnow city zone in 2018 [88].

Pollutants from the local background generate concentrations of 2,13-5,21 µg/m^3, while emissions from the urban background determine concentrations of 9,53 µg/m^3 (including primarily emissions from the municipal sector and emissions from outside the zone).

Benzo(a)pyrene

The target value of the average annual concentration of benzo(a)pyrene in Tarnow was exceeded in 2018, same as in the rest of the voivodeship. The share of sources affecting the level of benzo(a)pyrene concentrations is shaped similarly to the other voivodeship zones.

Table 27. Estimated level of regional background, urban background increment and local pollution background increment for B(a)P at monitoring stations in Tarnow city zone [89].

Background or background increment	Type of sources	B(a)P monitoring station codes	
		MpTarBitStud	MpTarRoSitko
Estimated regional background level for B(a)P [ng/m^3]	Trans-boundary	0,15	0,15
	National	0,87	0,85
	Natural	0,00	0,00
Estimated urban background increment for B(a)P [ng/m^3]	Other voivodeship zones	1,17	1,17
	SNAP 10 agriculture	0,00	0,00
	SNAP 1 heat and electricity production industry	0,20	0,20
	SNAP 5 fugitive	0,00	0,00
	SNAP 7 road transport	0,01	0,01

[88] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.
[89] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Background or background increment	Type of sources	B(a)P monitoring station codes	
		MpTarBitStud	MpTarRoSitko
	SNAP 2 commercial and housing sector, services, crafts	1,05	1,05
Estimated local background increment for B(a)P [ng/m³]	SNAP 7 road transport	0,00	0,04
	SNAP 2 commercial and housing sector, services, crafts	0,38	1,17

The analysis of the individual contributions of emission sources to the scale of benzo(a)pyrene concentration in the area of exceeded standards for the city of Tarnow indicates that regional concentrations at the locations of monitoring stations remain at the level of 1,00-1,02 ng/m³ – which exceed the target levels. The sources responsible for individual buildings heating are the source of increment in local background of benzo(a)pyrene concentrations in Tarnow, generating concentrations of 0,38-1,17 ng/m³. The national background contribution reaches as much as 1 ng/m³ and is significant in case of both stations.

The figure below presents the level of regional background, urban background increment and local background increment of individual sources in the areas of exceeded standards.

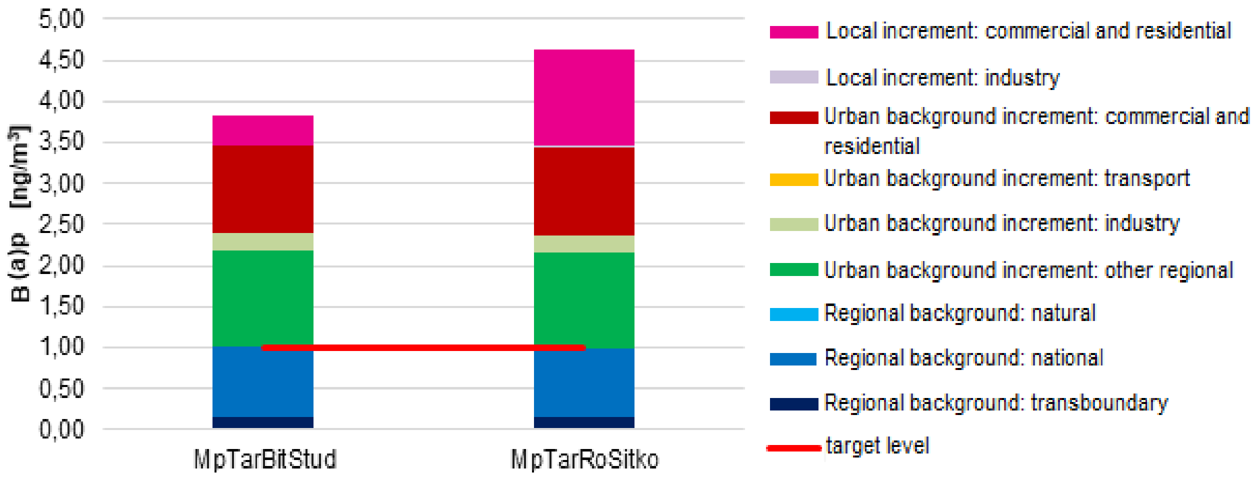


Figure 49. The picture of regional background levels, urban background increment, and local background increment for benzo(a)pyrene at monitoring stations in the Tarnow city zone in 2018 [90].

[90] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

5.2.3. *MALOPOLSKA ZONE*

The permissible and target levels of concentrations were exceeded in many of the Malopolska zone areas. The analysis covered the monitoring stations points, for which the impact of individual types of sources on the concentration level was analysed. The tables below describe in detail the regional and local backgrounds for the Malopolska zone in the concentrations of particulate matter PM10, PM2.5 and benzo(a)pyrene.

In the case of the Malopolska zone, the increment in the urban background was not analysed because this value refers only to cities and agglomerations. The increment in local background reflects changes in the concentration of the substance caused by emissions from local sources. Most of the monitoring stations are located outside of large cities.

The analysis refers to the permissible and the target levels of substance to illustrate what concentrations exceeded the regulatory standards. It also indicates the area of possible actions that can eliminate emissions of a given source types in the analysed area.

Areas of exceeded standards in the Malopolska zone are significant in relation to their surface, therefore it was impossible to indicate a representative point of occurrence of high concentrations to analyse the impact of individual emission sources. Therefore, the analysis was carried out for the locations of monitoring stations in areas of exceeded standards. The stations, at which annual permissible and target concentrations were not exceeded, were also included in the analysis

Particulate matter PM10

The analysis for PM10 concentration was carried out for 16 monitoring stations, where the contributions of regional background and local sources were indicated. Pollutants originating outside of the Malopolska zone (mainly regional background) affect PM10 annual concentrations in a divergent way. They generate concentrations at the level of 11,54-18,22 µg/m^3, i.e. approximately 30-40% of the permissible level for monitoring stations. A high contribution of domestic sources is visible in regional background concentrations, which are responsible for concentrations ranging from 8,15 µg/m^3 to 14,27 µg/m^3. The concentration values generated by trans-boundary sources ranged between 2,89 µg/m^3 and 3,66 µg/m^3. The natural background level ranged between 0,5 µg/m^3 to 1,26 µg/m^3. The local background increment in most of the stations is determined by emissions from municipal sources, and it varies significantly in different areas in the range from 4,98 to 26,35 µg/m^3. The impact of emissions from individual heating sources of buildings has a local nature. Remaining types of emission sources are of little importance for the urban and local background increment.

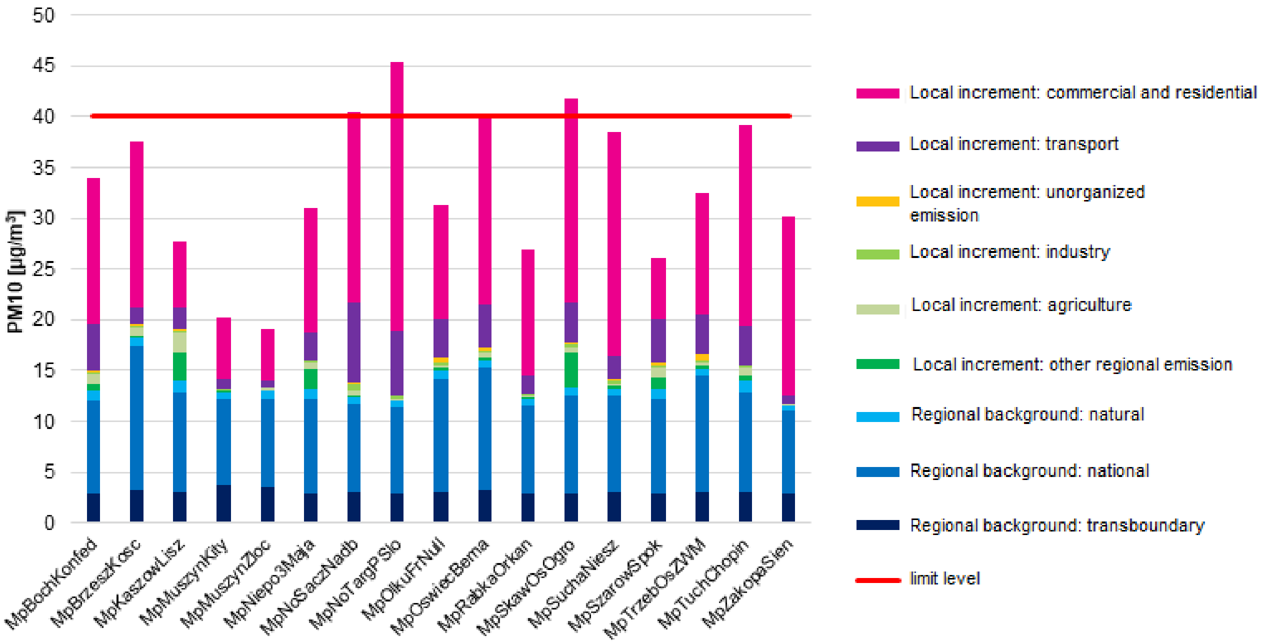


Figure 50. The picture of regional background levels, urban background increment, and local background increment for PM10 at monitoring stations in the Malopolska zone in 2018 [91].

The table and the figure below present in detail the PM10 concentration shares of different types of emission sources for each exceeded standard area.

[91] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Table 28. Estimated level of regional background, urban background increment and local background increment for PM10 at monitoring stations in Malopolska zone [92].

Background or background increment	Type of sources responsible	PM10 monitoring station codes																
		MpBochKonfed	MpBrzeszKosc	MpKaszowLisz	MpMuszynKity	MpMuszynZloc	MpNiepo3Maja	MpNoSaczNadb	MpNoTargPSlo	MpOlkuFrNull	MpOswiecBema	MpRabkaOrkan	MpSkawOsOgro	MpSuchaNiesz	MpSzarowSpok	MpTrzebOsZWM	MpTuchChopin	MpZakopaSien
Estimated regional background level for PM10 [µg/m³]	Trans-boundary	2,94	3,19	3,00	3,66	3,60	2,93	3,07	2,92	3,09	3,17	2,91	2,98	3,02	2,93	3,10	2,99	2,89
	National	9,17	14,27	9,82	8,59	8,58	9,33	8,62	8,41	11,16	12,14	8,64	9,53	9,56	9,25	11,37	9,86	8,15
	Natural	1,00	0,75	1,26	0,63	0,79	0,91	0,73	0,66	0,73	0,69	0,64	0,84	0,66	0,99	0,68	1,18	0,50
Estimated local background level for PM10 [µg/m³]	Other voivodeship zones	0,56	0,27	2,66	0,08	0,08	1,96	0,14	0,10	0,26	0,34	0,16	3,43	0,31	1,11	0,34	0,51	0,05
	SNAP 10 agriculture	0,97	0,67	2,01	0,13	0,24	0,61	0,52	0,21	0,30	0,41	0,25	0,51	0,21	1,07	0,29	0,73	0,08
	SNAP 1 heat and electricity production industry	0,27	0,20	0,13	0,06	0,06	0,17	0,57	0,17	0,19	0,20	0,05	0,37	0,27	0,18	0,25	0,15	0,04
	SNAP 5 fugitive	0,14	0,17	0,27	0,07	0,05	0,14	0,15	0,04	0,58	0,40	0,05	0,10	0,06	0,20	0,67	0,11	0,02
	SNAP 7 road transport	4,55	1,73	2,10	0,97	0,67	2,73	7,93	6,45	3,72	4,23	1,81	3,88	2,31	4,34	3,80	3,81	0,89
	SNAP 2 commercial and housing sector, services, crafts	14,27	16,32	6,55	6,10	4,98	12,17	18,70	26,35	11,37	18,73	12,49	20,08	22,09	6,03	11,97	19,82	17,52

[92] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Particulate matter PM2.5

Table 29. Estimated level of regional background, urban background increment and local pollution background increment for PM2.5 at monitoring stations in Malopolska zone [93]

Background or background increment	Type of sources responsible	PM2.5 monitoring station codes																
		MpBochKonfed	MpBrzeszKosc	MpKaszowLisz	MpMuszynKity	MpMuszynZloc	MpNiepo3Maja	MpNoSaczNadb	MpNoTargPSlo	MpOlkuFrNull	MpOswiecBema	MpRabkaOrkan	MpSkawOsOgro	MpSuchaNiesz	MpSzarowSpok	MpTrzebOsZWM	MpTuchChopin	MpZakopaSien
Estimated regional background level for PM2.5 [μg/m^3]	Trans-boundary	2,35	2,49	2,37	3,04	2,98	2,33	2,49	2,35	2,42	2,48	2,34	2,36	2,41	2,34	2,43	2,40	2,35
	National	7,75	12,46	8,30	7,28	7,28	7,89	7,29	7,09	9,51	10,44	7,28	8,05	8,12	7,82	9,71	8,43	6,88
	Natural	0,06	0,05	0,07	0,04	0,05	0,05	0,05	0,04	0,05	0,05	0,04	0,05	0,04	0,06	0,04	0,06	0,04
Estimated local background level for PM2.5 [μg/m^3]	Other voivodeship zones	0,39	0,18	1,87	0,05	0,06	1,25	0,10	0,07	0,19	0,22	0,11	2,38	0,21	0,73	0,24	0,38	0,04
	SNAP 10 agriculture	0,02	0,02	0,05	0,00	0,01	0,02	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,03	0,01	0,02	0,00
	SNAP 1 heat and electricity production industry	0,21	0,16	0,11	0,04	0,04	0,14	0,46	0,14	0,15	0,15	0,04	0,29	0,21	0,14	0,19	0,11	0,03
	SNAP 5 fugitive	0,03	0,04	0,06	0,02	0,01	0,03	0,03	0,01	0,14	0,10	0,01	0,02	0,02	0,05	0,16	0,03	0,00
	SNAP 7 road transport	1,43	0,55	0,68	0,32	0,22	0,90	2,66	2,03	1,22	1,36	0,57	1,24	0,74	1,43	1,21	1,21	0,28
	SNAP 2 commercial and housing sector, services, crafts	13,37	12,46	5,78	5,72	4,66	11,13	16,87	24,71	10,34	14,62	11,18	16,13	19,22	5,49	10,87	17,41	15,50

[93] Based on the results of modelling with the CALPUFF model and the Central for 2018. Detailed configuration of model in Chapter 17.2, ATMOTERM S.A.

Pollutants originating from outside of the Malopolska zone impact the average annual PM2.5 concentration diversely. In the area of exceeded standards, they generate concentrations at the level of 9,26-15,00 µg/m³, which translates into about 48% up to 75% of the level acceptable for phase II. A significant contribution of domestic background sources, which equals 6,88-12,46 µg/m³, is visible. However, pollutants originating from the local background generate concentrations at a strongly differentiated level from 5,0 to 26,96 µg/m³ (including mainly the municipal sector).

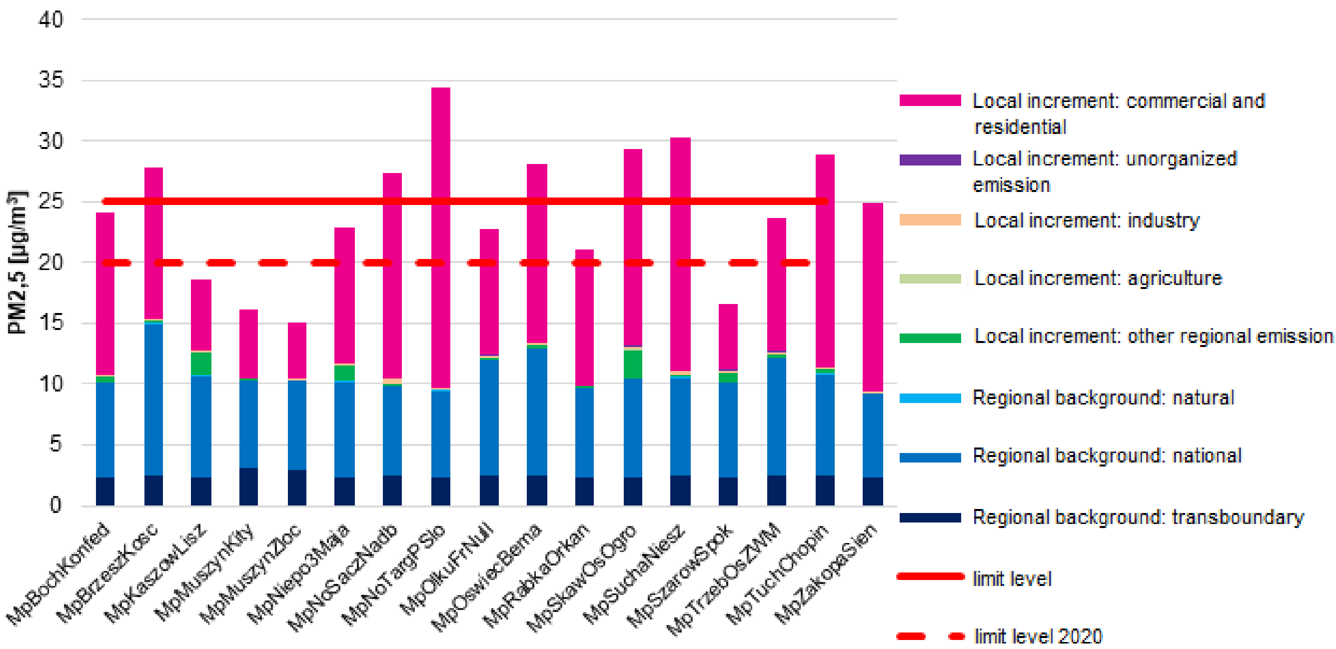


Figure 51. The picture of regional background levels, urban background increment, and local background increment for PM2.5 at monitoring stations in the Malopolska zone in 2018 [94]

[94] Based on the results of modelling with the CALPUFF model and the Central Emission Base for 2018. Detailed configuration of model in Chapter 17.2, ATMOTERM S.A.

Benzo(a)pyrene

Table 30. Estimated level of regional background, urban background increment and local pollution background increment for B(a)P at monitoring stations in Malopolska zone.[95]

Background or background increment	Type of sources responsible	Benzo(a)pyrene monitoring station codes																
		MpBochKonfed	MpBrzeszKosc	MpKaszowLisz	MpMuszynKity	MpMuszynZloc	MpNiepo3Maja	MpNoSaczNadb	MpNoTargPSlo	MpOlkuFrNull	MpOswiecBema	MpRabkaOrkan	MpSkawOsOgro	MpSuchaNiesz	MpSzarowSpok	MpTrzebOsZWM	MpTuchChopin	MpZakopaSien
Estimated regional background increment for B(a)P [ng/m^3]	Trans-boundary	0,16	0,13	0,13	0,48	0,45	0,14	0,23	0,17	0,12	0,13	0,16	0,14	0,15	0,15	0,13	0,16	0,18
	National	0,64	2,09	0,73	0,45	0,45	0,67	0,49	0,44	1,08	1,34	0,47	0,66	0,66	0,65	1,14	0,82	0,40
	Natural	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Estimated local background increment for B(a)P [ng/m^3]	Other voivodeship zones	0,09	0,04	0,50	0,01	0,01	0,29	0,02	0,01	0,05	0,06	0,02	0,62	0,05	0,17	0,06	0,10	0,01
	SNAP 10 agriculture	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	SNAP 1 heat and electricity production industry	0,17	0,06	0,05	0,02	0,02	0,05	0,27	0,38	0,07	0,06	0,03	0,06	0,07	0,09	0,06	0,03	0,05
	SNAP 5 fugitive	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
	SNAP 7 road transport	0,01	0,00	0,01	0,00	0,00	0,01	0,02	0,02	0,01	0,01	0,00	0,01	0,01	0,01	0,01	0,01	0,00
	SNAP 2 commercial and housing sector, services, crafts	5,52	5,32	2,16	1,16	1,02	4,61	8,87	15,71	3,48	5,98	5,34	5,95	10,47	2,07	4,26	7,28	6,24

[95] Based on the results of modelling with the CALPUFF model and the Central Emission Inventory for 2018. Detailed model configuration is described in Chapter 17.2, ATMOTERM S.A.

The analysis of the responsibility of individual emission sources for the concentration of benzo(a)pyrene at monitoring stations in the Malopolska zone indicates that the regional concentrations take values from 0,58 ng/m^3 to 2,22 ng/m^3. These values exceed the target level concentration. The individual heating sources are a major contributor to the local background increment of benzo(a)pyrene concentrations in the Malopolska zone by generating concentrations at 1,02-15,71 ng/m^3. The highest local background contribution in total concentration is observed in Nowy Targ, where emissions from the municipal sector are almost 100% responsible for exceeded standards.

The figure summarizing the exceeded standards for particulate matter PM10, PM2.5 and benzo(a)pyrene is presented below.

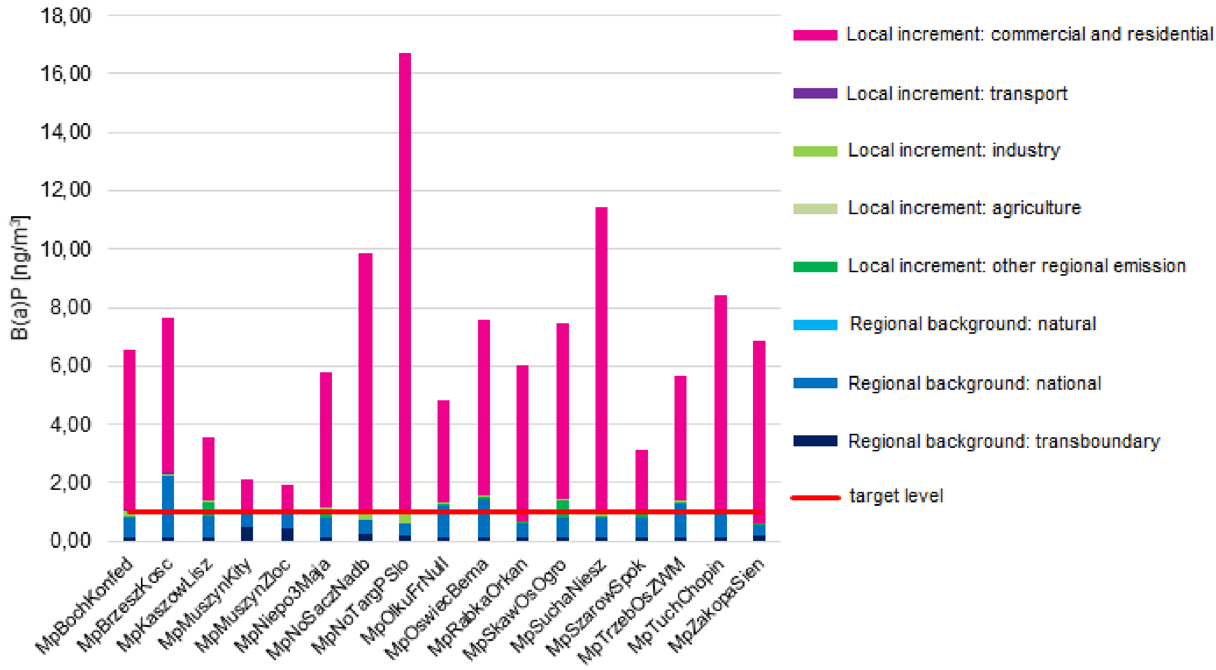


Figure 52. The picture of regional background levels, urban background increment, and local background increment for benzo(a)pyrene at monitoring stations in the Malopolska zone in 2018 [96].

5.2.4. ANALYSIS OF HIGH PM10 CONCENTRATIONS EPISODES

Analysis of the emission sources contributions in terms of exclusively average annual concentrations of substances allows to indicate the main causes of exceeded standards. However, in the case of 24-hour concentrations analysis, especially of PM10, the structure of individual sources contributions may change. Therefore, the emission sources shares in the concentrations was analysed for the two days in which high concentrations of PM10 occurred at the monitoring stations: **January 27** and **November 9, 2018.**

The values of concentrations recorded at monitoring stations these days are presented in the table below. The daily level standard was exceeded for all the 24 selected monitoring stations on January 27 and 18 stations on November 9. PM10 concentration on the first day exceeded 100 µg/m^3 at 16 stations, while on the second day, concentrations above 100 µg/m^3 occurred at 5 stations.

[96] Based on the results of modelling with the CALPUFF model and the Central Emission Inventory for 2018. Detailed model configuration is described in Chapter 17.2, ATMOTERM S.A.

Table 31. The daily concentrations of PM10 on the days of selected cases in 2018.[97]

Station	PM10 concentration on the indicated day 27.03.2018 [µg/m^3]	PM10 concentration on the indicated day 09.11.2018 [µg/m^3]
MpBochKonfed	89,87	100,86
MpGorlKrasin	68,29	41,82
MpKrakAlKras	139,10	141,40
MpKrakDietla	142,70	-
MpKrakBujaka	157,34	100,11
MpKrakBulwar	153,33	87,50
MpKrakOsPias	139,49	79,49
MpKrakTelime	110,62	-
MpKrakWadow	126,83	77,85
MpKrakZloRog	156,54	98,36
MpMuszynZloc	60,49	25,77
MpNiepo3Maja	135,99	76,08
MpNoSaczNadb	121,22	71,38
MpNoTargPSlo	169,67	84,81
MpOswiecBema	154,00	114,44
MpSuchaNiesz	110,49	89,03
MpSzymbaGorl	58,74	45,34
MpTarBitStud	70,53	68,51
MpTarRoSitko	86,50	65,60
MpTrzebOsZWM	142,68	76,07
MpTuchChopin	162,46	74,41
MpZakopaSien	82,88	57,36
MpSkawOsOgro	148,60	100,60

** values over 100 µg/m^3 are coloured red*

The contributions of individual emission sources in the zones of the Malopolska Region are presented in the figure below.

In the case of Krakow on November 9, a significant impact of sources of PM10 concentrations from other counties is visible. It reached 31% for several stations, which means that, taking into account other emissions inflow, more than 50% of the concentrations are emissions' sources from outside the city. In the case of locations in the proximity of the border of voivodeship, the contribution of supra-regional background reaches even 65% (for Zakopane). The contribution of transport sources was increased for traffic monitoring stations in Krakow, however surface sources have the largest share in the PM10 concentration among local sources.

Similar contributions of PM10 emission sources are observed in the second of the analysed days of high concentration episodes – January 27, 2018. On that day, a significant contribution of local, in particular surface sources from the municipal sector, is visible, which accounts for as much as 68% at some stations (monitoring station in Zakopane) or 74% – monitoring station in Nowy Targ.

[97] Air quality measurements 2018, Regional Department of Environmental Monitoring CIEP

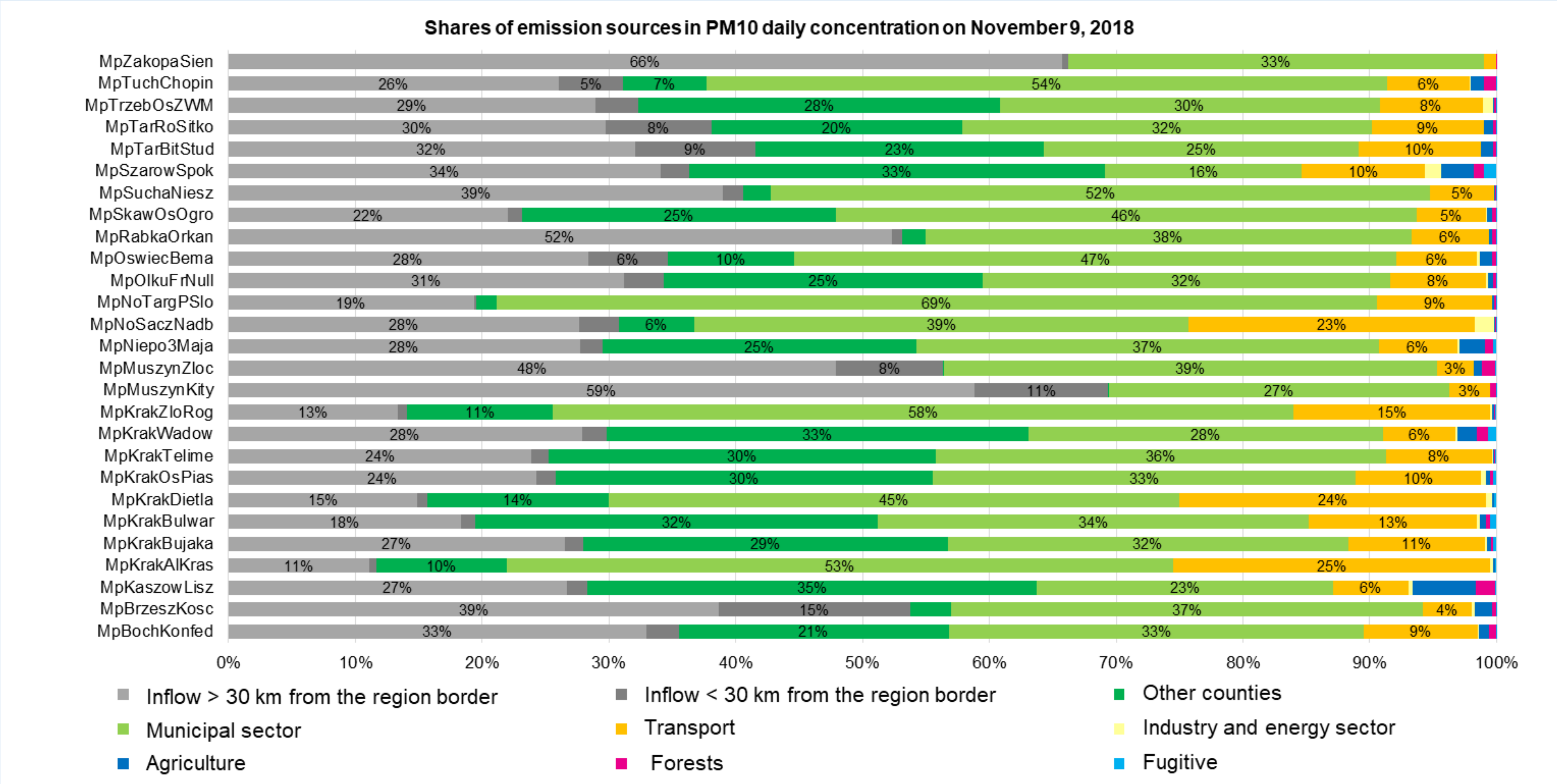


Figure 53. Summary of contributions of individual emission sources in PM10 concentrations at monitoring stations in the Malopolska Region on November 9, 2018. [98]

[98] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

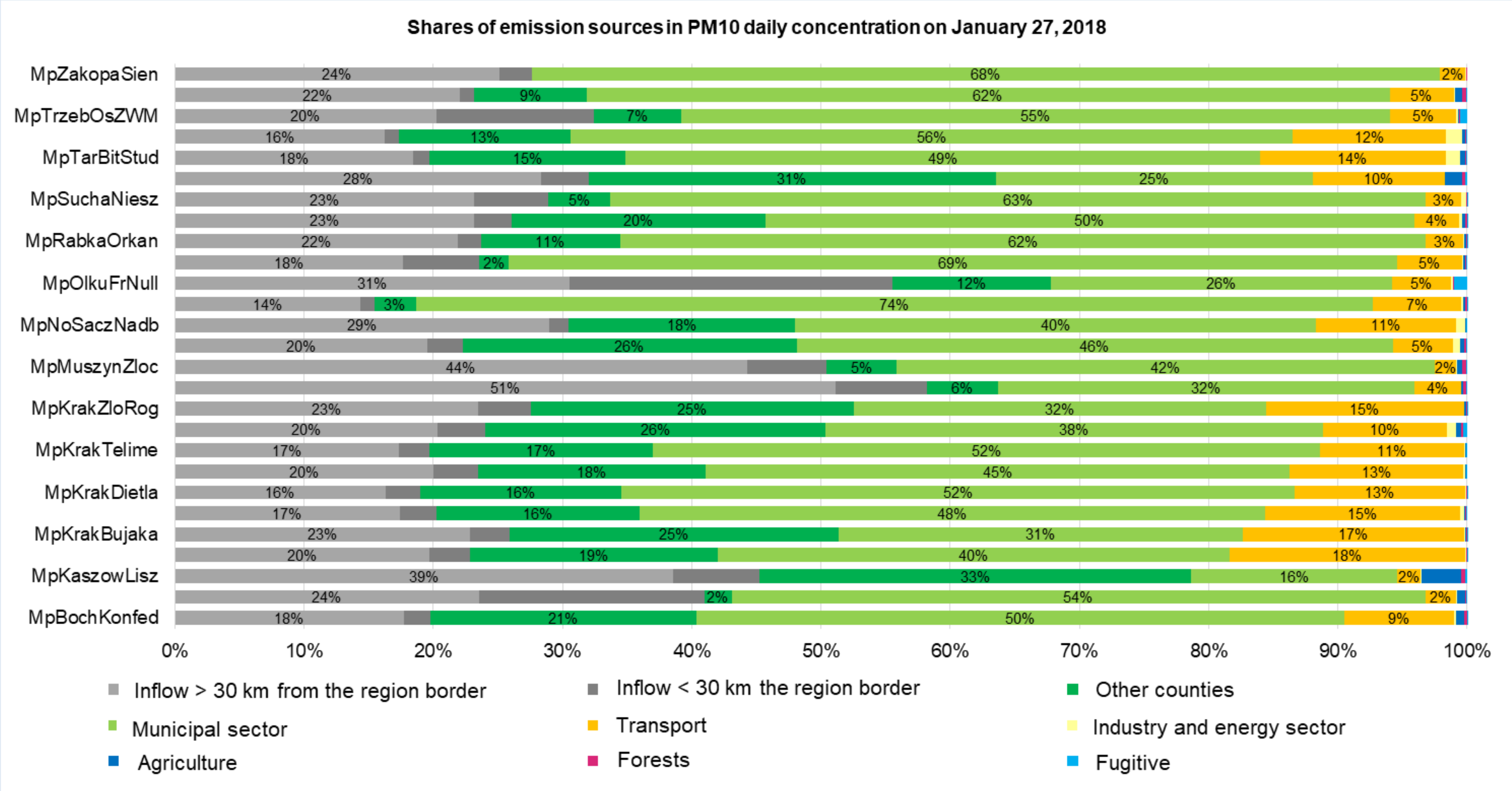


Figure 54. Summary of individual emission sources contributions in PM10 concentrations at monitoring stations in the Malopolska Region on January 27, 2018. [99]

[99] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Transport sources account for a maximum of 18% share in concentrations – at the traffic station Al. Krasinskiego. However, on the analysed day, the contribution of inflow from outside the zone and inflow from other counties reached 65% at the stations in Muszyna and Olkusz. The described contribution oscillated between 35% and 52% for PM10 concentrations in Krakow.

6. EMISSIONS BALANCE SHEET FOR THE YEAR OF FORECAST

6.1. Expected changes in emissions from sources located outside the zone in the forecast year

All voivodeships neighbouring the Malopolska Region are obliged to implement the remedial actions set out in the Air Quality Plans. In addition, remedial action is also coordinated at central level. Pursuant to the assumptions of Air Quality Plans for the zones of the voivodeships bordering the Malopolska Region, as a result of remedial actions, a significant reduction of emissions will occur, mainly from the municipal and household sector. For the air quality in the Malopolska Region, activities in the zones of the Silesian, Podkarpackie and Swietokrzyskie voivodeship are of particular importance. It was assumed that in the coming years the remedial actions indicated for implementation in the Plans will intensify. Based on the estimates, the forecast assumes a 30% reduction in dust emissions from neighbouring voivodeships and a 5% reduction in cross-border dust emissions outside Poland (in Slovakia). Assuming that the neighbouring voivodeship will also strive to reach the target level of benzo(a)pyrene, the reduction of this pollution, mainly from the municipal and household sector, has been estimated at about 60-80%.

Table 32. Comparison of PM10, PM2.5, B(a)P and NO_2 emissions from outside the Malopolska Region in the base year and in the forecast year 2026.

Emission from neighbouring voivodeship and countries	Emissions in the base year 2018 [Mg/year]				Emission volume in the forecast year 2026 [Mg/year]			
	PM10	PM2.5	B(a)P	NO_2	PM10	PM2.5	B(a)P	NO_2
Slaskie voivodeship	24 849,62	21 636,43	9,36	15 211,13	17 394,73	15 145,50	2,808	64 328,95
Podkarpackie voivodeship	5 982,72	4 718,81	2,26	3 587,57	4 187,90	3 303,16	0,677	45 258,88
Swietokrzyskie voivodeship	9 973,08	7 212,69	3,34	5 487,81	6 981,16	5 048,88	1,003	33 908,76
trans-boundary from a 30 km lane	4 600,00	3 600,00	0,20	13 300,00	4 370,00	3 741,67	0,140	8 267,95

The abovementioned changes in pollutant emissions should reduce the level of regional background emissions. The table below presents the average values of the regional background in individual zones of the Malopolska Region in the forecast year, determined on the basis of mathematical modeling.

Table 33. Size of the regional background in the Malopolska Region in the forecast year 2026

Zone code	Zone name	Average values of the regional background in the base year 2018				Average values of the regional background in the forecast year 2026			
		PM10 [μg/m³]	PM2.5 [μg/m³]	B(a)P [ng/m³]	NO_2 [μg/m³]	PM10 [μg/m³]	PM2.5 [μg/m³]	B(a)P [ng/m³]	NO_2 [μg/m³]
PL1201	Krakow Agglomeration	13,32	10,44	0,82	5,10	12,1	9,0	0,34	3,42
PL1202	Tarnow City	13,86	10,86	0,99	-	11,5	8,7	0,35	-
PL1203	Malopolska zone	13,83	10,75	0,94	-	12,3	9,4	0,38	-

6.2. Scenarios for the implementation of actions and changes in the volume of emissions in the forecast year 2023, 2026 and 2030

Remedial action scenarios set out actions that can be taken in the Malopolska Region to achieve air quality that meets the standards of acceptable and target levels of substances, such as PM10, PM2.5, benzo(a)pyrene and nitrogen dioxide. The intended target of the scenarios is to achieve acceptable values for PM10 and PM2.5 as early as 2023 in all voivodeship zones. In respect to nitrogen dioxide and benzo(a)pyrene, it was assumed that the designated activities will allow to reach the permissible and target levels (accordingly) in 2026. Five scenarios for the implementation of actions were analysed, one of which was adopted as the target variant.

At the same time, the goal of one of the variants, defined for 2030, is to achieve the levels of pollution recommended by WHO in the Malopolska Region. This option adopts measures aimed at transforming the region's low carbon emissions by improving air quality and reducing the impact on climate change. This option also includes actions that are to lead to the implementation of EU objectives in the use of renewable energy sources, improvement of energy efficiency and reduction of greenhouse gas emissions.

6.2.1. *Common assumptions for scenarios*

All scenarios indicate the actions that can be taken in the Malopolska Region until 2023 or 2026. Assumptions common to all action scenarios are described below.

Emissions from industry and energetics

Activities in the energetics and industry sectors include changes in the operation of conventional power plants, combined heat and power plants and other installations located in the country, which are projects that may have a significant impact on the environment (within the meaning of the Act of 3 October 2008 *on sharing information on the environment and its protection, public participation in environmental protection and environmental impact assessments*). The concentration values in the exceedance areas presented in chapter 5.2 (Estimated urban and local background increment in the base year 2018 grouped by emission sources) showed that these sources have little impact on the amount of concentrations of the analysed substances. Therefore, for the listed sources located in areas of exceedances, no analysis is necessary in terms of the need to set emission limit values lower than the emission standards resulting from national regulations.

According to the adopted provisions of the EU's energy and climate policy, the national scale should reduce greenhouse gas emissions by 40% by 2030 (in reference to the level from 1990). For sectors not covered by the European Union Emissions Trading System, emissions should be reduced by 30% compared to the level from 2005. Increasing energy efficiency will require the preparation of appropriate infrastructure that will enable the use of energy from renewable sources and its introduction into the power system.

The IED Directive introduced into Polish law in 2016, has tightened the standards for the so-called large combustion plants (heat input in fuel ≥ 50 MW). Amendments to the regulations are aimed at preventing and reducing pollution resulting from industrial activities and ensuring an integrated approach to preventing and controlling emissions of pollutants to air, water and soil, as well as regulating waste management issues, improving energy efficiency and preventing accidents. In the case of the Polish energy sector, which is based on high-emission fuels, it is necessary for production plants to take measures involving large investment outlays for the installation of high-performance exhaust gas treatment systems and the use of low-emission fuels.

For individual industries, requirements for the use of Best Available Techniques (BAT) are gradually introduced. They are announced in the form of legally binding BAT conclusions as decisions of the European Commission, which in turn means the need to include them in integrated permits. The schedule of adjusting industrial sectors to BAT requirements is spread over several years. For the cement and lime, glass, steel, refining and tanning industries, the adjustment deadline was 2018, and for the wood-based products production in 2019. In the analysed period, i.e. in the years 2020-2026, there are deadlines for technological adaptation to BAT requirements for the following industries:

- Non-ferrous metals industry (2020)
- Intensive breeding of poultry and pigs (2021)
- Large combustion plants (2021)
- Large-scale production of organic chemicals (2021)
- Waste processing (2022)
- Waste burning (2023)
- Food industry (2023)

In the context of dust emissions, particular attention should be paid to the group of large combustion plants. BAT requirements for these facilities include stricter dust emission standards compared to the emission standards originally defined in the IED. In addition, in the analysed period, the transitional provisions regarding the Transitional National Plan (until June 30, 2020) and the provisions on the heat derogation set out in ART.35 of the Directive (until the end of 2023) and the natural derogation, as defined in Art. 33 of the IED Directive (until the end of 2023)

Pursuant to Directive 2015/2193 of the European Parliament and of the Council of the EU of November 25, 2015 on the limitation of emissions of certain pollutants into the air from medium sized combustion plants, emission standards for new MCP facilities (with thermal input of not less than 1 MW and less than 50 MW) have been in force since 2018. Stricter standards will be introduced for existing facilities with a capacity of over 5 MW from 2025. In the case of dusts, the reduction required, compared to the current Regulation of the Minister of Environment, will be set at between 50 and 75%.

According to the register posted on the website of The National Centre for Emissions Management KOBIZE, 45 medium combustion plant (MCP) are located in the Malopolska Region: 11 in the Krakow Agglomeration and 34 in the Malopolska zone. Most of these facilities (35) were launched before December 20, 2018. Among them 15 are coal-fired plants. These plants will have to meet the emission standard out in Directive (EU) 2015/2193 of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from medium combustion plants (MCP), whereby:

- From January 1, 2025, it will apply to MCP sources with a capacity of 5-50 MW; 6 fired with hard coal and 7 fired with other fuels (in Annex II, part 1, tables 2 and 3 of the MCP Directive),
- From January 1, 2030, it will apply to MCP sources with a capacity of 1-5 MW: 9 coal-fired and 13 other-fuel-fired (in Annex II, part 1, tables 1 and 3 of the MCP Directive).

Due to the adopted forecasts of legal changes in industry, the reduction of emissions from the industry sector in the forecast year 2026 was estimated at 10% for particulate matter and nitrogen oxides and 5% for benzo(a)pyrene relative to the base year 2018. In the area of industry, it is possible to achieve of this level by 2026 due to technological progress, EU requirements in the scope of emissions trading, legal regulations and the need to adapt to new requirements. It is not necessary to introduce additional measures to reduce emissions from the activities of enterprises, aside from the measures whose implementation results from existing regulations.

Emissions from agriculture

The Common Agricultural Policy (CAP) introduced in the European Union countries assumes existence of changes in the volume of emissions of substances from the agricultural sector resulting from actions for environmental protection. The activities are focused on both direct emission reduction (support for farm modernization – modernization of buildings in terms of increasing energy efficiency) and supporting activities, such as the offers of training for farms, the offers of consultancy services and the promotion of biogas production. The trend of changes in agriculture is the result of improvements in agricultural technology, a systematic decrease in the numbers of cattle, reform solutions and legislation on environmental protection. Taking into account these conditions, changes occurring in agriculture, as well as its development, it was assumed that emission reduction in this area will not be necessary and the volume of emissions will remain at the current level.

Emission from transport

The basic document indicating the directions of actions in transport at the national level is the *Transport Development Strategy until 2020 with a perspective to 2030 and the Strategy for Sustainable Transport Development until 2030* adopted on September 24, 2019.

As shown by analyzes of the share of emission source groups in concentrations, linear emission has a significant share in nitrogen oxide pollution. According to the scientific expertise of prof. Zdzislaw Chlopek[100] it is forecasted that nitrogen oxide emission rates for passenger cars in 2015-2025 will decrease by approx. 23%. A reduction of around 28% can be expected for vans (light duty vehicles), and over 50% for trucks (heavy duty trucks) and buses. This is due to the increasingly high demands placed on car manufacturers regarding the EURO emissions standards. The decrease in exhaust emissions in the vehicles produced will be partially balanced by the constantly growing number of vehicles used.

In Poland, numerous actions are taken to expand the road network and improve the technical condition and safety of public roads. Traffic flow and road capacity are important for all road users and affect their economic calculation. The ownership structure of the vehicles is not the only thing that is changing – so is the philosophy of their use and the approach to mobility.

In addition, other transport development activities will be undertaken in the Malopolska Region independently, such as:

- development of the agglomeration railway in line with the long-term plans of the Marshal Office of the Malopolska Region,
- development of connections between major cities (Krakow, Tarnow, Nowy Sacz) and neighbouring municipalities, and increasing the frequency of these connections, shifting some of the car traffic to public transport

When determining the impact of each of the actions included in the emission scenarios on air quality, assumptions were made to forecast the volume of emissions in 2023 and 2026, assuming corrective measures indicated were used.

[100]Scientific expertise entitled "*Development of a calculation program for determining the road emission of carbon monoxide, hydrocarbons, non-methane volatile organic compounds, nitrogen oxides, solid particles, sulphur oxides and benzene for cumulated categories of vehicles: passenger cars, light trucks (delivery vans) as well as trucks and buses for years balancing: 2014, 2015, 2020, 2025, 2030, 2035 and 2040* "; prof. Zdzislaw Chlopek, 2016

6.2.2. Scenario 0 (baseline scenario)

The baseline scenario determines what changes in emissions can be expected if no additional action is taken, except for the actions necessary to comply with existing legislation. The emissions were analysed for 2023 as the forecast year. The purpose of the analysis is to indicate whether these measures will result in achieving air quality standards or whether additional corrective measures are necessary.

Emission of municipal and household sector

- Continued increase in the rate of boiler replacement in Malopolska Region at the current level – an increase in the rate by approx. 30-50% per year.
- Liquidation of all remaining boilers in Krakow

Emission from transport

It is assumed that the current activities will be continued, i.e. no additional restrictions for transport will be introduced. According to CSO (the Central Statistics Office) analyzes, there is an about 71-82 thousand increase in the numbers of passenger vehicles annually in the Malopolska Region, of which, on average, 60% are brand new vehicles. Whereas, 75% of the 7.5 thousand trucks registered annually in the Voivodeship are brand new vehicles. Every year, the share of new vehicles (up to 3 years old) in the structure of all vehicles in the Malopolska Region increases. In 2015, the percentage of brand new vehicles was 5.7%, in 2016 - 6.2%, in 2017 this number increased to 6.8%, and in 2018 to 7.3%. This means a steady increase in new vehicles that meet the highest emission standards, i.e. EURO 6.

The emissions of nitrogen oxides for petrol fuelled vehicles meeting the EURO 3 standard (i.e. 20-year old vehicles) are 2.5 times higher than for vehicles meeting the EURO 6 standard (i.e. 5-year old vehicles). For diesel fuelled vehicles, nitrogen oxide emissions are six times lower for cars that meet the EURO 6 standard (5 years old) than for those that meet the EURO 3 standard (20 years old). Even in the case of fourteen-year-old vehicles, nitrogen oxide emissions are three times higher than those of five-year-old and younger vehicles.

Due to the trends of changes in transport indicated, it was assumed that the emissions of nitrogen oxides will decrease by approximately 20% by 2026, which was adopted as the forecast year.

6.2.3. Scenario 1

Emission of municipal and household sector

A significant acceleration of the boiler replacement rate in the Region was assumed (up to 10 times) – the assumption was that in 2023 only 25% of the current number of non-class boilers in the Malopolska Region will remain to be replaced. The assumed share of boilers remaining for replacement is due to the situation in Krakow, where, after the anti-smog resolution entered into force, about 4,000 out of 24,000 boilers remained to be replaced (17%).

Emission from transport

It is assumed to create low emission zones in the centre of Krakow and Tarnow in accordance with the Act on electromobility and alternative fuels[101] (only for electric, hydrogen and natural gas powered vehicles). Clean transport zone areas should include:

- the Paid Parking Zone in Krakow (subzone A1, A2, A3, A4, excluding streets constituting the boundaries of this area),
- Paid Parking Zone in Tarnow

[101] Journal of Laws of 2020, item 908

6.2.4. *SCENARIO 2*

Emission from the municipal and household sector

The scenario assumes full implementation of anti-smog resolutions for the Malopolska Region, which means replacing all non-class boilers with low-emission heating systems. Only part of the 3rd and 4th class boilers will be left in place, remaining to be replaced by 2026.

Emission from transport

As part of the scenario, an introduction of a low emission zone based on EURO emission standards in the Krakow area is assumed, covering the area bounded by the III internal city ring road. The restriction should cover all vehicles – passenger cars, light trucks (delivery vans) and trucks as well as including the residents of Krakow. Entry into the zone would only be allowed for diesel vehicles that meet at least the EURO 6 emission standard requirements and petrol vehicles that meet at least the EURO 4 emission standard requirements. National regulations are necessary to implement the measure.

6.2.5. *SCENARIO 3*

Emission from the municipal and household sector

The scenario assumes full implementation of anti-smog resolutions for Malopolska Region, which means replacing all non-class boilers with low-emission heating systems. After 2022, only a part of the 3rd and 4th class boilers will be left in place, which should be replaced by 2026. Additionally, to limit the creation of new heating sources with the highest PM emissions, it is assumed that the following investments will not be financed from public funds:

- coal boilers – from January 1, 2021,
- biomass boilers with an PM emission factor over 20 mg/m^3 – from January 1, 2023.

Emission from transport

It is assumed to introduce a low emission zone based on EURO emission standards in the area of Krakow, selected on the basis of the "Variant expert opinion on the introduction of the limited communication emission zone (LEZ – Low Emission Zone) in Krakow" commissioned by the City of Krakow.

The low emission zone in the area of Krakow would cover the area bounded by the 4th ring road limited by national roads: A4, S52 and S7, which is practically the entire area of the city. The entry restriction would apply to light trucks (vans), trucks and public transport vehicles. Entry to the zone would only be possible for diesel vehicles that meet at least the **EURO 6** emission standard requirements and petrol vehicles that meet at least the **EURO 4** emission standard requirements. The implementation of the actions must be preceded by the necessary changes in national regulations about the possibility of the zone functioning.

6.2.6. *SCENARIO 4*

Emission from the municipal and household sector

The scenario assumes full implementation of anti-smog resolutions for Malopolska Region, which means replacing all non-class boilers with low-emission heating systems. After 2022, only a part of the 3rd and 4th class boilers will be left in place, which should be replaced by 2026.

In addition, the following assumptions were made:

- Introduction of a ban on the use of coal in newly installed boilers from 2021, which would require a change in the anti-smog resolution for Malopolska Region. Deadlines for replacing non-class boilers until the end of 2022 and 3-4 classes until the end of 2026. This means that residents replacing non-class boilers and 3rd and 4th class boilers from 1 January 2021 would not be able to replace them with a coal boiler.
- Introduction of restrictions for newly installed biomass boilers through raising PM emission standards – emissions for biomass will not be able to exceed 20 mg/m^3. The boilers will have to be equipped with a buffer tank of appropriate capacity.
- Installing new fireplaces and space heaters from 2021 will be allowed only if they are devices with a closed combustion chamber, and the value of PM emissions does not exceed 20 mg/m^3, and if they are equipped with an electrostatic precipitator or automation that allows the user to control air supply.
- Introduction of a total ban on the use of solid fuels (coal and biomass) in the area of zones A and B of all health resorts – for newly installed sources from 2021, for existing ones after the transitional period from 2027.
- Preferences for financing renewable energy sources while reducing funding for gas installations.

Emission from transport

It is assumed to introduce a low emission zone based on EURO emission standards in the Krakow area. The zone would cover the area bounded by the 4th city ring road. The restrictions would impact all vehicle types entering the city – passenger, light trucks (vans) and trucks, as well as public transport. Entry to the zone would only be possible for diesel vehicles that meet at least the requirements of the **EURO 6** emission standard and petrol vehicles that meet at least the requirements of the **EURO 4** emission standard. The implementation of the actions must be preceded by the necessary changes in national regulations which govern the creation of low emission zones.

6.2.7. *Scenario 5 for 2030*

Emission from the municipal and household sector

In scenario 5, the goal is to achieve climate neutrality in the Malopolska Region by 2050 and WHO standards for air pollution levels by 2030.

Actions set to achieve the goal:

- Introduction of a ban on the use of coal for newly installed boilers and fireplaces from 2021 and increase of biomass emission standards – 20 mg/m^3 (PM emissions). This means that residents replacing non-class boilers as well as 3rd and 4th class boilers will not be able to replace them with a coal-fired boiler from January 1, 2021. This is to stop the emergence of new emission sources.
- Increasing emission standards for newly installed biomass boilers and fireplaces to 10 mg/m^3 (PM emissions),
- a ban on the use of natural gas and heating oil in new buildings from 2030. Only sources understood as RES are allowed to be created. Completely ceasing the use of fossil fuels (gas, oil) in existing buildings by 2050.

Emission from transport

The scenario assumes transport using only electric and hydrogen vehicles.

SUMMARY OF THE SCENARIOS

As part of the scenarios, various corrective measures were analysed that could be implemented under the Plan to achieve better air quality. Given the organizational, social and technical possibilities of implementing the measures and the results of the initial public consultation of the proposed scenarios, option 3 was selected as the target option. In the case of transport sector, option 4 was selected for the year 2026. The analyses conducted within the Plan indicate that the target version of the low emission zone – in line with scenario 4 – should lead to achieving the permissible level of nitrogen dioxide. Nevertheless, it is underlined in the Plan that the final decision regarding the area of the zone and its restrictions should be preceded by a detailed analysis within the framework of an implementation plan. The achievement of the nitrogen dioxide permissible level is pointed out as one of the main assumptions that should be made in the detailed analysis. In addition a pilot version of a low emission zone is introduced within the corrective measures. The need to implement solutions in stages is a result of current social and financial conditions. Furthermore, legal instruments at national level are necessary to implement effective solutions to reduce linear emissions.

The activities were planned for implementation in two periods:

- **by 2023** all activities aimed at reducing PM10 and PM2.5 emissions will be implemented to a level ensuring that PM10 and PM2.5 permissible levels will be reached in said year,
- **by 2026** all measures will be implemented that will contribute to reducing NO_2 and benzo(a)pyrene emissions to levels ensuring that the permissible level for NO_2 and the target level for benzo(a)pyrene are reached in said year.

6.3. Balance of emissions in the forecast year in individual zones

Analyzes carried out as part of the Plan preparation indicated the need to reduce emissions from the municipal and household sector in the zones of the Malopolska Region, as well as emissions from transport, especially in the Krakow Agglomeration zone. The required amounts of reductions were determined on the basis of mathematical modelling of the spread of pollutants. The basic parameter deciding on the amount of reduction required was the need to comply with the permissible level of PM10, PM2.5 and nitrogen dioxide as well as the target level of benzo(a)pyrene. The comparison of emissions from the municipal and housing sector and the transport sector in the base year and forecast year in individual zones is presented below.

Emissions for PM10 and PM2.5 assume a further reduction until 2026, despite the fact that, according to variants, 2023 was adopted as the year when the permissible level will be reached. After 2023, emissions will be further reduced by eliminating class 3 and 4 boilers, which should be replaced by the end of 2026. Dust and benzo(a)pyrene emissions will be reduced simultaneously. Further reduction is also associated with the necessary achievement of the benzo(a)pyrene target level in 2026.

The base variant indicates the emission amounts for 2023, for which it was assumed that the permissible PM10 and PM2.5 levels would be reached. Due to the inability to reach the nitrogen dioxide permissible value and the benzo(a)pyrene target value during this period, option 3 assumes 2026 as the forecast year. The selected scenario 3 of activities in the following balance sheet includes the reduction of PM10 and PM2.5 dust by 2023 to achieve the permissible levels, as well as a further reduction until 2026 due to the need to achieve the permissible level for nitrogen dioxide and the target level for benzo(a)pyrene.

Table 34. Comparison of municipal and household sector emissions in the zones of the Malopolska Region in the base year and the forecast year for the base scenario of activities.

Administrative unit	Emission of air pollutants in 2018				Emission of air pollutants in the forecast year 2023			
	PM10	PM2.5	NO_2	B(a)P	PM10	PM2.5	NO_2	B(a)P
	[Mg/year]				[Mg/year]			
Krakow Agglomeration	574,89	564,92	286,22	0,272	83,19	51,09	186,93	0,0320
Tarnow city	444,52	437,29	135,97	0,23	292,10	280,18	109,63	0,1210
Malopolska zone	24 265,35	23 890,66	7 090,46	13,283	20 766,81	20 659,60	6 766,66	8,1030
Malopolska Region	25 284,76	24 892,87	7 512,65	13,785	21 142,10	20 990,87	7 063,22	8,2560

Table 35. Comparison of municipal and household sector emissions in the zones of the Malopolska Region in the base year and the forecast year for the selected scenario of activities, meaning scenario 3.

Administrative unit	Emission of air pollutants in 2018				Emission of air pollutants in the forecast year 2026			
	PM10	PM2.5	NO_2	B(a)P	PM10	PM2.5	NO_2	B(a)P
	[Mg/year]				[Mg/year]			
Krakow Agglomeration	574,89	564,92	286,22	0,272	83,19	51,09	186,93	0,0320
Tarnow city	444,52	437,29	135,97	0,23	208,87	170,32	107,47	0,1210
Malopolska zone	24 265,35	23 890,66	7 090,46	13,283	14 589,29	13 562,13	7 161,25	8,1030
Malopolska Region	25 284,76	24 892,87	7 512,65	13,785	14 881,35	13 783,54	7 455,65	8,2560

Table 36. Comparison of emissions from transport within the zones of the Malopolska Region in the base year and the forecast year.

Administrative unit	Emission of air pollutants in 2018				Emission of air pollutants in the forecast year 2026			
	PM10	PM2.5	NO_2	B(a)P	PM10	PM2.5	NO_2	B(a)P
	[Mg/year]				[Mg/year]			
Krakow Agglomeration	131,23	102,87	1 971,21	0,002	115,93	91,67	966,21	0,002
Tarnow city	21,59	16,80	322,30	0,000	21,59	16,81	322,30	0,000
Malopolska zone	1 438,74	1 117,92	21 209,66	0,021	1 438,75	1 117,92	21 209,67	0,021
Malopolska Region	1 591,56	1 237,59	23 503,17	0,023	1 576,27	1 226,40	22 498,18	0,023

7. ANTICIPATED LEVELS OF SUBSTANCES IN AMBIENT AIR FOR THE FORECAST YEAR

Based on the emission value determined for the forecast year, defined in the baseline and reduction scenarios (**Chapter 6.3**), modelling of the pollutants dispersion for the forecast years 2023 and 2026 was performed to determine the concentration levels in the air in the given year. This subsection discusses the impact of assumed emission reduction on the concentration levels to be expected in the baseline scenario. The forecast was conducted for the area of all zones of the Malopolska Region, for which the results of air quality modelling for the base year 2018 showed exceeding permissible concentrations of PM10, PM2.5 and nitrogen dioxide, as well as the target level of benzo(a)pyrene in the air.

7.1. Predicted levels of substances in the air after implementation of measures indicated by the current law

The level of substances in the forecast year if the actions indicated by law are implemented corresponds to the results of the analysis for scenario 0 indicated in chapter 6.2.2.

The baseline scenario prepared for the year 2023, taking into account the analysis of the concentrations of the substances, is insufficient to achieve the permissible level of PM10 and PM2.5, as well as nitrogen dioxide and the target level of benzo(a)pyrene. The reduction of emissions through the implementation of the measures provided in this scenario is too low. In addition, the significant impact of the regional background should be taken into account, which, in 2023, will not include the total reduction resulting from actions implemented nationwide under the Air Quality Plans. Corrective measures implemented in neighbouring regions have been anticipated until 2026, therefore in the analysed period (until 2023) there will be no significant reduction in the level of regional background, in particular of benzo(a)pyrene.

The table below presents the distribution of concentrations of substances under the Plan in the baseline scenario – assuming no additional actions are taken beyond those required by law, as well as results of the modelling for monitoring stations.

Table 37. Results of average annual concentrations of substances at monitoring stations in the forecast year 2023 after the implementation of the baseline scenario.[102]

Monitoring stations	PM10	PM2.5	NO_2	Benzo(a)pyrene
Krakow Agglomeration				
MpKrakAlKras	35,0	33,5	55,5	5,64
MpKrakBujaka	26,5	27,6	39,0	5,06
MpKrakBulwar	27,0	26,8	34,5	4,82
MpKrakDietla	27,4	29,5	41,8	5,21
MpKrakOsPias	23,4	22,4	29,4	4,05
MpKrakWadow	23,5	21,8	22,9	4,34
MpKrakZloRog	28,4	29,8	46,3	5,47
Tarnow city				
MpTarBitStud	27,5	21,9	37,1	3,68
MpTarRoSitko	28,7	24,8	34,2	4,47

[102] Based on the results of modelling with the CALPUFF model

Monitoring stations	PM10	PM2.5	NO_2	Benzo(a)pyrene
Malopolska zone				
MpBochKonfed	29,4	25,6	19,1	6,59
MpMuszynKity	18,7	16,5	7,4	2,13
MpKaszowLisz	24,1	19,2	22,2	3,57
MpMuszynZloc	17,8	15,3	6,8	1,96
MpNiepo3Maja	26,2	23,7	20,4	5,77
MpNoSaczNadb	38,4	29,9	30,4	9,89
MpNoTargPSlo	41,5	36,4	21,1	16,73
MpOlkuFrNull	26,4	24,0	17,5	4,81
MpOswiecBema	37,0	29,4	22,8	7,58
MpSkawOsOgro	32,9	30,5	25,9	7,44
MpSuchaNiesz	38,6	30,9	11,7	11,41
MpSzarowSpok	23,8	18,0	22,4	3,13
MpTrzebOsZWM	28,6	24,8	20,4	5,66
MpTuchChopin	33,3	30,0	16,9	8,40
MpZakopaSien	28,2	25,1	14,9	6,88

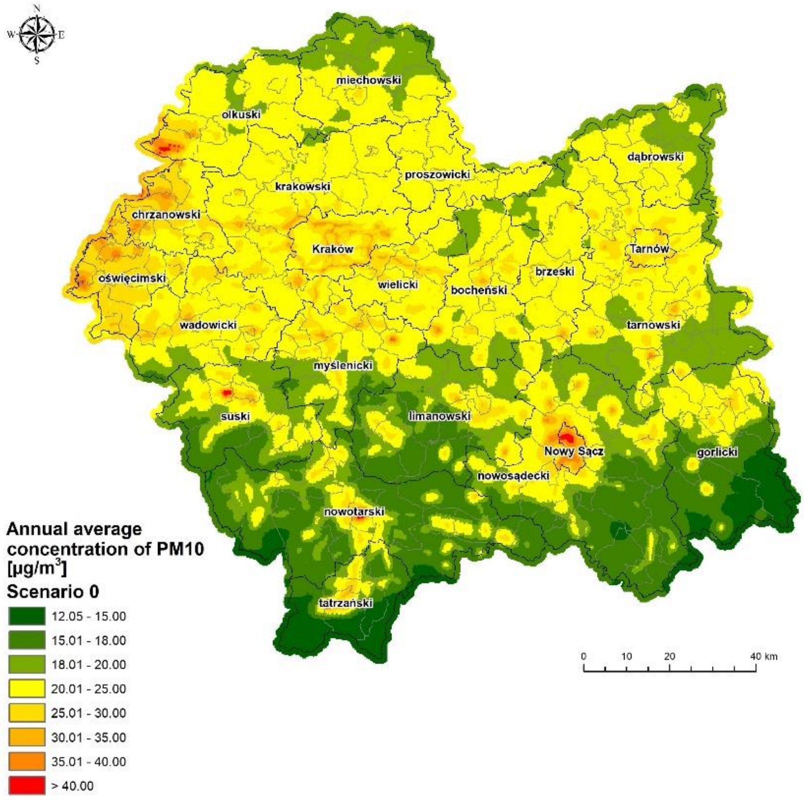


Figure 55. Distribution of annual average PM10 concentrations in the region in the forecast year 2023 in the baseline scenario [103].

[103] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

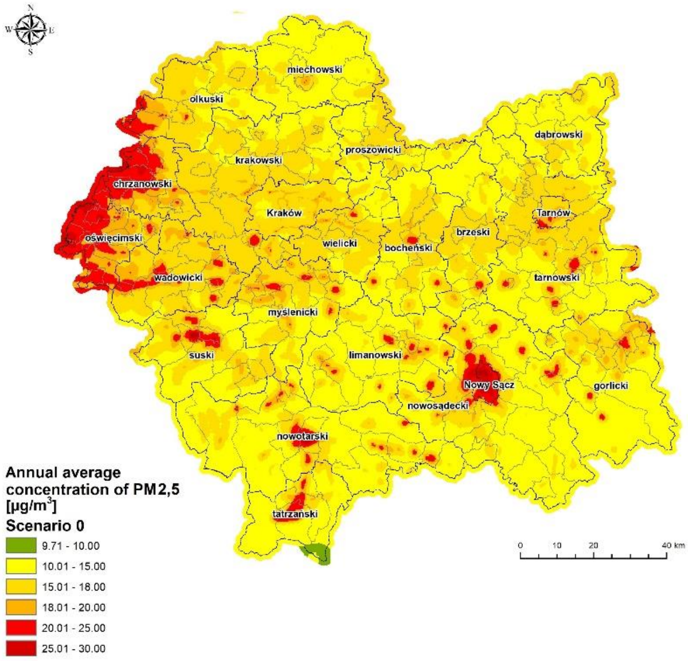


Figure 56. Distribution of annual average PM2.5 concentrations in the region in the forecast year 2023 in the baseline scenario. [104]

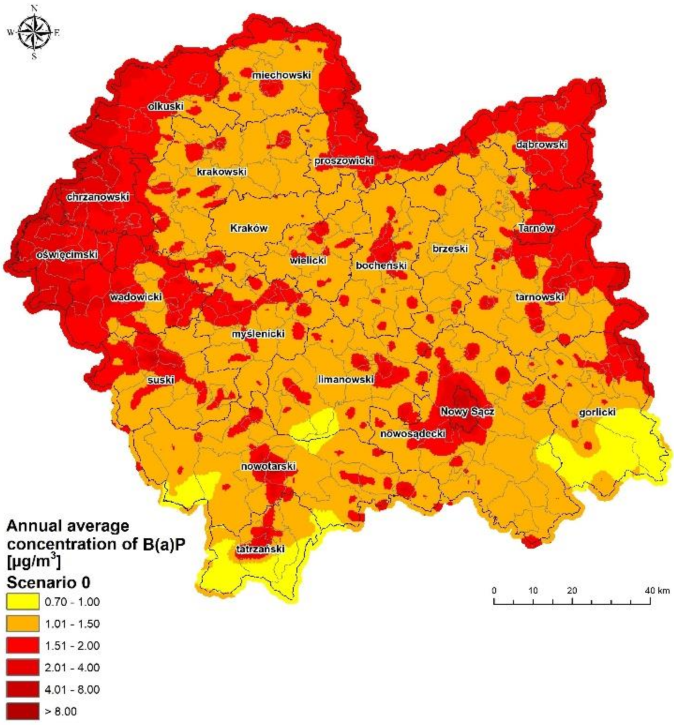


Figure 57. Distribution of average annual concentrations of benzo(a)pyrene in the region in the forecast year 2023 in the baseline scenario. [105]

[104] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

[105] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

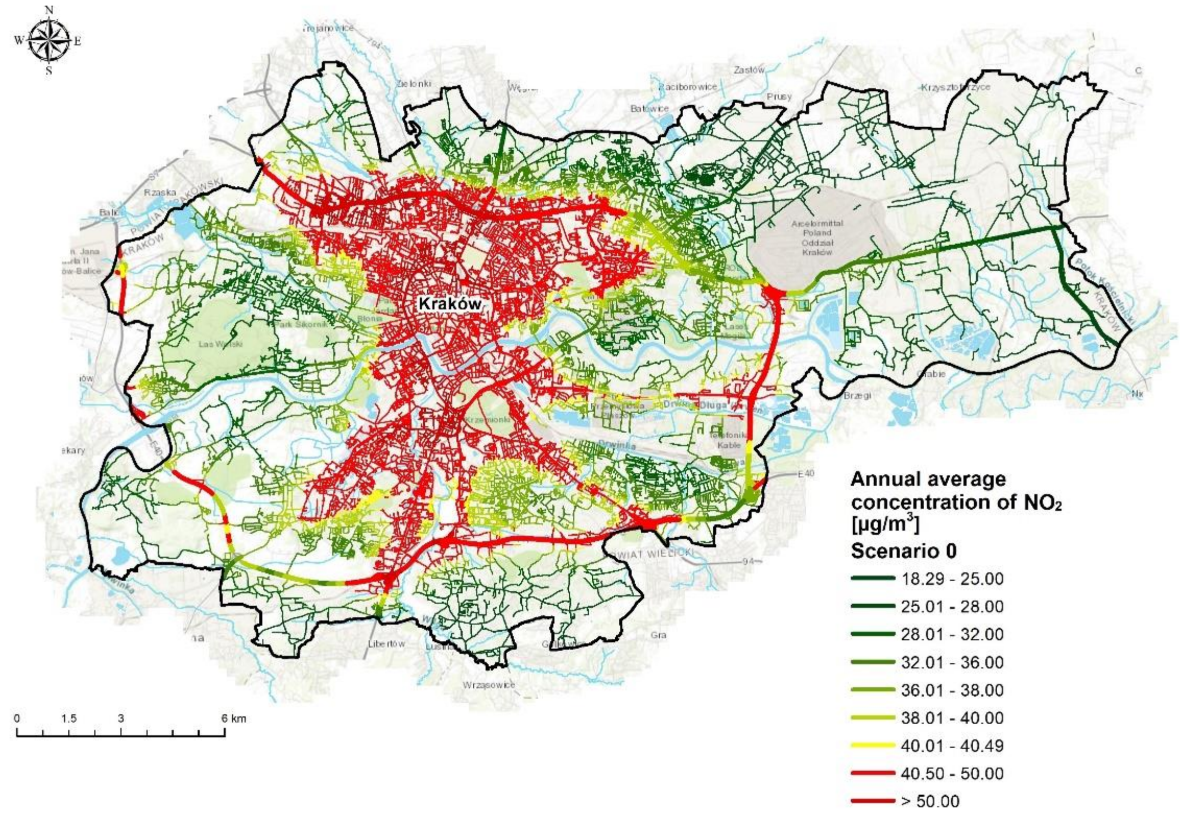


Figure 58. Distribution of average annual concentrations of nitrogen dioxide in the Krakow Agglomeration in the year 2023 in the baseline scenario. [106]

7.2. Anticipated levels of the substances in ambient air after implementation of actions indicated in the Plan

Based on the results of activities of the 3rd scenario, discussed in chapter 6.2.5., air quality analyzes were conducted, based on modelling of pollutant dispersion in the forecast years 2023 and 2026. Two forecast years were adopted for different pollutants due to conditions independent of measures taken on a regional scale.

The goal of the Plan is to achieve permissible and target levels of substances in the air. The analysis indicates that by 2023 the implementation of activities will bring the expected results for PM10 and PM2.5. Implementing the measures up to 2023 only, it is not possible to achieve the permissible level defined in relation to nitrogen dioxide and the target level for benzo(a)pyrene. This is influenced by:

- legal possibilities of implementing actions in the assumed time perspective,
- the need to reduce emissions in neighbouring regions, which will result in lowering of the regional background,
- social and financial limitations affecting the current structure of the vehicles fleet used for transport in the region,
- economic, social and technical limitations on the possibilities to introduce the most effective measures to significantly reduce emissions in the municipal and housing sector, including the inability to provide an alternative to coal heating in rural and health resort areas.

[106] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

Due to the above reasons, 2026 was indicated as the forecast year (year of achieving the required air quality standards) for nitrogen dioxide and benzo(a)pyrene. It coincides with the assumed forecasts of the Air Quality Plans in neighbouring regions, as well as measures conducted nationwide.

The table below presents the concentrations of substances covered by the Plan after implementation of scenario 3, both at the monitoring stations and throughout the region.

Table 38. Average annual concentrations of substances and the number of days with exceeded daily level for PM10 at monitoring stations in the forecast years 2023 and 2026 after the implementation of selected scenarios 3 for municipal sector and 4 for transport.[107]

Monitoring stations	Forecast year 2023			Forecast year 2026	
	PM10	PM10 - number of days with the exceedances of 50 µg/m^3	PM2.5	NO_2	Benzo(a)pyrene
Krakow Agglomeration					
MpKrakAlKras	32,3	35	16,9	35,5	0,68
MpKrakBujaka	24,0	27	14,1	35,5	0,65
MpKrakBulwar	24,7	21	14,9	32,5	0,69
MpKrakDietla	25,0	25	14,5	37,7	0,66
MpKrakOsPias	21,0	15	13,1	27,2	0,71
MpKrakWadow	20,9	11	13,1	22,0	0,72
MpKrakZloRog	25,9	28	14,7	32,0	0,69
Tarnow CIty					
MpTarBitStud	22,1	11	13,8	36,3	0,95
MpTarRoSitko	21,3	10	13,5	33,3	1,04
Malopolska zone					
MpBochKonfed	19,7	8	12,3	19,2	0,94
MpKaszowLisz	19,7	7	12,1	21,7	0,71
MpMuszynKity	14,3	1	10,9	7,5	0,82
MpMuszynZloc	14,2	1	10,7	7,0	0,79
MpNiepo3Maja	18,2	6	12,1	20,2	0,79
MpNoSaczNadb	22,3	13	13,6	31,5	1,20
MpNoTargPSlo	19,8	20	12,5	21,8	1,46
MpOlkuFrNull	20,1	14	13,8	17,4	0,96
MpOswiecBema	21,9	20	15,1	22,8	1,26
MpSkawOsOgro	20,1	13	13,0	25,4	0,82
MpSuchaNiesz	17,1	8	12,4	12,1	1,23
MpSzarowSpok	19,7	6	12,2	22,3	0,73
MpTrzebOsZWM	20,6	16	14,1	20,5	1,05
MpTuchChopin	19,7	11	12,9	17,1	1,02
MpZakopaSien	13,1	6	10,1	15,4	0,75

[107] Based on the results of modelling with the CALPUFF model

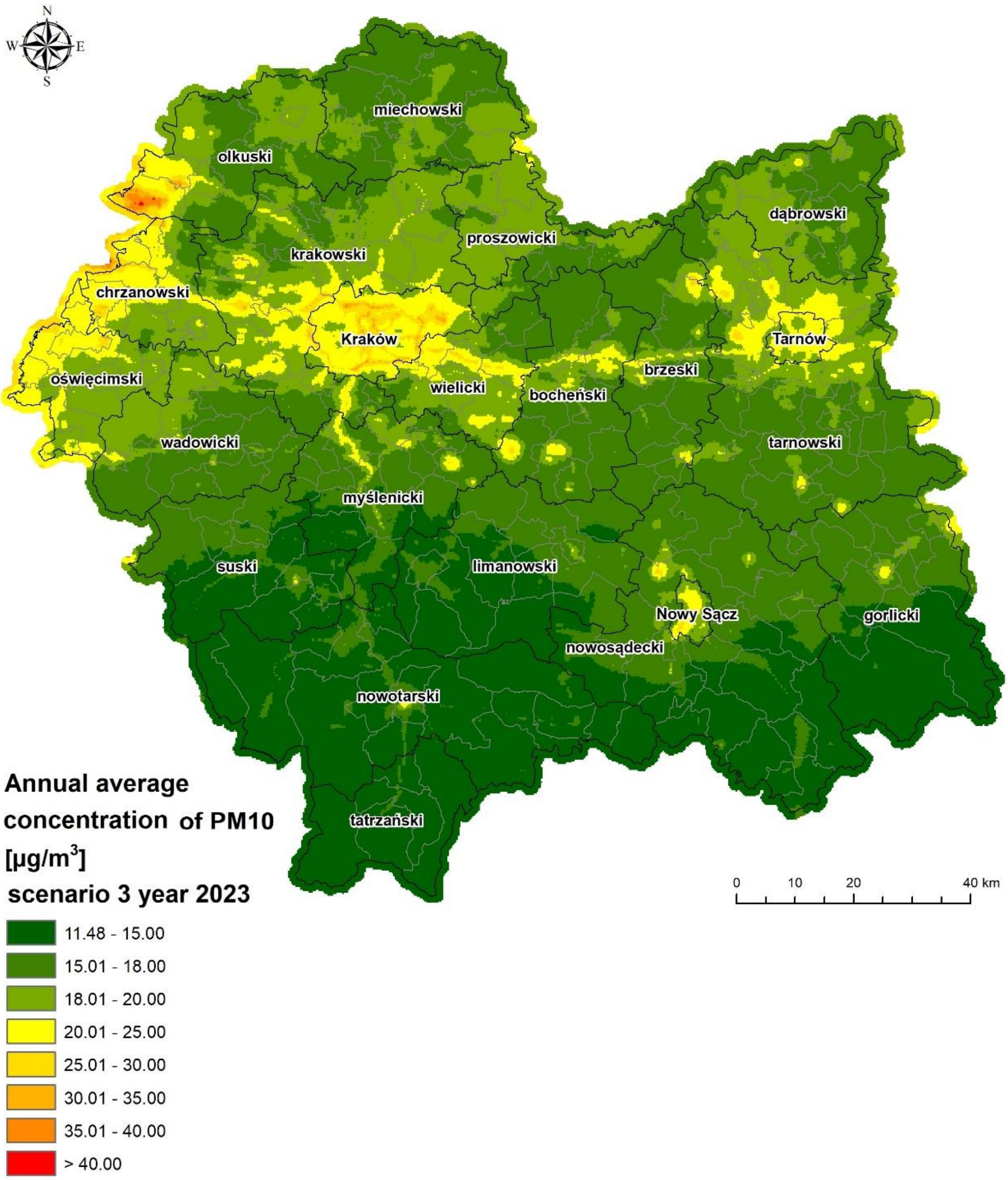


Figure 59. Distribution of average annual concentrations of PM10 in the region in the forecast year 2023 under scenario 3 [108].

[108] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

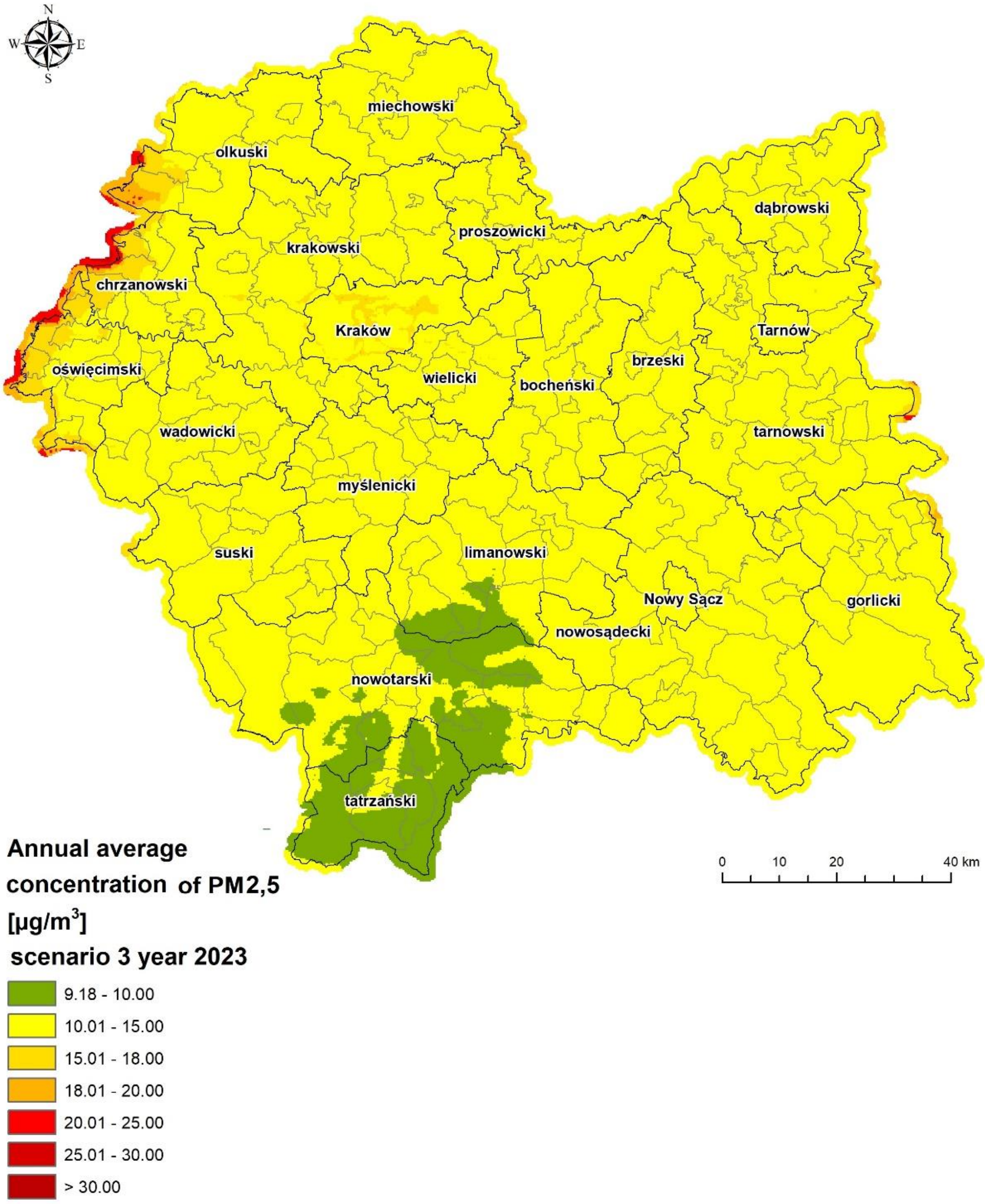


Figure 60. Distribution of average annual PM2.5 concentrations in the region in the forecast year 2023 under scenario 3. [109]

[109] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

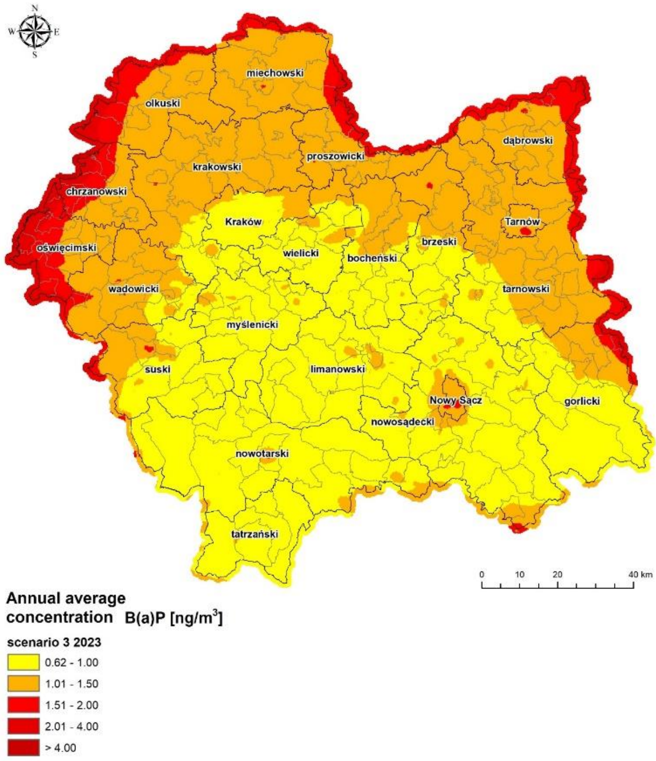


Figure 61. Distribution of average annual concentrations of benzo(a)pyrene in the region in the forecast year 2023 under scenario 3. [110]

Figure 62. Distribution of average annual concentrations of benzo(a)pyrene in the region in the forecast year 2026 under scenario 3. [111]

[110] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

[111] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

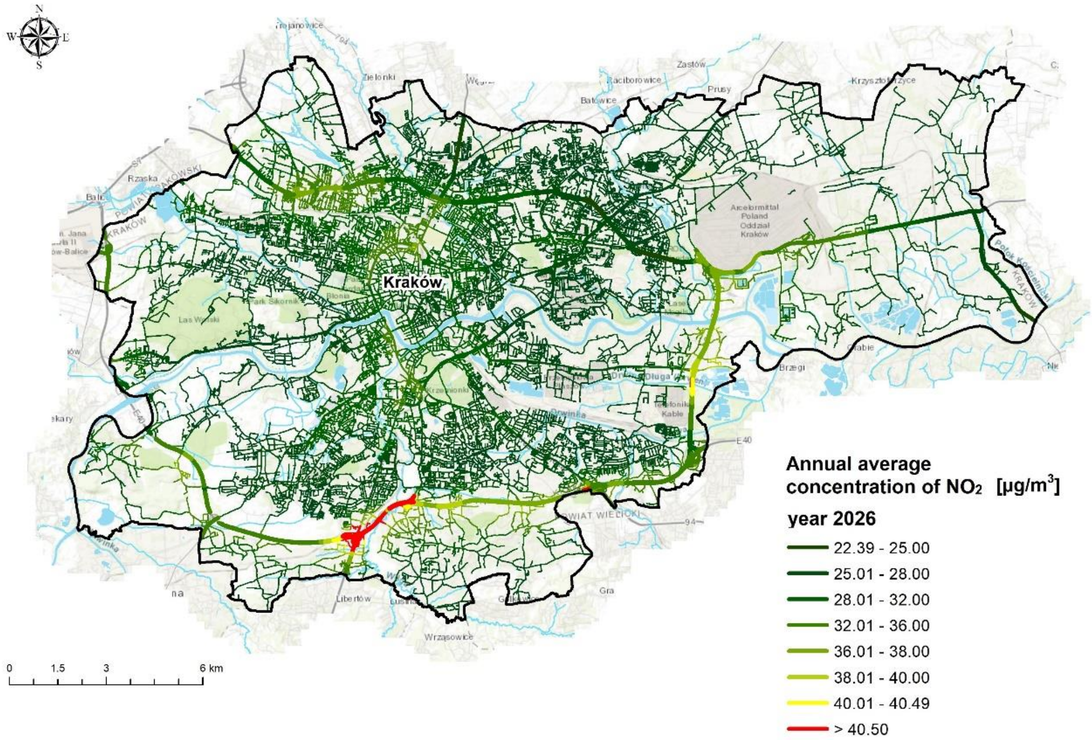


Figure 63. Distribution of average annual concentrations of nitrogen dioxide in the Krakow Agglomeration in the forecast year 2026 under scenario 4. [112]

[112] Source: Own work based on CALPUFF modelling results which are based on the emission inventory for the projected year. The detailed configuration of the model is described in Chapter 17.2, Atmoterm S.A.

8. ACTIONS INDICATED FOR IMPLEMENTATION TO MEET AIR QUALITY STANDARDS IN THE ZONES

This chapter presents actions that may result in reducing the levels of analysed substances in the air to levels not exceeding the permissible or target levels of substances.

8.1. Basic directions of activities

The main goal of the Air Quality Plan for the zones of the Malopolska Region is to improve the air quality and comply with applicable standards in order to reduce the adverse impact of pollution on the health and quality of life of the population. Therefore, the planned activities are aimed at achieving the maximum ecological effect by reducing the emission of pollutants from those sources which to the greatest degree contribute to the concentrations of substances in the air.

To achieve the Plan objective, it is necessary to implement the tasks indicated in the implementation schedule and adopt general directions of actions that indirectly positively affect the air quality.

The Plan indicates the following directions of Clean Air Actions:

1. Low-stack emission reduction and improvement of energy efficiency
2. Reduction of emissions from the transport sector
3. Reducing emissions from business activities

Under each of the above Clean Air Action, tasks and responsibilities were set out to be implemented by various entities.

8.2. List and description of Clean Air Actions planned for implementation

8.2.1. *LONG-TERM ACTIONS*

ACTION 1. LOW-STACK EMISSION REDUCTION AND IMPROVEMENT OF ENERGY EFFICIENCY

Action code: **PL12_ONE**

The main goal of the action is the full implementation of the requirements of anti-smog resolutions for the Malopolska Region and Krakow, as well as improving the energy efficiency of buildings and increasing the use of renewable energy sources.

Tasks to be implemented

Tasks of all public institutions

1) When public funding is provided for solid fuel heating installations up to 1 MW, the public authorities shall provide:

- financing from **1 January 2021** only for biomass installations [113]
- financing from **1 January 2023** only for biomass installations with particulate matter emission factor up to 20 mg/m³ (at 10% of O_2),
- the use of buffer tanks as mandatory for boilers with manual fuel feeding (gasification boilers) and recommended for boilers with automatic fuel feeding. The minimum capacity of the buffer tanks should be in accordance with the technical documentation of the boiler.

[113] Excluding ongoing projects

In addition, preferences in the form of higher funding for heat pumps, photovoltaic panels, solar collectors, heating installations connected to geothermal heating plants and biomass boilers with particulate matter emission factor up to 20 mg/m³ (at 10% O_2) should be ensured.

2) The municipality, county and the region are obliged to ensure that **from 1 January 2023** at least 50% and **from 1 January 2025** 100% of electricity consumed during the year by its public buildings will come from renewable sources[114]. The goal can be achieved by:

- investment in own installation generating electricity from renewable energy sources,
- purchase of energy certified with a guarantee of electricity origin from renewable sources or conclusion of a direct PPA (Power Purchase Agreement) with an energy producer with RES,
- participation in an energy cluster or an energy cooperative that produces electricity from RES,
- leasing of installations or purchase of energy from cooperatives or enterprises investing in RES on municipal facilities,
- purchase or lease of a virtually operated RES installation.

Tasks of heads of the municipalities, mayors, city presidents, and municipal councils

1) Establishment of the Clean Air Program information point based on the agreement with the Regional Fund for Environmental Protection and Water Management in Krakow until **1 January 2021** and its further maintenance.

2) Employment **until 30 September 2021** and maintenance of the position of an Eco-manager. In municipalities with a population of up to 20 thousand inhabitants **at least 1 Eco-manager** should be employed, in municipalities with a population of over 20 thousand inhabitants – **at least 2 Eco-managers**, in municipalities with a population of over 50 thousand inhabitants – **at least 3 Eco-managers**, in the case of the municipalities with a population of over 500 thousand inhabitants – **at least 6 Eco-managers**.

The support for employment costs of Eco-managers from the ROP funds for 2021-2027 is envisaged.

The tasks of the Eco-managers will, among others, include:

- advisory for residents in the field of RES technologies, heating sources, co-financing programmes and requirements of the anti-smog resolution,
- environmental education at the local level in the field of air protection,
- the Clean Air Program management, initiating and management of investments under the Stop Smog Program.

3) Conducting, in municipalities covered by the anti-smog resolution for Malopolska[115], an information campaign on the requirements of the resolution and the available forms of co-financing for heating source replacement. **From 2021**, the municipality is required to provide information at least once in each half year to each address point where the solid fuel installation is operated (applies to residential and non-residential buildings).

[114] The requirement refers to the total electricity consumption of all public buildings owned by a municipality, county, the region

[115] Resolution No. XXXII/452/17 of the Regional Assembly of the Malopolska Region of 23 January 2017 on the implementation of restrictions and bans which relate to operation of fuel combustion installations on the territory of the Malopolska Region (so called anti-smog resolution for the Malopolska Region)

4) By 31 October 2020 the following information should be published on the official website of the municipality (prominently displayed on the main page):

- current air quality and the degree of air pollution danger (if introduced),
- link to the Eco-intervention application (possibility of reporting violation of environmental protection provisions),
- link to information about the Clean Air Program.

5) Conducting an inventory of heat sources and installations of renewable energy sources in residential, non-residential and public buildings in the municipality:

- at least 70% of buildings **by the end of 2021**,
- at least 90% of buildings **by 30 June 2022.**

The data should be entered in the electronic Inventory Database for Heating Sources of Buildings in Malopolska.

After launching Central Building Emission Register[116], cooperation with chimney sweepers and county buildings inspectorates should be undertaken in order to make a full inventory of the solid fuel sources.

It is necessary to provide an ongoing update of the inventory database on the basis of data provided by building owners and managers as well as obtained as part of the controls carried out.

6) Conducting intervention inspections in the field of compliance with air protection regulations[117] by the municipal or inter-municipal guards, authorized municipal employees or in cooperation with the police.

a) Intervention inspections (reactions to notifications of infringements) should be carried out within 12 hours from the notification.

b) In the case of notifications made by the Eco-intervention application administered by the Marshal's Office, information on the actions taken and the results of the inspection should be updated within 3 working days from the inspection.

c) In case of at least 10% of conducted intervention inspections per year, an ash sample should be collected and ordered to be tested[118].

d) Intervention inspections should be combined with updating data in the database of heating sources.

7) Conducting planned inspections in the field of compliance with air protection regulations by the municipal or inter-municipal guards, authorized municipal employees or in cooperation with the police.

a) Planned inspections in 2020 should cover:

- 20 buildings in municipalities with up to 10,000 inhabitants,
- 40 buildings in municipalities with a population between 10,000 and 20,000,
- 80 buildings in municipalities with a population between 20,000 and 50,000,
- 200 buildings in municipalities with more than 50,000 inhabitants.

[116] Central Building Emission Register gathering uniform and coherent data across the country regarding emission sources in the municipal and household sector

[117] In the field of the thermal treatment of wastes and the implementation of the so-called “anti-smog resolutions”

[118] It is not applicable to intervention inspections which are conducted by the municipality of Krakow

b) Planned inspections in 2021 and 2022 should annually cover:

- 60 buildings in municipalities with up to 10,000 inhabitants,
- 100 buildings in municipalities with a population between 10,000 and 20,000,
- 200 buildings in municipalities with a population between 20,000 and 50,000,
- 500 buildings in municipalities with more than 50,000 inhabitants.

c) Planned inspections from 2023 should annually cover:

- 120 buildings in municipalities with up to 10,000 inhabitants,
- 200 buildings in municipalities with a population between 10,000 and 20,000,
- 400 buildings in municipalities with a population between 20,000 and more and 50,000,
- 1,000 buildings in municipalities with a population of over 50,000

d) In view of the anti-smog resolution applicable in the municipality of Krakow[119], planned inspections there should each year cover all buildings in which individual solid fuel heating sources are still in operation.

e) Planned controls should be combined with updating data in the database of heating sources.

f) **By 30 September 2021** municipalities should prepare an internal procedure for conducting inspections of heating sources in terms of compliance with the anti-smog resolution and the ban on waste incineration[120]. The procedure should be prepared in accordance with the guidelines provided by the Marshal’s Office of the Malopolska Region.

8) Preparation of an analysis of the problem of energy poverty in the municipality **by 30 June 2022**, in accordance with the guidelines prepared by the Marshal's Office:

- Preparation of a database of people who meet the requirements of the Stop Smog Program.[121]
- Identification of investment needs in the scope of replacement of heat sources and thermo-modernization in buildings where the abovementioned persons live.

9) Support for residents affected by energy poverty:

- It is recommended to launch a shielding programme in the form of subsidies for higher heating costs.
- It is recommended to implement the Stop Smog Program by the municipality through subsidising boiler replacement and thermo-modernization.

10) As part of the update of the study on conditions and directions of spatial management of the municipality, the municipality should identify and designate areas that, for technical and legal reasons, may be designated for facilities generating energy from renewable energy sources with a capacity exceeding 100 kW. The case of lack of such areas should also be indicated in the study.

[119] Resolution No. XXXII/243/16 of the Regional Assembly of the Malopolska Region of 15 January 2016 on the implementation of restrictions which relate to operation of fuel combustion installations on the territory of the City of Krakow (so called anti-smog resolution for Krakow)

[120] By the time an internal procedure for conducting inspections of heating sources is prepared, it is recommended to conduct inspections in accordance with “*The guidelines for conducting inspections of residential furnaces*” prepared by Institute for Chemical Processing of Coal and Frank Bold Foundation

[121] According to Article 11d paragraph 1, points 1-4 of the Act on supporting thermomodernization and renovation (Journal of Laws of 2020, item 412) or further changes in the program’s criteria

11) It is recommended that **from 2021**, within the municipality's budget, at least 1% of own revenues is allocated to activities related to air protection, among others including:

- employment of Eco-managers, establishment and service of the Clean Air Program information points,
- implementation of subsidy programs supporting the Clean Air Program and shielding programs for people affected by energy poverty,
- inspections regarding violations of air protection regulations,
- educational and information activities regarding air protection,
- inventory of building heating sources in the municipality,
- thermomodernization of public buildings or installation of renewable energy sources.

12) The municipalities covered by the anti-smog resolution for Malopolska[122], through activities carried out by them, should lead to the situation when the number of installed heating devices that do not meet the requirements of the anti-smog resolution:

- **from 1 January 2023** will not exceed 15% of all heating devices installed in the municipality,
- **from 1 January 2027** will not exceed 3% of all heating devices installed in the municipality.

The abovementioned does not exempt entities subject to the anti-smog resolution[122] from compliance with its provisions, i.e. from a full adjustment to its requirements within the prescribed deadlines. It also does not release inspection bodies from the obligation to enforce the requirements of the anti-smog resolution.

Tasks of county governors

1) Hiring **until 31 June 2021 at the latest** and maintaining a position of at least one Climate Eco-manager. The responsibilities of the Climate Eco-manager include:

- coordination of municipalities' activities in the field of RES use and energy-efficient construction,
- cooperation with municipalities and the Marshal's Office,
- exchange of experience and good practices of municipalities in the county area,
- initiating joint activities, projects and educational actions in municipalities,
- consulting services for municipal Eco-managers on the use of RES and energy-efficient construction,
- technical support for municipalities in implementing climate neutrality for schools and public buildings.

Support from the LIFE Programme is envisaged.

2) **By 31 October 2020** the following information should be published on the county official website (prominently displayed on the home page):

- current air quality and the degree of air pollution danger (if introduced),
- link to the Eco-intervention application (possibility of reporting violation of environmental protection provisions),
- link to information about the Clean Air Program.

[122] Resolution No. XXXII/452/17 of the Regional Assembly of the Malopolska Region of 23 January 2017 on the implementation of restrictions and bans which relate to operation of fuel combustion installations on the territory of the Malopolska Region (so called anti-smog resolution for the Malopolska Region)

3) Conducting an information campaign on the requirements of anti-smog resolutions as part of issuing building permits and accepting building notifications.

4) It is recommended to allocate **from 2021** within the county budget at least 0.5% of own revenues for activities related to air protection, including, among others:

- employment of Climate Eco-managers,
- support for municipalities in the implementation of tasks in the field of air protection,
- inspections regarding infringements of air protection regulations by entrepreneurs,
- educational activities regarding air and climate protection, renewable energy promotion, promotion of sustainable transport,
- thermomodernization of public buildings and installation of renewable energy sources.

Tasks of County Buildings Inspectors

1) Cooperation with heads of the municipalities, mayors and city presidents on inventorying heat sources and renewable energy installations in municipalities.

Tasks of the Management Board of the Malopolska Region and the Regional Assembly of the Malopolska Region

1) Ensuring co-financing of investments in the field of air protection from the Regional Operational Programme for 2021-2027:

- Co-financing of employment of Eco-managers in municipalities.
- Co-financing of equipment for inter-municipal guards carrying out inspections in the field of compliance with environmental protection regulations,
- Investment financing preferences for the most ambitious municipalities, i.e. those achieving the highest AQP implementation rates,
- Investment financing preferences for municipalities subject to additional restrictions in the field of operation of solid fuel devices (local anti-smog resolutions).

2) Preparation and adoption of resolutions introducing, at the municipalities' request, restrictions on the operation of installations in which fuel is burned (based on the Article 96 of the Environmental Protection Law – so called anti-smog resolutions).

- Developing **by 31 March 2021** unified rules for implementing the regulations in order to maintain a consistent approach at the regional level.
- In case of covering installations operating in a municipality by the requirements of environmental protection based on the Article 154 of the Environmental Protection Law (i.e. emission requirements ensuring achievement of limit and target values of pollutants in the air), the municipality is allowed to apply for an exemption for the abovementioned installations from the provisions of the anti-smog resolution.

3) Support for the implementation of tasks of other units and bodies in the field of air protection:

- Administration of the Eco-Intervention application for reporting violations of environmental law.
- Administration of the Inventory Database for Heating Sources of Buildings in Malopolska. Export of the database to the Central Building Emission Register at the moment of its launch.
- Providing guidelines for preparation of a database of people affected by energy poverty in a municipality **by 31 June 2021**.

- Organization of at least 6 trainings a year for employees of municipalities and counties on topics related to, among others air and climate protection, renewable energy sources and co-financing programs for the replacement of high-emission heating sources.
- Developing substantive and graphic educational materials related to the subject of air and climate protection and making their graphic designs available to all local government units and other interested entities.

4) Coordination and monitoring of the implementation of the Air Quality Plan and anti-smog resolution, including:

- Preparation and publication **by 31 May** of each year of a report on the state of implementation of the Air Quality Plan and implementation of the anti-smog resolution in the Malopolska Region for the preceding year.
- Performing **by 31 December 2021** an analysis of technological possibilities of adapting agricultural activity, smokehouse and traditional bread baking to the requirements of the anti-smog resolution.
- Preparation **by 31 December 2021** a guide book on financing the adaptation of agricultural activity to the air and climate protection priorities within the financial resources of the EU 2021-2027 financial perspective.
- Ordering by **31 December 2021** dust composition tests in order to identify its origins. The analysis should include the heating season and the period outside the heating season.
- Conducting at least once a year an educational and information campaign on a regional scale on topics related to air and climate protection.
- Preparation of a renewable energy sources potential map for the area of the Malopolska Region **by 31 December 2023**.
- Ordering and coordinating **by 30 June 2022** technical and economic analysis regarding the possibility of introducing a total ban on burning solid fuels in the health resorts of the Malopolska Region with preference for the use of renewable energy sources, district heating and gas network.
- Preparation of guidelines for the procedure of inspecting furnaces in terms of compliance with the anti-smog resolution and the ban on waste incineration **by 31 March 2021**.

5) Cooperation with the National Fund for Environmental Protection and Water Management and the Regional Fund for Environmental Protection and Water Management in Krakow:

- organization of information meetings and trainings for employees of municipalities and counties regarding current and future financial programs, in particular the Clean Air Program,
- creating and sharing information materials regarding the conditions of co-financing programs to be used at service points of the Clean Air Program,
- cooperation in obtaining support from the ELENA Program to support the implementation of the Clean Air Program in municipalities.

6) Coordination of the energy transformation process and the use of the funds of the Just Transition Fund (JTF):

- preparation of a territorial just transition plan,
- cooperation in developing projects that will be implemented under JTF.

7) Carrying out activities aimed at supporting and accelerating legal changes at the national level, which will make it possible to cover agricultural activities, smokehouses and traditional baking of bread with the obligation of notification (as part of the procedure of reporting installations introducing gases or dust into the air, from which emission does not require an emission permit) in order to exclude them from the requirements of the anti-smog resolution.

8) It is recommended to allocate **from 2021** within the region's budget at least 0.5% of own revenues for activities related to air and climate protection, including, among others:

- information and education activities in the field of air protection and climate protection,
- substantive support for municipalities and counties in the scope of implementation of tasks resulting from the Air Quality Plan,
- implementation of actions designated in the Air Quality Plan.

9) Conducting, throughout the whole period of implementation of the air quality plan, a wide-ranging social campaign to raise awareness of people of the obligations arising from the anti-smog resolution for Malopolska and to encourage them to the replacement of heat sources that do not meet the requirements of this resolution.

Tasks of entities using the environment and natural persons who are not entities using the environment

1) Managers and owners of buildings are obliged to submit and make available information on heating devices and RES installations to the head of the municipality, mayor, city president for the purpose of the inventory of heating devices and RES installations in the municipality. The obligation includes:

- providing information on existing heating devices and RES installations together with the data required in the inventory related to those devices and installations,
- providing information on the replacement or installation of new heating devices and RES installations together with the data required as part of the inventory of these devices and installations.

After the entry into force of the national regulations related to the Central Building Emission Register, the abovementioned obligations will be regulated by those regulations.

ACTION 2. REDUCTION OF EMISSIONS FROM THE TRANSPORT SECTOR

Action code: **PL12_OET**

The main objective of the action is to reduce the number of high-pollution vehicles and to eliminate vehicles that do not comply with emission regulations. For Krakow, it is particularly important to limit vehicle traffic in the city centre using restricted traffic zones – Low Emission Zones.

Actions that should be taken into account in strategies and plans at the municipality, county and regional level:

a) organisation of urban traffic should aim to reduce the number of vehicles in city centres and ensure the traffic flow,

b) creation and enforcement of calm traffic zones with a speed limit of 30 km/h,

c) expansion of public transport, in particular the connections between urban municipalities and the neighbouring municipalities located around,

d) creation of regular bus connections mainly in places where there is no (or no regular) bus communication,

e) implementation of energy-efficient and low-carbon solutions in public transport, including purchase of low-carbon and zero-carbon fleet,

f) development of connections within the Rapid Agglomeration Railway (the SKA), and cross connections to SKA railway lines – bus lines providing connection to SKA railway stations,

g) maintaining roads, pavements, bicycle paths and other paved passageways in a way that limits the secondary emission of pollutants through regular washing, repairs and improvement of the condition of road surfaces,

h) development of bicycle communication (including cargo bikes) through continuous modernization and extension of bicycle infrastructure,

i) creation of pedestrian-friendly green zones,

j) construction of Park&Ride and Bike&Ride car parks located near railway stations (including those of the Rapid Agglomeration Railway – SKA), bus and tram loops with lower P&R/B&R parking fees for those using periodic public transport tickets,

k) promotion of sustainable forms of transport (cycling and walking, public transport, car/bike sharing, scooters, car pooling)

l) implementation and development of city bicycle systems, including cargo bikes and special bikes for people with disabilities, both for short-term and long-term rental based on a subscription fee system; providing the necessary infrastructure for their functioning,

m) taking measures to develop a network of generally accessible charging stations,

n) restricting car traffic in city centres in favour of walking and cycling, including the creation of car-free zones,

o) no new parking spaces are created in the paid parking zone as they result in increased traffic in the city centre; development of paid parking zones in terms of their range and price level, and possible restrictions on the maximum parking time as a tool supporting the aim of limiting vehicle traffic in the city centre,

p) prioritizing pedestrian needs in public spaces,

q) inclusion in public procurement for the purchase of a fleet of vehicles commissioned by public institutions, bicycles, including cargo bikes,

r) ensuring the traffic flow and efficiency of public transport vehicles through appropriate measures, including creation of bus lanes,

s) creating integrated passenger hubs (interchange points) with appropriate infrastructure,

t) providing a user-friendly and affordable public transport as an alternative to the introduced restrictions on individual vehicles.

Apart from the recommended courses of action, mandatory tasks related to the transport sector have also been set.

Tasks to be implemented

Tasks of all public institutions

1) As part of green public procurement, the following requirements should be included in procurement criteria **from 1 January 2022**:

a) obligation for vehicles carrying out special regular transport and occasional transport services to comply with specified emission standards – the operator providing transport services must perform it with vehicles with a minimum standard EURO 4 for vehicles with petrol engines and EURO 6 for vehicles with Diesel engines,

b) As part of works contracts:

- obligation for non-road mobile machinery (i.e. construction machinery – excavators, loaders, bulldozers, etc.) **with a power exceeding 18 kW**[123] to meet the requirements of being equipped with a particulate filter,
- obligation to wet clean (by the contractor of the ordered order) streets and terrain around the construction site that are contaminated as a result of construction,
- sprinkling loose material dumps in the rainless period,
- use of stands for removing soil or mud from heavy equipment wheels leaving the construction site,
- use of wet concrete cutting elements,
- use of covers when transporting dusty materials.

Tasks of presidents and city councils of cities on the rights of a county

1) Developing and adopting by **30 June 2022** a Sustainable Urban Mobility Plan according to European Commission guidelines. The plan may be adopted as part of other plans and programmes (e.g. Low Carbon Economy Plan).

Additional tasks of presidents and city councils of cities with a population of over 500 thousand inhabitants

1) Preparation of a detailed plan for the implementation of a low emission zone based on the EURO emission standards and implementation of the zone in a pilot version **within 1 year of the entry into force of the national legislation** enabling its implementation.

a) The implementation plan should specify the vehicle types and EURO emission standards to be restricted and the area of the zone. For the pilot version it is recommended to apply restrictions to light duty vehicles, heavy duty vehicles, public transport vehicles and passenger cars whose emission standards are lower than:

  - EURO 4 for petrol and EURO 5 for Diesel vehicles (passenger cars and light duty vehicles),
  - EURO5/V (for heavy duty vehicles and public transport vehicles)

  and implementation of the pilot zone in the area limited at least by the II ring road of the city of Krakow[124].

[123] According to the Regulation of the Minister of Economy of 30 April 2014 *on the detailed requirements for internal combustion engines to reduce the emission of gaseous and particulate emissions for these engines* (Journal of Laws from 2014, item 588 and its further changes)

[124] The II ring road includes: M. Konopnicka Street with a tunnel under Grunwaldzkie Roundabout, Debnicki Bridge, Al. Krasinskiego, Al. A. Mickiewicza, Al. J. Slowackiego, viaduct over Warszawska Street and over the railway line (1977), A. 29 Listopada (road section), W. Stwosza Street (2004), A. Lubomirskiego street, Mogilskie Roundabout, Al. Powstania Warszawskiego, Grzegorzeckie roundabout, Kotlarska Street, Kotlarski Bridge (2001), Herlinga-Grudzinskiego street (2002),

b) The plan should include details of restrictions, the zone area, exemptions during the transition period and groups covered by it (e.g. residents living in the area of the zone, companies operating within the zone area), location of signs, control plan, proposals for alternative routes and exclusions used in the zone (e.g. historic vehicles, vehicles owned by people with disabilities, LPG-powered vehicles, single-tracked vehicles).

2) The implementation of the zone in the target version **by 31 December 2025 or after the completion of construction of the IV ring road[125] of the city of Krakow**.

a) The implementation plan of the target version of the zone should define types of vehicles and EURO emissions standards to be restricted and the area of the zone ensuring that the limit levels of nitrogen dioxide are achieved.

b) It is recommended to:

- create the zone on the area limited by the IV ring road of the city of Krakow,
- introduce the restrictions for Diesel vehicles meeting the EURO emission standard lower than EURO 6 and petrol vehicles meeting the EURO emission standard lower than EURO 4 (for passenger cars and light duty vehicles) and meeting the EURO emission standard lower than EURO 6/VI (for busses and heavy duty vehicles)
- impose the restrictions on residents of the zone in the future.

3) Preparation and implementation by the City of Krakow **by 31 December 2025** of a traffic emission monitoring system, allowing for ongoing monitoring of the impact of road traffic on air quality, including:

- a system for automatic measurement of the traffic volume and structure of vehicle traffic and the sectional speed of vehicles (by the use of a camera system recognising vehicle license plates),
- using traffic volume and structure modelling for all road sections in the city and conducting forecasting calculations,
- information on actual vehicle emissions by vehicle type and Euro category on the basis of remote emissions testing of vehicles updated annually,
- information on the number of passengers on particular traffic routes, determining changes in transport-related behaviour,
- linking individual traffic measurement points with information on concentrations of PM10, PM2.5 and NO_2.

4) Preparation (**by 31 December 2021**) of the Tempo-30 zones implementation plan for the area of Krakow. Zones should be designated on selected road sections inside the III ring road[126] of the city of Krakow.

The introduction of Tempo-30 zones according to the prepared implementation plan should take place in stages **by 31 December 2025**.

The Tempo-30 zones implementation plan should also specify the principles of control and enforcement of the restrictions introduced.

Klimeckiego street, voivodship road no. 776:, al. Powstancow Wielkopolskich, Obroncow Lwowa overpass over Wielicka Street (only one direction; 2003), Al. Powstancow Slaskich, H. Kamienskiego Street (road section), Matecznego roundabout

[125] The IV ring road includes: national road no 94, S7 and S52 express road S52, A4 motorway

[126] The III ring road includes: national road no 79, S7 and S52 express road

Tasks of county governors

1) Carrying out inspections of each vehicle diagnostic station **at least once a year**, and in the event of irregularities in the field of emission tests being detected at the station, carrying out a re-inspection.

2) Carrying out **annually**, in cooperation with the Police and Road Transport Inspection, **at least 10 verification actions** of vehicles leaving diagnostic stations.

Tasks of the Management Board of the Malopolska Region and the Regional Assembly of the Malopolska Region

1) Conducting activities aimed at supporting and accelerating legal changes at the national level, which will enable the implementation of low emission zones in cities based on EURO standards defined for pollutant emissions from vehicles.

ACTION 3. REDUCTION OF EMISSIONS FROM ECONOMIC ACTIVITIES

Activity code: **PL12_OEP**

The aim of the action is to reduce the negative impact of industry and economic activity on the environment, including the impact on air quality. The action is also aimed at increasing the residents' awareness of the impact of economic entities on air quality.

Tasks to be implemented

Tasks recommended for the Malopolska Regional Inspector of Environmental Protection

1) Carrying out regular planned controls and intervention controls on compliance with the legislation and permit records at the plants. Planned inspections in the field of air protection should cover at least 100 entities per year.

2) Conducting intervention controls of economic entities as a response to notifications of infringements of environmental protection regulations (including reactions to notifications under the Eco-intervention application) in accordance with statutory competences. Verification of notifications and control should be carried out immediately in accordance with statutory requirements.

Tasks of heads of the municipalities, mayors, city presidents, and municipal councils

1) Conducting an information campaign on the requirements of the anti-smog resolution for Malopolska and the available forms of co-financing for boiler replacement with reaching at least once a year to every entity operating in the municipality that operates a solid fuel combustion installation.

Tasks of county governors:

1) Conducting intervention controls of economic entities as a response to notifications of infringements of environmental protection regulations (including reactions to notifications under the Eco-intervention application) in accordance with statutory competences. Verification of notifications and control should be carried out immediately in accordance with statutory requirements.

2) Entering data on annual emissions of pollutants (defined in the permits issued for the introduction of gases or PM into the air and in the integrated permits) into the database made available by the Marshal's Office. The data should be entered and updated within 30 days of the issue of the permit or its amendment.

3) In the case of newly issued and amended permits for gas or PM emissions into the air and integrated permits, the authority should analyse and, where justified, introduce obligation to implement actions to reduce particulate matter emissions from installations in case of introduction of the third degree of air pollution danger. Information on the installations required to implement these actions should be forwarded to the relevant county crisis management centre.

4) Authorities issuing decisions should keep the municipality authorities informed about issued decisions or changes in decisions regarding the emission of pollutants into the air for plants located in a given municipality.

Obligations of entities which operate an installation covered by the obligation to obtain a permit for gas or PM emissions or to obtain an integrated permit or which operate an installation subject to notification procedure

1) Providing information on emergency incidents resulting in emissions of pollutants into the air or emissions in abnormal conditions, to a system made available by the Marshal's Office. The information should include an indication of the degree of danger of the event according to the following classification:

a) **1st degree –** an event whose impact does not go beyond the premises of the plant and does not constitute a serious failure within the meaning of the Environmental Protection Act – the information must be provided within 24 hours from the moment the entity gains knowledge about the event,

b) **2nd degree** – an event whose impact goes beyond the premises of the plant, but does not constitute a serious failure within the meaning of the Environmental Protection Act – the information must be provided within 6 hours from the moment the entity gains knowledge about the event,

c) **3rd degree –** an event which is a serious failure within the meaning of the Environmental Protection Act – the information must be provided within 3 hours from the moment the entity gains knowledge about the event.

2) The obligation to comply with the requirements arising from BAT conclusions. No possibility of applying derogations for installations located in areas where the limit values of air pollutants are exceeded in relation to pollutants whose permissible and targets values are exceeded (according to the current annual assessment of the Chief Inspectorate of Environmental Protection).

Tasks of the Management Board of the Malopolska Region

1) Creating **by 31 December 2021** and administrating a database by the Marshal's Office on industrial emissions, containing information on the following:

a) annual emissions granted under the emission permits and integrated permits and scans of such permits,

b) emissions reported under environmental charges,

c) environmental inspections carried out at the plant,

d) information on emergency events that occurred at the plant.

2) In the case of newly issued and amended permits for gas or PM emissions into the air and integrated permits, the authority should analyse and, where justified, introduce obligation to implement actions to reduce particulate matter emissions from installations in case of introduction of the third degree of air pollution danger. Information on the installations required to implement these actions should be forwarded to the relevant county crisis management centre.

3) Authorities issuing decisions should keep the municipality authorities informed about issued decisions or changes in decisions regarding the emission of pollutants into the air for plants located in a given municipality.

4) Preparation **by 31 December 2021** of guidelines regarding introducing within emission permits and integrated permits the obligation of taking measures to limit dust emissions to air from installations in the event of the third degree of air pollution danger.

8.2.2. SUBSTANTIVE AND FINANCIAL SCHEDULE FOR CORRECTIVE MEASURES

The schedule of corrective measures for the Malopolska zones was based of the diagnosis of the current air quality and the analysis of the basic reasons for non-compliance with air quality standards. It indicates priority activities and units responsible for their implementation, time scale, estimated costs and potential sources of financing.

Estimated average costs are the costs of implementation of the activity of changing the present method of obtaining the demanded heat from a coal for a different type of fuel, considering the average costs of thermo-modernization of buildings (understood as insulation of walls and roof and replacement of window frames).

The required ecological effect was determined for PM10, PM2.5, NO_2 and B(a)P as the scale of annual emission reduction. It was determined by modelling the pollution dispersion with consideration of different corrective measures. The variant resulting in improvement of air quality and containing plausible measures was chosen. When determining the required scale of reduction, the focus was on those groups of emission sources from the zones that are most responsible for exceedances of permissible and target levels. According to the analysis of pollutants concentrations broken down into groups by emission sources, described in **chapter 5.2**, these were sources of emissions from the communal and household sector, as well as from the transport sector.

Compliance with the target level of B(a)P in the Malopolska Region in 2026 will be possible only if the efforts to reduce benzo(a)pyrene emissions are also intensified in neighbouring regions. The reason for this is the level of regional background, which in 2018 in the zones of the Malopolska Region in many places exceeded the target level, as indicated in chapter 5.1. In connection with the ongoing work on Air Quality Plans in the neighbouring regions, it was assumed that as a result of the implementation of these programs, the national background of benzo(a)pyrene will be lowered in the forecast year 2026.

The required environmental effect is the difference in annual emissions between the base year and the forecast year. The calculated required ecological effect of implemented remedial measures was presented in the tables indicated in the schedule. The planned start and end dates for the implementation of individual activities, as specified in the schedules below, are set considering:

- the scale of the exceedances of the permissible level of PM10 and PM2.5, the permissible level of nitrogen dioxide and the target level of B(a)P in the air,
- emission sources according to SNAP categories
- the anticipated concentration level of the above substances in the air in the year in which the program ends, expressed in $\mu g/m^3$ or ng/m^3,
- distribution of population density in the zones covered by the Plan,
- financial, social and economic capabilities of entities covered by the Plan,
- conditions resulting from nature protection in the zone, referred to in art. 6 clause 1 point 1-9 of the Act of 16 April 2004 on nature protection

ACTIONS RELATED TO REDUCTION OF EMISSIONS FROM COMBUSTION OF FUELS

ACTION CODE	PL12_ONE
ACTION NAME	LOW-STACK EMISSION REDUCTION AND IMPROVEMENT OF ENERGY EFFICIENCY
DESCRIPTION	
The action is related to the implementation of the provisions of anti-smog resolutions in the region along with ensuring conditions for their implementation. Full implementation of the anti-smog resolutions provisions requires comprehensive measures – both hard and soft, which indirectly contribute to the improvement of air quality. In addition, it is assumed that the implementation of resolutions will go hand in hand with climate protection, i.e. using renewable energy sources and increasing the energy efficiency of buildings. To enable timely liquidation of high-emission solid fuels, the plan introduces comprehensive tasks for the following areas: • increasing efficiency of the use of available forms of financing pro-ecological investments (primarily Clean Air Program, Stop Smog and thermo-modernization tax relief) • dissemination of financial support programs among residents, • education about the requirements of an anti-smog resolution at the local level, • directing special support towards residents affected by energy poverty, • reducing the creation of new heating systems with high emissions, • monitoring progress, i.e. the number of listed boilers, based on an inventory of heating systems, • inspections for compliance with the requirements of the environmental protection resolution and regulations, • use of renewable energy to simultaneously reduce emissions of greenhouse gases and pollutants, • undertaking pro-ecological actions in public administration, aimed at increasing energy efficiency	
CLASSIFICATION	• Low-emission fuels for small, medium and large-sized stationary and mobile sources, replacement with low-emission fuels installations • Environmental education, educational campaigns, control activities, increasing energy efficiency • Use of renewable energy sources
CATEGORY	Activities integrated with the Air Quality Plan
LOCATION	All municipalities of the Malopolska Region
CODE(S) OF THE INCIDENTS OF EXCEEDING	All listed in chapter 3.5 except Mp18AKrNO2a01 (exceeding the average annual NO_2 permissible level in the Krakow Agglomeration)
EVALUATION SCENARIO	Scenario 3
ADMINISTRATIVE LEVEL ON WHICH MEASURES CAN BE TAKEN	Municipal, county, regional
UNIT IMPLEMENTING THE TASK	Municipality, county and regional government, building managers, property managers
CATEGORIES OF EMISSIONS SOURCES OR SECTORS UNDER THE CLEAN AIR ACTION	Residential, commercial and service sectors
SPATIAL SCALE	All municipalities and counties of the Malopolska Region
ACTION IMPLEMENTATION STATUS	Planned

ACTION CODE	PL12_ONE							
TIMELINE FOR CONCENTRATIONS REDUCTION	SHORT-TERM (type III – over one year, no longer than two years)		MEDIUM-TERM (2-4 years)		LONG-TERM (3-6 years)			
Estimated costs of the action implementation (mln/year)	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
Replacement of non-class, 3-class and 4-class boilers in total *(WITH THE COST OF REPLACEMENT AT AN AVERAGE LEVEL OF 15.000 PLN, ASSUMING A TOTAL REPLACEMENT OF 378.000 DEVICES ON THE REGIONAL SCALE)*	337.5	1 147.5	2 700.0	1 350.0	47.2	47.2	47.2	**5 676.6**
RES installation *(THE COST ESTIMATED ASSUMING THAT THERE ARE 42.5 THOUSAND OF SOLID FUEL DEVICES TO BE REPLACED WITH ZERO-EMISSION HEAT PUMPS/PHOTOVOLTAIC INSTALLATIONS/SOLAR COLLECTORS, AT AN AVERAGE COST OF PLN 28 000)*	70.0	280.0	560.0	238.0	9.8	9.8	9.8	**1 177.4**
Employment of the Eco-managers and providing services to beneficiaries *(223 ECO-MANAGERS IN MUNICIPALITIES AND 22 IN COUNTIES, THE COST ESTIMATED TAKING INTO ACCOUNT CURRENT AVERAGE ANNUAL EMPLOYMENT COSTS IN MUNICIPALITIES)*	4.7	5.5	17.1	17.1	17.1	17.1	17.1	**95.7**
Information and educational activities *(IT IS ASSUMED THAT THE COST OF INFORMATION CAMPAIGNS AMOUNTS TO PLN 2 500. THE NUMBER OF ACTIONS WAS ESTIMATED ON THE BASIS OF MUNICIPAL REPORTS – AROUND 1 840 EACH YEAR)*	3.0	4.6	4.6	4.6	4.6	4.6	4.6	**30.6**
Control activities *(ASSUMING 10% OF INSPECTIONS WITH SAMPLE TESTING AT THE PRICE OF PLN 500 EACH; UNIT COST OF AN INSPECTION SHALL AMOUNT TO PLN 140, ASSUMING AVERAGE NUMBER OF INSPECTIONS FROM 19 TO 37 THOUSAND A YEAR)*	2.0	4.2	4.0	7.9	7.8	7.8	7.8	**41.5**
Cost of municipal guards functioning *(COST OF MUNICIPAL GUARDS FUNCTIONING ESTIMATED TAKING INTO ACCOUNT THEIR EQUIPMENT, VEHICLES, SAMPLERS, EQUIPMENT NECESSARY FOR INSPECTION; THE NUMBER OF POSTS ASSUMING THE APPOINTMENT OF 50 INTER-MUNICIPAL GUARDS WITH 4 OFFICERS EACH)*	-	22.3	19.6	19.6	19.6	19.6	19.6	**120.3**
Costs of implementing other activities borne by municipal governments *(BASED ON 1% OF THE MUNICIPALITIES' OWN REVENUES IN 2017-2018) INCLUDING INVENTORIES OF SOURCES, THERMO-MODERNIZATIONS, CLEAN AIR PROGRAM INFORMATION POINTS, SUPPORT FOR THE POOR)*	40	80	80	80	80	80	80	**520.0**
TOTAL	**457.2**	**1 544.1**	**3 385.3**	**1 717.2**	**186.1**	**186.1**	**186.1**	**7 662.1**

SOURCES OF FINANCING [PLN MILLION]	Central programs (Clean Air, Stop Smog)							4 736.9
	Programs at the regional level (RPO, LIFE, regional budget)							420.2
	Municipality and county budgets (min. 1% of budget revenues)							727.6
	Beneficiaries of the AQP							1 777.4
ACTION CODE	PL12_ONE							
PLANNED DATES OF	**START**	**END**		**END**				
	01.10.2020	**31.12.2023** to achieve the PM10 and PM2.5 norms		**31.12.2026** to achieve the benzo(a)pyrene norms				
SUBSTANTIAL EFFECT	**ESTIMATED ECOLOGICAL EFFECT (EMISSION REDUCTION) [MG/YEAR]**							
YEAR	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**TOTAL**
Krakow Agglomeration								
PM10	116,39	116,39	145,49	145,53	-	-	-	523,80
PM2.5	107,05	107,05	133,81	133,82	-	-	-	481,73
B(a)P	0,05	0,05	0,07	0,07	-	-	-	0,24
NO_2	19,86	19,86	29,79	29,79	-	-	-	99,30
Tarnow city zone								
PM10	16,30	65,21	130,42	55,43	2,28	2,28	2,28	274,20
PM2.5	13,58	54,32	108,65	46,17	1,90	1,90	1,90	228,42
B(a)P	0,006	0,026	0,052	0,022	0,001	0,001	0,001	0,109
NO_2	1,69	6,78	13,56	5,76	0,24	0,24	0,24	28,51
Malopolska zone								
PM10	636,34	2545,36	5 090,72	2 163,55	89,09	89,09	89,09	10 703,24
PM2.5	553,00	2211,98	4 423,96	1 880,18	77,42	77,42	77,42	9 301,38
B(a)P	0,31	1,23	2,46	1,05	0,04	0,04	0,04	5,17
NO_2	-4,21	-16,83	-33,66	-14,31	-0,59	-0,59	-0,59	-70,78

ACTION CODE	PL12_ONE		
PLANNED IMPACT ON CONCENTRATION LEVELS IN THE END YEAR OF THE PLAN [μG/M^3] OR [NG/M^3]	**Change in PM10 concentrations at monitoring stations in the year of forecast 2023, after implementation of activities**		
	Krakow Agglomeration	station al. Krasinskiego	24 μg/m^3
	Tarnow city	station ul. R. Sitko	14 μg/m^3
	Malopolska zone	station Nowy Targ	27 μg/m^3
		station Tuchow	22 μg/m^3
	Change in the number of days with exceeded daily PM10 concentration at monitoring stations in the forecast year 2023, after implementation of activities		
	Krakow Agglomeration	station al. Krasinskiego	131 days
	Tarnow city	station ul. R. Sitko	45 days
	Malopolska zone	station Nowy Targ	86 days
	Change in PM2.5 concentrations at monitoring stations in the year of forecast 2023, after implementation of activities		
	Krakow Agglomeration	station al. Krasinskiego	22 μg/m^3
	Tarnow city	station ul. R. Sitko	12 μg/m^3
	Malopolska zone	station Nowy Sacz	19 μg/m^3
	Change in benzo(a)pyrene concentrations at monitoring stations in the forecast year 2026, after implementation of activities:		
	Krakow Agglomeration	station ul. Bulwarowa	4,5 ng/m^3
	Tarnow city	station ul. Bitwy pod Studziankami	2,5 ng/m^3
	Malopolska zone	station Nowy Targ	16,5 ng/m^3
		station Tuchow	8,3 ng/m^3
REPORTING AUTHORITY	Municipalities and counties of the Malopolska Region		
RECEIVING AUTHORITY	Board of the Malopolska Region		
DATE OF REPORT	• by 31 January each year for the previous year • by 31 July of each year for the period by 30 June as for the progress of replacement of heating sources and inventory of buildings		

PROGRESS MONITORING INDICATORS	
Number and area of buildings, including single-family and multi-family buildings, in which an ineffective individual solid fuels heat source was liquidated and connected to the heating network	qty., m^2
Number and area of buildings, including single-family and multi-family buildings, in which an ineffective individual solid fuels heat source was replaced with gas heating	qty., m^2
Number and area of buildings, including single-family and multi-family buildings, in which an inefficient individual solid fuels heat source was replaced with a renewable energy source	qty., m^2
Number and area of buildings, including single-family and multi-family ones, in which an ineffective individual solid fuels heat source was replaced with electric heating	qty., m^2
Number and area of buildings, including single-family and multi-family buildings, in which an inefficient individual solid fuels heat source was replaced with a coal boiler meeting the Ecodesign requirements	qty., m^2
Number and area of buildings, including single-family and multi-family buildings in which an inefficient individual solid fuels heat source was replaced with a biomass boiler meeting the Ecodesign requirements	qty., m^2
Number and area of newly built residential buildings that use low or zero carbon heat sources	qty., m^2
Number of conducted inspections on compliance with the anti-smog resolution	qty.
Number of conducted inspections on waste and plant residues incineration	qty.
Number of modernized public buildings	qty.

ACTION CODE	**PL12_ONE**
Number of public buildings in which renewable energy sources were installed	qty.
Number of buildings entered into the Inventory Database for Heating Sources of Buildings	qty., %
Number of people covered by information and education activities	people
Number of information campaigns conducted regarding the anti-smog resolution and available subsidies for the exchange of heat sources among residents	qty.
Number of Eco-managers employed in the region (in municipalities)	people
Number of Climate Eco-managers employed in the region (in counties)	people
Number of the Clean Air Program information points in the region	qty.

ACTIONS REDUCING LINEAR EMISSIONS

ACTION CODE	**PL12_OET**
NAME OF ACTIVITY	**REDUCTION OF EMISSIONS FROM THE TRANSPORT SECTOR**
DESCRIPTION	
The action aims to reduce the number of high emissions vehicles and eliminate vehicles that do not comply with emissions regulations. A detailed description of the operation can be found in chapter 8.1. Activities focus on introducing restrictions on vehicle traffic, especially in the urban zone, the result of which will be reduced exhaust and non-exhaust emissions. The activities comprise the development of public transport, cycling and improvement of road traffic. It is also advisable to invest in a public transport fleet to increase its attractiveness. The most important element of the operation is the implementation of a low emission zone based on EURO emission standards in Krakow. However, it requires national legislation.	
CLASSIFICATION	Public procurement, Traffic management and planning: • paid parking zones, • LEZ zones, • management of car parks and parking spaces, • lowering the speed limit and monitoring compliance thereof • other forms of transport, e.g. development of cycling paths and walking routes, • freight transport, • effective development of public transport, • spatial planning as a means of planning facilitating the means of transport, • encouraging a change in means of transport
CATEGORY	Activities integrated with the Air Quality Plan
LOCATION	All municipalities of the Malopolska region, in particular the Krakow Agglomeration, the city of Tarnow and the city of Nowy Sacz
CODE(S) OF THE INCIDENTS OF EXCEEDING	All listed in chapter 3.5
EVALUATION SCENARIO	scenario 4 in 2026
ADMINISTRATIVE LEVEL ON WHICH MEASURES CAN BE TAKEN	Municipalities, county, region
UNIT IMPLEMENTING THE TASK	Local government, road managers, public transport companies, private carriers, city dwellers.
CATEGORIES OF EMISSIONS SOURCES OR SECTORS UNDER THE CLEAN AIR ACTION	Transport sector
SPATIAL SCALE	cities of Krakow, Tarnow and Nowy Sacz
ACTION IMPLEMENTATION STATUS	Planned

Action code	PL12_OET							
Timeline of achieving concentration reduction	**Long-term** (3-6 years)							
Estimated costs of implementing the activities [thousand PLN / year]	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
Urban mobility plans	-	750,0	-	-		-	-	**750,0**
The cost of implementing the low emission zone based on EURO emission standards and TEMPO-30	50,0	100,0	200,0	200,0	50,0	200,0	50,0	**850,0**
Implementation of a traffic emission monitoring system in Krakow	-	-	-	-	-	30 000,0	30 000,0	**60 000,0**
Cost of inspections of diagnostic stations	57,6	57,6	57,6	57,6	57,6	57,6	57,6	**403,2**
Total	**107,6**	**907,6**	**257,6**	**257,6**	**107,6**	**30 257,6**	**30 107,6**	**62 003,2**
	Municipality and county budgets							**62 003,2**

Planned dates of	Start	End	Dates of achieving the environment effect
	1.07.2020	31.12.2026	31.12.2026

Substantial effect	Estimated ecological effect (emission reduction) [Mg/year]							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
Year	**Krakow Agglomeration**							
PM10	0	0,3	0,3	7,2	2,5	2,5	2,5	**15,3**
PM2.5	0	0,2	0,2	5,7	1,7	1,7	1,7	**11,2**
B(a)P	0	0	0	0	0	0	0	**0**
NOx	9,5	94,8	94,8	445,9	120,0	120,0	120,0	**1 005,0**

ACTION CODE	**PL12_OET**	
PLANNED IMPACT ON CONCENTRATION LEVELS IN THE END YEAR OF THE PROGRAM [μG/M^3] OR [NG/M^3]	The change in NO_2 concentrations in the forecast year 2026 after the implementation of activities at the monitoring stations of the Agglomeration of Krakow will range from 0,9 to 20,08 μg/m^3.	
CHANGE OF NO_2 CONCENTRATION AT THE STATION WHERE THE HIGHEST CONCENTRATIONS ARE OBSERVED – AL. KRASINSKIEGO	**2018**	**2026**
	61	35
REPORTING AUTHORITY	Municipalities and counties of the Malopolska Region	
RECEIVING AUTHORITY	Board of the Malopolska Region	
REPORT DATE	by 31 January each year for the previous year	

PROGRESS MONITORING INDICATORS	
Number of conducted diagnostic station inspections	qty.
Number of conducted vehicle verification actions	qty.
Number of conducted educational campaigns promoting the use of sustainable forms of transport	qty.
Length of created cycling path	km
Length of alternative vehicle routes	km
Number of established parking spaces with higher parking fees	qty.
Number of established Park&Ride car parks with indicated number of parking spaces	qty., qty.
Number of established Bike&Ride car parks with indicated number of parking spaces	qty., qty.
Number of eco vehicles purchased in municipalities under public procurement	qty.,
Number and area of established low emission zones	qty., km^2
Number of established electric vehicle charging stations	qty.

ACTIONS AIMED AT REDUCTION OF INDUSTRIAL EMISSIONS

ACTION CODE	PL12_OEP
NAME OF ACTIVITY	REDUCTION OF EMISSIONS FROM BUSINESS ACTIVITIES
DESCRIPTION	
The measures include inspections of those business entities whose operation affects air quality. In addition, it is planned to implement a permit database, allowing monitoring and verifying information on actual and emissions defined in emission permits. All types of industrial accidents will be made public. Activities carried out by business entities will be implemented within the framework of applicable law and the need to adapt technologies and conditions for using the environment in accordance with the regulations.	
CLASSIFICATION	Low-emission fuels for small, medium and large-sized stationary and mobile sources
CATEGORY	Activities integrated with the Air Quality Plan
LOCATION	All municipalities of the Malopolska Region
CODE(S) OF THE INCIDENTS OF EXCEEDING	All of the items mentioned in chapter 3.5
EVALUATION SCENARIO	None
ADMINISTRATIVE LEVEL ON WHICH MEASURES CAN BE TAKEN	Regional
UNIT IMPLEMENTING THE TASK	Regional government, counties, enterprises
CATEGORIES OF EMISSIONS SOURCES OR SECTORS UNDER THE CLEAN AIR ACTION	Industrial sector according to SNAP01, 03, 04
SPATIAL SCALE	All municipalities of the Malopolska Region
ACTION IMPLEMENTATION STATUS	Planned

ACTION CODE	PL12_OEP							
TIMELINE OF ACHIEVEMENT OF CONCENTRATION REDUCTION	**LONG-TERM** (4-6 years)							
ESTIMATED COSTS OF IMPLEMENTING THE MEASURES [THOUSAND PLN/YEAR]	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
COSTS FOR CREATING AND MAINTAINING THE BASE OF PERMITS	0	225	25	25	25	25	25	**350**
COSTS OF CONDUCTING CONTROLS BY REGIONAL INSPECTORATE FOR ENVIRONMENTAL PROTECTION	50	100	100	100	50	50	50	**500**
TOTAL	**50**	**325**	**125**	**125**	**75**	**75**	**75**	**850**
SOURCES OF FUNDING [THOUSAND PLN]	Programs at the regional level (LIFE Programme, Region budget)							350
	Regional Inspectorate of Environmental Protection budget, Regional Fund for Environmental Protection and Water Management funds							500

PLANNED DATES OF	START	END	DATES OF ACHIEVING THE ECOLOGICAL EFFECT
	01.10.2020	31.12.2026	31.12.2023

SUBSTANTIAL EFFECT	ESTIMATED ECOLOGICAL EFFECT (EMISSION REDUCTION) [MG/YEAR][127]							
	2020	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**Total**
YEAR	**Krakow agglomeration**							
PM10	0	0	0	3,29	6,58	6,58	5,48	21,93
PM2.5	0	0	0	2,55	5,10	5,10	4,25	17,00
B(a)P	0	0	0	0,0001	0,0002	0,0002	0,0002	0,0007
NOx	0	0	0	57,16	114,31	114,31	95,26	381,04
	Tarnow city							
PM10	0	0	0	3,49	6,98	6,98	5,81	23,26
PM2.5	0	0	0	2,30	4,59	4,59	3,83	15,31
B(a)P	0	0	0	0,001	0,001	0,001	0,001	0,0040
NOx	0	0	0	80,93	161,86	161,86	134,88	539,53
	Malopolska zone							
PM10	0	0	0	9,98	19,97	19,97	16,64	66,56
PM2.5	0	0	0	6,08	12,16	12,16	10,13	40,53
B(a)P	0	0	0	0,005	0,010	0,010	0,008	0,033
NOx	0	0	0	88,20	176,40	176,40	147,00	588,00

[127] Estimated environmental effect defined as 10% emission reduction by 2026 from the industrial sector. The description of the assumptions is given in chapter 6.2.1.

ACTION CODE	**PL12_OEP**
ESTIMATED ECOLOGICAL EFFECT (EMISSION REDUCTION) [μG/M³] OR [NG/M³]	No significant impact
REPORTING AUTHORITY	Regional Inspectorate for Environmental Protection, counties of the Malopolska Region, enterprises
RECEIVING AUTHORITY	Board of the Malopolska Region
REPORT DATE	by 31 January each year for the previous year

PROGRESS MONITORING INDICATORS	
Number of intervention inspections carried out by county governors (in response to the notification) of industrial plants/entities conducting economic activity during the year	qty.
Number of permits entered into the Permit Database of the Marshal's Office during the year	qty.
Number of information campaigns conducted regarding the anti-smog resolution and available subsidies for the exchange of heat sources among entrepreneurs	qty.
Total number of compensation proceedings carried out, when issuing emission permits or integrated ones	qty.

8.2.3. POSSIBLE SOURCES OF FUNDING OF THE ACTIVITIES INDICATED IN THE PROGRAM

Activities aimed at air protection can be financed from own funds and from external funds, such as domestic and foreign funds, mainly from the European Union. The own funds of investors (about 50%), local governments, communal entities and enterprises with the obligation to implement Community requirements have the largest share in financing the activities. Implementation of activities often involves bank loans. The basic information on the existing sources of financing of activities indicated in the Program is presented below.

FOREIGN SOURCES OF FUNDING

Norway and European Economic Area (EEA) Grants[128]

The EEA financial mechanisms and the Norwegian Financial Mechanism (i.e. so-called Norwegian and EEA grants) are among the available sources of co-financing tasks related to environmental protection (including air protection). They are a form of non-returnable foreign financial assistance granted by Iceland, Norway and Liechtenstein to new EU members, i.e. several countries of Central and Southern European and the Baltic States. These funds are result of Poland's accession to the European Union and the accession of our country to the European Economic Area. In return for financial assistance, donor countries benefit from access to the EU internal markets, even though they are not members thereof. The main goal of the EEA and Norway Grants is to contribute to reducing economic and social disparities within the EEA and to strengthen bilateral relations between donor and beneficiary countries. As regards the environmental program, the operator is the Ministry of the Environment with the National Fund for Environmental Protection and Water Management, and the partner of the program is the Norwegian Directorate for Water Resources and Energy, Norwegian Environment Agency, and Iceland's Energy Agency. Programs under the 3rd edition of the EEA and Norway Grants will be implemented until 2024.

Information: https://www.eog.gov.pl

LIFE Programme

The LIFE Programme is the only financial instrument of the European Union devoted exclusively to co-financing environmental and climate protection projects. Its main purpose is to support the implementation of Community environmental law, the implementation of EU policy in this respect, as well as to identify and promote new solutions to environmental problems. A beneficiary of the LIFE Programme can be any entity (individuals, business entities, public or private institutions) registered in the territory of an EU country[129]. In the years 2015-2023, the Malopolska Region is the coordinating beneficiary of the LIFE integrated project entitled "*Implementation of the Air Quality Plan for the Malopolska Region – Malopolska in a healthy atmosphere*". It engages 69 partners, including 62 municipalities. The project value is approximately EUR 17 million (PLN 70 million), of which EU funding is PLN 42 million[130].

Information: http://nfosigw.gov.pl/oferta-finansowania/srodki -zagraniczne/instrument-finansowy-life/

ELENA European Local Energy Assistance / European aid for local energy

ELENA is the European technical assistance instrument. It offers grants to regions and local authorities to accelerate their investment programs in the field of energy and climate change (funding level – up to 90% of eligible costs). ELENA is part of the wider activities of the European Investment Bank aimed at implementing the tasks of the European Union in the field of climate and energy policy.

[128] Source: https://www.eog.gov.pl
[129] Source: http://nfosigw.gov.pl/oferta-finansowania/srodki -zagraniczne/instrument-finansowy-life/
[130] Source: https://powietrze.malopolska.pl/life/

EU Member States can propose investment programs to improve energy efficiency in buildings or streets (lighting), use renewable energy in buildings, renovate or construct district heating networks based on cogeneration (combined heat and energy) or renewable energy sources energy. Funds granted by ELENA can be used to prepare investment projects, business plans and additional energy audits, prepare tender procedures and contracts, and cover the costs of units implementing the project. The Krakow Metropolis Association, which brings together the Municipality of Krakow and the municipalities around it, thanks to the ELENA fund, launched a project entitled ECO-TEAM. It aims to create a network of 44 eco-managers in Krakow and the municipalities surrounding it. Their work will focus on providing residents with assistance what should result in the implementation of activities worth approximately EUR 48 million[131].

Information:
https://www.eib.org/en/products/advising/elena/index.htm

DOMESTIC SOURCES OF FUNDING

National Fund for Environmental Protection and Water Management (NFOSiGW)

The fund implements the state environmental protection policy and the energy policy. The main goals of funding are investments to protect the environment, activities to improve the state of the environment, water protection, protection of the atmosphere, preservation of the natural heritage, including the preservation of biodiversity and raising the ecological awareness of residents. NFOSiGW offers loans, subsidies and other forms of financing of implemented projects, e.g. by local governments, enterprises, public entities, social organizations and individuals. It is also the largest partner in Poland in servicing foreign grants for environmental protection. In the years 2017-2020, it has approximately PLN 13 billion from its own (statutory) funds and, with a 2023 perspective, above PLN 20 billion of foreign funds. NFOSiGW implements, among others projects that can contribute to supporting activities undertaken in the region for improving air quality and are addressed to authorities, entrepreneurs and individuals. The most important projects and programs are characterized below.

Clean Air Program

The goal of the program is to limit the emission of harmful substances produced in the processes of providing single-family homes with heat, where outdated heat sources and low-quality fuel are used. The program offers co-financing for replacing old and ineffective solid fuel heat sources for modern heat sources that meet the highest standards, as well as carrying out accompanying thermo-modernization works of the building. The program is scheduled for 2018-2029. The total budget of the program is PLN 103 billion. Applications can be submitted to regional funds for environmental protection and water management, as well as in municipalities that have signed a cooperation agreement with regional fund for environmental protection and water management.

On average, over PLN 4.7 billion may be available for the Malopolska Region, assuming that 60% of replacements will be carried out with Clean Air funds, and the average investment cost based on an average from 60 thousand applications is PLN 18,900.

Clean Air Program is adjusted in every year to the requirements of the beneficiaries and the objectives of the Program, as a result, the procedures are standardized and simplified in order to improve access to funds for the country's inhabitants.

Information:
https://www.wfos.krakow.pl/czyste -powietrze/

[131] http://metropoliakrakowska.pl/

My Electricity Programme

The purpose of "My Electricity" programme is to increase the production of electricity coming from photovoltaic micro installations in Poland. Co-financing includes projects consisting in the purchase and assembly of photovoltaic micro installations with installed electrical power from 2 kW to 10 kW, serving the needs of existing residential buildings. Projects involving the increase of the power of an existing solar installation are not subject to co-financing. The program is dedicated to persons who generate electricity for their own needs and who have a comprehensive agreement that regulates issues related to the introduction of electricity generated in micro-installations into the national grid. The allocation amount for non-returnable forms of financing is up to PLN 1,000,000 k.

Information:
https://mojprad.gov.pl

County heating

This program is directed to heating plants with a thermal power up to 50 MW, in which local government units have a minimum 70% share. Funds in the form of a loan (up to 100% of eligible costs) and subsidies (up to 30% of eligible costs) can be allocated, among others for the expansion of the heating network and connecting new customers (residents who used solid fuels for heating).

Information:
http://www.nfosigw.gov.pl/ofertafinansowania/srodkikrajowe/programy/priorytetowe/cieplownictwo-powiatowe--pilotaz/nabor-2019-cieplownictwo-powiatowe--pilotaz/

Energy Plus

This program applies to enterprises, including heating plants, covers a very wide range of investments, ranging from reducing fuel consumption, renewable energy use, the use of new technologies to the expansion of the heating network. Co-financing is offered in the form of a loan. The program budget for returnable and non-returnable forms of financing is up to PLN 4,000,000 k:

1. for non-returnable forms of financing – up to PLN 50,000 k

2. for returnable forms of financing – up to PLN 3,950,000 k

The funds will be expended until 2025.

Information:
http:www.nfosigw.goc.pl/oferta-finansowania/srodki-krajowe/programy-priorytetowe/energia-plus/

Polish Geothermal Energy Plus

Its conditions for co-financing are similar to those of Polish Geothermal Plus program. It is a program for enterprises and it is aimed at increasing the use of Poland's geothermal resources. The allocation amount for returnable and non-returnable forms of financing is:

1. for non-returnable forms of financing – up to PLN 300 000 k

2. for returnable forms of financing – up to PLN 300 000 k

Information:
http://www.nfosigw.gov.pl/oferta-finansowania/srodki-krajowe-programy-priorytetowe/polska-geotermia-plus/

Ecological education

Co-financing in this program may apply to educational projects that contribute to the implementation of the principles of sustainable development, support in the implementation of environmental policy and the development of the civil society's awareness, including the air and climate protection.

Information:

http://www.nfosigw.gov.pl/oferta-finansowania/srodki-krajowe-programy-priorytetowe/edukacja-ekologiczna

A nationwide system of advisory support for the public, housing and industry sectors in the field of energy efficiency and renewable energy

It is a project implemented by the National Fund for Environmental Protection and Water Management (NFOSiGW) and Partners, Regional Funds for Environmental Protection and Water Management in 16 regions throughout the country. The counselling and consultations on energy efficiency is aimed at municipalities with the purpose of improving the efficiency of implemented measures. In addition, as part of the project, municipalities are comprehensively informed about current possibilities of receiving grants from various financial sources that are dedicated to a given region.

Tasks contributing to air protection are also financed from inter-ministerial programs of the NFOSiGW:

- Tasks designated by the legislator;
- Support from the Minister of Environment in the implementation of the environmental protection policy – concerns expertise and studies, the beneficiaries may be the Ministry of the Environment, the Polish National Water Management, the General Directorate for Environmental Protection, the Chief Inspectorate of Environmental Protection;
- Environmental monitoring.

The largest financial resources for activities related to environmental protection are available under the European Union's Structural and Investment Funds. There are 5 funds that focus on the following areas: research and innovation, digital technologies, supporting low-carbon economy, sustainable management of natural resources and SMEs. All funds are managed independently by EU countries on the basis of partnership agreements. At the national level, expenditure from the Structural and Investment Funds is determined under Operational Program Infrastructure and Environment 2014-2020 (OPI&E) and 16 Regional Operational Programs 2014-2020 (RPO), which are the system for implementing the uniform National Strategic Reference Framework.

The Operational Program for Infrastructure and Environment 2014-2020 (OPI&E)

The Operational Program for Infrastructure and Environment 2014-2020 is one of the operational programs that are the basic tool for achieving the objectives set out in the National Strategic Reference Framework for 2014-2020 (NSRF). The OPI&E relies on European Funds, and its budget is EUR 27 513.9 million. It is a national program whose main goal is to support the economy efficiently managing resources, environmentally friendly, and conducive to territorial and social cohesion. The tasks listed in POP, which contribute to air protection, can be co-financed mainly under the following priority axes of the OPI&E.

Axis I – Low-emission economy

Axis II – Environmental protection, including adaptation to climate change

Axis III – Development of the TEN-T road network and multimodal transport

Axis IV – Road infrastructure for cities

Axis VI – Development of low-emission public transport in the cities

Axis VII – Improving energy security

Axis VIII – Protection of cultural heritage and development of cultural resources

The general objective of the activities of the Regional Fund for Environmental Protection and Water Management in Krakow is to improve the state of the environment and the sustainable management of its resources by stable, effective and efficient support of pro-environmental projects and initiatives with full and consistent with the principles of sustainable development use of funds from the European Union for environmental protection and water management.

The assistance applies to ecological activities and investments, among others, in the field of air protection and renewable energy sources. Local governments, state budget institutions, independent public health care institutions, economic entities, social organizations churches and religious associations, cooperatives, public universities and natural persons may apply for funds.

The main forms of assistance are: low-interest loans, subsidies, transfer of funds to state budget units, subsidies to bank loans and partial remission of loans.

Currently, work and negotiations are underway to complete the arrangements for the new financial framework of the European Union for 2021-2027, which will define new rules for allocating funds from the funds to individual countries and areas.

Among the priority areas of support, the European Commission indicates:

- increasing energy efficiency,
- CO_2 reduction,
- advanced thermal modernization or energy efficiency,
- actions based on renewable energy,
- waste management and circular economy,
- adaptation to climate change and low emissions.

Information:
https://www.rpo.malopolska.pl

Regional Fund for Environmental Protection and Water Management in Krakow:

Regional fund for Environmental Protection and Water Management in Krakow allows to get support on broadly understood environmental protection. Every year, a list of priority projects is defined as well as the rules for financing activities in the field of: air protection, environmental education, use of renewable energy and others.

Information:
https://www.wfos.krakow.pl

STOP SMOG Program

The program is dedicated to residents affected by energy poverty who are owners or co-owners of single-family residential buildings. As part of the Program, financing covers the replacement or liquidation of heat sources, thermo-modernization of single-family buildings owned by energy-poor residents and the connection to the heating or gas network. The applicant in the Program is the municipality, which receives up to 70% co-financing of investment costs from the state budget. The support in the Program is in a form of subsidy. The program time span is up to 3 years.

For the Malopolska Region, it is possible to obtain PLN 1.69 billion from the program, assuming the poverty rate for the region at 11% and the average cost of subsidy is PLN 37 100.

9. PROPOSED PROGRESS MONITORING INDICATORS FOR PLANNED CLEAN AIR ACTIONS

Each task indicated for implementation in the Clean Air Action schedule of the Plan has been assigned appropriate indicators for monitoring progress.

Part of the proposed indicators for monitoring progress for planned Clean Air Actions is also related to conducting audits. One of the methods of implementing the Malopolska anti-smog resolution, is the introduction of control by authorized entities. Bodies authorized to carry out inspections include in particular:

- Municipal police, pursuant to art. 10 paragraph 1 of the Act of August 29, 1997 on municipal police
- Police, based on art. 1 clause 2 point 4 of the Act of 6 April 1990 on Police
- Buildings Inspectors, pursuant to art. 81 section 1 point 1 of the Act of July 7, 1994. – Building law
- Regional Environmental Protection Inspector, based on art. 2 clause 1 point 1 of the Act of 20 July 1991 on the Environment Inspectorate.

Therefore, the indicators listed in the following table have been defined for each of the three categories of corrective measures.

Table 39. Progress monitoring indicators adopted for Action 1. Low-stack emission reduction and improvement of energy efficiency.

Action 1. Low-stack emission reduction and improvement of energy efficiency[132]									
Indicator	**Unit**	**Zone**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Number and area of buildings, including single-family and multi-family buildings, in which an ineffective individual solid fuels heat source was liquidated and connected to the heating network	**qty., m²**	**Krakow Agglomeration**	201 /26 130	149 /19 370	45 /5 850	22 /2 860	8 /1 040	0/0	0/0
		Tarnow City Zone	35 /4 239	141 /16 954	283 /33 909	120 /14 411	5 /593	5 /593	5 /593
		Malopolska Zone	490 /50 801	2054 /212 952	4 143 /429 533	1761 /182 574	72 /7 464	73 /7 568	73 /7 568
Number and area of buildings, including single-family and multi-family buildings, in which an ineffective individual solid fuels heat source was replaced with gas heating	**qty., m²**	**Krakow Agglomeration**	759 /98 670	562 /73 060	169 /21 970	84 /10 920	28 /3 640	0/0	0/0
		Tarnow City Zone	294 /35 224	1 174 /140 896	2 348 /281 793	998 /119 762	41 /4 931	41/ 4931	41 /4 931
		Malopolska Zone	13 279 /1 376 725	55 628 /5 767 337	112 227 /11 635 344	47 684 /4 943 728	1 938 /200 925	1 967 /203 932	1 967/ 203 932
Number and area of buildings, including single-family and multi-family buildings, in which the individual solid fuels heat source was replaced with a renewable energy source	**qty., m²**	**Krakow Agglomeration**	276 /35 880	204 /26 520	61 /7 930	31 /4 030	10 /1 300	0/0	0/0
		Tarnow City Zone	76 /9 062	302 /36 250	604 /72 500	257 /30 812	11 /1 269	11 /1 269	11 /1 269
		Malopolska Zone	2 789 /289 154	11 684 /1 211 360	23 573 /2 443 974	10016 /1 038 427	407 /42 196	413 /42 818	413 /42 818
Number and area of buildings, including single-family and multi-family ones, in which an ineffective individual solid fuels heat source was replaced with electric heating	**qty., m²**	**Krakow Agglomeration**	114 /1 4820	85 /11 050	25 /3 250	13 /1 690	4 /520	0/0	0/0
		Tarnow City Zone	1/146	5/585	10 /1 169	4 /497	0/0	0/0	0/0
		Malopolska Zone	638 /6 6145	2 673/ 277 128	5 393 /559 129	2 292 /237 627	93 /9 641	95 /9 849	95 /9 849
Number and area of buildings, including single-family and multi-family ones, in which an inefficient individual solid fuels heat source was replaced with a coal boiler meeting the Ecodesign requirements	**qty., m²**	**Krakow Agglomeration**	0	0	0	0	0	0	0
		Tarnow City Zone	0	0	0	0	0	0	0
		Malopolska Zone	6 009 /622 994	165 /17 069	330 /34 243	138 /14 354	6/644	5/540	5/540

[132] To estimate the indicators in m² the following average building surface areas have been defined for each of the zones: 120 m² for the Tarnow City zone, 130 m² for the Krakow Agglomeration and c.a. 103,5 m² for Malopolska zone.

Action 1. Low-stack emission reduction and improvement of energy efficiency[132]									
Indicator	**Unit**	**Zone**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Number and area of buildings, including single-family and multi-family buildings in which an inefficient individual solid fuels heat source was replaced with a biomass boiler meeting the Ecodesign requirements	**qty., m²**	**Krakow Agglomeration**	0	0	0	0	0	0	0
		Tarnow City Zone	0	0	0	0	0	0	0
		Malopolska Zone	39 /4 086	25 174 /2 609 961	50 789 /5 265 644	21 580 /2 237 299	877 /90 924	890/ 92 272	890/ 92 272
Number and area of newly built residential buildings that use low or zero carbon heat sources [133]	**qty, m²**	**Krakow Agglomeration**	700 /91 000	700 /91 000	748 /97 240	748 /97 240	748 /97 240	748 /97 240	748 /97 240
		Tarnow City Zone	120 /14 400	120 /14 400	97 /11 640	97 /11 640	97 /11 640	97 /11 640	97 /11 640
		Malopolska Zone	7 000 /724 500	7 000 /724 500	6 573 /680 306	6 573 /680 306	6 573 /680 306	6 573 /680 306	6 573 /680 306
Number of conducted inspections on compliance with the anti-smog resolution [134]	**qty.**	**Krakow Agglomeration**	2 850	1 500	500	200	50	0	0
		Tarnow City Zone	200	500	500	1000	1000	1000	1000
		Malopolska Zone	7 040	18 440	18 440	36 880	36 880	36 880	36 880
Number of conducted inspections on waste and plant residues incineration	**qty.**	**Krakow Agglomeration**	2 850	1 500	500	200	50	0	0
		Tarnow City Zone	200	500	500	1000	1000	1000	1000
		Malopolska Zone	7 040	18 440	18 440	36 880	36 880	36 880	36 880
Number of modernized public buildings	**qty.**	**Krakow Agglomeration**	5	5	5	5	5	5	5
		Tarnow City Zone	2	2	2	2	2	2	2
		Malopolska Zone	43	43	43	43	43	43	43
Number of public buildings in which renewable energy sources were installed	**qty.**	**Krakow Agglomeration**	1	1	2	2	2	2	2
		Tarnow City Zone	1	1	1	1	1	1	1
		Malopolska Zone	10	10	10	10	10	10	10

[133] It is assumed that all newly constructed buildings will be equipped with devices meeting at least the Ecodesign requirements
[134] It is assumed that the control will cover both the issue of compliance with the anti-smog resolution and the issue of waste incineration

Action 1. Low-stack emission reduction and improvement of energy efficiency[132]									
Indicator	**Unit**	**Zone**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Number of buildings entered into the Inventory Database for Heating Sources of Buildings	**%**	**Krakow Agglomeration**	-	70%	90%	100%	100%	100%	100%
		Tarnow City Zone	-	70%	90%	100%	100%	100%	100%
		Malopolska Zone	-	70%	90%	100%	100%	100%	100%
Number of people covered by information and education activities	**qty.**	**Krakow Agglomeration**	150 000	150 000	150 000	150 000	150 000	150 000	150 000
		Tarnow City Zone	50 000	50 000	50 000	50 000	50 000	50 000	50 000
		Malopolska Zone	300 000	300 000	300 000	300 000	300 000	300 000	300 000
Number of information campaigns conducted regarding the anti-smog resolution and available subsidies for the exchange of heat sources among residents	**qty.**	**Krakow Agglomeration**	2	2	2	0	0	0	0
		Tarnow City Zone	2	2	2	2	2	2	2
		Malopolska Zone	360	360	360	360	360	360	360
Number of Eco-managers employed in the region (in municipalities)	**people**	**Krakow Agglomeration**	6	6	6	6	6	6	6
		Tarnow City Zone	1	1	3	3	3	3	3
		Malopolska Zone	60	60	214	214	214	214	214
Number of Climate Eco-managers employed in the region (in counties)	**people**	**Krakow Agglomeration**	0	1	1	1	1	1	1
		Tarnow City Zone	0	1	1	1	1	1	1
		Malopolska Zone	0	20	20	20	20	20	20
Number of Clean Air Program information points in the region	**qty.**	**Krakow Agglomeration**	1	1	1	1	1	1	1
		Tarnow City Zone	0	1	1	1	1	1	1
		Malopolska Zone	52	180	180	180	180	180	180

Table 40. Monitoring indicators for Action 2. Reduction of emissions from the transport sector.

Action 2. Reduction of emissions from the transport sector									
Indicator	**Unit**	**Zone**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Number of conducted diagnostic station inspections	**qty.**	**Krakow Agglomeration**	76	76	76	76	76	76	76
		Tarnow City Zone	25	25	25	25	25	25	25
		Malopolska Zone	345	345	345	345	345	345	345
Number of conducted vehicle verification actions	**qty.**	**Krakow Agglomeration**	4	4	4	4	4	4	4
		Tarnow City Zone	4	4	4	4	4	4	4
		Malopolska Zone	80	80	80	80	80	80	80
Number of conducted educational campaigns promoting the use of sustainable forms of transport	**qty.**	**Krakow Agglomeration**	3	3	3	4	4	4	4
		Tarnow City Zone	2	2	2	2	3	3	3
		Malopolska Zone	60	60	60	60	60	60	60
Length of created cycling path	**km**	**Krakow Agglomeration**	5	5	5	5	5	5	5
		Tarnow City Zone	1,5	1,5	1,5	1,5	1,5	1,5	1,5
		Malopolska Zone	100	100	100	90	90	90	90
Length of alternative vehicle routes	**km**	**Krakow Agglomeration**	0	1	2	10	1	1	10
		Tarnow City Zone	0	0	0	0	0	0	0
		Malopolska Zone	0	0	0	0	0	0	0
Number of established parking spaces with higher parking fees	**qty.**	**Krakow Agglomeration**	0	0	0	15	0	0	20
		Tarnow City Zone	0	0	0	10	0	0	10
		Malopolska Zone	0	0	0	0	0	0	0

Action 2. Reduction of emissions from the transport sector									
Indicator	**Unit**	**Zone**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Number of established Park&Ride car parks with indicated number of parking spaces	**qty.**	**Krakow Agglomeration**	2/500	1/80	0	1/80	0	0	2/160
		Tarnow City Zone	1/80	0	0	1/80	0	0	0
		Malopolska Zone	3/200	1/50	2/100	2/100	2/100	2/100	2/100
Number of established Bike&Ride car parks with indicated number of parking spaces	**qty.**	**Krakow Agglomeration**	2/100	1/50	0	1/50	1/20	1/20	1/50
		Tarnow City Zone	1/50	0	0	1/50	1/20	1/20	1/50
		Malopolska Zone	3/100	3/100	3/100	3/100	3/100	3/100	3/100
Number of eco vehicles purchased in municipalities under public procurement	**qty.**	**Krakow Agglomeration**	50	50	50	50	10	10	10
		Tarnow City Zone	10	10	5	2	2	2	2
		Malopolska Zone	90	90	50	50	20	20	20
Number and area of established low emission zones	**qty., km^2**	**Krakow Agglomeration**	0	0	0	1 / 4	0	1 / 150	0
		Tarnow City Zone	0	0	0	0	0	0	0
		Malopolska Zone	0	0	0	0	0	0	0
Number of established electric vehicle charging stations	**qty.**	**Krakow Agglomeration**	20	10	10	5	5	5	5
		Tarnow City Zone	10	5	3	3	3	3	3
		Malopolska Zone	60	20	20	20	20	20	20

Table 41. Monitoring indicators for Action 3. Reduction of emissions from economic activities.

Action 3. Reduction of emissions from economic activities									
Indicator	**Unit**	**Zone**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**
Number of intervention inspections carried out by county governors (in response to the notification) of industrial plants/entities conducting economic activity during the year	**qty.**	**Krakow Agglomeration**	10	10	10	10	10	10	10
		Tarnow City Zone	5	5	5	5	5	5	5
		Malopolska Zone	85	85	85	85	85	85	85
Number of permits entered into the Permit Database of the Marshal's Office during the year	**qty.**	**Krakow Agglomeration**	0	0	5	5	5	5	5
		Tarnow City Zone	0	0	3	3	3	3	3
		Malopolska Zone	0	0	40	40	40	40	40
Number of information campaigns conducted regarding the anti-smog resolution and available subsidies for the exchange of heat sources among entrepreneurs	**qty.**	**Krakow Agglomeration**	1	1	1	1	0	0	0
		Tarnow City Zone	1	1	1	1	1	1	1
		Malopolska Zone	180	180	180	180	180	180	180
Total number of compensation proceedings carried out, when issuing emission permits or integrated ones	**qty.**	**Krakow Agglomeration**	1	0	0	0	0	0	0
		Tarnow City Zone	0	1	0	0	0	0	0
		Malopolska Zone	4	4	5	5	5	5	5

10. SHORT-TERM ACTION PLAN

10.1. Legal bases

The short-term action plan specified for the zones of the Malopolska region is implemented in the event of a risk of exceedance of alert or information thresholds and permissible or target values of substances in ambient air or actual occurrence of the exceedances. The plan sets types of activities and the way they be implemented in order to:

- reduce the risk of substances exceedances,
- limit the effects and duration of exceedances.

The legal basis for the development and implementation of the Short-term Action Plan is the Environmental Protection Act and implementing acts:

- regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air, specifying permissible levels, target levels, information levels and alert levels of substances in the air,
- regulation of the Minister of Environment of 8 of October 2019 amending the regulation on levels of certain substances in ambient air, lowering the information level and the alert level,
- regulation of the Minister of Environment of 14 June 2019 on Air Quality Plans and short-term action plans, specifying the scope of plan, and indicating examples of short-term actions,
- regulation of the Minister of Environment of June 6, 2018 on the scope and method of providing information on air pollution, specifying the scope of information on the exceeded alert level of a substance in the air, referred to in art. 93 of the Environmental Protection Act,

Table 42. Obligations of units according to the competences of individual authorities in developing a short-term action plan.

ADMINISTRATIVE AUTHORITY	LEGAL BASIS	ACTIVITIES
Board of a region	Art. 92 point 1 of the Environmental Protection Act	Preparation and submission of the draft resolution on Short-term Action Plan to the relevant municipality heads, mayors or city presidents and county governors, within 12 months of receiving information on the risk of exceeding the permissible, target or alert level
Regional assembly	Art. 92 point 1c of the Environmental Protection Act	Adopting Short-term Action Plan within 15 months of receiving information on the risk of exceeding the permissible, target or alert levels.
Regional Department of Environmental Monitoring	Art. 94 point 1b of the Environmental Protection Act	Notification to the board of the region of the risk or the actual exceedance.
	Art. 94 point 1c of the Environmental Protection Act	Notification for Regional Crisis Management Centre of level exceedance, obliging to take short-term actions.

Administrative authority	Legal basis	Activities
Chief Inspectorate of Environmental Protection	Art. 96a of the Environmental Protection Act	Supervising the timely adoption and implementation of the short-term action plan.
Regional Crisis Management Centre	Art. 92 point 1d of the Environmental Protection Act	Informing the competent authorities on the need to take short-term actions.
Municipality head, mayor, president of the city, county governors	Art. 92 point 1a of the Environmental Protection Act	Providing opinions on the short-term action plan

A short-term action plan for the Malopolska Region was prepared for PM10 and PM2.5, benzo(a)pyrene, nitrogen dioxide and ozone. The activities were divided into:

- operational activities aimed at reducing emissions from sources in Plan areas,
- informative and preventive activities aimed at warning about the negative impact of air quality on the health of residents.

10.2. The risk of exceeding the alert levels and public information levels with a list of short-term actions to reduce this risk

According to the regulation of the Minister of Environment of 6 June 2018 on the scope and method of providing information on air pollution, the Institute of Environmental Protection – National Research Institute (IOS-PIB) provides the Chief Inspector of Environmental Protection with the results of mathematical modelling of transport and transformation of substances in the air. Furthermore rhe Institute of Environmental Protection – National Research Institute (IOŚ -PIB) provides analysis of the modelling results for the purposes of, among others, determination of the risk of exceeding the alert, information, permissible or target levels of substances in the air, referred to art. 93 point 1 of the Environmental Protection Law.

In the event of a risk of exceeding, or in the event of an exceeding of the alert, information, permissible or target levels of substances in the air in a given zone, the Chief Inspector of Environmental Protection shall notify the competent Region Board and the Regional Crisis Management Centre thereof.

Air quality analysis for the base year 2018

The analyses of the results of air quality measurements, in order to determine whether there is a risk of exceeding air quality standards, were carried out in 2018 by the Regional Inspectorate for Environmental Protection in Krakow. In 2018, the Regional Crisis Management Centre (RCMC) in Krakow:

- 115 times informed residents about **the first degree** of air pollution danger in the City of Krakow due to high concentration of **PM10**;
- once informed residents about **the first degree** of air pollution danger in the City of Krakow due to high **ozone** concentration;
- 3 times informed the residents about **the second degree** of air pollution danger in the City of Krakow due to high concentration of **PM10**;
- 7 times the Crisis Management Centre of the City of Krakow launched free public transport in the area of the Krakow city and in neighbouring municipalities (covered by public communication network), which joined the agreement in order to jointly provide the public transport services.

Adverse weather conditions, such as low wind (so-called "wind silence"), low temperatures, low pressure gradients – anti-cyclone circulation, determine the appearance of higher concentrations of pollutants, especially of particulate matter. An improvement in air quality can be observed when wind speed and precipitation increase.

Meteorologically, the year 2018 was extremely warm in Poland. It was caused by relatively high temperatures in winter, and a very long warm season (with high temperatures from April to October). A comparison of the winter and summer temperatures in 2018 with those in the years 1971-2000 indicates an increase by approx.. 1°C in winter and by 2°C in summer. In 2018, the specific air pressure distribution over Europe above the earth's surface, as well as in the lower and middle troposphere, caused warm, tropical air from North Africa (mainly from the Sahara) to flow into Poland. The inflow of such air masses could have caused a transfer of dust from its natural sources.

In 2018, the defined alert level (300 μg/m^3) and information level (200 μg/m^3) about the danger of air pollution with PM10 were higher than currently. On 11 October 2019, these levels were lowered: respectively, the information level to 100 μg/m^3, and the alert level to 150 μg/m^3. The table below summarizes the number of days when the information level was exceeded – the level applicable until 2018 (200 μg/m^3). The table compares it with the number of days when the information level would be exceeded in the same period if the applicable level was 100 μg/m^3.

Table 43. Number of days with exceedance of the information level according to the previous (daily concentration of PM10 200 μg/m^3) and current (daily concentration of PM10 100 μg/m^3) standards – monitoring stations in the Malopolska Region.

Location of the monitoring stations	Number of days with a concentration PM10 >200 μg/m^3						Number of days with a concentration PM10 >100 μg/m^3					
	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Krakow ul. Bujaka	1	1	-	1	5	-	19	21	24	14	9	13
Krakow ul. Bulwarowa	1	1	3	1	6	-	21	24	24	11	15	4
Krakow os. Piastow	-	-	-	-	5	-	-	-	-	9	11	6
Krakow ul. Telimeny 9	-	-	-	-	3	-	-	-	-	-	6	7
Krakow Wadow	-	-	-	-	6	-	-	-	-	-	8	5
Krakow Zloty Rog	-	-	-	1	8	-	-	-	-	12	12	14
Krakow al. Krasinskiego	3	2	4	-	8	1	30	39	40	20	18	27
Krakow ul. Dietla	-	-	-	1	6	-	-	-	-	20	8	16
Tarnow, ul. Bitwy pod Studziankami	-	-	-	-	-	-	3	8	5	5	5	6
Tarnow, ul. Ks. R. Sitko	-	-	-	-	3	-	3	-	-	14	14	9
Nowy Sacz ul. Nadbrzezna	-	-	-	1	-	-	15	24	23	24	21	18
Nowy Targ Plac Slowackiego	-	-	-	5	7	4	-	-	-	5	26	24
Sucha Beskidzka ul. Handlowa	1	2	-	-	-	-	13	35	-	-	-	-
Sucha Beskidzka ul. Nieszczynskiej	-	-	-	-	-	-	-	-	-	-	-	26
Sucha Beskidzka ul. Semika	-	-	-	-	-	-	-	-	18	-	-	-
Trzebinia os. Zwiazku Walki Mlodych	-	-	-	-	6	-	5	1	3	11	8	3
Zakopane ul. Sienkiewicza	1	-	-	1	-	-	3	15	1	9	12	6
Olkusz ul. Francesco Nullo	-	-	-	-	3	-	-	3	4	4	10	1
Skawina os. Ogrody	1	-	-	1	9	-	27	16	20	19	10	10
Minimum number of days	**1**	**1**	**3**	**1**	**3**	**1**	**3**	**1**	**1**	**4**	**5**	**1**
Maximum number of days	**3**	**2**	**4**	**5**	**9**	**4**	**30**	**39**	**40**	**24**	**26**	**27**

Lowering of the information level from 200 µg/m³ to 100 µg/m³ for the particulate matter concentration PM10 by the current air quality, increases the frequency of informing the public and announcement of the 2nd degree of air pollution danger. In 2018, the number of days with information exceedances would increase from 4 to 24 days in Nowy Targ, where the number of days with exceedances was the highest.

Table 44. Number of days with exceeded PM10 alert level, according to previous (daily PM10 concentration 300 µg/m³) and current (daily PM10 concentration 150 µg/m³) standards – monitoring stations in the Malopolska Region.

Location of the monitoring stations	Number of days with a concentration PM10 >300 µg/m³						Number of days with a concentration PM10 >150 µg/m³					
	2013	2014	2015	2016	2017	2018	2013	2014	2015	2016	2017	2018
Krakow ul. Bujaka	-	-	-	-	1	-	7	10	5	2	19	3
Krakow ul. Bulwarowa	-	-	-	-	1	-	4	6	9	2	9	4
Krakow os. Piastow	-	-	-	-	1	-	-	-	-	1	11	1
Krakow ul. Telimeny 9	-	-	-	-	2	-	-	-	-	-	17	2
Krakow Wadow	-	-	-	-	1	-	-	-	-	-	13	-
Krakow Zloty Rog	-	-	-	-	1	-	-	-	-	3	13	3
Krakow al. Krasinskiego	-	-	-	1	2	-	12	19	23	10	21	4
Krakow ul. Dietla	-	-	-	1	1	-	-	-	-	3	15	3
Tarnow, ul. Bitwy pod Studziankami	-	-	-	-	-	-	-	-	-	-	3	4
Tarnow, ul. Ks. R. Sitko	-	-	-	-	1	-	-	-	-	-	8	-
Nowy Sacz ul. Nadbrzezna	-	-	-	-	-	-	3	1	4	8	11	1
Nowy Targ ul. Powstancow	-	-	-	-	1	-	-	-	-	9	18	12
Sucha Beskidzka ul. Handlowa	-	-	-	-	-	-	2	5	-	-	-	-
Sucha Beskidzka ul. Nieszczynskiej	-	-	-	-	-	-	-	-	-	-	-	-
Sucha Beskidzka ul. Semika	-	-	-	-	-	-	-	-	-	-	-	-
Trzebinia os. Zwiazku Walki Mlodych	-	-	-	-	1	-	1	-	1	1	14	-
Zakopane ul. Sienkiewicza	-	-	-	-	-	-	5	3	3	6	-	-
Olkusz ul. Francesco Nullo	-	-	-	-	-	-	-	-	-	-	8	-
Skawina os. Ogrody	-	-	-	-	1	-	6	3	4	5	19	3
Minimum number of days	0	0	0	1	1	0	1	1	1	1	3	1
Maximum number of days	0	0	0	1	2	0	12	19	23	10	21	12

Lowering of the alert level for PM10 from 300 µg/m³ to 150 µg/m³ with maintaining pollutant concentrations at the same level as in 2018, results in an increased frequency of alerting the public and announcement of the 3rd - the highest degree of air pollution danger. The number of days with exceeded alert level would increase in Nowy Targ from 0 to 12 days, and in Krakow from 0 to 4 days.

Potential sources of exceeding alert, information, permissible or target levels of concentration of substances in the air in zones

1. The main reason for exceeding the norms specified for PM10, PM2.5 and benzo(a)pyrene is the impact of emissions associated with individual heating of buildings and specific conditions for the dispersion of pollution in built-up areas.
2. The main reason for exceeding the norms for nitrogen dioxide is the impact of emissions associated with the intense traffic of vehicles in the city centre and, as in the case of dust, specific conditions for the dispersion of pollution.
3. Exceedances of ozone concentration norms were mainly caused by meteorological conditions conducive to ozone formation and inflow of pollutants from outside the zone.

10.3. The mode of implementing and announcing short-term activities

Short-term measures should be implemented in situations when there is a risk of occurrence or exceeded alert, information, permissible and target levels of concentration of substances in the air. Their purpose is to reduce the risk of such exceedances and to limit the effects and duration if they occur.

There are 3 levels of air pollution danger:

- **1st degree of danger (code yellow)** means the risk of exceeding the permissible values or target values of pollution in the air,
- **2nd degree of danger (code orange)** means the risk of exceeding the information threshold for air pollutants,
- **3rd degree of danger (code red)** means the risk of exceeding the alert threshold for air pollutants.

Due to the method of averaging the results of measurements of substances in the air, the danger levels are determined on the basis of concentrations of PM10, ozone, sulphur dioxide and nitrogen dioxide. Danger levels (degrees) are introduced separately for each county.

10.3.1. TASKS SUPPORTING IMPLEMENTATION OF THE SHORT-TERM ACTION PLAN

The Chief Inspectorate of Environmental Protection will eventually launch an application interface (API) that will automatically read the introduction of the 2nd or 3rd degree of danger, its area of validity and the notification content.

The Regional Crisis Management Centre is obliged to update the contact list to the representatives of the largest regional media (radio, press, television, online media) on an ongoing basis and to transmit directly notifications about introduction of the 2nd and 3rd degree of danger

Municipalities are obliged to supervise the completeness and timeliness of the list of e-mail addresses of educational and childcare centres as well as health and social care institutions to which messages about the introduction of the danger degree should be sent. Current lists of e-mail addresses should be forwarded to the county crisis management centres.

The authorities issuing decisions, where obligations of entities to reduce emissions in the case of introduction of the 3rd degree of danger are defined, are obliged to transmit the information about these entities to the locally competent county crisis management centres.

Recommended behaviour of citizens when danger degrees have been announced

All residents should:

- consider limiting intense outside physical exercise,
- reduce room ventilation,
- avoid activities that increase air pollution, e.g. using the fireplace, using a car, using leaf blowers, making bonfires

Sensitive groups of the population – children under 5 and adolescents, seniors and the elderly people, people with respiratory system disorders, people with blood system disorders, people professionally exposed to particulate matter and other contaminants, smokers and passive smokers should:

- limit intense outdoor activity
- not forget about the medicines you normally take
- people with asthma may experience symptoms (dyspnea, coughing, swishings) more often and need their medication more often than normal,
- reduce room ventilation,
- use dust masks and air purifiers,
- avoid activities that increase air pollution, such as using a fireplace, using a car, using a leaf blower, lighting campfire.

If the symptoms worsen, consultation with a doctor is recommended.

The following is also recommended:

- increasing supervision of chronically ill people, including the disabled,
- conducting broad education addressed primarily to primary and secondary school students and their legal guardians, regarding the problem of air pollution and possible behaviours and activities to reduce the risk of exposure to high concentrations of pollutants, including particulate matter,
- keeping track of information on air pollution

10.3.2. *SHORT-TERM ACTIONS DUE TO EXCEEDING PERMISSIBLE, TARGET, ALERT AND INFORMATION LEVELS*

1st degree of danger – code yellow

Procedure and manner of announcing the occurrence of exceedances

The 1st degree of danger for PM10 is introduced automatically between 6:00 and 18:00 when the average concentration of PM10 over the last 12 hours exceeds 80 µg/m³. Once introduced, the degree of danger is valid for the rest of the day.

The 1st degree of danger for ozone is introduced automatically between 6:00 and 18:00 when the average concentration of ozone over the last 8 hours exceeds 120 µg/m³. Once introduced, the degree of danger is valid for the rest of the day.

The degree of danger is determined separately for each county or city with county rights on the basis of the average concentration from monitoring stations of the Chief Inspectorate of Environmental Protection (CIEP) located in a given county. In the case of counties where CIEP stations are not located, data from stations considered by CIEP to be representative of the area of a given county are used.

Marshal's Office:

- Publishes a notification on the website https://powietrze.malopolska.pl/komunikaty
- Allows for downloading the message via e-mail newsletter and API.

City, municipal, and county offices:

- Publish a notification on the municipality/county website..

Short-term activities[135]

General obligations:

- Ban on using fireplaces and local space heaters fired by solid fuels if they are not the only heating source.

Tasks of heads of the municipalities, mayors and city presidents:

- Obligation to carry out preventive inspections in terms of waste incineration and compliance with the requirements of the anti-smog resolution.

2nd degree of danger - orange code

Procedure and manner of announcing the occurrence of exceedances

2nd degree of danger for PM10 or ozone is introduced on the basis of information from the Chief Inspectorate of Environmental Protection[136].

Chief Inspectorate of Environmental Protection:

- sends the notification to the Regional Crisis Management Centre,
- forwards the message to the Ministry of Climate's Crisis Management Centre,
- forwards the notification to the Marshal's Office.

[135] Activities to be taken in the case of the 1st degree of danger for PM10
[136] According to the value of the information threshold specified in the Regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air (Journal of Laws of 2019, item 1931).

Regional Crisis Management Centre:

- immediately informs the public in the manner customary in the Malopolska Region,
- forwards the notification to the relevant county crisis management centres,
- publishes the notification in the Regional Alert System,
- forwards the notification to the media.

County Crisis Management Centres:

- forward the notification to municipality offices in their area,
- forward the notification to the e-mail addresses of educational and childcare centres (schools, kindergartens, nurseries, children's homes, etc.), health care and social welfare facilities,
- publish the notification on the county's website.

City and municipal offices:

- publish a notification on the municipality website.

Short-term activities[137]

General obligations:

- Ban on outdoor activity of children and adolescents studying in educational and childcare centres.
- Ban on leaf blowers.
- Ban on using fireplaces and local space heaters fired by solid fuels if they are not the only heating source.

Tasks of heads of the municipalities, mayors and city presidents:

- Obligation to carry out preventive inspections in terms of waste incineration and compliance with the requirements of the anti-smog resolution in the amount of at least 5 inspections per day for municipalities with a population of up to 20,000 inhabitants, at least 10 inspections per day for municipalities with a population of between 20 and 50,000 inhabitants and at least 20 inspections per day in other municipalities.

3rd degree of danger – code red

Procedure and manner of announcing the occurrence of exceedances

3rd degree of danger for PM10, ozone or nitrogen dioxide is introduced on the basis of information from the Chief Inspectorate of Environmental Protection.[138]

Chief Inspectorate of Environmental Protection:

- forwards the notification to the Regional Crisis Management Centre,
- forwards the notification to the Marshal's Office,
- forwards the notification to the Ministry of Climate's Crisis Management Centre,
- forwards the message to the Government Security Centre

[137] Activities to be taken in the case of the 2nd degree of danger for PM10

[138] According to the value of the alert threshold specified in the Regulation of the Minister of Environment of 24 August 2012 on levels of certain substances in ambient air (Journal of Laws of 2019, item 1931).

Regional Crisis Management Centre:

- immediately informs the public in the manner customary in the Malopolska Region,
- forwards the notification to the relevant county crisis management centres,
- publishes the notification in the Regional Alert System,
- requests the RCB (Government Centre for Security) to send SMS alerts,
- forwards the notification to the media.

County Crisis Management Centres:

- forward the notification to the municipal offices in their area,
- forward the notification to the e-mail addresses of educational and childcare centres (schools, kindergartens, crèches, orphanages, etc.) as well as health and social care institutions,
- forward a notification to entities using the environment obliged under the gas or PM emission permit or the integrated permit to take actions to reduce emissions,
- publish a notification on the county website.

City and municipal offices:

- publish a notification on the municipality website

Short-term activities[139]

General obligations:

- Ban on outdoor activity of children and adolescents studying in educational and childcare centres.
- Ban on using fireplaces and local space heaters fired by solid fuels if they are not the only heating source.
- Ban on using heating devices powered by solid fuels (coal, biomass) if alternative heating can be used.
- Ban on using leaf blowers.
- Ban on dry cleaning of the streets, excluding devices operating in a vacuum system, reducing dust pollution.

Tasks of heads of the municipalities, mayors and city presidents:

- Obligation to carry out preventive inspections in terms of waste incineration and compliance with the requirements of the anti-smog resolution in the amount of at least 5 inspections per day for municipalities with a population of up to 20,000 inhabitants, at least 10 inspections per day for municipalities with a population of between 20 and 50,000 inhabitants and at least 20 inspections per day in other municipalities.

Tasks of presidents and city councils of cities on the rights of a county

- Recommended introduction of free public transport.

[139] Activities to be taken in the case of the 3rd degree of danger for PM10

- Recommended introduction of an entry ban for lorries over 3.5 tonnes[140]:
    - in the case of Krakow – to the area inside the city's second ring road,
    - in the case of Tarnow – to the paid parking zone.
    - in the case of Nowy Sacz – to the paid parking zone.

Tasks of the entities using the environment:

- Implementation of actions limiting the emission of pollutants specified in permits for the emission of gases or PM into the air and in integrated permits in situations where the third degree of danger is announced.
- Ban on road and construction works related to PM emissions in built-up areas except for renovations carried out in emergency and intervention mode.[141]

10.3.3. List of entities affecting the environment who are obliged to reduce or stop emitting gasses and dusts into the air

As part of the short-term action plan, measures shall be introduced, including, but not limited to reduction of emissions from the industry sector. The authorities responsible for issuing permits for the introduction of gases or dusts into the air/integrated permits when considering an application for a permit or its update, are obliged to analyse and, in justified cases, introduce, the obligation for the business entities to implement measures to reduce dust emissions to air from their installations, in the event of announcement of the 3rd degree danger.

Once the 3rd degree of air pollution danger is announced, entities affecting the environment, operating in the area where pollution concentration standards are exceeded, are required to implement measures to reduce emissions specified in permits for gas or dust emissions into the air and integrated permits.

10.3.4. Organization and restrictions on the traffic of vehicles powered by combustion engines

The short-term action plan lists measures to reduce the negative impact on air quality of sources classified as traffic sources. Within the 3rd degree of air pollution danger, restrictions on the movement of vehicles and other devices powered by internal combustion engines are recommended. The restrictions should apply to trucks (weighing over 3.5 Mg) and the designated area in the cities of Krakow, Tarnow and Nowy Sacz. On announcement of the third degree danger, it is recommended to introduce the ban on trucks from the centre of these cities.

On announcement of the degree of danger of air pollution, implementation of the ban on the entry of heavy vehicles over 3.5 Mg to designated areas (does not apply to direct supply cars) may be introduced through:

- limiting the restriction to city centres, within Paid Parking zones and limited by city ring roads,
- designation of alternative roads and defining the area to which the ban applies,
- organization of the restriction notification system, through information boards, announcements in local media.

The obligation to manage introduction of the ban lies with the Regional Crisis Management Centre, which provides information to the relevant units responsible for their implementation, i.e. road managers.

[140] The restriction does not apply to emergency vehicles, vehicles performing activities related to road cleaning and waste collection, vehicles performing activities carried out in an emergency and intervention mode

[141] The competent county buildings inspector is responsible for the enforcement of the ban.

The units supervising the implementation of the action are the Police and city/municipal guard during the alert.

The ban on vehicles entering city centres may not apply to direct supply vehicles and emergency vehicles.

10.3.5. EFFECTS OF IMPLEMENTING THE SHORT-TERM ACTION PLAN, DANGERS AND BARRIERS TO ACTIONS

According to the air quality diagnosis in the Malopolska Region, the reason for the exceedances for the analysed substances is the activity of surface sources related to the municipal and household sector, as well as emissions from sources related to transport, especially in the Krakow Agglomeration. The implementation of short-term actions proposed in the Plan, due to the specificity of the possibilities of their implementation, may bring financial effects and result in the need to implement organizational changes.

Considering the impact on the population residing in region zones (areas of exceedances), compliance with the actions indicated in the Short-term Action Plan may bring positive effects, primarily limiting the negative impact of high concentrations of the substance on the health and life of residents. However, this requires the following changes to be applied:

- increasing the scope of the information system on air quality in zones,
- raising public ecological awareness,
- organization of the system controlling the implementation of short-term activities,
- ways of using of public transport,
- changes in production processes in plants to reduce fugitive emissions when alerts have been announced,
- organization of vehicle traffic in restricted areas for vehicles over 3.5 Mg during the alert periods

Effective implementation of Short-term Action Plan is also associated with elimination of barriers that do not allow the implementation of all activities to the full extent. These barriers include:

- limited possibilities of influencing individual heating systems and their functioning,
- limited possibilities of controlling the restriction of the use of fireplaces within individual heating systems,
- limitation in the designation of alternative transit routes for vehicles over 3.5 Mg and temporary control of the application of bans,
- lack of clear legal basis to control the implementation of short-term activities, e.g. temporary suspension of construction works or an order to water-spray dust piles.

Each implementation of short-term activities has financial, legal and social consequences. The larger the area they apply to and the longer they last, the higher the costs.

Table 45. List of ecological effects of short-term activities in the zones of the Malopolska Region[142]

Short-term action	Description of the ecological effect	Ecological effect PM10	Ecological effect PM2.5
Ban on road and construction works which emit dust into the air in built-up areas	Depending on the scale of construction works carried out in the city in a given period, the volume of emissions may vary. The ecological effect refers to one construction – the effect for three days. According to US EPA AP42 13.2.3 Heavy Construction Operations, total dust emission may be around 0.538 kg/are/day. Emission reduction may be insignificant, noted locally and be related to the construction site only.	0,002 kg per km of road, max. effect: 0,08 kg per km of road For construction site around 1 kg/are	0,0016 kg per km of road, max. effect: 0,07 kg per km of road For construction site around 0,7 kg/are
Introduction of a ban on trucks over 3.5 tonnes	Based on the average traffic of trucks in the city – the effect for three days for the cities of Krakow, Tarnow and Nowy Sacz	Krakow - 9 kg Tarnow – 9 kg Nowy Sacz – 4,5 kg	Krakow - 7,8 kg Tarnow – 7,8 kg Nowy Sacz - 3,8 kg
Introduction of free public transport	It was assumed that the information campaign, and free passenger transport will cause a decrease in the intensity of passenger cars traffic in the city by about 2%. Assuming there are two people in a car, this would mean that about 31,000 persons a day more would use public city and suburban transport – an effect for three days of operation.	Tarnow – 2,7 kg Krakow – 2,7 kg Nowy Sacz – 2,3 kg	Tarnow – 2,4 kg Krakow – 2,4 kg Nowy Sacz – 2,1 kg
Obligatory preventive inspections of waste incineration and compliance with the requirements of the anti-smog resolution	16 kg/20 carried out inspections would result in the cessation of waste incineration in household appliances. During intensified controls, the ecological effect could reach 48 kg for 60 inspections.	48 kg	44 kg
No dry cleaning of streets	Assumed for a road with a traffic of 10,000 vehicles per day for one day.	1,44 kg	0,34 kg
Ban on leaf blowers	No effect estimation possible	-	-
Ban on the use of solid fuels (coal, biomass) heating devices if alternative heating can be used	It was assumed that about 100 houses with automatically powered coal-burning boilers will resign from burning coal during the first day of the alert	8,1 kg	7,4 kg

[142] Based on "Expertise of pilot preparation and implementation of short-term action plans in selected places of the Malopolska"

Short-term action	Description of the ecological effect	Ecological effect PM10	Ecological effect PM2.5
Ban on the use of fireplaces and local solid fuel space heaters	It was assumed that wood burning would be eliminated during this period. Cessation of fireplace exploitation shall lead to minimal pollution reduction. The effect for 100 houses with an area of 120 m^2. Heat demand determined for the heating season in relation to one day of ban.	2,13 kg	0,53 kg

II. RESTRICTIONS AND OBLIGATIONS RELATED TO THE IMPLEMENTATION OF THE PLAN

11. OBLIGATIONS RESULTING FROM THE PLAN

11.1. Obligation on the public administration bodies to forward information on their decisions and locally-binding acts to the Region Board

Implementation of the Air Quality Plan requires cooperation of many parties and day-to-day assessment of work progress. An important element enabling the implementation of the provisions of the Air Quality Plan for the Malopolska Region is the transfer of basic assumptions and directions of activities to all strategic documents at the regional, county and municipality level. This will enable effective and efficient cooperation of the organizational units responsible for implementation thereof, and timely implementation of Clean Air Actions.

Units responsible for the implementation of tasks, including public administration bodies, are indicated in the Clean Air Actions schedule for the zones covered by this Plan. The short-term action plan also implies obligations and restrictions for public administration bodies.

Relevant administrative bodies, such as county boards and cities with county rights should provide the Management Board of the Malopolska Region with:

- information on issued decisions whose arrangements contribute to the improvement of air quality,
- information on issued locally-binding legal acts (e.g. local spatial development plans), whose provisions implement the directions of activities indicated in chapter 8.2 and/or have a direct or indirect impact on air quality.

This information should be attached to the report on the implementation of the Plan referred to in chapter 11.2.

11.2. Monitoring of the Plan implementation

Systematic monitoring is the basis for the implementation of the Air Quality Plan. It gives the opportunity to assess the degree of implementation of assigned tasks and to correct the directions of scheduled Clean Air Actions. For the full implementation of corrective measures, it is important to assess the state of the environment and simultaneous monitoring of the compliance with environmental laws.

County governors, presidents of cities, mayors and municipality heads are obliged to report on the implementation of corrective measures indicated in the Plan in a given year for the previous year, and submit by **31 January** of each year to the Management Board of the Malopolska Region. The scope of information provided by units implementing the measures is defined as a template reporting sheet, available to each unit annually, and based on the inventory base of heating of buildings in Malopolska, administered by the Marshal's Office, and run by all municipalities of the region. Reports should be sent only in an electronic form to the e-mail address: powietrze@umwm.malopolska.pl (or e-mail address provided by the Marshal's Office of the Malopolska Region), administered by the Department of the Environment of the Marshal's Office of the Malopolska Region, as a completed sheet.

The report on activities related to emission reduction should cover all scheduled activities of the Air Quality Plan, together with activities included in the Short-Term Action Plan. The reports should present the costs of the actions taken, the environmental effect achieved, and indicate the sources of their financing. The most important element of reporting is the inclusion of information which enable monitoring the progress of the measures implementation. Therefore, to monitor the progress of the Plan implementation, it is necessary to use indicators coherent with those specified in the schedule.

Based on the reports on the implementation of Clean Air Actions, on the results of measurements of air pollution carried out by the Chief Inspector of Environmental Protection (Regional Department of Environmental Monitoring in Krakow), the Management Board of the Malopolska Region shall submit, by **31 March**, to the minister competent for the environment, a report on the implementation of the Plan in the previous year.

In addition, by **31 July** of each year, municipalities should provide data on the progress of replacing solid fuel heating devices, and the progress of inventory of heating sources, as of 30 June.

Every three years, the Board of the Malopolska Region should carry out a detailed assessment of the implementation of the Air Quality Plan. One of the objectives of monitoring the implementation of the Plan is the need to provide the European Commission with information on actions taken to prevent excessive pollution and comply with air quality standards.

The Governor of the Malopolska Region, assisted by the Malopolska Region Inspector of Environmental Protection, pursuant to art. 96a of the Environmental Protection Law, supervises the performance of long-term and short-term tasks, specified in this Air Quality Plan by municipality heads, mayors or city presidents, county governors and other entities. In the event of failure to meet the deadlines for the implementation of assigned tasks, the body responsible for this is subject to a financial penalty from PLN 50,000 to PLN 500,000.

The inspections of the Malopolska Region Inspector for Environmental Protection regarding the implementation of tasks listed in the AQP for the period until 2019 is based on the implementation indicators contained in the previous Air Quality Plan, i.e. adopted by resolution No. XXXII/451/17 of the Regional Assembly of the Malopolska Region of 23 January 2017.

III. JUSTIFICATION OF THE SCOPE OF ISSUES SPECIFIED AND ASSESSED BY THE BOARD OF THE MALOPOLSKA REGION

12. CONDITIONS RESULTING FROM SPATIAL DEVELOPMENT PLANS

The basic legal act regulating the process of spatial planning in Poland is the Act of 27 March 2003 on spatial planning and development. The purpose of the provisions of the Act is to allocate land for selected purposes and to determine how they should be used, adopting the principle of sustainable development. Sustainable development should be understood as socio-economic development, in which there is a process of integrating political, economic and social activities with preservation of natural balance and sustainability of basic natural processes, in order to guarantee the ability to meet the basic needs of the community or citizens of both the contemporary and future generations.

The Air Quality Plan is part of the environmental policy of the area, which is why the proposed corrective measures **must be integrated with existing plans, programs or strategies**. This document should be in line with the implementation of microscale, regional and local objectives.

During the creation of this Plan, *the Spatial Development Plan of the Malopolska Region*, adopted by the Regional Assembly of the Malopolska Region by Resolution No. XLVII/732/18/2018 of 26 March 2018, was analysed.

In 2018, there were **2,553** biding spatial development plans in municipalities in the Malopolska Region, covering about 67% of the Region's area. Of all the municipalities, 32 included 100% of the area in their spatial development plans.

Analysis of plans and conditions studies indicates the following development directions defined in the documents:

- changes in the production and consumption model to improve energy and raw material efficiency, wider use of renewable energy sources and minimize emissions of air pollutants by all basic types of sources;
- assembly of devices and installations effectively neutralizing environmental risk in existing facilities;
- decommissioning of leaded gasoline and adjusting gasoline and diesel requirements to European norms;
- creating conditions for smooth driving at a speed optimal for fuel consumption and emissions, improving transit and transport within the city, using traffic privileges for public transport, promoting and facilitating cycling and walking, using road lining with embankments and greenery, at the design stage creating continuous and collision-free roads, avoiding steep grade gradients (reduction of exhaust emissions);
- successive thermo-modernization of buildings (reduction of heat demand);
- using ecologically clean fuels in heat sources, using technologies that ensure minimum gas and dust emissions to the air, or alternative energy sources;
- reduction of pollutant emissions from fuel combustion processes in the industrial and municipal sector (use of good quality fuels, combustion of fuels adapted to the types of furnaces of heating devices, modernization of furnaces, technological systems, introduction of new combustion technologies, fumes cleaning, use of renewable heat sources, conducting rational waste management eliminating wild combustion);

- modernization and extension of the existing gas network – development of heating based on natural gas (supply gas to more areas);
- development of heating based on electricity and renewable energy sources;
- expansion of the mains and distribution networks and supply of new customers from the heating system.

13. ANALYSIS OF USE AND POTENTIAL OF RENEWABLE ENERGY SOURCES

The analysis of the use of renewable energy sources for the Malopolska Region aims at:

- identification of renewable energy resources in the region,
- identification of the degree to which renewable energy resources are used at present,
- indication of areas particularly predestined for the use of renewable energy resources.

The above issues were developed in relation to the following renewable energy sources: **biomass, hydropower, wind, solar and geothermal energy**. The potential of renewable energy in the Malopolska Region was determined on the basis of existing studies, in particular concerning the potential of hydropower, geothermal, wind, solar and biomass energy potential.

As part of the analysis, local government units were surveyed to identify installations using renewable energy sources. Data sources for the project were:

- planning documentation and programs implemented in the region,
- surveys carried out in municipalities on the needs of the Air Quality Plan for the Malopolska region,
- the Inventory Database for Heating Sources of Buildings in Malopolska, run at the request of the Marshal's Office of the Malopolska Region, of 5 December 2019.
- Register of energy producers in a small installation, kept by the Energy Regulatory Office, as of 25 October 2019.
- List of basic projects to be co-financed from the funds of the Regional Operational Program of the Malopolska Region for 2014-2020, under the 4th Priority Axis "Regional Energy Policy", Actions 4.2. "Eco-enterprises", of 17 September 2019.
- List of the number and capacity of connected PV sources shared for the purpose of LIFE Integrated Project – *Implementation of the Air Quality Plan for the Malopolska Region – Malopolska in a healthy atmosphere*, provided by TAURON Dystrybucja S.A., of 29 November 2019.
- List of active landfills with a degassing installation, prepared by the Central Statistical Office of Poland, as of 31 October 2018.
- Map of hydropower plants prepared by Male Elektrownie Wodne S.C., as of 16 December 2019 (http://mew.pl/narzedzia/mapa-mew)
- Location of boreholes: Map of boreholes and documentation points, prepared by the Polish Geological Institute – National Research Institute, as of 14 December 2019 (https://geologia.pgi.gov.pl/arcgis/apps/MapSeries/); Installed capacity - "Geothermal energy as a source of development of the tourist offer of the region" by dr hab. inz. Wieslaw Bujakowski professor of Polish Academy of Sciences, 2017,

- Register of agricultural biogas producers drawn up by the National Agricultural Support Center, as of 3 December 2019.
- CURRENT STATE DIAGNOSIS for the needs of preparing the Regional Action Plan for Climate and Energy for the Malopolska Region (RAPCE), in the scope of estimating the degree of use of renewable energy sources in the Malopolska Region, AGH Faculty of Geology, Geophysics and Environmental Protection, Department of Energy Resources, January 2020

Data collected for the analysis show that solar collectors, hydropower and photovoltaics have the largest share in the renewable energy sources in the Malopolska Region. Another significant source of energy is energy obtained from geothermal sources. The leading municipalities in using renewable energy installations are the following counties: Nowotarski (139 600 kW), Nowosadecki (94 310 kW), Tatrzanski (52 349 kW), Limanowski (33 454 kW), Krakowski (32 908 kW) and the city of Krakow (29 377 kW). The table below presents data by type of installation and counties.

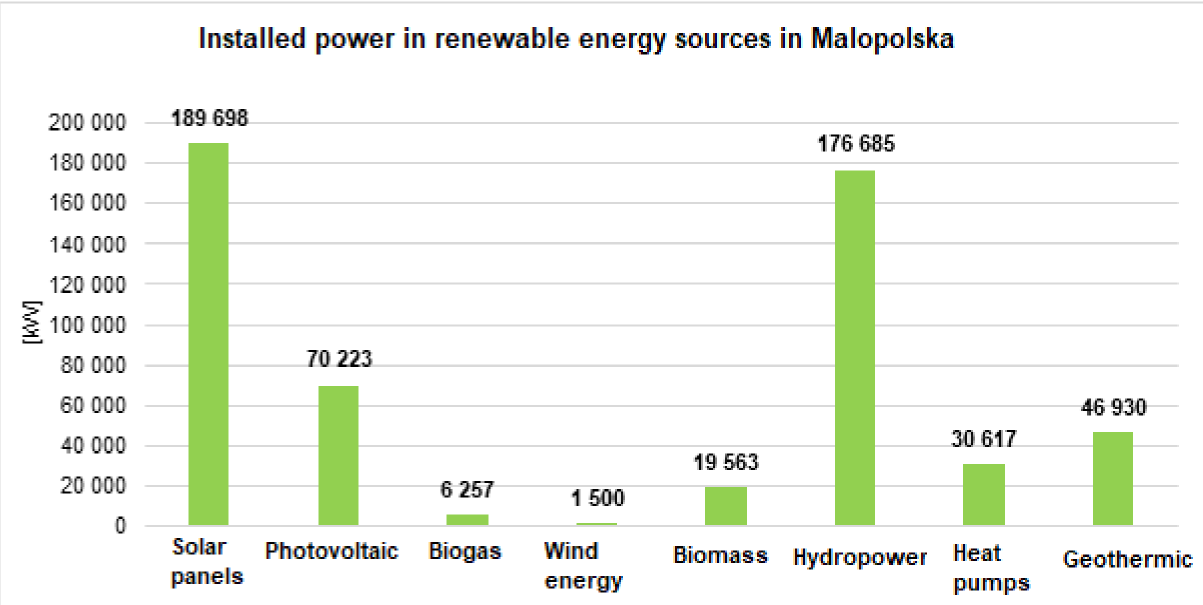


Figure 64. Capacity of installations on renewable energy sources in the Malopolska Region[143]

[143] Prepared on the basis of data from local governments, the Energy Regulatory Office, TAURON.

Table 46. Capacity of installations using renewable energy sources in counties of the Malopolska Region[144]

County	Installation based on biogas [kW]	Installations based on biomass [kW]	Installations on solar energy [kW] – photovoltaic installations	Installations based on solar energy [kW] – Solar collectors	Installations based on wind energy [kW]	Heat pumps [kW]	Geothermal installations [kW]	Hydropower installations [kW]	TOTAL [kW]
Bochenski	0	110	2 497	4 440	0	850	0	0	7 897
Brzeski	153	120	1 953	3 890	0	2 104	0	8 400	16 619
Chrzanowski	85	0	2 621	3 111	0	909	0	0	6 726
Dabrowski	1 000	177	771	1 332	0	278	0	0	3 558
Gorlicki	0	50	1 468	3 699	0	270	0	1 100	6 588
Krakowski	300	1834	8 548	17 344	0	1 882	0	3000	32 908
Limanowski	0	0	4 448	28 410	0	596	0	0	33 455
Miechowski	0	0	45	12 556	0	602	0	0	13 203
Myslenicki	246	1 016	3 399	5 766	0	200	0	0	10 627
Nowosadecki	0	1 536	6 661	26 834	0	3 204	0	56 075	94 310
Nowotarski	22	11 494	7 575	22 743	0	1 696	140	95 930	139 600
Olkuski	420	0	1 909	4 321	0	751	0	70	7 471
Oswiecimski	0	0	3 036	5 768	0	2 210	0	3 150	14 164
Proszowicki	0	0	466	1 884	1500	200	0	110	4 160
Suski	0	971	2 384	9 461	0	589	0	0	13 405
Tarnowski	0	195	5 114	13 042	0	1 121	0	0	19 472
Tatrzanski	0	625	1 123	2 730	0	451	46 790	630	52 349
Wadowicki	64	1 200	4 578	6 975	0	1 708	0	2 400	16 925
Wielicki	0	0	3 597	9 401	0	891	0	0	13 889
Krakow	3 628	0	5 779	4 130	0	10 020	0	5 820	29 377
Tarnow	324	118	1 221	1 151	0	32	0	0	2 845
Nowy Sacz	15	117	1 030	710	0	52	0	0	1 924
TOTAL	**6 257**	**19 563**	**70 223**	**189 698**	**1 500**	**30 617**	**46 930**	**176 685**	**541 473**

[144] Based on data sources from the self–governments of the Malopolska Region, TAURON data and other available sources.

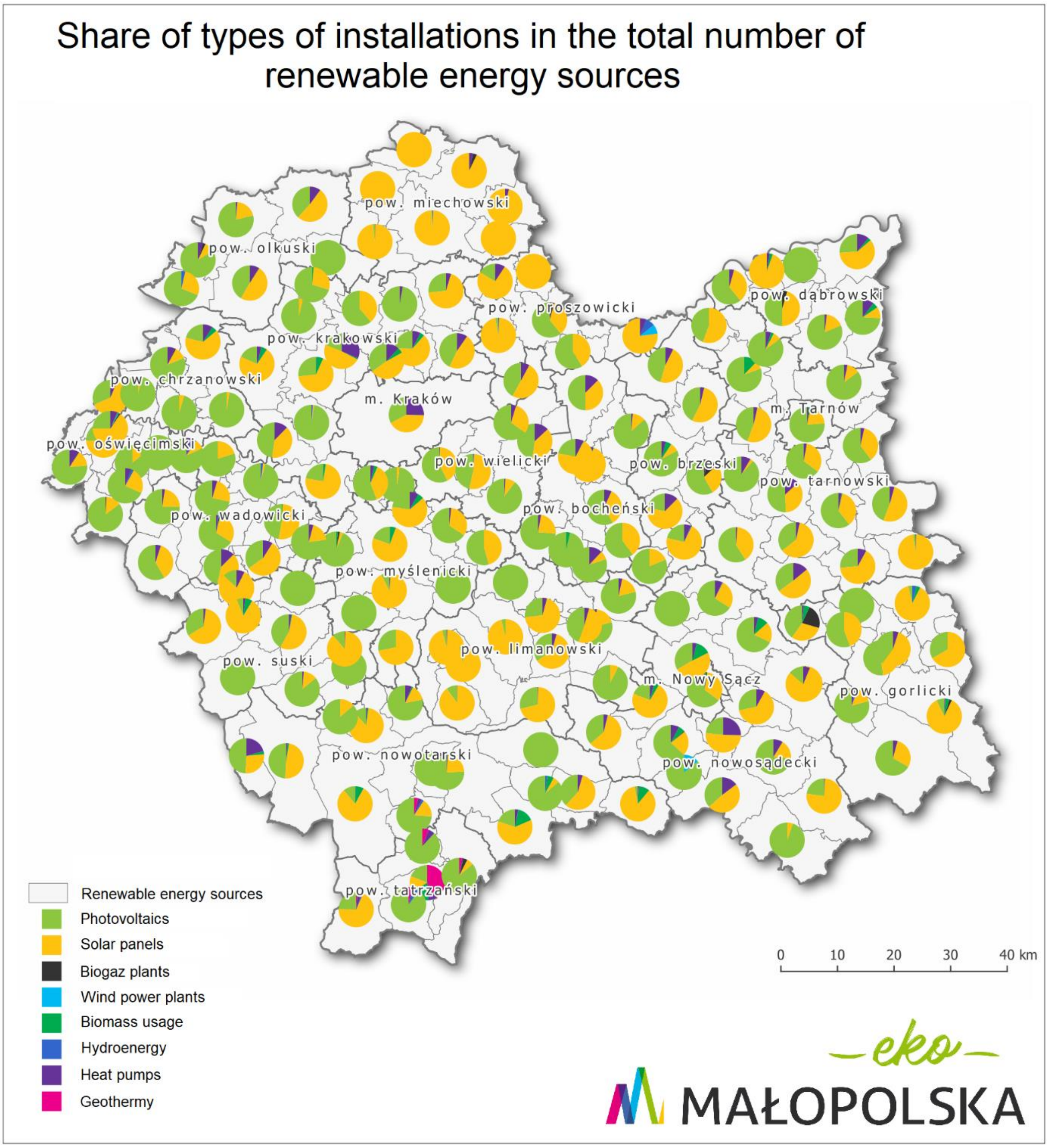


Figure 65. Share of types of installations in the total number of renewable energy sources in Malopolska municipalities (own study)

Photovoltaics and solar collectors are the most popular sources of renewable energy in Malopolska municipalities. Other renewable energy sources reflect the specificity of a given county, such as geothermal energy used in the southern part of the region. Biogas plants are located mainly in the eastern part – in the counties: Gorlicki, Dabrowski and Brzeski. The use of hydro-energy installations depends on the watercourses.

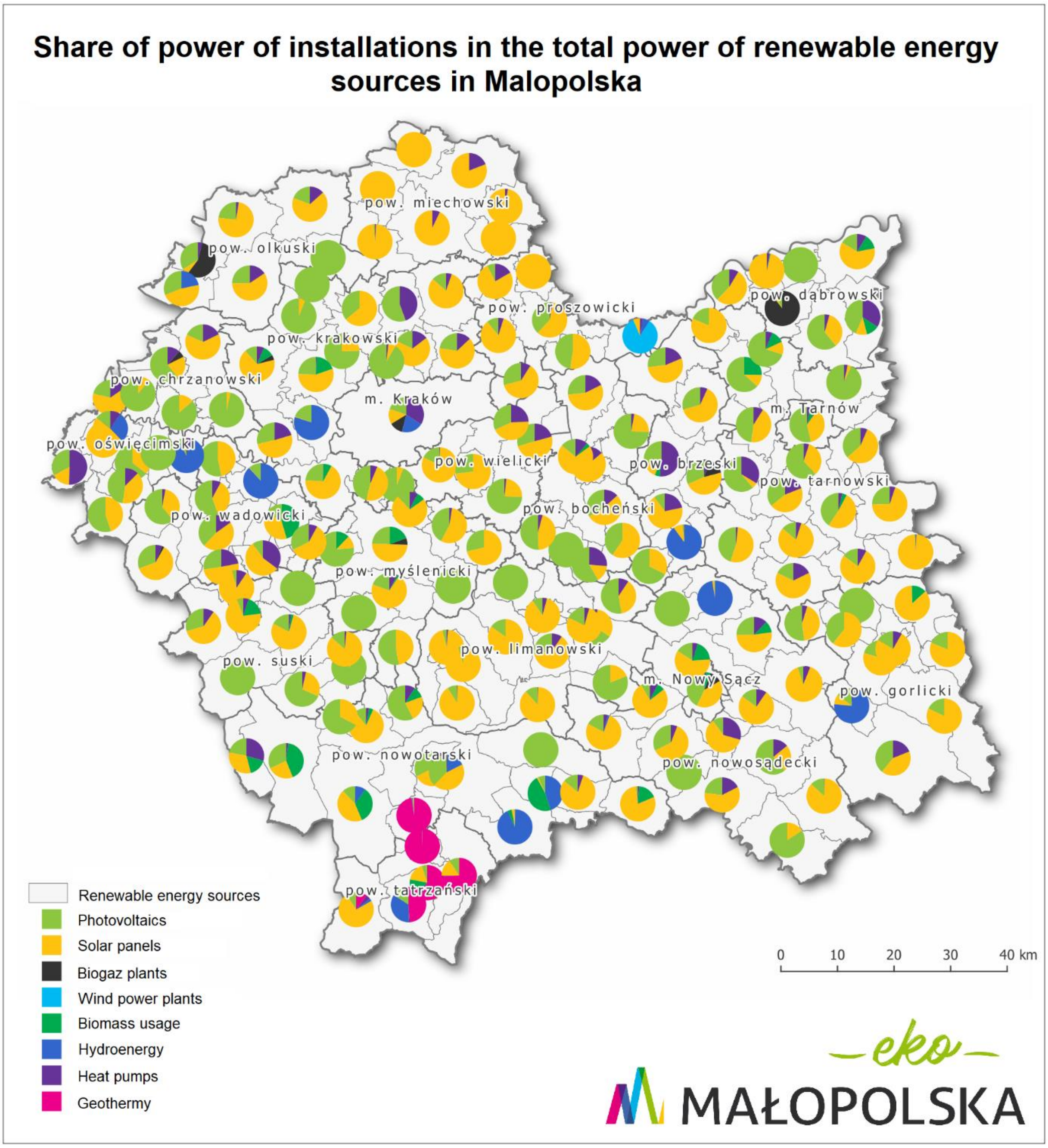


Figure 66. Share in the capacity of types of installations in the total installed capacity of renewable energy sources in Malopolska municipalities (own study)

Solar energy

Installations on solar energy (solar collectors) and installations on hydropower are the largest share in the total installed capacity of renewable energy sources. Photovoltaic installations also have a significant share of installed power. Installations on wind energy and biogas plants have the smallest share in the installed capacity.

The spatial distribution of the use of solar energy in the region is presented on the maps below.

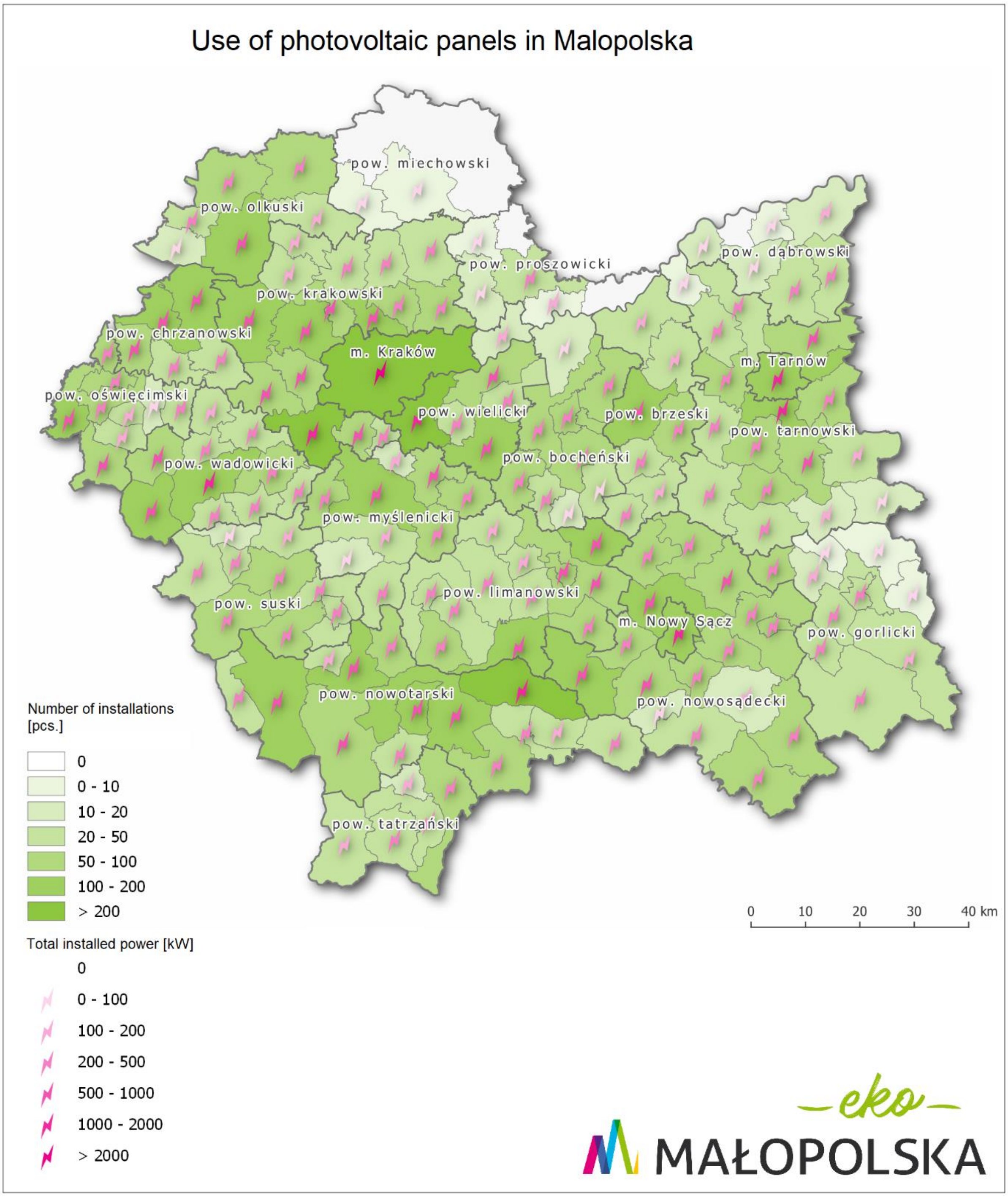


Figure 67. Use of photovoltaic panels in the Malopolska Region (own study)

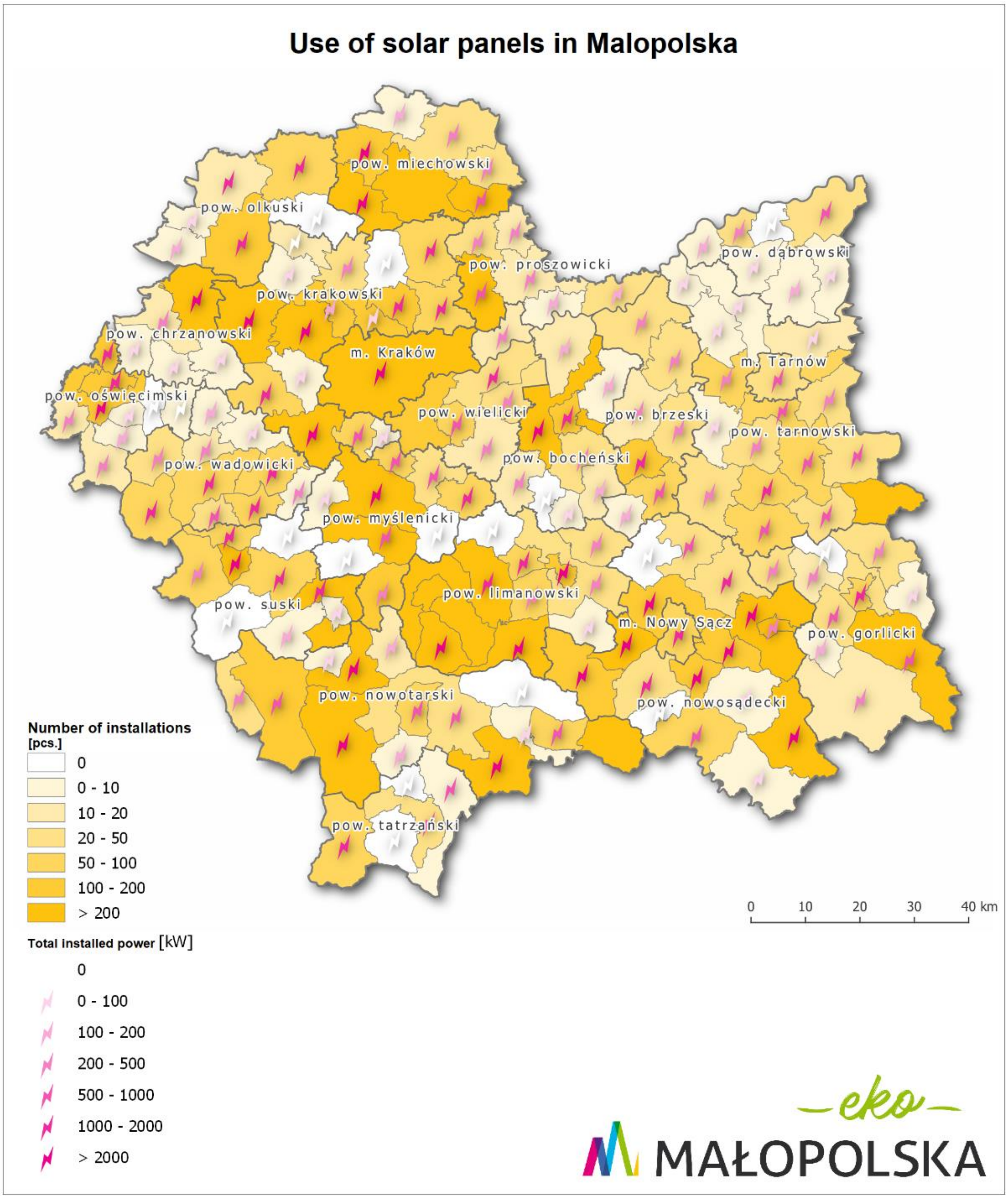


Figure 68. Use of solar collectors in the Malopolska Region (own study)

PV sources are zero-emission, they can stabilize the functioning of the power system, especially when they lower demand peaks. The development of photovoltaics to date has been based on micro-installations, which are increasingly installed on the roofs of houses. The total solar installations capacity in the Malopolska Region amounts to 70 223 kW.

The highest value of solar installations power in the Malopolska Region occurred in the following counties:

- Krakowski, 12,2%;
- Nowotarski, 10,8%;
- Nowosadecki, 9,5%;
- the city of Krakow, 8,2%;
- Tarnowski, 7,3%;
- Wadowicki, 6,5%.
- Limanowski, 6,3%;

The greatest use of photovoltaic installations was recorded in the following municipalities: the city of Krakow, Ochotnica Dolna, Wieliczka, Skawina, Nowy Sacz, Wadowice, Tarnow and Myslenice.

The factor that significantly influenced the development of solar collectors was the availability of EU subsidies and grants, including those in the programs implemented by the Regional and National Fund for Environmental Protection and Water Management. The total installed capacity in the Malopolska Region is 189 968 kW. The highest value of installed capacity of this type of installations in the Malopolska Region, used for hot water preparation, from solar collectors occurred in the following counties:

- Limanowski, 15,0 %;
- Nowosadecki, 14.1 %;
- Nowotarski, 12,0 %;
- Krakowski, 9,1 %;
- Tarnowski, 6,9 %;
- Miechowski, 6,6%;
- Suski, 5,0%;
- Wielicki, 5 %.

The largest number of investments in renewable energy sources, installation of solar collectors occurred in the following municipalities: Szczawnica, Mszana Dolna (urban municipality), Mszana Dolna (rural municipality), Wieliczka, Szerzyny, Miechow, Raba Wyzna, Grybow, and Krzeszowice.

Biogas

According to the register of agricultural biogas producers, the number of operating biogas plants is increasing every year. The total installed capacity of the biogas installation in the Malopolska Region is 6 257 kW. The highest value of the installed capacity of installations using biogas in the Malopolska Region occurred in the following counties:

- the city of Krakow, 58,0%;
- Dabrowski, 16,0%;
- Olkuski, 6,7%;
- the city of Nowy Sacz, 5,2%.

Most biogas installations are located in the following municipalities: Krakow, Olesno, Boleslaw, and Nowy Sacz.

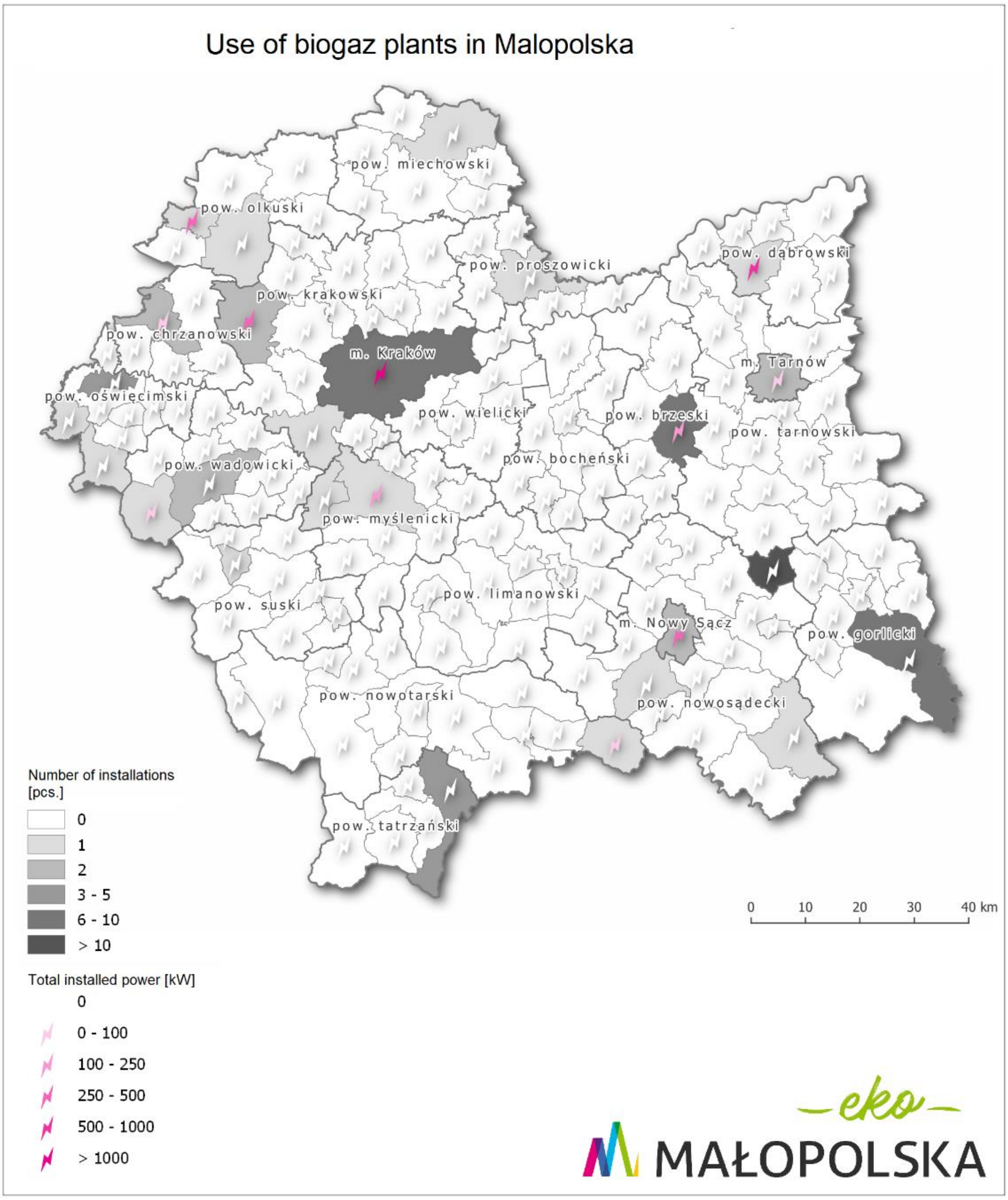


Figure 69. Biogas installations in the Malopolska Region (own study)

Biomass

Biomass has a greater share in the structure of renewable energy use than biogas. In the Malopolska Region, the estimated biomass power is 19 563 kW. The highest value of energy production from biomass in the Malopolska Region occurred in the following counties:

- Nowotarski, 58,8%;
- Krakowski, 9,4%;
- Nowosadecki, 7,9%;
- Wadowicki, 6,1%.

The use of energy from renewable sources (RES) – based on biomass, is one of the key factors reducing production costs. It is also an element of sustainable development of agriculture based on natural resources that are available on every farm. Currently preferred source of energy from biomass is the more effective use of farm by-products (e.g. crop residues, straw or wood from orchard trimming) and post-production bio-waste (e.g. from agro-food processing). The highest level of biomass use occurs in the following municipalities: Lapsze Nizne, Szczawnica, Czorsztyn, and Czarny Dunajec.

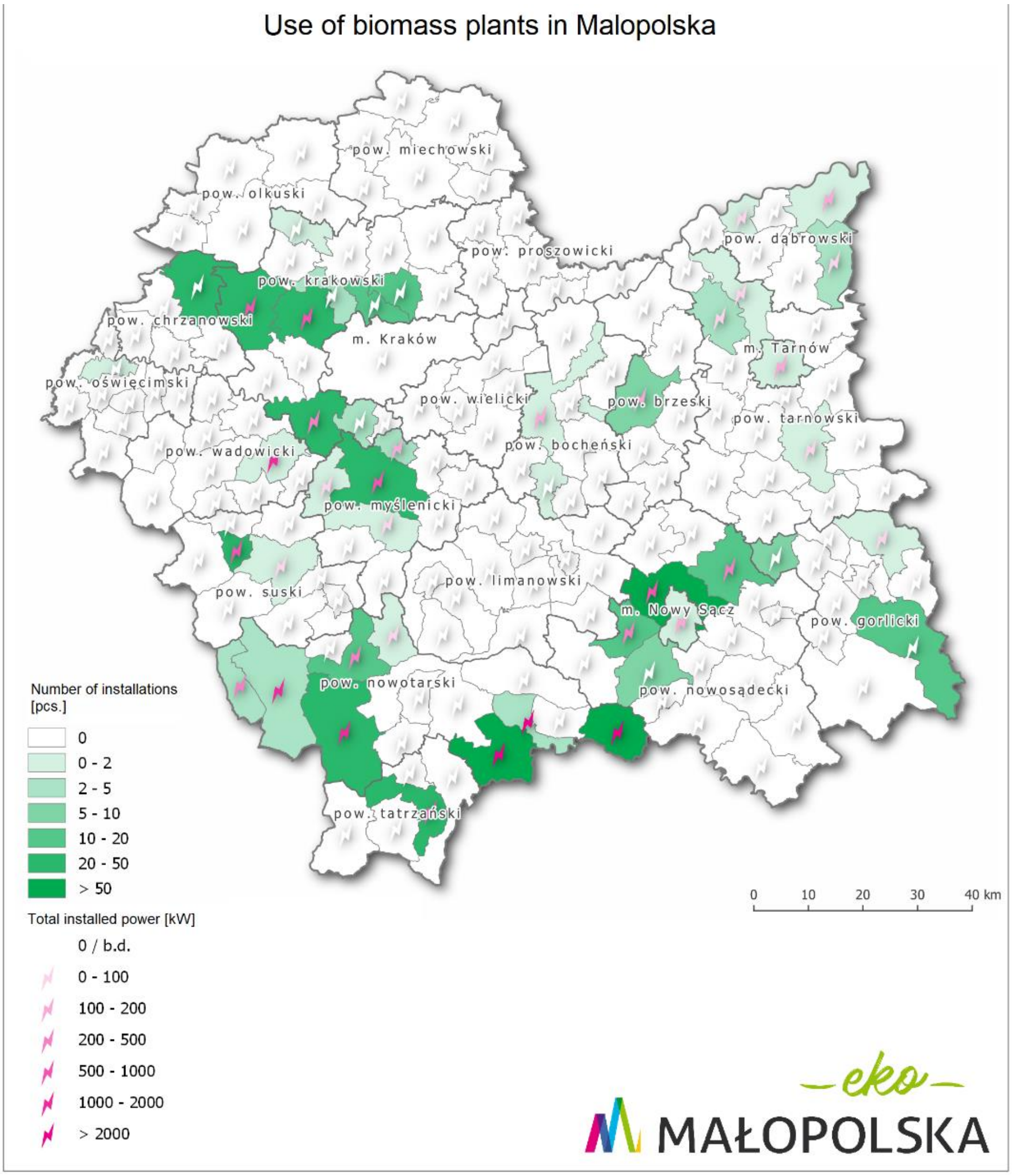


Figure 70. Installations on biomass in the Malopolska Region (own study)

Hydropower

Hydropower installations and hydropower stations constitute one of the largest shares in the production of electricity from renewable energy sources in the region. The total installed capacity in the Malopolska Region was estimated at nearly 176 685 kW. The highest installed capacity in the Malopolska Region occurred in the following counties:

- Nowotarski, 54,3%;
- Nowosadecki, 31,7%;
- Brzeski, 4,8%.

The largest hydropower installations are located in the following municipalities: Lapsze Nizne, Grodek nad Dunajcem, Czchow.

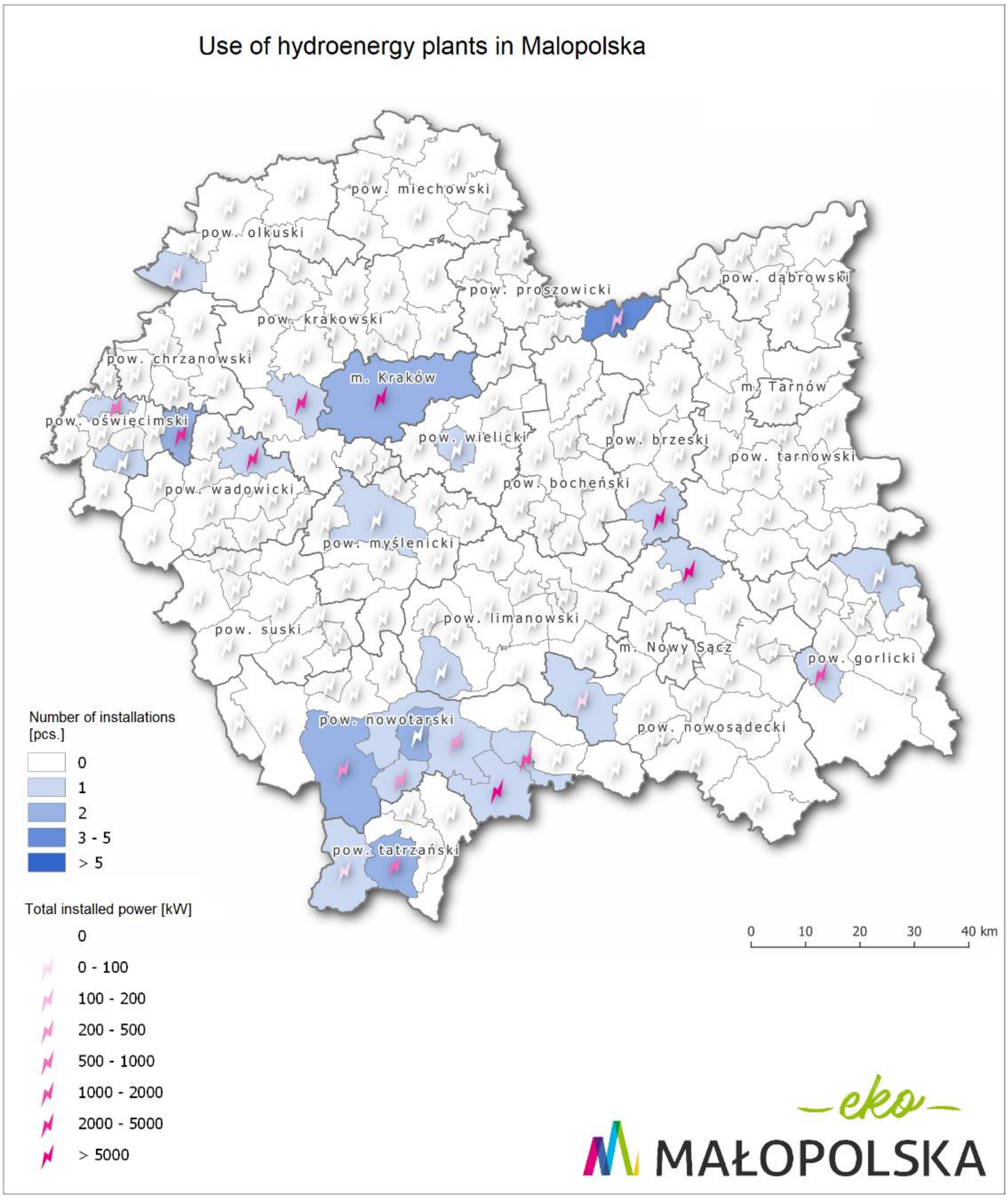


Figure 71. Installations on hydro energy in the Malopolska Region (own study)

Heat pumps

The total installed capacity of air and ground source heat pumps in the Malopolska Region is 30 616 kW. The highest value of power in the Malopolska Region installations with air and ground source heat pumps occurred in the following counties:

- the city of Krakow, 32,7%;
- Nowosadecki, 10,5%;

- Oswiecimski, 7,2%;
- Brzeski, 6,9%;
- Krakowski, 6,1%;
- Wadowicki, 5,6%;
- Nowotarski, 5,5%.

Most installations with air and ground source heat pumps are located in the following municipalities: the city of Krakow, Brzesko, Brzeszcze Nawojowa, Trzebinia, Stryszow, and Niepolomice.

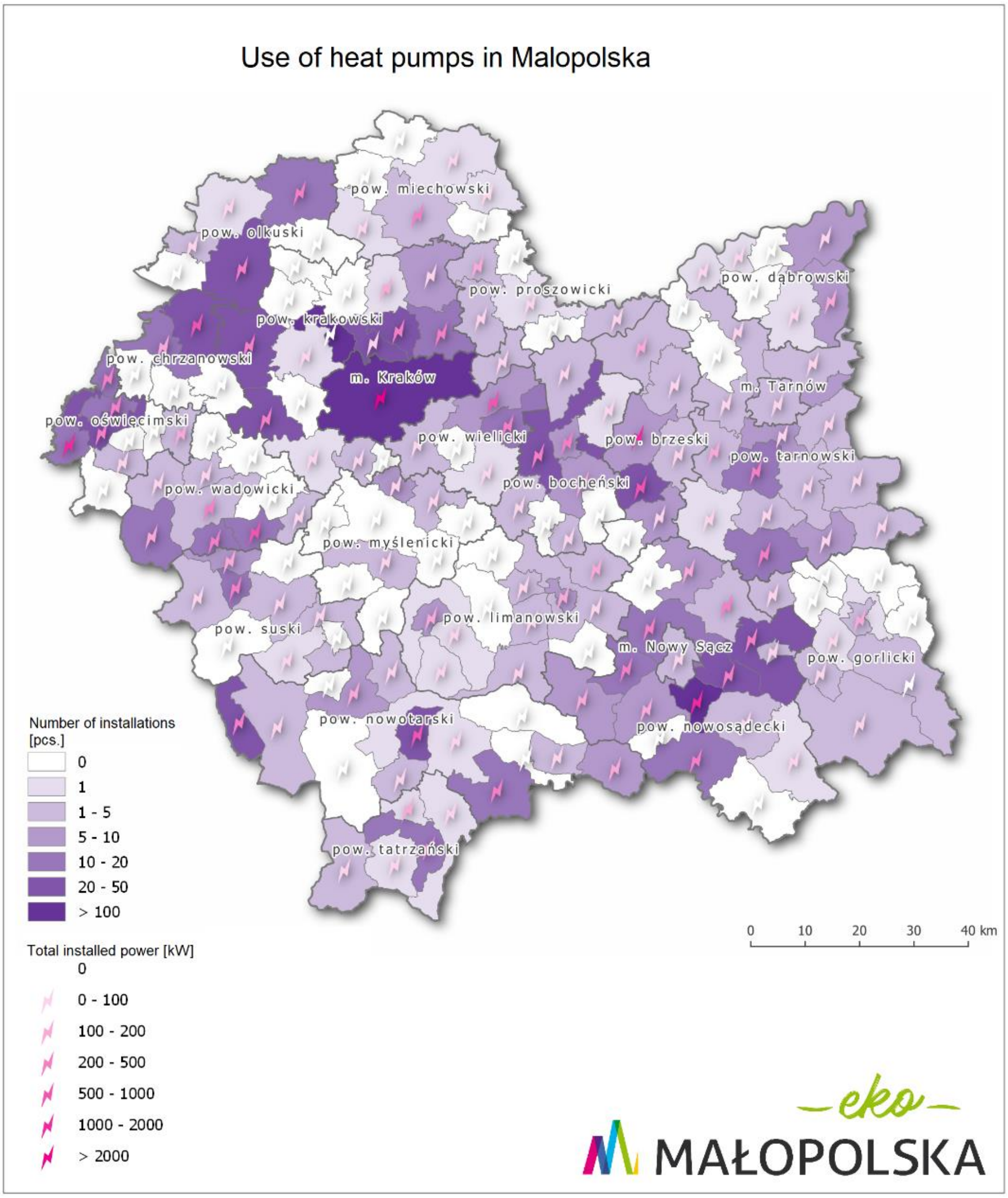


Figure 72. Installations with heat pumps in the Malopolska Region (own study).

Geothermal Energy

Estimated power from geothermal installations in the Malopolska Region is 46 930 kW. The highest value of energy production from geothermal sources in the region occurred in the following counties:

- Tatrzanski, 99,7%;
- Nowotarski, 0,3%.

The highest degree of utilization of geothermal energy occurred in the following municipalities: Bialy Dunajec, Bukowina Tatrzanska, Poronin, Zakopane, Kodcielisko, Szaflary.

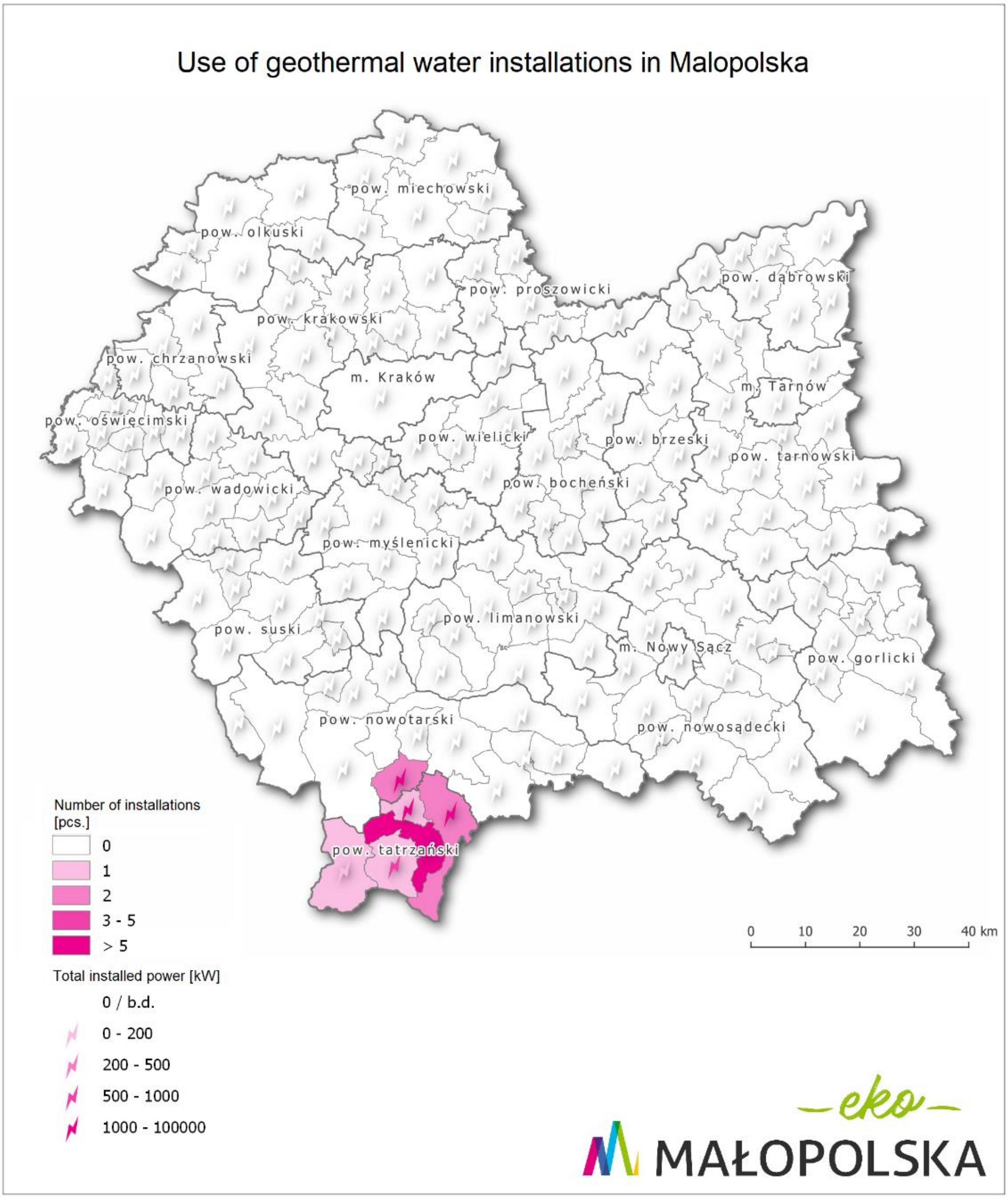


Figure 73. Installations on geothermal water systems in the Malopolska Region (own study)

Cogeneration

The installed capacity in the Malopolska Region from cogeneration is estimated at 1 148 kW. Installations using electricity in cogeneration from renewable sources occurred in the municipalities of Trzciana and Olesno.

Wind energy

The largest number of installations on wind energy, with the largest installed capacity, occurs in the counties of Proszowice.

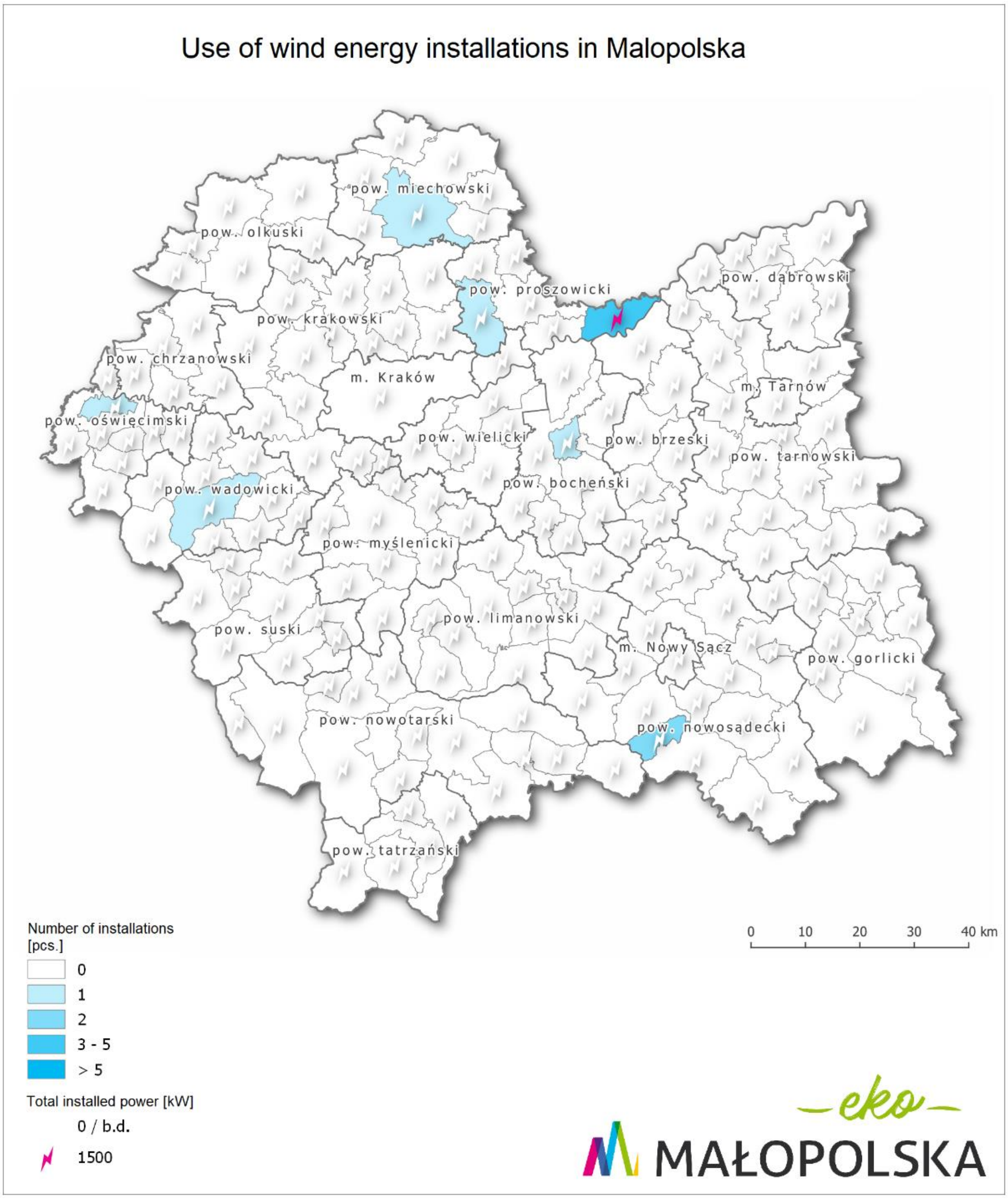


Figure 74. Installations on wind energy in the Malopolska Region (own study)

13.1. Analysis of the potential for use of renewable energy sources in the Malopolska Region.

The use of local renewable energy potential in Malopolska Region is the most effective method of reducing emissions to the atmosphere, not only of air pollution, but also of greenhouse gases responsible for inevitable climate changes. The use of these sources for energy production can bring a significant ecological effect on both a local and regional scale. In addition, the use of renewable energy may contribute to increased energy security of the region, and in particular to improving energy supply in areas with a poorly developed energy infrastructure.

The assessment of the economic, technical and ecological potential indicates that the Malopolska Region has substantial renewable energy resources that can be used by individual households as well as in energy clusters, energy cooperatives and virtual power plants.

It is estimated that, in the Malopolska Region, there are over 35,000 renewable energy installations with a total installed capacity of 541 MW. Solar collectors (35% of installed capacity) and hydropower (32% of installed capacity) play a key role on the market of renewable energy installations in Malopolska. Forecasts indicate accelerated development of renewable energy installations in the coming years. This particularly applies to heat pumps and photovoltaics, which currently account for 12% of the total installed capacity in renewable energy sources. Undoubtedly, the need to improve air quality, as well as applicable anti-smog resolutions, will contribute to this.

In terms of the regions, the greatest potential (technical, economic and ecological) relates to solar installations (both photovoltaic panels and solar collectors), and heat pump systems (both ground and air source). Locally, in Malopolska there are good conditions for the use of water/water heat pumps and the development of geothermal energy (including the possibility of connecting to a geothermal network) and the use of biogas (from waste landfills, sewage treatment plants, as well as agricultural biomass, agricultural by-products and residues from agro-food processing for energy purposes in agricultural biogas plants). Locally, there are also relatively satisfactory conditions for the development of small hydropower plants and wind farm installations.

The most favourable solar conditions occur in the northern and western parts of the region, however, the possibility of producing electricity and hot utility water from solar radiation is possible throughout the entire Malopolska Region. The number of installed solar collector and solar panel installations indicates the large market potential of this type of installation.

The second leading type of installation are systems supported by heat pumps, which can be used as individual units (for heating or production of domestic hot water), but, in combination with photovoltaic panels (so-called integrated systems), they allow a significant reduction of energy costs. Such systems can be an alternative to electric heating, heating oil or liquid gas, and also are a worthy alternative in the absence of a connection to natural gas network. Both air and ground heat pumps can be successfully used throughout the Malopolska region (unless local zoning plans state otherwise – regarding ground heat pumps).

Connecting buildings to the geothermal network allows using the local potential of resources. The development of the geothermal network is currently only possible in Podhale, however, conducted research and analyzes indicate that the development of deep geothermal energy is also possible locally in other parts of the region.

Further development of renewable energy installations in the Malopolska Region and indication of the most promising areas (counties, municipalities) requires a detailed analysis of the local renewable energy potential, in terms of its use in households, energy clusters, energy cooperatives and virtual power plants.

14. ECONOMIC ANALYSIS OF ENVIRONMENTAL COSTS

The health impact of air pollution

The impact of each pollutant depends on the amount of emissions, the harmfulness of the substance and its level of interaction with other substances in the air. The impact also depends on where it is emitted, how long the pollutant remains in the atmosphere and ultimately where the pollutant goes and how vulnerable the exposed population or environment is. Particularly vulnerable people suffer the greatest impact from poor air quality.

The World Health Organization has ranked air pollution and climate change as the top 10 health threats in the world in 2019. **According to WHO, air pollution causes 25% of deaths due to heart disease – in Malopolska in 2018, 3 700 people could have died of it**.

Air pollution is one of the major risk factors affecting public health, along with cancer, heart disease and obesity. It causes more harm than secondhand smoke. A World Health Organization review found that long-term exposure to air pollution reduces life expectancy by increasing the incidence of lung, heart, and cardiovascular disease.

Conditions caused or exacerbated by air pollution include asthma, chronic bronchitis, chronic heart disease (CHD), and strokes. These conditions significantly reduce the quality of life. It also means that people are less able to work and require more medical care, resulting in higher social costs and a burden on the national health service.

Poor air quality can affect health at all stages of life. Children and the elderly are the most vulnerable. In children, there is evidence of decreased lung capacity, decreased birth weight, and even the effect of air quality on IQ.

Increased exposure to air pollution throughout life can result in a reduction in life expectancy and a deterioration in well-being at the end of life. There is also new evidence of a link between air pollution and accelerated cognitive decline. The standards indicated by WHO as safe for health in the scope of PM10 concentration are the value of 20 μg/m^3 for the average annual concentration and 50 μg/m^3 for the average daily concentration. For PM2.5, these values are 50% lower and amount to 10 and 25 μg/m^3, respectively.

Particularly high levels of pollution occur locally at the sources of their emissions, for example near busy roads, industrial installations or large clusters of single-family houses. This exposure to high concentrations of pollutants is likely to directly cause negative social and health effects. The impact is cumulative, therefore residents' exposure to pollution should be reduced in all places and situations, at home, on the road, at school and at work.

The World Health Organization, conducting research on the quality of life and health of people, also studies the impact of air quality on the lives of the inhabitants of individual countries. According to a report from September 2016, nine out of ten people live in an environment where the level of air pollution is excessive, which contributes to the occurrence of, inter alia, strokes, heart disease and lung cancer. Air pollution is estimated to cause 3 million deaths annually worldwide. In Europe, due to air pollution, life expectancy is reduced by an average of 8,5 months.

According to estimates, air pollution is responsible for:

- 25% of deaths due to cardiovascular diseases,
- 43% of deaths due to respiratory diseases,
- 29% of deaths from lung cancer
- 24% of deaths from stroke.

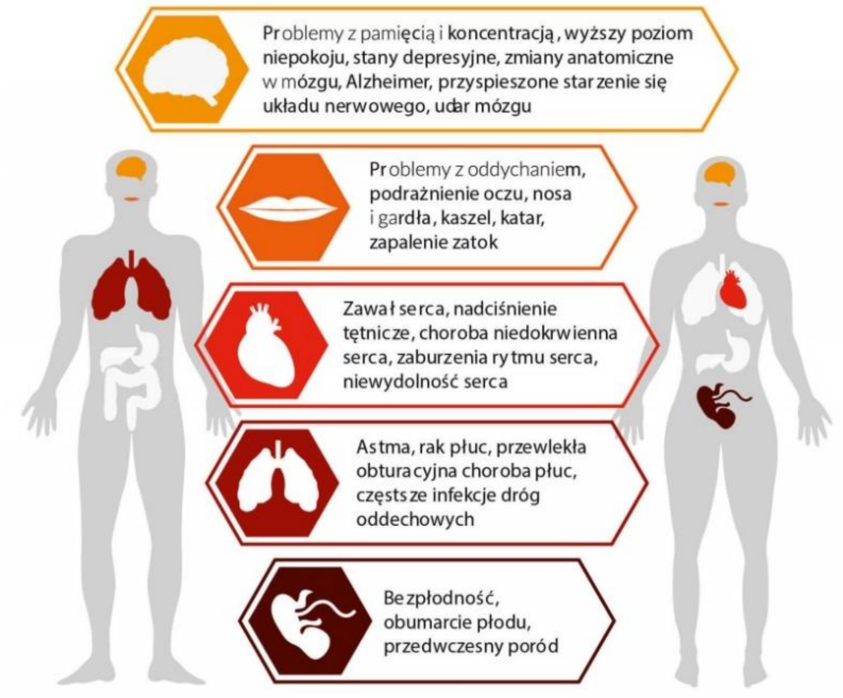


Figure 75. The impact of air pollution on human health[145]

Air quality and the COVID-19 pandemic

New light on the issue of the impact of air quality on human health is also shed by observations made after the outbreak of the COVID-19 pandemic – a disease caused by the SARS-CoV-2 virus. One of the hardest hit regions are Italy (mainly Lombardy), China and the United States. In many regions of these countries, one of the highest exceedances of air quality standards in the world is also recorded. The number of cases in the most polluted places in Europe and in the world prompted scientists to study the impact of air quality on both the scale of the disease and the course of the disease itself.

Scientists from the Harvard Department of Public Health have investigated whether long-term exposure to PM2,5 particulate air pollution is associated with an increased risk of death from COVID-19, based on the course of the pandemic in the United States[146]. For this purpose, data from over 3,000 counties was collected, representing 98% of the US population. The analysis also took into account other factors that may affect the incidence of COVID-19 in people. The results of the analyses showed that an increase in the average long-term concentration of PM2.5 by only 1 μg/m^3 was associated with an 8% increase in the percentage of deaths from COVID-19 infection. **This means that even a small increase in exposure to air pollution leads to a huge increase in the risk of death from COVID-19 disease.** Lung damage caused by breathing poor quality air is a significant risk factor in addition to cardiovascular disease, diabetes and smoking.

Similar studies were also carried out by researchers from the Faculty of Environmental Sciences of the University of Aarhus (Denmark) and the University of Siena (Italy)[147]. They analysed the significantly higher national fatality rate in northern Italy (Lombardia and Emilia Romagna) in the context of the fact that it is one of the most polluted regions in Europe. The authors of the study emphasize that important factors influencing the morbidity should not be overlooked, such as the high average age of the region's inhabitants, a significant difference in the level of healthcare

[145] The influence of air pollutants on human health, The Krakow Smog Alert Association 2017

[146] Source: *Exposure to air pollution and COVID-19 mortality in the United States: A nationwide cross-sectional study*, Xiao Wu i in., T.H. Chan School of Public Health, Boston

[147] Source: *Can atmospheric pollution be considered a co-factor in extremely high level of SARS-CoV-2 lethality in Northern Italy?* Edoardo Conticini, Bruno Frediani, Dario Caro, Uniwersytet w Sienie, Uniwersytet w Aarhus

between regions, the efficiency of health care or the classification of cases. However, they directly indicate that people living in areas with high levels of pollution are more susceptible to the development of conditions conducive to chronic respiratory diseases in the body and exposure to other infectious agents. Moreover, long-term exposure to air pollution leads to chronic inflammatory disease of the airways even in young and healthy people. Excessive concentrations of pollutants should be considered as an additional factor increasing mortality in the analysed areas. Living conditions in northern Italy, already weakened by harmful substances in the air, can lead to complications and a more severe course of COVID-19 disease.

Similar conclusions were reached by scientists studying the factors influencing the course of the SARS (severe acute respiratory syndrome) epidemic in China as early as 2002. This is a different virus than the one responsible for the COVID-19 pandemic, however, the authors pointed directly to a strong relationship between the risk of dying from SARS and the values of the air pollution index. As today, exposure to high concentrations of pollutants has contributed to increased mortality[148].

In addition to research on the impact of air quality on the incidence of COVID-19 and the level of mortality from infection, dust particles were also tested for the presence of SARS-CoV-2 genetic material on their surface. In the province of Bergamo, 34 PM10 dust samples were collected for three weeks (February 21-March 13, 2020). The authors, in their preliminary conclusions from the study, indicated that at least 1 marker (indicator) of the virus genetic material was present in 20 out of 34 samples. The authors are conducting further research to confirm the preliminary conclusions, but also to determine how many virus particles can be transmitted through PM10 particles and how long it remains contaminated[149].

Although the conducted research will be expanded and supplemented, due to the pandemic that is still ongoing, in all scientific research there is a thesis or hypothesis that air quality is one of the factors that may affect both the course of the disease and the percentage of deaths COVID-19. Moreover, the first studies have emerged indicating that air pollution may contribute to the spread of the virus. This is an extremely important fact in the context of the potential second wave of disease in the fall and winter season, when pollutant concentrations are the highest throughout the year. **Experts also point out that due to the potential second wave of the COVID-19 epidemic, anti-smog measures should be strengthened. Actions related to the reduction of emissions and the improvement of air quality are particularly urgent during the epidemic as they relieve the health service.**

The observations made to date should therefore be a driving force for even more intense efforts to protect the air, which may contribute to positive health effects not only in the long term, but also in the short term.

Effects of exposure to air pollution

The effects of exposure to air pollution are:

- increased mortality,
- hospital visits caused by cardiovascular and respiratory diseases,
- emergency interventions caused by attacks of respiratory or cardiovascular diseases,
- absence from work or school,
- acute symptoms (cough, respiratory infections),
- costs of treating respiratory and cardiovascular diseases.

[148] Source: *Air pollution and case fatality of SARS in the People's Republic of China: an ecologic study*, Yan Cui i in.
[149] Source: SARS-Cov-2RNA found on particulate matter of Bergamo in Northern Italy: First evidence, Leonardo Setti i in.

Estimating costs related to air quality

The bottom-up approach is considered to be the best-developed method and with the best practices in calculating external costs caused by air pollution, which is primarily used to calculate external environmental costs for individual projects and their elements. This method – bottom-up approach – is recommended by *Guide to Cost-Benefit Analysis of Investment Projects – Economic appraisal tool for Cohesion Policy 2014-2020*. The bottom-up approach is based on the impact path method, which is implemented in the following two steps:

- estimating the amount of additional or non-emitted air pollutants,
- valuations of the total costs of air pollution – the estimated amount of emissions should be multiplied by the unit costs attributable to the pollutant,

It is possible to separate external costs resulting from emissions from the municipal and household sector and costs arising from emissions from transport. The national average costs of pollutant emissions from transport were based on the data contained in Table 14 of the *Handbook on the external costs of transport*[150] (data for 2016).

Table 47. Cost of air pollution: average cost of damage (including all effects: health effects, loss of crops, loss of biodiversity, material damage) [EUR / kg emissions] for the national average of transport in 2016 (excluding sea transport)

	Cost $€_{2016}$/kg	Cost PLN/kg
NOx transport in rural areas	8,9	38,8
NOx transport in cities	14,7	64,1
PM2.5 transport in cities over 500,000 inhabitants	282,0	1 230,4
PM2.5 transport in cities	91,0	388,5
PM2.5 transport in rural areas	52,0	222,0
PM10 medium	5,2	22,7

** PM10 cost indicators can be used for non-exhaust emissions (e.g. from brake blocks and tire wear)*

The unit costs of air pollutants set out in the *Handbook on the external costs of transport – January 2019*[151] were used for the need to monetize pollution emissions.

Unit costs from the tables *Handbook on the external costs of transport* were calculated using the average euro exchange rate in the base year, as well as taking into account the change in costs resulting from macroeconomic indicators related to inflation, GDP and population change in the forecast years. Due to the change in the above ratios, the cost rates take the values in the convicts for individual years concerning the rates from 2016 in the table below.

[150] Handbook on the external costs of transport, ver.2019, European Commission, January 2019, https://ec.europa.eu/transport/sites/transport/files/studies/internalisation-handbook-isbn-978-92-79-96917-1.pdf

[151] Handbook on the external costs of transport, ver.2019, European Commission, January 2019; table 14; p. 49

Table 48. Cost of air pollution: average cost of damage [PLN/kg emission] for the national average from transport in 2018, 2023 and 2026.[152]

	2018	2023	2026
NOx transport in rural areas	42,7	49,4	53,3
NOx transport in cities	70,5	81,5	88,1
PM2.5 transport in cities over 500,000 inhabitants	1 352,7	1 564,2	1 689,4
PM2.5 transport in cities	436,5	504,7	545,2
PM2.5 transport in rural areas	249,4	288,4	311,5
PM10 medium	24,9	28,8	31,1

The direct determination of the costs of health damage (increase in morbidity/mortality) caused by air pollution is a matter of subjective assessment. The value of human life is difficult to determine – the "market price" of human life and health is estimated at between EUR 1 and 2 million. External costs are determined based on the number of cases and the estimated cost per case.

There are lots of studies dealing with the subject of estimating the external costs of poor air quality. Following the methodology used in the European Union, the Clean Air Program for Europe determined the number of external costs incurred by each country in connection with the emission of specific pollutants, such as PM2.5, NOx, SO_2, inorganic volatile compounds, as well as ammonia. The analyzes according to the CAFE-CBA methodology take into account the volume of emissions of each substance, the size of the area and the number of the exposed population. The emission of each kilogram of pollutants, such as PM2.5, nitrogen dioxide, sulphur dioxide or others, causes external costs resulting from the negative impact of these pollutants on human health and ecosystems.

To estimate the number of external costs that can be avoided by the reduction of surface emission, the study *Internalization of external costs in Lithuania and Poland* has been used to adopt the results of the analysis of external costs for 2020. The individual (contaminating pollution) indicators were referred to as determined based on specific simulations ecological effect scenarios. External costs that can be avoided have been set for all regions and pollution. Cost estimation by health impact, impact on biodiversity reduction and impact on buildings and materials were used.

Table 49. Rates of external costs resulting from surface emissions by type of impact and type of substance.[153]

	EURO/Mg	PLN/Mg
Impact on health		
NO_x	8 401	35 866
PM10	1 185	5 059
PM2.5	24 224	103 419
Biodiversity decline		
NO_x	912	3 893
Impact on buildings		
NO_x	132	563

[152] Based on the rates in Table 41, including monetary indexation indicators at the end of the year
[153] PLN values calculated on the basis of the EURO exchange rate for public procurement at the level of 4.2693 PLN/Euro

Taking into account the change in costs over time, the rates for external emissions have been calculated for the forecast years 2023 and 2026. The change in external costs is associated with the change in the indexation of monetary values at the end of a given year.

Table 50. Rates of external costs broken down by type of impact and type of substance for the 2023 and 2026 forecast years [PLN/Mg of emissions].

	2023	2026
Impact on health		
NO_x	45 594,4	49 244,9
PM10	6 431,2	6 946,1
PM2.5	131 470,7	141 966,7
Biodiversity decline		
NO_x	4 356,7	4 705,5
Impact on buildings		
NO_x	630,1	680,5

The amount of external costs can be referred to as the total substance emission in the zones of the Malopolska Region, indicating how many costs are incurred each year due to the emission of the substance. Additionally, it is possible to indicate the number of costs avoided due to the introduction of remedial actions within the framework of the Air Quality Plan. The table below indicates the external costs of the total emissions and avoidable due to the implementation of the Air Quality Plan until 2023 and 2026.

Table 51. The amount of external costs s caused by emissions of pollutants from transport sources and sources of the municipal and household sector in the zones of the Malopolska Region and the number of costs avoided due to the reduction of emissions in the forecast years 2023 and 2026.

Substance	Costs incurred due to poor air quality in 2018 [PLN million/year]	Amount of external costs avoided due to emission reduction in the forecast years	
		2023 [PLN million/year]	2026 [PLN million/year]
Surface emission			
NOx	333[154]	3	3
PM2.5	2 830	1 285	1 422
PM10	141	72	80
Linear emission			
NOx	1 657	53[155]	89
PM2.5	1 674	10	19
PM10	40	0,20	0,5

[154] Total cost of impact on health, changes in biodiversity and impact on buildings.
[155] Avoided costs related to emission reduction in the Krakow Agglomeration.

The subject of external costs of poor air quality was also discussed locally in the study of the Malopolska Regional Development Observatory entitled "***The influence of air pollution on economic activities in Malopolska Region***"[156]. 4 analyzes were performed on the following topics:

1. The impact of air pollution on business activities in the opinion of company representatives
2. Sickness absence in the Malopolska Region related to exposure to polluted air.
3. Sickness absence by reasons.
4. Opinions of the inhabitants of Malopolska on smog.

The first part of the report examines the impact of air pollution on three business sectors: tourism, outsourcing and industry. In the case of the tourism industry, it was indicated that air pollution in Malopolska has little impact on its functioning. However, among entrepreneurs operating in locations considered polluted by tourists, there are persistent concerns about a decline in the number of tourists. Poor air quality may discourage them from visiting the region in winter. Representatives of the tourism industry fear that without solving the problem of poor air quality, they may lose more and more customers, as awareness of the issue of air quality is growing. Such a trend may contribute to lowering the revenues from tourism activity. The ecological offer should therefore be developed in tandem with the tourist offer.

In the case of the outsourcing industry (industries such as information and communication, professional, scientific and technical activities), the impact of air pollution is very small. Despite the still existing exceedances of air quality standards in Krakow, where a significant number of companies from the outsourcing industry are located, the city of Krakow is perceived as effectively fighting smog, which results in no impact on recruitment processes. Moreover, the number of days of sick leave caused by air pollution in Krakow is one of the lowest in the region.

A significant impact of air pollution is visible in the industrial sector. This impact, however, forces modernization activities due to environmental standards that entrepreneurs must meet. Despite the fact that company representatives did not indicate any relationship between sickness absence of employees and poor air quality, the level of absence in this industry is one of the highest (on average 13,3 days a year compared to the average for Malopolska, i.e. 11 days).

In the second and third parts of the report, the main reasons for sickness absence in Malopolska were identified. The average absence rate per 1 employee was also determined in 5 disease groups, the presence of which is related to air pollution. The most common air pollution diseases are:

- respiratory diseases (14%),
- nervous system diseases (6,6%),
- mental and behavioural disorders (6,2%),
- cardiovascular diseases (4,6%),
- cancer (3,4%)

[156] The influence of air pollution on economic activities in Malopolska Region, Regional Development Observatory of the Malopolska Region, https://www.obserwatorium.malopolska.pl/wp-content/uploads/2020/06/Wp%C5%82yw_zanieczyszczenia_powietrza_na_dzia%C5%82alno%C5%9B%C4%87_gospodarcz%C4%85.pdf

In terms of sickness absence related to exposure to polluted air, the citizens of Malopolska lose from 2.05 million to 2.23 million working days a year due to air pollution. Most sick days are observed in January and February, i.e. the heating season. In turn, the worst month in 2015-2018 was January, which means that on average it is the worst period in terms of air quality and during this period the most lost work days attributable to air pollution occur. **The average annual cost of lost working days associated with the gross salary is PLN 400 million.**

In terms of the number of absences from work caused by poor air quality, Krakow had the highest absolute number for the analysed years. However, it results not only from the air quality, but to a greater extent from a significantly higher population than in other cities of the voivodeship. Per employee, the number of lost working days is the highest in Nowy Sacz.

The highest average absenteeism rate per 1 employed person is recorded in the following counties: Nowy Sacz (5,23 days per person), Limanowski (5,13), Gorlicki (5,04), Chrzanowski (4,84), Miechowski (4,79)) and Oswiecim (4,74). In turn, the lowest values of this indicator are achieved in the following counties: Proszowicki (3,31), Tatrzanski (3,35), Wadowicki (3,6), Nowy Targ (3,67) and in Krakow (3,67).

15. ESTIMATED TIME REQUIRED TO ACHIEVE THE FRAMEWORK OBJECTIVES

The air quality analysis in this Plan was carried out assuming 2023 forecast year due to the achievement of permissible levels for PM10 and PM2.5 and the forecast year 2026 to achieve the permissible level of nitrogen dioxide and the target level of benzo(a)pyrene. This period was adopted as an estimated time for the implementation of corrective measures. All remedial actions can be divided by time of implementation into:

- short-term:
    - type I activities – less than one year,
    - type II activities – one year,
    - type III activities – over one year,
- medium-term – for a period not exceeding 4 years,
- long-term activities – for a period not longer than 6 years.

The analysis of air quality in the forecast year indicates that keeping to the level of intentional benzo(a)pyrene will not be possible in the case of carrying out activities only in the zones of the Malopolska Region. This is due to the significant share of sources outside the voivodeship in average annual concentrations of benzo(a)pyrene. Therefore, due to the ongoing implementation of the Air Quality Plans in the neighbouring regions whose year of achievement of air quality standards is 2026, for benzo(a)pyrene a forecast year coinciding with other regions is 2026. To achieve the target level of benzo(a)pyrene in the Malopolska Region, it is necessary that the neighbouring regions, as well as the remaining regions in the whole country, carry out very intensive activities resulting in a concentration reduction of 70-80%.

The conditions for achieving a permissible level of nitrogen dioxide are similar to those indicated for benzo(a)pyrene. It is necessary to take national measures to accelerate the development of electromobility, introduce legal possibilities to create low emission zones based on EURO emission standards, as well as measures to develop sustainable transport across the country. Such activities may result in the reduction of nitrogen oxides emissions from transport and compliance with the permissible level in the Malopolska Region. Therefore, a long-term goal has been set for the forecast year 2026.

The implementation of actions to comply with the levels acceptable for PM10 and PM2.5 should be carried out by December 31, 2023. Then it is possible to achieve the set objectives of the Plan in the field of air quality.

16. CLEAN AIR ACTIONS WHICH HAVE NOT BEEN SELECTED FOR IMPLEMENTATION

During the analysis of corrective measures scenarios, activities that would have an ecological effect were analysed, but due to social, economic, technical and organizational conditions, they were not included in the schedule:

- The ban on the use of coal and biomass in the health resorts of the Malopolska Region – was not indicated as implementable due to the lack of possibility to provide alternative heating sources in the health resorts. The gas network does not operate in a significant area of the region, in rural as well as urban areas, while the current level of renewable energy development does not allow the provision of heating systems at the appropriate level. Renewable energy solutions are still too expensive for the inhabitants of the region, especially those affected by energy poverty, who use a high-emission heating source.

- Introduction of a clean air zone in cities – Krakow's experience shows significant limitations of such a solution due to the insufficient level of electromobility development in the Malopolska region.
- Forbidding to install new coal fired heating sources – it is not possible to provide alternative solutions to heating systems that meet financial and social requirements.
- The obligation to appoint municipal guards in each municipality – control obligations may be implemented through other means, such as cooperation with the Police and the Municipality Guard. An action encouraging the appointment of guards is to provide funds under the ROP for 2021-2027, which may partially cover the costs of the guard. The action is available for interested municipalities of the region.
- Low emission zone in Krakow based on EURO emission standards, covering all types of vehicles on Krakow's roads: trucks, cars, vans and buses. This action was indicated for implementation as the next stage of transport solutions. The pilot version of the zone, after the relevant national regulations come into force, is to allow assessment of effectiveness of the zone and constitute a necessary transition period for residents. In addition, full implementation of the zone requires provision of appropriate transport infrastructure and alternative routes. The Plan indicates the recommended version of the target low emission zone. According to the analyses carried out in this document, the selected target version will achieve the permissible level of nitrogen dioxide. Due to the fact that there are currently no regulations allowing for the implementation of the proposed zone, one of the tasks of the President and the City Council of Krakow is to prepare a detailed plan for the implementation of the zone, which should take into account the need to achieve air quality standards related to nitrogen dioxide concentration. The plan, based on current data on the fleet of vehicles and road infrastructure, will allow to choose the optimal version of the zone, which should ultimately be implemented in Krakow.

16.1. Summary of the analysis of documents, materials and studies used to develop the Plan

In the course of work on the Plan, a number of strategic documents were analysed, as well as policies, plans and programs implemented at the level of the country, region, counties and municipalities of the Malopolska Region. These include, among others:

- spatial development studies,
- local spatial development plans,
- plans and draft plans for the supply of heat and electricity and gas fuels,
- low-carbon economy plans,
- environmental protection programs,
- long-term investment plans,
- reports on the implementation of the currently applicable Air Quality Plan,
- other local strategies and documents.

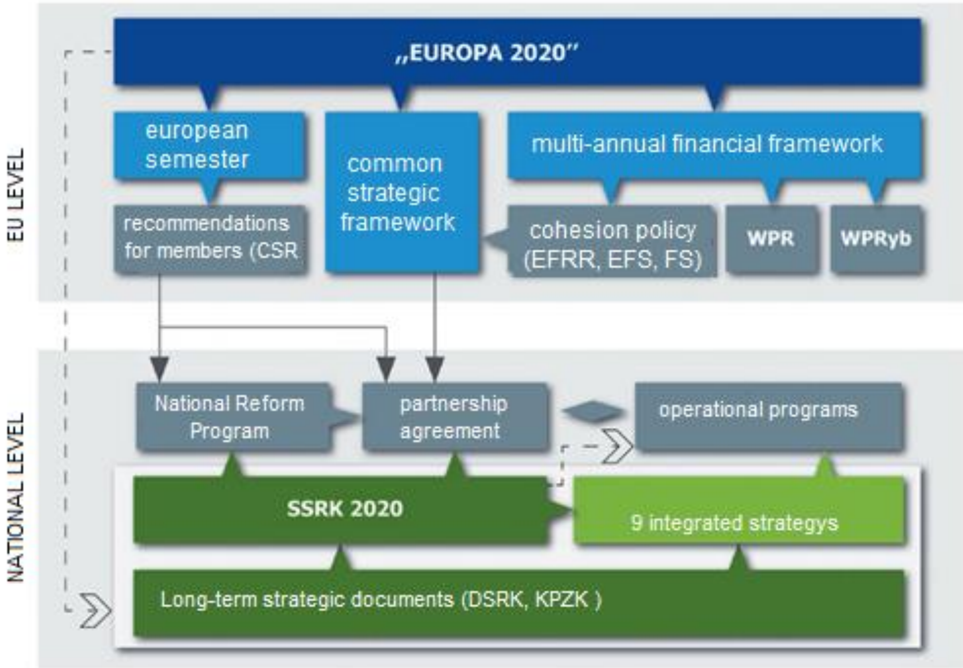


Figure 76. The link between strategic documents of Poland and the EU.

Long-Term National Development Strategy: "Poland 2030. Third Wave of Modernity"

The objectives of the Strategy include, among others: supporting the pro-development allocation of resources in the economy, improving the accessibility and quality of education at all levels, increasing the competitiveness of science, increase in efficiency and competitiveness of economy, ensuring energy security, protection and improvement of the environment, strengthening mechanisms of territorial sustainability for the development and full use of regional potential, increasing Poland's territorial accessibility, by creating a sustainable, coherent and user-friendly transport system, and increasing social development capital. By 2030, thanks to the strategy, following indicators shall be achieved: energy consumption of the economy 167 ktoe, share of energy from renewable sources in final energy consumption> 15%, CO_2 emissions< 0,70 t/MWh.

National Spatial Development Concept 2030

The concept provides the effective use of the country's territory and its territorially diverse development potentials for achieving general development goals – competitiveness, increasing employment, efficiency of the state's functioning and cohesion in the social, economic and territorial dimension. One of the main goals of the NSDC is to increase the resistance of the country's spatial structure to natural dangers and to loss of energy security, and to shape spatial structures that support the defence capabilities of the state. The most important areas of activity include counteracting the loss of energy security and appropriate response to this threat.

A strategy for responsible development by 2020 with a perspective to 2030

The strategy for responsible development until 2020 (SRD) replaces the current *Medium-Term National Development Strategy.* It covers all directions of the country's development. The main goals of the strategy are:

- sustainable economic growth based on knowledge, data and organizational excellence,
- socially-conscious and territorially sustainable development,

- an effective state and institutions promoting growth and social and economic inclusion

In connection with the Air Quality Plan, attention should be paid to, among others, the following strategic projects to be implemented under the Strategy in specific areas:

- industry:
  - New industrial policy,
  - Strategy for transformation into a low-carbon economy,
  - Road map for transformation towards a circular economy;
- development of innovative companies:
  - Environmental Technology Verification System (ETV);
- transport:
  - national traffic management system,
  - modernizing the fleet of rolling stock,
  - development of the inland navigation sector,
  - development of intermodal transport,
  - ecological transport;
- power industry:
  - Polish nuclear energy program,
  - gas hub,
  - intelligent power grid construction program,
  - electromobility development program,
  - development and use of geothermal potential, distributed power generation, the use of hydropower potential;
- environment:
  - The Clean Air Program,
  - Poland's raw material policy.

National Strategy for Regional Development 2010-2020: Regions, Cities, Rural Areas

The strategy lists the basic objectives of regional development policy. The strategic goal of the policy implemented by the government in cooperation with regional governments is the effective use of specific regional (and other) development potentials to achieve the country's long-term goals – growth, employment and sustainability.

The new regional policy puts the main emphasis on increasing the role of the regional level in launching development processes. Regional policy, along with other policies, and activities addressed to specific problems, should be spatially integrated, preferably at the regional level. The strategic challenges of the new regional policy's include: "Increasing the potential for creating, diffusing and absorbing innovation, as well as responding to climate change and ensuring energy security.".

Poland's Energy Policy until 2040 – draft

Poland's Energy Policy until 2040 (PEP2040) is one of the nine strategies resulting from the country's development management system, based on the *Strategy for Responsible Development (SRD)* described earlier.

PEP2040 defines the directions of development of the energy sector, specifying the tasks necessary for implementation in the short term. The implementation of PEP2040 is to take place through eight directions of activities in the fuel and energy sector, divided into executive tasks.

The directions and activities include the entire energy supply chain – from obtaining raw materials, to energy production and supply, to the way it is used.

Each of the eight directions of PEP2040 and all the activities contained therein are embedded in three elements of the goal of PEP2040 – energy security, competitiveness and improvement of the energy efficiency of the economy, and reduction of the impact on environment. Five indicators were adopted as a global measurement of achieving the PEP2040 goal:

- 56-60% coal in electricity production in 2030,
- 21-23% RES in gross final energy consumption in 2030,
- implementation of nuclear energy in 2033,
- reducing CO_2 emissions by 30% by 2030 (compared to 1990),
- 23% increase in energy efficiency by 2030 (compared to forecasts for primary energy consumption in 2007).

2030 Ecological policy of the state – development strategy in the area of environment and water management

The 2030 ecological policy of the state – development strategy for environment and water management (PEP2030) clarifies and operationalizes the *Strategy for Responsible Development (SDR)* described earlier. The main goal of PEP2030 is to develop the potential of the environment for citizens and entrepreneurs.

The specific objectives relate to health, economy and climate. The implementation of environmental objectives is to be supported by horizontal objectives regarding environmental education and the effectiveness of the instruments for environmental protection. In particular, measures will be implemented to improve air quality by reducing emissions. This means preparing appropriate provisions and financial support instruments at the national level, such as the Clean Air Program, for necessary investments, and coordinating their implementation in the regions.

PEP2030 will form the basis for investing European funds from the financial perspective for 2021-2027. The strategy also supports the implementation of Poland's goals and commitments at the international level, including those at the EU and UN levels, particularly in the context of the EU's 2030 climate and energy policy goals and the sustainable development goals set out in the 2030 Agenda.

National Air Quality Plan

The objective of the *National Air Quality Plan (NAPR*) is to improve air quality throughout Poland. This applies, in particular, to areas with the highest concentrations of air pollution and areas with large population concentrations. The improvement of air quality should lead at least to such a condition thereof that does not pose a threat to human health, in accordance with the requirements of European Union legislation transposed into the Polish legislation, and by 2030, achieve goals set by the World Health Organization. The following lines of action were specified in the Plan:

- Raising the importance of air quality by consolidating actions at national (region and local) level and establishing a broad Partnership for improving air quality;
- Creating a legal framework conducive to the implementation of effective measures to improve air quality;
- Involving society in actions to improve air quality by increasing public awareness and creating durable platforms for dialogue with social organizations;
- Development and dissemination of technologies conducive to improving air quality;
- Development of mechanisms to control low-stack emission sources conducive to improving air quality;
- Dissemination of financial mechanisms conducive to improving air quality.

The program contains a detailed action plan, in the abovementioned directions, at the national, regional and local levels.

Recommendations of the Economic Committee of the Council of Ministers regarding necessary activities in connection with the occurrence of high concentrations of air pollution in a large area of the country.

The recommendations contain 14 key activities to improve air quality in Poland, including, but not limited to:

- requirement of gradual connection of buildings in urban and suburban areas to the heating network, unless they have an effective source of heat, to minimize the associated costs;
- development of a network of monitoring stations, which should enable localization of pollution sources and more effective control of harmful practices in using of boilers and industrial installations;
- inclusion of social welfare services in activities to support boiler replacement and thermo-modernization of poor residents' buildings, in a way that takes into account the level of pollution generated and providing funds for necessary operating costs;
- introduction of regulations counteracting the blocking of city aeration corridors, and raising the urban planning profession in the spatial development to a higher rank.

National Air Pollution Reduction Program

The National Air Pollution Reduction Program (NAPRP) was prepared on the basis of art. 6 of Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of domestic emissions of certain types of atmospheric pollution, amendment of Directive 2003/35/EC and repealing Directive 2001/81/EC (NEC Directive). In accordance with the provisions of the abovementioned directive, NAPRP is to ensure that countries meet their obligations to reduce emissions, as well as effectively contribute to the achievement of air quality objectives. Poland's commitments to reduce emissions relate to two periods: 2020–2029 and from 2030 and relate to sulfur dioxide (SO_2), nitrogen oxides (NO_X), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and fine dust (PM2.5). These commitments were determined (by reference to emissions in 2005) respectively for both of the above periods for: SO_2 – reduction by 59% and 70%, for NOx by 30% and 39%, for NMVOC by 25% and 26%, for NH_3 by 1% and 17% and for PM2.5 by 16% and 58%.

National for energy and climate for 2021-2030

National plan for energy and climate for 2021-2030 (NPEC) presents assumptions and goals, as well as policies and activities for the implementation of the five dimensions of the Energy Union, i.e.:

- energy security,
- internal energy market,
- energy efficiency,
- decreasing emissions
- research, innovation and competitiveness.

The document was prepared on the basis of national development strategies and the *Polish Energy Policy project until 2040*. *The national energy and climate plan for 2021-2030* sets the following climate and energy goals for 2030:

- 7% reduction in greenhouse gas emissions in non-ETS sectors compared to 2005 level,
- 21-23% share of renewable energy in final gross energy consumption (the 23% target will be achievable if Poland is granted additional EU funds, including those intended for equitable transformation), considering 14% share of renewable energy in transport, annual increase in the share of renewable energy in heating and refrigeration by 1.1 percentage points on average,
- 23% increase in energy efficiency compared to the PRIMES2007 forecasts,
- reducing to 56-60% the share of coal in electricity production.

National Urban Policy 2023

National Urban Policy (NUP) is a document defining the planned activities of government administration regarding urban policy. It serves the purposeful, territorially directed operation of the state for the sustainable development of cities and their functional areas, and the use of their potentials in the country's development processes.

The strategic goal of urban policy is to strengthen the capacity of cities and urban areas to develop sustainably and create jobs, and to improve the quality of life of residents. This plan addresses, among others, transport and urban mobility, low-carbon and efficient power industry, environmental protection and adaptation to climate change.

National Renewable Energy Action Plan (Ministry of Economy, Warsaw 2010)

The National Renewable Energy Action Plan sets national targets for the share of energy from renewable sources in the transport sector, electricity industry, heating and cooling in 2020 (15%), taking into account the impact of other energy efficiency policy measures on final energy consumption, and relevant measures to be taken to achieve national general objectives regarding the share of renewable energy in final energy use.

National Action Plan on Energy Efficiency

This document describes the planned energy efficiency improvement measures specifying measures to improve energy efficiency in specific sectors of the economy, necessary to achieve the national target for energy efficiency, as well as measures to achieve the general goal of energy efficiency understood as achieving 20% savings in primary energy consumption in the European Union by 2020.

Strategic adaptation plan for sectors and areas sensitive to climate change by 2020 with a perspective by 2030 (SPA 2020)

The main objective of the document is to ensure sustainable development and effective functioning of the economy and society in the conditions of climate change. The specific objectives are to ensure energy security and good environmental state, effective adaptation to climate change in rural areas, development of transport in the conditions of climate change, ensuring balanced regional and local development in the changing climate, stimulating innovation conducive to adaptation to climate change, shaping favourable social attitudes toward adaptation to the climate change.

Strategy for Sustainable Development of Transport to 2030

The Strategy for Sustainable Development of Transport to 2030 (SRT2030) is one of 9 integrated strategies to achieve the objectives set in the SRD. Its main goal is to increase transport accessibility while improving the safety of road users and the efficiency of the entire sector, by creating a coherent, balanced, innovative and user-friendly transport system on a national, European and global scale.

SRT2030 sets the most important directions of transport development in Poland to 2030 and is a key document related to the European Union's financial perspective for 2021-2027.

The implementation of the main objective in the perspective to 2030 involves the implementation of six directions of intervention appropriate for each of the transport modes:

- construction of an integrated, interrelated transport network serving a competitive economy;
- improving the organization and management of the transport system;
- changes in individual and collective mobility;
- improving the safety of road users and transported goods;
- reducing the negative impact of transport on the environment;
- improving the efficiency of using public funds for transport projects.

Electromobility development plan in Poland "Energy for the future"

The Plan sets three main goals:

- creating conditions for the development of electromobility of the Polish people,
- development of the electromobility industry,
- stabilization of the power grid.

The Plan specifies the benefits of achieving the above objectives, including those related to the widespread use of electric vehicles in Poland. It was also pointed out that the development of electromobility should contribute to improving air quality. The support instruments proposed in the Plan have been designed so that, after implementation, they contribute to the development of the electromobility industry, creating demand for electric vehicles, modernization of the power grid and improvement of cooperation between science and the enterprise sector.

Through education to sustainable development. National strategy for ecological education

The strategy indicates the following objectives:

- Shaping full awareness and raising public interest in interrelated economic, social, political and environmental issues

- Allowing everyone to acquire the knowledge and skills necessary to improve the state of the environment.
- Creating new behaviour patterns, shaping attitudes, values and beliefs of individuals, groups and societies, promoting care for the quality of the environment.

The document outlines activities at all levels of formal education and elsewhere.

Summary

Based on the analysis of the presented strategic documents at the national level, which are directly or indirectly related to air protection and improvement of its quality, the following conclusions can be made:

- Poland's strategic documents demonstrate consistency with documents at global and EU level in terms of goals and directions of activities;
- Key strategic projects of the state, resulting from the strategy for responsible development until 2020 with a perspective to 2030 (SDR), relate to the transformation into a low-carbon circular economy, the development of low-carbon transport and electromobility, as well as the use of renewable energy sources and improvement of air quality through the implementation of the Clean Air Program;
- An important document from the point of view of securing the country's energy needs – Poland's Energy Policy to 2040 (PEP2040 – project) assumes limiting coal consumption in electricity production (56-60% in 2030), increasing the share of renewable energy in gross final energy consumption (21 -23% in 2030), as well as the implementation of nuclear energy and an increase in energy efficiency (by 23% by 2030 compared to the forecasts of primary energy consumption in 2007);
- Goals and directions of activities to be included, in particular at the local level, in Air Quality Plans, are set by the National Air Quality Plan (NAPP). The NAPP indicates that the reduction potential, in particular in relation to zones where the permissible levels of PM10 and PM2.5 and the benzo(a)pyrene target level are exceeded, lies in the activities and regulations regarding the domestic, municipal and transport sector;
- Considering the above, it is important to create a relevant legal framework, including coherent spatial planning, with consideration of air quality issues at the national, regional and local levels (development and adoption of outstanding assumptions for plans or programs for supplying municipalities with heat, electricity and gas fuels); involving society in activities to improve air quality by increasing public awareness; dissemination and use of technologies conducive to improving air quality (the use of high-efficiency boilers that meet the highest emission requirements, when replacing and modernizing old heating devices, increasing the energy efficiency of residential and public buildings through deep thermo-modernization, development of cogeneration and the use of renewable energy and the development of low-emission rolling stock, using alternative propulsion systems (including electric, natural gas); development of mechanisms to control low-stack emission sources (in terms of compliance of the installed heating system with the system included in the construction project);

In addition, articles, studies and data were used, the list of which is presented in chapter 17.2. These documents helped to indicate corrective measures leading to the achievement of air quality standards required by law.

17. ANNEXES

17.1. Giving opinions on the draft program and the consultation process

The Board of the Malopolska Region as a body developing a draft document requiring public participation, following art. 39 paragraph 1, art. 40 and 41 of the EIA Act, on February 5, 2019, made public information about:

- commencing the development of the draft Air Quality Plan and its subject,
- possibilities of getting acquainted with the documentation of the case and the place where it is available for inspection,
- the possibility of submitting comments and proposals,
- the manner and place of submitting comments and proposals to the Plan assumptions, indicating at the same time the deadline for their submission (by March 31, 2019).

According to Art. 91 par. 1 and par. 5 of the Environmental Protection Law Act, the voivodeship management board is obliged to submit to the competent heads of municipalities, mayors, city presidents and county governors a draft resolution of the regional council on the air quality plan for an opinion. In connection with the above, the draft resolution of the Malopolska Regional Assembly on the Air Quality Plan for the Malopolska Region was submitted to the competent authorities for their opinion. The said authorities are required to issue their opinion within one month of receiving the draft. Failure to issue an opinion within this period means acceptance of the draft resolution (Art. 91 par. 2a).

Based on art. 42 of the Act of October 3, 2008 *on the sharing of information on the environment and its protection, public participation in environmental protection and on environmental impact assessments*, the authority considered all comments and proposals that were received as part of public consultations and attached a justification containing information about the participation of the public in the proceedings and how and to what extent the submitted opinions were taken into account. Comments considered justified were taken into account, and in the event that they were considered unjustified, the reason for not taking them into account was explained.

Preliminary public consultation

As part of the initial public consultation, 6 consultation meetings were held:

- on January 10, 2020, at 10:00 in Nowy Targ,
- on January 13 and 15, 2020, at 10:00 in Krakow,
- on January 14, 2020, at 10:00 in Tarnow,
- on January 16, 2020, at 10:00 in Chrzanow,
- on January 17, 2020, at 10:00 in Nowy Sacz.

During the meetings, issues related to the Air Quality Plan were presented, which were then discussed to develop the most effective solutions resulting in the improvement of air quality. Items discussed:

- proposals for corrective measures to improve air quality from the perspective of 2023 and 2027,
- proposals for extending the Short-term Action Plan with three danger levels,
- proposals for the corrective measures implementation scenarios in the long term.

During the period of consultancy and initial public consultations, which lasted from January 10 to January 24, 2020, 450 comments and opinions regarding the proposals of corrective measures that were proposed for the Plan implementation were received. The presented scenarios of corrective measures during the initial consultations have been transformed into actions that can be introduced in the Malopolska Region.

Some of the proposed activities have been changed due to reported implementation barriers and restrictions on achieving the effects of these activities. This particularly concerning activities related to inspections in municipalities, restrictions on the use of heating devices and solid fuels in the region, as well as activities related to low emission zones based on EURO emission standards.

Official public consultations

As part of preparation Air Quality Plan for Malopolska Region two turns of public consultations took place:

1. I turn from March 13 to June 5, 2020
2. II turn from July 2 to July 27, 2020

First public consultations

In March 12, 2020 the draft resolution of the Regional Assembly of the Malopolska Region regarding the Air Quality Plan for the Malopolska Region was accepted by The Management Board of the Malopolska Region by Resolution no. 380/20 and shared to public consultations and submitted to heads of municipalities, mayors, cities presidents and city governors.

Public consultations planned for the period of March 13 – April 10, 2020 were suspended in the period March 31– May 22, 2020 (lasted on March 13–March 30, 2020), pursuant to Art. 15 zzs of the Act of March 2, 2020 *on special solutions related to the prevention, counteraction and combating of COVID-19, other infectious diseases and emergencies caused by them*. Then, pursuant to the Act of May 14, 2020, *amending certain acts in the field of protective measures in connection with the spread of the SARS-CoV-2 virus*, public consultations were resumed between May 23 and June 5, 2020. The submitted comments were considered.

Second public consultations

Due to significant change in the socio-economic situation, the comments and opinions presented in the first round of public consultations were analysed. On their basis and taking into account the different socio-economic situation, changes were proposed in the corrective actions of the Plan.

In view of the above on July 2, 2020, Resolution no. 906/20 of The Management Board of the Malopolska Region announced the beginning of the second round of public consultations and issuing opinions on the draft of *the Air Quality Plan for the Malopolska Region*. Comments on the draft Plan could be submitted until July 27, 2020.

17.1.1. CONSULTATION PROCESS AND OPINIONS

First public consultations

On March 12, 2020 the Management Board of the Malopolska Region adopted a resolution on the consultation of the draft Resolution of the Regional Assembly of the Malopolska Region *on the Air Quality Plan for the Malopolska Region* and thus sent the draft Plan for public consultations and assessment by municipality heads, mayors, and city presidents and county governors.

Information on public consultations was released:

- On March 16 as an announcement with an article in the journal "Rzeczpospolita",
- On March 16 at rp.pl,
- On March 16 as an announcement in the journal "Dziennik Polski",
- on the website powietrze.malopolska.pl,
- in Public Information Bulletin of the Malopolska Region,
- as an announcement in customary manner, in headquarters of the competent authority in that case.

In addition, on March 12, 2020, the Department of the Environment of the Marshal's Office of the Malopolska Region provided information on the commencement of public consultations in writing (case no.: SR-V.721.2.7.2020):

- the Minister of Climate,
- the Governor of the Malopolska Region,
- the Chief Inspector of Environmental Protection,
- President of the Regional Fund for Environmental Protection and Water Management in Krakow,
- Councillors of the Malopolska Region,
- the Regional Director of Environmental Protection in Krakow,
- the Regional Inspector of Environmental Protection,
- the Regional Department of Environmental Monitoring in Krakow,
- all municipality heads, mayors, and city presidents and county governors.

Comments and opinions could be sent via the online form, https://powiertrze.malopolska.pl/konsultacje/. It was also possible to submit comments in writing.

The public consultation process lasted from March 13 to April 10. The consultation process planned for the period of March 13 – April 10, 2020 were suspended in the period of March 31– May 22, 2020 (held on March 13–March 30, 2020), pursuant to Art. 15 zzs act. of March 2, 2020 *on special solutions related to the prevention, counteracting and combating COVID-19, other infectious diseases and the emergencies caused by them.* Then, pursuant to the Act of May 14, 2020 *amending certain acts on protective measures in connection with the spread of the SARS-CoV-2 virus*, public consultations and opinions were resumed between May 23 and June 5, 2020. The submitted comments were considered.

Opinion of the Minister of Climate

According to Art. 91 par. 2c of the Act of April 27, 2001, Environmental Protection Law, on April 7, 2020, the Minister of Climate in writing (case ref.: DPKI.0311.10.2020.MZ1172996.3542954. 2740542) presented an opinion on the draft resolution of the Regional Assembly of the Malopolska Region *on the Air Quality Plan for the Malopolska Region*. The submitted opinion consisted of general and specific comments. The opinion indicated the need to supplement the document with the following elements:

- information on the mathematical estimation methods and methods of mathematical modeling used in the Plan, selected input data, model configuration and meteorological conditions,

- the values of the proposed progress monitoring indicators for each year of the Plan implementation,
- information on all emission data used for the Plan,
- analysis of the technical possibilities of introducing a complete ban on solid fuel combustion in health resorts, i.e. analysis of the possibilities of developing and modernizing heating and gas networks,
- correction of information included in the air quality diagnosis in terms of compliance with the document *Annual air quality assessment in the Malopolska Regio*n Report for 2018,
- extended information on the assumptions made for calculations under corrective action scenarios,
- revision of the procedure for informing about the risk of exceeding the permissible levels, information and alert under the Short-Term Action Plan,
- information on large combustion plants, which are not only subject to stricter standards from 2016 (except for sources submitted for derogation), but will also have to be adapted to the BAT conclusions by 17 August 2021.

A full list of comments submitted by the Minister of Climate, along with the manner of their examination, is included in the Report on public consultations, which was included in the Public Information Bulletin of the Malopolska Region. As a result of the analysis of the comments to the Plan submitted by the Minister of Climate, the following changes were introduced:

- the information included in the air quality diagnosis was corrected in order to maintain its compliance with the Annual air quality assessment in the Malopolska Region. Report for 2018,
- the Plan was supplemented with a detailed analysis of corrective action scenarios, including an analysis of the possibilities of developing and modernizing the heating and gas networks in the region (Chapter 17.4),
- information related to the modeling of pollutant transport for the purposes of this Plan, along with a comparison of measurement data and modeling results for the analysed pollutants in the base year 2018 (Chapter 17.2) was added,
- information on limitations related to the operation of medium and large fuel combustion sources has been supplemented under Chapter 6.2.1,
- the procedure for introducing air pollution degrees under the Short-Term Action Plan (Chapter 10.3) was corrected,
- their values were added to the proposed progress monitoring indicators broken down into successive years of the Plan implementation (Chapter 9),
- information was presented on the emission data used in the Plan (Chapter 4).

During the first public consultations, **3,749** comments were received, including those submitted by:

- Non-governmental organizations – 22
- Research institutions – 4
- Enterprises – 30
- Private persons – 93
- Administration – 118

- An appeal for effective Air Quality Plan for the Malopolska Region submitted by the Krakow Smog Alert Association and signed by 3,482 (state by April 10, 2020)

43 comments were followed up, 198 partially, while 28 claims were rejected. Moreover, the appeal for an effective Air Quality Plan for the Malopolska Region, submitted by the Krakow Smog Alert, signed by 3,482, **was partially accepted.**

During the public consultation, 103 municipalities out of all 182 municipalities in the Malopolska Region and 10 out of 22 counties (including 3 cities with county rights) submitted their comments. In addition, the public institutions that presented their opinion also include the Chief Inspector of Environmental Protection, the Regional Inspector of Environmental Protection, the Public Transport Authority, the Regional Department of Environmental Monitoring and the Regional Fund for Environmental Protection and Water Management.

After analysing the conclusions of the first round of consultations, the following changes were made to the Air Quality Plan for the Malopolska Region

a) Accelerating activities that strengthen the implementation of the government's Clean Air Program,

b) Extension of deadlines for the performance of some corrective actions:

- When public funding is provided for solid fuel heating installations up to 1 MW, the public authorities shall provide financing from January 1, 2022 only for biomass installations (excluding ongoing projects) and financing from January 1, 2023 only for biomass installations with particulate matter emission factor up to 20 mg/m³ (at 10% O_2),
- Employment from January 1, 2022 and maintenance of the position of an Eco-manager,
- Publishing by October 31, 2020 on the official website of the municipality and county (in a visible place on the home page) information on, inter alia, the current air quality, a link to the Eco-intervention application and the Clean Air Program,
- Conducting an inventory of heat sources and renewable energy installations in residential and non-residential buildings in the municipality: at least 70% of buildings by the end of 2021 and at least 90% of buildings by 30 June 2022,
- Preparation of an analysis of the problem of energy poverty in the municipality by September 30, 2021,
- As part of green public procurement, from 2022, specific requirements should be taken into account in the procurement criteria,
- Development and adoption by 30 June 2022 of the Sustainable Urban Mobility Plan according to the guidelines of the European Commission,
- Preparation of a detailed plan for the implementation of a low emission zone based on Euro emission standards and implementation of the zone in a pilot version within 1 year from the entry into force of national regulations enabling its implementation,
- Implementation of a low emission zone based on EURO emission standards for the City of Krakow in the target version by December 31, 2025,
- Preparation and implementation by the city of Krakow by December 31, 2022 of a traffic emissions monitoring system,
- Preparation of the implementation plan for the Tempo-30 zones in Krakow by December 31, 2021, the introduction of the Tempo-30 zones according to the prepared plan should take place in stages by December 31, 2025.

- **c)** Relaxation of the restrictions of low emission zone in Krakow in stage 1 (EURO 5 instead of EURO 6), and the target stage with EURO 6 introduced from 2025,
- **d)** Adding a much larger number of tasks to be carried out by the Region as part of the coordination of activities in the field of air protection.

Apart from changes in corrective actions, the following elements were added to the Plan:

- **a)** The information on the negative impact of air pollution on the vulnerability to COVID-19 was supplemented on the basis of the available research results in the world,
- **b)** The analysis of the economic effects of air pollution was extended based on the report of the Regional Development Observatory of the Malopolska Region,
- **c)** Information has been added on opportunities arising from EU initiatives and domestic ones – The European Green Deal and Renovation Wave, Just Transition Fund, Clean Air Program reform, reconstruction of the Polish economy after the COVID-19 epidemic (thanks to Clean Air Program and RES),
- **d)** The program was supplemented with an economic analysis of options for action and an analysis of the possibilities of developing heating and gas networks.

However, the Plan did **not** take into account comments regarding:

- **a)** Resignation from introducing restrictions in the financing of solid fuel devices – only the deadline assigned to the task has been changed, because the implementation of the Plan requires limiting the use of the most emitting sources,
- **b)** Extending the time for the implementation of intervention controls from 1 business day to 3 business days – a change in this respect would significantly reduce the effectiveness of controls,
- **c)** Introducing the obligation to educate in the field of "proper combustion of solid fuels" due to the temporary nature of the action and the lack of guarantee of its impact on the reduction of pollutant emissions,
- **d)** Resignation from the obligation to establish the Clean Air Program information points in municipalities, as this action is necessary for the effective use of government funds for the replacement of heating sources
- **e)** Resignation from the obligation of municipalities to carry out information campaigns related to the anti-smog resolution and subsidy programs, because this action can be implemented with little or no cost as part of the activities already undertaken by municipalities,
- **f)** Reduce the number of preventive inspections that municipalities have to carry out after announcing the introduction of the degree of air pollution risk, as this measure applies only to days with exceedance of the pollution concentration standards, when the necessary measures must be implemented to reduce the negative impact of pollution on human health,
- **g)** Reducing the number of planned inspections to be carried out by municipalities, as these numbers have been determined on the basis of the values reported by municipalities so far, moreover, from 2023 it will be necessary to control compliance with the replacement of non-class boilers, resulting from the anti-smog resolution,
- **h)** Resignation from the recommendation to allocate 1% of municipalities' own revenues to activities related to air protection, because this task is a recommendation that may have a positive impact on planning the implementation of the Plan activities,
- **i)** Resignation from the obligation to employ Eco-managers in municipalities and to determine their number depending on the number of inhabitants, as this action will contribute to activating

municipalities in terms of reaching for available funds. The number of Eco-managers should also be adequate to the needs of the municipality,

j) Withdrawal from indicating that there is no possibility of derogation from BAT requirements for entrepreneurs in areas where the pollution concentration standards are exceeded, because this action is one of the most effective solutions in the field of industry sector,

k) Actions, the implementation of which would require interfering with acts of higher order, e.g. regarding the imposition of obligations on entities whose work is regulated by law, introducing changes to documents at the government level, etc.

Second public consultations

The Management Board of the Malopolska Region on July 2, 2020 adopted a resolution on the consultation of the draft Resolution of the Regional Assembly of the Malopolska Region *on the Air Quality Plan for the Malopolska Region* (second public consultation) by the Resolution no. 906/20 and thus sent the draft Plan for public consultations and assessment by municipality heads, mayors, and city presidents and county governors. Information on public consultations was released:

- in Public Information Bulletin of the Malopolska Region,
- as an announcement in customary manner, in headquarters of the competent authority in that case,
- on July 6, 2020 as an announcement in press in the journal “Gazeta Krakowska”,
- on the website powietrze.malopolska.pl,

In addition the Department of the Environment of the Marshal's Office of the Malopolska Region provided information on the commencement of public consultations in writing (case no.: SR-V.721.2.12.2020):

- the Minister of Climate,
- the Governor of the Malopolska Region,
- the Chief Inspector of Environmental Protection,
- President of the Regional Fund for Environmental Protection and Water Management in Krakow,
- Councillors of the Malopolska Region,
- the Regional Director of Environmental Protection in Krakow,
- the Regional Inspector of Environmental Protection,
- the Regional Department of Environmental Monitoring in Krakow,
- all municipality heads, mayors, and city presidents and county governors.

Comments and opinions could be sent via the online form, https://powiertrze.malopolska.pl/konsultacje/. It was also possible to submit comments in writing and orally for the record in the Department of Environment of the Marshal’s Office.

As part of the public consultation, a consultation meeting was held on July 16 this year at the Congress Hall of the Congress Centre of the University of Agriculture in Krakow. 85 people took part in it. They were mainly residents, local governments, institutions, entrepreneurs, chambers of agriculture and commerce, non-governmental organizations and representatives of universities. As part of the meeting, an on-line broadcast was provided.

3,227 comments were received within the deadline**,** including those submitted by:

- Administration – 125
- Non-governmental organizations – 31
- Research institutions – 22
- Enterprises – 105
- Private persons – 1 476
- Public Institutions – 2
- An appeal for effective Air Quality Plan for the Malopolska Region submitted by the Krakow Smog Alert Association and additionally signed by 566 (signed by 3,458 residents during first consultations)
- The opinion of the Management Board of the Malopolska Association of Stove Fitters and Related Professions (Malopolski Cech Zdunow i Zawodow Pokrewnych) regarding the proposal for a new Air Quality Plan for the Maopolska Region was supported by 848 people.
- Comments submitted during the consultation meeting on 16 July by 31 entities and people.

79 comments were followed up, 1635 partially, while 99 claims were rejected. Moreover, the appeal for an effective Air Quality Plan for the Malopolska Region, submitted by the Krakow Smog Alert Association and The opinion of the Management Board of the Malopolska Association of Stove Fitters and Related Professions (Malopolski Cech Zdunow i Zawodow Pokrewnych) was partially accepted.

During the public consultation, 113 municipalities out of all 182 municipalities in the Malopolska Region and 12 out of 22 counties (including 3 cities with county rights) submitted their comments. In addition, the public institutions that presented their opinion also include the Regional Inspector of Environmental Protection and Department of Safety and Regional Crisis Management Centre.

After analysing the conclusions of the second round of consultations, the following changes were proposed:

1. Introduction of a transitional period until 2022 with an extension to 2 working days of the time for conducting inspection in the field of compliance with air protection regulations.
2. Introducing the obligation for residents to provide information on the type of building heating for the purposes of inventory management by municipalities (until the introduction of the national CEEB database).
3. Introduction of a possibility of a municipality to request the exclusion of types of installations from the requirements of the anti-smog resolution, if they are covered by the obligation to limit their environmental impact pursuant to Art. 154 of Environmental Protection Law.
4. Extending the deadline by 2023 for ensuring the use of 50% of energy from RES by public buildings.
5. Reformulation of the obligation of municipalities to replace heating devices in order to facilitate the enforcement of this obligation by Regional Inspector of Environmental Protection.
6. The implementation of a low emission zone in Krakow should be preceded by an implementation plan prepared by the city. The area and Euro standards will remain recommended in order to achieve the required nitrogen dioxide reduction effect.

7. Extending the deadline for the preparation and implementation of the traffic emission monitoring system by the city of Krakow by 2025.
8. Extending the deadline for counties to employ the Climate Eco-Manager and adjusting the deadline to the deadlines set in the LIFE EKOMALOPOLSKA Project.
9. Extension of the deadline by 9 months for the preparation of the analysis of the problem of energy poverty in municipalities.
10. Adjustment of intervention controls (Eco-intervention) at business entities to the competences of Regional Inspector of Environmental Protection and county governors.
11. Extension of activities under the 2nd degree of danger – adding a provision:
    - Ban on the use fireplaces and solid fuel local space heaters if they are not the only heating source.
12. Remaining within the 3rd degree of danger a ban on construction works that affect air quality (removal of the ban on <u>road</u> works). Defining the following activities as <u>recommended</u>, not obligatory:
    - No trucks allowed to enter the centre of Krakow (2nd ring road), Tarnow and Nowy Sacz,
    - Free public transport in Krakow, Tarnow and Nowy Sacz.
13. Exclusion of the City of Krakow from the obligation to collect ash samples.
14. Adding an obligation within the Action *Low-stack emission reduction and improvement of energy efficiency* for the County Buildings Inspectors – cooperation in creating an inventory of heating devices and renewable energy installations in municipalities.

The following proposals have <u>not</u> been taken into account as a result of the second public consultations:

1. Resignation from introducing limitations in financing solid fuel devices – implementation of the Program requires limiting the use of the most emitting sources.
2. Introducing a corrective action introducing education in the field of "proper combustion of solid fuels" – due to the short-term nature of the action and the lack of guarantee of its impact on the reduction of pollutant emissions.
3. Resignation from the obligation to establish the Clean Air Program information points in municipalities, as this action is necessary for the effective use of government funds for the replacement of heating sources.
4. Resignation from the obligation of municipalities to carry out information campaigns related to the anti-smog resolution and subsidy programs, because this action can be implemented with little or no cost as part of the activities already undertaken by communes.
5. Reducing the number of preventive controls that municipalities have to carry out after announcing the introduction of the air pollution danger, as this measure applies only to days with exceedance of the pollution concentration standards, when the law requires implementation of the necessary measures limiting the negative impact of pollution on human health.
6. Reducing the number of planned inspections to be carried out by municipalities, because these numbers have been determined on the basis of the values reported so far by municipalities. Moreover, from 2023 it will be necessary to control compliance with the replacement of non-class boilers, resulting from the anti-smog resolution (the current proposals take into account the epidemic situation in the country).

7. Resignation from the recommendation to allocate 1% of municipalities' own revenues to activities related to air protection, because this task is a recommendation that may have a positive impact on the planning of the implementation of Plan activities.
8. Resignation from the obligation to employ Eco-managers in municipalities and to determine their number depending on the number of inhabitants, as this action will contribute to activating municipalities in terms of reaching for the available funds.
9. Actions, the implementation of which would require interference in legal acts of a higher order, incl. concerning the imposition of obligations on entities whose work is regulated by law, introducing changes to documents at the government level, etc.
10. Withdrawal of the ban on the use of solid fuels in Krakow - the anti-smog resolution is not the subject of these consultations. Upholding the resolution is also necessary to ensure the reduction of air pollution.
11. Further extension of the deadlines for the implementation of corrective actions – in order for the Air Quality Plan to be compliant with the law, it must indicate actions adequate to the level of air pollution, which will allow to achieve air quality standards in the shortest possible time, while the actions may be planned for a maximum of 6 years.

In addition, the Regional Director of Environmental Protection in Krakow by decision OO.410.17.5.2020.MaS of August 3, 2020 upheld the decision No. OO.410.17.3.2020.MaS of April 2, 2020 and stated that there is no need to conduct a strategic environmental impact assessment for the draft Air Quality Plan for the Malopolska Region.

Adoption of the Air Quality Plan for the Malopolska Region by the Regional Assembly of the Malopolska Region

As a result of the first reading of the draft Air Quality Plan for the Malopolska Region, which took place on September 2, 2020 during the 24th Session of the Malopolska Region Assembly, by September 16, 2020, seven Councillors of the Malopolska Region submitted a total of 30 proposals of amendments to the draft resolution.

In September 28, 2020 during 25th Session of the Malopolska Region Assembly Councillors of the Malopolska Region accepted the following amendments to the content in Air Quality Plan for the Malopolska Region.

1. Accelerating the deadline for introducing the ban on public financing (except for ongoing projects) for coal-fired heating installations from January 1, 2022 to January 1, 2021.
2. Shortening the time for conducting intervention inspections by municipalities (response to notifications of violations) to 12 hours from reporting a violation. In the case of notifications made by the Eco-intervention application, shortening the time for updating information on actions taken and inspection results to 3 working days from taking the inspection.
3. Acceleration of the term of employment of Eco-managers in all municipalities from January 1, 2022 to September 30, 2021.
4. Increasing the frequency of information campaigns in municipalities on the requirements of the anti-smog resolution for Malopolska and the available forms of co-financing for the replacement of boilers from carrying out one action at least once a year to at least one action once every six months.
5. Adding to the tasks of the Management Board of the Malopolska Region and the Regional Assembly the obligation to conduct a broad social campaign on the requirements of the anti-

smog resolution and on the replacement of heat sources throughout the implementation period of the Air Quality Plan.

6. Introduction, as part of the short-term action plan, of a ban on the use of fireplaces and solid fuel local space heaters if they are not the only heating source, not only for 2nd and 3rd degree of air pollution danger, but also for 1st degree.

17.2. Description of the methods for modelling the dispersion of pollutants used in the analyses

In order to analyse the air quality in the Malopolska Region in the base year and in the forecast years, both the results of air quality measurements and mathematical modelling processes were used. In the base year 2018, the results of the *Annual air quality assessment in the Malopolska Region for 2018* were used.

Air quality modelling for the needs of the annual air quality assessment 2018

The GEM-AQ air quality model (Kaminski et al, 2008) was used to model the concentrations of pollutants near the ground for annual air quality assessment. The model is used in the European Copernicus service (CAMS_50 Copernicus Atmosphere Monitoring Service – Regional Production) and in the European FAIRMODE initiative (Forum for Air Quality Modelling in Europe). Calculations using the GEM-AQ model and analyses carried out to support the annual assessment of air quality in Poland were performed in two stages on a global variable-resolution grid, with a resolution over Poland with a wide margin of 2.5 km. The resolution used for 30 agglomerations and cities > 100,000 inhabitants was 0.5 km.

For the purpose of air quality analysis, global meteorological fields were used in the form of objective analyses from 2018, constituting a starting point for the global domain, taken from the Canadian Meteorological Centre (CMC). Atmospheric pressure field and sea level temperatures, earth surface temperature, snow cover thickness. Additionally, for 28 vertical layers: geopotential fields, air temperatures, two components of wind and relative air humidity.

Other methods used in the analysis of air quality in the annual assessment for the Malopolska Region

Among other available methods of air quality assessment, objective estimation was used to determine the areas of exceedance of the criterion values for particulate matter PM10 and PM2.5. For this purpose, the results of national modelling carried out to support the assessment of air quality in 2018 were used, and the results of assessments carried out in 2016-2017, taking into account the range of exceedance areas for PM10 and PM2.5 determined at that time. The values of individual emission types and the distribution of emissions in individual municipalities were also used (data from KOBIZE and the Regional Environmental Emissions Database). In addition, considering the results of measurements obtained in 2018, areas of exceedances were determined for annual concentrations of PM10 due to the exceedance of the limit value at the measurement points in Tuchow, Skawina, Oswiecim and Sucha Beskidzka.

Air quality modelling for the needs of the air quality plan

The following were used to model the dispersion of pollutants:

- CAMx model (modelling of air quality on a national scale to determine boundary conditions for the Malopolska Region taking into account transboundary inflows);
- CALPUFF model (detailed air quality modelling in the Malopolska Region);

- WRF model (meteorological field modelling necessary for air quality modelling – version 3.8).

The modelling methodology is described synthetically later in this section.

The CAMx model (the Comprehensive Air Quality Model with extensions) was used to model the dispersion of pollutants on a national scale. This is the latest generation Euler model developed by ENVIRON International Corporation (USA). The CAMx model is a three-dimensional, large-scale model with a wide range of applications from urban areas to the continental scale. In this work the CAMx model was used to prepare boundary conditions for high-resolution simulations. The large-scale calculations in the CAMx model were performed using the following options and parameters:

- model version – 6.3;
- mapping – LCC;
- resolution of the external domain (Central European) to determine cross-border inflows and boundary conditions on a national scale – 15 × 15 km;
- resolution of the internal (national) domain to determine boundary conditions in a high-resolution simulation for Malopolska Region – 5 × 5 km;
- chemical transformation mechanism – Carbon Bond 6 revision 2 (CB06r2);
- data supply in the scope of meteorological fields – using the WRF model, where the meteorological grid covers an area of 150 km outside the country borders;
- emission data for the external domain (Central Europe) – derived from the TNO MACC III project, with a resolution of 7.5 × 7.5 km, cover an area of at least 50 km outside the country;
- emission data for the internal domain – a database from the Malopolska Region prepared for the needs of the AQP in question, supplemented by data from the TNO MACC III project (a zone outside the country);
- speculative profiles for point and surface emission sources – own work based on world literature (among others ENVIRON/UCR, EPA, DEFRA, MEGAN-MACC, AirWare);
- time variability profiles for emission sources – own work based on available data, according to the adopted methodology;
- statistical processing of one-hour series – using the developed result file processing tool.

All components of the CAMx model (including the source code) were downloaded from the http://www.camx.com/ website. The calculations were carried out using a computer cluster, running on the Linux operating system, equipped with all necessary libraries and programs for processing input and output files.

The CALPUFF model was used to model pollution dispersion on the scale of Malopolska Region. It is a model designed by Sigma Research Corporation (SRC), modelling dispersion of pollutants over a wide range of spatial scales: from tens of meters to hundreds of kilometres. The model cooperates with the following auxiliary modules: CALMET (meteorological pre-processor) and CALSUM/CALPOST (processing and presentation of results). The CALPUFF model used for modelling for the year of the forecast in the Air Quality Plan is the model recommended for regional air quality assessment. It was indicated in the *Methodological guidelines for mathematical modelling in the air quality management system* issued by the Ministry of Environment in 2003. It was also used for air quality assessment in the years 2015-2017.

The model used gives the possibility to compare the modelling results between the Air Quality Plans for which it was used, and also gives the possibility to determine in detail the impact of individual emission sources on the level of concentrations in the zone.

The model allows to model the dispersion of pollutants in a wide range of spatial scales, including terrain, stagnation, inversion, recirculation, smoke, transport in the coastal zone, in low winds and silence. It takes into account the variability of meteorological conditions during the movement of pollutants and their spatial variability, buoyant and dynamic effects during the plume rise, dry deposition and absorption.

Calculations in the CALPUFF model were carried out using the following settings and parameters:

- model version – 6.42;
- rectangular coordinate system used – LCC;
- variable-step grid – basic for undeveloped areas (0.5 × 0.5 km) and more dense in built-up areas (0.25 × 0.25 km);
- discrete receptors – for points where measuring stations are located;
- chemical transformation mechanism – RIVAD (MCHEM=3), taking into account mechanisms of dry and wet deposition;
- supplying the boundary conditions module (BCON.DAT file) – concentration values obtained from Euler model calculations (national scale);
- supplying the CALMET meteorological model – processing the results obtained from the WRF model with the CALWRF tool;
- emission data – a database for Malopolska Region prepared for the needs of the AQP;
- time variability profiles for emission sources – own work based on available data, according to the adopted methodology;
- summing the concentrations coming from different runs of the CALPUFF model (creating a CONC.DAT file) – using the CALSUM postprocessor;
- statistical processing of full one-hour series using a CALPOST postprocessor;
- All components of the CALPUFF model were downloaded (including the source code) from http://www.src.com/.

The calculations were carried out using a scalable computing platform composed of multi-core processors, which allowed for a significant reduction in the time needed to obtain results. Thanks to the application of high resolution (calculations in the 0.5 × 0.5 km grid compacted to the 0.25 × 0.25 km grid for the development areas), detailed results were obtained in terms of spatial distribution of the concentrations of the analysed pollutants, which allowed for a thorough analysis of the air quality in the base year (2018) and projected years (2023 and 2026) in the Malopolska Region. The analyses for the base year were performed after verification of model data with measurement data.

Model verification

Verification of the calculation model was based on the results of measurements from measurement stations operating within the State Environmental Monitoring located in the area of the Malopolska Region and used in *Annual air quality assessment for the year 2018*. In the process of model verification only points with sufficient coverage of measurements were included. In order to verify the CALPUFF modelling results with the results of measurements, the so-called discrete receptors, i.e. additional points where the measuring stations are located, were set up before the start of modelling in order to obtain the concentrations of the analysed pollutants exactly at the station points. The modelling uncertainty analysis was carried out on the basis of modelling results for the base year 2018.

The results obtained allowed for comparison of modelling with the results of measurements of the concentrations of the analysed substances. The averaging periods used to determine the modelling uncertainty result from the Regulation of the Minister of Environment of 8 June 2018 on the assessment of substance levels in the air. According to the CAFE Directive, modelling uncertainty is defined as the maximum deviation between the measured and calculated concentration level for 90% of monitoring points in a given period, for the limit value. Below (Table 52), a comparison of measurement and modelling results for PM10, PM2.5, nitrogen dioxide and benzo(a)pyrene is shown.

Table 52. Comparison of measurement and modelled concentrations for the analysed pollutants in the base year 2018.

No.	Measuring point code	Modelling result – annual average concentrations				Measurements – annual average concentrations				Absolute modelling error			
		PM10	PM2.5	B(a)P	NO_2	PM10	PM2.5	B(a)P	NO_2	PM10	PM2.5	B(a)P	NO_2
		[$\mu g/m^3$]		ng/m^3	[$\mu g/m^3$]			ng/m^3	[$\mu g/m^3$]			ng/m^3	[$\mu g/m^3$]
1	MpBochKonfed	34	26	7	19	36	29	7		-5.9%	-11.5%	-8.9%	
2	MpKrakAlKras	50	33	6	56	56	39		61	-12.0%	-18.2%		-8.9%
3	MpKrakBujaka	39	28	5	39	43	31	5	32	-10.3%	-10.7%	3.2%	17.9%
4	MpKrakBulwar	38	27	5	34	37	27	6	27	2.6%	0.0%	-13.9%	19.7%
5	MpKrakDietla	41	30	5	42	47			41	-14.6%			2.4%
6	MpKrakOsPias	31	22	4	29	36		5		-16.1%		-18.3%	
7	MpKrakWadow	31	22	4	23	33		6		-6.5%		-25.1%	
8	MpKrakZloRog	43	30	5	46	42		5		2.3%		6.9%	
9	MpMuszynZloc	20	16	4	7	20		2		0.0%		33.3%	
10	MpNiepo3Maja	31	24	6	20	35		7		-12.9%		-19.4%	
11	MpNoSaczNadb	40	30	10	30	40	33	10	25	0.0%	-10.00%	2.4%	16.7%
12	MpNoTargPSlo	45	36	17	21	46		18		-2.2%		-9.3%	
13	MpOlkuFrNull	31	24	5	18								
14	MpOswiecBema	37	27	7	23	43		8		-16.2%		-15.6%	
15	MpSkawOsOgro	42	31	7	26	41			22	2.4%			15.4%
16	MpSuchaNiesz	38	31	11	12	43		13		-13.2%		-13.9%	
17	MpTarBitStud	31	22	4	37	32	25	4	20	-3.2%	-13.64%	-2.7%	45.9%
18	MpTarRoSitko	33	25	4	34	35	25			-6.1%	0.00%		
19	MpTrzebOsZWM	32	25	6	20	32	24	5	16	0.0%	4.00%	13.3%	20.0%
20	MpTuchChopin	39	30	8	17	41		10		-5.1%		-15.1%	
21	MpZakopaSien	30	25	7	15	30	24	8	20	0.0%	4.00%	-10.3%	-33.3%

17.3. List of literature and sources

- Annual air quality assessment in the Malopolska Region, Report for 2013, Regional Inspectorate of Environmental Protection (RIEP) 2014
- Annual air quality assessment in the Malopolska Region, Report for 2014, RIEP 2015
- Annual air quality assessment in the Malopolska Region, Report for 2015, RIEP 2016
- Annual air quality assessment in the Malopolska Region, Report for 2016, RIEP 2017
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- Annual air quality assessment in the Malopolska Region, Report for 2018, CIEP Regional Department of Environmental Monitoring in Krakow 2019,
- EMEP/EEA air pollutant emission inventory guidebook. European Environment Agency, Copenhagen 2019
- A User's Guide for the CALPUFF Dispersion Model (Version 5). Earth Tech, Inc. 196 Baker Avenue, Concord, MA 01742. SCIRE JS, STRIMAITIS DG, YAMARTINO RJ 2000
- The forecast of the demand for fuels and energy until 2030 Appendix 2 to the "Polish Energy Policy until 2030" the Ministry of Economy, 2009.
- Information prepared by municipality, city, and county offices of the Malopolska Region,
- Report on estimation based on the measurement of the emission factors of basic air pollutants emitted from individual heat sources – Institute for Chemical Processing of Coal (Instytut Chemicznej Przerobki Wegla), Zabrze, 2017
- Scientific expertise entitled "Development of a calculation program for determining the road emission of carbon monoxide, hydrocarbons, non-methane volatile organic compounds, nitrogen oxides, solid particles, sulphur oxides and benzene for cumulated categories of vehicles: passenger cars, light trucks (delivery vans) as well as trucks and buses for years balancing: 2014, 2015, 2020, 2025, 2030, 2035 and 2040 "; prof. Zdzislaw Chlopek, 2016
- Forecast of PM10 and PM2.5 concentrations for 2020 and 2025 and determination of the pollution background for the period 2016-2020, ATMOTERM SA 2016
- Forecast of demand for fuels and energy until 2030 Annex 2. to "Poland's energy policy until 2030" Ministry of Economy 2009

17.4. Detailed analysis of scenarios for corrective measures

17.4.1. *EMISSIONS FROM THE MUNICIPAL AND HOUSEHOLD SECTOR*

In order to determine the ecological effects of the introduction of new corrective measures, also connected with the change of legal regulations in the region, a number of factors have been assumed for analysis, which may influence the situation in the municipal and household sector. The assumptions of changes within the analysed scenarios take into account as follows:

- **Heat demand change ratio in 2026 compared to 2018.**
  This ratio takes into account changes in the amount of heat demand resulting from thermo-modernization and newly constructed buildings. Within the variants, the heat demand change ratio for construction works compared to 2018 was adopted at the level of 0.9 (for 2026); for the analysis for 2023, the ratio was adopted at the level of 0.95;

- **Indicator of the change in the fuel mix and ways of supplying heat to residential buildings**, which determines how the structure of heat demand coverage may change as part of corrective actions. The combustion of oil and gas, the use of RES and connection to the heating network, as well as changes in the use of coal and wood have been taken into account. It has been assumed that changes in the demand for heat from wood and coal will take place with respect to the connection to gas, oil and district heating network. In variants 2, 3, 4 and 5 no increase in the share of coal in relation to the base year is assumed, therefore the index is 0. The percentages indicate a potential increase in the use of a given type of heat supply method, taking into account also newly constructed buildings. No decrease in the share of new coal-fired devices was assumed, as those in operation will continue to operate. The table does not specify how the share of old coal-fired devices will change. The use of low-efficiency coal-fired fuel devices will decline year by year and, according to the scenarios, they will no longer operate in the region in the year of the forecast. The percentage indicator relates mainly to the replacement structure of outdated devices. The 0% indicator means that new coal fuel devices will no longer be built. The indicators presented below specify average changes, while for each municipality the share of new individual fuels was calculated separately, depending on the possibility of their use. If the municipality has no district heating network, its presence in the forecast year was not assumed. In the scope of the gas network, the extension of the network based on data from the Central Statistical Office was also adopted.

Table 53. Indicator of the increase in the share of various types of fuels in heat supply on average for the region.

Scenario	Renewable energy sources	District heating network	Wood	Natural gas	Coal – new
Scenario 0	5%	10%	30%	10%	40%
Scenario 1	10%	20%	30%	20%	20%
Scenario 2	15%	10%	20%	15%	0%
Scenario 3	15%	10%	20%	15%	0%
Scenario 4	15%	10%	20%	15%	0%
Scenario 5	25%	30%	0%	0%	0%

- The indicator of the increase in the floor area of apartments in municipalities through construction of new buildings was taken into account. The assumed percentage changes also result from the year-on-year change in the surface of apartments in CSO data.

Table 54. Indicator of increase in the floor area of apartments in subsequent years based on changes in the floor area noted in previous years on the basis of the CSO data.

Year	Cities	Rural areas	Krakow	Nowy Sacz	Tarnow	Health resorts
2019	1.0131	1.0177	1.0297	1.0146	1.0080	1.0051
2020	1.0136	1.0175	1.0319	1.0159	1.0080	1.0036
2021	1.0141	1.0173	1.0341	1.0172	1.0080	1.0021
2022	1.0146	1.0171	1.0363	1.0185	1.0080	1.0006
2023	1.0151	1.0169	1.0385	1.0198	1.0080	0.9991
2024	1.0156	1.0167	1.0407	1.0211	1.0080	0.9976
2025	1.0161	1.0165	1.0429	1.0224	1.0080	0.9961
2026	1.0166	1.0163	1.0451	1.0237	1.0080	0.9946

- In relation to the emission factors defined for solid fuels, fuel oil and the emission factors specified for gas, emissions growth rate under operating conditions was adopted (conversion rate from laboratory conditions to actual operating conditions of the source). It has been assumed that the operation of new sources with the use of fuels present on the market may result in an increase in emissions for particular types of devices due to the operating conditions and the way the equipment is used. Emission factors are calculated according to laboratory conditions, while temporary wear and tear of equipment during operation may result in higher emissions than assumed by emission factors. The assumptions include an increase in emissions compared to the assumed emission factors according to the factors shown in the table.

Table 55. Emissions growth rate for individual fuel types.

Fuel Type	Emissions growth rate
gas	1.05
oil	1.05
wood	1.10
coal	1.20

These conditions have been considered for scenarios 0 to 4.

For scenario 0 of the forecast, it is assumed that all new solid fuel boilers installed after 2020, in accordance with the regulations, will meet the Ecodesign standard. In each municipality, a certain percentage of boilers (different for each municipality), depending on the degree of replacement of newly installed solid fuel boilers and those operating in municipalities prior to the AQP implementation, will also meet the Ecodesign standard. In each municipality there will still be a number of devices that were replaced before the anti-smog resolutions came into force and may still function in the region and do not meet the Ecodesign requirements. Under this variant, normal replacement of old devices will take place, similarly as before, only at an increased rate compared to previous years.

In scenario 1, it was assumed that 25% of the non-class boilers would remain to be replaced out of all those to be replaced by the deadline indicated in the anti-smog resolution. Scenarios 2, 3 and 4 assume that all the non-class boilers in the region would be replaced and that the boilers meeting Ecodesign requirements would be the only ones that would remain in service after the replacement process. On the other hand, with respect to new boilers which were already installed in the base year and were fully operational, it was assumed that about 10% of the boilers would meet class 3 and 4 of PN-EN 303:5/2012 standard, and they should be replaced by 2026. The new boilers included in the database, which meet class 5 of the standard, are those which are not subject to replacement. In accordance with the anti-smog resolution for Malopolska, class 5 boilers installed before 1 July 2017 may be operated until the end of their service life.

The assumption concerns the target state in 2023, and in order to assess the impact of further actions on concentration levels, assumptions are also made for 2026 in order to meet the standards for benzo(a)pyrene and nitrogen dioxide at said date. For 2026, a decrease in emissions from the neighbouring regions resulting from activities undertaken under the air quality plans was also taken into account. It was assumed for 2026 that all the boilers would meet the Ecodesign requirements in the entire region, except for Krakow, where solid fuels would not be used due to the anti-smog resolution.

Within the framework of the variants, the possibilities of supplying the inhabitants with gas and district heating networks during the years of AQP implementation were analysed. A number of new investments are being carried out in the Malopolska Region in order to expand the heating and gas networks and provide the residents with alternative methods of heat supply. This is particularly important when analysing the possibility of introducing a ban on the use of solid fuels in some municipalities. In Scenario 4, such a measure was analysed for the area of health resorts located in the Malopolska Region: Muszyna, Szczawnica, Piwniczna Zdroj, Krynica Zdroj, Rabka Zdroj, Wapienne (municipality of Sekowa) and Wysowa (municipality of Uscie Gorlickie).

According to the data of the Central Statistical Office, in 2018 there were 1 693 boiler rooms providing heat and 1415 km of transmission and distribution network providing heat to the residents of the region. In recent years, the length of connections to buildings increased by 32 km in 2017, and in 2018 by 23 km compared to the previous year. The heating networks operate mainly in cities, while few municipalities have the possibility to use this type of medium. The smallest number of district heating networks are located in the counties Dabrowski, Miechowski, Limanowski, Myslenicki, Nowosadecki, Proszowicki as well as Tarnowski and Wielicki. The length of the transmission network in these counties does not exceed 3 km.

Length of district heating in the counties of the Malopolska Region.

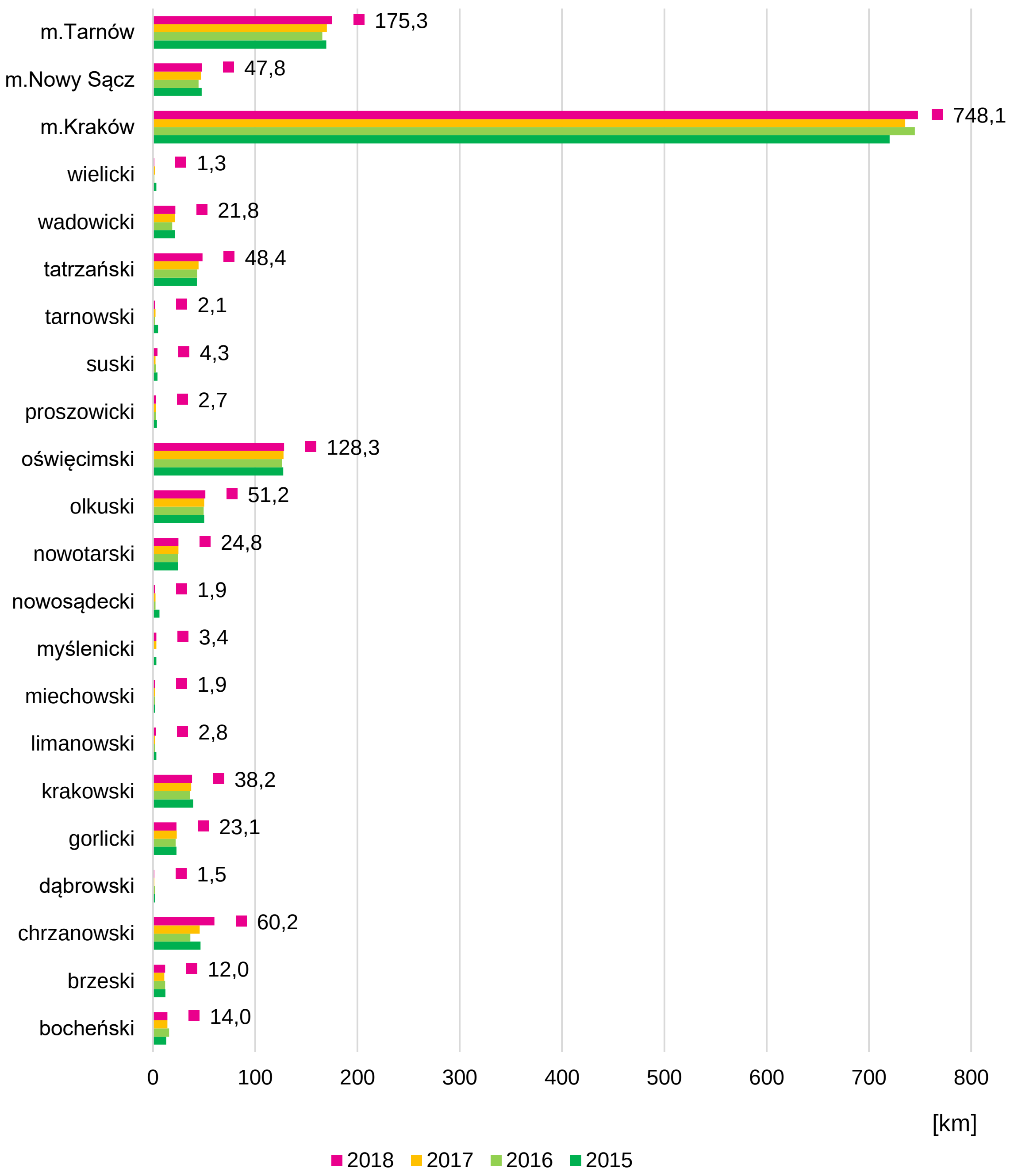


Figure 77. Length of the district heating network and distribution network in the counties of the Malopolska Region in 2018. [157]

Under the EU funds, in 2019, projects related to the expansion of the district heating network were subsidized, so there are grounds for assuming that the development of district heating networks will take place in the following years, but in particular this assumption was made with regard to cities where such a network currently operates. The scenarios did not assume the expansion of the new network in areas where there is no district heating network. The indicated investments include:

[157] Source: CSO www.stat.gov.pl

- Reconstruction of the heating system of Krakow and Skawina – MPEC S.A. Krakow project POIS.01.05.00-00- 0005/19,
- Modernization of the heating network in MPEC Nowy Sacz – MPEC S.A. Nowy Sacz project POIS.01.05.00-00- 0008/19,
- Distribution of heat from the municipal heating network for water heating in selected multi-family residential buildings in the city of Gorlice – MPGK Sp. z o.o. in Gorlice - project POIS.01.05.00-00-0014/19,
- Construction and modernization of heating networks at the Osiedle Chemikow (Chemists Housing Estate) in Oswiecim – PEC sp. z o.o. Oswiecim – POIS.01.05.00-00- 0020/19 project
- Construction of MPEC Nowy Targ local (housing estate) district heating network in order to improve the efficiency of heat distribution and target use of geothermal energy – MPEC Nowy Targ Sp. z o.o. – project POIS.01.05.00-00- 0026/19, (assumed length of the newly built network is 5 690 m[158])

District heating companies are constantly modernizing and expanding their district heating network to supply heat to new consumers. At the same time, a very important element of further functioning of heating systems is to attract new heat consumers and expand the heat market, on the one hand, and to optimise system operation, on the other, in order to appropriately manage the surplus heat capacity that occurs in heating systems.

The shape of the implemented corrective measures and their effectiveness under the scenarios will also be affected by the development of gas networks that will provide an alternative source of heat in areas where there is currently no district heating network and where mainly coal-fired sources operate. According to the CSO data, in 2018, 24 150 km of the total gas network and 1490 km of the transmission network operated in the Malopolska Region. From year to year, the number of people using the gas network increases. In 2018, it was used by 2 112 869 people, i.e. by over 6100 people more than in 2017. Of the 735 084 households which use gas, 287 021 use gas to heat their homes. This number has been increasing steadily since 2015. In 2018, 13 558 more households used gas for heating purposes than in 2017. In 2017, 8 270 more households used gas for heating purposes than in 2016. This trend will continue, as the gas network is being increasingly expanded. In the last two years, an average of over 197 km of the total gas network and about 189 km of the distribution network was built.

Among the health resorts in the region, the gas network does not function in Piwniczna Zdroj and Szczawnica. On the other hand, in Uscie Gorlickie and Sekowa, about 38 and 44% of households using gas use it for heating purposes. In other health resorts, households in Rabka Zdroj use the gas network for heating to the greatest extent – about 76% of all that are using gas.

[158] Source: Update of the Draft plan of supply of heat, electricity and gas fuels for the municipality of the city of Nowy Targ,

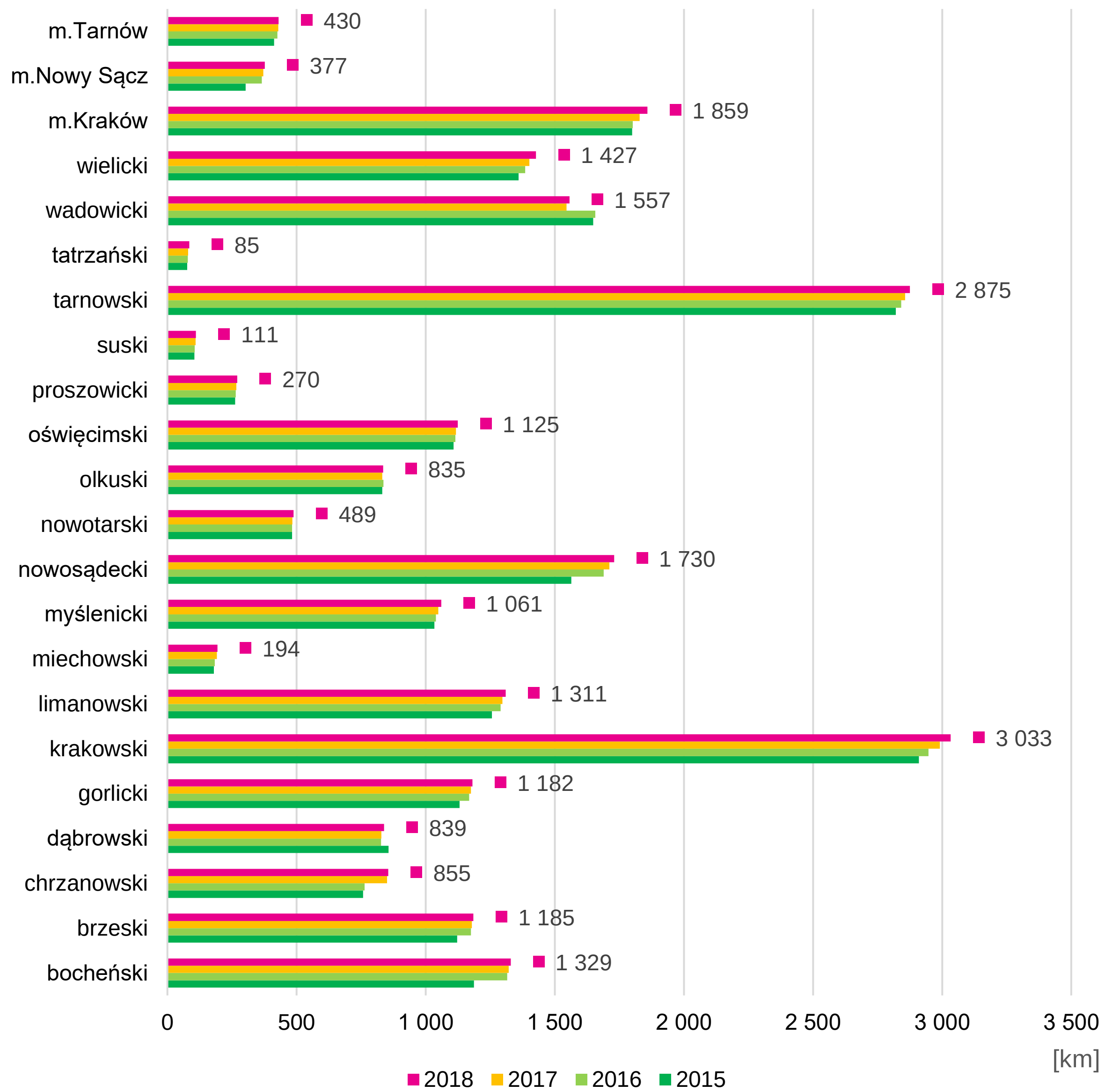


Figure 78. Length of the active gas network in the counties of the Malopolska Region in the years 2015-2018[159]

In 20 municipalities there is no gas network at all or its length does not exceed 1 km. The largest increase in the gas network occurred during the last two years in Krakow as well as in Krakowski and Wielicki counties. In 23 municipalities, no more than 10 metres of the gas network has been built, which proves the low level of network development in these municipalities.

In health resorts where the gas network operates, the growth of the gas network was the largest in the municipality of Krynica Zdroj (1.04 km). The smallest increase in the network occurred in Sekowa and Muszyna – just over 600 m of the new network.

The analysis of the expansion of the gas network also took into account the plans of Polska Spolka Gazownictwa Sp. z o.o. (Polish Gas Distribution Group) for the years 2020-2024 according to the material and financial Investment Plans which constitute the basis for carrying out investments in the Malopolska Region from two tariff areas: Zabrzanski and Tarnowski. These plans include both the reconstruction of the gas network and the construction of the network in non-gasified areas.

As part of the expansion of the gas network in non-gasified areas, it is planned to connect new consumers in municipalities that have been included in the multiannual plan. These municipalities also

[159] Source: CSO, www.stat.gov.pl

include health resorts, also those with no gas network. These include: Szczawnica and Piwniczna Zdroj, where 242 new gas consumers will be connected. Among other health resorts, there are no plans to expand the gas network in Muszyna, Rabka Zdroj, Sekowa and Uscie Gorlickie. Similarly, no new connections are planned in Krynica Zdroj, despite the expansion of the Krynica - Muszyna gas pipeline. Additionally, modernization and reconstruction of the existing network and connections in Krynica Zdroj will be carried out. The reconstruction will involve 439 connections and 13.5 km of gas network. This may also affect the availability of this heating source. Similarly, 246 connections and 6.1 km of gas network will be reconstructed in Muszyna.

Table 56. Lengths of gas pipelines and connections planned to be extended by PSG Sp. o.o. in the years 2020-2024 in the Malopolska Region[160].

Municipality	Length of the planned gas pipeline [m]	Length of the planned connections [m]	Number of planned connections [pcs]
Bialy Dunajec	14 283	2 750	479*
Budzow	70 702	8 844	1 474*
Bukowina Tatrzanska	29 648	5 297	575*
Bystra Sidzina	15 455	1 470	294*
Chelmiec	40 488	4 408	806
Czernichow	13 010	2 600	500
Gromnik	3 075	270	50
Jablonka	4 580	465	55*
Jordanow	42 655	9 226	1 134
Koniusza	100	0	0
Koscielisko	33 016	5 384	671*
Krynica	13 200	0	0
Krzeszowice	3 670	584	73
Limanowa	4 300	0	0
Krakow	223 098	375 730	23 292
Nawojowa	13 876	1 640	322
Niepolomice	1 801	0	0
Nowy Sacz	23 152	0	0
Oswiecim	5 299	752	124
Piwniczna Zdroj	4 539	465	78*
Podegrodzie	28 552	3 060	569*
Poronin	36 463	5 714	978
Raciechowice	6 679	1 000	125
Raclawice	25 610	2 810	339*
Rytro	2 731	990	97
Slomniki	32 955	4 766	713
Stryszawa	25 100	6 817	840*
Sucha Beskidzka	14 650	3 150	625
Szaflary	15 941	2 400	464*
Szczawnica	67 007	8 834	164
Trzyciaz	22 980	1 926	321
Wieliczka	1 108	0	0

[160] Source: based on PSG Sp. z o.o. data.

Municipality	Length of the planned gas pipeline [m]	Length of the planned connections [m]	Number of planned connections [pcs]
Wielka Wies	100	0	0
Zawoja	41 400	4 920	926
Zabierzow	3 451	0	0
Zator	3 700	160	1
Zielonki	2 510	0	0
TOTAL	**890 884**	**466 432**	**36 089**

* Municipalities that did not have a single building connection in 2018.

Some projects are carried out collectively for several municipalities i.e. Krynica Zdroj together with Muszyna or Szczawnica with Kamienica, Ochotnica Dolna, Lacko, and Kroscienko nad Dunajcem. The table presents the main municipalities covered by the project. The gas network expansion plans indicate that in the following years the gas network will be expanded the most in the municipality of Budzow, the municipality of Szczawnica, and surrounding municipalities, as well as in the municipality of Jordanow. Krakow is the area where most investments related to the expansion of the gas network will be carried out, as over 223 km of the gas network and about 23,000 connections will be built. In total, outside Krakow, over 12,000 new connections will be made to consumers in the Malopolska Region.

In the case of 10 municipalities, the expansion of the gas network and the construction of connections will be the first to be built in recent years. In municipalities: Budzow, Bukowina Tatrzanska, Bystra Sidzina, Jablonka, Szczawnica, Koscielisko, Piwniczna Zdroj, Podegrodzie, Raclawice and Stryszawa there was no gas network until 2018 (according to CSO data), therefore investments in its development are very important for the development of the municipality and changes in the way of heat supply. The largest increase in the gas network in relation to 2018 will occur in the following municipalities: Bialy Dunajec (280%), Jordanow (2809%), Poronin (1111%), Rytro (7954%) and Szaflary (286%). In Krakow, the growth of the gas network will amount to about 32% of the total network.

11 municipalities will gain network connections to buildings, which have not existed before, while the largest number of network connections has been planned in the municipalities of Budzow and Jordanow – over 100 buildings are planned to be connected to the gas network. In some municipalities, the gas network will be extended, but there will be no new connections to buildings, as the investment will concern the transmission network (9 municipalities).

All planned investments in the expansion of the gas network will cost about PLN 982 million in the years 2020-2024. The costs for particular years have been indicated in the table below.

Table 57. Summary of estimated costs of gas network expansion between 2020 and 2024 by Polska Spolka Gazownictwa Sp. z o.o.[161]

Costs in thousand PLN				
2020	**2021**	**2022**	**2023**	**2024**
263 199	156 513	220 074	163 990	178 401

Taking into account the previous rate of investment in the gas and heating network, similar changes in the municipalities were also assumed in the following years. It is natural that plans in this respect may significantly change. Depending on the investment plans of the gas or heat supplier, areas not yet covered by investments may be connected to the network. Analyses of the possibilities of gas and district heating network expansion should be updated every two to three years.

[161] Source: based on PSG Sp. z o.o. data.

In addition, in the area of Malopolska Region, reconstruction of the existing gas network, gas pipelines and connections in 66 municipalities is planned in the following years. Expenditures on these investments will amount to about PLN 660.45 million in the years 2020-2024.

On the basis of the assumptions indicated and on the basis of the applied emission factors for particular types of heating devices, the change of emission values in air quality zones was determined for each of the scenarios, as well as changes in the concentration levels in the region.

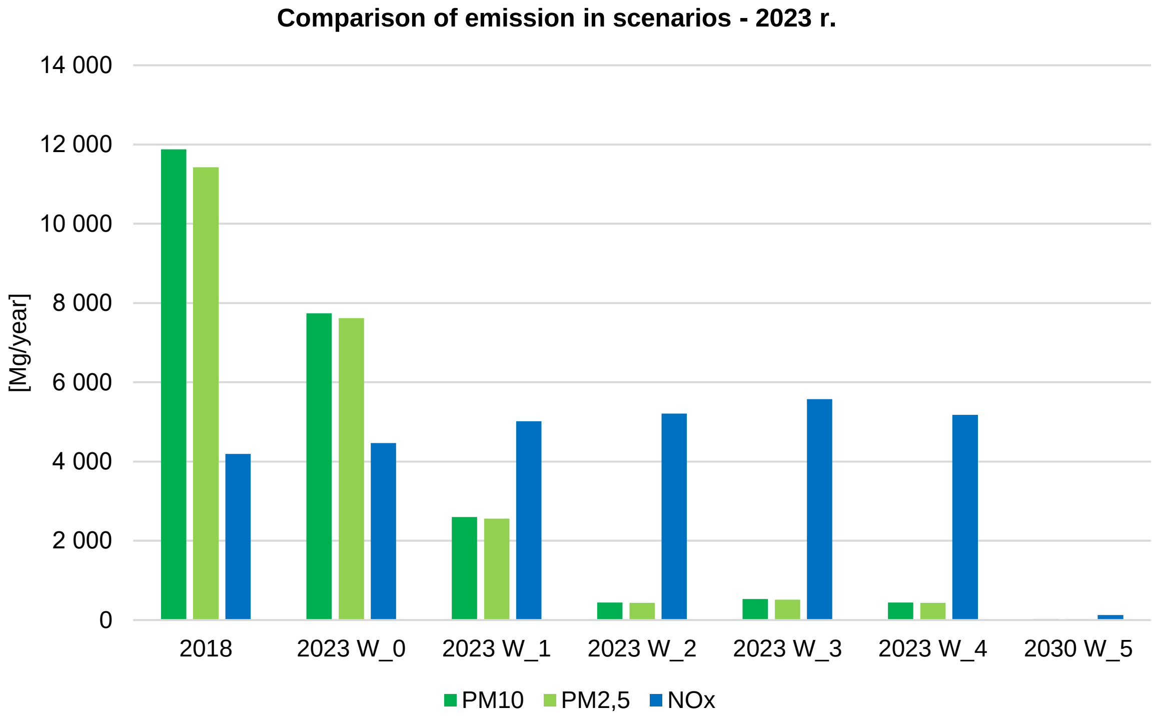


Figure 79. Substance emissions in individual scenarios for the Malopolska Region for the municipal and household sector for the forecast year 2023. [162]

[162] Based on the inventory made for the Malopolska Region for 2018 from the Inventory Database for Heating Sources of Buildings in Malopolska and the CSO data.

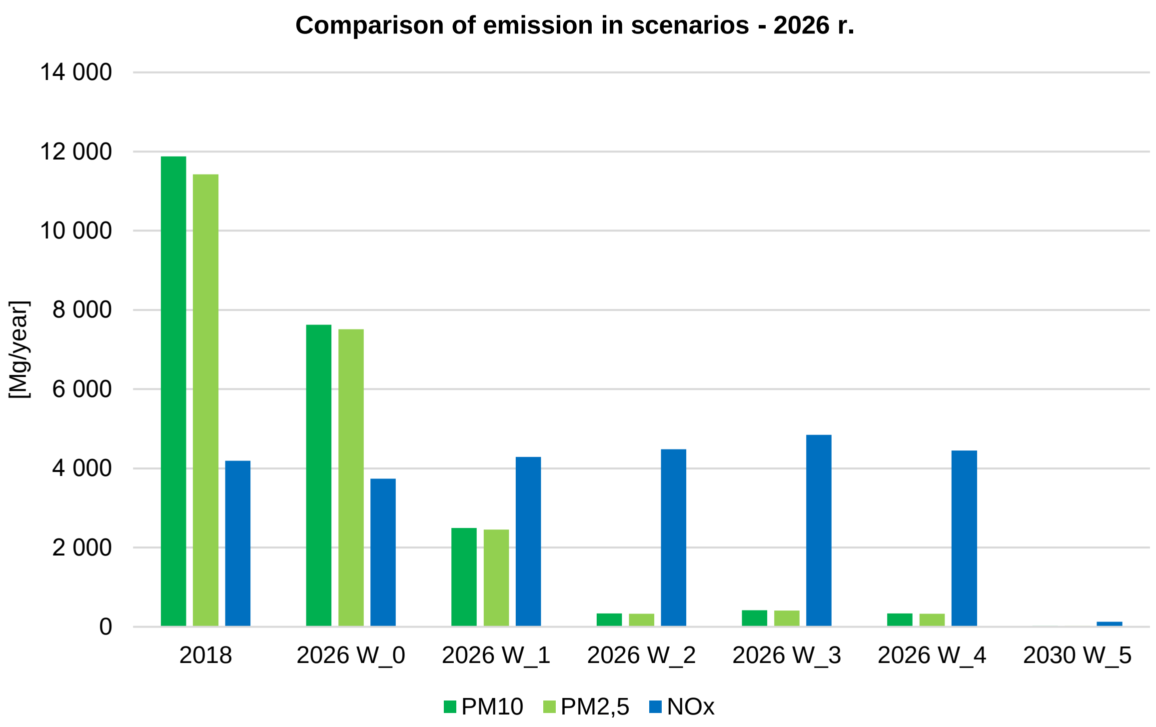


Figure 80. Substance emissions in individual scenarios for the Malopolska Region for the municipal and household sector for the forecast year 2026.[163]

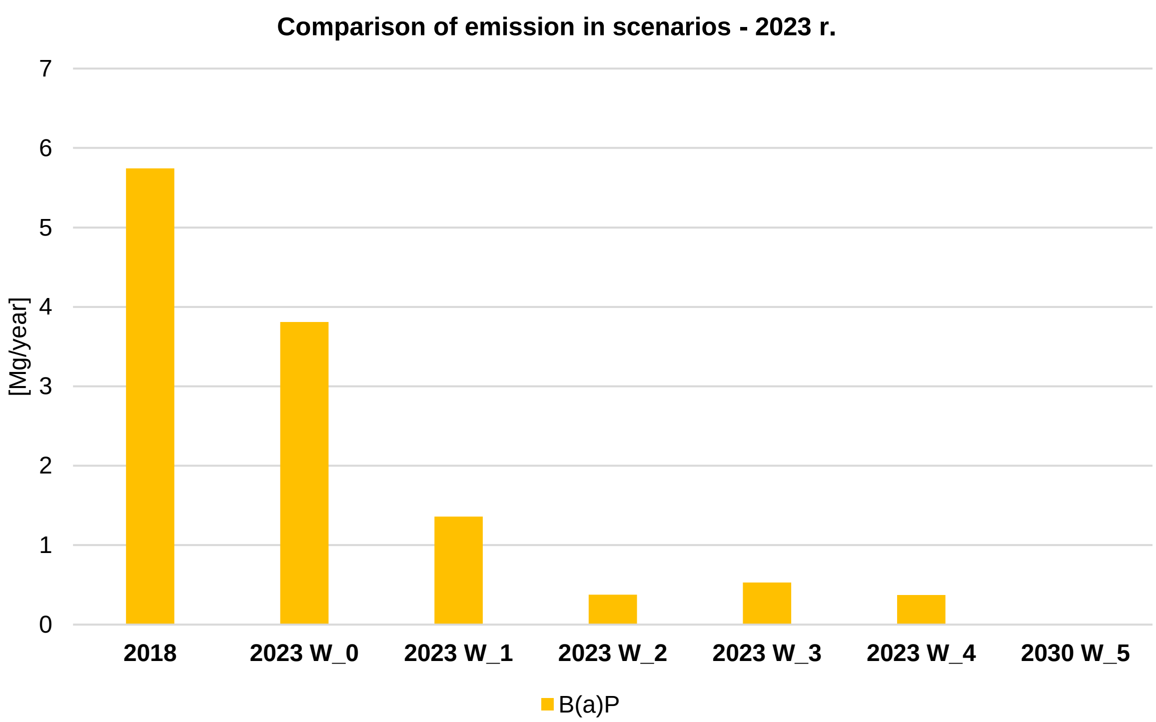


Figure 81. Benzo(a)pyrene emissions in individual scenarios for the Malopolska Region for the municipal and household sector for the forecast year 2023. [164]

[163] Based on the inventory made for Malopolska Region for 2018 from the Inventory Database for Heating Sources of Buildings in Malopolska and the CSO data.
[164] Based on the inventory made for Malopolska Region for 2018 from the Inventory Database for Heating Sources of Buildings in Malopolska and the CSO data.

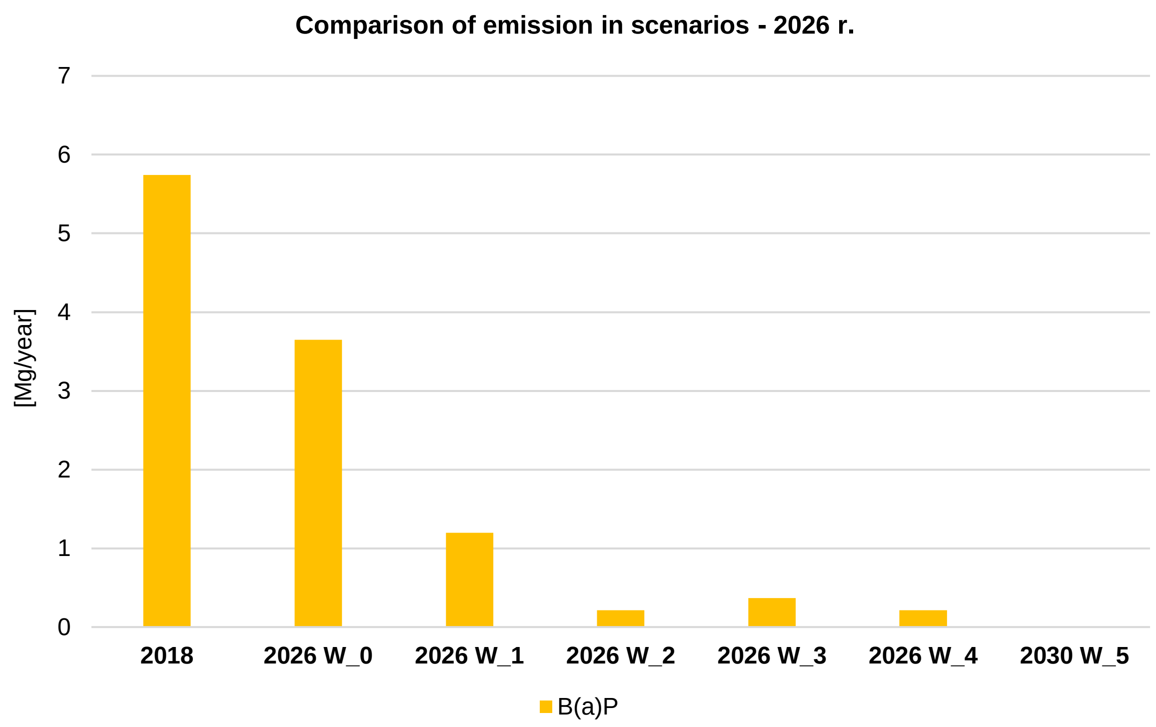


Figure 82. Benzo(a)pyrene emissions in individual scenarios for the Malopolska Region for the municipal and household sector for the forecast year 2026.[165]

17.4.2. EMISSIONS FROM TRANSPORT

The assumptions for the scenarios for transport related activities are indicated in the scenarios:

1. **Scenario 0** – Assumes continuation of the existing measures, i.e. no additional restrictions for transport.
2. **Scenario 1 –** Assumes establishment of clean transport zones in the centre of Krakow and Tarnow[166].
3. **Scenario 2** – The scenario assumes introduction of a low emission zone based on EURO emission standards in the area of Krakow, including the area bounded by the city's 3rd ring road. The restriction should cover all vehicles – passenger cars, light duty trucks (vans) and heavy duty trucks, including those belonging to residents of Krakow. Only vehicles with diesel engines meeting at least the requirements of the EURO 6 emission standard and petrol vehicles meeting at least the requirements of the EURO 4 emission standard would be able to enter the zone. This variant requires the introduction of legislative solutions at the national level.
4. **Scenario 3** – Low emission zone based on EURO emission standards in the area of Krakow would cover the area bounded by the city's 4th ring road limited by national roads A4, S52 and S7, i.e. practically the entire area of the city. The entry restriction would apply to light duty trucks (vans), heavy duty trucks and public transport vehicles. Entry into the zone would be possible only for diesel vehicles meeting at least the requirements of the EURO 6 emission standard and petrol vehicles meeting at least the requirements of the EURO 4 emission standard. This variant requires the introduction of legislative solutions at the national level.
5. **Scenario 4** – Assumes introduction of a low emission zone based on EURO emission standards in Krakow. The zone would include the area bounded by the city's 4th ring road. Entry to the city

[165] Based on the inventory made for Malopolska Region for 2018 from the Inventory Database for Heating Sources of Buildings in Malopolska and the CSO data.
[166] According to art. 39 of the Act on electromobility and alternative fuels (Journal of Laws 2020, item 908 uniform text)

would be restricted to **all vehicles** – passenger cars, light duty trucks (vans) and heavy duty trucks as well as public transport vehicles, including those belonging to residents. Only vehicles with diesel engines meeting at least the requirements of the EURO 6 emission standard and petrol vehicles meeting at least the requirements of the EURO 4 emission standard would be able to enter the zone. This scenario requires the introduction of legislative solutions at the national level.

6. **Scenario 5** – The scenario assumes transport in the entire region with the use of electric and hydrogen vehicles only.

Based on the assumptions of the scenarios, the volume of emissions from national and regional roads in the cities of Krakow and Tarnow, as well as county and municipal roads was estimated.

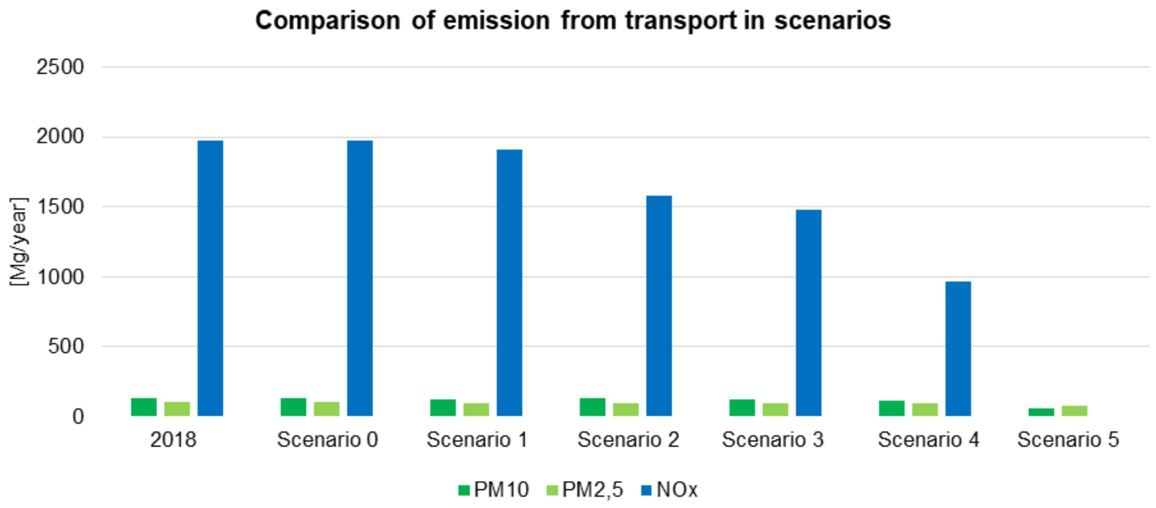


Figure 83. Substance emissions from the transport sector in individual scenarios for the Malopolska Region.[167]

The calculations were based on emission factors according to the EURO category based on the indications in the 2019 Technical Report – Tier 2 EMEP air pollutant emission inventory guidebook 2019.

17.4.3. CHANGES IN POLLUTANT CONCENTRATIONS DUE TO IMPLEMENTATION OF THE VARIANTS

Using changes in the emission values for the scenarios, modelling was carried out in order to determine concentrations of substances for the whole region after the implementation of individual scenarios. The analysis compared the change of concentrations at points of measurement stations after taking into account the change of emissions under the introduced legal regulations. The emission from the point sources remains at the same level in the baseline scenario and in scenarios of changes. Concentration changes result mainly from changes in emissions from the municipal and household sector and linear emissions.

Table 58. Annual average concentrations of PM10 at points of measurement stations in the base year 2018 and in scenarios of introducing corrective measures for the forecast year 2023[168]

Annual average PM10 concentration [µg/m^3]							
Station code	**Baseline 2018**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
MpBochKonfed	33.9	29.5	22.5	19.7	19.7	19.7	16.7
MpBrzeszKosc	37.6	34.8	25.2	21.5	21.5	21.5	18.7
MpKaszowLisz	27.8	24.1	21.0	19.7	19.7	19.7	17.2
MpKrakAlKras	50.5	35.1	32.5	32.5	32.3	32.2	27.8

[167] Based on the inventory made for Malopolska Region for 2018 from the Inventory Database for Heating Sources of Buildings in Malopolska and the CSO data
[168] Source: CALPUFF modelling results based on the AQP emission inventory and KOBIZE Central Emission Inventory

Annual average PM10 concentration [μg/m³]							
Station code	Baseline 2018	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
MpKrakBujaka	38.7	26.6	24.8	24.0	24.0	23.9	20.7
MpKrakBulwar	38.4	27.0	25.4	24.7	24.7	24.6	21.7
MpKrakDietla	41.3	27.4	25.8	25.1	25.0	25.0	21.5
MpKrakOsPias	31.2	23.4	21.8	21.1	21.0	21.0	18.2
MpKrakTelime	38.4	23.3	21.5	20.8	20.7	20.7	17.9
MpKrakWadow	31.1	23.5	21.7	20.9	20.9	20.9	18.5
MpKrakZloRog	43.1	28.5	26.7	26.0	25.9	25.8	22.3
MpMuszynKity	20.3	18.8	15.7	14.3	14.3	14.3	12.2
MpMuszynZloc	19.1	17.8	15.3	14.2	14.2	14.2	12.1
MpNiepo3Maja	30.9	26.2	20.7	18.2	18.2	18.2	15.5
MpNoSaczNadb	40.4	38.5	28.9	22.3	22.3	22.3	16.9
MpNoTargPSlo	45.3	41.5	26.3	19.8	19.8	19.7	16.1
MpOlkuFrNull	31.4	26.5	21.9	20.1	20.1	20.1	17.4
MpOswiecBema	40.3	37.0	26.1	21.9	21.9	21.9	18.6
MpRabkaOrkan	27.0	25.1	17.9	14.8	14.8	14.8	12.3
MpSkawOsOgro	41.7	33.0	24.0	20.1	20.1	20.1	16.9
MpSuchaNiesz	38.5	38.6	23.3	17.1	17.1	17.1	13.9
MpSzarowSpok	26.1	23.9	21.0	19.7	19.7	19.7	17.1
MpTarBitStud	30.7	27.6	23.7	22.1	22.1	22.1	19.0
MpTarRoSitko	33.2	28.7	23.6	21.3	21.3	21.3	18.2
MpTrzebOsZWM	32.5	28.6	23.0	20.6	20.6	20.6	17.6
MpTuchChopin	39.1	33.3	23.8	19.7	19.7	19.6	16.6
MpZakopaSien	30.2	28.3	17.9	13.1	13.1	13.1	10.7

The annual average PM10 concentrations in the individual variants of corrective measures compared to 2018 are decreasing and remain mostly below the limit value. In scenario 5, the aim was to meet the WHO standards for Malopolska. The modelling results indicate that it is possible to meet the air quality standards in Malopolska practically with a very large elimination of emissions from the region and the necessary reduction of emissions from neighbouring regions and in most of the country, i.e. the total background, by more than 60% in relation to the current state.

Table 59. Annual average concentrations of PM2.5 at points of measurement stations in the base year 2018 and in scenarios of introducing corrective measures for the forecast year 2023[169].

Annual average PM2.5 concentration [μg/m³]							
Station code	Baseline 2018	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
MpBochKonfed	25.61	21.81	15.06	12.35	12.3	12.35	10.17
MpBrzeszKosc	28.41	26.40	19.02	16:19	16:19	16:19	14.05
MpKaszowLisz	19.29	16.12	13.33	12.14	12.1	12.13	10.21
MpKrakAlKras	33.50	18.93	17.53	16.95	16.9	16.87	14.10
MpKrakBujaka	27.61	16.22	14.74	14.12	14.1	14.08	11.81
MpKrakBulwar	26.87	16.88	15.48	14.88	14.9	14.86	12.68

[169] Source: CALPUFF modelling result.

Annual average PM2.5 concentration [µg/m^3]							
Station code	**Baseline 2018**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
MpKrakDietla	29.54	16.37	15.06	14.51	14.5	14.46	12.14
MpKrakOsPias	22.41	15.14	13.72	13.12	13.1	13.10	11.07
MpKrakTelime	26.80	15.16	13.65	13.01	13.00	12.99	10.91
MpKrakWadow	21.83	15.43	13.82	13.13	13.1	13.12	11.27
MpKrakZloRog	29.81	16.72	15.29	14.69	14.7	14.64	12.26
MpMuszynKity	16.51	15.18	12.20	10.93	10.9	10.92	9.19
MpMuszynZloc	15.30	14.23	11.79	10.74	10.7	10.74	9.08
MpNiepo3Maja	23.74	19.56	14.39	12.07	12.1	12.07	10.01
MpNoSaczNadb	29.96	28.24	19.58	13.58	13.6	13.58	10.39
MpNoTargPSlo	36.45	33.12	18.65	12.48	12.5	12.44	9.78
MpOlkuFrNull	24.01	19.64	15.41	13.76	13.8	13.76	11.61
MpOswiecBema	29.42	26.97	18.38	15.07	15.1	15.07	12.70
MpRabkaOrkan	21.59	20.03	13.48	10.69	10.69	10.67	8.74
MpSkawOsOgro	30.53	23.60	16:19	12.96	13.0	12.96	10.61
MpSuchaNiesz	30.98	31.20	17.81	12.38	12.4	12.38	9.89
MpSzarowSpok	18.08	16.11	13.42	12.25	12.2	12.25	10.21
MpTarBitStud	21.90	19.23	17.04	13.85	13.85	13.84	11.65
MpTarRoSitko	24.80	20.96	17.44	13.59	13.59	13.59	11.41
MpTrzebOsZWM	24.85	21.58	16.31	14.08	14.1	14.08	11.94
MpTuchChopin	30.05	25.35	16.66	12.90	12.9	12.90	10.60
MpZakopaSien	25.12	23.64	14.34	10.08	10.1	10.08	8.11

The annual average concentrations of PM2.5, the standard of which will be 20 µg/m^3 from 2020, will be met if the action scenarios are implemented. Only if no additional action is taken, i.e. under scenario 0, there could be exceedances of the standard anticipated after 2020. In scenario 5, which was based on meeting the WHO standards, the results indicate that it will not be possible to achieve concentrations of PM2.5 below 10 µg/m^3 because of the overall background effect on concentrations. The analysis showed that with the current assumptions of emission levels for Malopolska Region, the WHO standard may not be met in 2030 due to significant amounts of emissions on the national scale (outside the Region), which affect the total background concentrations of PM2.5.

Table 60. Annual average concentrations of benzo(a)pyrene at points of measurement stations in the base year 2018 and in scenarios of introducing corrective actions for the forecast year 2026.[170]

Annual average benzo(a)pyrene concentration [ng/m^3]							
Station code	**Baseline 2018**	**Scenario 0**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
MpBochKonfed	6.59	5.10	2.28	1.20	0.94	0.94	0.90
MpBrzeszKosc	7.65	6.73	3.65	2.50	1.46	1.46	1.46
MpKaszowLisz	3.57	2.39	1.41	1.00	0.71	0.71	0.84
MpKrakAlKras	5.64	1.59	1.14	0.96	0.68	0.68	0.80
MpKrakBujaka	5.06	1.64	1.12	0.91	0.65	0.65	0.77
MpKrakBulwar	4.82	1.68	1.17	0.97	0.69	0.69	0.83
MpKrakDietla	5.21	1.57	1.12	0.94	0.66	0.66	0.80
MpKrakOsPias	4.05	1.70	1.20	1.00	0.71	0.71	0.86
MpKrakTelime	5.09	1.70	1.15	0.93	0.67	0.67	0.79
MpKrakWadow	4.34	1.83	1.25	1.02	0.72	0.72	0.89
MpKrakZloRog	5.47	1.67	1.18	0.98	0.69	0.69	0.83
MpMuszynKity	2.13	1.86	1.25	1.00	0.82	0.82	0.88
MpMuszynZloc	1.96	1.73	1.19	0.97	0.79	0.79	0.86
MpNiepo3Maja	5.77	4.20	2.01	1.05	0.79	0.79	0.81
MpNoSaczNadb	9.89	8.93	4.26	1.40	1.20	1.20	0.91
MpNoTargPSlo	16.73	14.90	5.50	1.73	1.46	1.46	0.92
MpOlkuFrNull	4.81	3.51	1.98	1.40	0.96	0.96	1.19
MpOswiecBema	7.58	6.51	3.08	1.79	1.26	1.26	1.46
MpRabkaOrkan	6.03	5.38	2.19	0.91	0.71	0.71	0.59
MpSkawOsOgro	7.44	4.66	2.14	1.08	0.82	0.82	0.79
MpSuchaNiesz	11.41	11.67	4.39	1.50	1.23	1.23	0.81
MpSzarowSpok	3.13	2.43	1.41	0.99	0.73	0.73	0.82
MpTarBitStud	3.68	2.97	1.81	1.30	0.95	0.95	1.13
MpTarRoSitko	4.47	3.52	2.04	1.38	1.04	1.04	1.18
MpTrzebOsZWM	5.66	4.60	2.40	1.50	1.05	1.05	1.26
MpTuchChopin	8.40	6.55	2.88	1.35	1.02	1.02	0.97
MpZakopaSien	6.88	6.25	2.49	0.91	0.75	0.75	0.56

The concentrations of benzo(a)pyrene, according to the analysis of the results of the implemented scenarios of corrective measures, may exceed the target value at many points of the region in several scenarios except scenarios 3, 4 and 5. In order to obtain concentration values meeting the target standard in the Malopolska Region, it is necessary to reduce benzo(a)pyrene emissions in the country at a level above 70%. Particularly significant is the share of benzo(a)pyrene inflow from the area of the Silesia Region, where concentrations in the western municipalities of the Malopolska Region (Oswiecim, Brzeszcze, Bukowno, Olkusz, Chrzanow, Kety, Libiaz, Trzebinia, Klucze, Babice) may exceed the target value despite the reduction of total emissions in the Malopolska Region due to the background concentration value.

When analysing the modelling results for scenarios of the implementation of corrective measures, it is necessary to take into account factors that influence the concentration results. These include in particular the meteorological conditions to which the modelling referred (2018). In case of significantly worse meteorological conditions than in 2018, concentrations may be higher. Modelling results for particular scenarios have been presented in the form of maps of distribution of concentrations of particular substances in the area of the Malopolska Region.

[170] Source: CALPUFF modelling result.

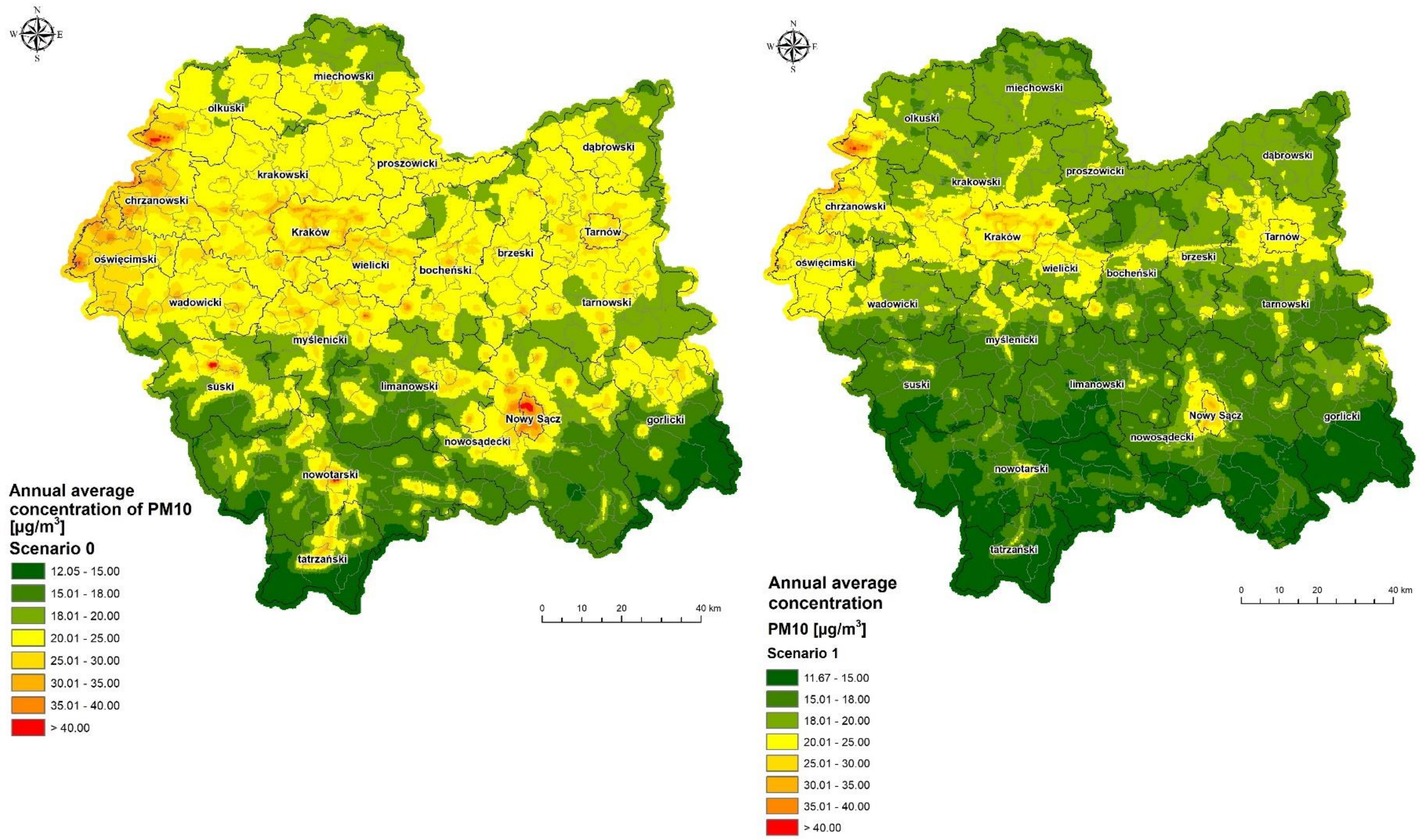


Figure 84. Distribution of annual average concentrations of PM10 in scenario 0 and scenario 1 for 2023.[171]

[171] Source: CALPUFF modelling result.

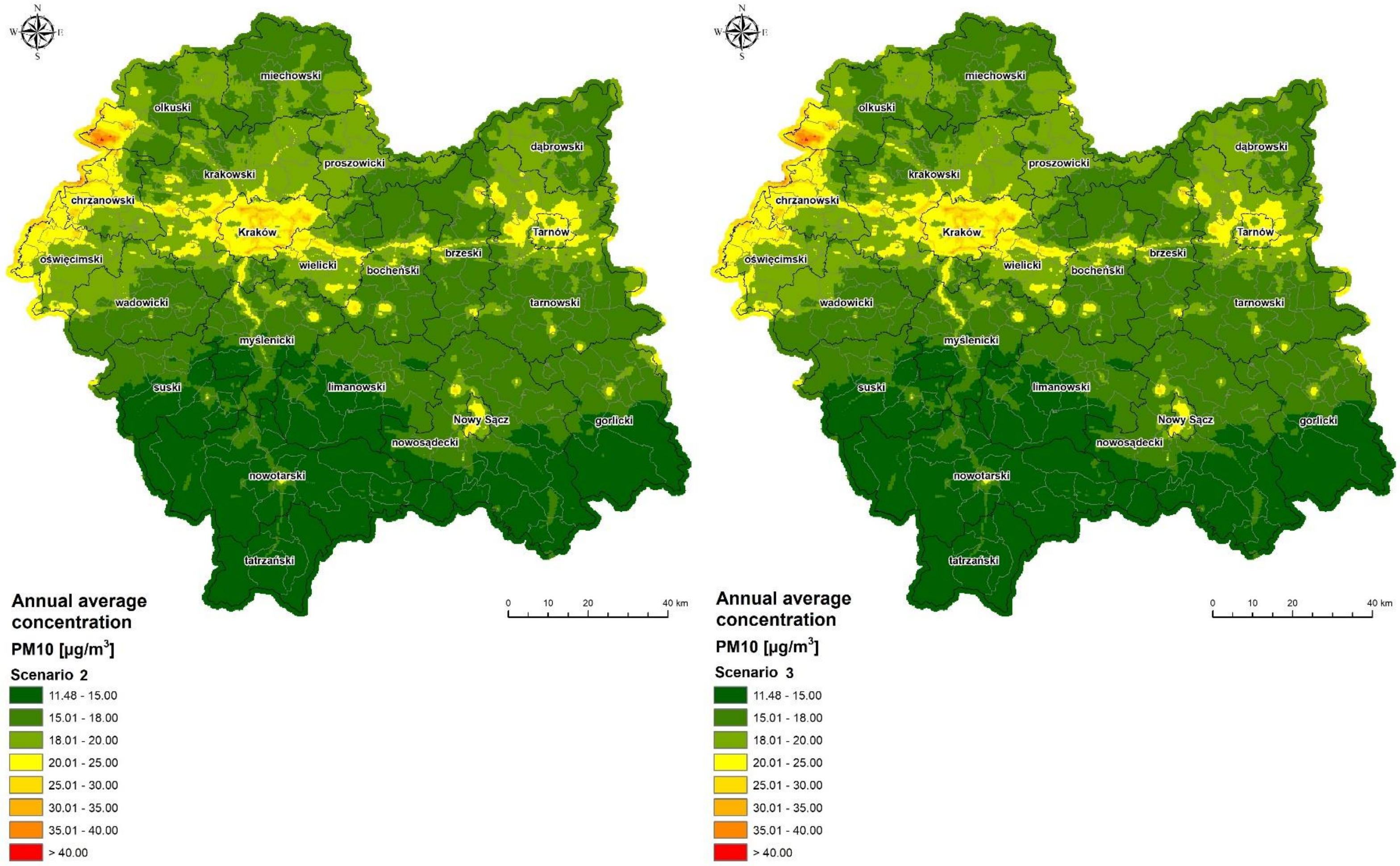


Figure 85. Distribution of annual average concentrations of PM10 in scenario 2 and variant 3 for 2023.[172]

[172] Source: CALPUFF modelling result.

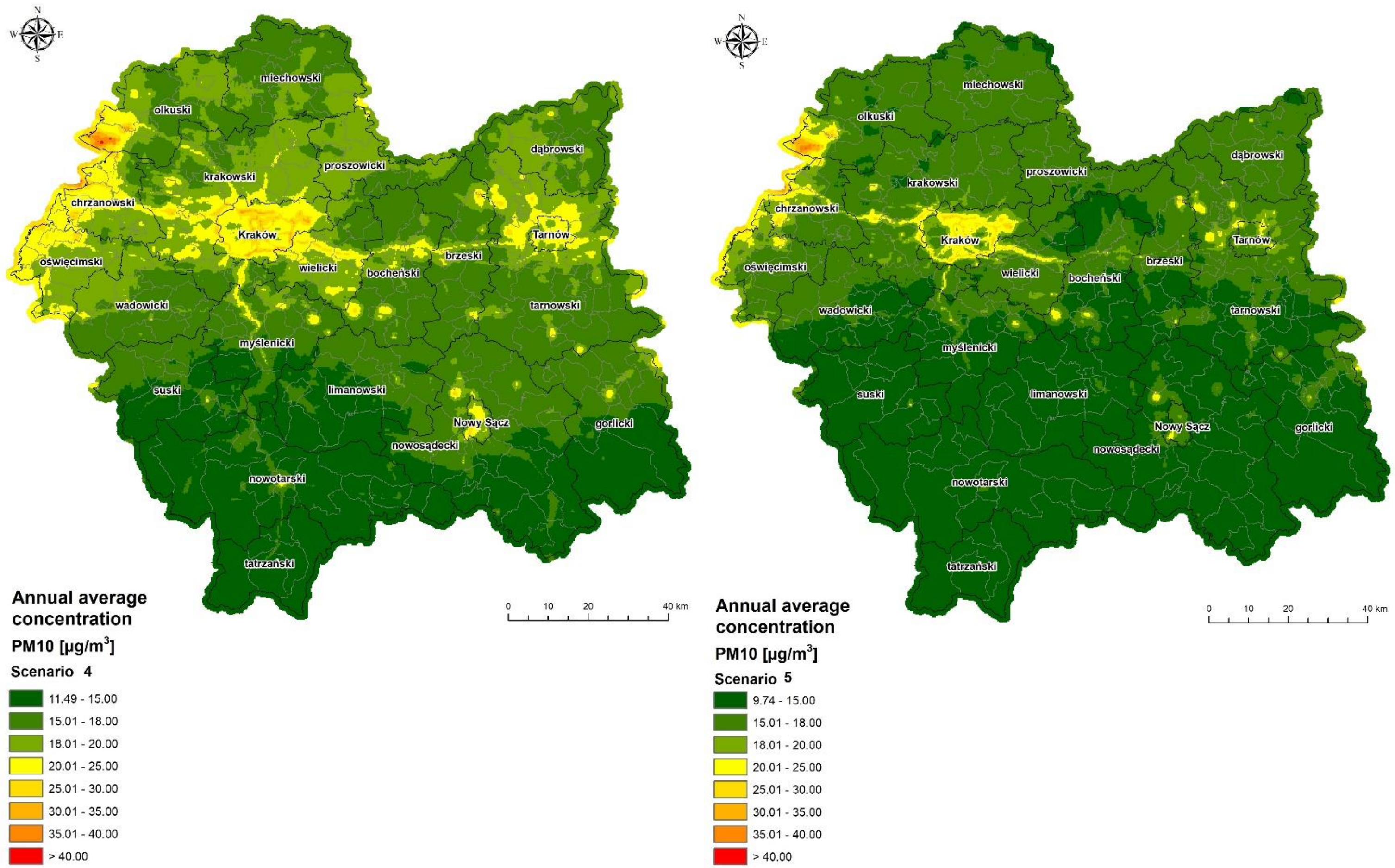
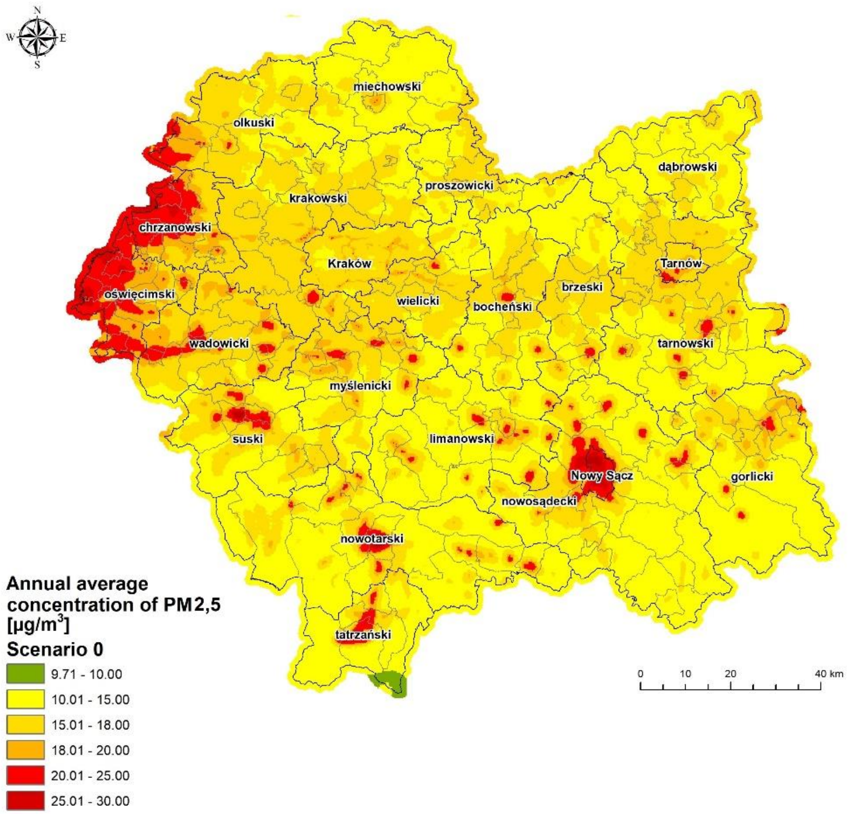


Figure 86. Distribution of annual average concentrations of PM10 in scenario 4 for 2023 and in scenario 5 for 2030.[173]

[173] Source: CALPUFF modelling result



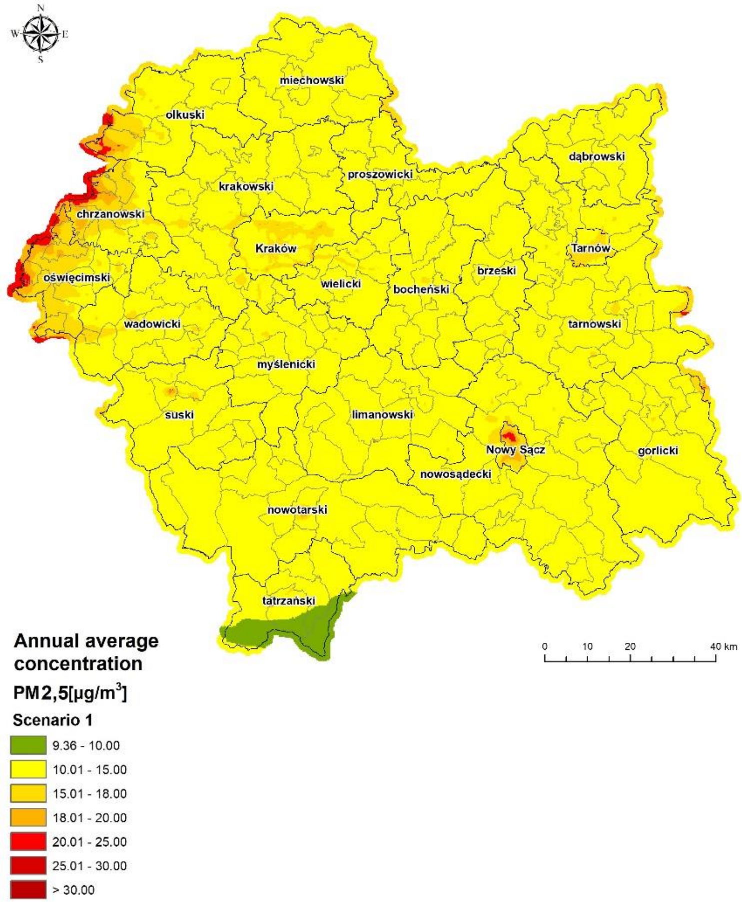


Figure 87. Distribution of annual average concentrations of PM2.5 in scenarios 0 and 1 for 2023.[174]

[174] Source: CALPUFF modelling result

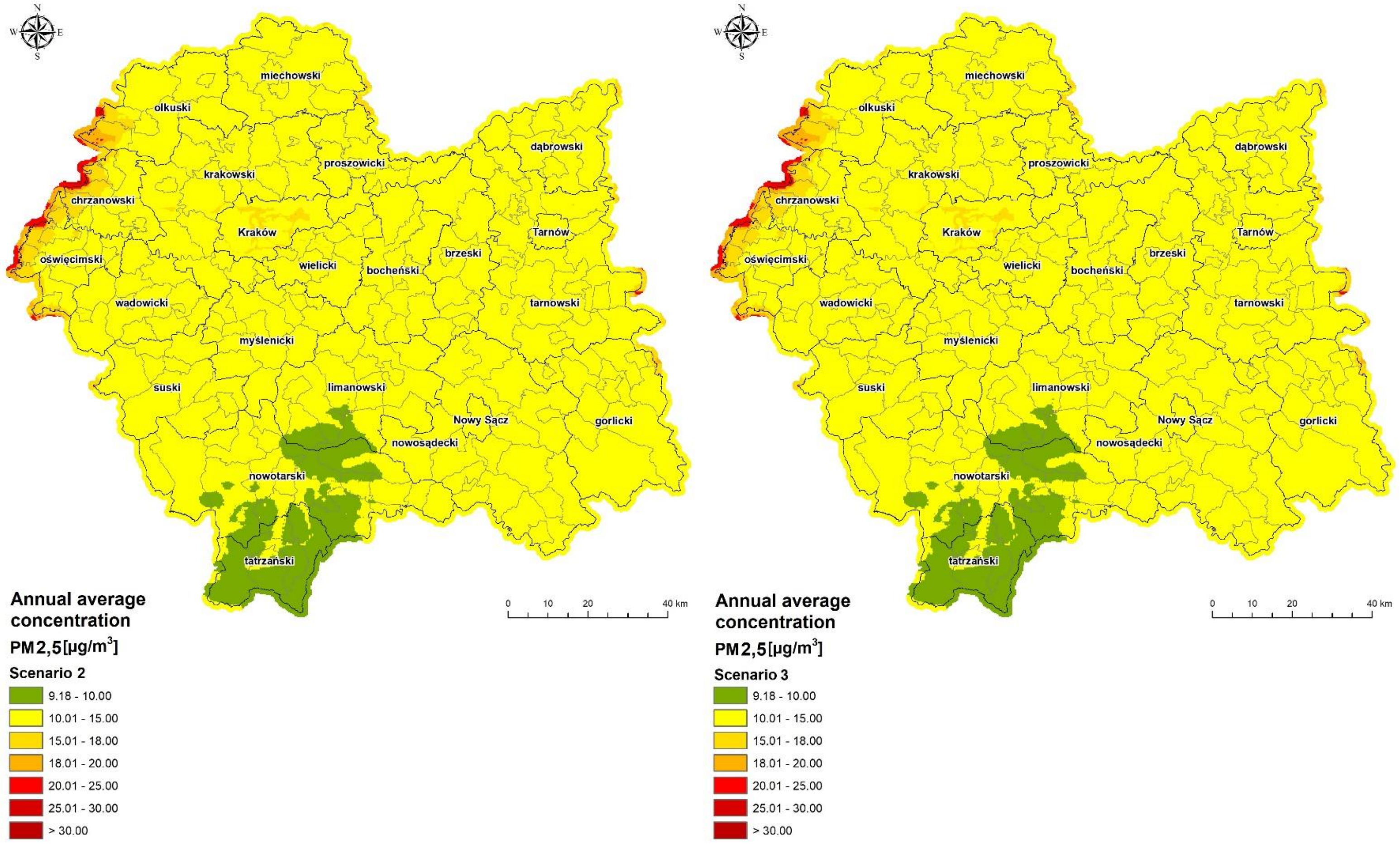


Figure 88. Distribution of annual average concentrations of PM2.5 in scenarios 2 and 3 for 2023.[175]

[175] Source: CALPUFF modelling result

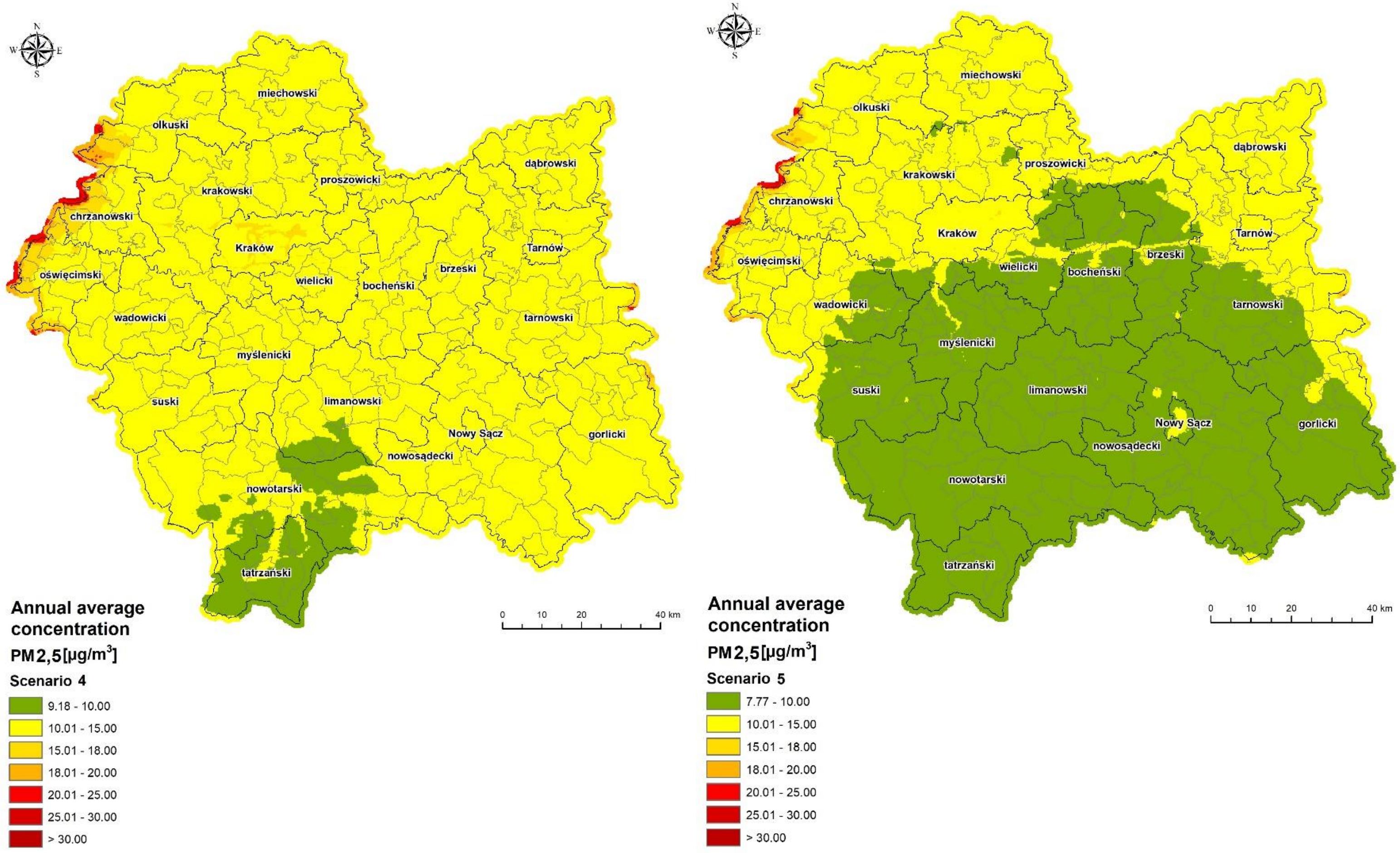


Figure 89. Distribution of annual average concentrations of PM2.5 in scenario 4 for 2023 and in scenario 5 for 2030.[176]

[176] Source: CALPUFF modelling result

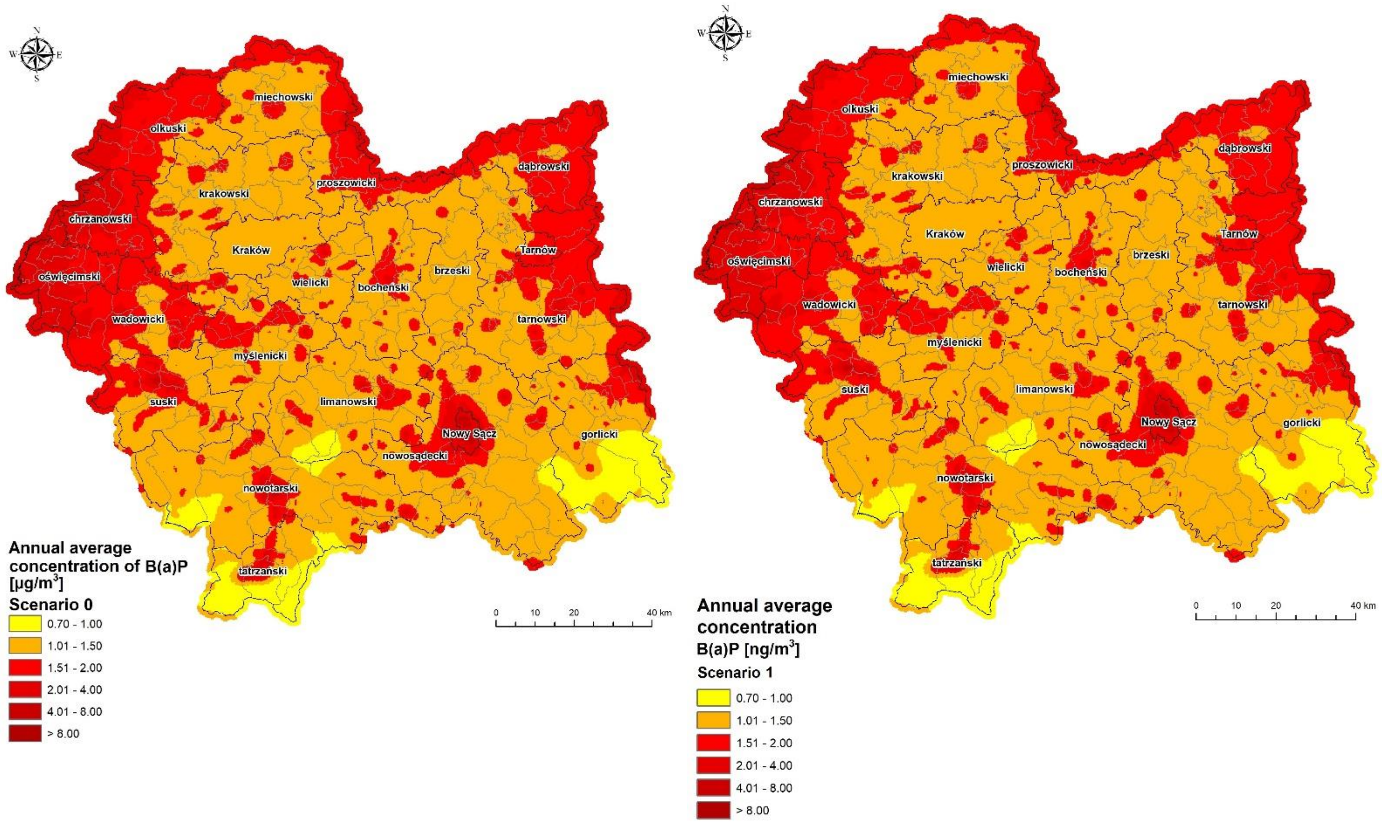


Figure 90. Distribution of annual average concentrations of benzo(a)pyrene in scenarios 0 and 1 for 2026.[177]

[177] Source: CALPUFF modelling result

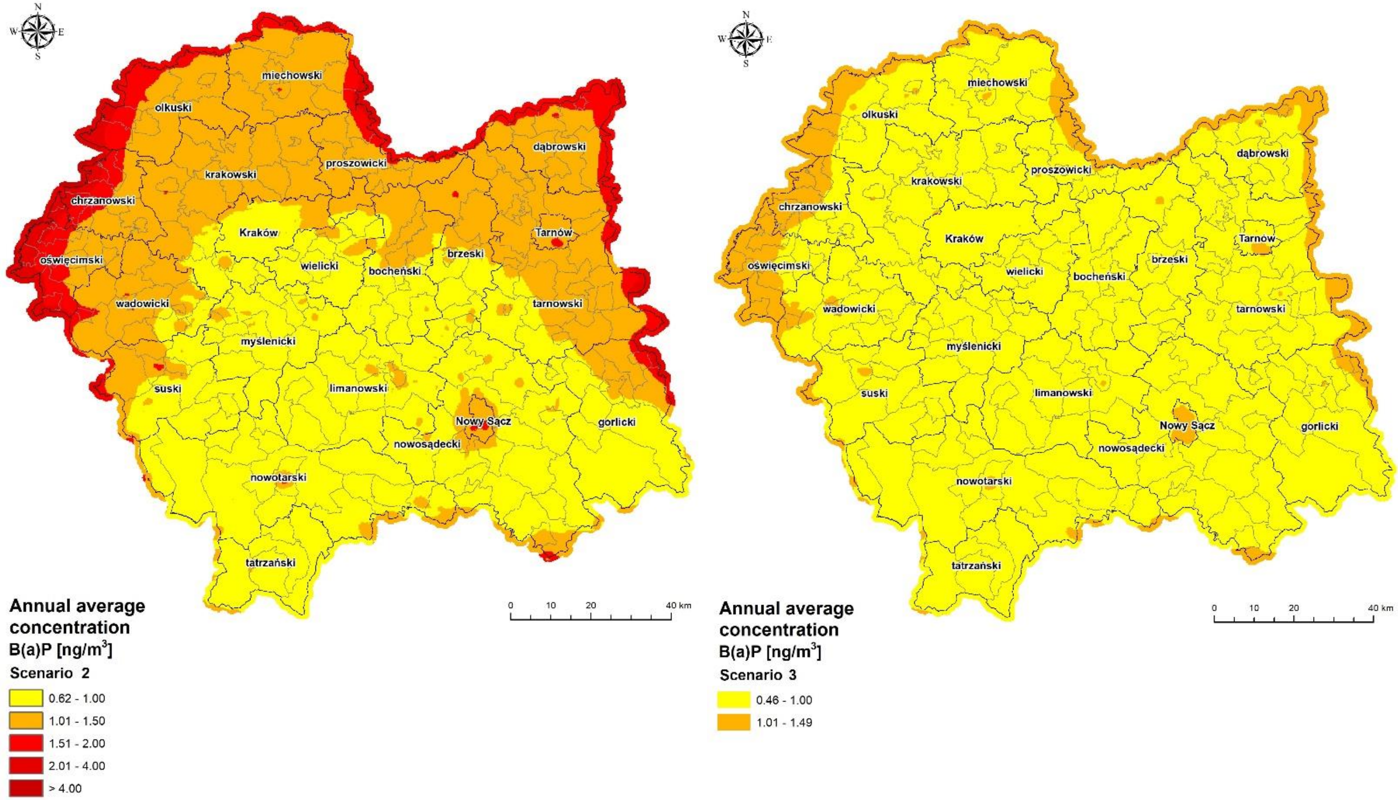


Figure 91. Distribution of annual average concentrations of benzo(a)pyrene in scenarios 2 and 3 for 2026.[178]

[178] Source: CALPUFF modelling result

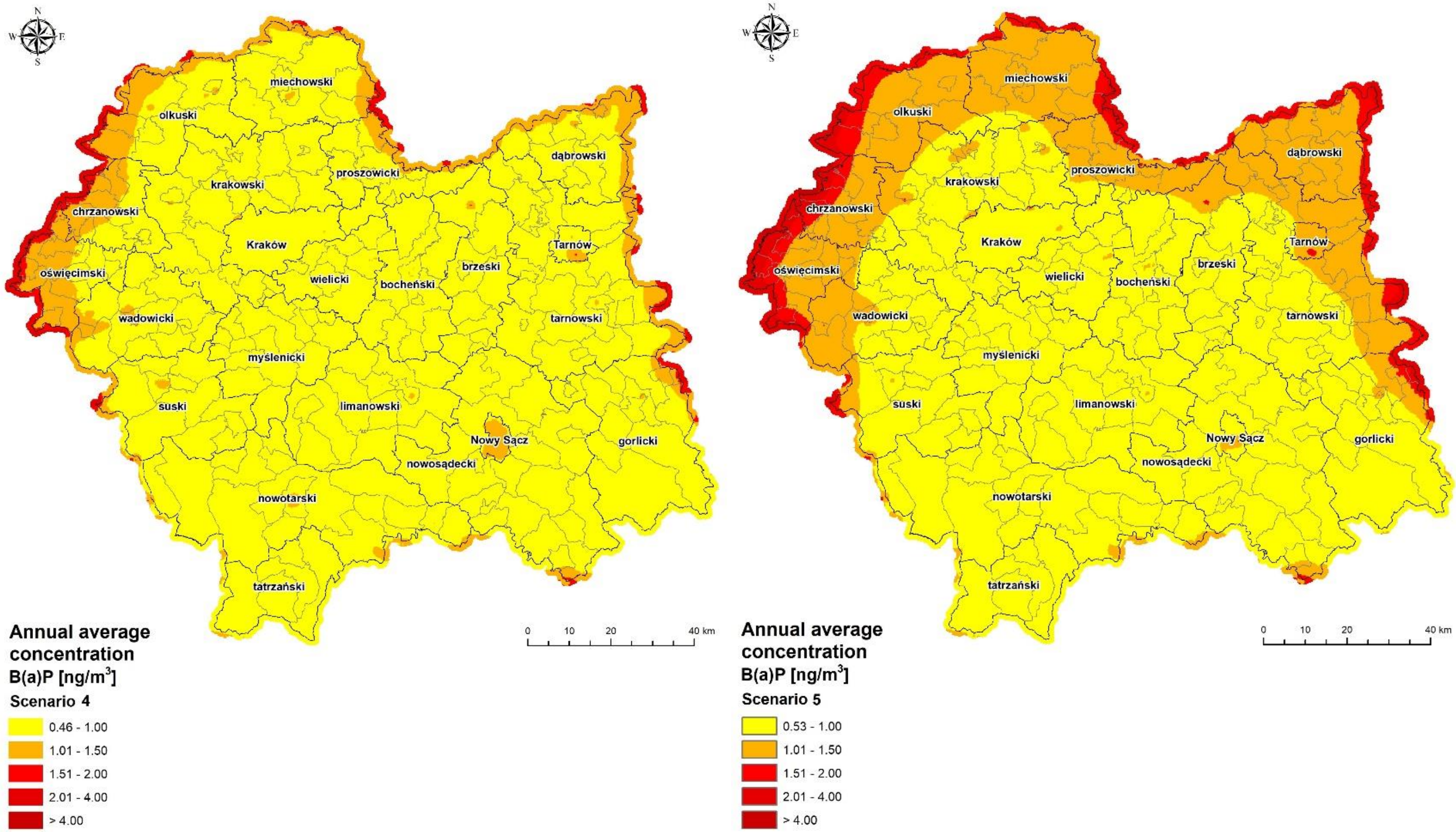
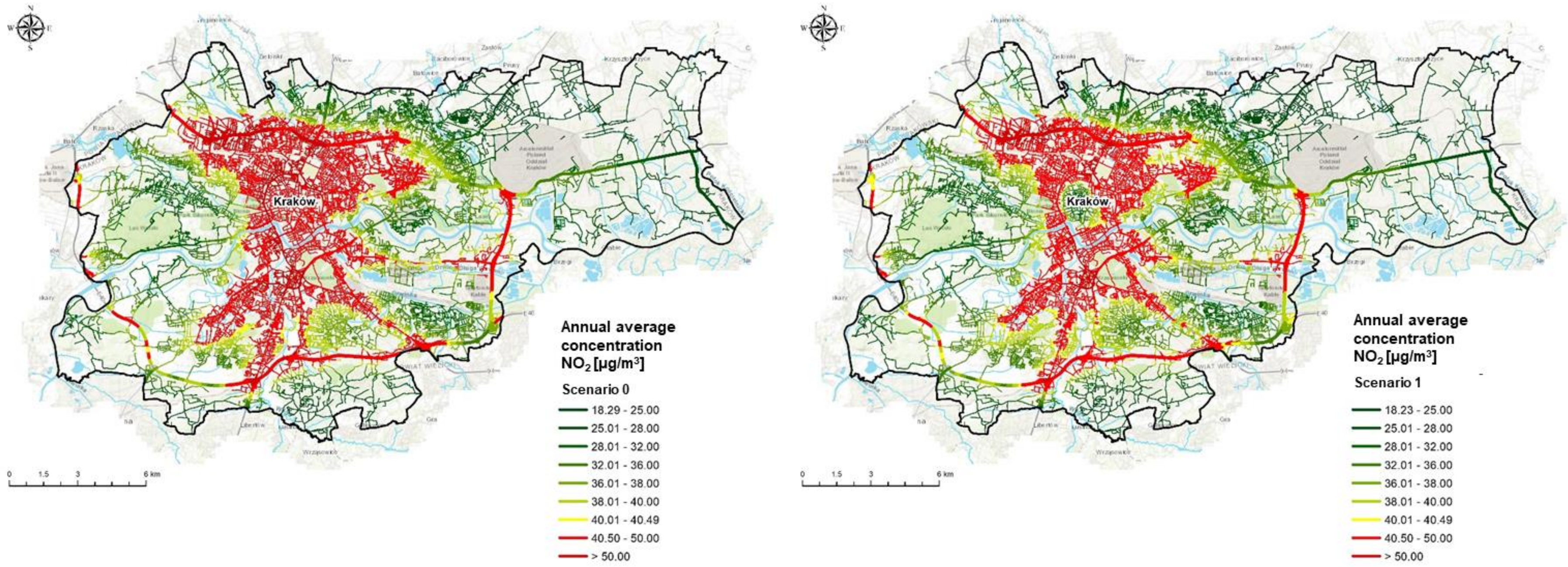


Figure 92. Distribution of annual average concentrations of benzo(a)pyrene in scenario 4 for 2026 and in scenario 5 for 2030.[179]

[179] Source: CALPUFF modelling result



. Figure 93. Distribution of annual average concentrations of nitrogen dioxide in scenarios 0 and 1 for 2026. [180]

[180] Source: CALPUFF modelling result

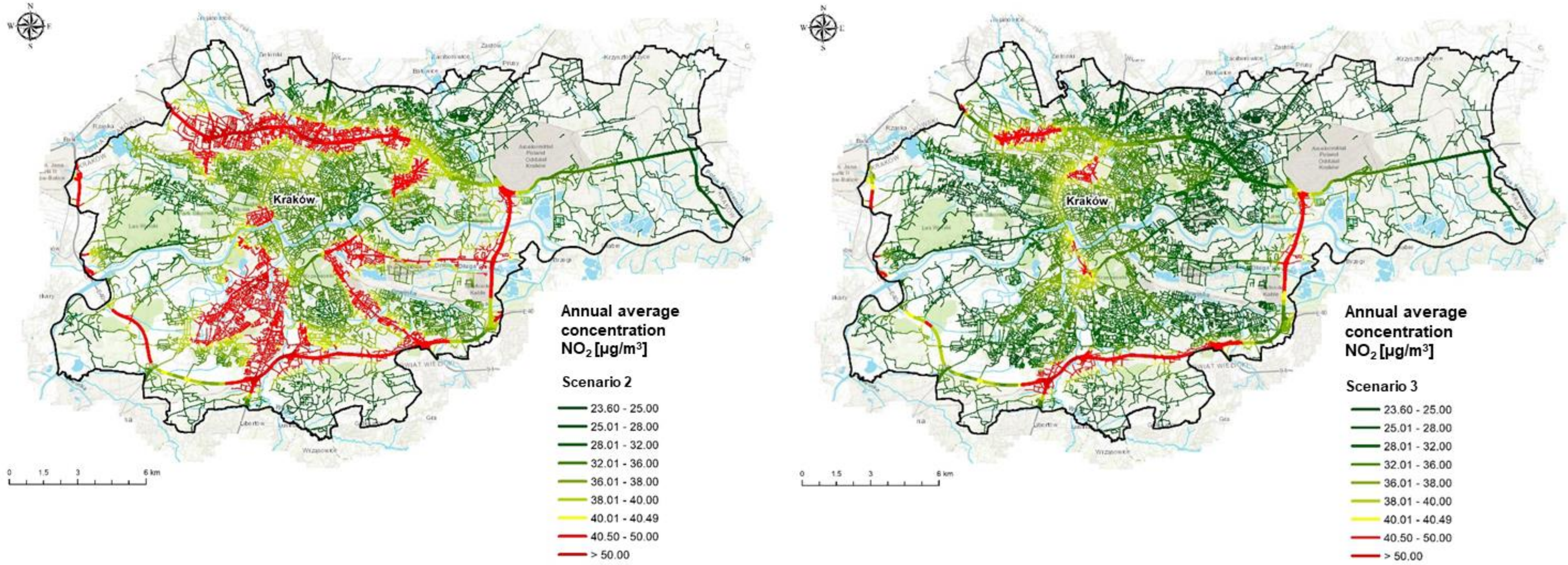


Figure 94. Distribution of annual average concentrations of nitrogen dioxide in scenarios 2 and 3 for 2026.[181]

[181]Source: CALPUFF modelling result

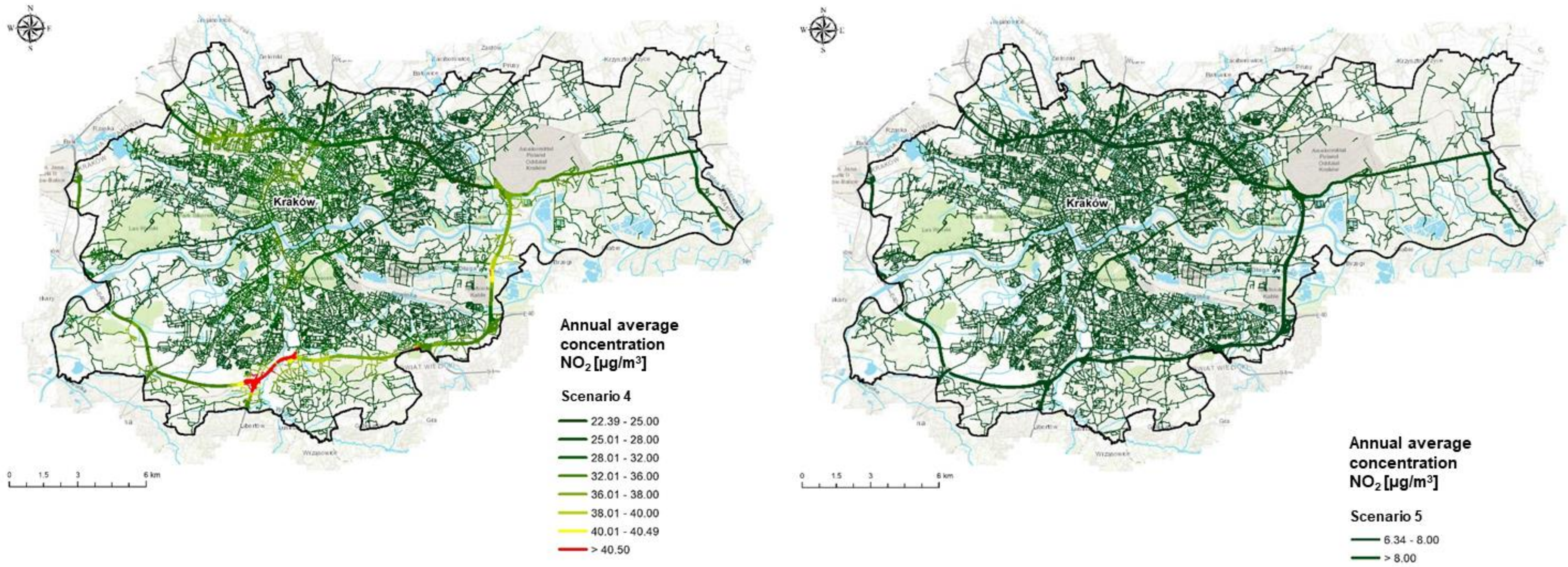


Figure 95. Distribution of annual average concentrations of nitrogen dioxide in scenario 4 for 2026 and in scenario 5 for 2030.[182]

[182] Source: CALPUFF modelling result

17.4.4. SCENARIOS IMPLEMENTATION COSTS

In order to determine the investment costs related to the implementation of scenarios of corrective measures, the number of existing and newly installed (until 2026) solid fuel boilers was estimated. Based on GIS layers and the CSO data, the amount of heat demand for buildings supplied from coal fuels was taken into account as well as the number of buildings within the zones. The data from Inventory Database for Heating Sources of Buildings in Malopolska used by the municipalities of the Malopolska Region to carry out the equipment inventory were also taken into account. The database includes single-family and multi-family residential buildings, service facilities, service and residential buildings and public utility facilities.

Taking into account the data estimated for the Malopolska Region for the base year in terms of the amount of heat demand for buildings covered by particular utilities, such as: natural gas (from CSO data), heating network (from municipalities), fuel oil, renewable energy sources, and above all wood and coal, broken down into new and old devices, the average heat demand per apartment was determined by the average size of the apartment.

On the basis of the CSO data, data from Inventory Database for Heating Sources of Buildings in Malopolska and heat demand estimates for residential buildings as well as public and service facilities, unit heat demand in GJ per m^2 of apartment was determined.

On the scale of the Malopolska Region, the estimated number of solid fuel devices that should be replaced according to the anti-smog resolution may be around 420,500. It should be emphasized that this number is an estimation based on the heat demand indicator calculated per apartment according to the Central Statistical Office (CSO) or per building according to data from the GIS layer. In the inventory of solid fuel devices maintained by the municipalities of the Malopolska Region, as at March 2020, the data for the GIS layer were introduced for:

1. 59 975 coal-fired non-class devices,
2. 23 895 devices meeting class 3 and 4,
3. 12 986 solid fuel devices meeting the requirements of the Ecodesign or class 5,
4. 12 185 tiled stoves, including 6 708 with an efficiency of less than 80%,
5. 12 429 fireplaces of which 5 260 have an efficiency below 80%,
6. 2 256 cast iron stoves (so called potbelly stoves), of which 27 meet Ecodesign requirements,
7. 5 645 kitchen stoves and 45 other devices not qualified for the above.

In some municipalities, the indicated number of boilers remaining to be replaced may be overestimated, while in others it may be underestimated, but the key to solving the problem of the number of sources is to continue inventorying the devices in municipalities and cities using the inventory database. Bearing in mind the possible differences in the number of devices to be replaced in the following years, it was assumed that the number of devices to be replaced is 420 500. Based on this value, the amount of potential costs to be incurred in the future years was estimated.

Under each variant, the number of solid fuel devices that can be replaced or eliminated has been estimated, taking into account the assumptions of each variant, the trend of replacement of combustion sources and the requirements in each variant.

The costs were determined on the basis of average prices of devices currently operating on the market and meeting certain classes of the standard and others, such as non-class devices, as well as average costs taken into account in the programs of co-financing the replacement of heating sources, such as Clean Air or Stop Smog. On the basis of the determined average prices, average investment costs were determined for each of the scenario.

Table 61. Average investment costs for new boiler purchase[183].

Investment costs	Average cost [PLN]
Sources emitting air pollutants: connection to the district heating/electric heating/automatically fed Ecodesign coal-fired boilers/automatically fed Ecodesign biomass boilers/gas boilers/fuel oil boilers	15 000
Replacement with renewable energy sources (heat pumps/solar collectors/photovoltaic installations)	28 000

On the basis of average costs for individual devices, the total costs of introducing the scenarios were estimated.

The assumptions made for each scenario:

1. **Scenario 0** – continued increase of boiler replacement rate in Malopolska at the current level – increase of rate by about 30-50% per year. The current replacement level for 2018 amounted to 15,000 eliminated devices, therefore it was assumed that in the following years there will be a 10% increase in replacement rates to reach 28,500 boilers per year in 2026. It has been assumed that in the first years 10% of replacements will be with RES, and in the last three years it will account to 15%.
2. **Scenario 1** – a significant acceleration of the boiler replacement rate in the region was assumed (even 10 times) – assumption that in 2023 only 25% of the current number of non-class boilers in Malopolska will remain to be replaced, and will be replaced by 2026 in full. It has been assumed that every year 10% of the replacements will be with RES.
3. **Scenario 2** – the scenario assumes full implementation of anti-smog resolutions for Malopolska, which means replacement of all non-class boilers with low-emission heating systems. Only some class 3 and 4 boilers will remain, which should be replaced by 2026. It has been assumed that every year 10% of the replacements will be with RES.
4. **Scenario 3** – the scenario assumes full implementation of anti-smog resolutions for Malopolska, which means replacement of all non-class boilers with low-emission heating systems. Only some class 3 and 4 boilers will remain, which should be replaced by 2026. It has been assumed that every year 10% of the replacements will be with RES.
5. **Scenario 4** – the scenario assumes full implementation of anti-smog resolutions for Malopolska, which means replacement of all non-class boilers with low-emission heating systems. Only some class 3 and 4 boilers will remain, which should be replaced by 2026. In health resorts, it will not be possible to replace the equipment with solid fuel devices, therefore it has been assumed that about 8400 boilers in health resort municipalities will be replaced with RES. The cost assumptions are that from 2022 the percentage of replacement of devices with RES will increase to 25% per year.
6. **Scenario 5** sets the goal of achieving climate neutrality in Malopolska by 2050 and WHO standards for substance levels in the air by 2030. This means a move away from solid fuels except biomass and no financing for gas devices from 2030. It is assumed that the annual rate of replacing devices for RES will increase to 15% by 2023, and in 2023 the rate of replacing devices with RES will increase to 40% yearly, while from 2024 the share of RES would reach 50% of the annual replacement rate.

[183] Based on market prices and costs of investments financed from Clean Air Program.

Table 62. Costs of implementation of actions according to scenarios for corrective measures[184]

Costs [PLN million]	2020	2021	2022	2023	2024	2025	2026	TOTAL
Scenario 0								**2,791.1**
Replacement with polluting sources[185]	263.3	283.5	303.8	324.0	325.1	344.3	363.4	2,207.3
Replacement with non-polluting sources (RES)	54.6	58.8	63.0	67.2	107.1	113.4	119.7	583.8
Scenario 1								**6,854.2**
Replacement with polluting sources	253.1	1,012.5	2,025.0	860.6	508.5	508.5	508.5	5,676.8
Replacement with non-polluting sources (RES)	52.5	210.0	420.0	178.5	105.5	105.5	105.5	1,177.4
Scenario 2								**6,854.2**
Replacement with polluting sources	337.5	1,350.0	2 700.0	1,147.5	47.2	47.2	47.2	5,676.6
Replacement with non-polluting sources (RES)	70.0	280.0	560.0	238.0	9.8	9.8	9.8	1,177.4
Scenario 3								**6,854.2**
Replacement with polluting sources	337.5	1,350.0	2,700.0	1,147.5	47.2	47.2	47.2	5,676.6
Replacement with RES	70.0	280.0	560.0	238.0	9.8	9.8	9.8	1,177.4
Scenario 4								**7,430.4**
Replacement with polluting sources	337.5	1,350.0	2,250.0	956.3	39.4	39.4	39.4	5,011.9
Replacement with non-polluting sources (RES)	70.0	280.0	1,400.0	595.0	24.5	24.5	24.5	2,418.5
Scenario 5								**7,725.2**
Replacement with polluting sources	318.8	1,275.0	2,250.0	765.0	21.0	21.0	21.0	4,671.8
Replacement with non-polluting sources (RES)	105.0	420.0	1,400.0	952.0	58.8	58.8	58.8	3,053.4

17.4.5. Costs of transport related activities

In the analysis of the costs of implementation of the scenarios in terms of changes in the transport system in the area of Tarnow and Krakow, the estimated exemplary costs of introducing and creating a low emission zone based on EURO emission standards and a clean transport zone within the meaning of the Act on Electromobility and Alternative Fuels were assumed.

The costs of introducing a video verification system and costs of zone marking by replacing or supplementing part of the marking have been assumed. Additionally, the following elements were also taken into account:

- number of intersections covered by the marking,
- number of signs by type: E1, B3/B5, thermoplastic signs,
- number of cameras to be installed within the system,
- restrictions on parking zone charges.

[184] Own work based on assumptions of the number of boilers and investment costs described in the section
[185] 'Polluting' relates to emission of air pollutants such as particle matter

The exemplary costs of a video verification system include: purchase and installation of cameras, operating system licenses and supporting devices. The unit costs of such a system include as follows:

- ANPR cameras – PLN 4 500,
- NVR server for collecting information from camera readouts – PLN 2 900,
- Camera docking stations and gantries above the road – PLN 15 000.

In the case of city entrance routes that require marking on lower class streets, it is assumed that the marking will have to be replaced within the B-3a/B5 sign. The cost of 1 set is PLN 500.00 (based on the estimated sign production values available among the manufacturers of road signs).

In the case of the Krakow motorway ring road, within the A-4 motorway and S-7 expressway, it is assumed that it is necessary to exchange signs from category E, i.e. E-1 in the number of 2 for each motorway exit for each direction. The cost of one E-1 sign is about PLN 6 250.00. It is assumed that it is necessary to mark 9 motorway exits by changing E-1 signs.

Horizontal signs in the form of a thermoplastic sign can also be placed on the roadways of the streets of the city. According to the manufacturers' price list for such marking, the unit cost for thermoplastic sign is PLN 1 300.00.

The one-time cost of the zone launch assumes, among others, the necessity to change road marking. On the other hand, during the statistical year, the costs of zone operation may be incurred in connection with supplementing the marking or carrying out media campaigns. Additionally, the control is to be performed by the Police and the Road Transport Inspectorate, which will be their responsibility. Costs that have not yet been estimated may include such costs as:

- costs of design and analytical work in the period preceding the establishment of the zone,
- costs of designing and implementing software for zone administration (registration of applications, issuing labels, handling fees and penalties),
- administrative staff training costs,
- costs of training and equipping the services involved in monitoring compliance with the rules applicable in the zone,
- costs of the programme of supporting the zone inhabitants in adjusting to the requirements in the zone (economic support mechanisms in the period preceding the establishment of the zone),
- costs of maintaining software and other tools for zone administration,
- costs of the programme of supporting the zone inhabitants in adjusting to the LEZ requirements (economic support mechanisms during the zone's operation).

These costs may range from 200 thousand to PLN 3 million. The annual costs include replacement and extension of the video verification system, markings in the sequence of intersections, as well as extension of the system in subsequent years.

Table 63. Table of costs of the scenarios for introducing the zones in Tarnow and Krakow.

Clean transport zone costs in scenarios		**Scenarios**				
		1	**2**	**3**	**4**	**5**
TARNOW	**Assumptions for cost analysis**					
Number of roads to be covered by the zone	33 intersections access roads to the zone					
Zone marking	Introduction of thermoplastic signs	20				
	Introduction of B3/B5 road signs at each intersection in both directions	70				
Camera monitoring	Number of cameras installed	15				
COSTS						
Monitoring system	Number of cameras installed, including instrumentation and system	643 500				
Media	Media campaign of the zone introduction	100 000				
Marking system	Introduction of permanent marking at intersections and on the roadway	61 000				
Revenues from parking fees	Reduction of parking zone revenues based on the 2020 budget. No costs assumed.	4 200 000				

Clean transport zone costs in scenarios		**Scenarios**				
		1	**2**	**3**	**4**	**5**
KRAKOW	**Assumptions for cost analysis**					
Number of roads to be covered by the zone	Access roads to the zone are included as intersections where markings are to be placed	26 main intersections	27 access roads on main roads and about 40 side intersections	9 access roads from the motorway and 36 main access roads to the city, about 40 side intersections	access roads from the motorway and 36 main access roads to the city, about 40 side intersections	All access roads to the region: national, regional and local
Zone marking	Introduction of thermoplastic signs	15	30	40	40	300
	Introduction of B3/B5 road signs at each intersection in both directions	60	100	170	170	1000
	Introduction of E1 road signs			18	18	25
Camera monitoring	Number of additional verification cameras installed	15	25	40	40	45
COSTS						
Monitoring system		225 000	375 000	600 000	600 000	1 500 000
Media		100 000	150 000	200 000	200 000	PLN 100 million
Marking system		495 00	89 000	249 500	249 500	1 046 250
Revenues from parking fees	According to the data of the Krakow City Office, current parking revenues for 2019 amounted to 57,000,000. Depending on the variant, a reduction of the parking revenues (in percentage) was assumed, due to a smaller number of vehicles	60%	20%	20%	30%	90%

17.4.6. SUMMARY

The presented analysis of possible scenarios of corrective actions to reduce air emissions of substances from surface and linear sources has been made in terms of the achievable environmental effect while taking into account the economic aspect of the actions carried out, mainly in the municipal and household sector. The analysis took into account expected changes in trends in demand and supply of both fuels and heating devices as well as technical possibilities of application of particular measures.

The analyses of the distribution of pollutant concentrations after the application of individual scenarios are presented on maps, which show the areas of exceedances that may still potentially occur after the implementation of a given action scenario. In addition to the lists of achievable ecological effects in the form of changes in the concentrations and emissions after the application of individual corrective scenarios, the amount of financial resources that may be spent at the stage of undertaking the equipment replacement investment was also estimated for the individual years until 2023 and 2026.

Analyses of all factors of ecological, economic and social effect allowed to choose the optimal corrective scenario. Due to the lack of sufficient improvement of air quality in Malopolska, scenarios 0 and 1 were rejected.

The action in scenario 4 related to ban on the use of solid fuels in health resorts is also not included in the implementation, due to the lack of possibility to ensure an adequate level of availability of alternatives to solid fuels. In the area of two of the health resorts there is no gas network, but it will be developed in the coming years. In the area of four of the health resorts there are no plans to develop the gas network in the following years until 2024. In the remaining health resorts new connections are planned only in the amount of 242, which may turn out to be insufficient to ensure an appropriate level of an alternative way of supplying heat sources in health resorts in case of ban on solid fuels. A new gas pipeline Krynica-Muszyna will be built in Krynica Zdroj, but no new connections to the pipeline are planned, therefore there will be no adequate level of development to provide new building connections.

Scenario 5, after which no exceedances would be recorded, is too restrictive and may be introduced from 2030 onwards, taking into account also the specific actions carried out at the scale of neighbouring regions and even the country to achieve concentration levels corresponding to the WHO recommendation. Under this scenario, even the complete elimination of emission sources from the Malopolska Region may not be sufficient to meet the level of WHO guidelines for PM2.5 or benzo(a)pyrene. This scenario is a forward-looking one, when the activities will be carried out not only regionally but broadly on a national scale, as it is necessary to significantly reduce the impact between the regions.

Scenario 3 does not differ in the level of expenditure from scenario 2, and enables reaching the target level of benzo(a)pyrene in 2026 and the permissible levels of other substances.

17.4.7. HEALTH EFFECTS OF SCENARIOS

Health impact of the proposed scenarios

The analysis of the impact of the implementation of the proposed scenarios of actions on health was carried out by the European Clean Air Center[186] (*"Health analysis of variants of the draft Air Quality Plan for the Malopolska Region 2020").* It determined the number of avoided health effects per year in relation to the base year – 2018. The study was conducted using results of the modelling of the average annual PM2.5 concentration performed for each of the variants, data on the current and projected population, health data (number of deaths and hospitalizations) and the concentration-response functions of the World Health Organization.

A comprehensive summary of the number of avoided premature deaths, hospitalizations due to cardiovascular and respiratory causes, which were determined in the analysis, is presented in the table below.

Table 64. Annual avoided health effects for specific AQP scenarios[187]

Health effect	Scenario					
	0	1	2	3	4	5
Premature death	637	1 195	1 452	1 453	1 454	1 802
Hospitalization* for cardiovascular reasons	208	562	661	662	662	841
Hospitalization* for respiratory reasons	167	378	451	451	452	567

* patient's stay in hospital, lasting **at least one night**, from the time of entry in the hospital register until patient's discharge.

The greatest annual health benefits are achieved under scenario 5, i.e. reaching the levels recommended by the World Health Organisation. The implementation of the proposed actions would make it possible to avoid more than 1800 deaths per year in the scale of Malopolska. The authors of the analysis indicate that **scenario 5 should be a long-term objective of the air protection strategy**. **In the short term, however, full implementation of the anti-smog resolution should be ensured.** The analysis indicates that the implementation of this objective allows to avoid over 1400 deaths per year. Therefore, emphasis should be placed in the AQP on elimination of the non-class boilers by the end of 2022 and class 3 and 4 boilers by the end of 2026.

The table below presents values of particular health effects by counties for the scenario selected for implementation under the AQP (scenario 3). It is worth noting that the largest absolute number of health effects occurring in the area of Krakow does not mean that the air quality is the worst in the scale of the region. This results from a much larger number of people living in Krakow than in other counties.

[186] Source: *"Health analysis of variants of the draft Air Quality Plan for Malopolska Region 2020"*, Łukasz Adamkiewicz, Dominika Mucha, Warsaw, April 2020

[187] Source: Own study based on *"Health analysis of variants of the draft Air Quality Plan for Malopolska Region 2020*, Łukasz Adamkiewicz, Dominika Mucha, Warsaw, April 2020

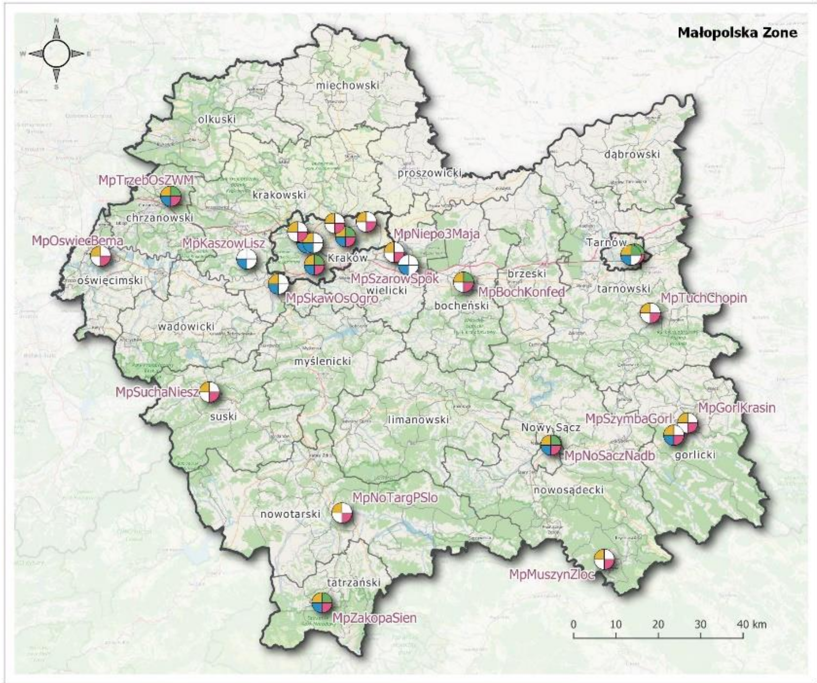
Table 65. Summary of health effects resulting from implementation of variant 3 presented by county. [188]

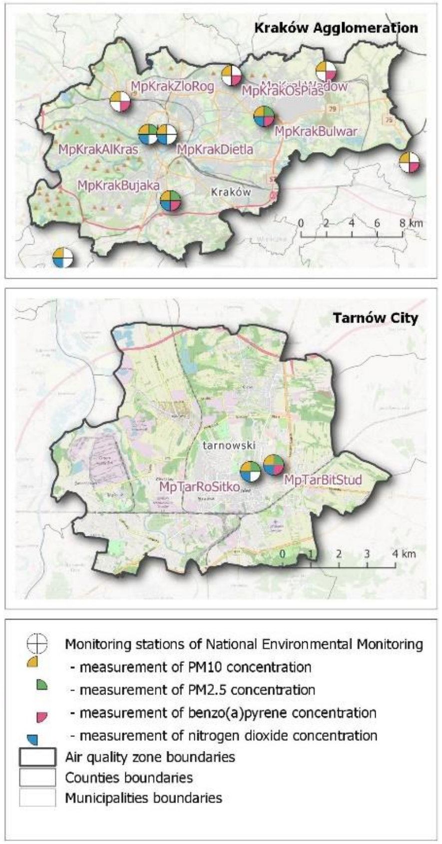
Scenario 3				
County	**Number of avoided premature deaths**	**Number of avoided hospitalizations due to cardiovascular diseases**	**Number of avoided hospitalizations due to respiratory diseases**	**Number of avoided premature deaths per 100,000 population**
Bochenski	37	16	11	49
Brzeski	24	10	7	26
Chrzanowski	72	31	21	57
Dabrowski	9	2	2	15
Gorlicki	26	8	7	23
Krakowski	97	35	26	35
Limanowski	35	14	11	27
Miechowski	12	4	3	24
Myslenicki	39	14	11	31
Nowosadecki	62	24	19	29
Nowotarski	78	37	26	41
Olkuski	40	15	11	35
Oswiecimski	75	31	22	49
Proszowicki	11	4	3	24
Suski	30	13	9	35
Tarnowski	49	18	14	25
Tatrzanski	36	18	11	53
Wadowicki	66	28	20	41
Wielicki	38	11	9	30
the city of Krakow	503	271	168	65
the city of Nowy Sacz	63	33	22	75
the city of Tarnow	51	24	16	47

[188] Source: Own study based on *"Health analysis of variants of the draft Air Quality Plan for Malopolska Region 2020*, Lukasz Adamkiewicz, Dominika Mucha, Warsaw, April 2020

18. GRAPHIC ATTACHMENTS

18.1. Monitoring stations locations





zone code	station code	longitude	latitude
PL1201	MpKrakAlKras	50.057678	19.926189
PL1201	MpKrakBujaka	50.010575	19.949189
PL1201	MpKrakBulwar	50.069308	20.053492
PL1201	MpKrakDietla	50.057447	19.946008
PL1201	MpKrakOsPias	50.098508	20.018269
PL1201	MpKrakWadow	50.100569	20.122561
PL1201	MpKrakZloRog	50.081197	19.895358
PL1202	MpTarBitStud	50.020169	21.004167

zone code	station code	longitude	latitude
PL1202	MpTarRoSitko	50.018253	20.992578
PL1203	MpBochKonfed	49.969017	20.439511
PL1203	MpGorlKrasin	49.658889	21.163336
PL1203	MpKaszowLisz	50.025028	19.726833
PL1203	MpMuszynZloc	49.374147	20.879581
PL1203	MpNiepo3Maja	50.035117	20.212689
PL1203	MpNoSaczNadb	49.619281	20.714403
PL1203	MpNoTargPSlo	49.483597	20.028992

zone code	station code	longitude	latitude
PL1203	MpOswiecBema	50.033083	19.245275
PL1203	MpSkawOsOgro	49.971047	19.830422
PL1203	MpSuchaNiesz	49.743131	19.600339
PL1203	MpSzarowSpok	50.0075	20.259167
PL1203	MpSzymbaGorl	49.633714	21.116833
PL1203	MpTrzebOsZWM	50.159406	19.477464
PL1203	MpTuchChopin	49.894169	21.051061
PL1203	MpZakopaSien	49.293564	19.960083

Figure 96. Monitoring stations locations in the Malopolska Region zones[189]

[189] Source: Prepared by Atmoterm S.A. based on the data of the State Environmental Monitoring

18.2. Air pollution emissions distribution

18.2.1. PARTICULATE MATTER PM10 EMISSION SOURCES

Malopolska Zone

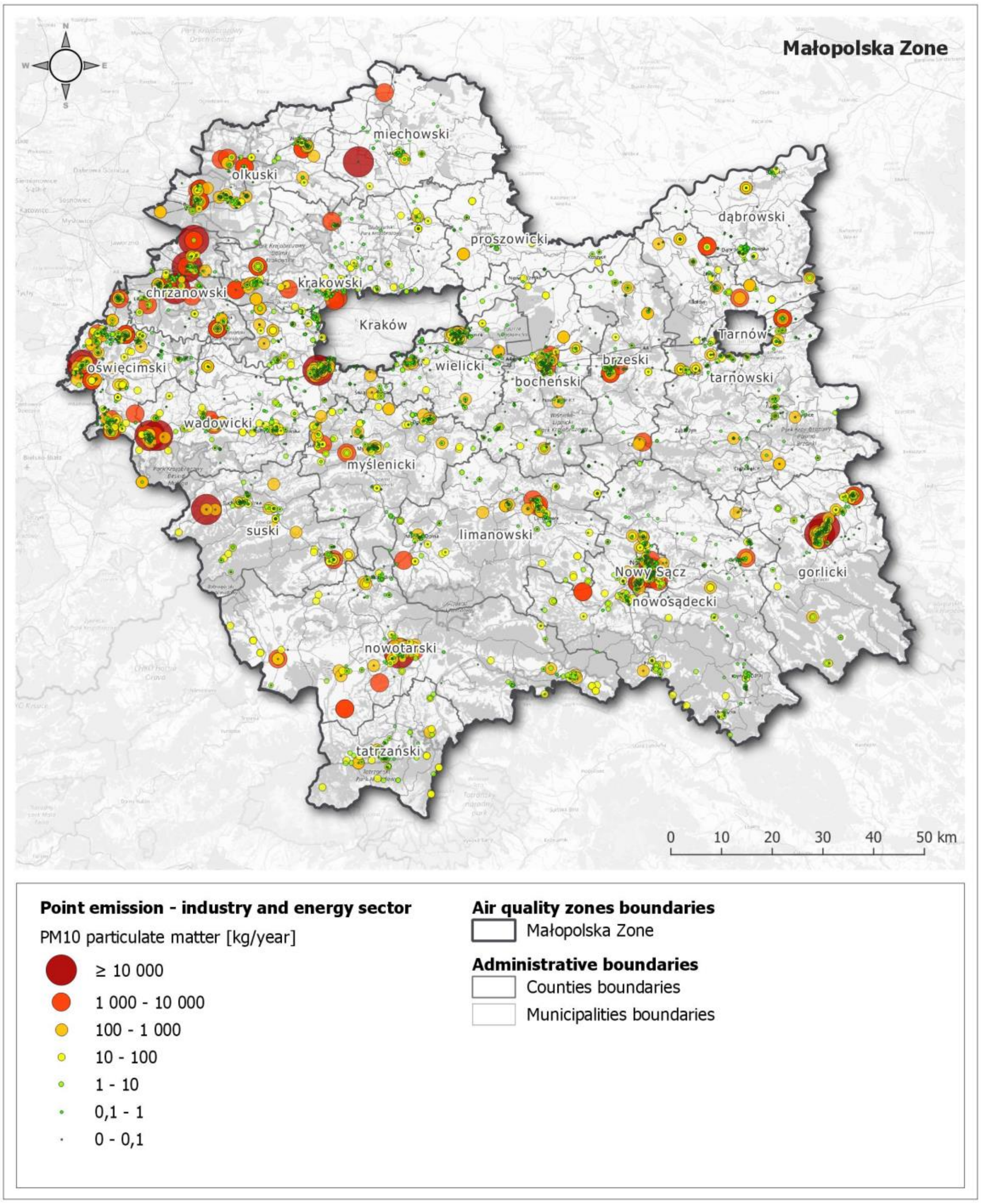


Figure 97. Particulate matter PM10 from industrial and energy emissions[190]

[190] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

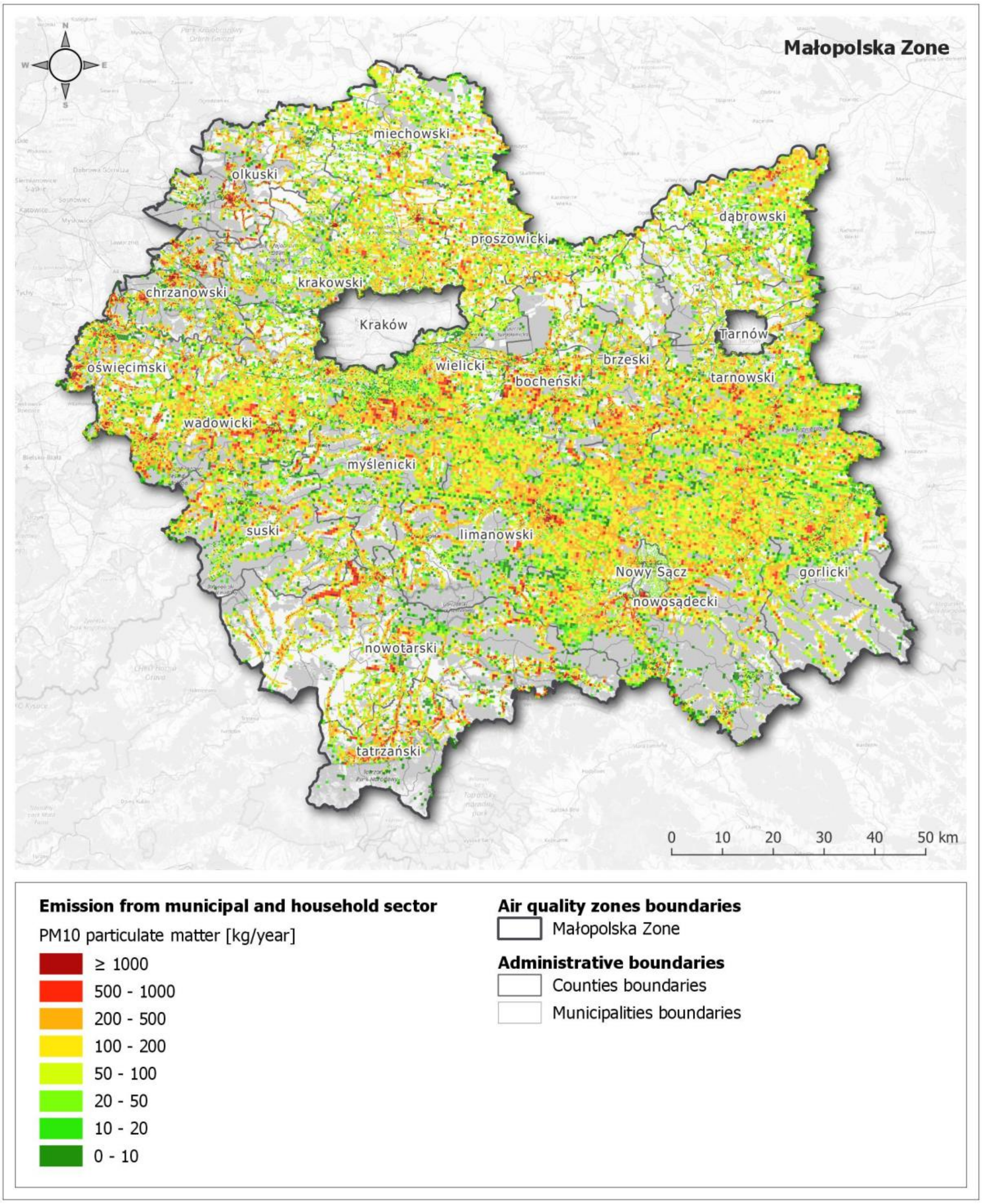


Figure 98. Particulate matter PM10 from municipal emissions[191]

[191] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan. For Krakow and Tarnow a grid of a higher resolution was used – 0,25 kmx0,25 km

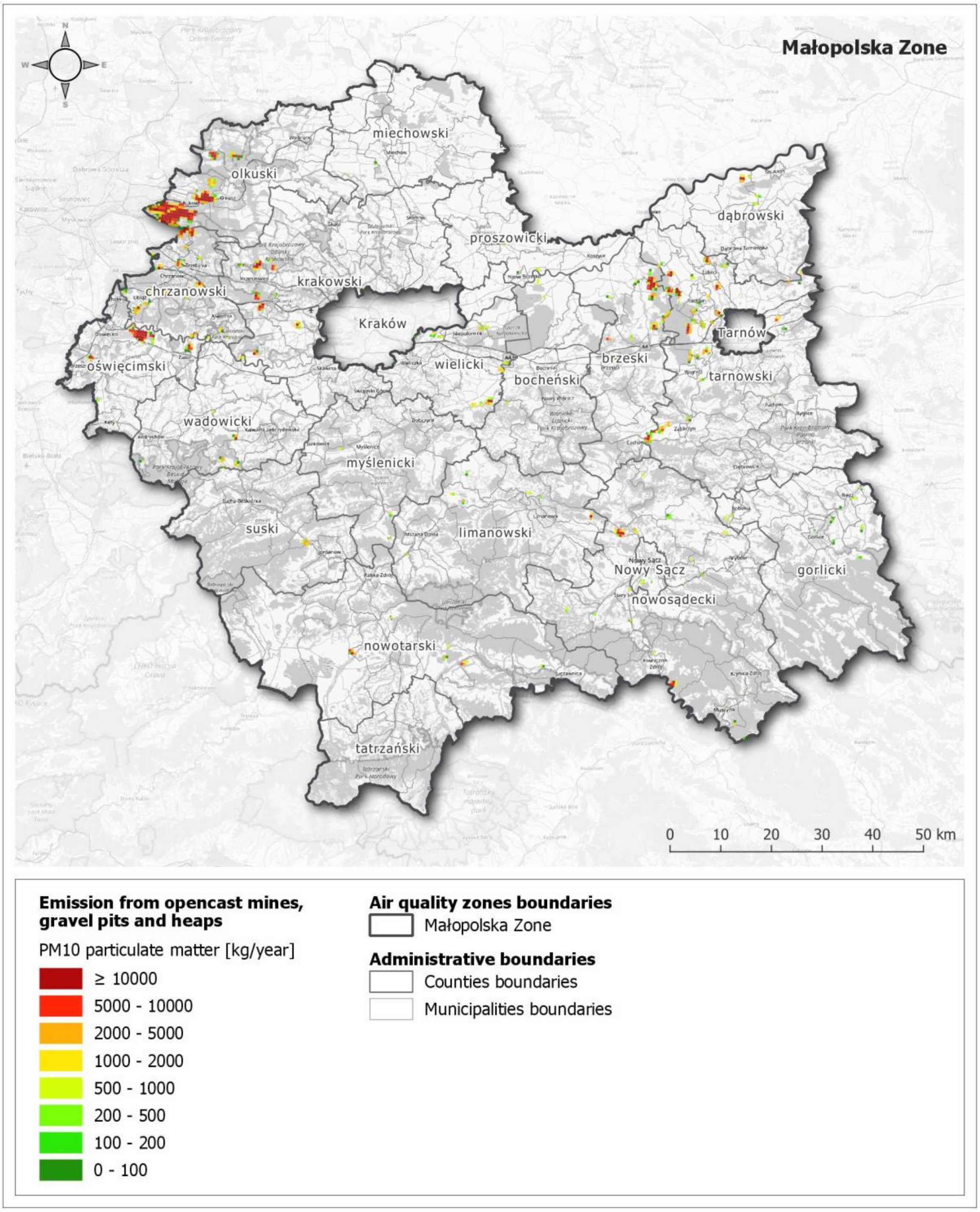


Figure 99. Particulate matter PM10 from fugitive emissions (aggregate quarries)[192]

[192] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

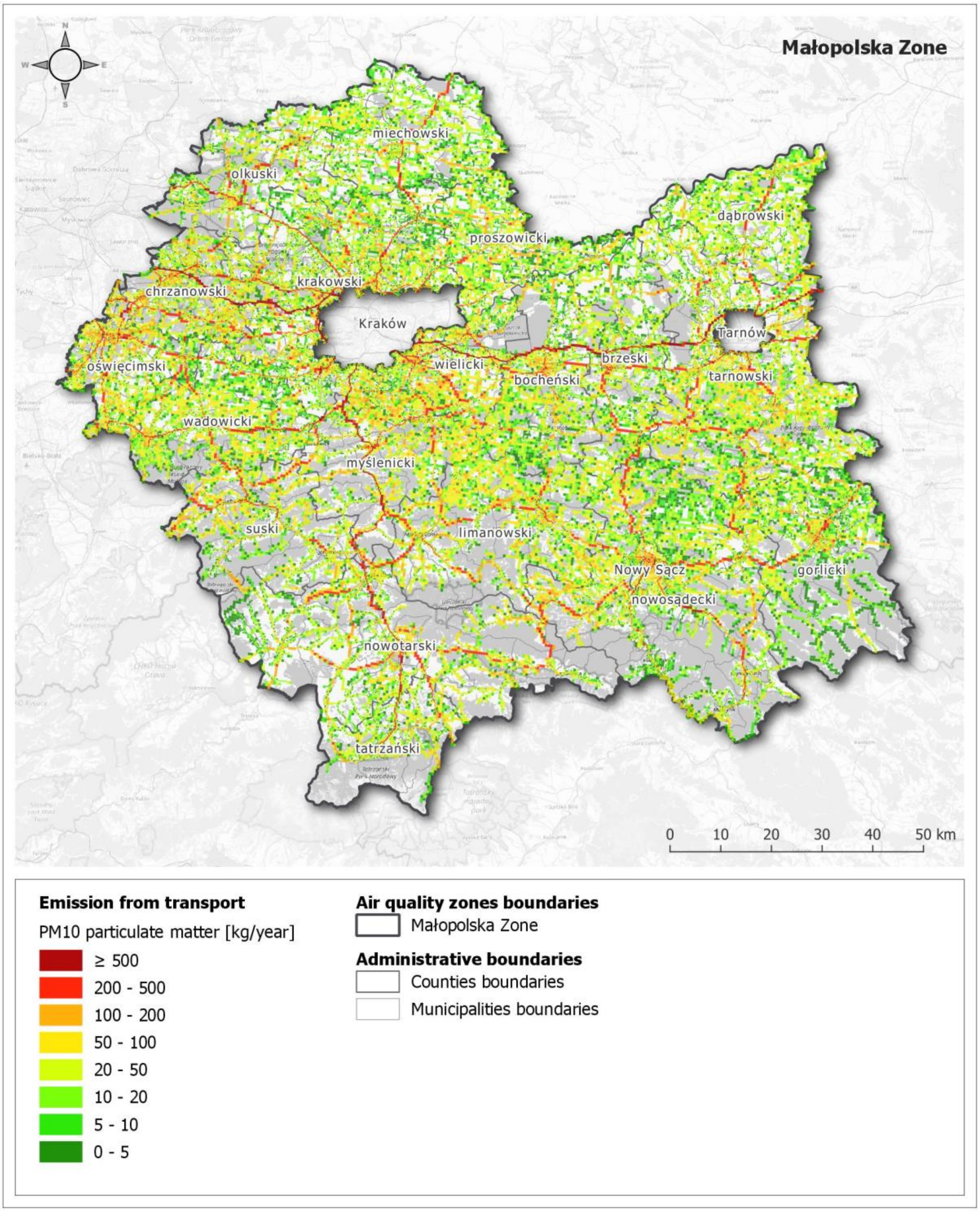


Figure 100. Particulate matter PM10 from road transport emissions[193]

[193] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

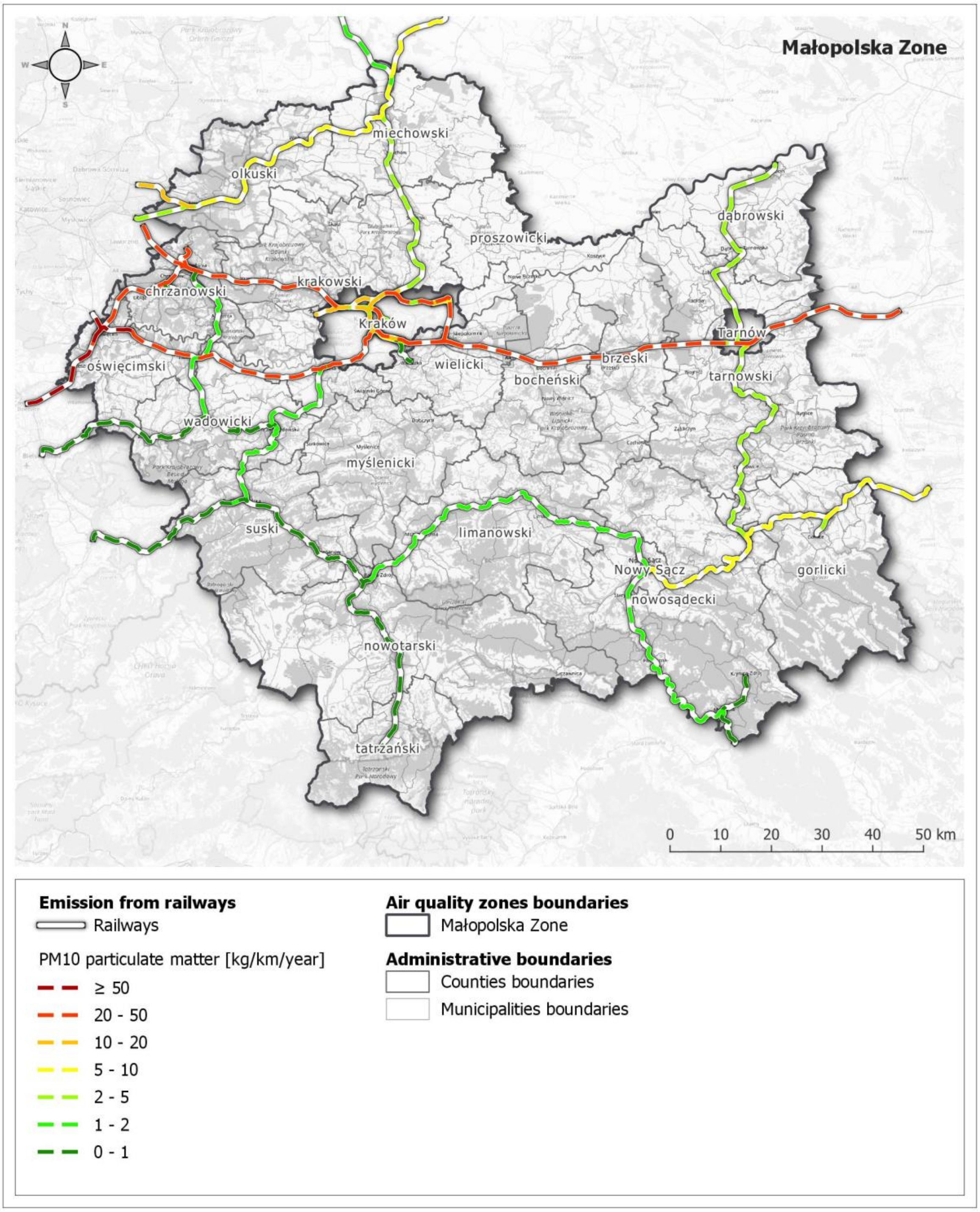


Figure 101. Particulate matter PM10 from other emissions (railway)[194]

[194] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

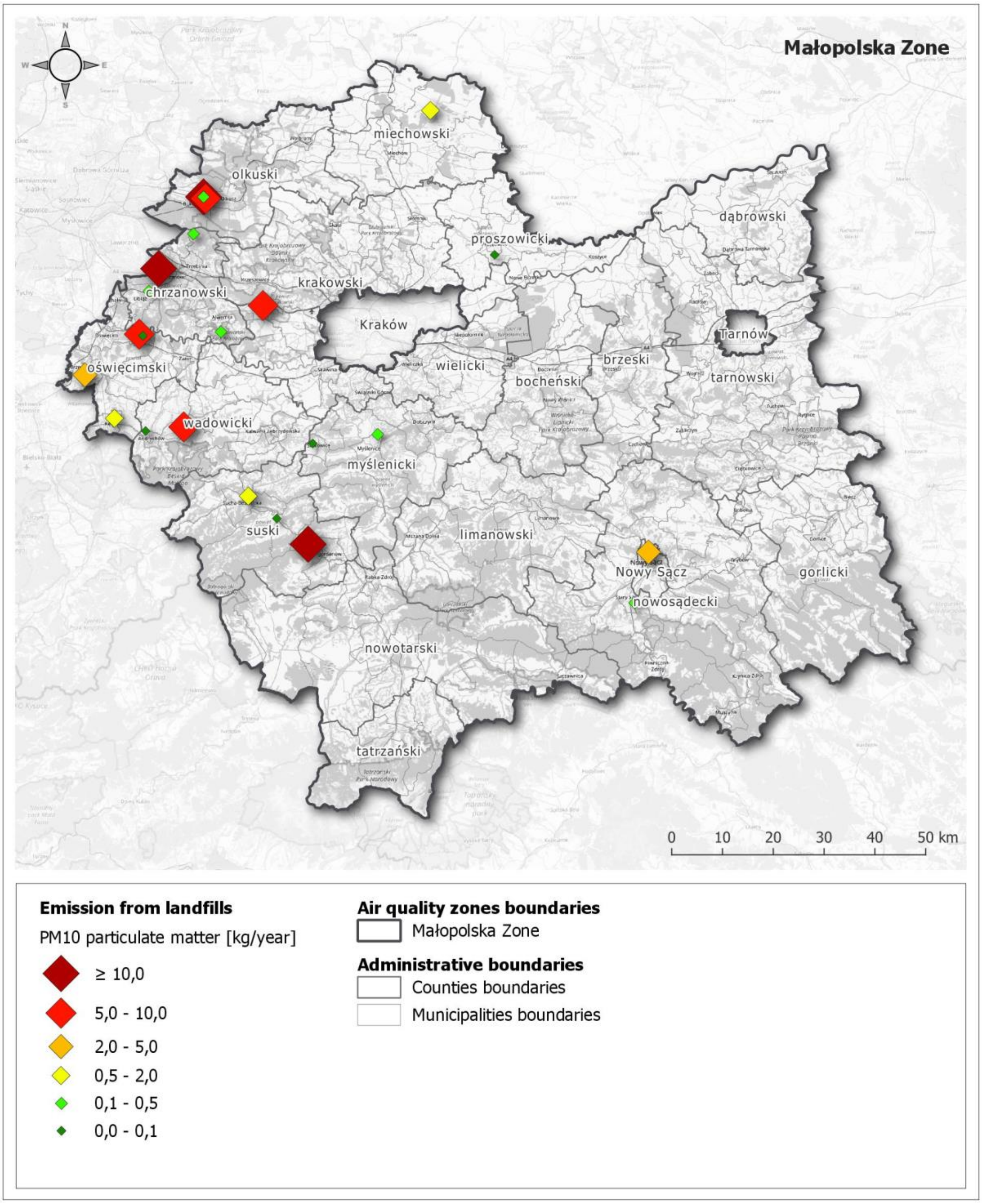


Figure 102. Particulate matter PM10 from landfills emissions [195]

[195] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

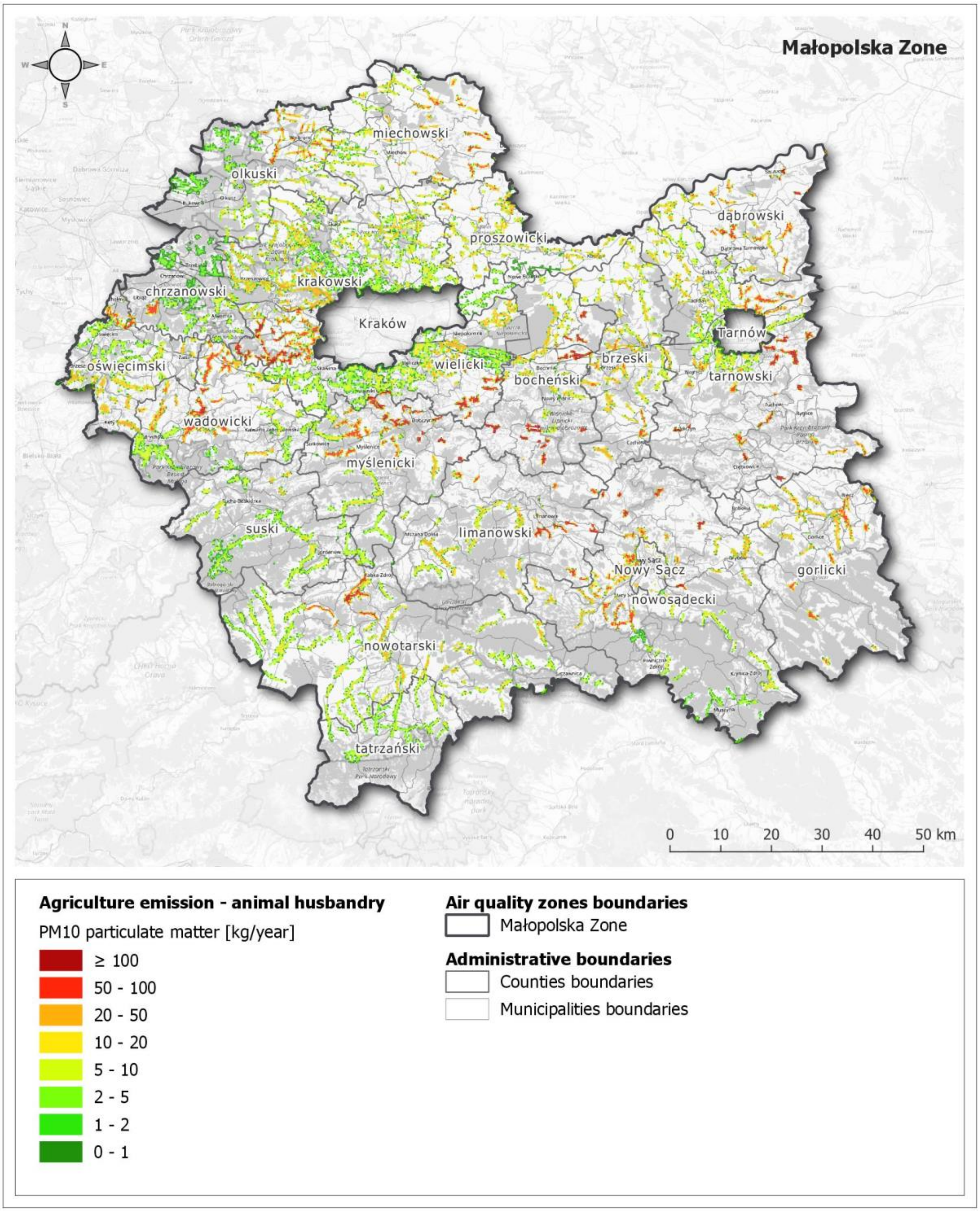


Figure 103. Particulate matter PM10 from agricultural emissions (animals' breeding)[196]

[196] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

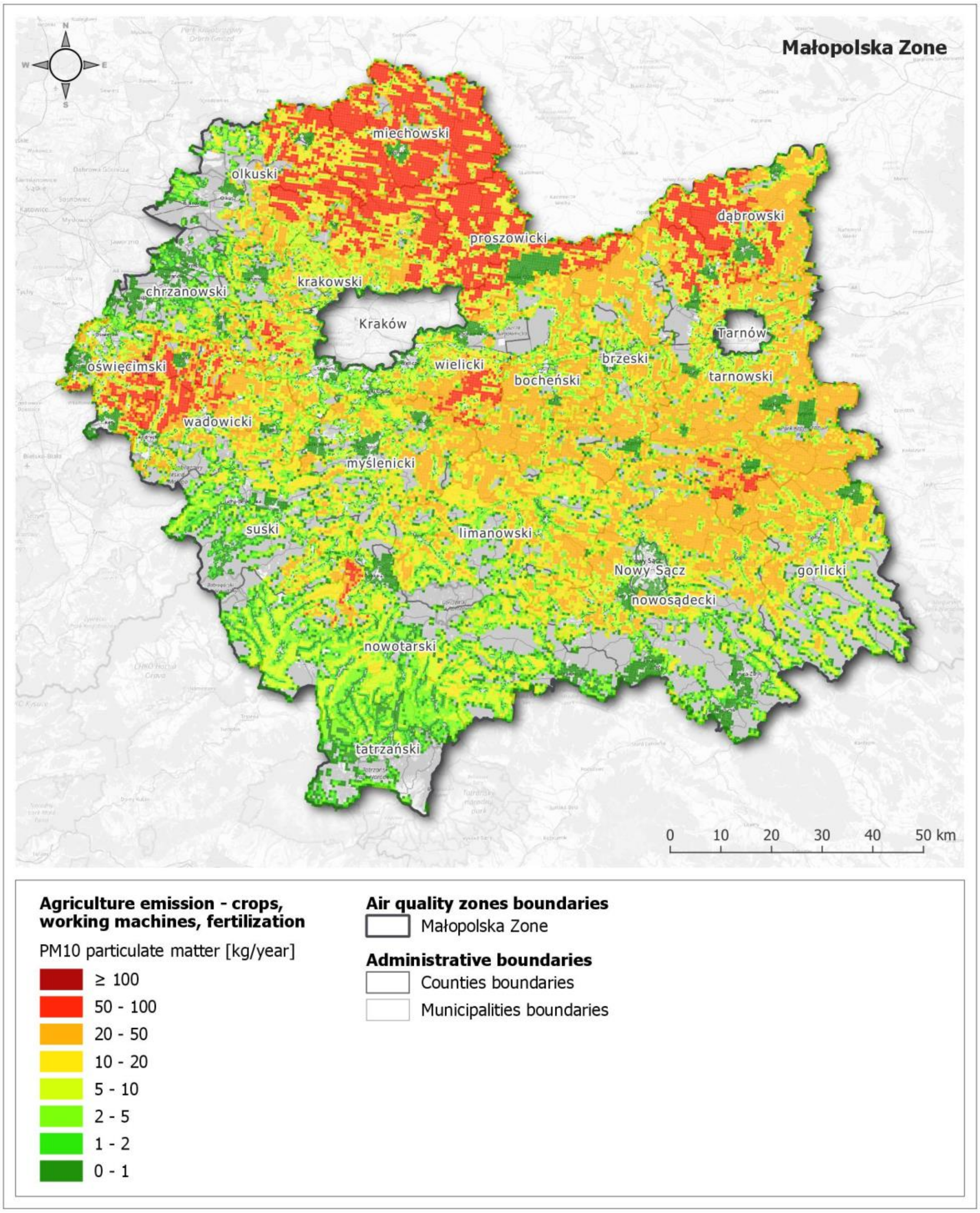


Figure 104. Particulate matter PM10 from agricultural emissions (crops, agricultural machinery, fertilizers)[197]

[197] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

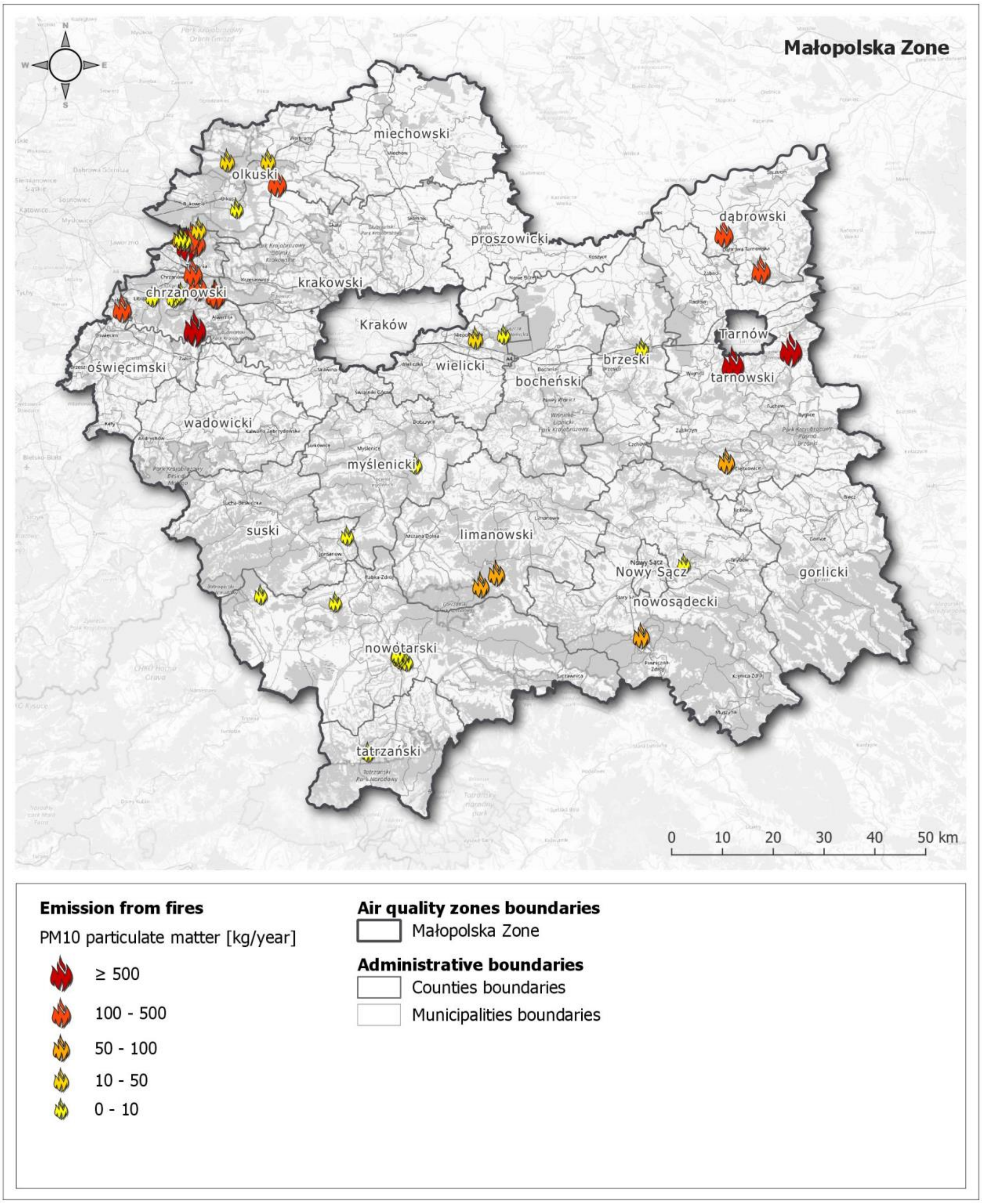


Figure 105. Particulate matter PM10 from fires emissions [198]

[198] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

Krakow Agglomeration Zone

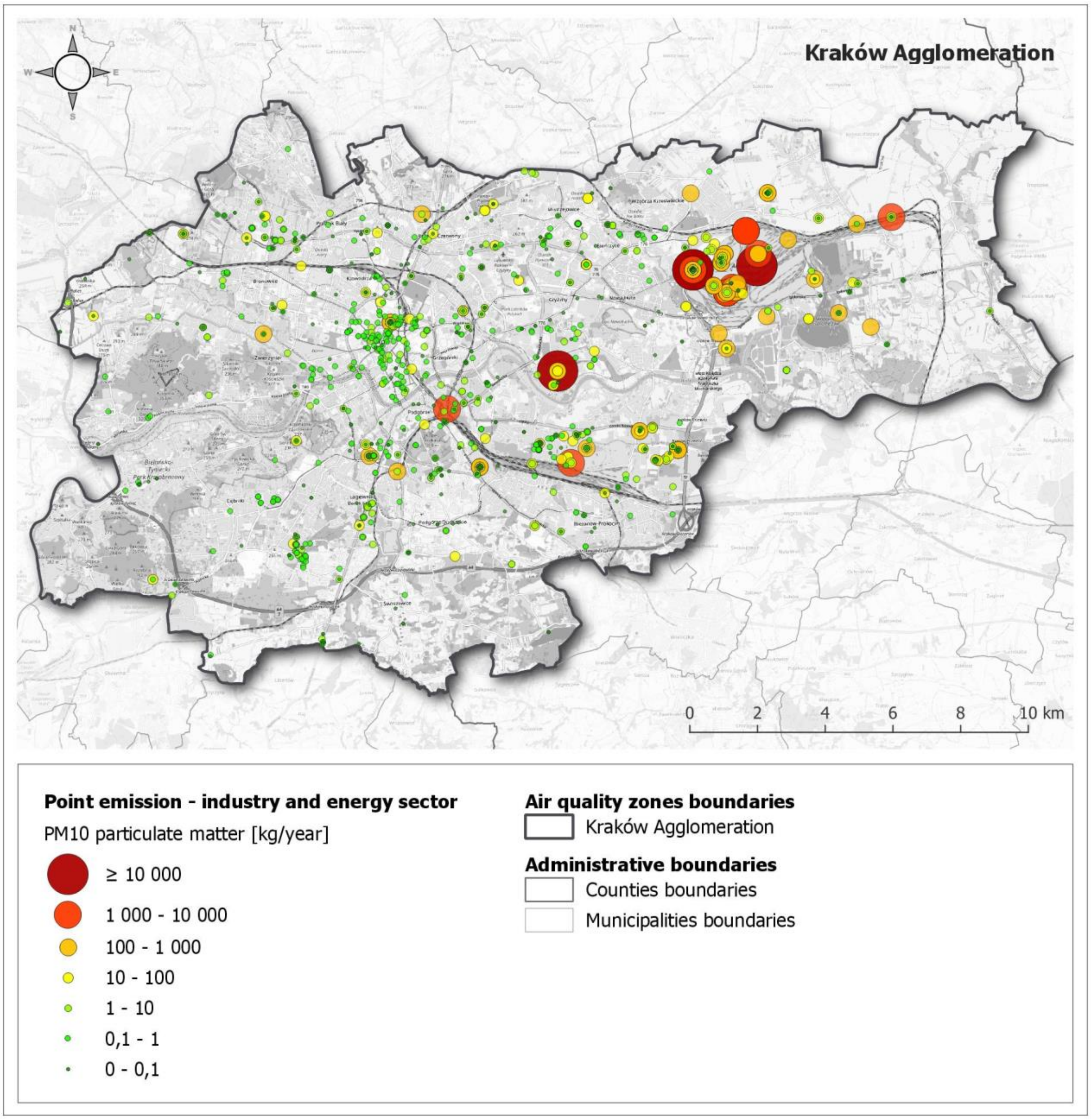


Figure 106. Particulate matter PM10 from industrial and energy emissions[199]

[199] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

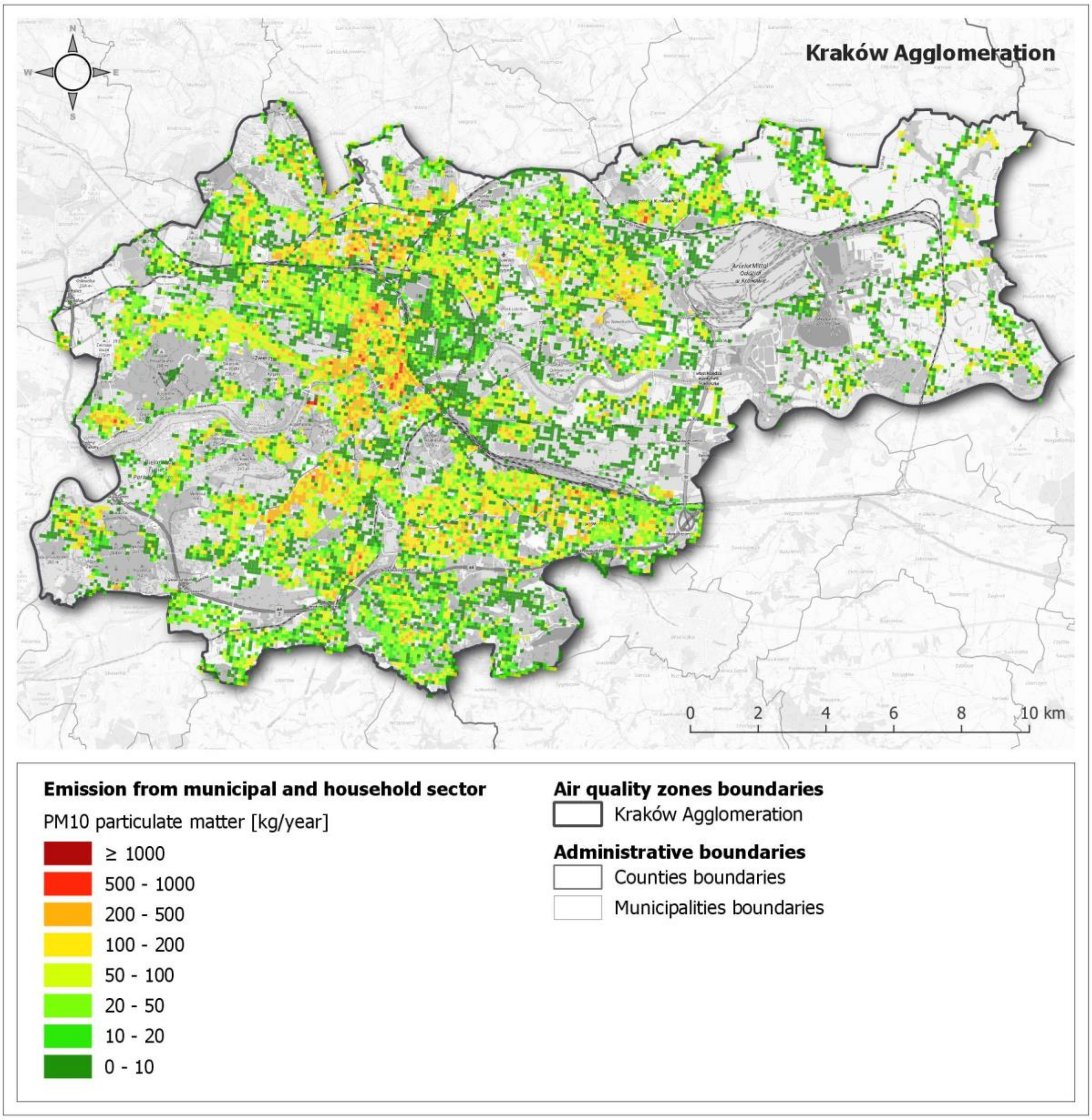


Figure 107. Particulate matter PM10 from municipal and household emissions[200]

[200] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

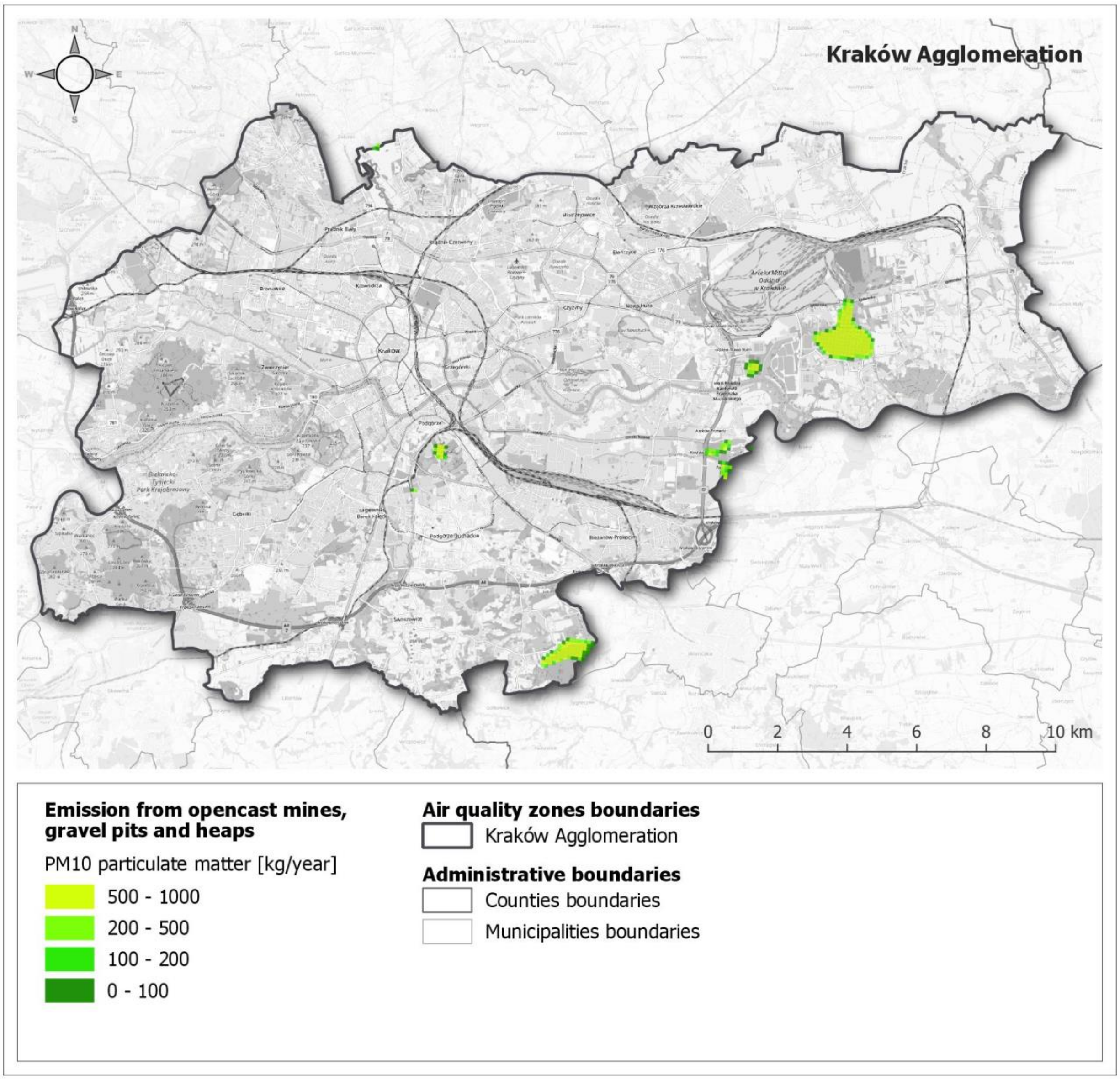


Figure 108. Particulate matter PM10 from fugitive emissions (aggregate quarries)[201]

[201] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

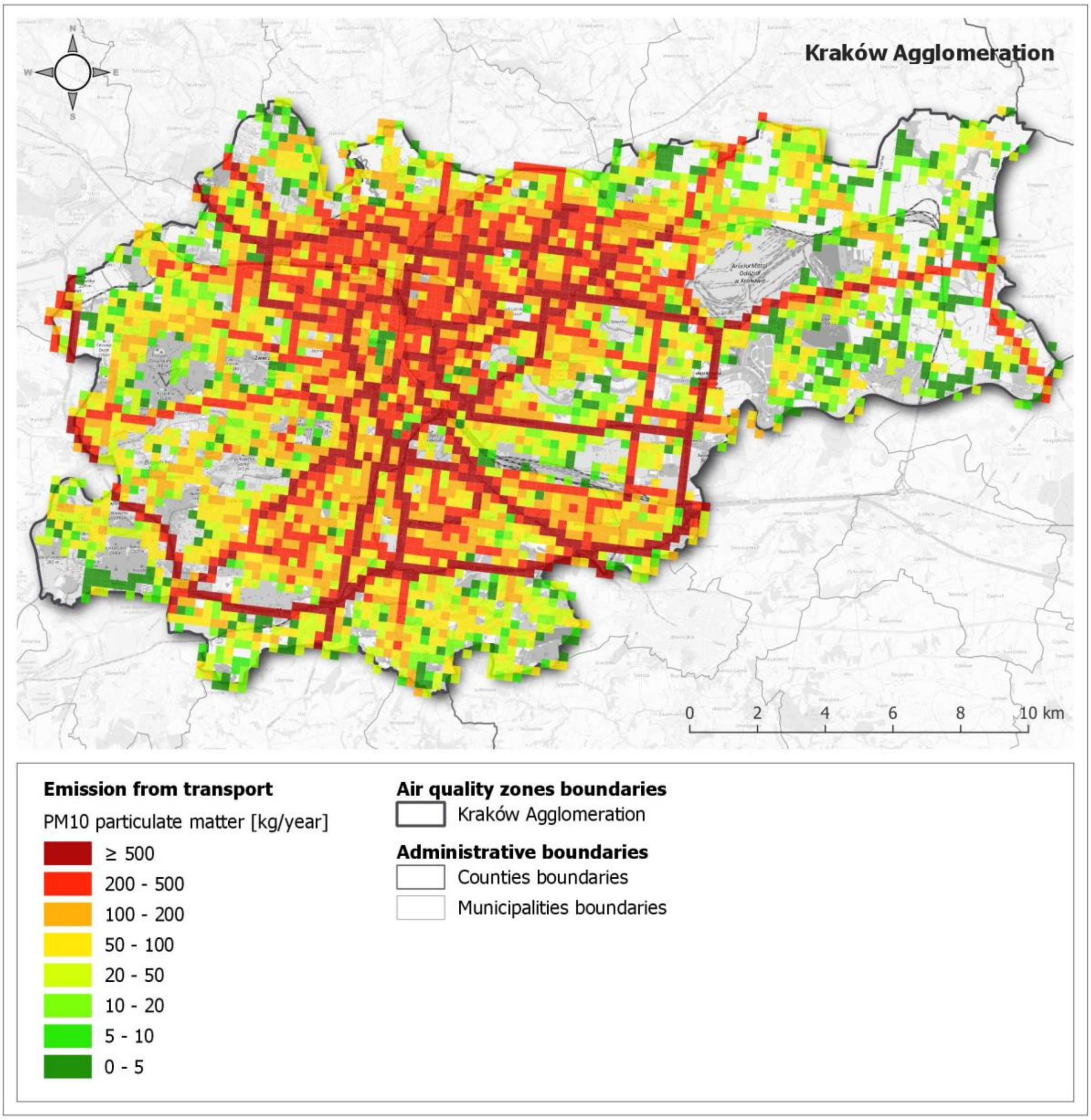


Figure 109. Particulate matter PM10 from road transport emissions[202]

[202] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

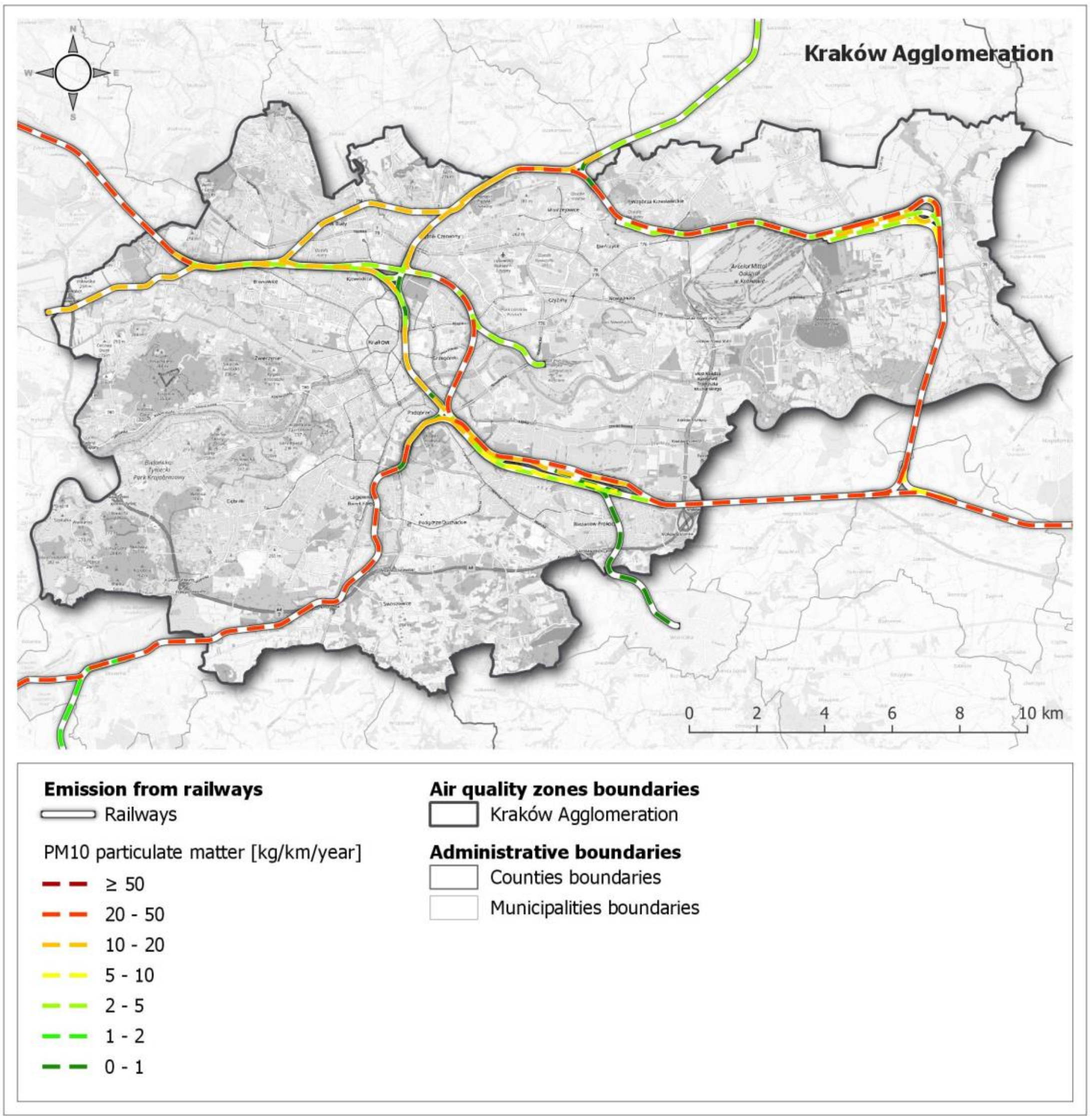


Figure 110. Particulate matter PM10 from other emissions (railway)[203]

[203] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

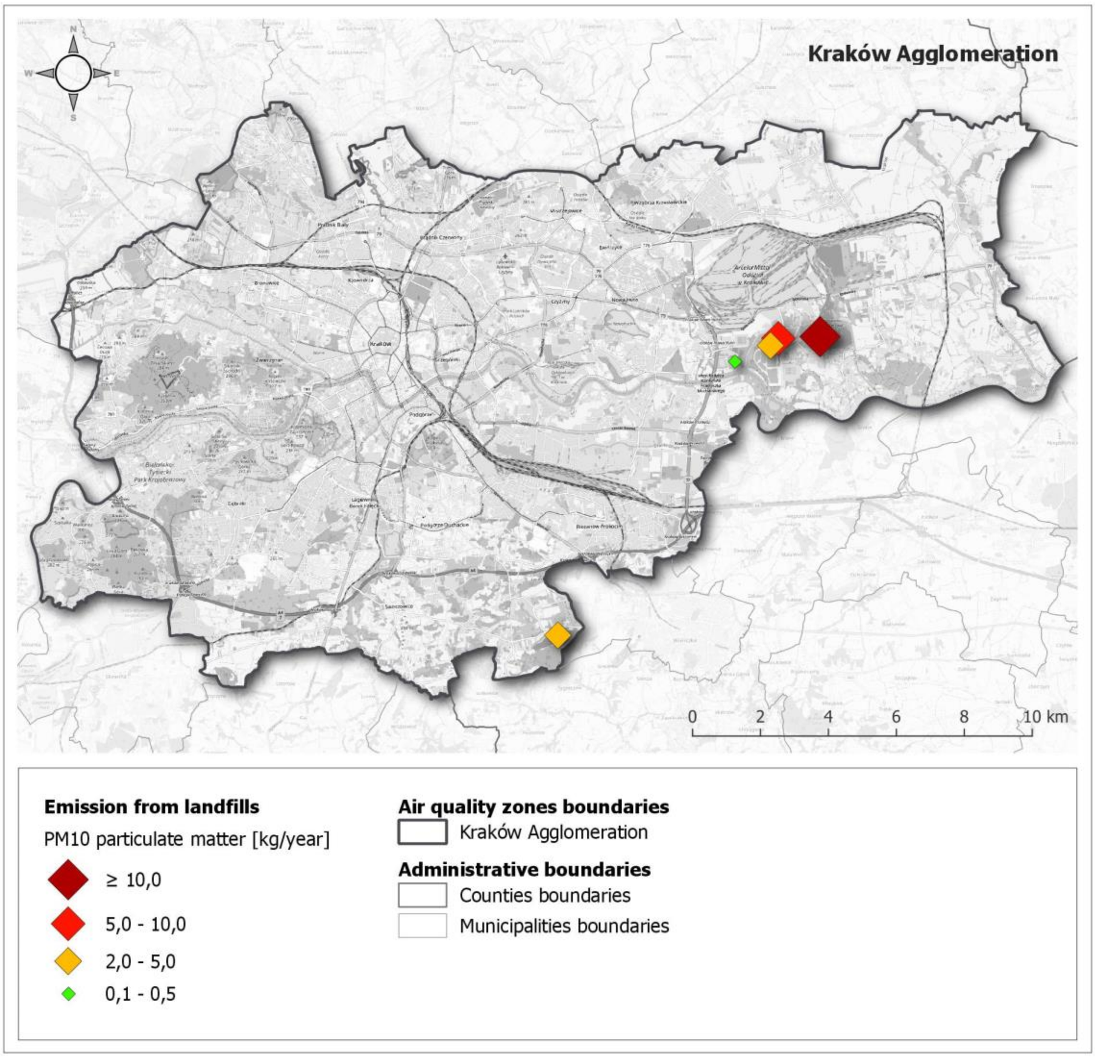


Figure 111. Particulate matter PM10 from landfills emissions[204]

[204] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

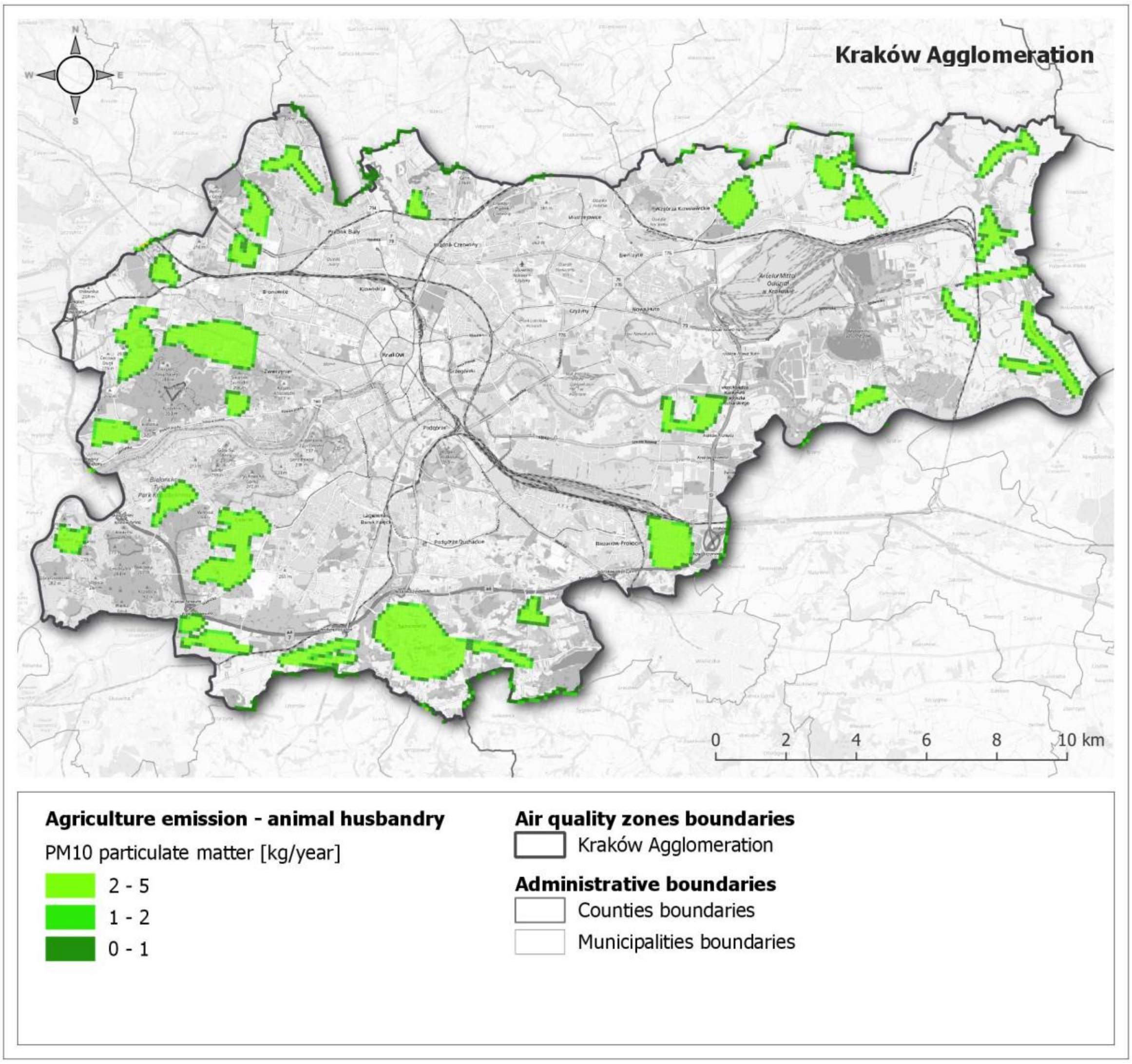


Figure 112. Particulate matter PM10 from agricultural emissions (animals' breeding)[205].

[205] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

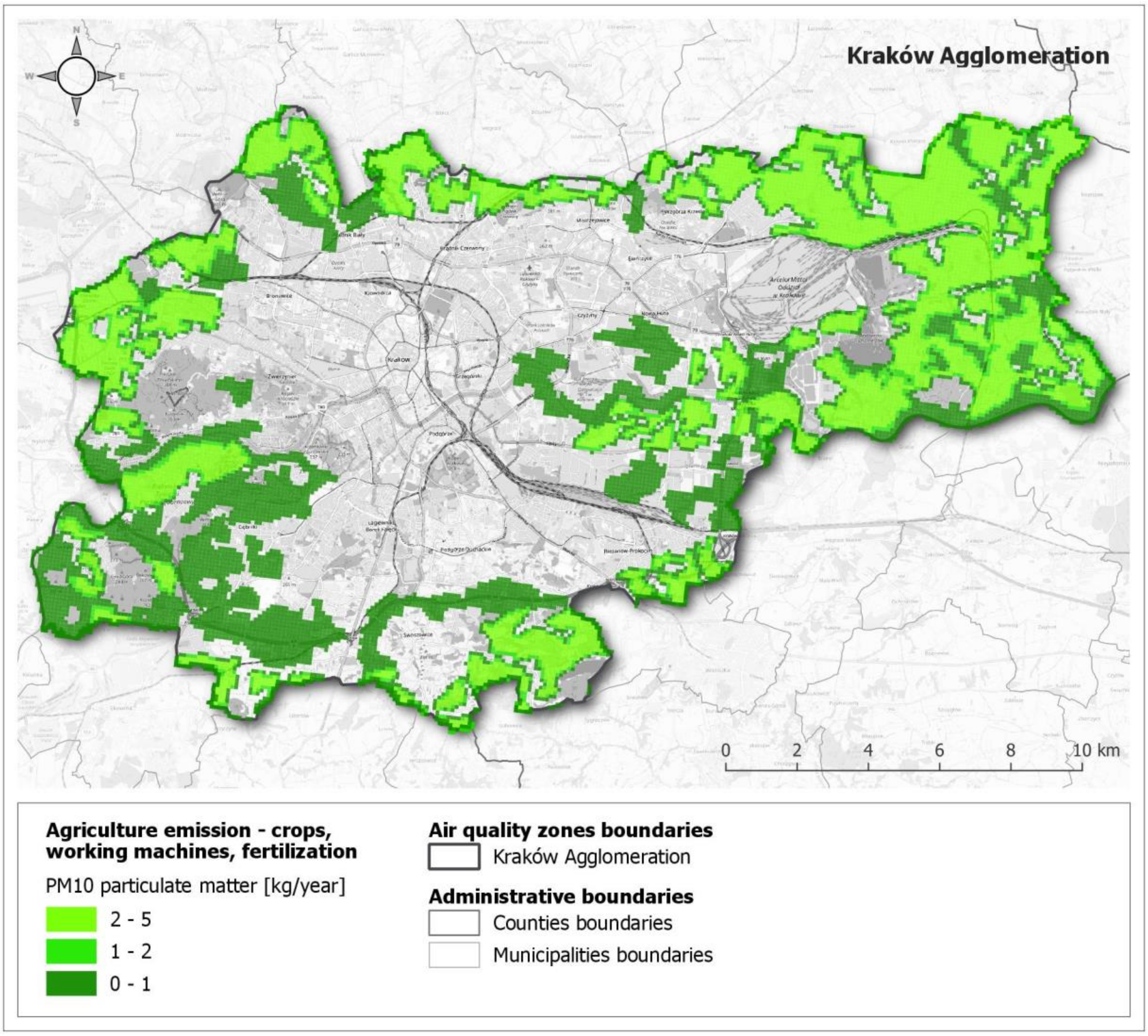


Figure 113. Particulate matter PM10 from agricultural emissions (crops, agricultural machinery, fertilizers) [206]

[206] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

Tarnow city zone

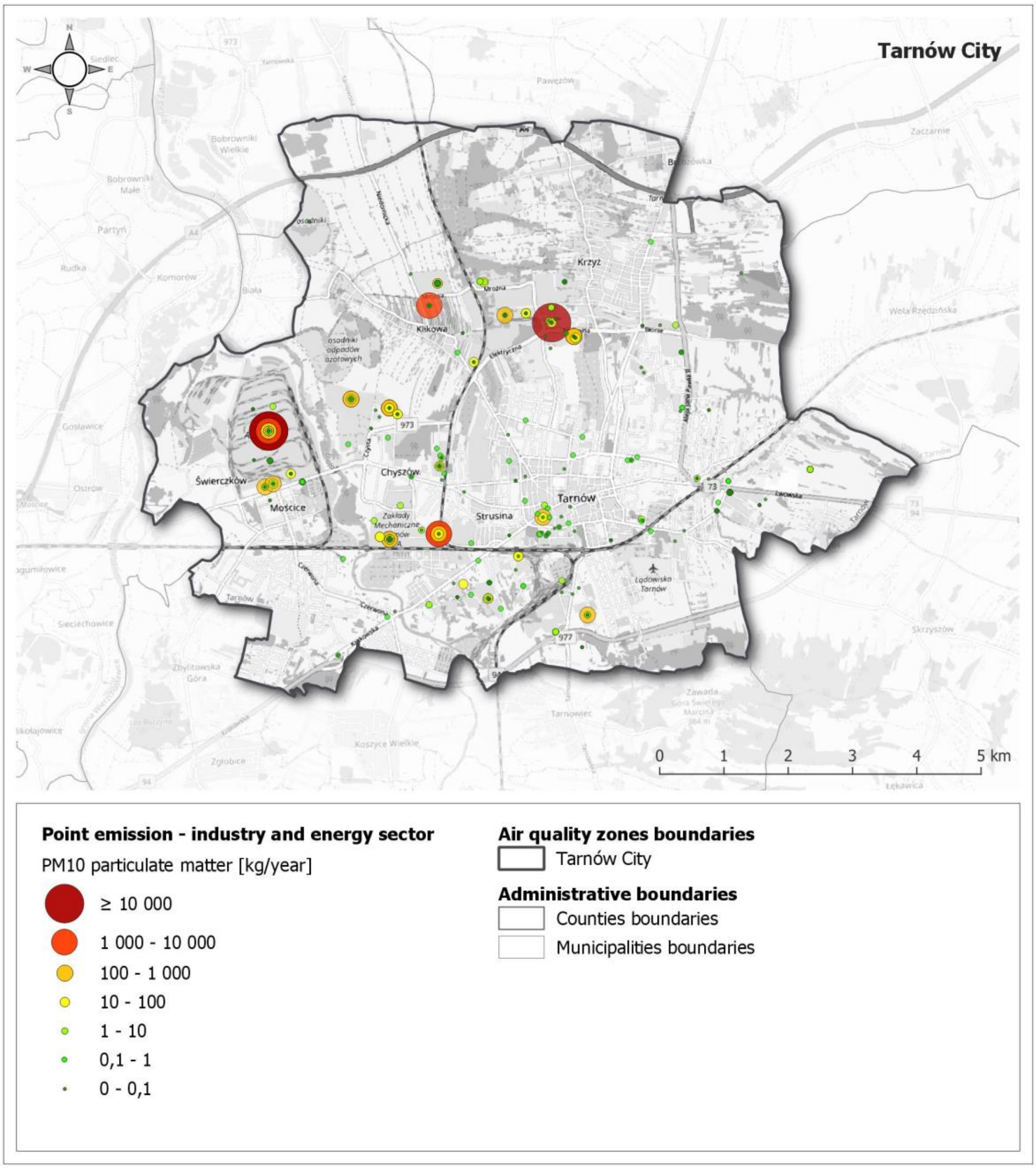


Figure 114. Particulate matter PM10 from industrial and energy emissions [207]

[207] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

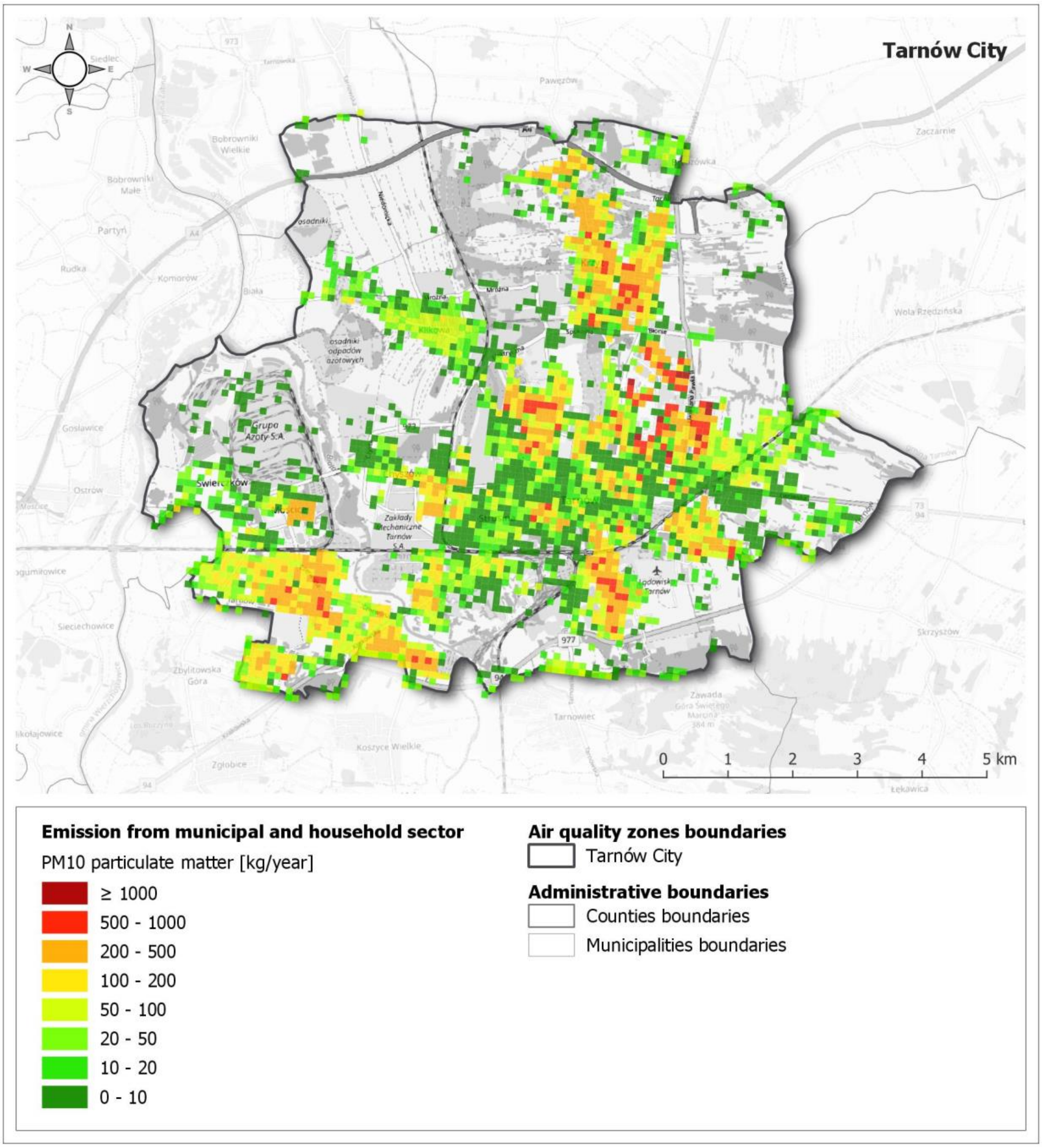


Figure 115. Particulate matter PM10 from municipal emissions [208]

[208] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

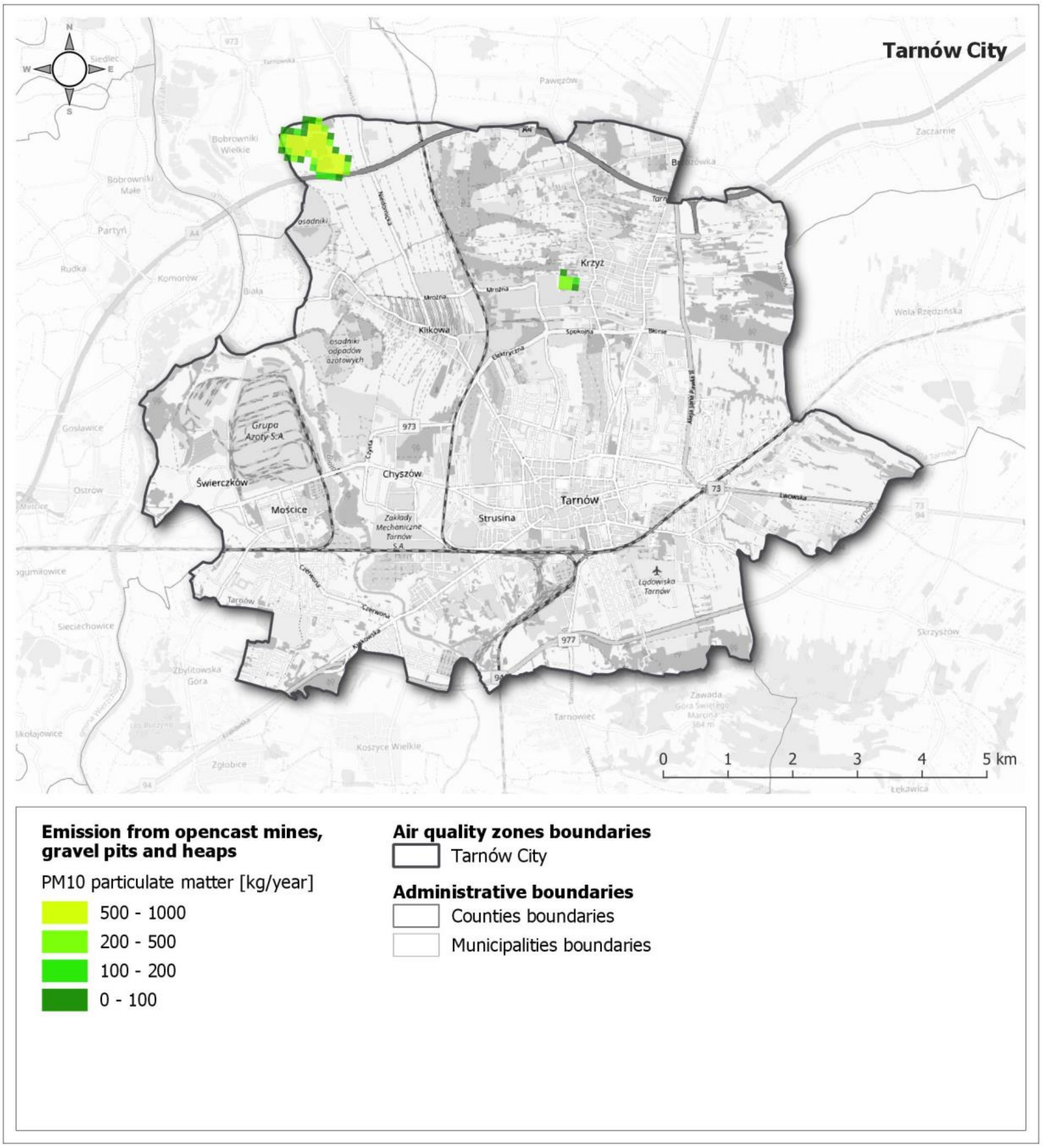


Figure 116. Particulate matter PM10 from fugitive emissions (aggregate quarries)[209]

[209] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

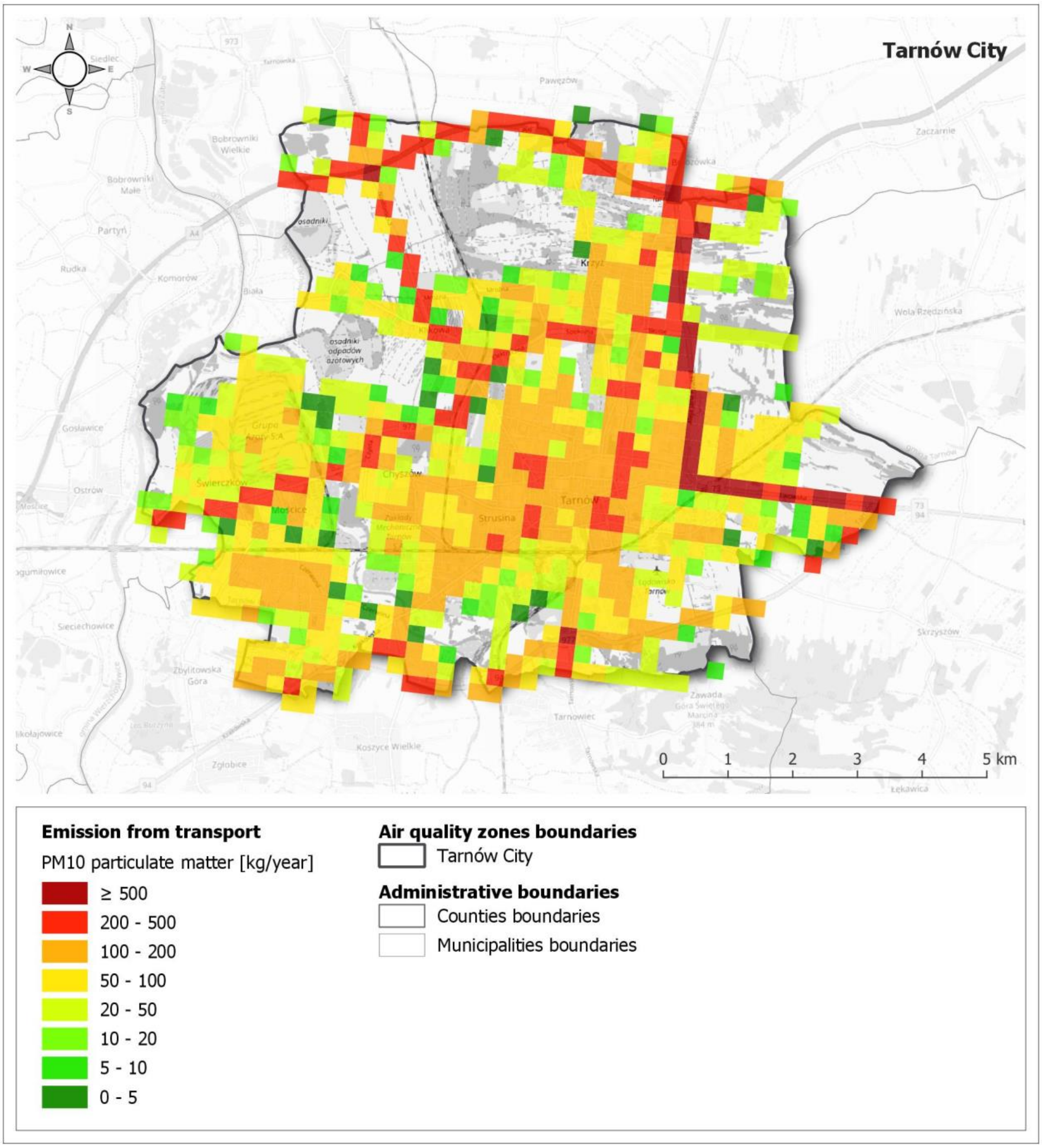


Figure 117. Particulate matter PM10 from road transport emissions [210]

[210] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

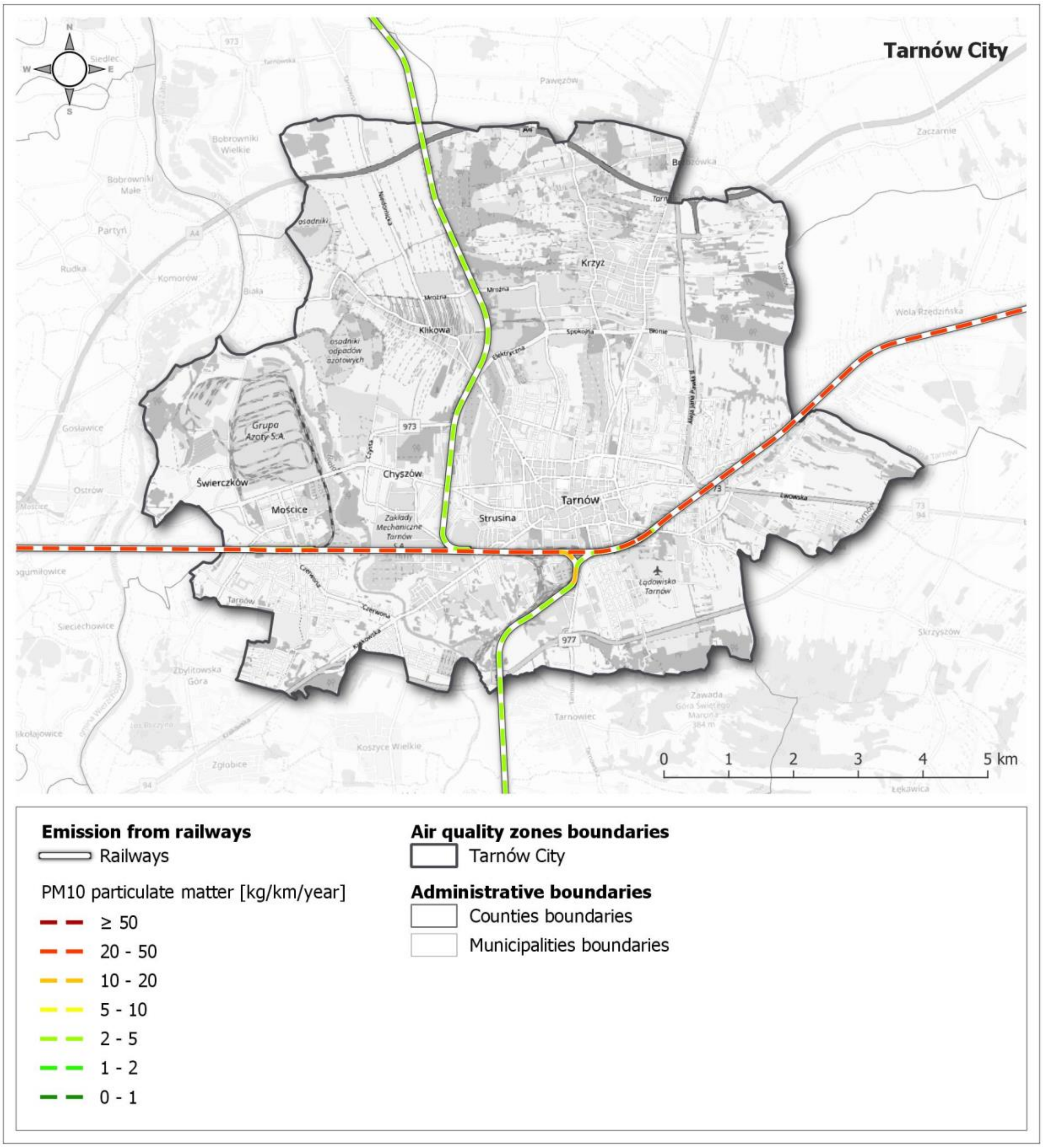


Figure 118. Particulate matter PM10 from other emissions (railway)[211]

[211] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

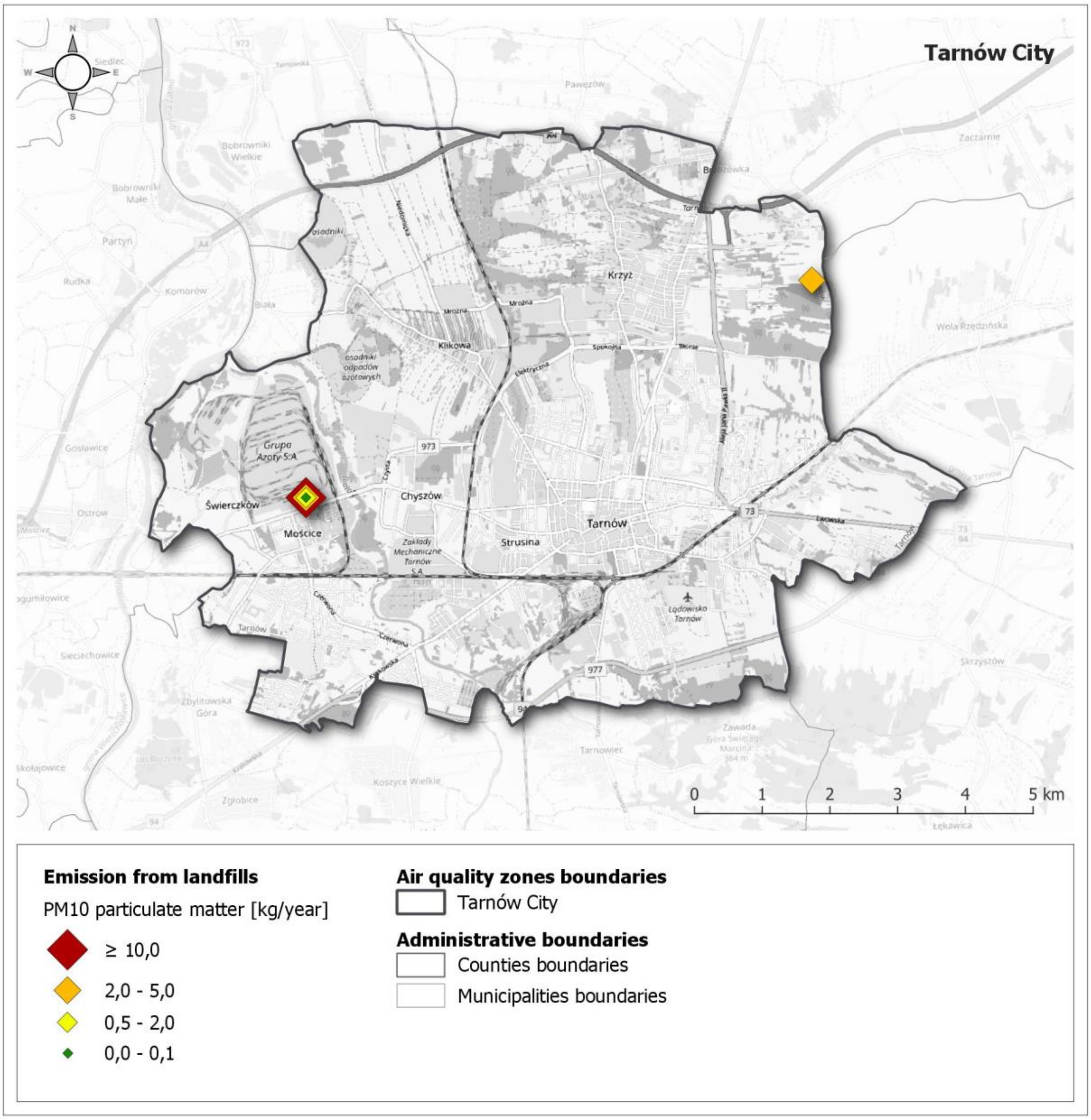


Figure 119. Particulate matter PM10 from landfills emissions [212]

[212] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

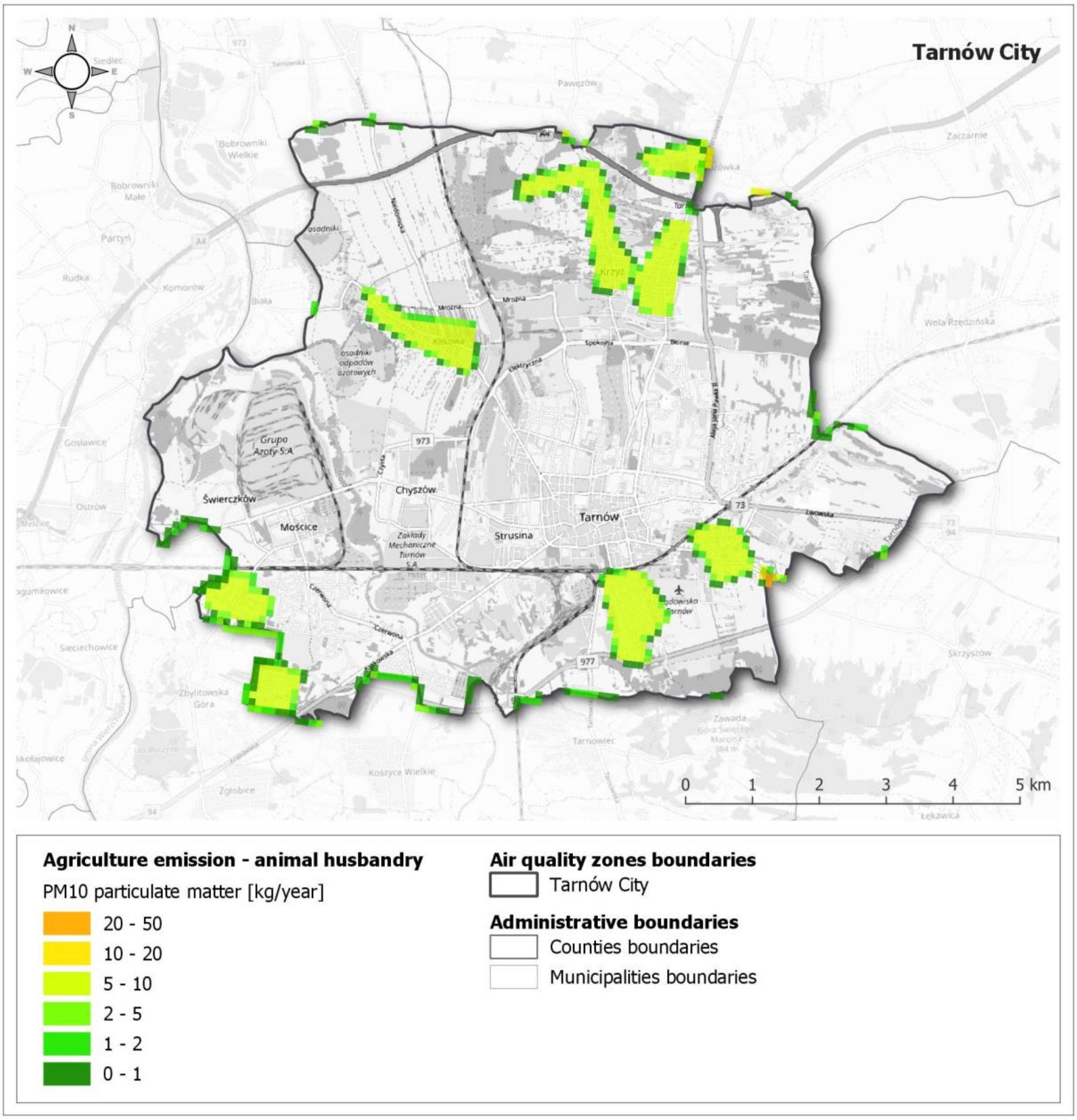


Figure 120. Particulate matter PM10 from agricultural emissions (animals' breeding)[213]

[213] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

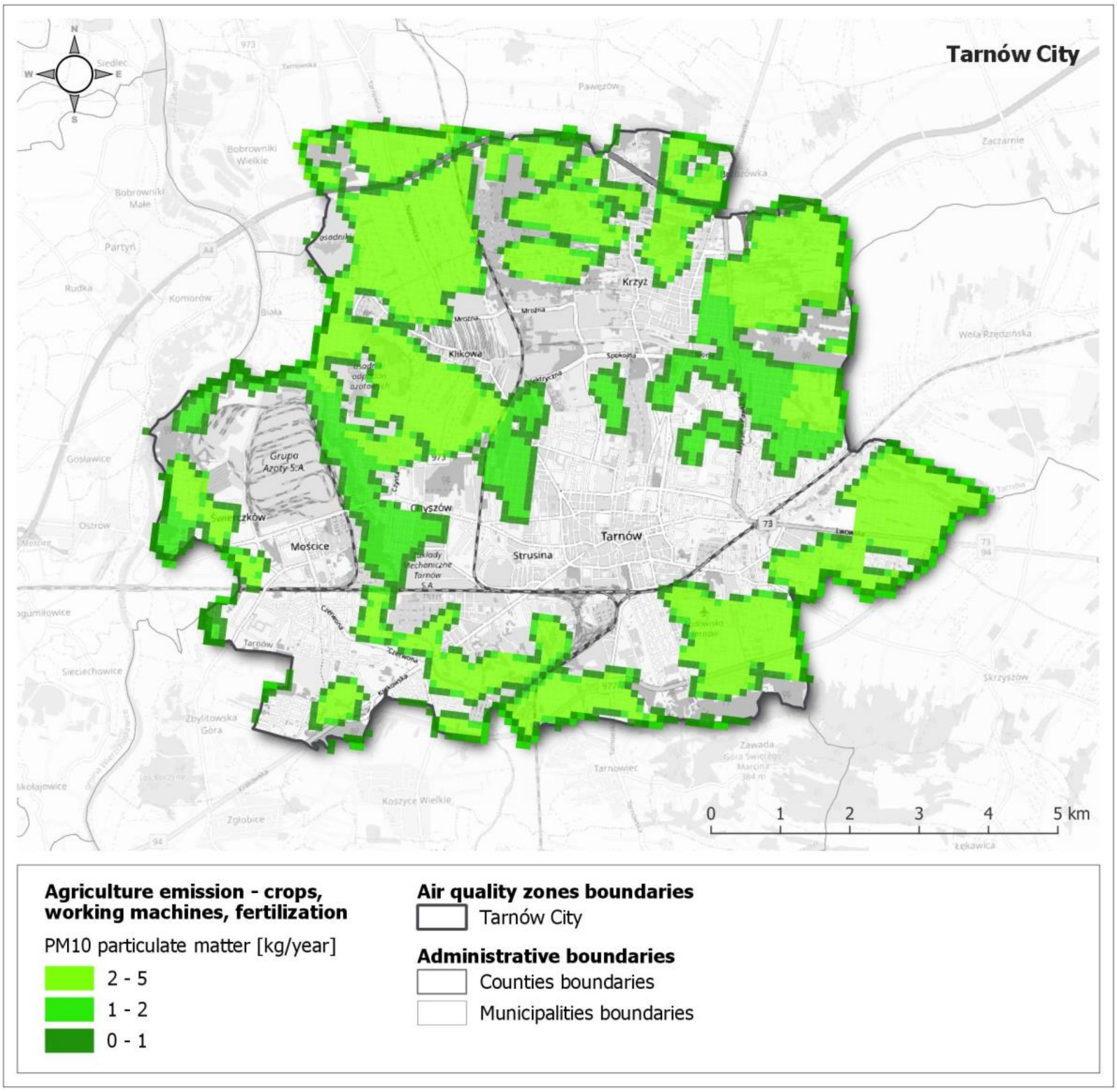


Figure 121. Particulate matter PM10 from agricultural emissions (crops, agricultural machinery, fertilizers)[214]

[214] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

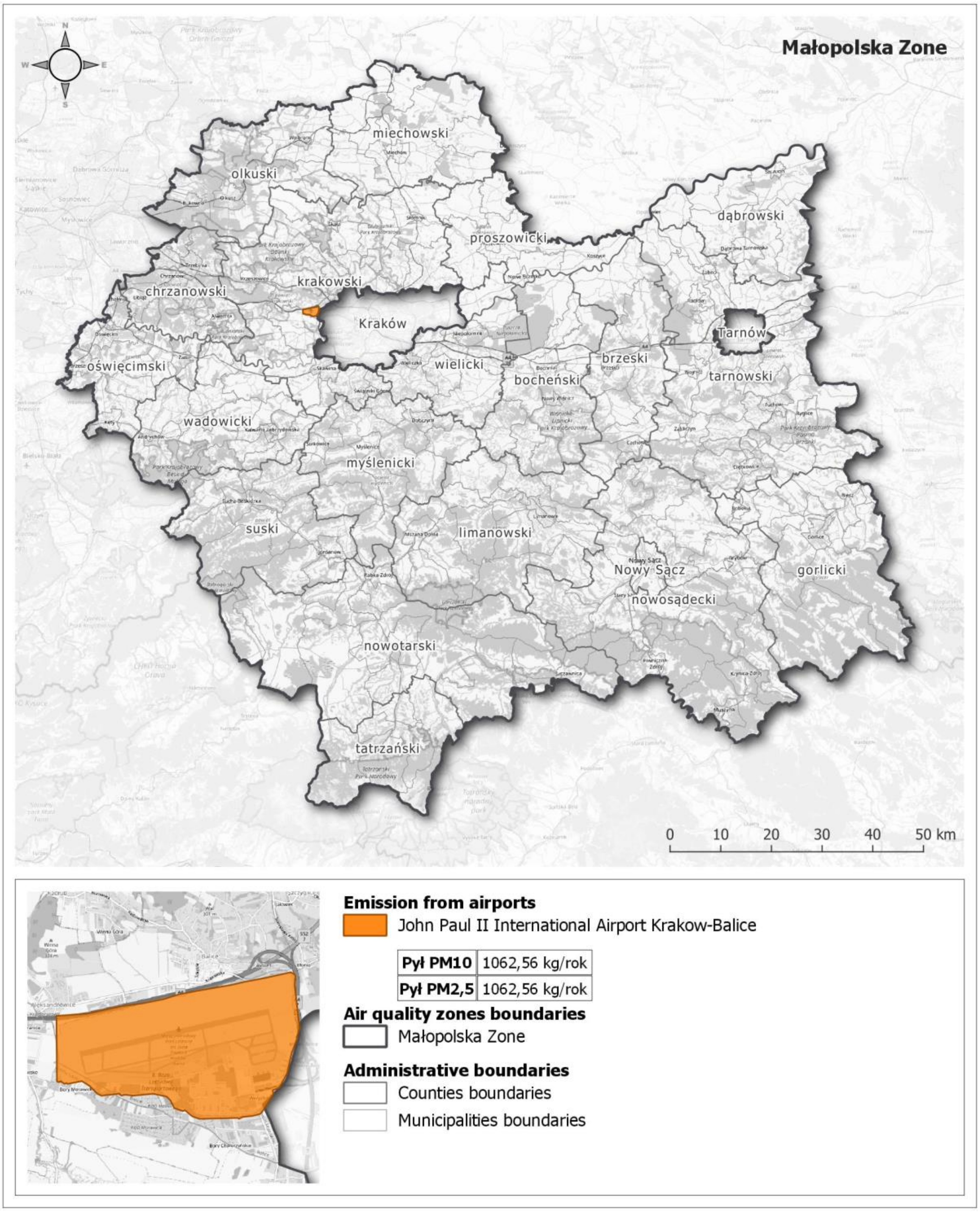


Figure 122. Particulate matter PM10 from other emissions (airports)[215]

[215] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

18.2.2. *PARTICULATE MATTER PM2.5 EMISSION SOURCES*

Krakow Agglomeration zone

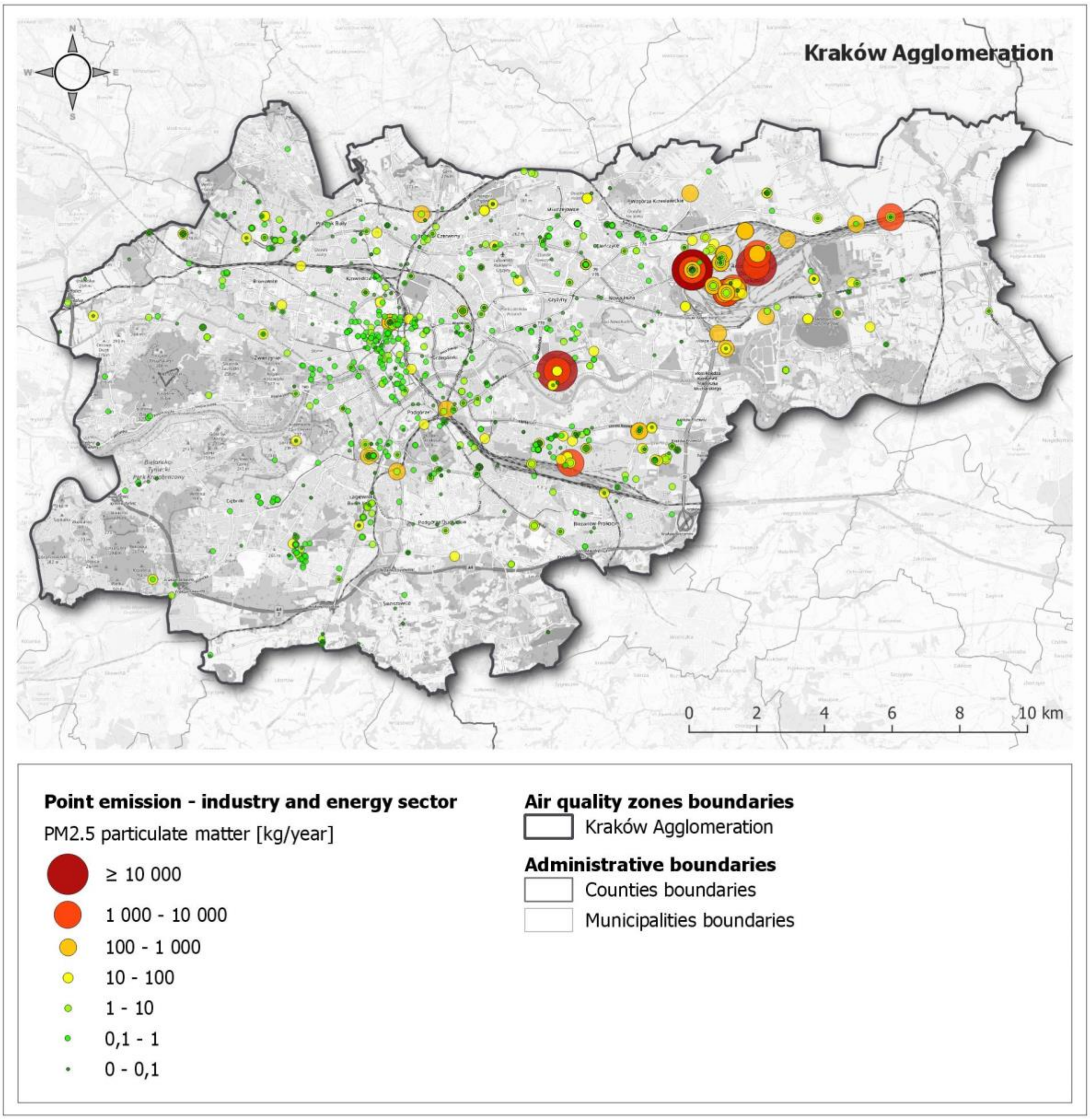


Figure 123. Particulate matter PM2.5 from industrial and energy emissions[216]

[216] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

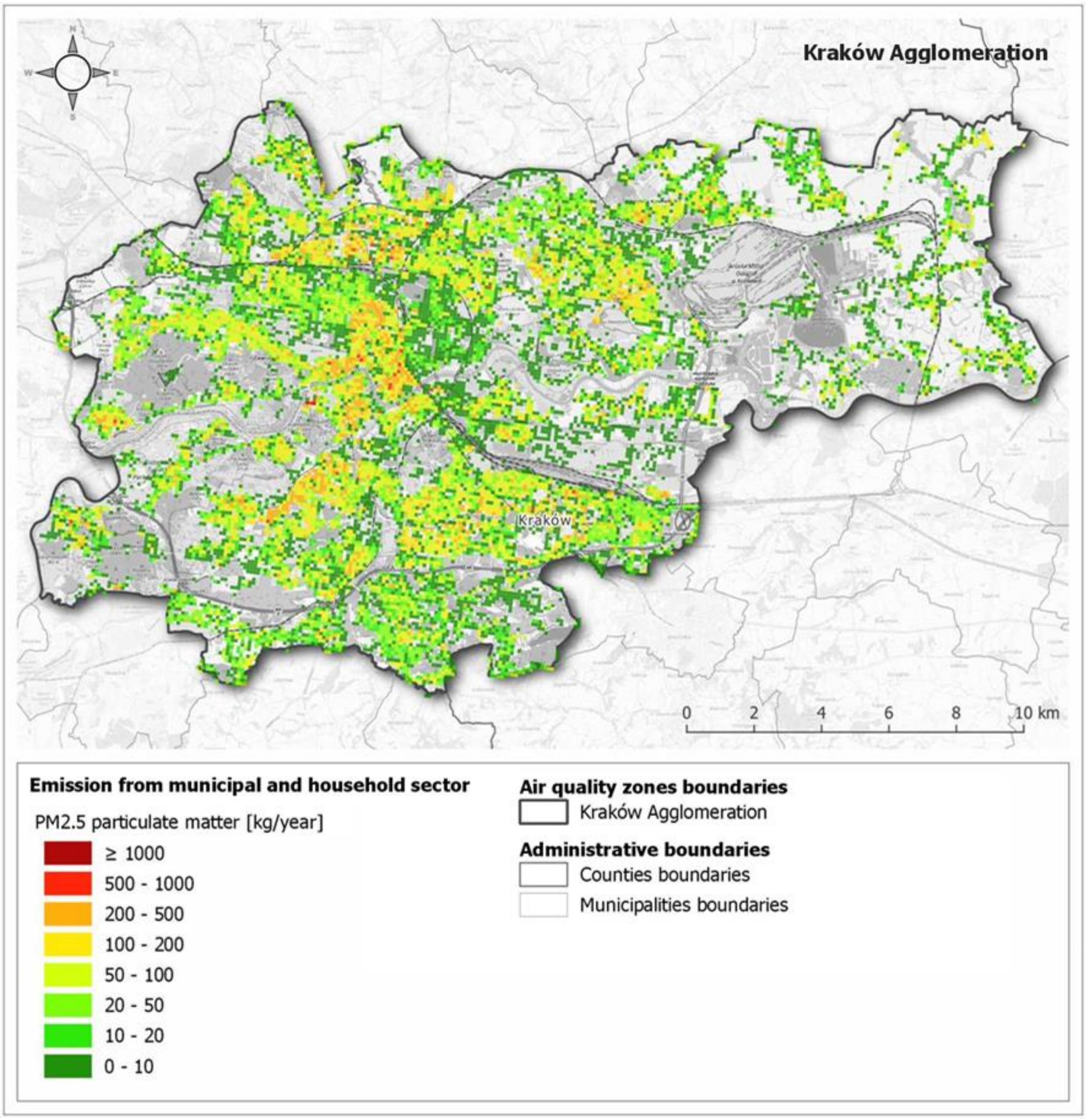


Figure 124. Particulate matter PM2.5 from municipal emissions[217]

[217] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

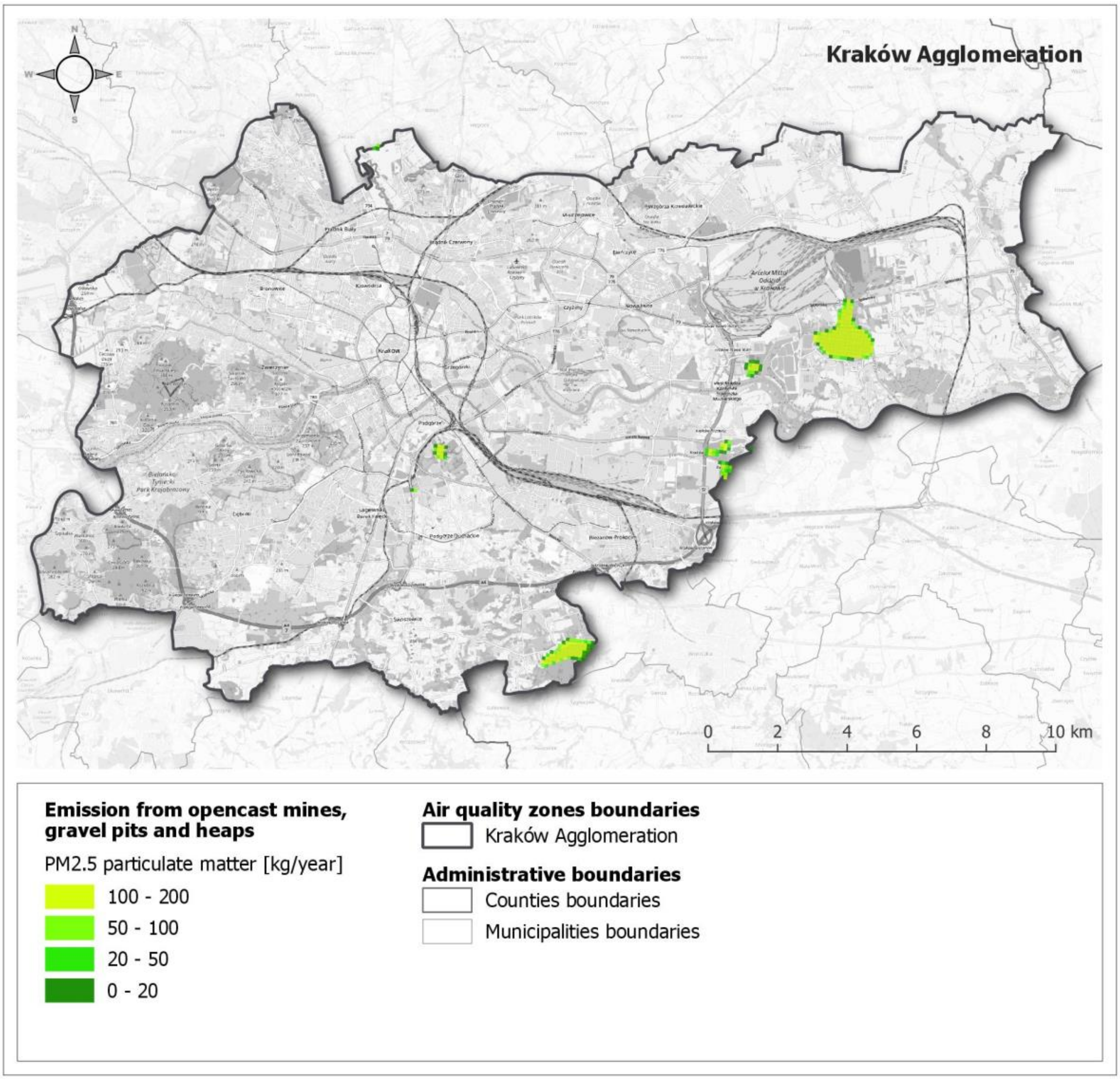


Figure 125. Particulate matter PM2.5 from fugitive emissions (aggregate quarries)[218]

[218] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

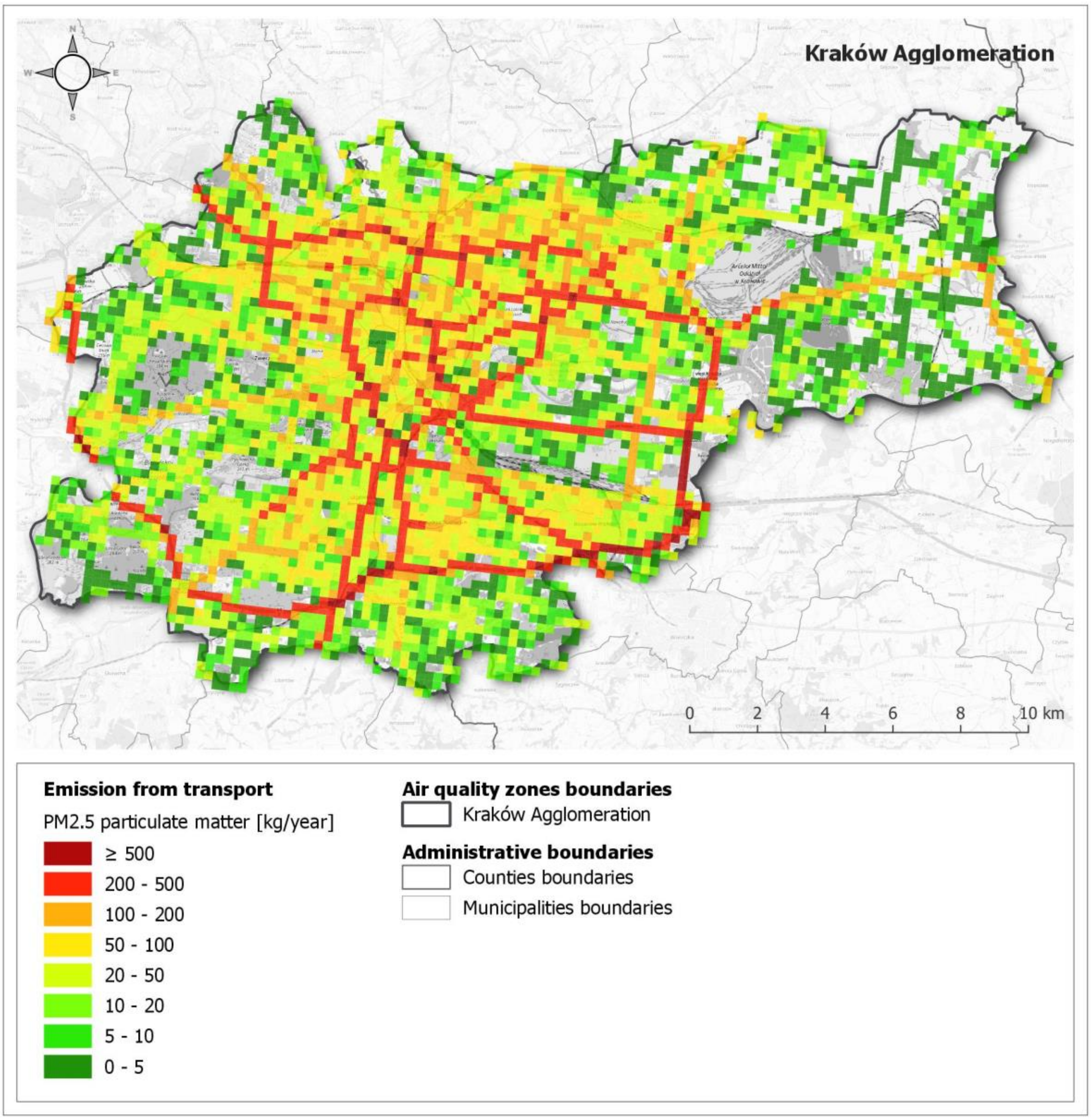


Figure 126. Particulate matter PM2.5 from road transport emissions[219]

[219] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

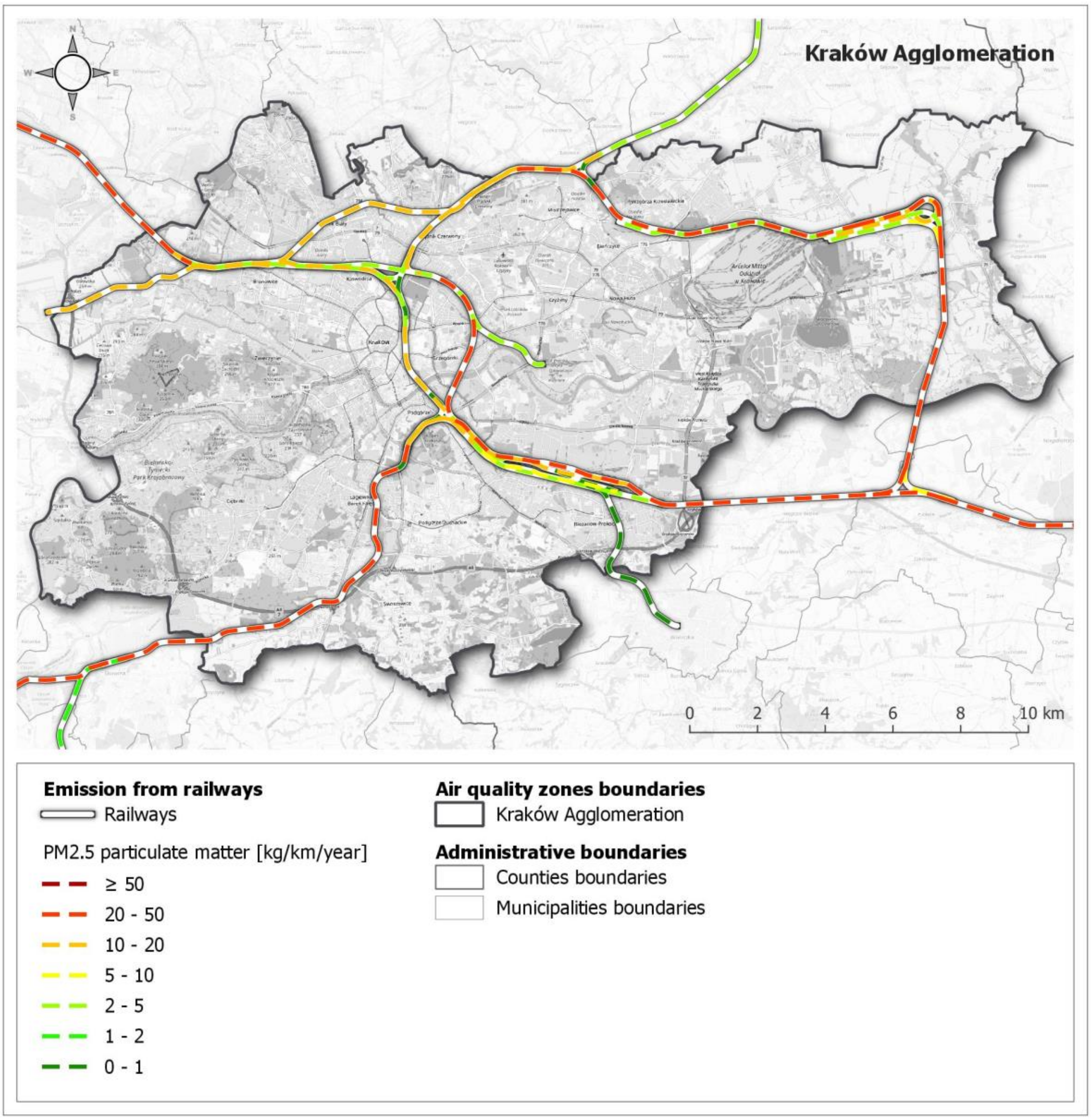


Figure 127. Particulate matter PM2.5 from other emissions (railway)[220]

[220] Source: Prepared by Atmoterm S.A. based on the data of the Central Issue Base KOBIZE 2018

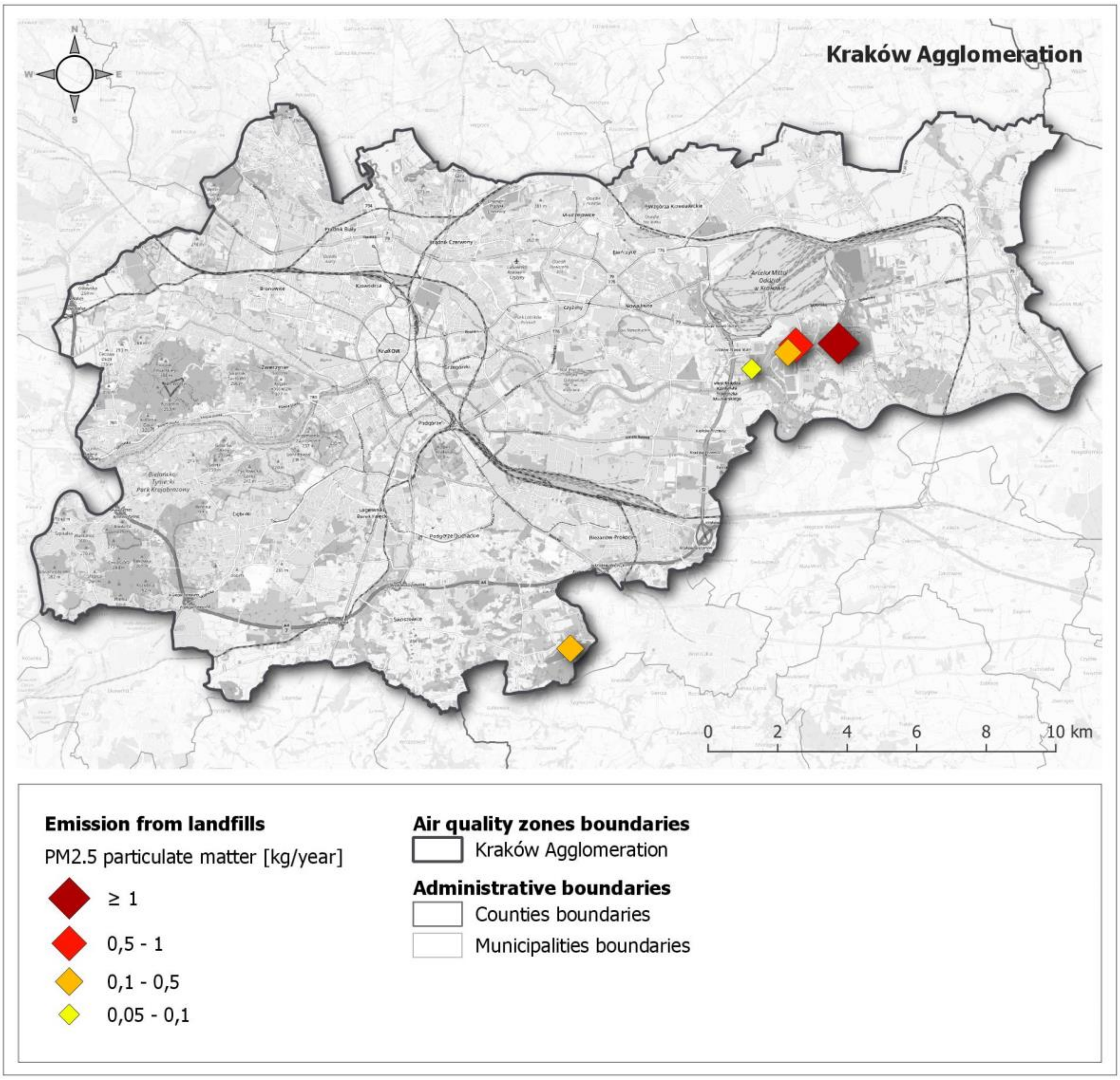


Figure 128. Particulate matter PM2.5 from landfills emissions[221]

[221] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

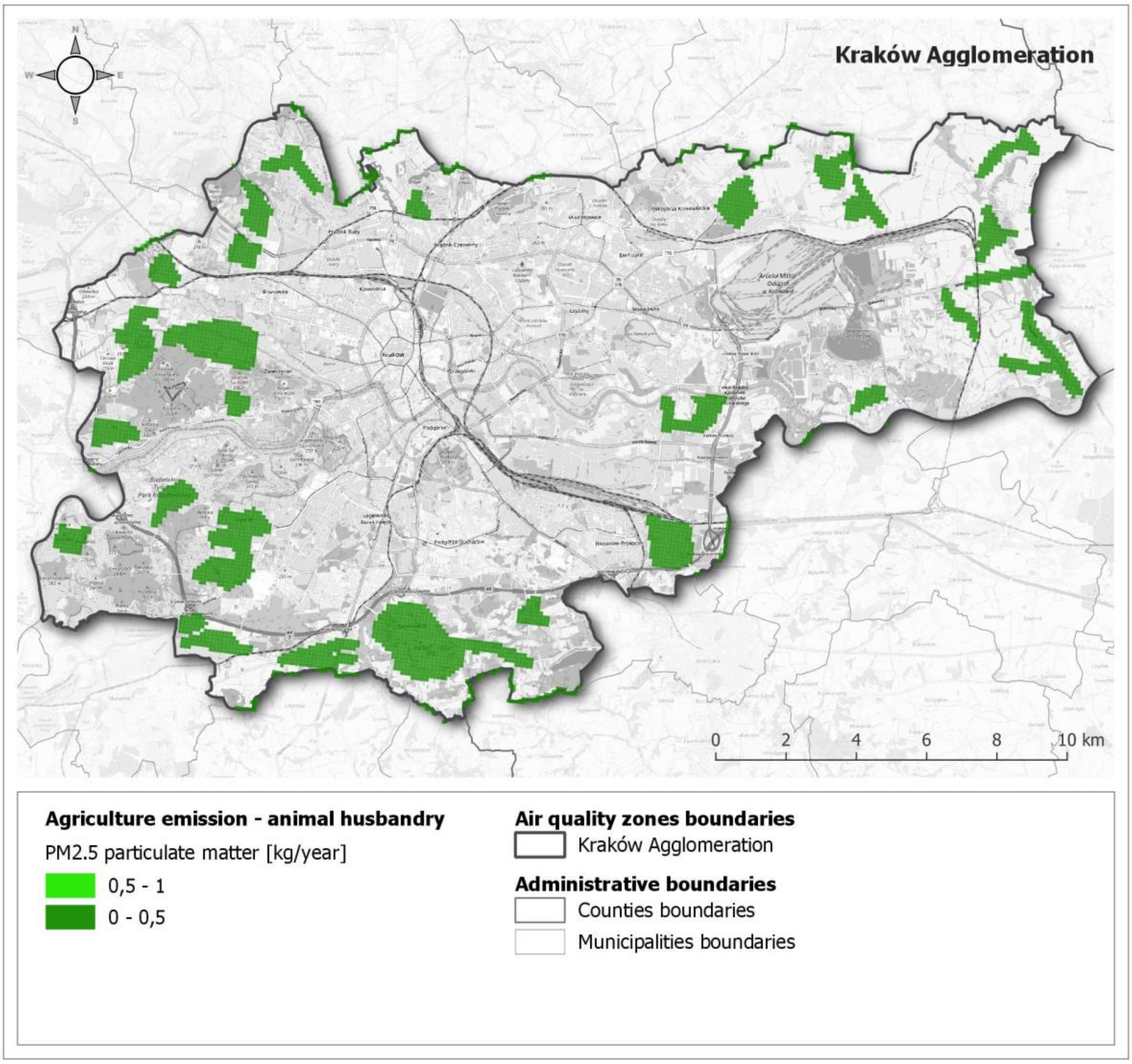


Figure 129. Particulate matter PM2.5 from agricultural emissions (animals' breeding)[222]

[222] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

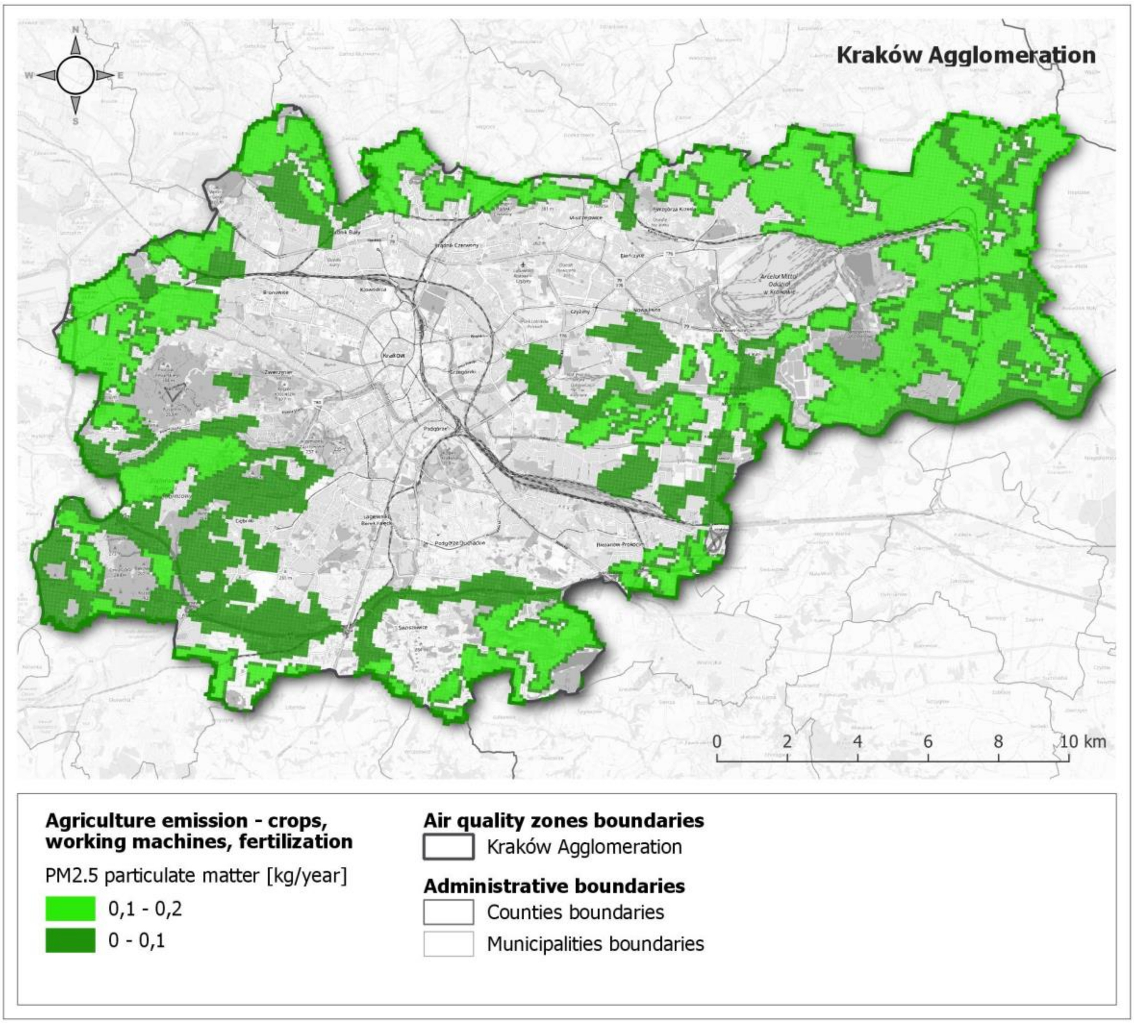


Figure 130. Particulate matter PM2.5 from agricultural emissions (crops, agricultural machinery, fertilizers)[223]

[223] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

Tarnow city zone

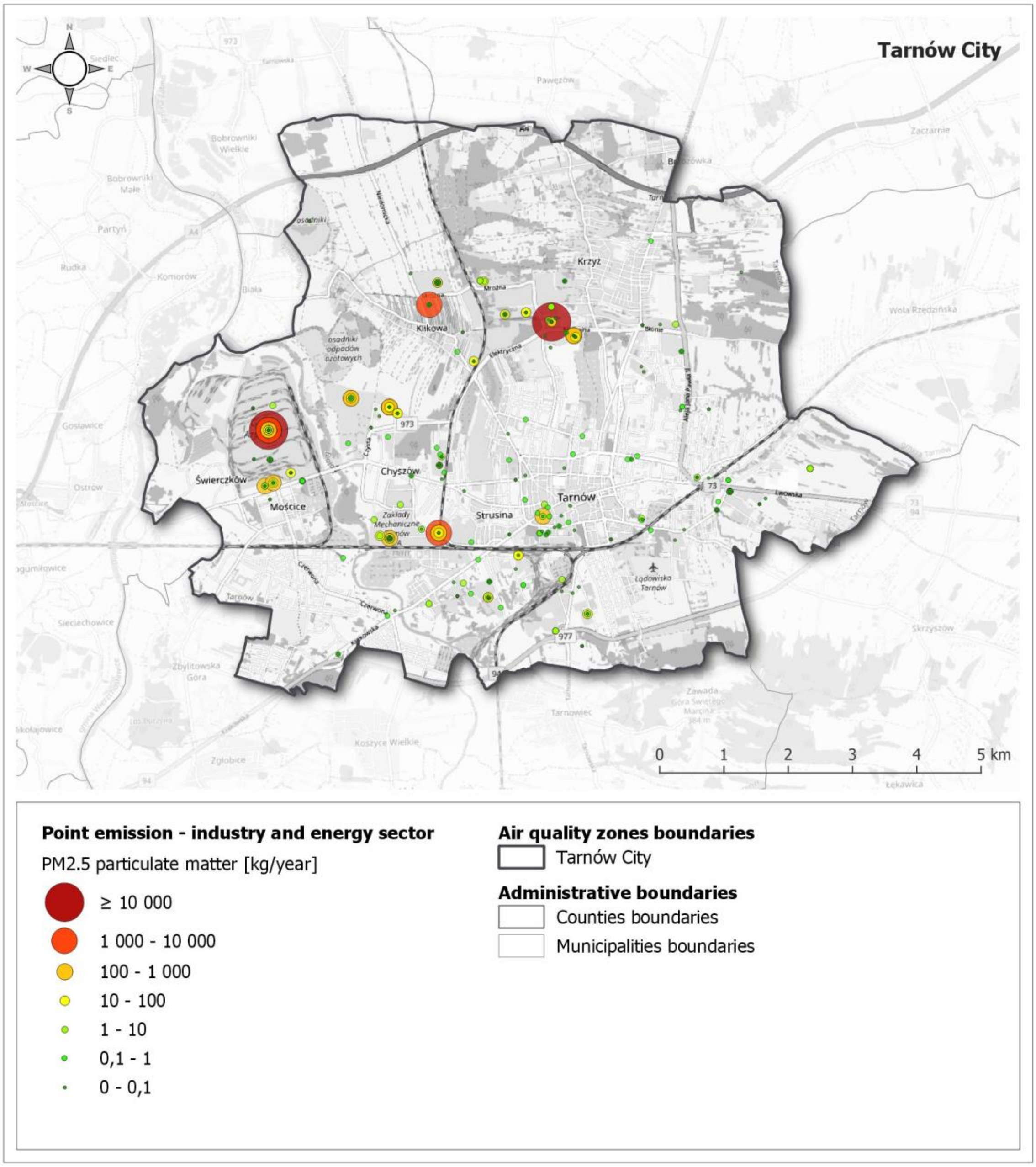


Figure 131. Particulate matter PM2.5 from industrial and energy emissions[224]

[224] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

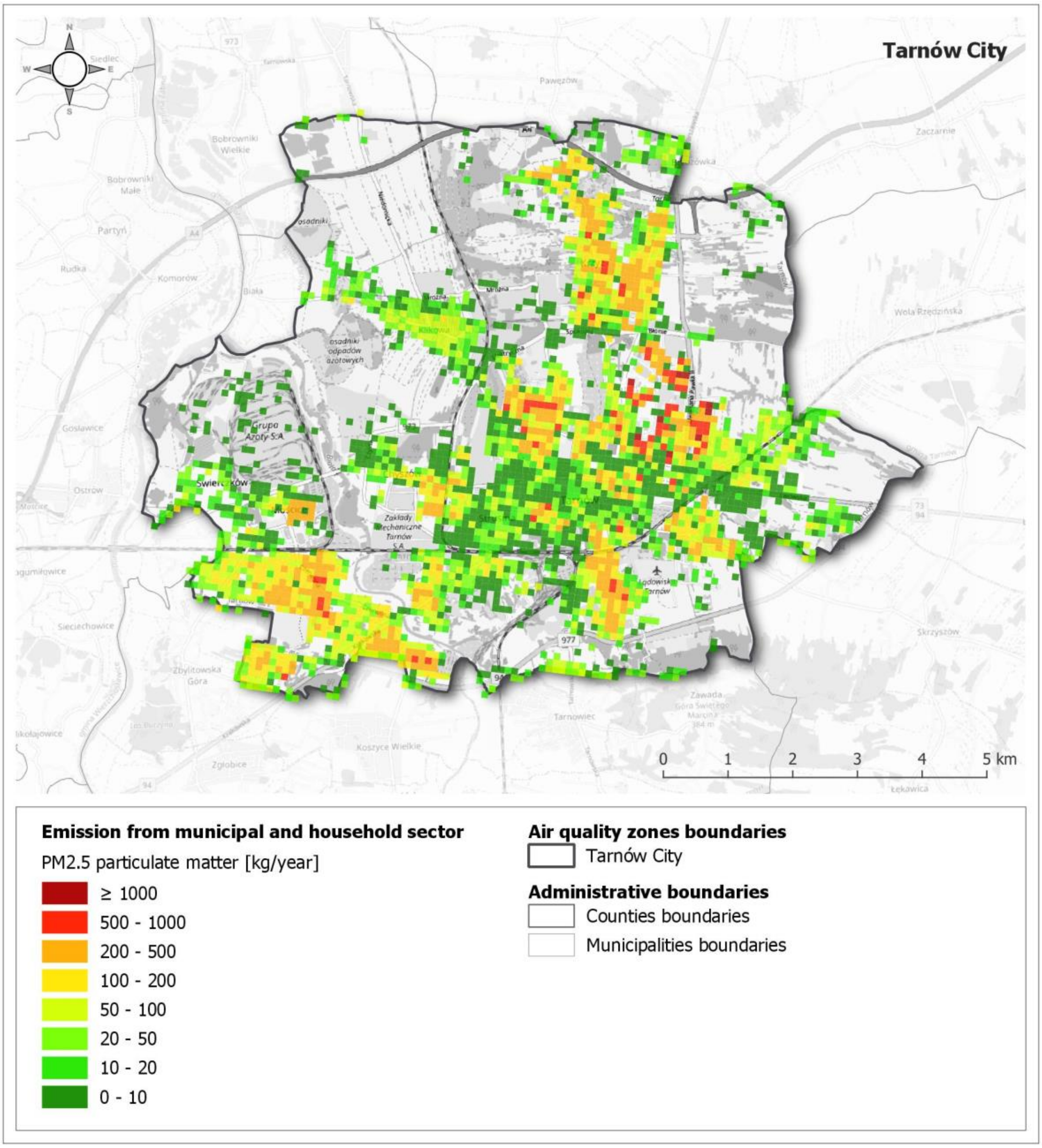


Figure 132. Particulate matter PM2.5 from municipal emissions[225]

[225] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

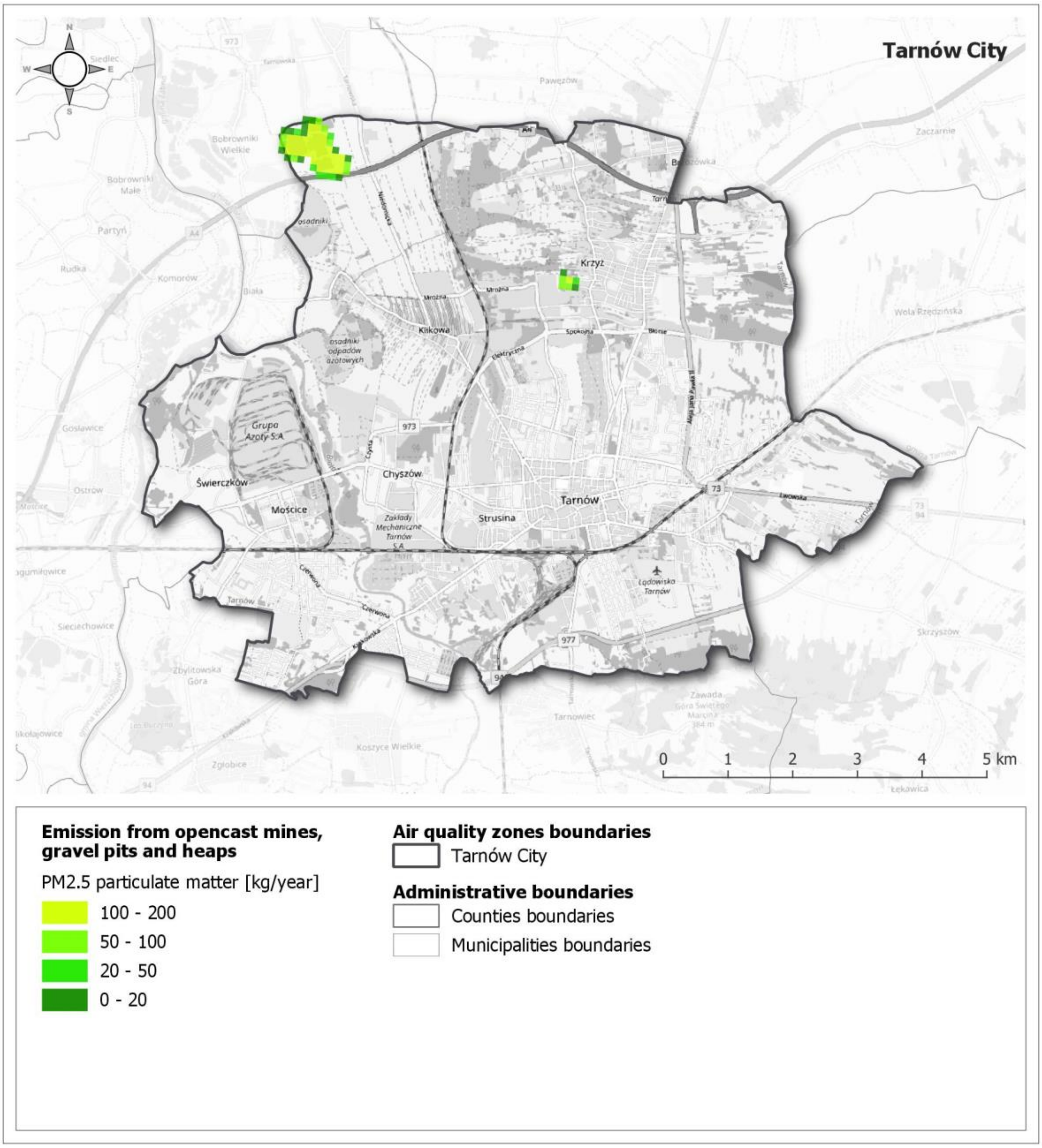


Figure 133. Particulate matter PM2.5 from fugitive emissions (aggregate quarries)[226]

[226] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

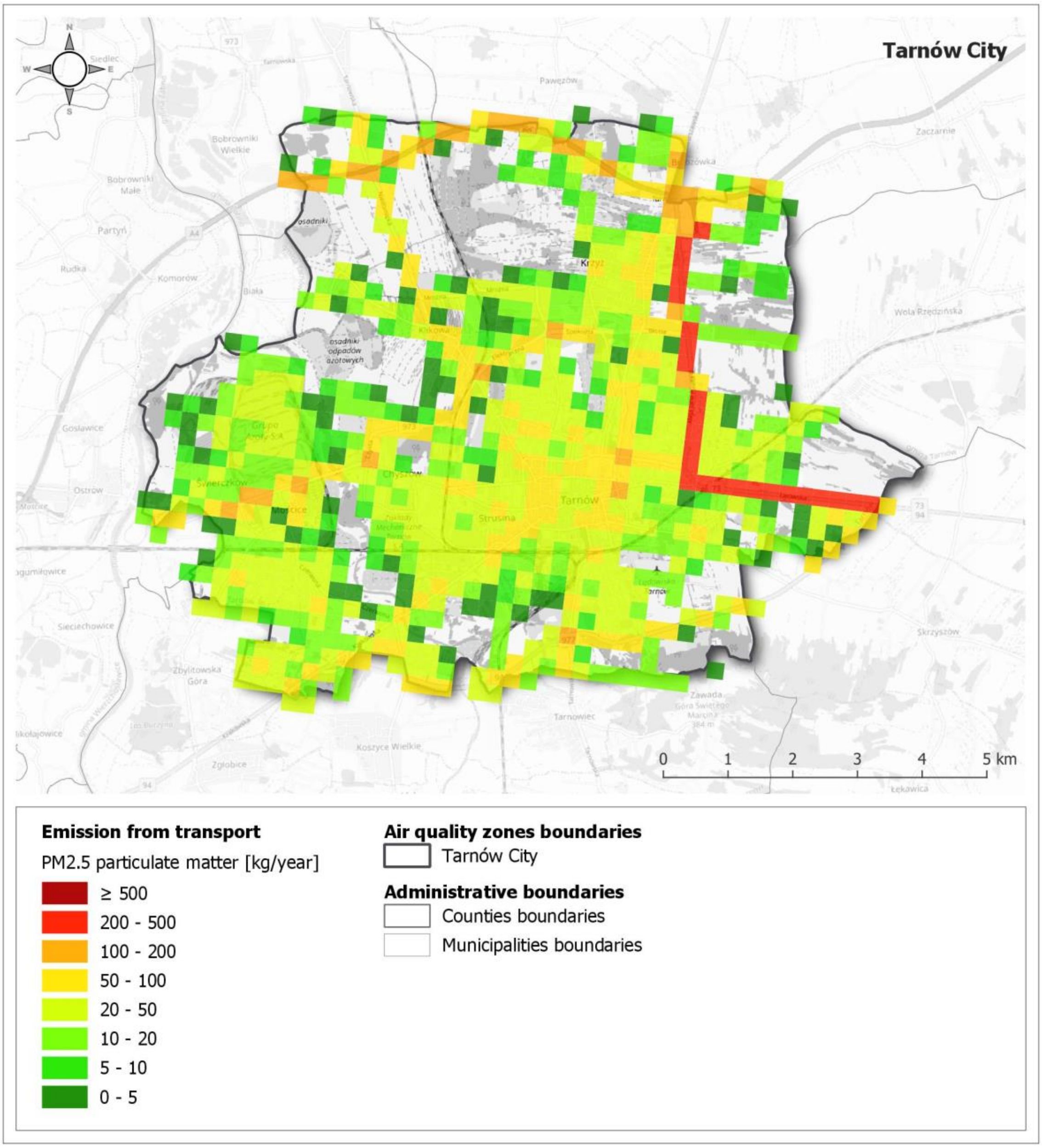


Figure 134. Particulate matter PM2.5 from road transport emissions[227]

[227] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

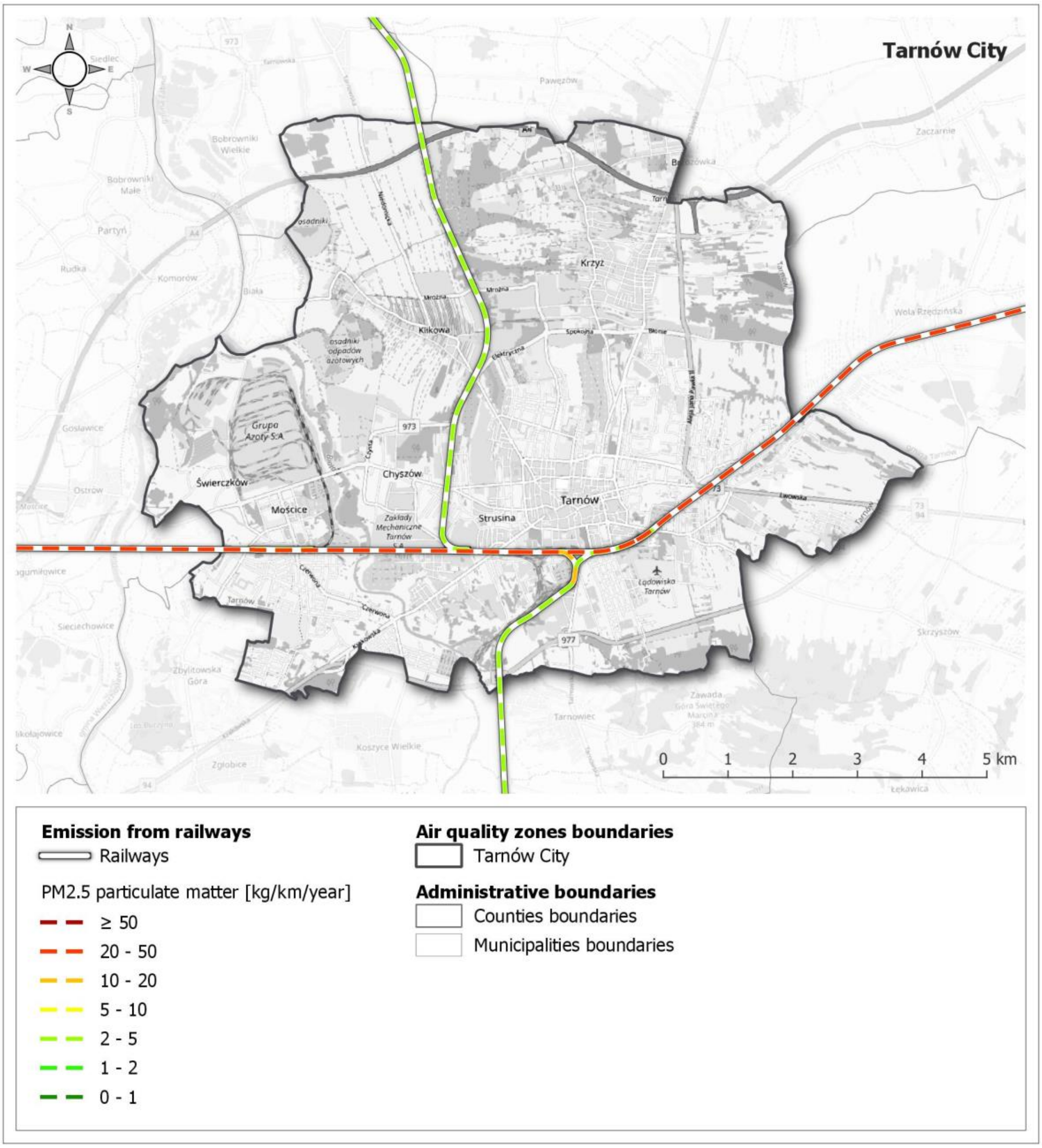


Figure 135. Particulate matter PM2.5 from other emissions (railway)[228]

[228] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

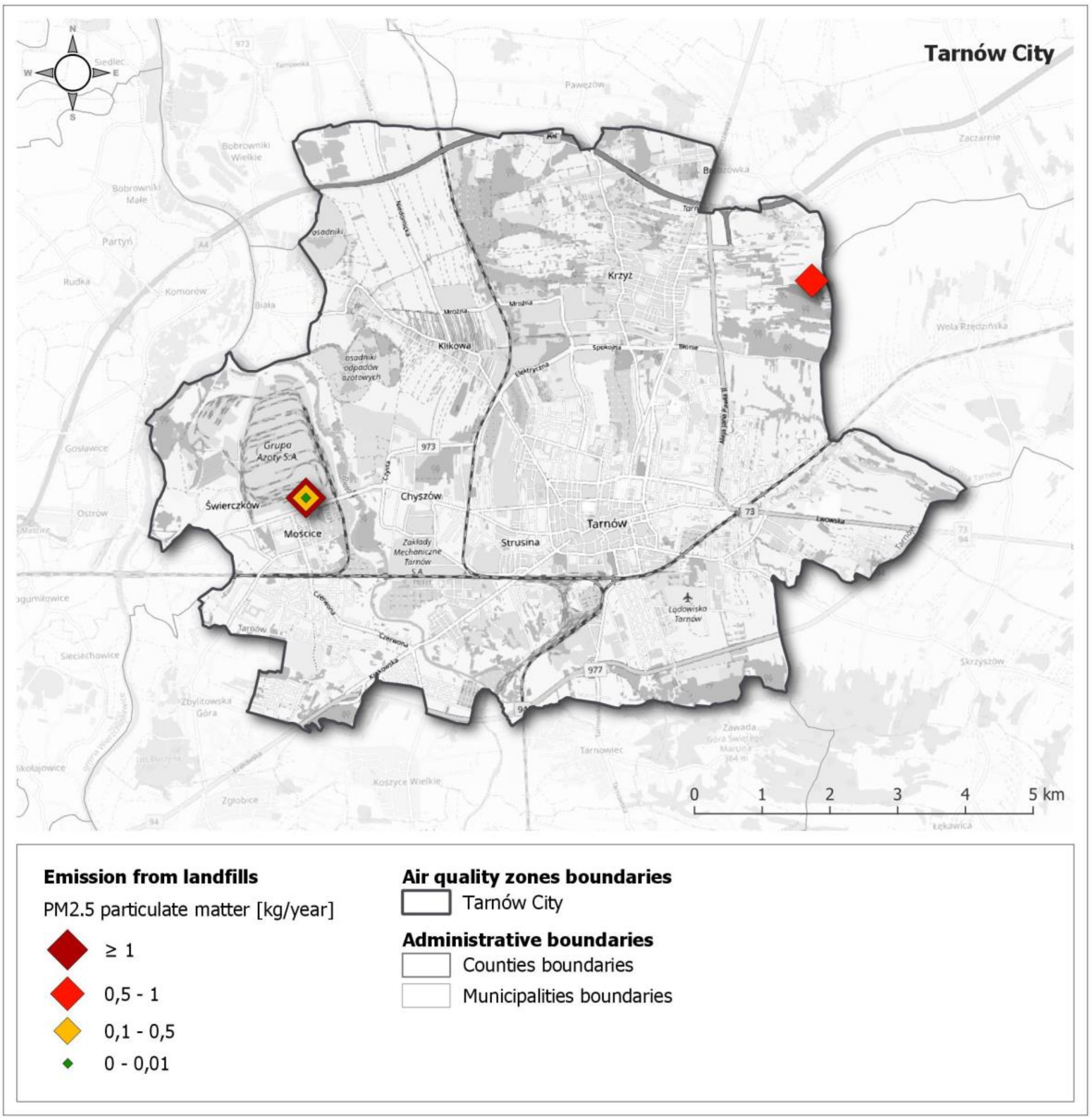


Figure 136. Particulate matter PM2.5 from landfills emissions[229]

[229] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

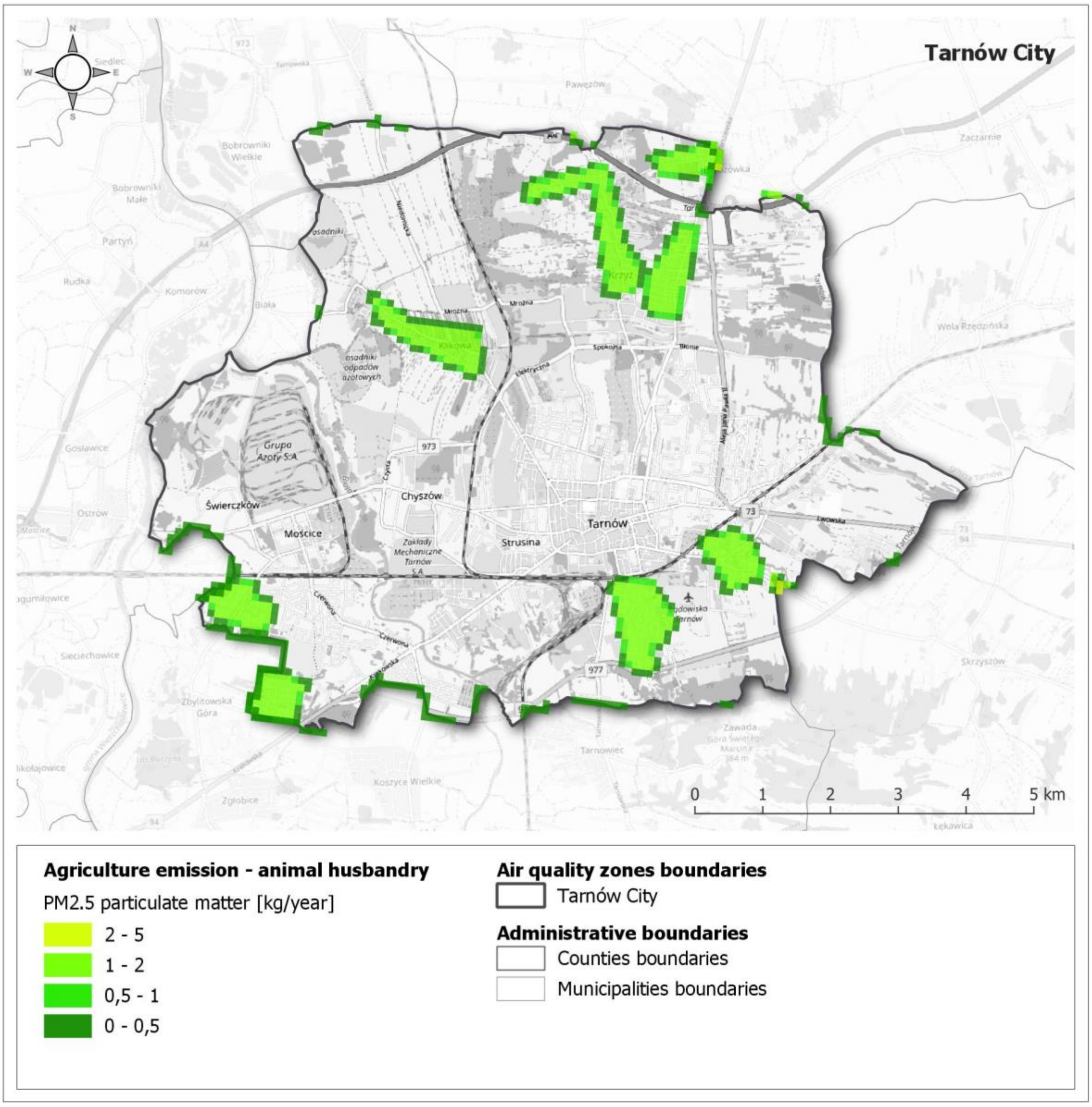


Figure 137. Particulate matter PM2.5 from agricultural emissions (animals' breeding)[230]

[230] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

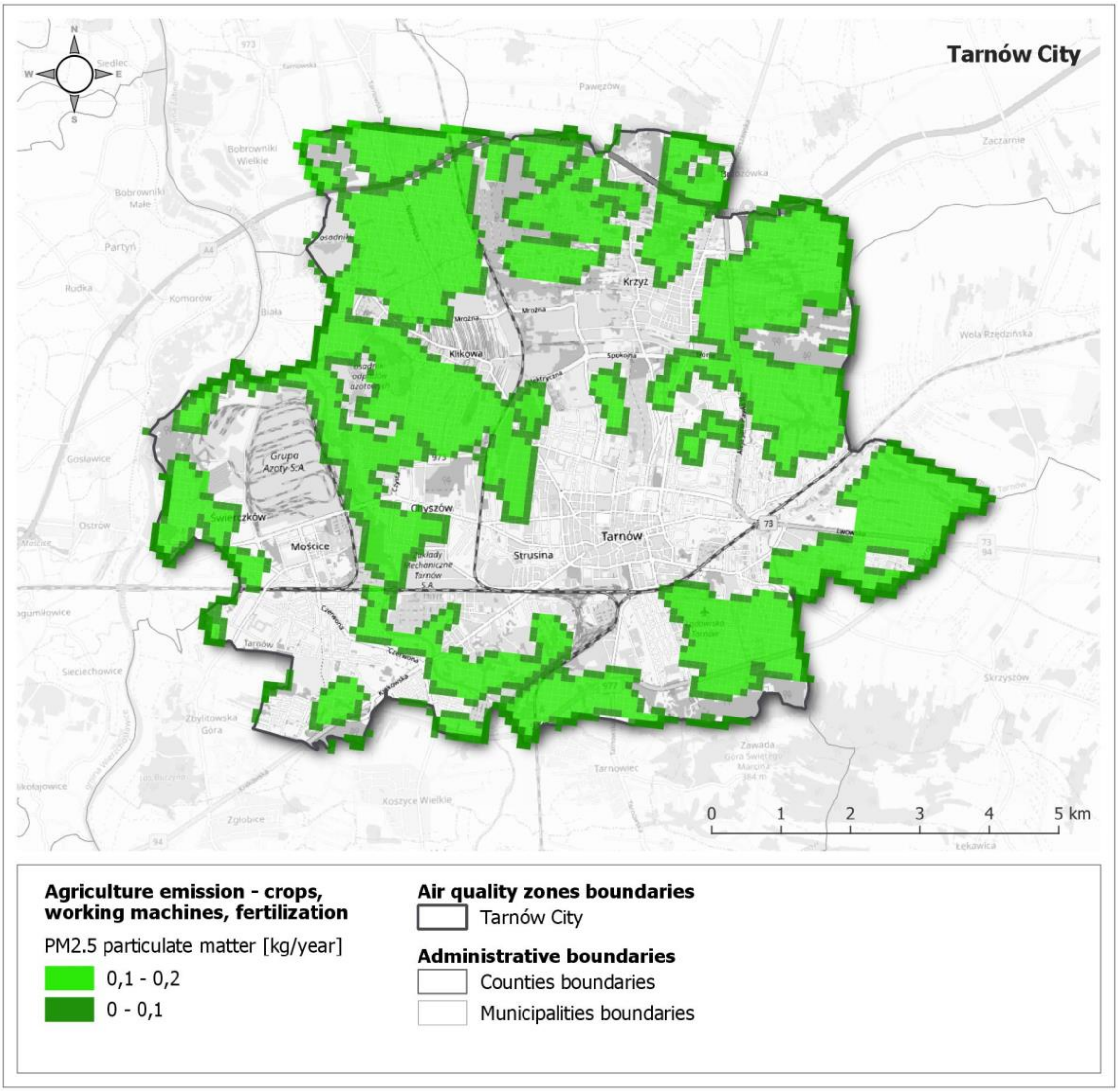


Figure 138. Particulate matter PM2.5 from agricultural emissions (crops, agricultural machinery, fertilizers)[231]

[231] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

Malopolska zone

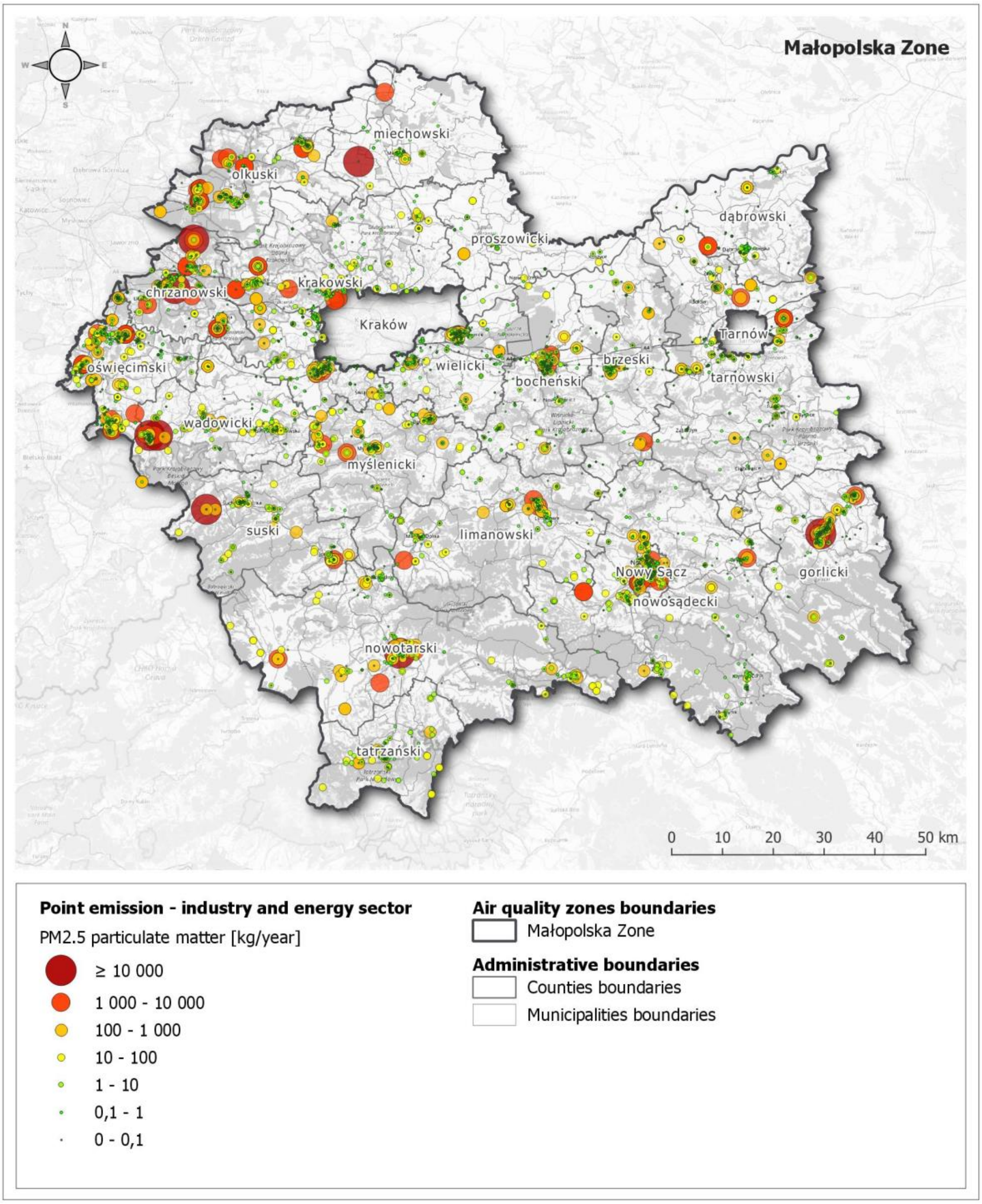


Figure 139. Particulate matter PM2.5 from industrial and energy emissions[232]

[232] Source: Prepared by Atmoterm S.A. based on the data of the Central Issue Base KOBIZE 2018

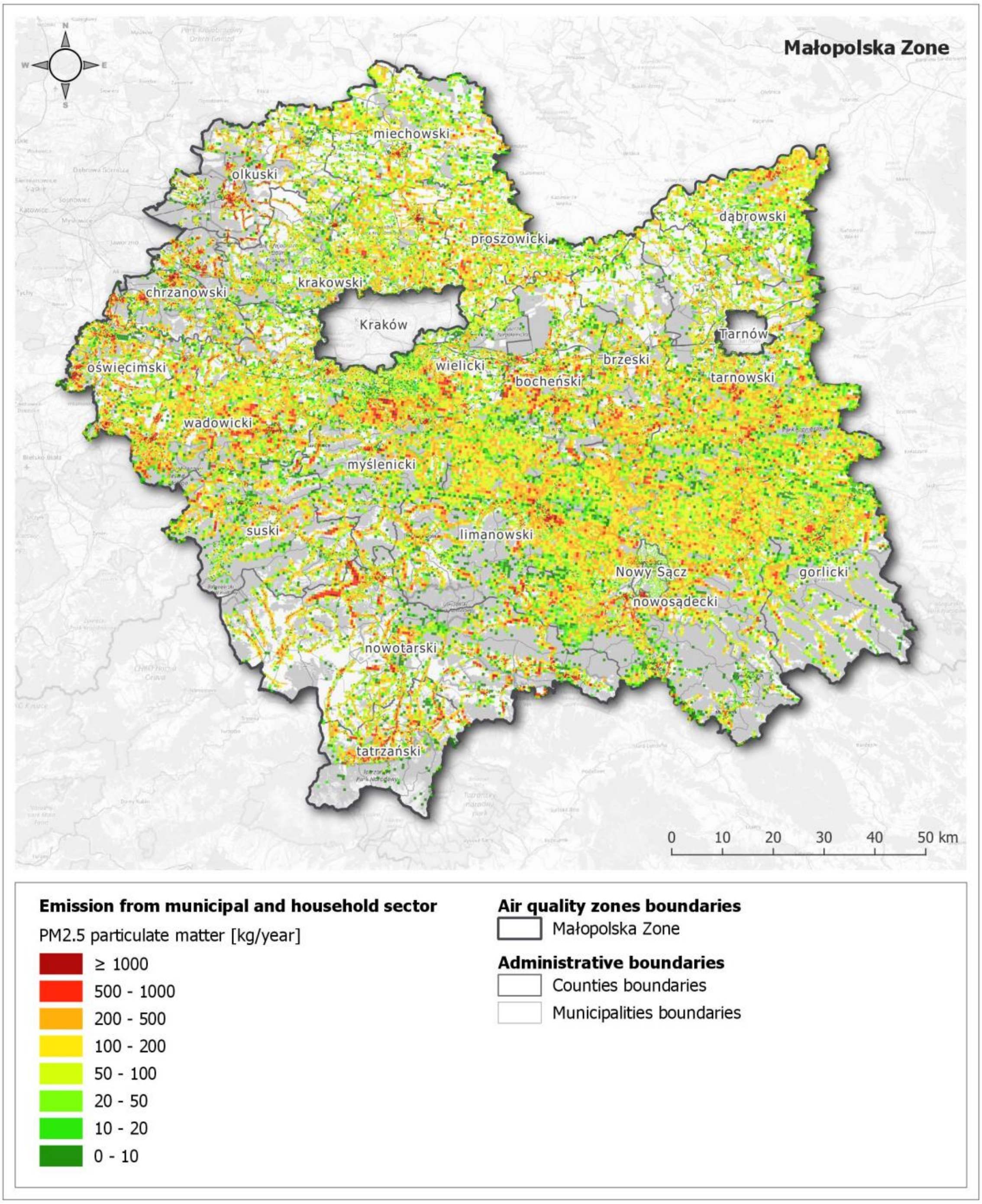


Figure 140. Particulate matter PM2.5 from municipal emissions[233]

[233] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

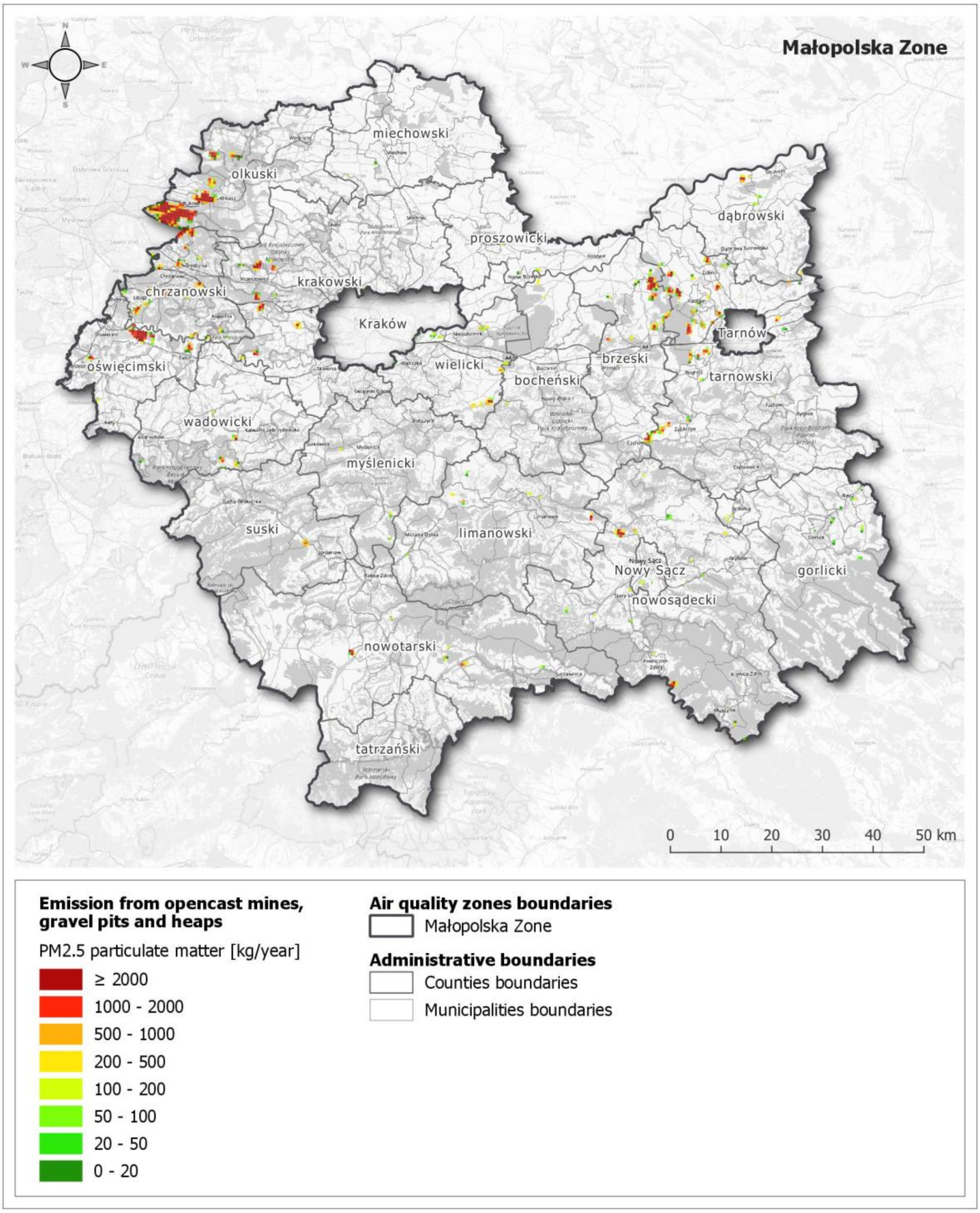


Figure 141. Particulate matter PM2.5 from fugitive emissions (aggregate quarries)[234]

[234] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

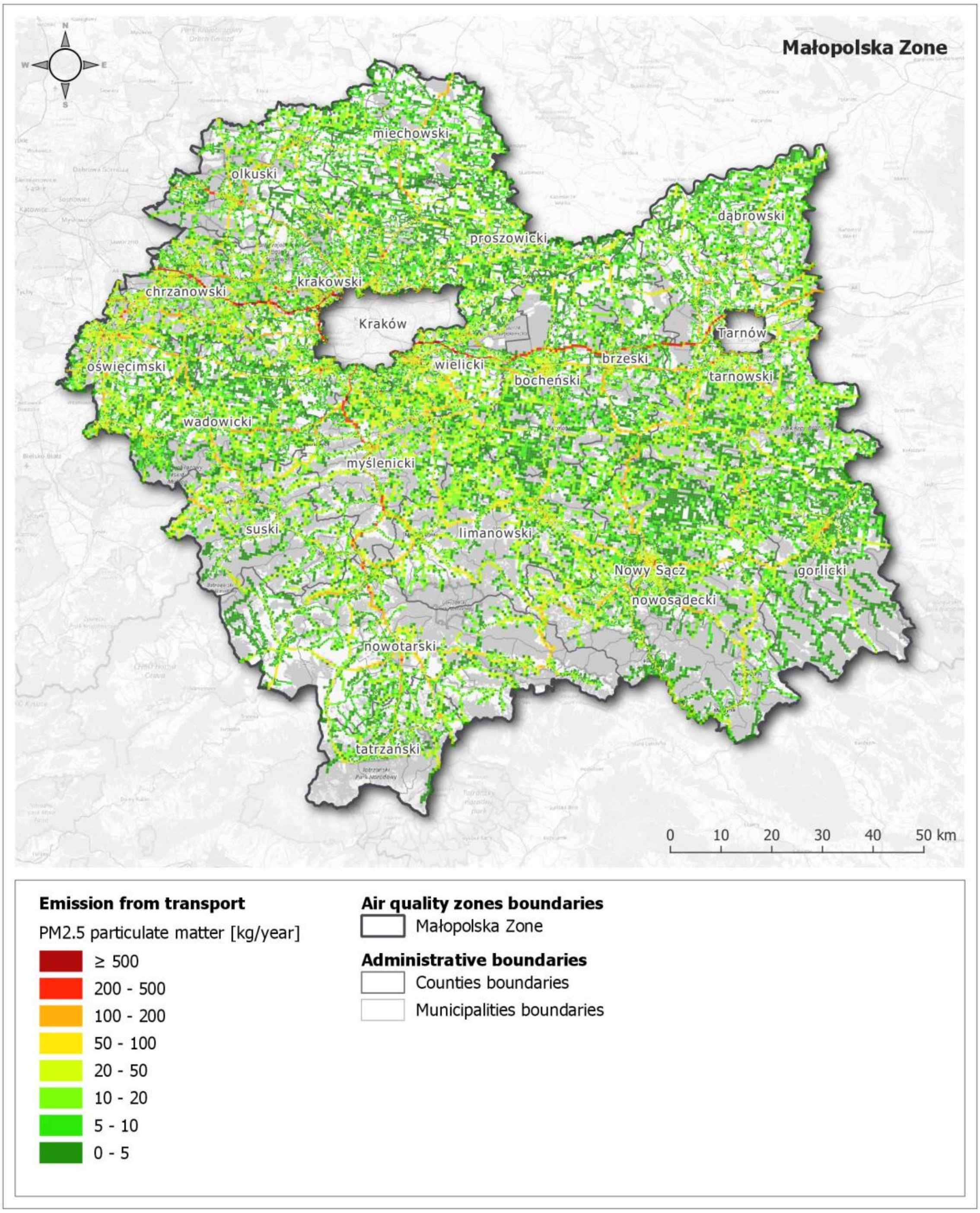


Figure 142. Particulate matter PM2.5 from road transport emissions[235]

[235] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

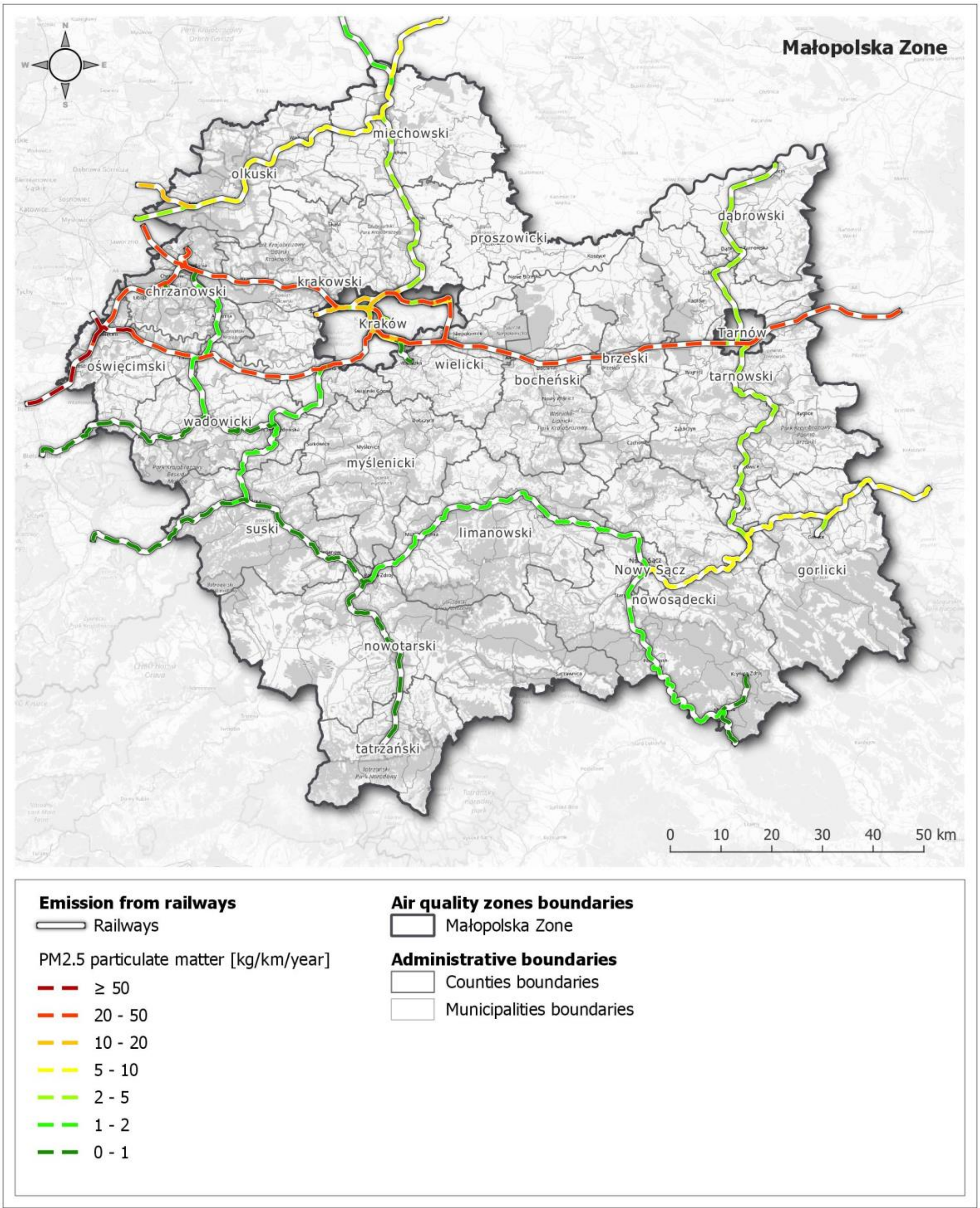


Figure 143. Particulate matter PM2.5 from other emissions (railway)[236]

[236] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

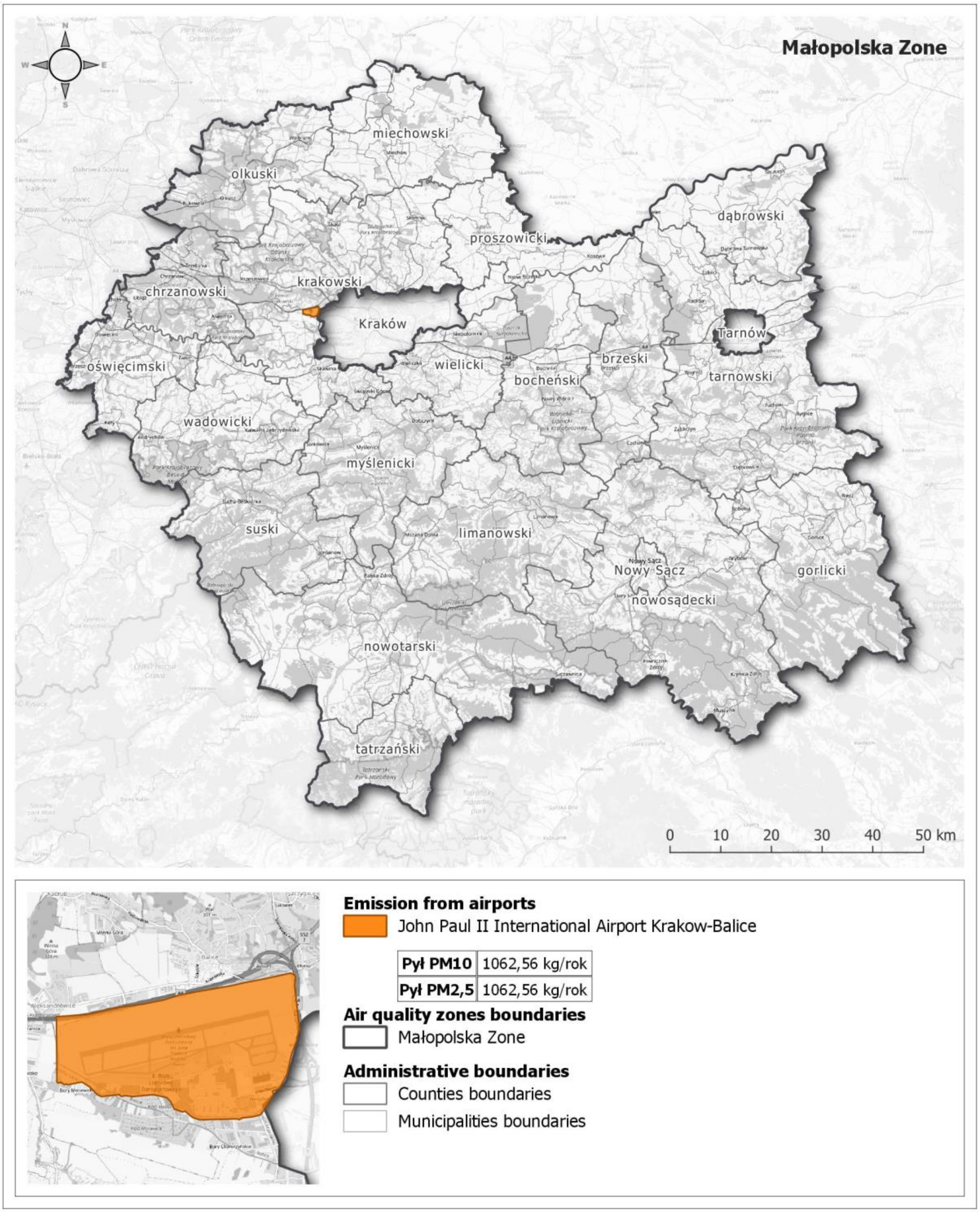


Figure 144. Particulate matter PM2.5 and PM from other sources (airports)[237]

[237] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

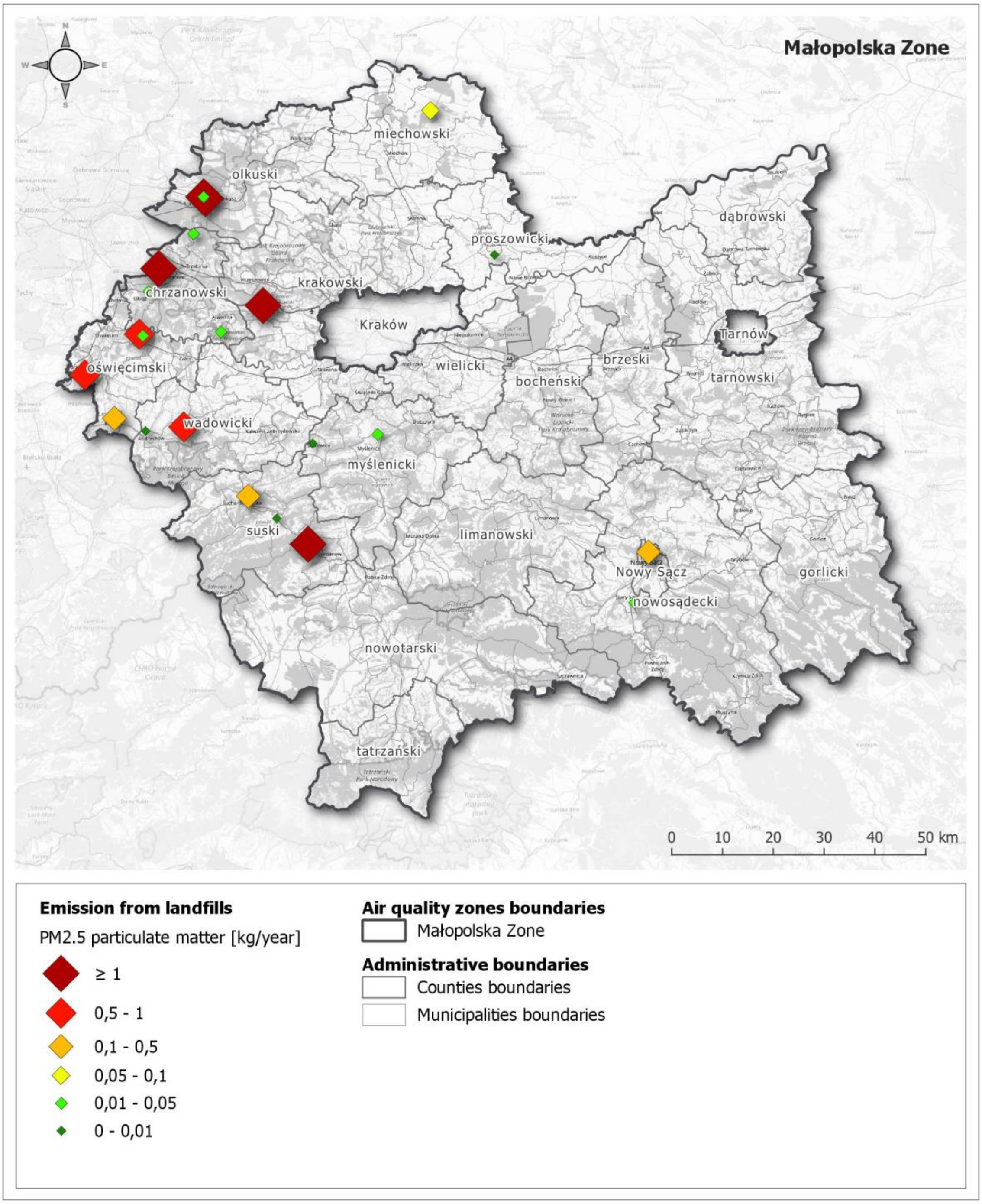


Figure 145. Particulate matter PM2.5 from landfills emissions[238]

[238] Source: Prepared by Atmoterm S.A. based on the data of the Central Issue Base KOBIZE 2018

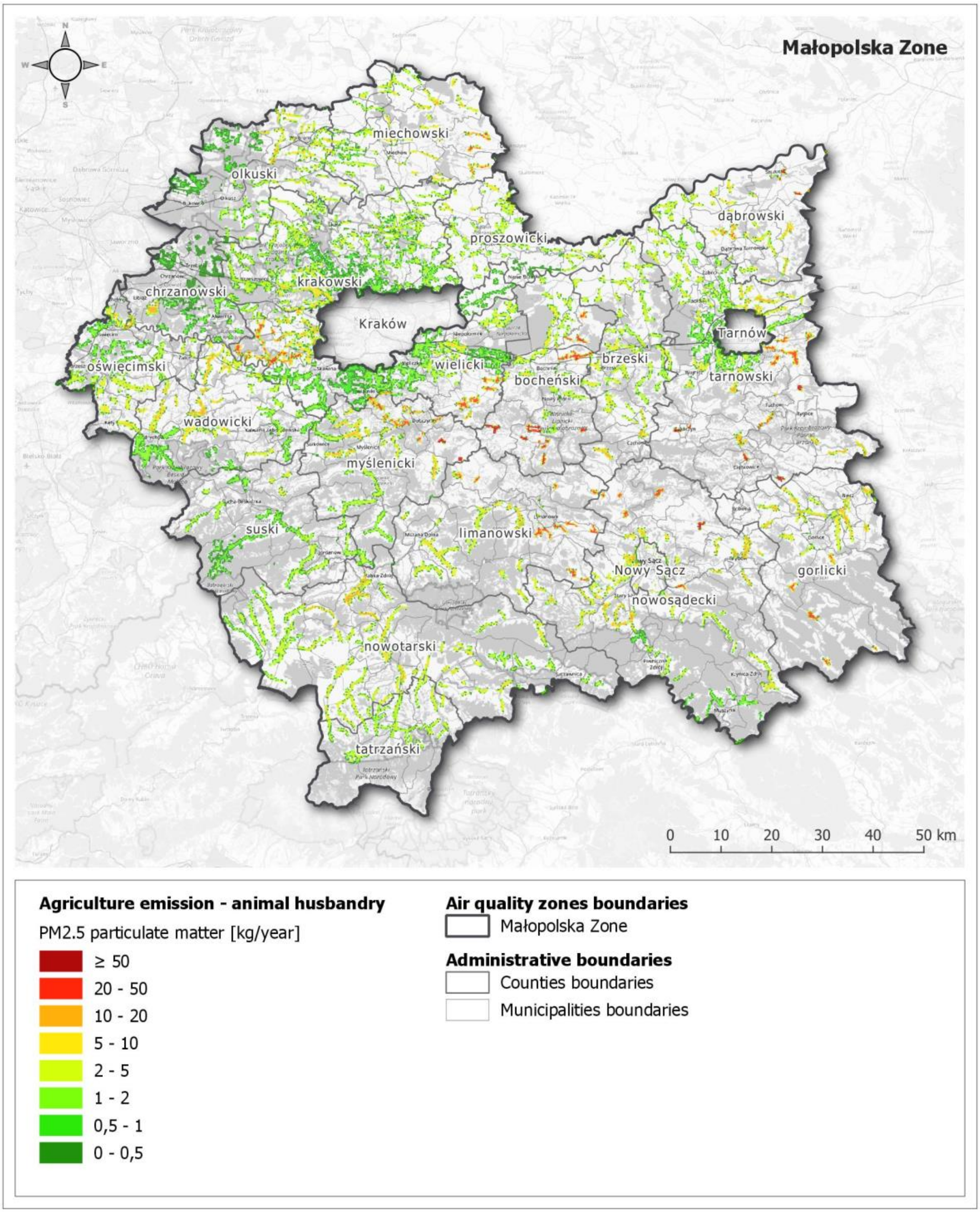


Figure 146. Particulate matter PM2.5 from agricultural emissions (animals' breeding)[239]

[239] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

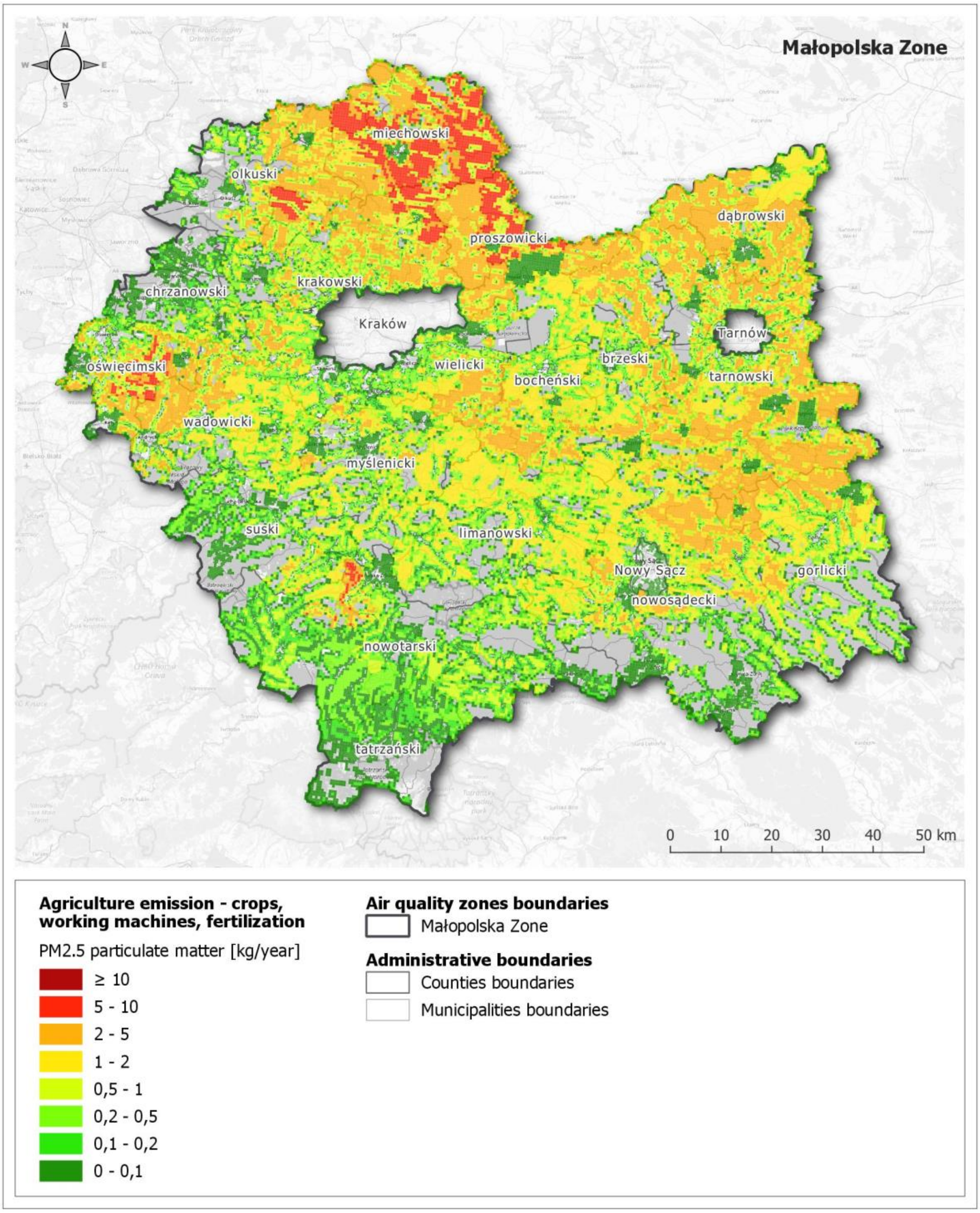


Figure 147. Particulate matter PM2.5 from agricultural emissions (crops, agricultural machinery, fertilizers)[240]

[240] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

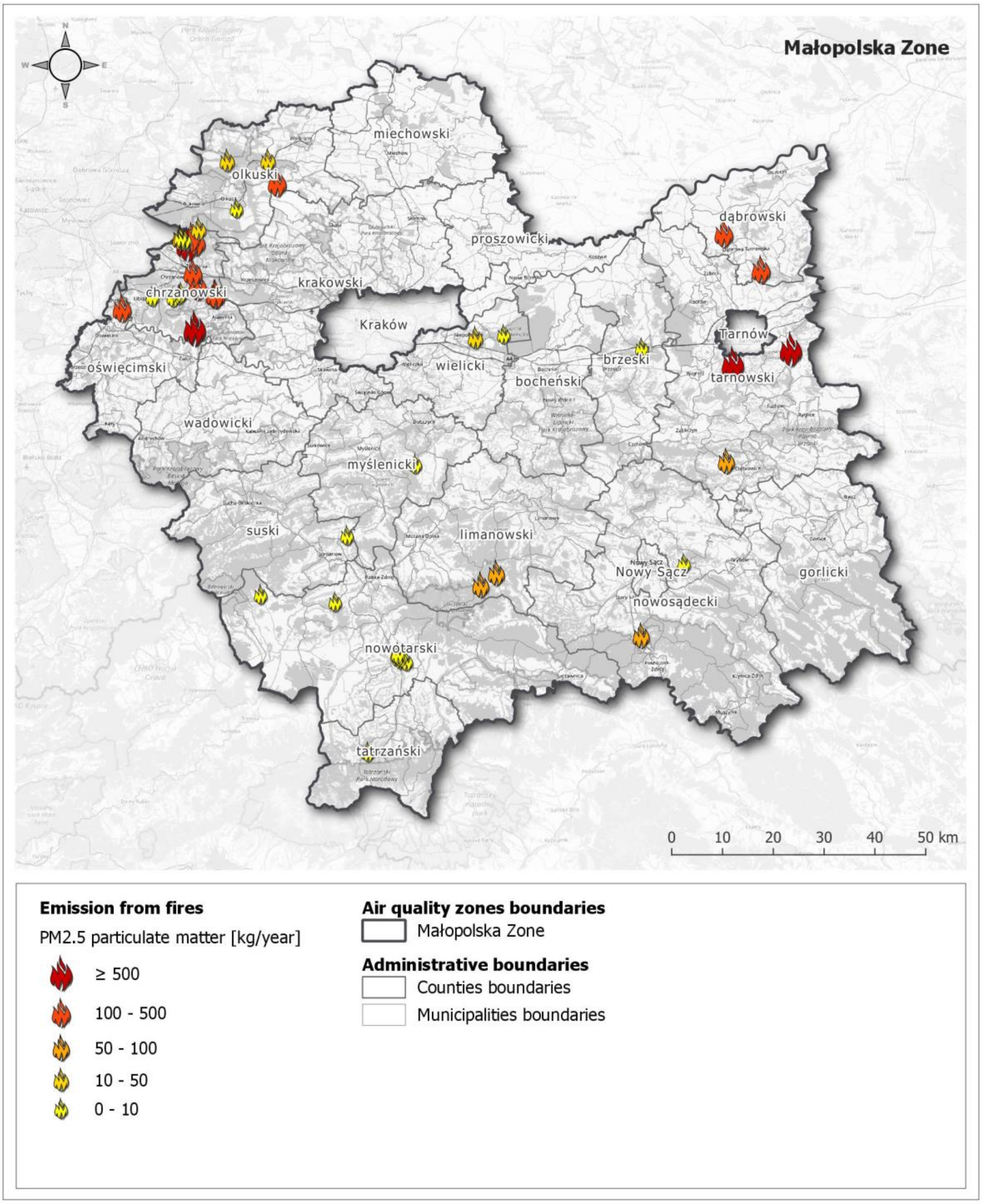


Figure 148. Particulate matter PM2.5 from fires emissions[241]

[241] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

18.2.3. BENZO(A)PYRENE EMISSION SOURCES

Krakow Agglomeration zone

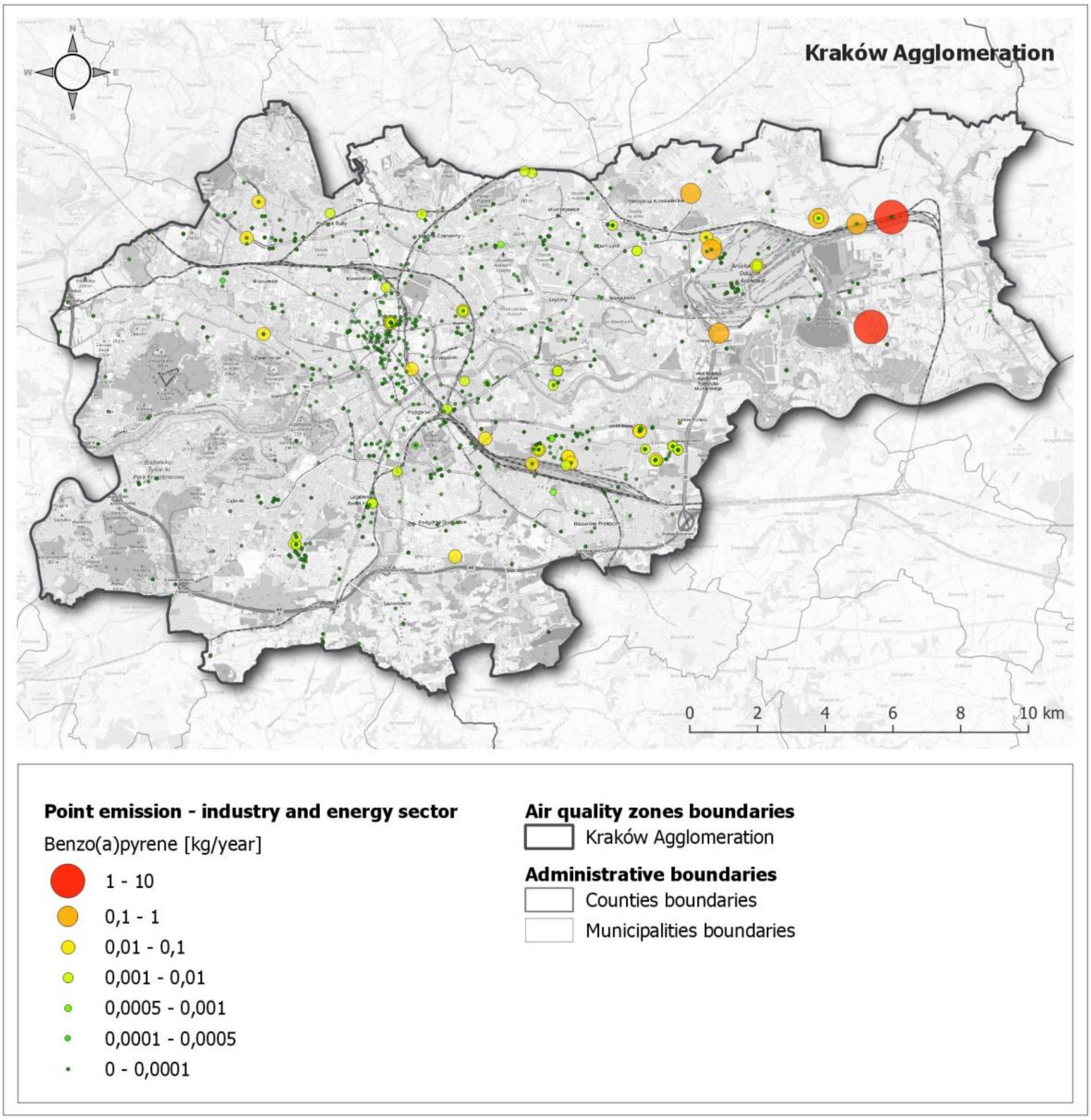


Figure 149. Benzo(a)pyrene from industrial and energy emissions [242]

[242] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

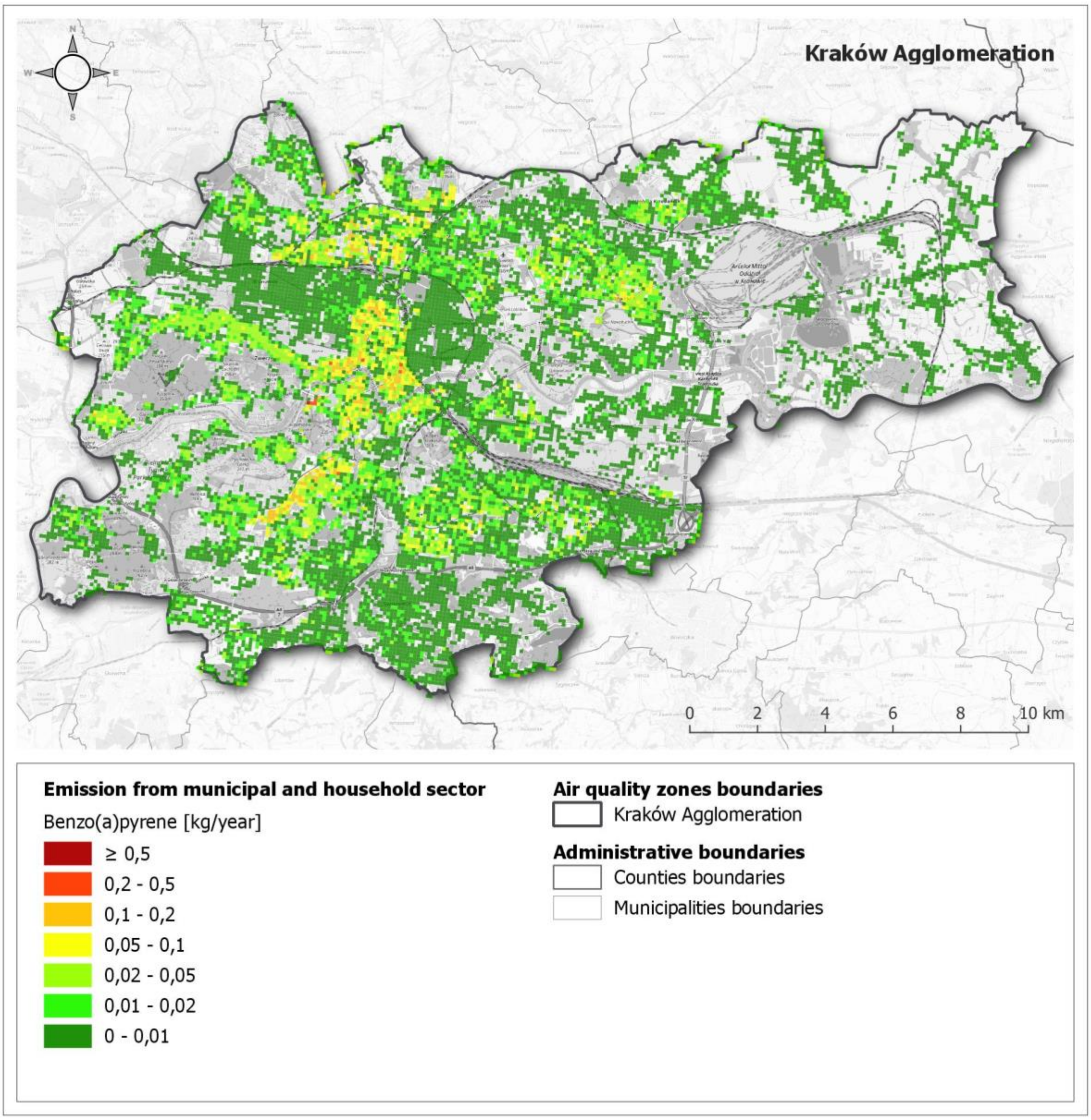


Figure 150. Benzo(a)pyrene from municipal emissions [243]

[243] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

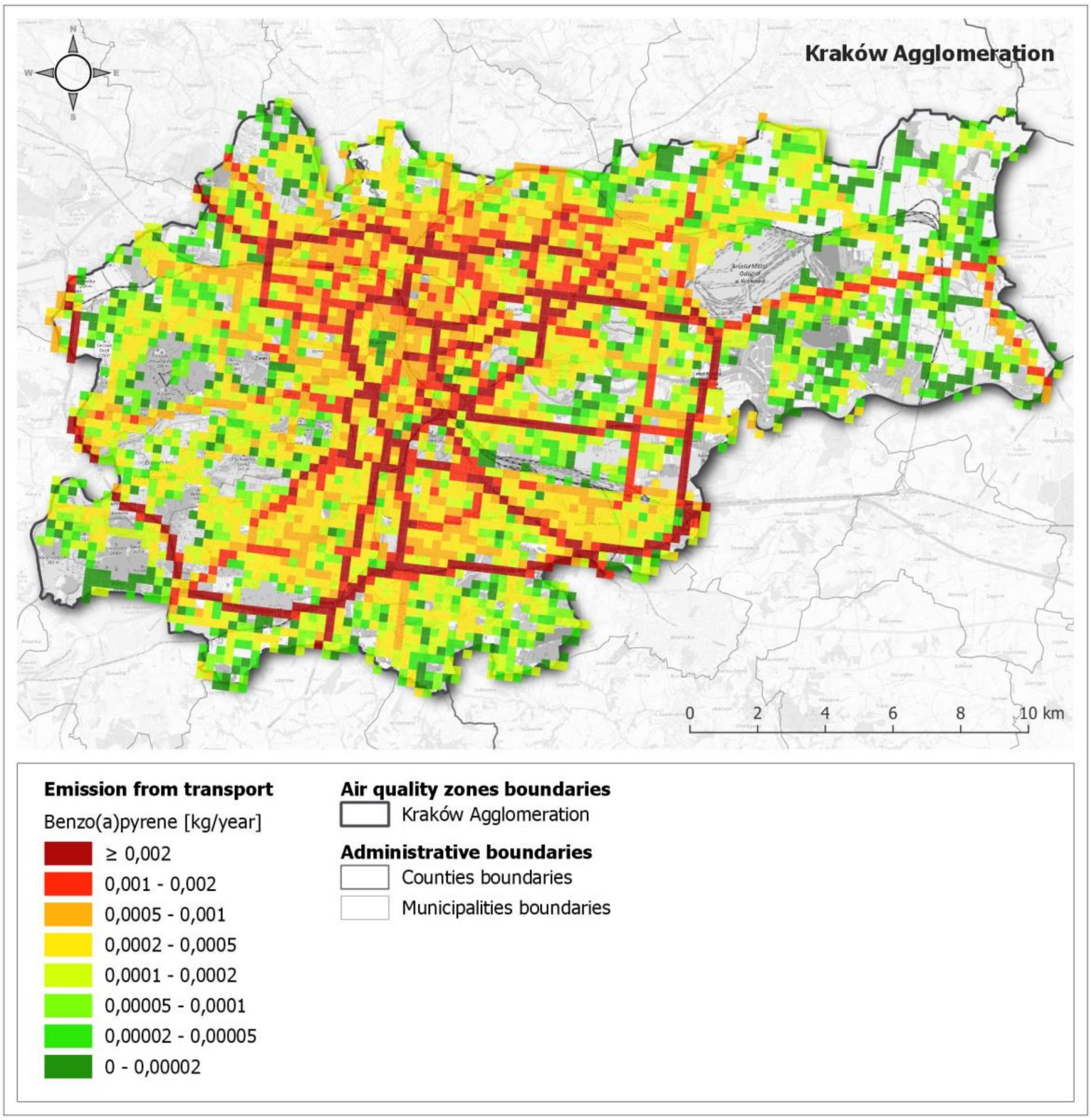


Figure 151. Benzo(a)pyrene from road transport emissions [244]

[244] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

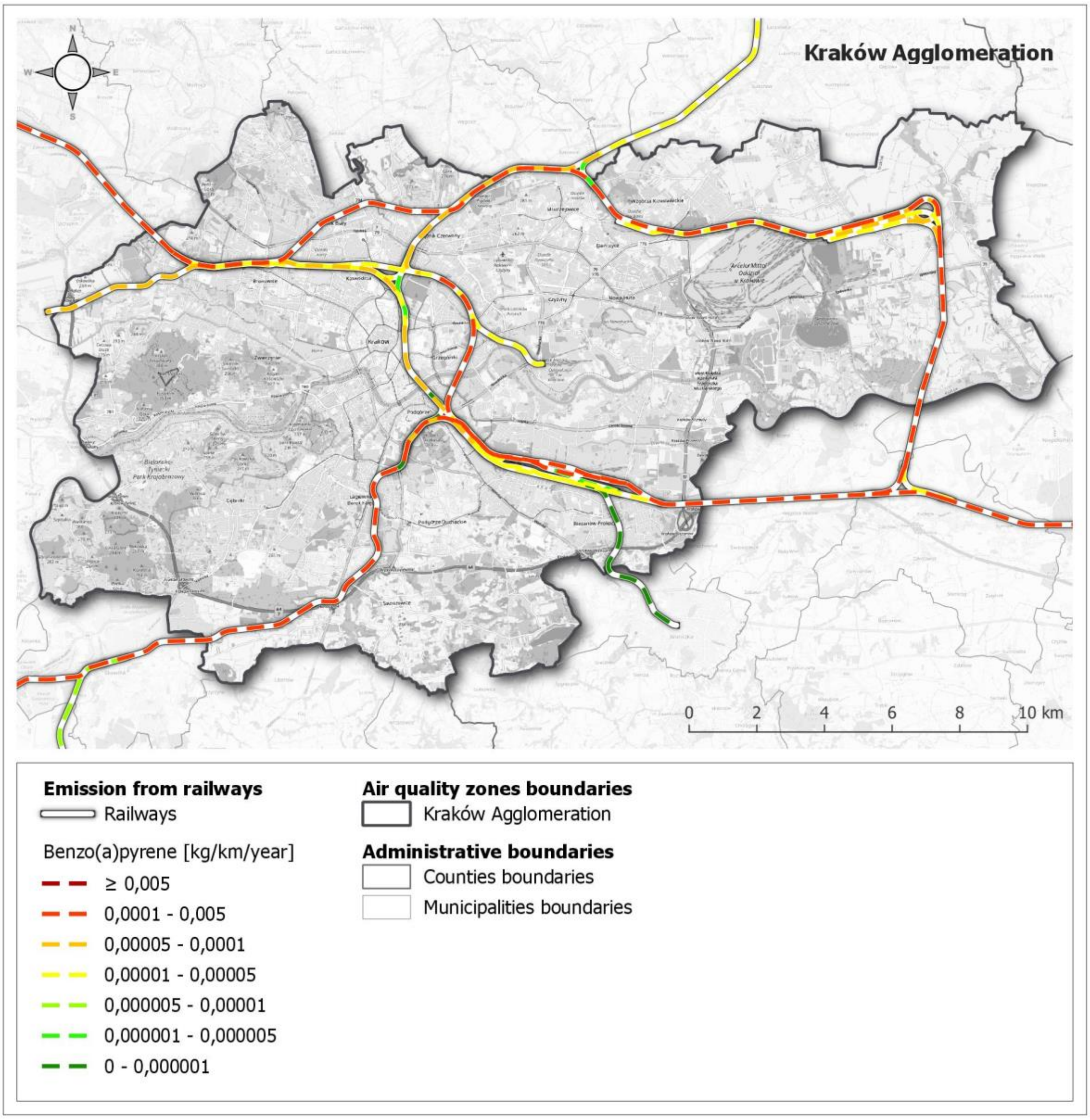


Figure 152. Benzo(a)pyrene from other emissions (railway)[245]

[245] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

Tarnow city zone

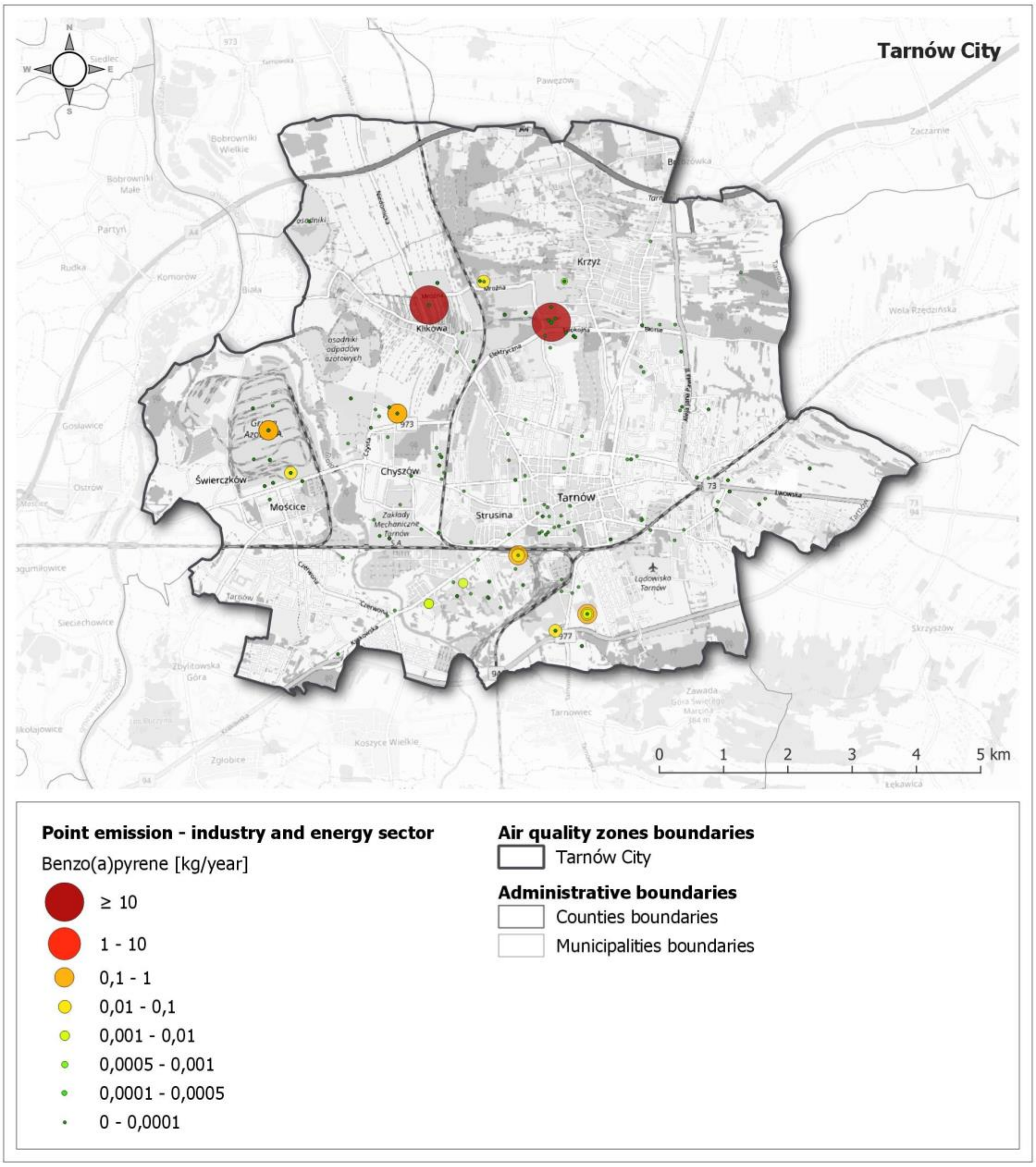


Figure 153. Benzo(a)pyrene from industrial and energy emissions [246]

[246] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

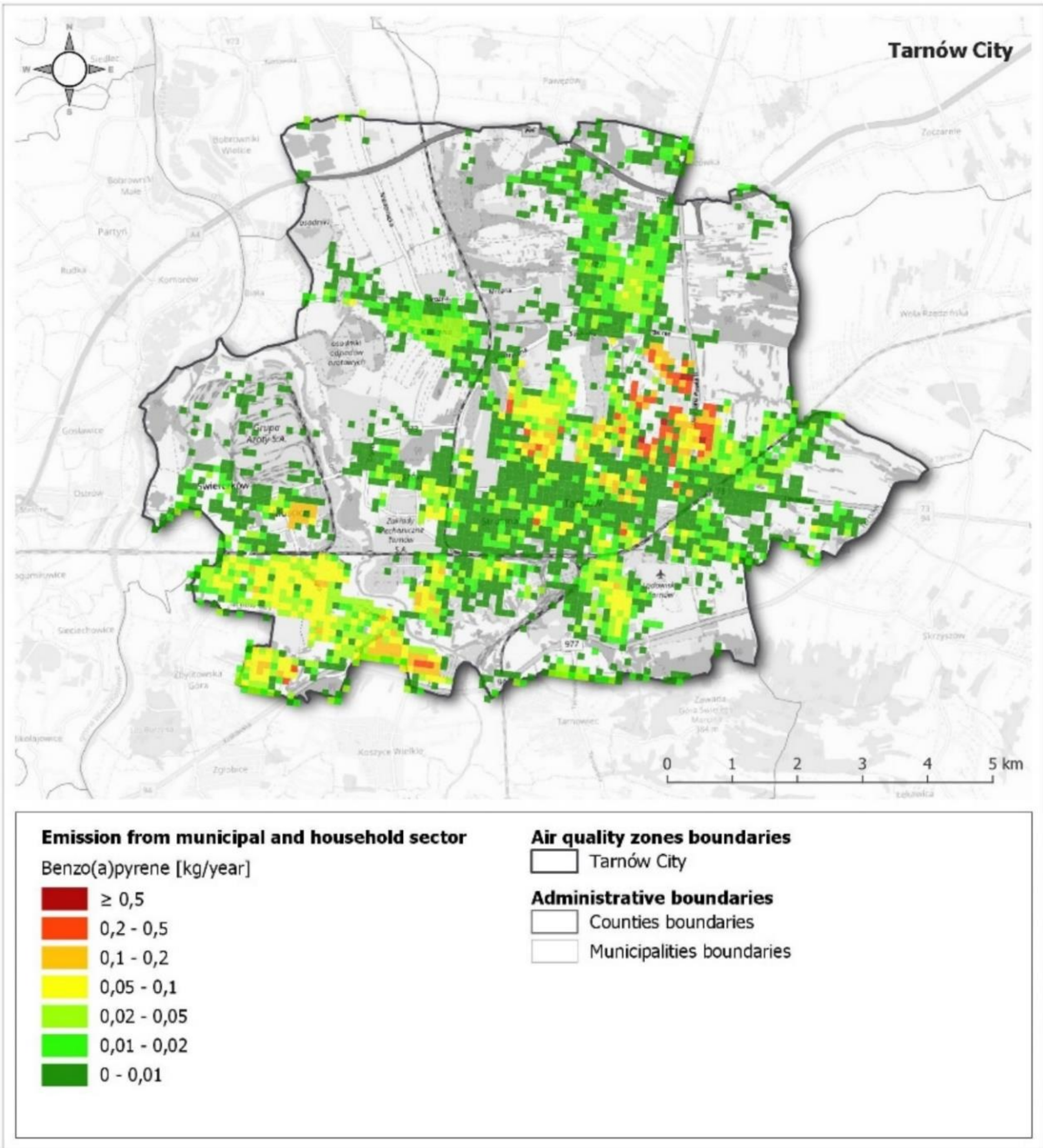


Figure 154. Benzo(a)pyrene from municipal emissions [247]

[247] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

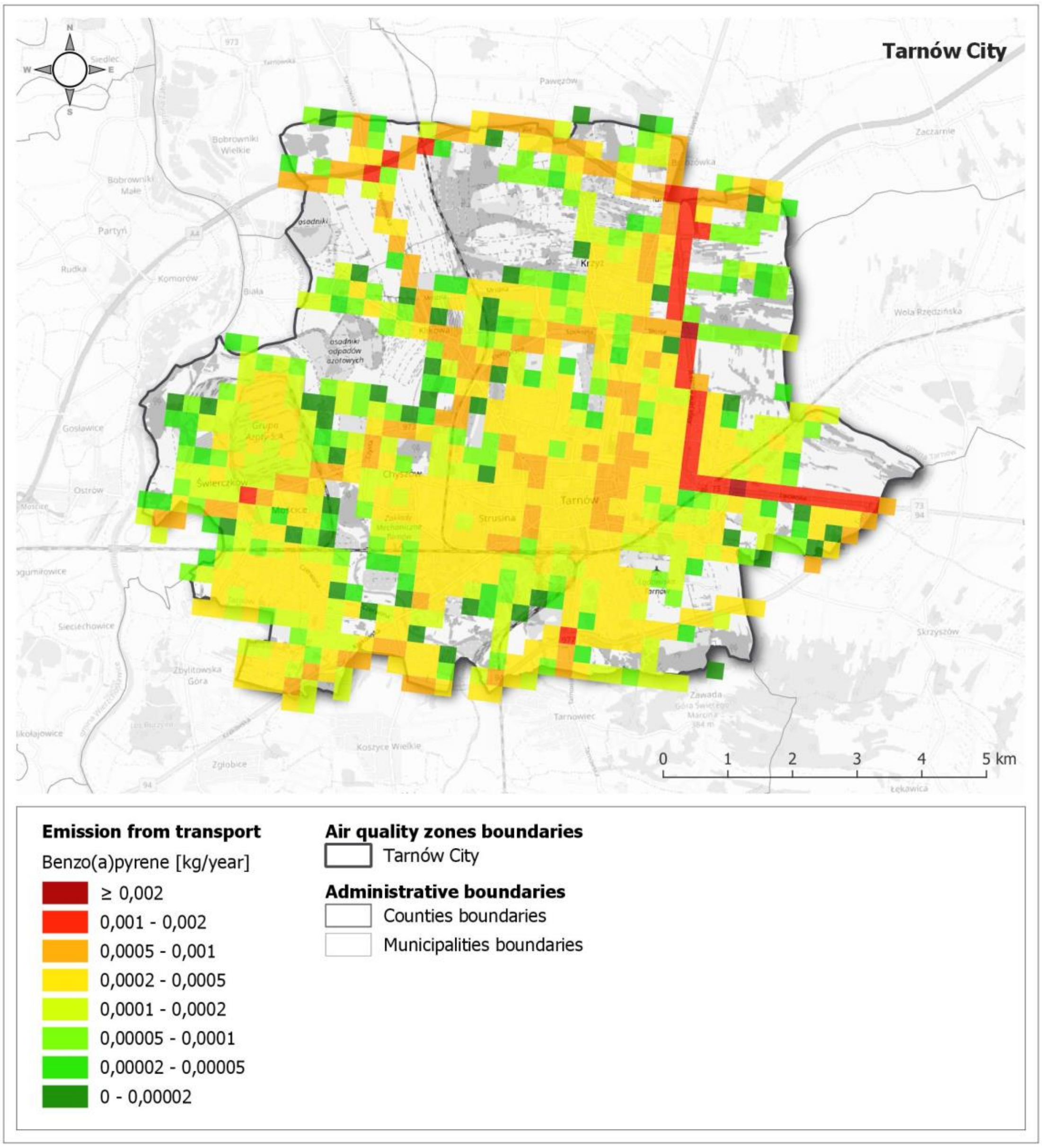


Figure 155. Benzo(a)pyrene from road transport emissions [248]

[248] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

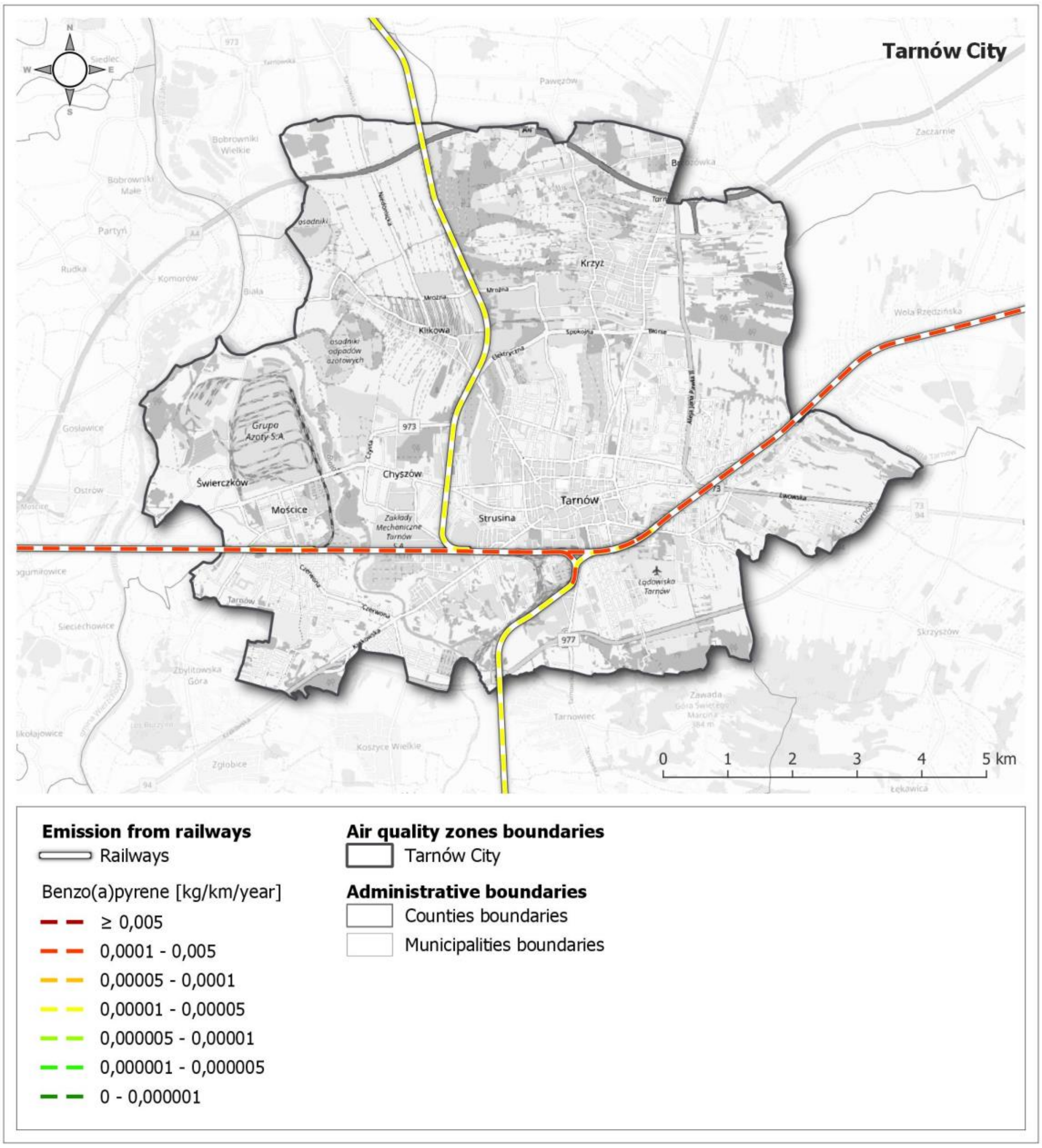


Figure 156. Benzo(a)pyrene from other emissions (railway)[249]

[249] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

Malopolska zone

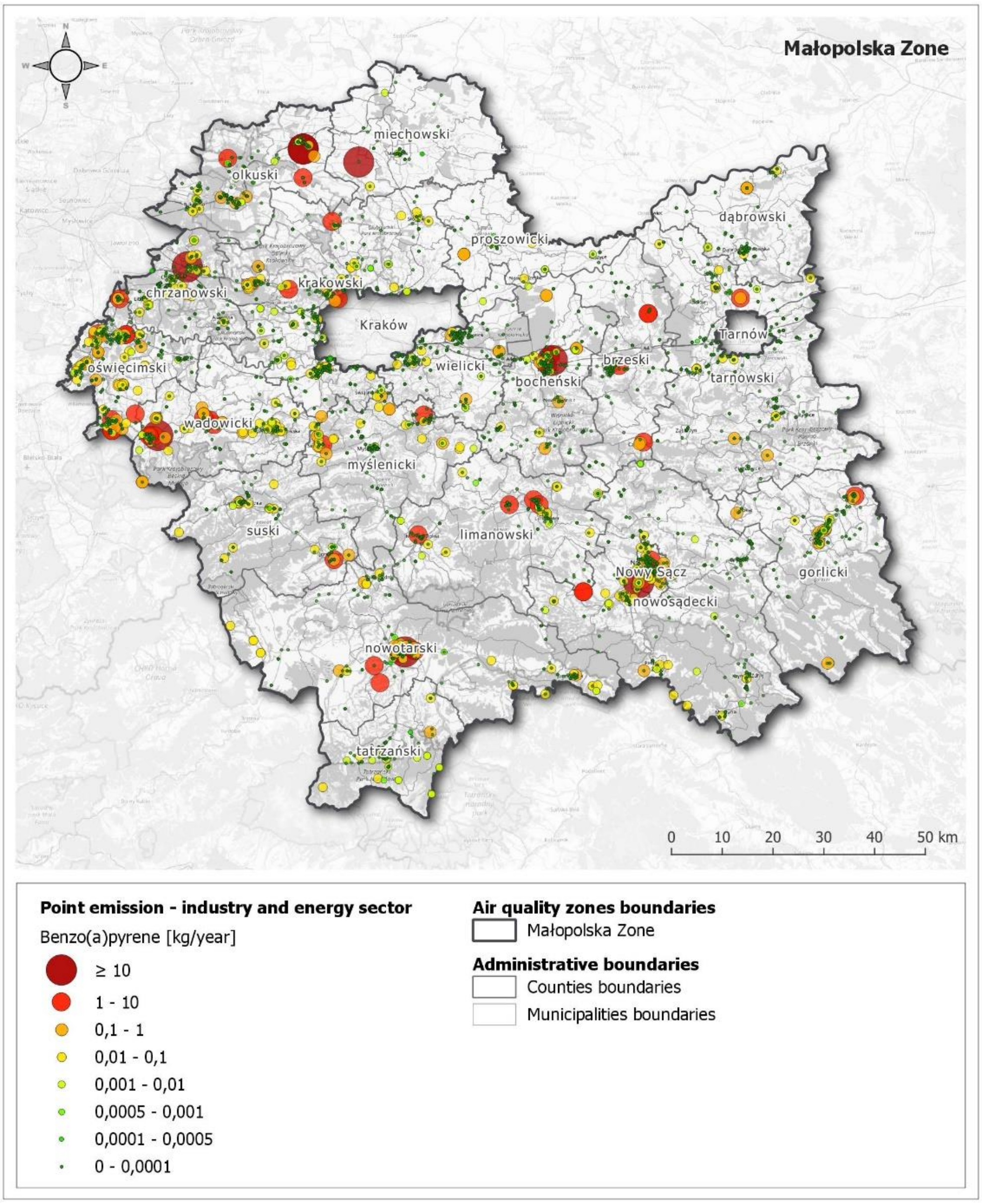


Figure 157. Benzo(a)pyrene from industrial and energy emissions [250]

[250] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

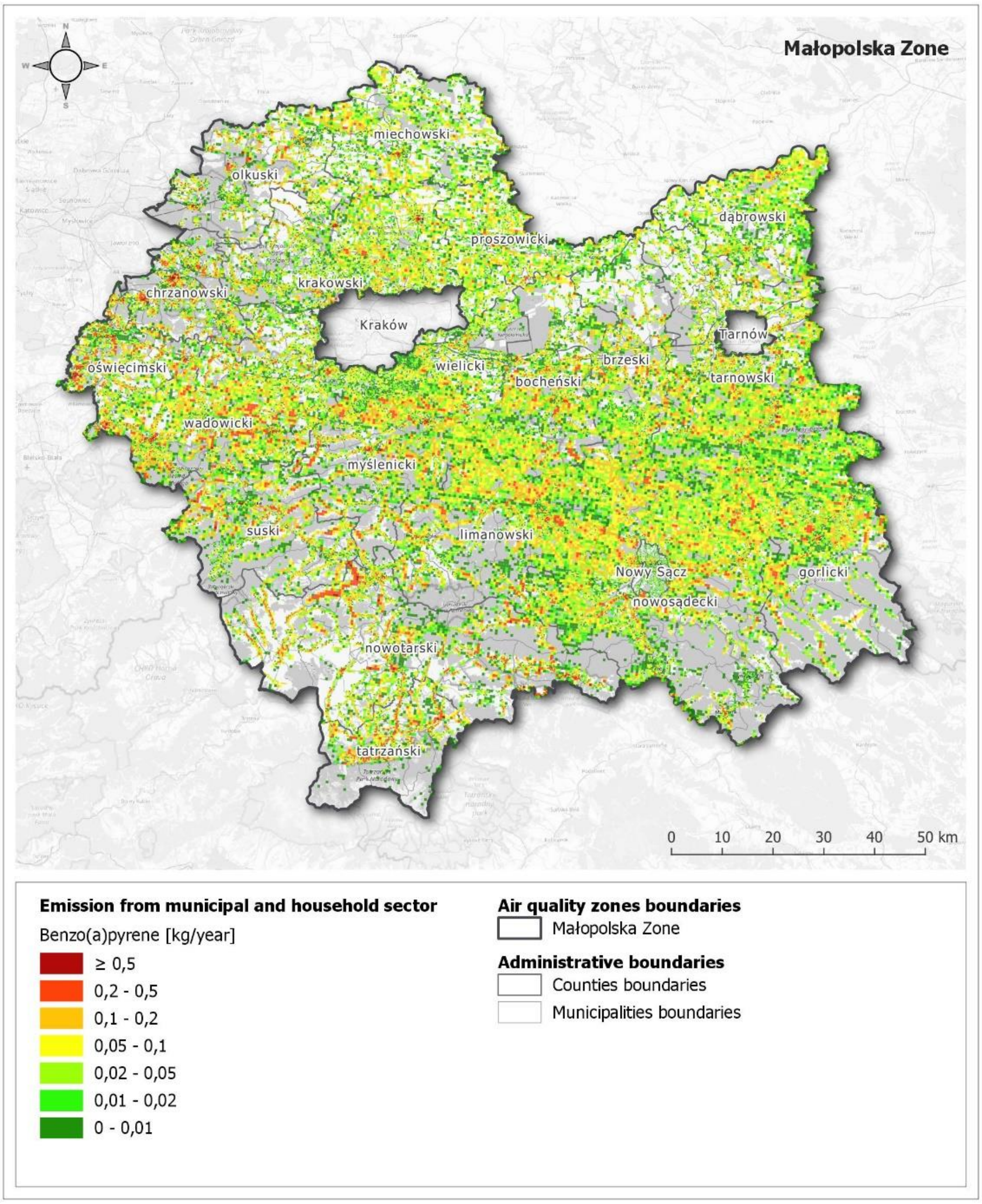


Figure 158. Benzo(a)pyrene from municipal emissions [251]

[251] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

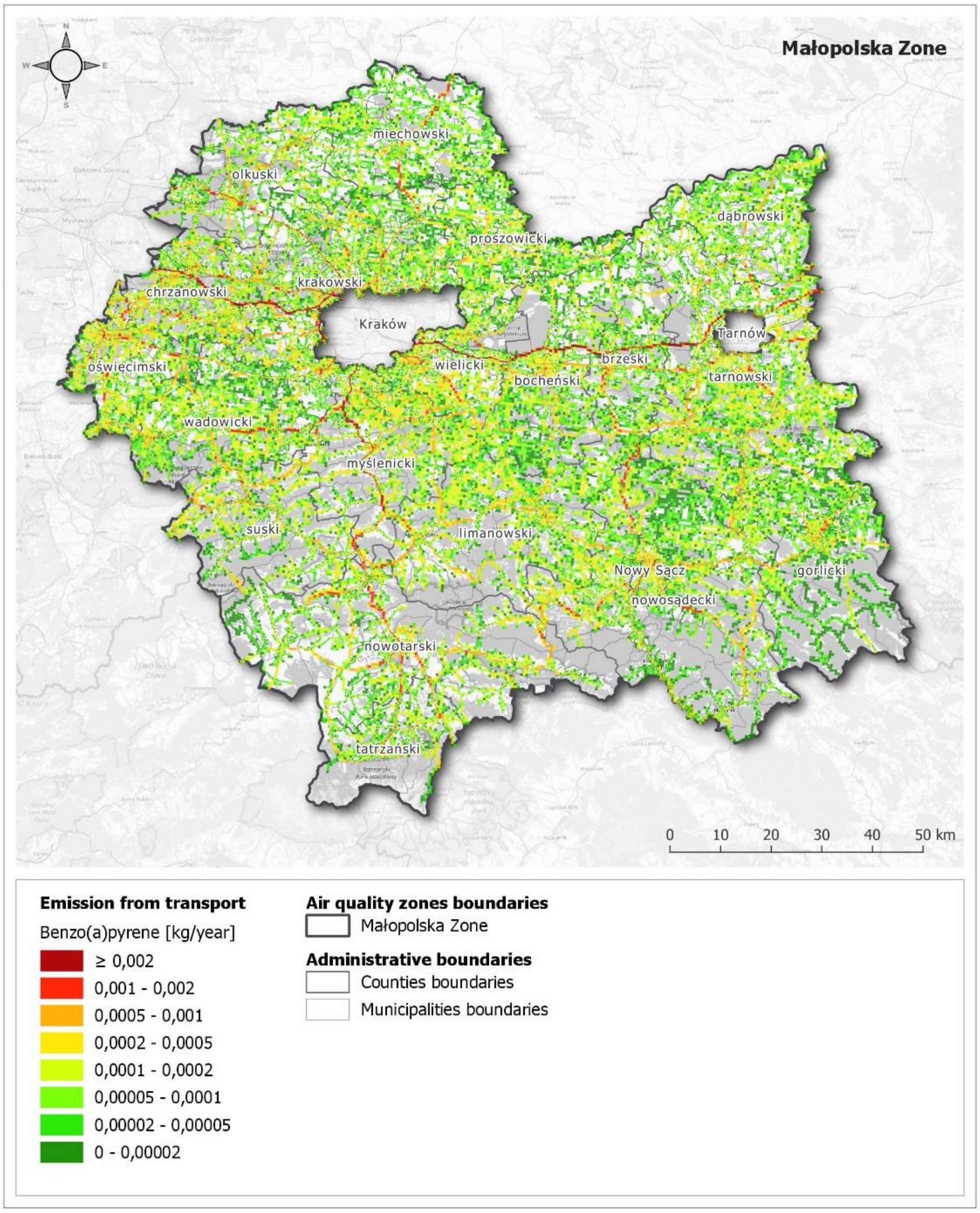


Figure 159. Benzo(a)pyrene from road transport emissions [252]

[252] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

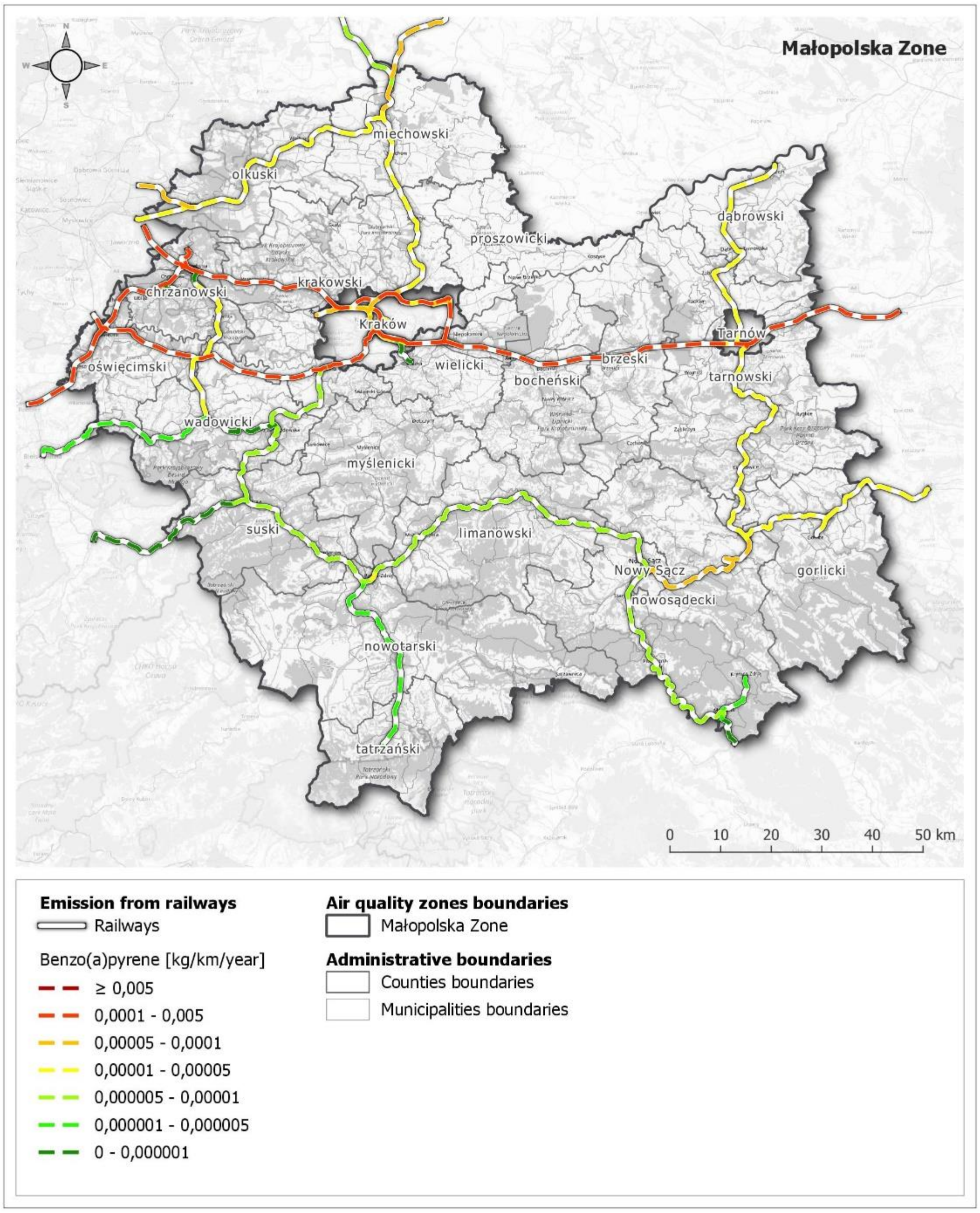


Figure 160. Benzo(a)pyrene from other emissions (railway)[253]

[253] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

18.2.4. NO_2 EMISSION SOURCES

Krakow Agglomeration zone

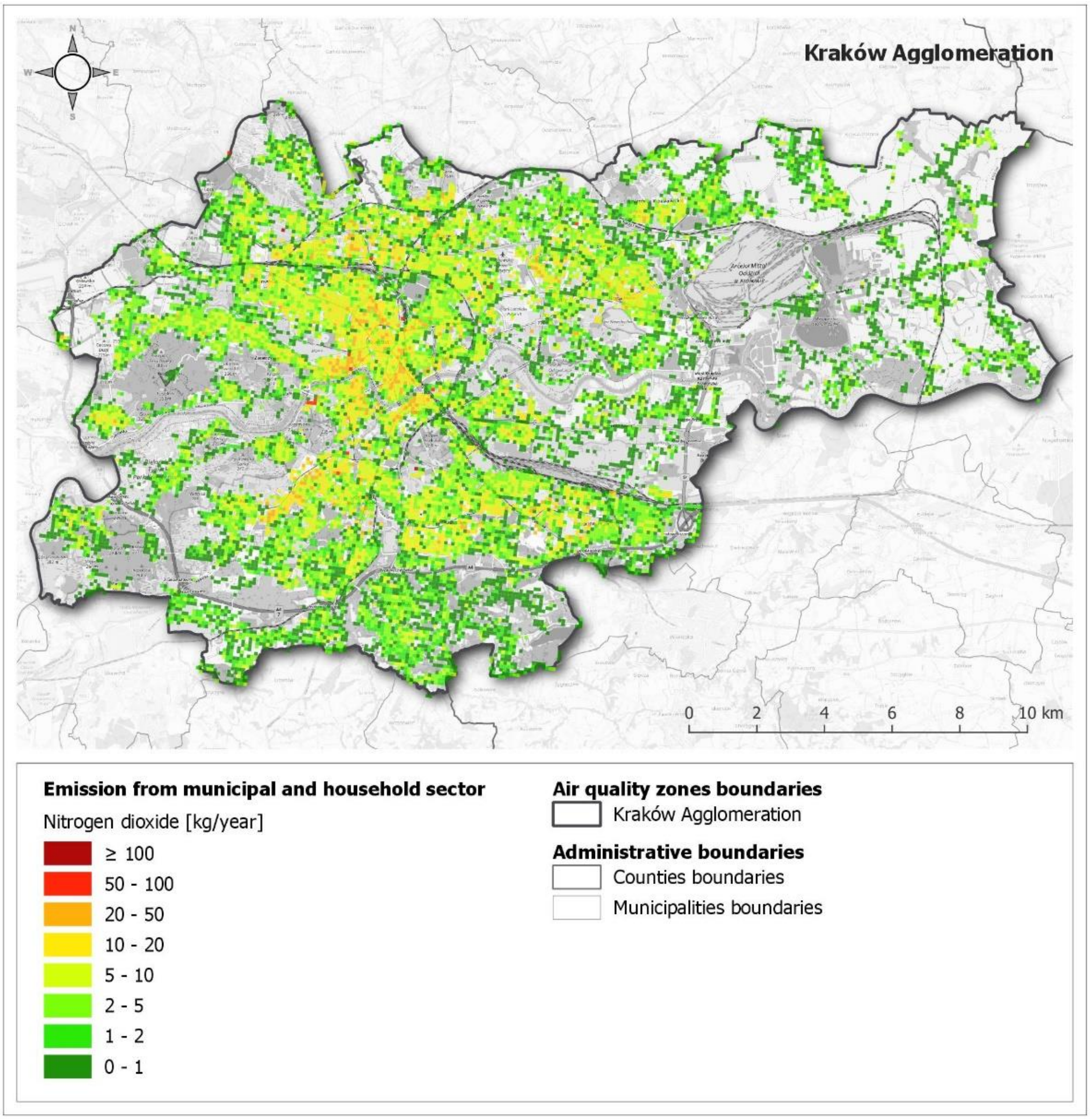


Figure 161. NO_2 from municipal emissions [254]

[254] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

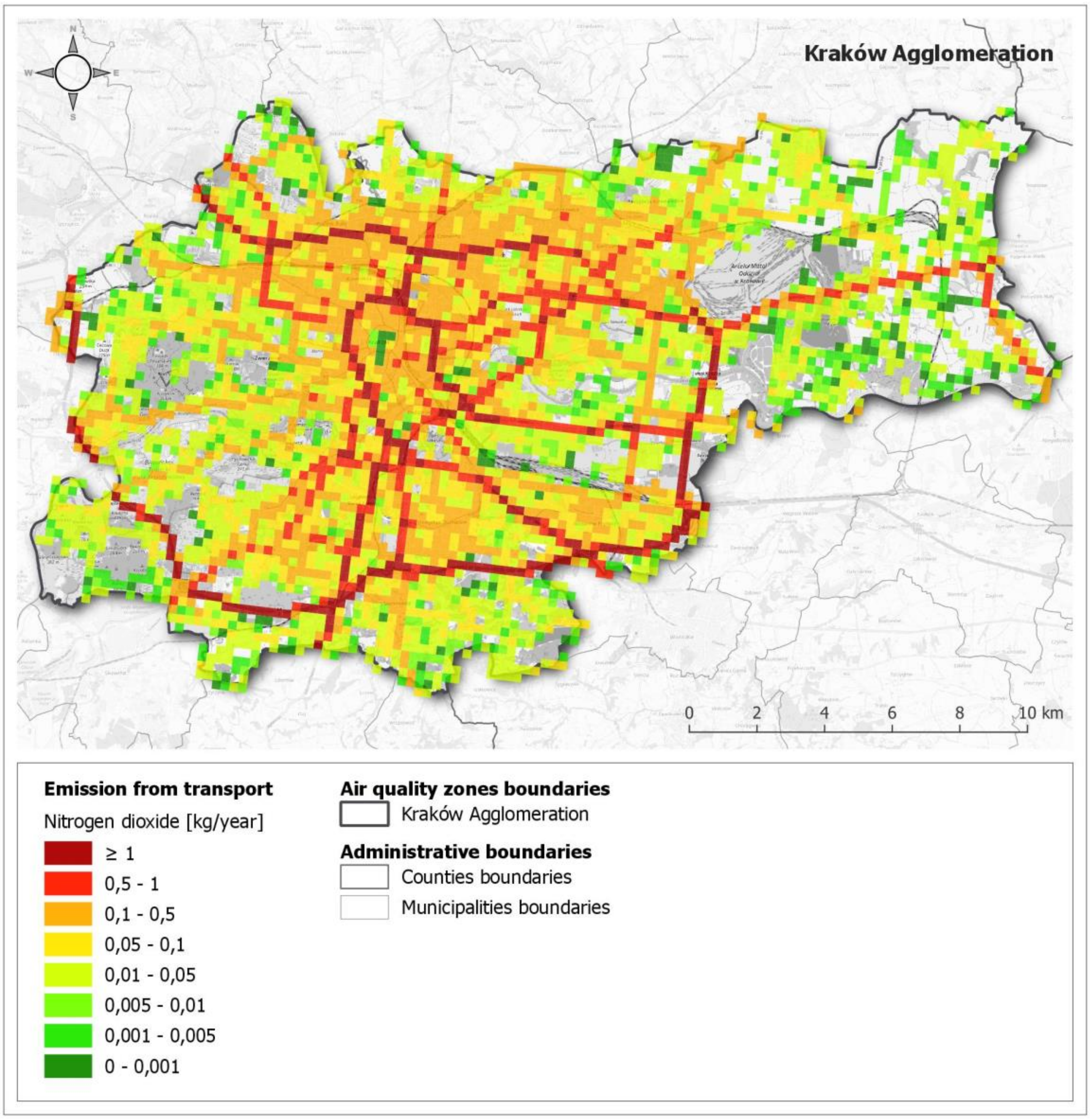


Figure 162. NO_2 road transport emissions [255].

[255] Source: Prepared by Atmoterm S.A. based on the 2018 inventory prepared for the purpose of the Air Quality Plan

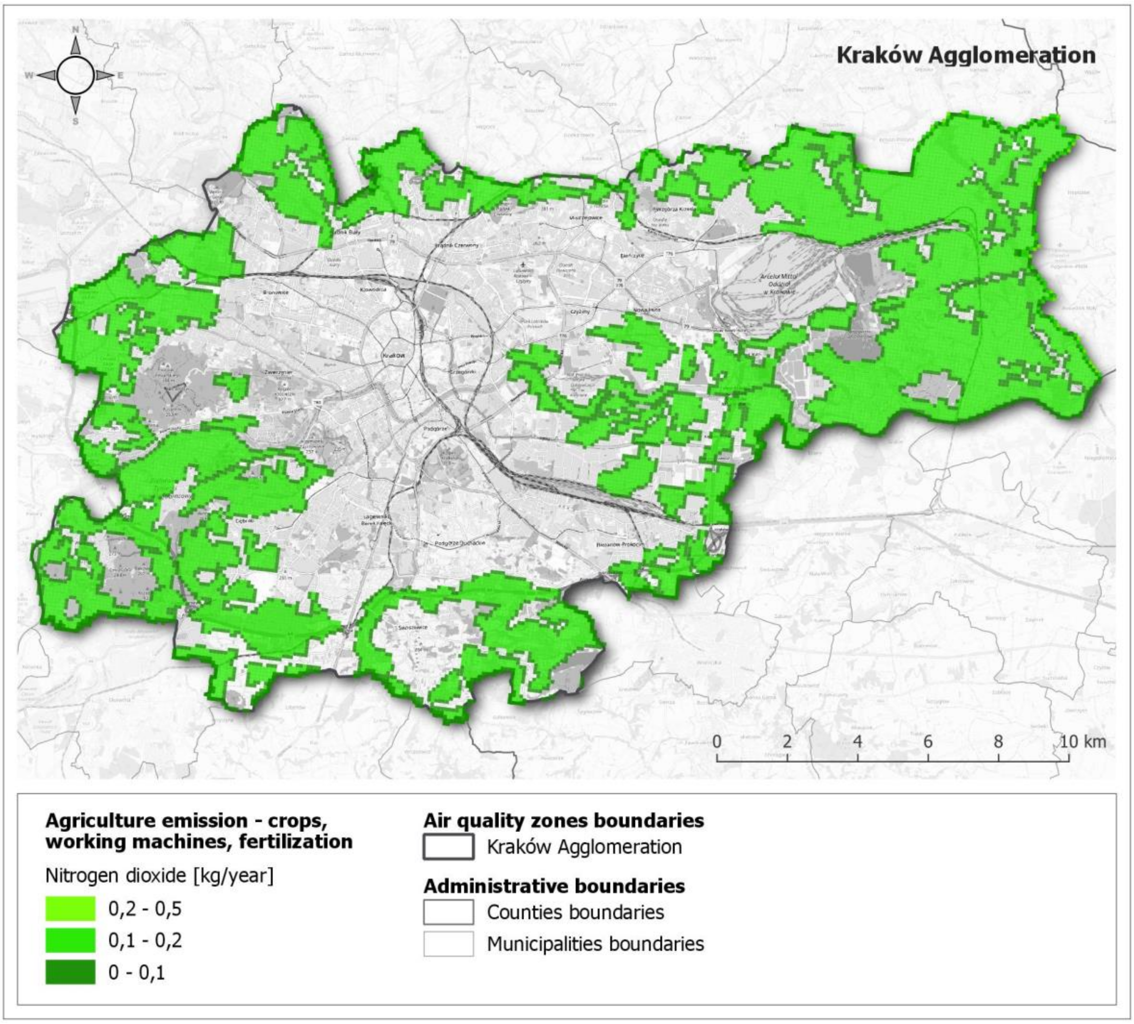


Figure 163. NO_2 from agricultural emissions (agricultural machinery)[256]

[256] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

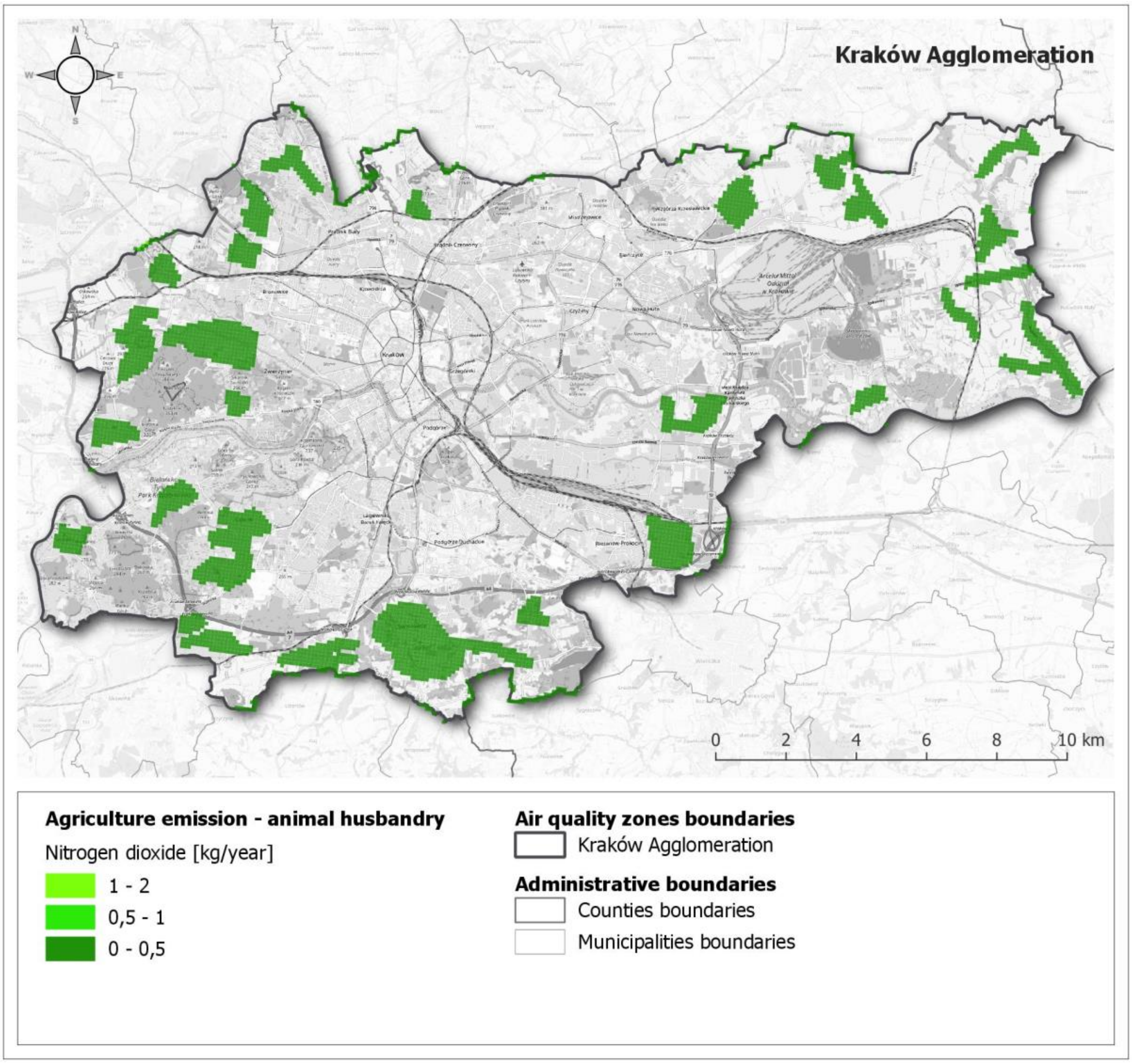


Figure 164. NO_2 from agricultural emissions (husbandry)[257]

[257] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

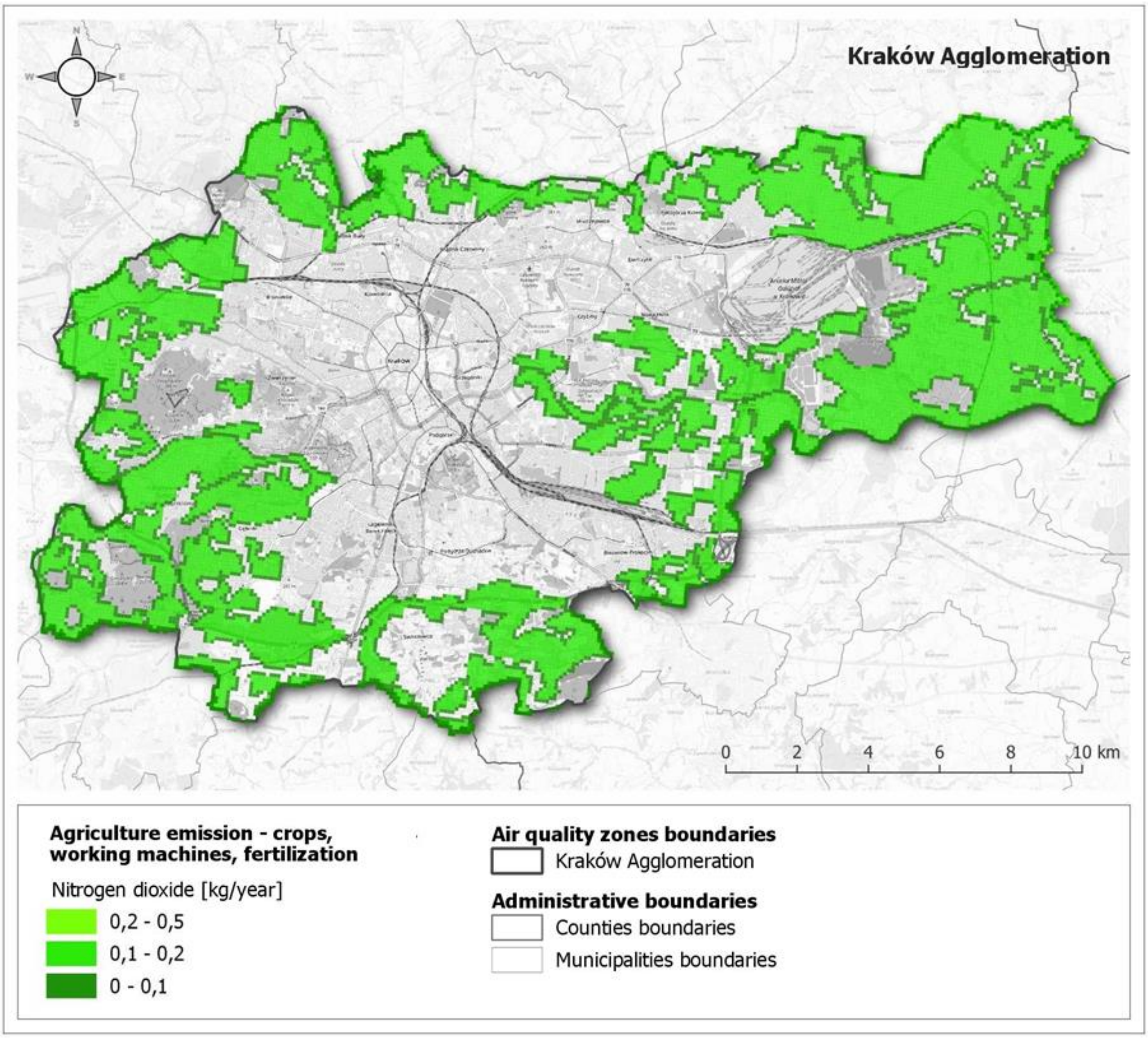


Figure 165. NO_2 from agricultural emissions (crops).[258]

[258] Source: Prepared by Atmoterm S.A. based on the Central Emission Inventory KOBIZE 2018

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