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Air quality improvement during the winter season - city vs. suburban areas of the Warsaw metropolitan area.

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**Remote Sensing
Laboratory**



Air pollution

Air pollutants are fine dust particles, liquid droplets, or gases suspended in the atmosphere.

They can be classified as **natural** and **anthropogenic** (source) or **primary** and **secondary** (formation method).

The most common anthropogenic pollutants are **products of fossil fuel combustion** (NO_2 , SO_2 , O_3^*), **industrial emissions**, and **municipal emissions** (PM_{10} , $\text{PM}_{2.5}$).

*ozone is a secondary pollutant produced by photochemical reactions

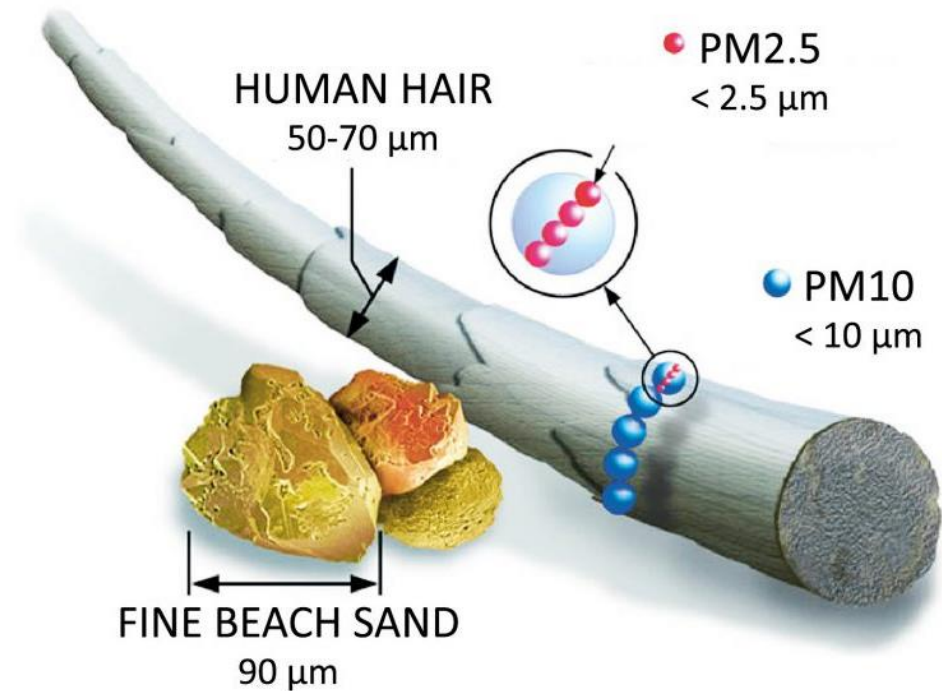


Fig. 1: What is the size of PM_{10} i $\text{PM}_{2.5}$? – Illustrative graphic.

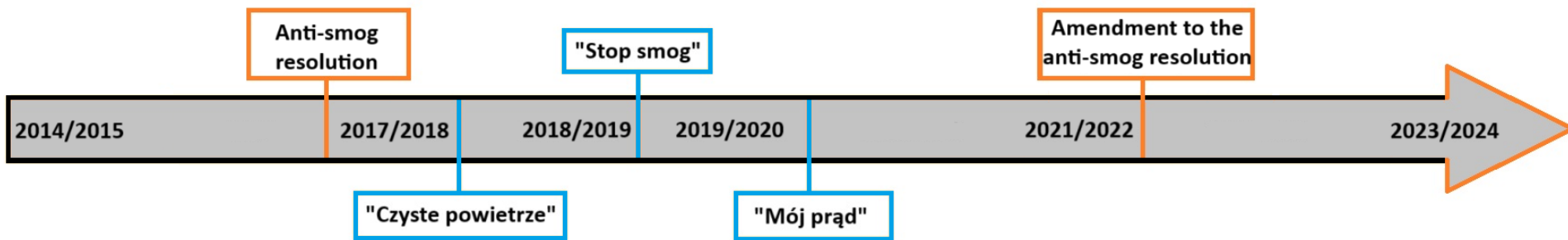
Source: <https://urbangreenbluegrids.com/thema/air-quality/>



Actions taken to improve air quality

Anti-smog resolution in the Mazovian voivodeship – 24th October 2017

Amendment to the anti-smog resolution – 19th April 2022



Subsidy programs aimed directly at individuals:

- **Czyste powietrze** (2018-2029) – thermal modernization of single-family houses
- **Mój prąd** (>01.01.2020) – construction of micro-photovoltaic installations

Programs aimed at local governments:

- **Stop smog (2019-2028)** - subsidizing thermal retrofitting of the poorest households in municipalities located in the area of anti-smog resolutions;



Other government programs to improve air quality

➤ **Programs aimed at entrepreneurs:**

- **Energia Plus (2019-2020)** – subsidisation of the construction, expansion or modernization of production lines to reduce environmental impact;
- **GreenEvo (2009-...)** - support for small and medium-sized companies that offer interesting products and services, conducting business with respect for the environment;

➤ **Programs aimed at local governments:**

- **Ciepłownictwo Powiatowe (2019-2021)** - support for modernization of energy production enterprises for municipal purposes, in which 70% of the share capital belongs to local governments



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Air quality monitoring - CIEP

The Chief Inspectorate for Environmental Protection (CIEP) is responsible for continuous air quality monitoring.

The nationwide network now has **288** stations.

In the Mazovian Voivodeship alone, measurements are taken by **20** stations.

They provide publicly available measurement data from all stations. Access to the data (archive and in the near real-time) is provided through a website:

<https://powietrze.gios.gov.pl/pjp/current>





→ **Air Quality Index (AQI)** is an indicator presenting the state of the air at a given moment. It is determined on the basis of measurements or forecasts of concentrations of specific pollutants.

Table 1: Air Quality Index (AQI) according to CIEP. The colors used are consistent with the AQI - green means clean air, while shades of red indicate increasingly polluted air.

Air Quality Index (AQI)	PM ₁₀ [ng/m ³]	PM _{2,5} [ng/m ³]	NO ₂ [ng/m ³]	SO ₂ [ng/m ³]	O ₃ [ng/m ³]
Very good	≤ 20	≤ 13	≤ 40	≤ 50	≤ 70
Good	20,1-50	13,1-35	40,1-100	50,1-100	70,1-120
Moderate	50,1-80	35,1-55	100,1-150	100,1-200	120,1-150
Adequate	80,1-110	55,1-75	150,1-230	200,1-350	150,1-180
Bad	110,1-150	75,1-110	230,1-400	350,1-500	180,1-240
Very bad	>150	>110	>400	>500	>240

Source: Chief Inspectorate for Environmental Protection (CIEP) website: <https://powietrze.gios.gov.pl/>



Data taken into consideration

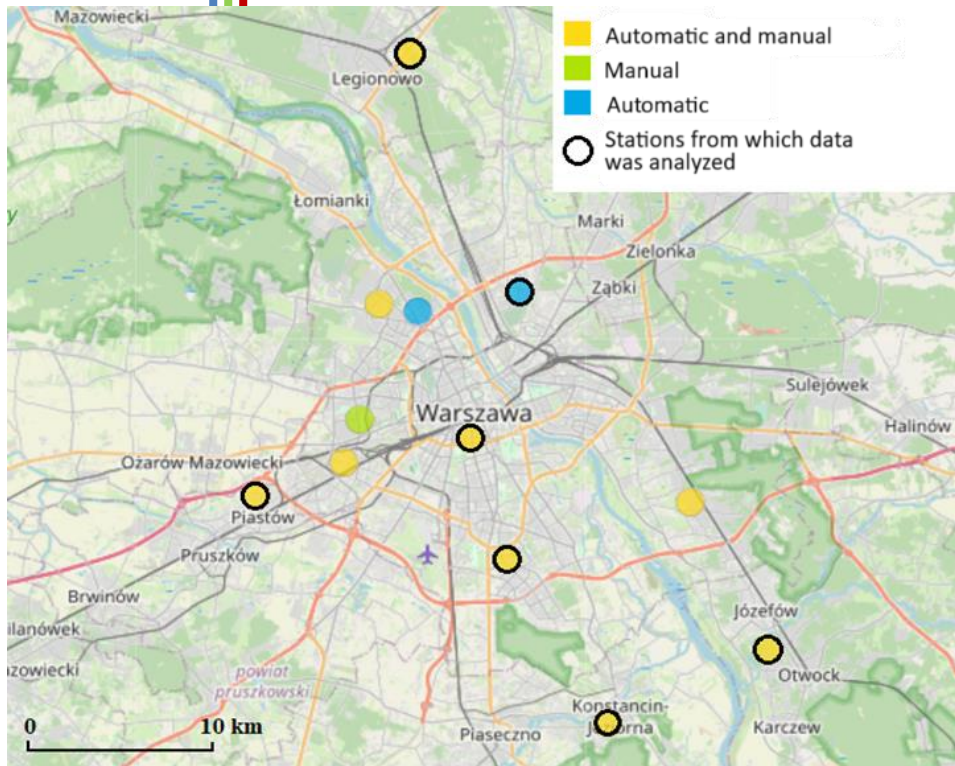


Fig. 2. Map of Warsaw and its surroundings with CIEP air quality monitoring stations marked, indicating the station type. The stations included in the analysis are marked with a black rim. From the top are Legionowo Zegrzyńska, Warszawa Kondratowicza, Warszawa Niepodległości, Piastów Pułaskiego, Warszawa Wokalna, Otwock Brzozowa and Konstancin – Jeziorna Wierzejewskiego.

Source: Modified after <https://powietrze.gios.gov.pl/>

➤ Area:

7 measuring stations, including:
1 **communication station** and
2 **background stations of the urban area**, as well as 4 **background stations of suburban areas** (one in each geographical direction from Warsaw).

➤ Time frames:

Ten **winter seasons** (December-February) over 2014-2024 period.

➤ Pollutants:

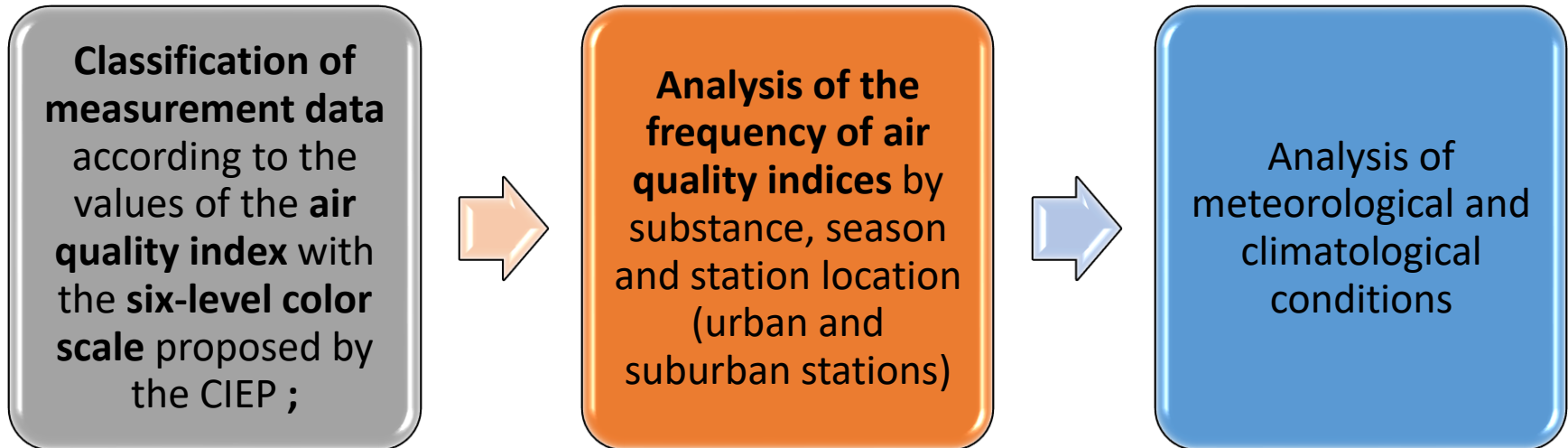
Concentrations: particulate matter **PM10** and **PM2.5**, nitrogen dioxide (**NO2**), and sulfur dioxide (**SO2**).

➤ Measurement method:

Gravimetric or equivalent method.



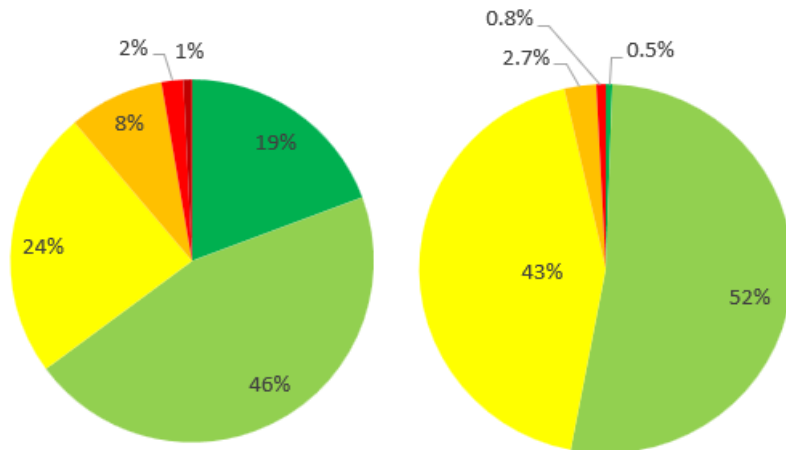
Methodology





PM10 concentration – 24 hour averaging

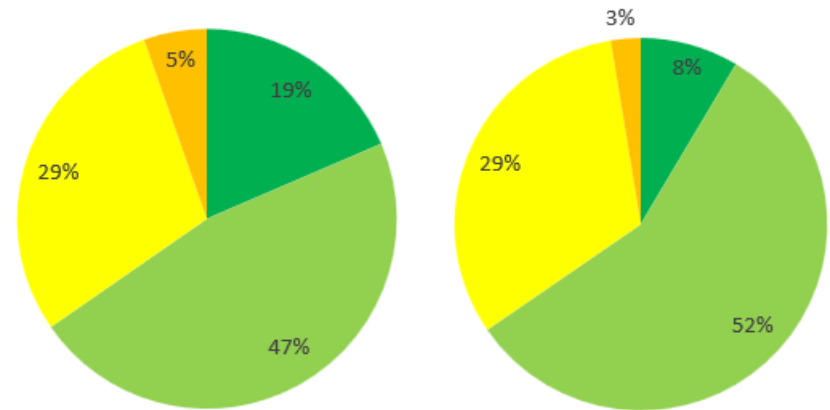
Suburban



2014/2015

2023/2024

City



2014/2015

2023/2024

AQI

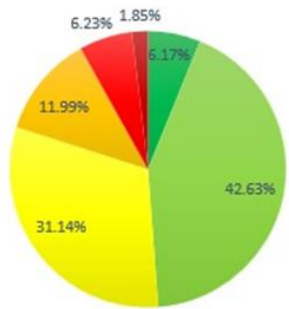




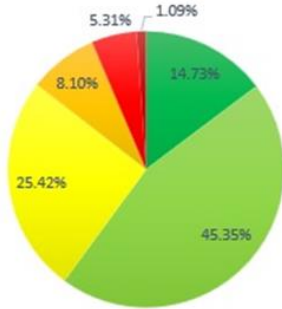
PM10 concentration - 1h averaging

City

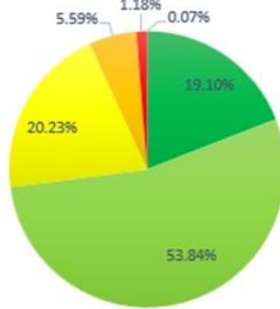
2017/2018



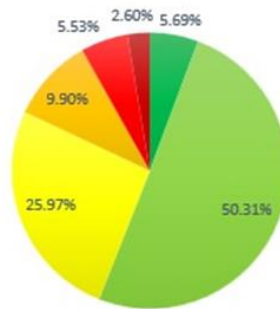
2018/2019



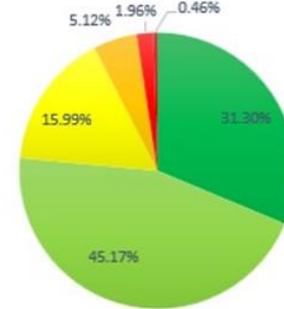
2019/2020



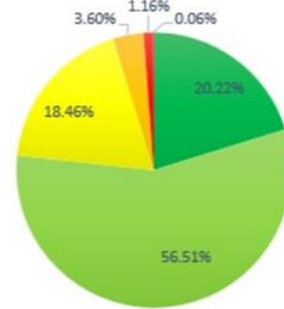
2020/2021



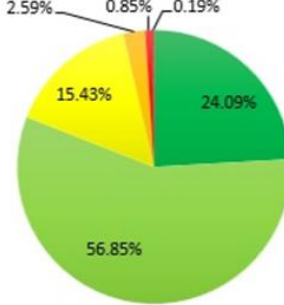
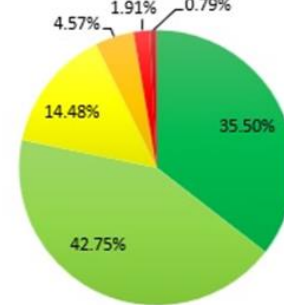
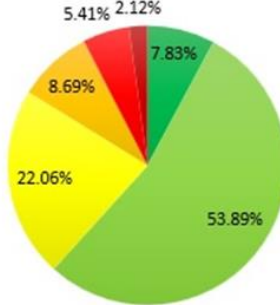
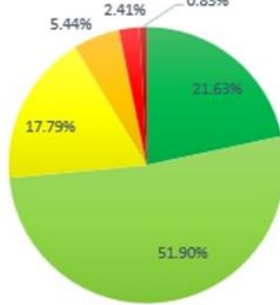
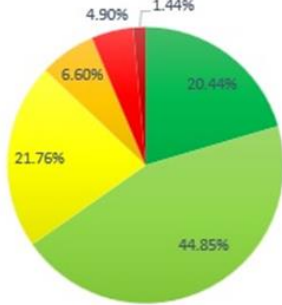
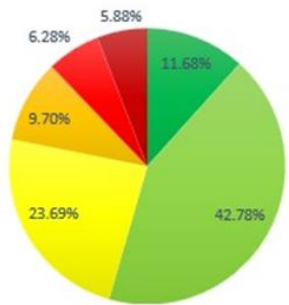
2021/2022



2022/2023



Suburban



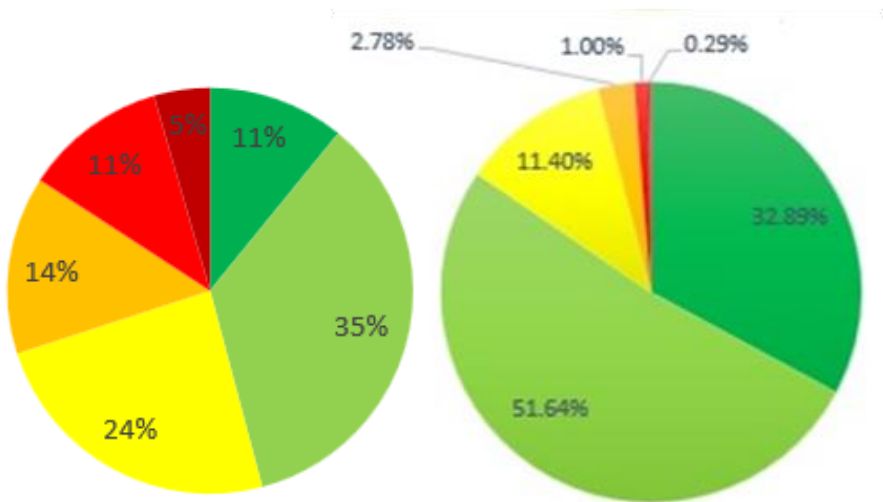
AQI





PM2.5 concentration – 1 hour averaging

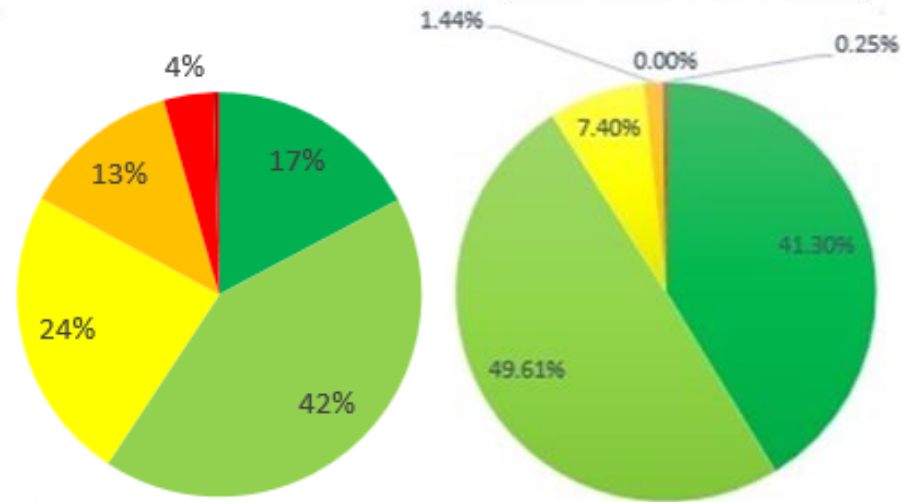
Suburban



2014/2015

2023/2024

City



2014/2015

2023/2024

AQI





PM2.5 concentration - 1h averaging

City

2016/2017

2017/2018

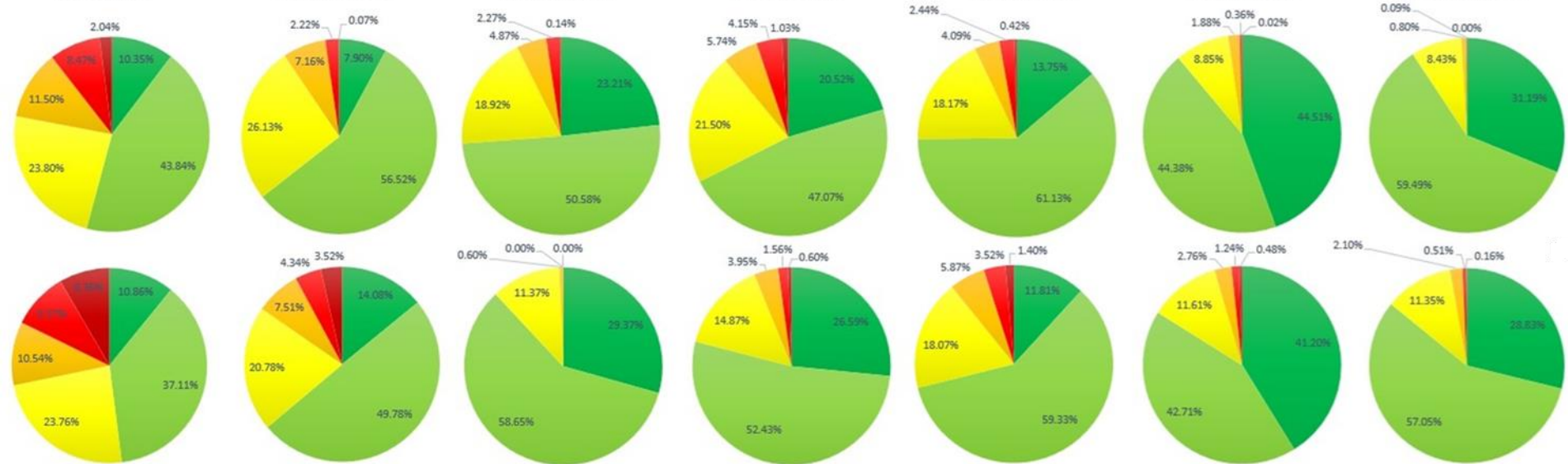
2018/2019

2019/2020

2020/2021

2021/2022

2022/2023



Suburban

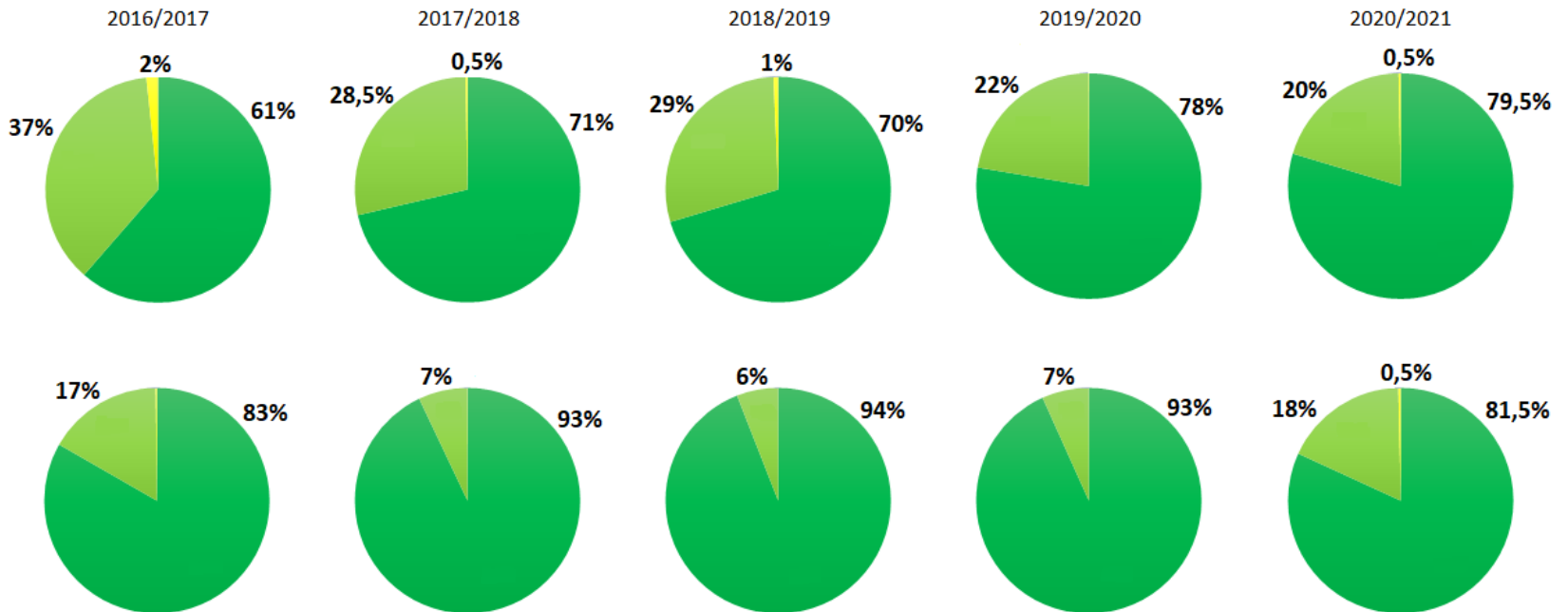
AQI





NO₂ concentration – 1h averaging

City



Suburban





Better-than-moderate air quality index frequency

The frequency of occurrence of the better-than-moderate air quality index expressed as a percentage of cases. Values in brackets refer to the frequency of occurrence of air of very good quality.

Pollutant	PM10		PM2.5		NO ₂	
	Urban	Suburban	Urban	Suburban	Urban	Suburban
2016/2017	40,3	X	54,2	47,9 ↓	100 (61)	100 (83)
2017/2018	48,8	54,5	64,4	63,9 ↓	100 (71)	100 (93)
2018/2019	60,1	65,3	73,8 ↓	67,6	100 (70)	100 (94)
2019/2020	72,9	73,5	88,0 ↓	79,0	100 (78)	100 (93)
2020/2021 !	56,0! ↓	61,7! ↓	74,5!	71,1!	100 (80)	100 (82)!
2021/2022	76,5 ↓	78,3 ↓	88,9	83,9	100 (82)	100 (95)
2022/2023	76,7	80,9	90,7	85,9	100 (85)	100 (98)
2023/2024	78,0	80,4	90,9	84,5	100 (100)!!	100 (100)!!



Summary

- There **has been a steady improvement in air quality in Warsaw and its suburban area**. This may be due to the introduction and amendment of the Anti-Smog Law through the inclusion of more air quality improvement programs;
- The deterioration of the **air quality index in the winter of 2020/2021, may be due to meteorological conditions** - this winter was “*cool or slightly cool*”, while the others of the analyzed winters were considered “*warm or extremely warm*” concerning the 1991-2020 norm (Biuletyn PSHM, Rok 2021);
- The decrease in concentrations of PM10 and PM2.5 particulate matter may be related to both the occurrence of increasingly mild winters and the use of better home heating technologies;



Thank you for your attention!

- *The research was made possible by the support of grants*
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- *This work utilizes measurement data from the air quality monitoring stations operated by the Chief Inspectorate of Environmental Protection (CIEP).*
- *Some of the results presented in this study were obtained during a volunteer internship at the Faculty of Physics of the University of Warsaw of mgr inż.K.Deptuła. This work is part of his master's thesis titled "The Study of the Causes of Smog Episodes in Warsaw", conducted under the supervision of Prof. J. Rakowska at the Fire Academy in Warsaw.*



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