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INCREASING THE VISIBILITY AND KNOWLEDGE BASE ON AIR QUALITY WITH BIG DATA AND ITS IMPACT ON THE POPULATION HEALTH

Erasmus+ KA220 Cooperation Partnerships

AN OVERVIEW OF AIR QUALITY

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1 INTRODUCTION

Professional scientific articles on air quality address a broad spectrum of subjects, ranging from the fundamental processes of pollution to its impacts on health, climate, and ecosystems (Vallero, 2014), (Chow, 2006). Air quality is a critical environmental and health concern that impacts human well-being, ecosystems, and overall quality of life. Air pollution originates from various sources, including industrial activities, transportation, energy production, agriculture, and natural events like wildfires and volcanic eruptions (Cohen et al., 2015). Much of the research is dedicated to international initiatives and policy frameworks to enhance air quality. Organizations like the World Health Organization (WHO) and the United Nations Environment Program (UNEP) establish global standards and guidelines to coordinate and unify the efforts of various countries in improving air quality (Beloconi et al., 2024). Your text should be written in English in the same format as this file.

Research also emphasizes the impact of air pollution on human health, often revealing a connection between exposure to pollutants like particulate matter (PM2.5), nitrogen oxides (NOx), sulphur dioxide (SO2), and ground-level ozone, and a higher incidence of diseases such as asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disease, and lung cancer. Some studies also explore how long-term exposure to air pollution reduces life expectancy and premature mortality (Joshi et al., 2024), (Lelieveld et al., 2015).

Lastly, scientific articles also concentrate on the advancement of new technologies and strategies to enhance air quality (Castell et al., 2017), Shi et al., 2015). This includes the creation of cleaner combustion technologies, the more efficient utilization of renewable energy sources, and the enhancement of air pollution monitoring systems. Beyond technical solutions, these studies also investigate political and regulatory approaches, such as implementing emission limits, promoting sustainable transportation, and improving urban planning to reduce pollution (Gäbel et al., 2022). Scientific studies frequently explore and enhance methods for monitoring air quality. Researchers are developing new sensors and technologies that allow more accurate and cost-effective real-time measurement of pollutants. Additionally, satellite imagery and drones are increasingly employed to monitor air quality across large geographic areas, identifying pollution sources and analysing their dispersion (Achieng' et al., 2024), (Ma et al., 2022).

1.1 Recommended main reliable sources for project solution

The main reliable source for data collection, acquisition and implementation of relevant analyses and gain of new knowledge for the needs of fulfilling project goals of Increasing the Visibility and Knowledge Base on Air Quality with Big Data and Its Impact on the Population Health is the **European Environment Agency EEA** (www.eea.europa.eu).

The EEA is an agency of the European Union. Together with our knowledge Eionet network provides the knowledge and the data needed to achieve sustainability in Europe.

The European Environment Agency (EEA) provides valuable insights on the **state of Europe's environment**. Thanks to reliable data collected from extensive network actively supports **Europe's environment and climate policies**. EEA collects and validates data from reliable sources to analyse trends and produce policy-relevant analyses on environment and climate topics. EEA works in close cooperation with a multitude of organisations at European, regional and global levels.

Its knowledge network **EIONET** (*European Environment Information and Observation Network*) is their main partner and brings together 38 member countries (include the 27 European Union Member States, Iceland, Liechtenstein, Norway, Switzerland and Turkey and 6 West Balkan cooperating countries. These include Albania, Bosnia and Herzegovina, North Macedonia, Montenegro, Serbia and Kosovo). Eionet was founded in 1994 and is a well-known and trusted provider of high-quality data, information and sustainability assessments for Europe. Eionet is bringing together around 2,000 experts from more than 400 national institutions that have expertise in environmental issues.

Vision of EEA and Eionet: The EEA and Eionet will enable a sustainable Europe through trusted and actionable knowledge for informed decision-making on priorities and solutions, in line with Europe's policy ambitions.

EEA and Eioned prepared a strategy for the years 2021 to 2030 to provide data and knowledge in the fields of environment and climate.

1.1 Historical framework of environmental policy development in the world and in the EU: general principles and basic framework

The EU is dealing with a variety of difficult environmental problems, such as pollution, resource depletion, and climate change and biodiversity loss. European environment policy uses the concepts of "polluter pays," "precaution," "rectification of pollution at source," and prevention to address these problems. By introducing the European Green Deal in 2019, the Commission elevated environmental issues to the forefront of EU policymaking. The table shows the historical development of environmental policy in the world and the EU.

Table 1: Historical development of environmental policy in the world and the EU

Year	Origins and development	Range
1972	In Stockholm, there was the first United Nations Conference on the Environment. In addition to adopting the Stockholm Declaration and Action Plan for the Human	International Declarations

	Environment as guidelines for responsible environmental management, it elevated environmental issues to the top of the global agenda.	
1992	Rio de Janeiro was the site of the "Earth Summit." Numerous significant statements, including the Rio Declaration, Agenda 21, the Convention on Biological Diversity, and the United Nations Framework Convention on Climate Change (UNFCCC), were adopted as a result of this meeting.	
1972	The European Council meeting in Paris emphasized the importance of integrating environmental policy with economic strategies and called for an action program aimed at preserving and enhancing the environment, as well as addressing pollution and other disturbances.	European Treaties
1987	The Single European Act introduced a new "Environment Title" (Title VII), establishing the first legal foundation for a common environmental policy. Its objectives include preserving environmental quality, protecting human health, and ensuring the sustainable use of natural resources. Subsequent treaty revisions further reinforced the Community's commitment to environmental protection and enhanced the European Parliament's role in shaping this policy.	
1993	The Treaty of Maastricht established the environment (Title XVI) as an official EU policy area. It introduced the codecision procedure and made qualified majority voting in the Council the standard practice. Additionally, the treaty encouraged Member States to evaluate their environmental impact and adhere to the principle of sustainable growth.	
1999	Article 3c of the Treaty of Amsterdam required the integration of environmental	

	protection into all EU sectoral policies, aiming to promote sustainable development.	
2007	The Treaty of Lisbon prioritized climate change and sustainable development. It also granted the EU legal personality, enabling it to enter into international agreements.	
2019	These advancements solidified the EU's position as a leading global actor in environmental matters, paving the way for major initiatives like the European Green Deal.	
2021	European Climate Law	

Source: European Parliament. Environment Policy: General Principles and Basic Framework

2 GREENHOUSE GASES IN EU27 AND IN SELECTED COUNTRIES (CZECH REPUBLIC, CROATIA, SLOVAK REPUBLIC, SPAIN)

Greenhouse gases (also known as GHGs) are gases that occur in the Earth's atmosphere and absorb long-wave infrared radiation, which warms the lower atmosphere and the Earth's surface. The most significant gases that cause global warming via the greenhouse effect are the following:

- Carbon dioxide 76%
- Methane 16%
- Nitrous oxide 6%
- Fluorinated gases 2%
- Water vapour - reacts to temperature changes, is referred to as a 'feedback', because it amplifies the effect of forces that initially caused the warming.

Explanation to figures

- What does carbon dioxide equivalent (CO_2e) mean? There are many different greenhouse gases, the most famous of which is carbon dioxide. Different greenhouse gases affect the climate in different ways. Some remain in the atmosphere for a long time, but do not cause as much warming per kilogram of emissions as carbon dioxide, for example. Others, like methane, warm the Earth a lot but don't stay in the atmosphere very long. There is a so-called exchange rate that allows comparison of

different gases. The exchange rate expresses how much a kg of carbon dioxide emissions warms the climate in the same way as 1 kg of another greenhouse gas. The exchange rate is called Global warming potential (GWP). By knowing the GWP of various gases, the product's overall impact on the climate can be summed up in one unit: kilograms of carbon dioxide equivalents (kg CO_2e).

- Total net emission (all greenhouse gases) in EU27 and selected countries according to UNFCCC (United Nations Framework Convention on Climate Change, signed by 154 countries at the Rio de Janeiro summit in 1992)

The following figures show processed data from the EU's Total greenhouse gas emissions and removals based on data reported by EU Member States under the EU Governance Regulation (European Environment Agency. Greenhouse gases viewer, 2024).

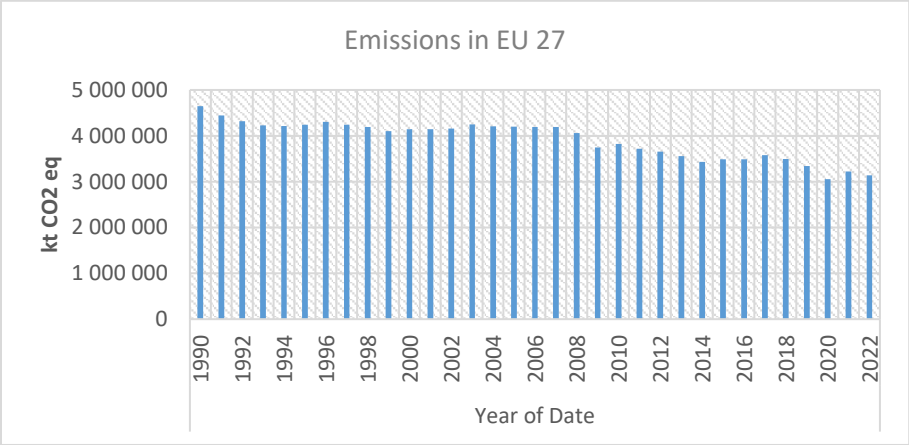

Figure 1: Total net emission (all greenhouse gases) in EU27

Source: EEA greenhouse gases — data viewer

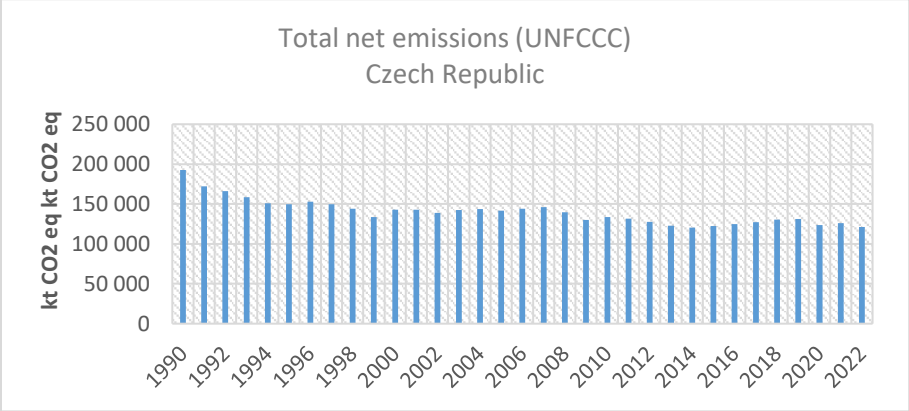

Figure 2: Total net emission (all greenhouse gases) in Czech Republic

Source: EEA greenhouse gases — data viewer

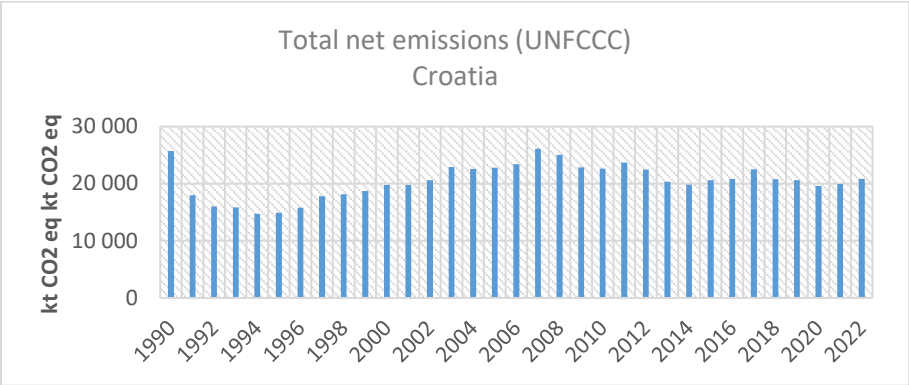

Figure 3: Total net emission (all greenhouse gases) in Croatia

Source: EEA greenhouse gases — data viewer

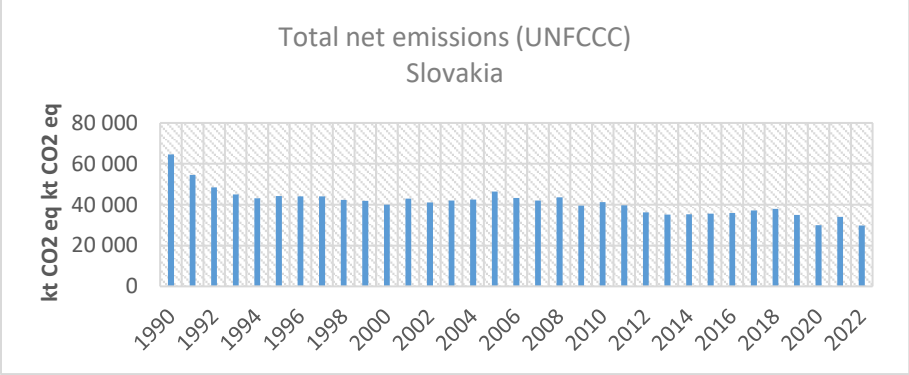

Figure 4: Total net emission (all greenhouse gases) in Slovakia

Source: EEA greenhouse gases — data viewer

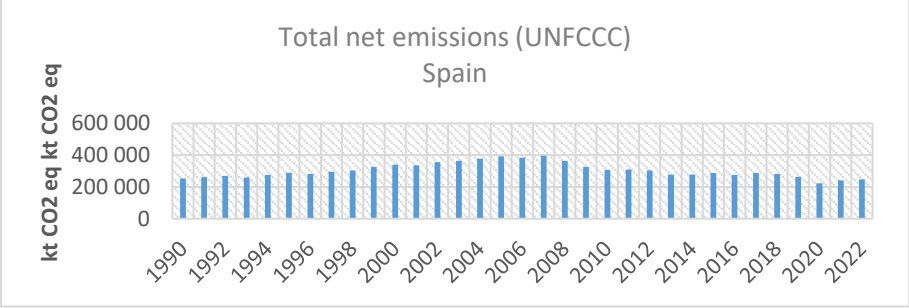

Figure 5: Total net emission (all greenhouse gases) in Spain

Source: EEA greenhouse gases — data viewer

2.1 Air pollution statistics in Europe

Although air quality in Europe has improved over recent decades, air pollution remains a significant environmental and health challenge. Climate change can exacerbate air pollution levels, particularly by increasing ozone formation (Air quality in Europe, 2021). Combatting air pollution is, therefore, a central priority in EU policy, as reflected in initiatives like the European Green Deal, which aims to lower emissions and enhance air quality across Europe. According to the European Environment Agency (EEA), the primary air pollutants include fine particulate matter (PM2.5), nitrogen oxides (NOx), and ozone (O3). The European Union has been actively working to improve air quality for several decades, focusing on reducing emissions from various sectors, promoting sustainable transportation, and decreasing reliance on fossil fuels (Beloconi et al., 2023), (Manders et al., 2023).

Despite the progress made, Europe continues to face significant challenges related to air pollution:

- Climate Change: Rising temperatures due to climate change can lead to increased ground-level ozone formation and exacerbate air pollution issues. To address this interconnected challenge effectively, it is crucial to align measures for improving air quality with climate change policies.
- Traffic Density and Urbanization: The growth of urban areas and high traffic volumes in cities contribute to elevated levels of air pollution. While initiatives like low-emission zones and the promotion of public transportation are essential, further action is required to manage and mitigate pollution effectively.
- Internationalization: Air pollution crosses national boundaries, making international cooperation essential. The EU is actively collaborating with non-EU countries to tackle cross-border air pollution issues and coordinate efforts for cleaner air (Guerreiro et al., 2014), (Manders et al., 2023).

The next figures and maps show the pollutant level for selected countries, the selected pollutant, and the type(s) of area and station. The pollution levels are based on the annual mean values for NO2, PM2.5, and PM10, while they are based on the annual maximum 8-hour running average for O3 (European Environment Agency. Air quality reporting for public portal, 2024).

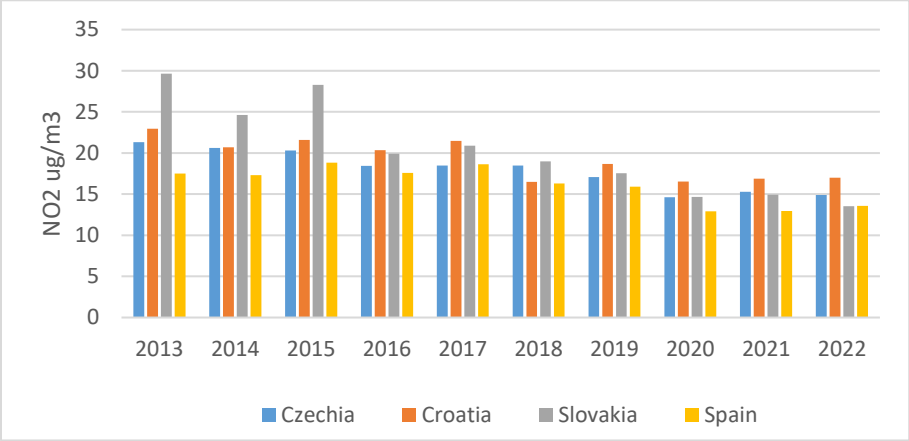

Figure 6: Evolution of pollution NO2 level throughout the years of selected countries

Source: EEA's AQ e-reporting database

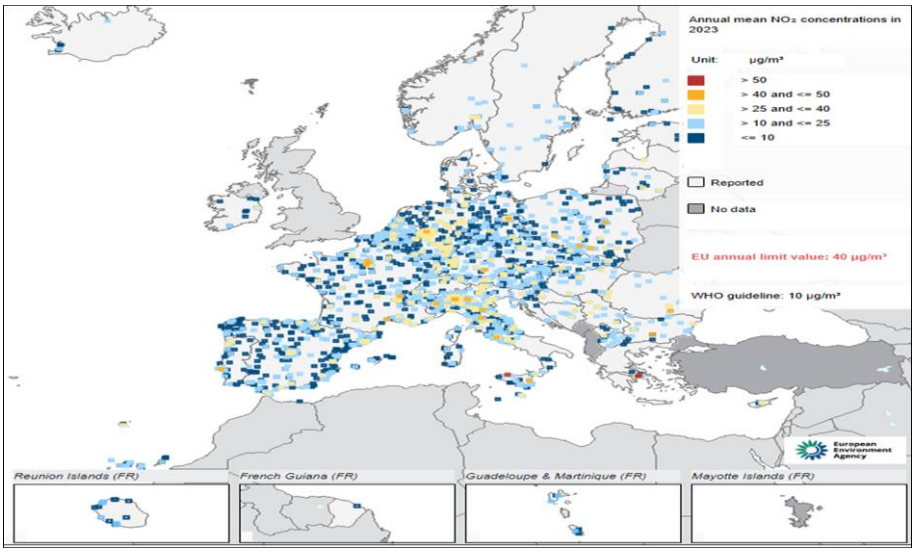

Figure 7: Concentrations of NO2 in 2022 and 2023 in relation to the EU annual limit value and the WHO annual guideline level

Source: EEA's AQ e-reporting database

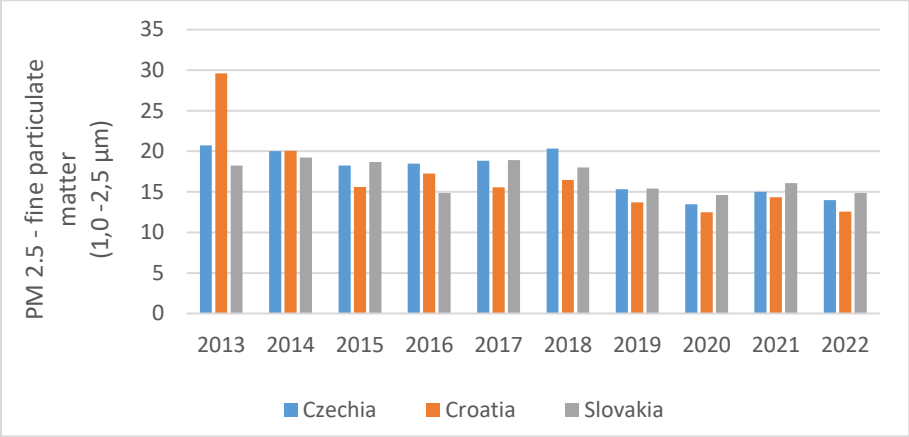

Figure 8: Evolution of pollution PM 2.5 level throughout the years of selected countries

Source: EEA's AQ e-reporting database

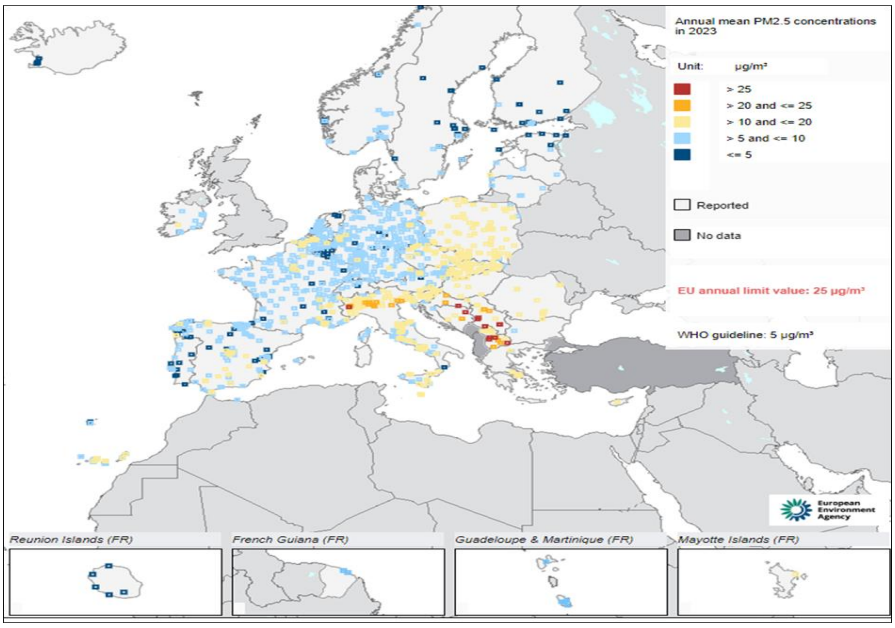

Figure 9: Concentrations of PM2.5 in 2022 and 2023 in relation to the EU annual limit value and the WHO annual guideline level

Source: EEA's AQ e-reporting database

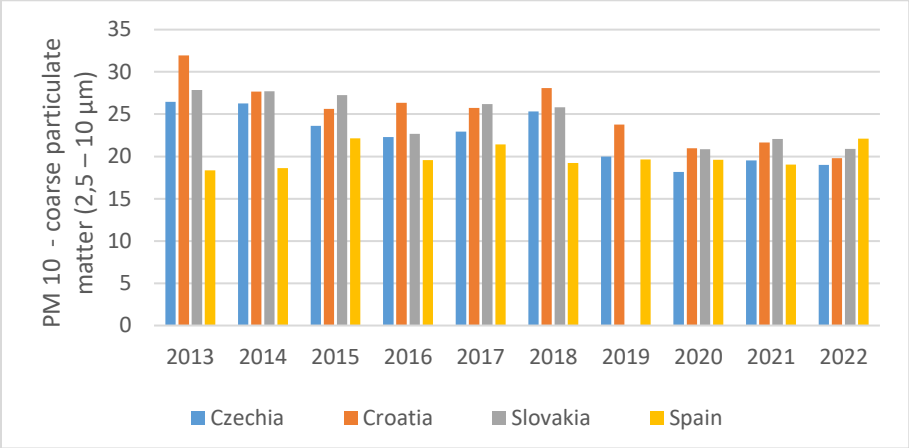

Figure 10: Evolution of pollution PM 10 level throughout the years of selected countries

Source: EEA's AQ e-reporting database

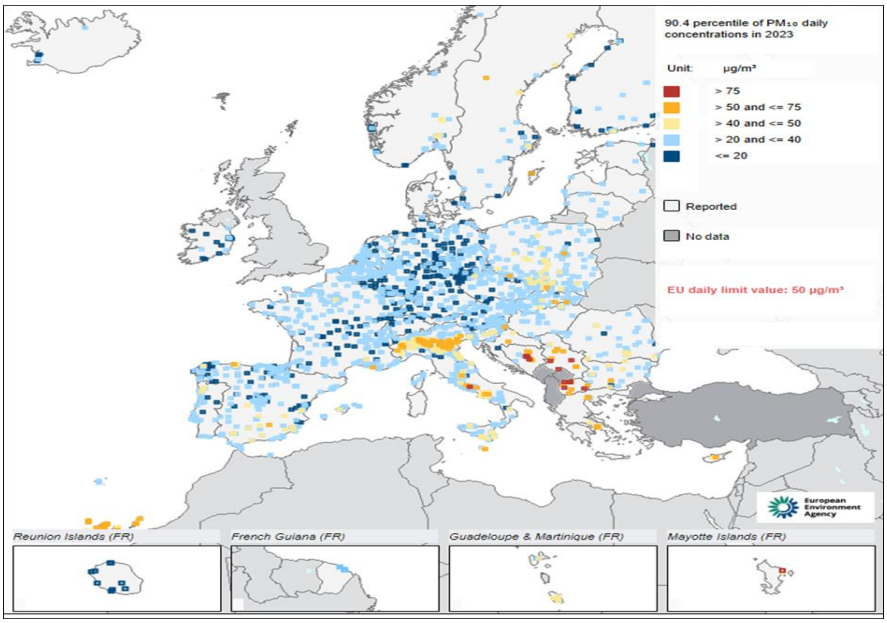

Figure 11: Concentrations of PM10 in 2022 and 2023 in relation to the EU daily limit value

Source: EEA's AQ e-reporting database

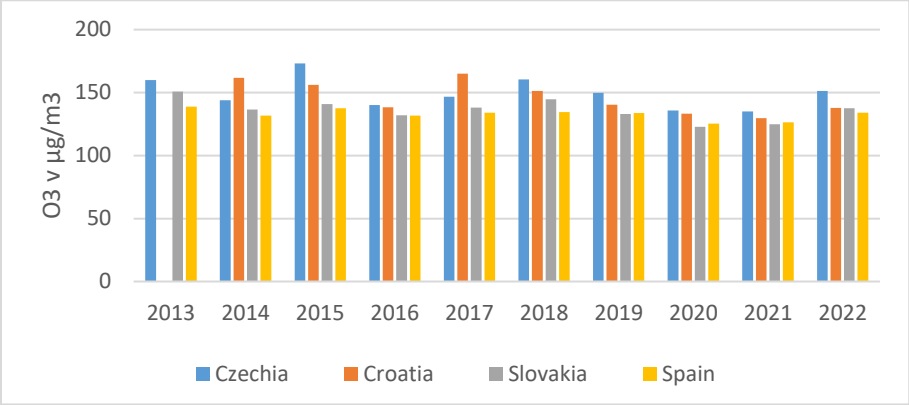

Figure 12: Evolution of pollution O3 level throughout the years of selected countries

Source: EEA's AQ e-reporting database

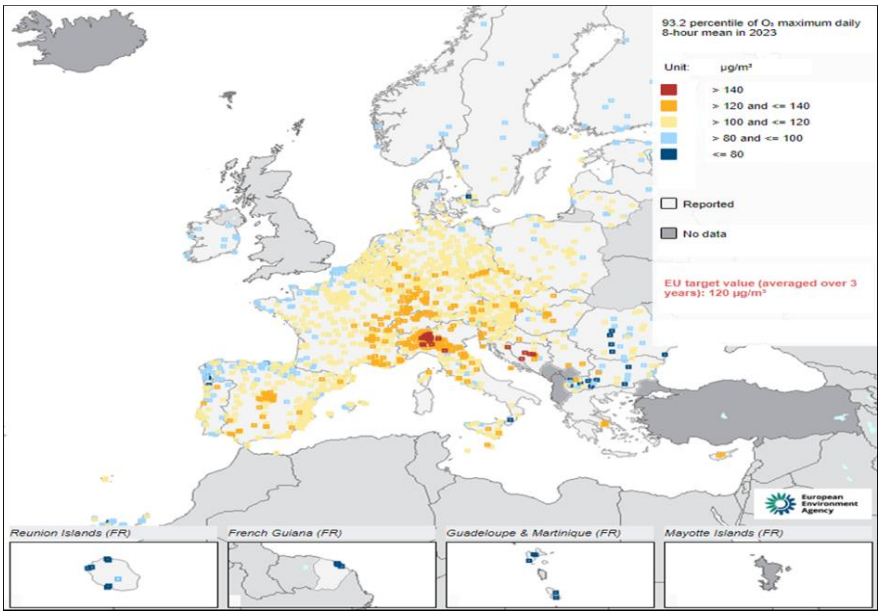

Figure 13: Concentrations of O3 in 2022 and 2023 in relation to the EU target value

Source: EEA's AQ e-reporting database

Table 2: PM10 concentrations in 2022 by selected country (the worst region) in relation to the EU daily limit value (50 µg/m3), average air pollution level

Country	Region	µg/m3	Median in country, µg/m3

Czech Republic	Vernovice	56	33,0
Croatia	Kutina-1	54	30,0
Slovakia	Veľká Ida-Letná	64	35,0
Spain	San Augustín	101	34,0

Source: European Environment Agency. Europe's air quality status 2024

Table 3: PM2.5 concentrations in 2022 by selected country (the worst region) in relation to the EU annual limit value (25 µg/m3), average air pollution level

Country	Region	µg/m3	Median in country, µg/m3
Czech Republic	Ostrava-Radvanice	24	14,0
Croatia	Slavonski Brod	26	12,0
Slovakia	Veľká Ida-Letná	22	14,0
Spain	AGOST	25	10,0

Source: European Environment Agency. Europe's air quality status 2024

Table 4: Ozone concentrations in 2022 by selected country (the worst region) in relation to the EU target value (averaged over 3 years: 120 µg/m3), average air pollution level

Country	Region	µg/m3	Median in country, µg/m3
Czech Republic	Snežník	127	118
Croatia	Pula-Fižela	130	113
Slovakia	Bratislava-Jeseniova	127	110
Spain	Algete	138	107

Source: European Environment Agency. Europe's air quality status 2024

Table 4: NO2 concentrations in 2022 by selected country (the worst region) in relation to the EU annual limit value (40 µg/m3), WHO guideline (10 µg/m3) average air pollution level

Country	Region	µg/m3	Median in country, µg/m3
Czech Republic	Praha 2 – Legerova	40	13,0
Croatia	Zagreb 1	40	16,0
Slovakia	Prešov – arm. gener. L.Svobodu,	32	13,0
Spain	Barcelona L´Eixample,	42	12,0

Source: European Environment Agency. Europe's air quality status 2024

3 CONCLUSION

Air quality is a long-term challenge that must be addressed. Despite progress in many developed countries and regions, air quality in developing areas still needs to improve due to uncontrolled industrialization, rapid urbanization and lack of effective environmental measures. Over the past decades, European countries have focused on reducing pollutant emissions, bringing positive results. Policies such as the EU Air Quality Directive have reduced the concentration of pollutants such as nitrogen oxides (NO2) and fine particulate matter (PM2.5), especially in urban areas. Nevertheless, air pollution remains a problem, especially in more densely populated regions and near industrial centres. Negative health consequences, including respiratory and cardiovascular diseases, continue to persist. Given these challenges,

it is crucial to continue to apply strict environmental regulations and to support the transition to cleaner technologies and renewable energy sources. At the same time, it is important to raise public awareness of the consequences of polluted air and its impact on health. The goal of future measures must be to improve air quality further, not only from the point of view of mitigating climate change but also from the point of view of protecting the population's health and the sustainable development of society. Healthier air contributes to a better life; therefore, its protection is a global priority.

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