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AIR POLLUTION SOURCES AND THEIR IMPACT ON THE ENVIRONMENT

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Abstract. This paper provides an overview of the various sources of air pollution and their impact on the environment and human health, distinguishing between natural and anthropogenic (man-made) sources. The study assessed the environmental impact of these sources – the overall level of air pollution, taking into account the predominant anthropo-genic source, such as emissions from vehicles and industrial activities. The important role of geographic information systems (GIS) in monitoring air pollution, performing spatial data analysis, and identifying pollution hotspots is emphasized. This method proposes to analyze the impact of the air quality result on public health and the environment. The main focus of the study is on the predominant pollutants in the atmosphere such as particulate matter (PM), nitrogen oxides (NO_x), and sulfur dioxide (SO_2). The object of the study was the Old Town of the city of Vilnius. A calculation model was created in the MatLab environment to determine the pollution. The results reveal trends in environmental indicators. In the Old Town, decreasing pollution levels of PM_{10} and CO are observed, and NO_2 remained relatively constant from 2020 the month of January until 2022 December. The primary importance of environmental monitoring depends on government regulation, technological advancements, and public participation to effectively reduce air pollution and protect the environment.

Keywords: air pollution, anthropogenic sources, particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO_2), ozone (O_3), geographic information systems (GIS).

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1. Introduction

The increasing significance of air pollution in recent times is undeniable, as countries worldwide intensify efforts to control, monitor, and respond to its changes. The development of mapping applications, comprehensive reports, and strategic plans signifies a concerted attempt to mitigate the adverse effects of air pollution. This study aims to elucidate the nature of air pollution, its components, and the profound impact these pollutants have on human health and the environment. Through detailed examples, we will highlight the successful strategies implemented by various nations that have led to a positive shift in air quality management by investigate a case of study in Old Town Vilnius, Lithuania. Additionally, this research seeks to enhance awareness and understanding of air pollution, emphasizing the critical need for collective action in preserving our planet.

Air pollution data is divided into anthropogenic and natural sources. Anthropogenic sources encompass emissions from stationary and mobile entities such as factories, vehicles, and ships, as well as activities like agricultural burning, mining, and military operations including nuclear tests. Natural contributions arise from events like wildfires and volcanic eruptions. Additionally, pollution from landfill methane production and the use of aerosols and solvents is notable (Air Quality Index, 2017).

The delineation between natural and anthropogenic sources is crucial for understanding the dynamics of air pollution and devising effective mitigation strategies. This classification is supported by the extensive review of scientific literature, including key references such as the World Health Organization's comprehensive assessments on air quality and health, which elucidate the significant impact of air pollutants on human well-being (World Health Organization [WHO], n.d.-c), the application of Geographic Information Systems (GIS) in tracking and analyzing air pollution patterns is highlighted by studies such as those conducted by showcasing the utility of GIS in identifying pollution hotspots and understanding the spatial distribution of pollutants (Matejicek, 2005).

The purpose of this research is to explore the impact of regulations on air pollution levels. This study examines different pollutants and investigates their concentrations in the Old Town of Vilnius as an example of regulatory effects.

2. Air pollutant sources and datasets

This research is of interest to environmental scientists, policymakers, urban planners, and public health officials who are concerned with air pollution data and its implications for the environment. The study analyses air quality data, including 25,327 records for CO measured in mg/m^3, 25,376 records for NO_2 in μg/m^3, and 24,767 records for PM_{10}, also quantified in μg/m^3. These were collected from January 2020 to December 2022 in the Old Town of Vilnius, providing insights into pollution trends and the efficacy of regulations.

The Old Town of Vilnius, recognized as a UNESCO World Heritage site, is one of the largest surviving medieval old towns in East Northern Europe, covering an area of 3.59 square kilometers. It's a testament to the city's historical and cultural development over centuries, featuring a diverse mix of Gothic, Renaissance, Baroque, and Classical architecture. This part of Vilnius has played a significant role in the cultural and architectural development of Eastern Europe, managing to preserve an impressive array of historical buildings despite invasions and destructions throughout its history (UNESCO Multimedia Archives, n.d.), the dataset com-prises air quality measurements collected from the "Vilnius – Senamiestis" station, part of Lithuania's "National Air Monitoring Network," situated in the old town area of Vilnius. The geographical coordinates of this station are 25.2852° longitude and 54.6776° latitude, falling within the "Senamiesčio seniūnija" municipality. Data were gathered from January 2020 to December 2022, adhering to the UTC+02 timezone. The pollutants measured include PM_{10}, NO_2, and CO. This data was extracted from the European Environment Agency (EEA).

PM_{10} has significant impacts on both human health and the environment. These particles are small enough to penetrate deep into the respiratory tract, reaching the lungs and potentially causing health issues, on the human health side. There are studies shown that exposure to PM_{10} can lead to a range of health problems. These include respiratory and cardiovascular issues, as well as impacts on mental health. For example, exposure to PM_{10} has been linked to increased symptoms of depression and anxiety. The severity of these health impacts depends on various factors including the duration of exposure and the concentration of PM_{10} in the air (Khaniabadi et al., 2017; Petrowski et al., 2021), both PM_{10} and $PM_{2.5}$, pose significant environmental challenges. PM_{10} particles, contributed by natural sources like dust storms and anthropogenic emissions such as SO_2 and NO_2, degrade air quality and visibility, impacting ecosystems and wildlife. This can result in reduced plant growth and broader ecosystem damage (Yousif & Alattar, 2020). Similarly, $PM_{2.5}$ has far reaching effects, persisting in the atmosphere and causing widespread air pollution, even in regions distant from the emission sources. Exposure to $PM_{2.5}$ is linked to serious health issues, including respiratory and cardiovascular diseases. Additionally, $PM_{2.5}$ plays a complex role in climate change, with components like black carbon contributing to atmospheric warming, while others have cooling effects. This dual impact of $PM_{2.5}$ highlights the necessity for comprehensive policies and interventions to mitigate its multifaceted environmental impact (Eljarrat et al., 2020; McDuffie et al., 2021; Paisi et al., 2024).

The environmental impact of CO involves its interaction with various components of the ecosystem. In the atmosphere, CO reacts with hydroxyl radical, leading to its transformation into CO_2. This process is crucial for maintaining CO at stable concentrations despite significant emissions from both natural and anthropogenic sources (Figure 1). Additionally, CO's interaction with the hydroxyl radical in the troposphere is significant for the atmospheric balance of other gases like methane and ozone, indirectly affecting the energy budget of the atmosphere. While CO is not a direct greenhouse gas, its role in atmospheric chemistry makes it a critical factor in environmental health and climate dynamics (Sobieraj et al., 2022; Téllez et al., 2006). SO_2 is emitted from both natural and anthropogenic sources. Despite global efforts to reduce emissions, SO_2 remains a major concern (United States & Environmental Protection Agency, n.d.), particularly in developing countries. Studies have shown that inhaling SO_2 can adversely affect the human respiratory, cardiovascular, and nervous systems. It is also associated with an increased risk of type 2 diabetes and non-accidental deaths. While some evidence suggests that certain concentrations of SO_2 may not have harmful health effects, its combined effects with other air pollutants could be significant (Khalaf et al., 2022), NO_2 contributes significantly to the formation of ground-level ozone and fine particulate matter, which are key components of smog. This not only affects human health but also harms wildlife, damages vegetation, and reduces visibility. NO_2 also contributes to acid rain, which can harm sensitive ecosystems such as lakes and forests, and affect the chemical balance of soil and

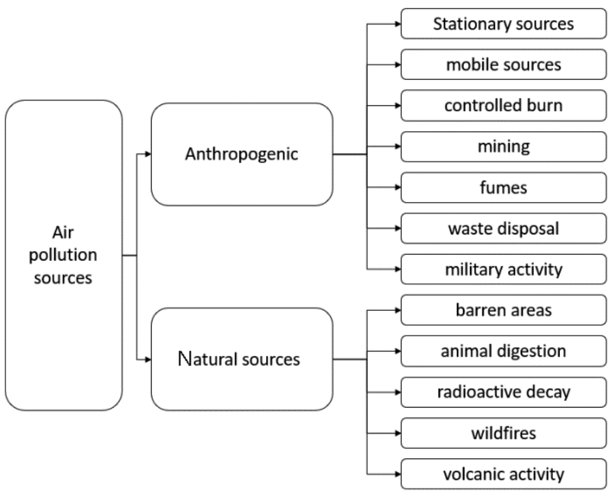

Figure 1. Examples of AP causes (source: the authors)

water bodies, leading to further environmental degradation (United States Environmental Protection Agency, n.d.) as mentioned one of the recent scientific studies on NO_2 have significantly enhanced understanding of this pollutant's behavior and impacts. Research utilizing advanced technologies like TROPOMI satellite instrument on board the Copernicus Sentinel-5 Precursor satellite. The Sentinel-5 Precursor (S5P) is the first of the air quality and climate atmospheric composition planned for a mission of a minimum of seven years. The observations have provided valuable insights into the spatial distribution and variability of NO_2 in urban areas, as exemplified by the study conducted in Paris. This research demonstrates the effectiveness of satellite monitoring in assessing air quality, particularly in densely populated urban environments where NO_2 levels are influenced by various factors including traffic and industrial activities (Lorente et al., 2019), O_3 is a key air pollutant formed from the reaction of volatile organic compounds (VOCs) and nitrogen oxides (NO_x) under sunlight. Its impacts are diverse and significant, affecting both human health and the environment. Health-wise, ozone can cause respiratory issues, exacerbate lung diseases, and impair lung function. Environmentally, it damages vegetation, affects crop yields, and contributes to climate change. Understanding ozone's formation and effects is crucial for air quality management and protecting public health (Wang et al., 2022), Benzo[a]pyrene (B[a]P) is a significant polycyclic aromatic hydrocarbon found in air, water, soil, and sediments, primarily resulting from the combustion of organic matter. Its presence is notably high in cigarette smoke, diesel exhaust, and certain foods, particularly those that are charred or grilled. Humans are exposed to B[a]P through inhalation and dietary intake, leading to various health risks due to its carcinogenic, genotoxic, and pro oxidative properties, B[a]P exposure is associated with reproductive and developmental toxicity. The risk of B[a]P exposure is heightened in certain occupational settings and through tobacco smoke, contributing to a range of adverse health effects (Bukowska et al., 2022).

The research examines air pollution in Vilnius Old Town, utilizing data from over 75,000 records on CO, NO_2, and PM_{10} pollutants gathered between January 2020 and December 2022. Collected at the "Vilnius – Senamiestis" monitoring station, part of the national network, the analysis provides insights into environmental trends and the effectiveness of pollution controls in a historically significant urban area.

3. Health and environmental impacts

The intersection of air pollution with health and environmental impacts is a critical area of study, shedding light on the profound effects pollutants have on human health and ecosystems. Air pollution contributes to a significant number of health issues worldwide, paralleling the detrimental effects of smoking tobacco in terms of its impact on stroke, lung cancer, and heart disease (WHO, n.d.-b). Remarkably, the World Health Organization highlights that nine out of ten people breathe air containing high levels of pollutants, which results in approximately 7 million deaths annually. This alarming statistic underscores the urgency of addressing air pollution to safeguard public health (WHO, n.d.-a).

Further exacerbating the situation, air pollution's reach extends beyond human health, affecting the environment and contributing to climate change. The combustion of fossil fuels, a primary source of air pollution, is also a major driver of climate change, indicating a complex relationship between these two global crises. The health sector, too, is implicated, with hospitals in developed countries being among the most energy intensive buildings, suggesting a need for the health sector to reduce its carbon footprint as part of broader climate change mitigation efforts.

Moreover, the National Institute of Environmental Health Sciences (NIEHS) provides comprehensive insights into the sources and types of air pollution (National Institute of Environmental Health Sciences, n.d.), including traffic-related air pollution (TRAP), which comprises a mix of gases and particles such as ground-level ozone, nitrogen oxides, sulfur oxides, and fine particulate matter. These pollutants are known to cause oxidative stress and inflammation in human cells, laying a foundation for chronic diseases and cancer. The NIEHS's research confirms the continued advancement in our understanding of how air pollution affects health, highlighting the association between air pollution exposure and increased risks of many diseases like.

Cancer: is a broad term for a class of diseases characterized by abnormal cells that grow uncontrollably and have the potential to invade or spread to other parts of the body. Unlike normal cells, cancer cells can evade the body's defense mechanisms, allowing them to grow and divide without restraint (Siegel et al., 2023).

Cardiovascular Disease: This refers to a class of diseases that involve the heart or blood vessels. Cardiovascular diseases include conditions such as coronary artery disease which can lead to heart attacks, cerebrovascular disease leading to strokes, high blood pressure (hypertension), and heart failure, among others. These diseases are often related to atherosclerosis, a condition characterized by the buildup of fatty deposits inside the arteries (American Heart Association, 2023).

Respiratory Diseases: encompass a variety of conditions that affect the lungs and other parts of the respiratory system. Common respiratory diseases include chronic obstructive pulmonary disease (COPD), asthma, pulmonary hypertension, and respiratory infections like pneumonia and tuberculosis. These conditions can significantly impair lung function and breathing (Gould et al., 2023).

Other Health Concerns include a wide range of health issues that can be influenced by air pollution, such as diabetes mellitus, obesity, and reproductive, neurological, and immune system disorders. Exposure to air pollutants can exacerbate these conditions or increase the risk of developing them, impacting overall health and well being, health and environmental impacts of air pollution form a multifaceted challenge that necessitates a concerted effort from global to local levels, integrating policy, research, and public awareness to mitigate the adverse effects on our planet and our health.

4. Air quality monitoring methods

The evolution of air quality monitoring reflects a journey from rudimentary tools to the cutting-edge technologies we rely on today. Initially, air quality monitoring relied heavily on manual methods and chemical analysis to detect and measure the concentration of pollutants in the atmosphere. These traditional methods, while effective for their time, were labor intensive and often limited in scope and precision. With advancements in technology, air quality monitoring has undergone a significant transformation. The introduction of automated monitoring stations marked a pivotal shift, enabling continuous, real time tracking of air pollutants (Ullo & Sinha, 2020). These stations are equipped with advanced sensors that can detect a wide range of pollutants, such as particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide, sulfur dioxide, carbon monoxide, and ozone, among others. The data collected by these sensors is invaluable for assessing air quality, identifying pollution sources, and formulating strategies to mitigate air pollution, furthermore, the advent of satellite remote sensing has revolutionized air quality monitoring by providing comprehensive data on a global scale. Satellites equipped with specialized instruments can now monitor atmospheric composition, offering insights into the distribution, movement, and evolution of air pollutants over vast areas. This capability is crucial for understanding transboundary air pollution and assessing the impact of pollution on climate change (Lee et al., 2016). In recent years, the proliferation of low-cost air quality sensors has democratized air quality monitoring, allowing individuals and communities to collect data on their local air quality. These devices, while not as accurate as professional-grade equipment, provide a cost-effective means for widespread monitoring, raising public awareness and engagement in air pollution issues. GIS technology has become an invaluable tool for air pollution monitoring, enabling precise and dynamic tracking of pollutants across various scales and environments. The use of GIS technology in conjunction with advanced sensing and networking technologies, such as Internet Protocol version 6 (IPv6) and low-cost sensors, has significantly enhanced our ability to monitor, analyze, and manage air quality in real time.

One innovative approach integrates GIS technology with IPv6 to create a high-precision monitoring and early warning system for air pollutants. This system utilizes a combination of hardware and software platforms, including wireless sensor networks that collect data on air pollutant concentrations. These sensors are designed to monitor various air quality indicators, such as CO, NO_2, and O_3 levels, and are integrated with a software platform that provides functionalities for data acquisition, analysis, visualization, and early warning. The system is capable of delivering minute-level observations of air quality, allowing for timely analysis and alarms regarding changes in atmospheric conditions (Yang et al., 2022). This real-time monitoring capability is crucial for the government and environmental agencies to respond quickly to air quality deteriorations and implement effective pollution control measures.

The integration of advanced technologies such as artificial intelligence and machine learning into air quality monitoring systems marks the latest frontier in this field. These technologies enhance data analysis, improve the accuracy of pollution forecasts, and enable the development of personalized air quality alerts, thereby empowering individuals to take proactive measures to protect their health.

5. Methodology

5.1. Data preparation and cleaning phase

In the initial phase of our analysis, we focus on preparing and cleaning the dataset to ensure its accuracy and reliability for our findings. This process begins with data loading, where the dataset, consisting of time-stamped value observations, is imported from a CSV file integrated for analysis. Following this, we convert "Start" timestamps to a DateTime format for temporal analysis and filter out any rows with missing or NaN (Not a Number) values in the "Start" or Value columns to uphold data integrity. Our analysis is then narrowed down to a specific period, from January 2020 to December 2022, to concentrate on the most pertinent and recent data. Finally, outlier detection and removal are conducted using the Interquartile Range (IQR) method, where outliers–defined as values below Q1 – 1.5 × IQR or above Q3 + 1.5 × IQR–are identified and removed to refine the dataset further for analysis.

5.2. Polynomial curve fitting

we embarked on fitting a first-degree polynomial curve to show overall the relationship between time (as the independent variable) and the observed values, thereby exploring the underlying patterns within the data. To achieve this. The selection of the polynomial's degree was informed by the first degree as overall analyses that describe the trends for each dataset the calculations have been held using Matlab. This process is used in the formulation of the curve equation, represented in Equation (1) as:

$$y = p_1 x^n + p_2 x^{n-1} + \cdots + p_n x + p_{n+1}, \tag{1}$$

where $p_1, p_2 \ldots p_{n+1}$ denote the coefficients derived from polyfill, and n signifies the polynomial's degree. Subsequent to determining these coefficients, the polyval function facilitates the evaluation of the polynomial at a continuum of points, thereby generating a smooth curve. This curve, juxtaposed with the original data points, is visually plotted to the trends of the overall dataset trend. Through this meticulous process, we aim to provide a comprehensive visualization and analysis, shedding light on trends within the temporal data.

5.3. Statistical analysis

We quantitatively evaluated the quality of the polynomial fit to the dataset through several key metrics. To assess the average discrepancy between the observed values and those applied by the model, we computed the Root Mean Square Error (RMSE) as Equation (2), alongside the Mean Absolute Error MAE, defined as Equation (3). These metrics collectively offer an evaluation of the model's accuracy and capability and the validity of the polynomial fitting approach in capturing the underlying trends and patterns within the data.

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(y_i - \widehat{y_i}\right)^2}, \qquad (2)$$

where y_i observed value, $\widehat{y_i}$ value by the model, n number of observations.

$$\mathrm{MAE} = \frac{1}{n}\sum_{i=1}^{n}\left|y_i - \widehat{y_i}\right|, \qquad (3)$$

where y_i observed value, $\widehat{y_i}$ value by the model, n number of observations.

6. National and international strategies for air pollution control

International strategies for air pollution control are evident in the collective actions and agreements facilitated by global organizations. The Paris Agreement, focusing on climate change mitigation, indirectly addresses air pollution by advocating for reduced reliance on fossil fuels (Meinshausen et al., 2022). The Convention on Long-range Transboundary Air Pollution (CLRTAP) confirms the importance of cross-border cooperation in Europe for managing air pollutants (Abas et al., 2019). The World Health Organization's Air Quality Guidelines offer a global standard for air quality, influencing national policies. Similarly, the European Union's Clean Air Policy imposes strict air quality regulations on member states.

Within Lithuania, national strategies to combat air pollution are informed by a commitment to adhere to European Union air quality standards, reflecting a harmonized approach to limit emissions from key sectors such as transport, industry, and energy, in the context of Vilnius's Old Town, a traffic regulation initiative, specifically the loop traffic arrangement implemented from July 2020, has been scrutinized for its impact on air quality. This strategy, by mandating one-way traffic along with the installation of prohibitive road signs and barriers, is aimed at curtailing vehicular presence in the area. The move was driven by the necessity to address the air and noise pollution exacerbated by high transit traffic, which at times constituted over 70% of the total traffic during peak hours. The intervention's primary goal was to enhance the living conditions by reducing vehicular emissions, thus contributing to the overall improvement of air quality within this historically and culturally significant locale (Bekesiene & Meidute-Kavaliauskiene, 2022). Based on the Environmental Protection Agency (EPA) of Lithuania's findings, there has been a notable decrease in the average concentrations of several pollutants from 2020 to 2022, as depicted in Figures 2, 3 and 4. These figures illustrate reductions in the levels of Benzo[a]pyrene (B[a]P), PM_{10}, and $PM_{2.5}$. This trend indicates progress in air quality improvement efforts, reflecting the effectiveness of environmental policies and measures implemented during this period, initiatives may include the implementation of stricter vehicle emissions standards, investment in renewable energy sources, and enhancement of waste management systems to curtail air pollutant release. Moreover, Lithuania's efforts to augment urban green spaces and enforce rigorous emissions regulations for industries contribute significantly to its national air quality improvement agenda.

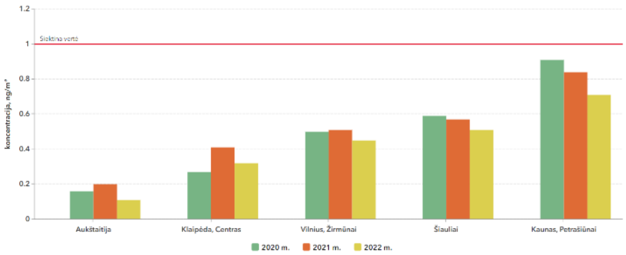

Figure 2. Concentration of BaP in Lithuania (Environmental Protection Agency [EPA], n.d.)

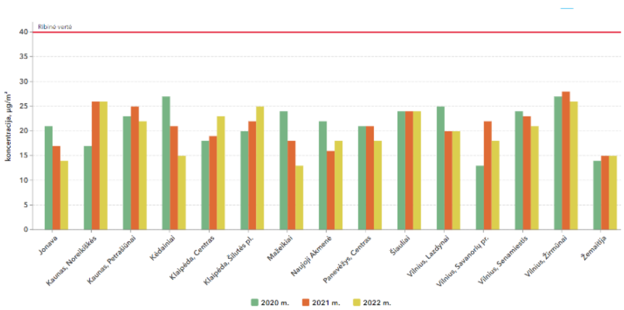

Figure 3. Concentration of PM_{10} in Lithuania (EPA, n.d.)

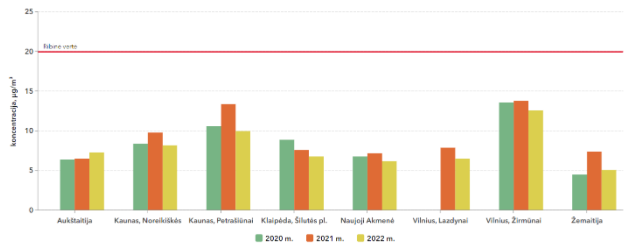

Figure 4. Concentration of $PM_{2.5}$ in Lithuania (EPA, n.d.)

7. Results and discussion

Our analysis of the air quality parameters revealed discernible trends over the selected period from January 2020 to December 2022. Specifically, we observed a downward trend in the levels of nitrogen dioxide (NO_2), particulate matter (PM_{10}), and carbon monoxide (CO), indicating an improvement in air quality over time. The simplest model to describe whether the data values decrease or increase overall is indeed a linear (first-degree polynomial) model. Figure 5 depicts the concentration and the estimated polynomial curve for PM_{10}. This type of model can effectively capture a trend over time, with the slope indicating the direction and rate of change. PM_{10} concentrations were modeled with the equation:

$$y = -0.0060 * x + 4413.2545$$

while x is a time serial number the RMSE of 7.9644 μg/m^3 and an MAE of 6.3808 μg/m^3.

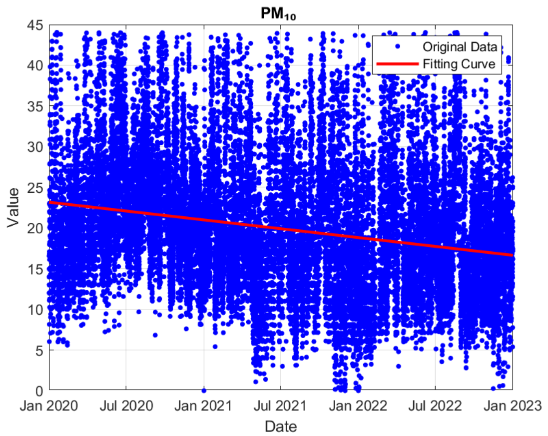

Figure 5. Estimated polynomial curve of PM_{10} pollution in the Vilnius Old Town

For CO Figure 6 represent the fitted polynomial curve. The RMSE was 0.095107 mg/m^3, and the MAE was 0.076629 mg/m^3, indicating the average discrepancy between the observed data points and the values predicted by the model.

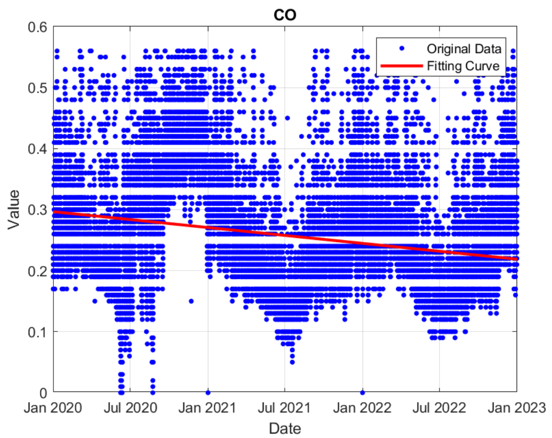

Figure 6. Estimated polynomial curve of CO pollution in the Vilnius Old Town

NO_2 data fitted a polynomial curve is illustrated in Figure 7 with the RMSE and MAE. The results were 8.7975 μg/m^3 and 7.0939 μg/m^3, respectively.

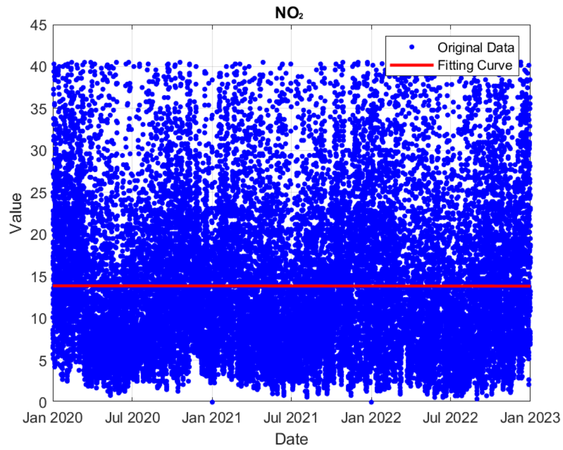

Figure 7. Estimated polynomial curve of NO_2 pollution in the Vilnius Old Town

The decreasing coefficients of the time variable x in each polynomial equation indicate a downward trend in pollutant levels over time.

8. Conclusions

The study delves into the escalating issue of air pollution, focusing on pollutant types, their health and environmental impacts, and the mitigation efforts in Lithuania and globally. We differentiate between natural and human-made pollutants, highlighting the severe health risks associated with PM_{10}, $PM_{2.5}$, CO, O_3, BaP, and NO_2, alongside their environmental damage. Advances in monitoring technologies, such as satellite remote sensing and AI, have enhanced our response capabilities to air quality challenges.

Lithuania's strategies, aligned with EU directives, exemplify national efforts of international cooperation, underscored by initiatives in many key sectors such as transport regulations underlines the critical need for continuous improvements in policies, technology, and collective action to combat air pollution effectively. Our focused advocates for an approach to ensure a healthier, sustainable future, emphasizing the significant progress made and the ongoing need for enhanced efforts globally.

The analysis of linear model analyse data from Vilnius Old Town reveals trends in environmental indicators. There's a noted decline in PM_{10} with a slope of –0.0060, and a slight decrease in CO levels, indicated by a slope reduction of –0.0001. Additionally, NO_2 levels have maintained a relatively steady state from January 2020 to December 2022. These findings highlight the importance of basic environmental monitoring and emphasize the need for stricter regulations to further reduce air pollution.

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ORO TARŠOS ŠALTINIAI IR JŲ POVEIKIS APLINKAI

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Santrauka

Šiame darbe pateikiama įvairių oro taršos šaltinių ir jų poveikio aplinkai ir žmonių sveikatai apžvalga, išskiriant natūralius ir antropogeninius (žmogaus sukurtus) šaltinius. Tyrime įvertinta šių šaltinių įtaka aplinkai – bendras oro taršos lygis, atsižvelgiant į vyraujantį antropogeninį šaltinį, pvz., transporto priemonių išmetamus teršalus ir pramoninės veiklos atliekas. Pabrėžtas svarbus geografinės informacijos sistemų (GIS) vaidmuo stebint oro taršą, atliekant duomenų erdvinę analizę ir nustatant taršos židinius. Šiuo metodu siūloma analizuoti oro kokybės rezultato poveikį visuomenės sveikatai ir aplinkai. Atliekant tyrimą pagrindinis dėmesys skirtas vyraujantiems atmosferoje teršalams, tokiems kaip kietosios dalelės (PM), azoto oksidai (NO_x) ir sieros dioksidas (SO_2). Tyrimo objektu pasirinktas Vilniaus miesto senamiestis, taršai nustatyti sudarytas skaičiavimo modelis *MatLab* programos aplinkoje. Rezultatai atskleidžia aplinkosaugos rodiklių tendencijas. Senamiestyje pastebimas mažėjantis PM_{10} ir CO taršos lygis, o NO_2 kiekis nuo 2020 m. sausio mėn. iki 2022 m. gruodžio mėn. išliko gana pastovus. Aplinkos stebėsenos svarba labiausiai priklauso nuo vyriausybės reguliavimo, technologijų pažangos ir visuomenės dalyvavimo siekiant veiksmingai sumažinti oro taršą ir apsaugoti aplinką.

Reikšminiai žodžiai: oro tarša, antropogeniniai šaltiniai, kietosios dalelės (PM), azoto oksidas (NO_x), sieros dioksidas (SO_2), ozonas (O_3), geografinės informacinės sistemos (GIS).