THE INFLUENCE OF THE TREND OF URBAN GROWTH OF CITY OF NOVI SAD ON AIR QUALITY IN PARKS

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Abstract

Quality control of air in urban green areas - urban parks are rarely studied spaces, and this paper is based on research on the effects and impacts of microclimatic parameters on the detected suspended particles (PM 2.5 and PM10) with a multidisciplinary influence on public health and the quality of life of Novi Sad citizens. Excessive urbanization of urban environments and global migrations are among the most important causes of increased concentrations of air pollutants, even in urban green areas such as parks. This scientific research is part of a project focused on the effects and discrepancies of microclimatic parameters on detected concentrations of total suspended particles in the city's green parks in Novi Sad. Three urban parks of different sizes and locations with varying microclimatic influences were selected. Measurements of suspended particles (PM) were conducted at Futoški Park (FP), Dunavski Park (DP), and Limanski Park (LP) using a mobile device Aeroqual Series 500. At each location (FP, DP, LP), 10 measurements of suspended particle concentrations were conducted, with the device reporting changes in detected particle concentrations in real time. The results of the measured concentrations of suspended particles indicate variations in detected particle concentrations, with PM2.5 ranging from 4 to 36.1 μg/m3, while PM10 was detected in the range of 7 to 40.1 μg/m3. The measurement period for suspended particle pollution ranged from 12:00 to 17:30, with measured temperature fluctuations from 24.1 to 30.0°C and measured relative humidity oscillating between 39.1% and 54.4%.

Keywords: air quality, suspended particles PM 2.5 μm and PM10 μm, parks, city of Novi Sad, urban growth.

Introduction

According to reports from the World Health Organization (WHO), approximately 90% of the world's population lives in areas that exceed the concentrations deemed safe in prescribed air quality guidelines [1]. Particulate matter (PM 2.5 and PM10) in the air is highly respirable and, as such, very harmful to human health. In recent times, it has garnered significant attention from experts, legislative and regulatory bodies, as well as non-governmental and civil sectors, along with the general public [2].The significant global migrations and the increase in the population are accompanied by urbanization and economic activities. According to United Nations projections, 68% of the world's population will live in cities by 2050. Therefore, it is crucial for cities to implement adequate measures to protect the health of their residents and the environment, as these areas are closely interconnected [3]. This trend of urbanization and population migration is also evident in the city of Novi Sad, which serves as the administrative center and seat of the autonomous province of Vojvodina. Atmospheric particles (PM - particulate matter) represent microscopic suspended particles in Earth's atmosphere, consisting of solid or liquid matter. Anthropogenic particles are formed during combustion processes, such as diesel fuel soot, during photochemical reactions like urban smog, from vehicle exhaust emissions, industrial facilities with high-temperature processes, coal-fired power plants,

foundries, steel mills, internal combustion engines, waste incineration, as well as from the resuspension of dust originating from construction sites [2].
Clean air is a fundamental need for every human being, especially in urban ecosystems where lifestyle and high population density lead to a rapid increase in the number of passenger cars and urban public transport on city roads, accompanied by a rise in the construction industry and the number of construction sites. If we consider all the negative impacts on air quality in urban environments, we can identify the benefits of improving public health and reducing pollutants of anthropogenic origin (urban traffic, industry, construction sites, and others). Knowing that the most numerous visitors to city parks are children and elderly individuals, who represent the most vulnerable groups that are most affected by polluted air, measurements of air pollution with suspended particles PM2.5 and PM10 in these locations are crucial. This is particularly important because such measurements are not covered within the framework of the national air quality monitoring in Novi Sad.

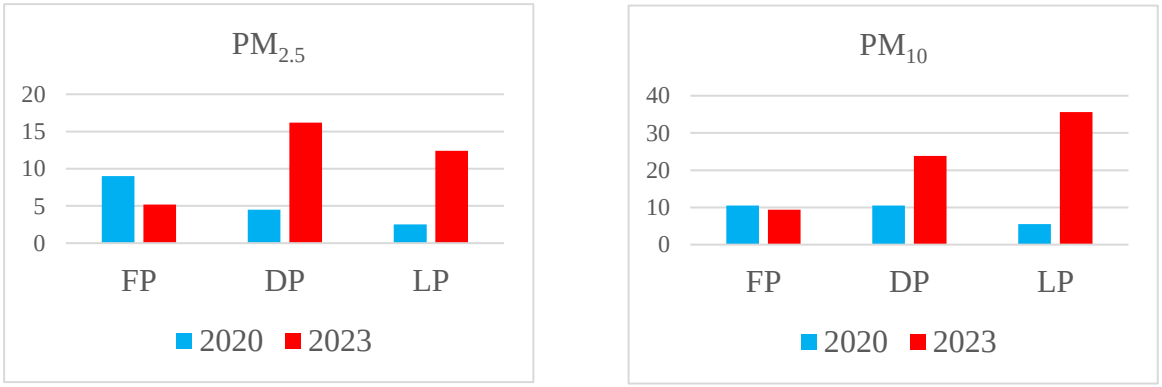
Experimental

For indicative air quality measurements, we used the mobile device Aeroqual Series 500 - monitor, which measures and records changes in pollution levels in real-time. This device operates based on the use of semi-permeable sensors that are sensitive to various particles and gases. This technology combines smart measurement techniques and semiconductor sensors based on metal oxides that exhibit changes in electrical resistance in the presence of the measured gas. The sensors are housed in a replaceable sensor head that connects to the base of the monitor. Each sensor head contains only one gas or particle sensor. The sensor head uses a built-in fan for active sampling, directing air towards the sensor, after which the air exits on the opposite end. The device utilizes a long-lasting lithium battery. The device's screen displays the minimum, maximum, and average values of the measured gas in ppm or mg/m3 [8]. The sensor head for measuring PM2.5 and PM10 particles has the following characteristics: the measurement range is from 0.000 to 1.000 mg/m3, with a laser particle counter, a minimum detection limit, and a resolution of 0.001 mg/m3. The accuracy is ± (0.002 mg/m3 + 15% of the reading). The sensor head operates at temperatures between 0 and 40°C and air humidity of 0 - 90% without condensation [9].

For this research, air quality measurements of particulate pollution PM2.5 and PM10 were conducted in three city parks that are considered natural monuments and are under state protection. The selected parks vary in size, occupying different areas, and are located in different parts of the city, each surrounded by varying levels of traffic frequency. These parks were included in the study with the aim of assessing air quality, detecting possible pollution, and comparing the results with measurements from the year 2020 [2]. The research aims to propose measures for further reducing potential environmental pollution and influencing more aggressive greening efforts on other public areas in the city, including the construction and development of new city parks.

Table 2 Average values of measurements

	Temperature (°C)		Relative humidity (%)		$PM_{2.5}$ ($\mu g/m^3$)		PM_{10} ($\mu g/m^3$)	
Location	2020	2023	2020	2023	2020	2023	2020	2023
FP	18.35	28.35	48	42.65	9	5.2	10.5	9.4
DP	22.1	24.3	41.5	53.6	4.5	16.2	10.5	23.8
LP	22.5	25.16	41	48.77	2.5	12.4	5.5	35.6



Picture 1 Comparision of particulate matter average values

Results and discussion

The benefits of spending time in urban nature/city parks are significant for both physical and mental health. There are several hypotheses regarding the positive effects of being in nature on the human body, especially for modern individuals who often lack the time to venture into natural settings during their workweek or weekends. Improving air quality can result in sustainable health benefits, including reducing air pollution levels, which can lead to a decrease in premature deaths and diseases such as stroke, heart disease, lung cancer, and chronic and acute respiratory illnesses, including asthma. Implementing sustainable environmental policies to reduce air pollution and mitigate climate change can yield multiple interdisciplinary benefits for urban residents, especially in the transportation, industry, and construction sectors. These benefits include noise reduction and more. Environmental air pollution, both ambient and indoor air, is gaining increasing importance in the healthcare sector every year, particularly when polluted air represents a significant ecological risk to human health, alongside climate change. Each year, it is responsible for nearly 7 million deaths that can be attributed to global causes [1].

By analyzing the measured average values of suspended particles in the city parks, specifically at the locations FP, DP, and LP, in the year 2023 and comparing them with the results from 2020, the following conclusions can be drawn:

1. In FP, the measured values of PM2.5 and PM10 have decreased compared to 2020. PM2.5 values exhibited a more dominant drop, decreasing by 43,3%, while PM10 values decreased by 11,7%.
2. In DP, the values in 2023 have increased compared to 2020. PM2.5 values have risen by a factor of 3.6 and PM10 values have exhibited nearly identical growth, increasing by a factor of 2,26.
3. In LP, there has been an increase in PM2.5 values by a factor of 4.96, and PM10 values have increased by a factor of 6,47.

All the measured values of PM2.5 and PM10 in 2023 were within the time range of 12:00 to 17:30, with measured average temperature fluctuations between 24.30°C and 28.30°C, and relative humidity oscillations ranging from 42.65% to 53.36%. In 2020, the average temperature fluctuations were between 18.35°C and 22.5°C, and the measured average relative humidity oscillated between 41% and 48%. The comparison between data from 2020 (a year marked by COVID-19 with restrictive measures promoting reduced human activities) and 2023 reveals a significant increase in particulate air pollution in 2023, especially when considering the measured values for DP and LP. However, FP experienced a decrease in the concentration of PM2.5 and PM10.

These noticeable differences in suspended particle concentration are the result of multiple factors, including: 1. Park Location: Parks located near major urban thoroughfares with intense motor vehicle traffic and lacking adequate protective green barriers or tree lines on the street side of the park to shield against vehicular exhaust pollution and noise. 2. Population Growth: An increase in the number of residents over the last three years, which has been accompanied by a rise in the number of passenger vehicles on city roads. 3. Construction Sites: The presence of construction sites, which can contribute to air pollution. 4. Climate Change: The presence of climate change effects, such as rising temperatures, increased humidity, and moderately gentle winds. These conditions can also contribute to increased particulate pollution, although not to the same extent.

These factors, combined with the absence of restrictive measures like those implemented during the COVID-19 pandemic, have likely contributed to the observed increase in particulate air pollution, especially in DP and LP. It emphasizes the importance of ongoing efforts to monitor and mitigate air pollution in urban areas. FP, in 2023, shows reduced particle pollution levels compared to measurements taken in 2020, which can be explained by its advantageous location. This park, of medium size relative to other city parks, is enriched with a substantial number of trees and shrubs with extensive canopies that serve as an effective green barrier. These natural features diminish the potential transmission of particle pollution from nearby roadways and adjacent residential areas. The abundant presence of canopy and shrub vegetation within the park creates a robust green barrier, and the park itself acts as an isolated protected ecosystem. These factors, along with favorable climatic conditions, contribute to the reduction of particle pollution. DP, considered the most beautiful urban park located in the city center, exhibits a remarkable surge in the levels of PM particles detected in 2023 compared to measurements taken in 2020. This alarming increase can be attributed to the substantial presence of suspended particles originating from nearby major roadways, as well as the immediate vicinity of two large construction sites (the construction of two extensive underground garages and individual residential unit projects). Additionally, the park's proximity to the Danube River may also play a role in this rise in particle concentration. LP, in terms of its surface area, is the largest compared to the previous two parks. Its location and the proximity to major roadways, extensive vegetation, and the Danube River, along with several nearby construction sites, directly contribute to the detected significant increase in suspended particle levels in 2023 compared to 2020.

Conclusion

Monitoring air quality in urban areas is becoming increasingly important, with a particular focus on urban locations that lack automatic stations for measuring and directly monitoring air quality. The rise in air pollution from particulate matter serves as an alarm for taking necessary measures in terms of early warning and preventive actions. The data presented in this study highlights the significance of this research for the public health of the urban population and the need for installing more monitoring stations in city locations not covered by national, local,

regional, and national networks. The focus of this study is on air quality in urban parks to provide better information on air quality and recommendations for spending time in urban green oases. It's essential to enhance and empower the advantages of the flat terrain and expand the existing 100 km of cycling lanes in Novi Sad, suitable for eco-friendly means of transportation. An increasing number of Novi Sad residents opt for bicycles, and the 40,000 residents who currently use them must be a driving force for further investments in new cycling lanes, especially as electric scooters are on the rise. Consistent enforcement of legal and sub-legal acts, sound urban planning, and a multidisciplinary approach to expanding green spaces in cities aim to promote and improve physical activity as a healthy lifestyle and, of course, enhance public health for the urban population of Novi Sad.

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