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SMART CITY SOLUTIONS AND THE AIR QUALITY IN THE COVID TIMES – CASE STUDY OF BRATISLAVA

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The aim of the paper is to determine the status of adoption of smart city initiative in Bratislava, capital of Slovakia, in relation to the air quality in the context of the current COVID-19 pandemic and its cost. Consistent with recently published studies, the results of our analysis did not show a significant improvement in all pollution parameters. The only significant improvement was observed for the NO_2 pollutant. Following this fact, the results of an informant interview with the city of Bratislava can be interpreted, which unfortunately confirmed that the city lags significantly behind smart solutions to support air quality, although the pollution rate in Bratislava is relatively high and did not decrease significantly during 2020. Moreover, the economic costs of the effects of pollution are higher than its prevention.
Key words: smart environment, smart city, air quality, pollution cost, Bratislava, COVID-19
JEL: Q50, Q53

1 INTRODUCTION

Congested traffic, constant traffic jams, poor quality of the environment, lack of housing – these are just some of the main problems that plague the capital of Slovakia, Bratislava. The population of cities is growing, as well as daily commuting to work places. This increases the pressure on existing infrastructure and brings not only

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discomfort but also economic losses. The ever-increasing number of cars in cities is contributing to the deterioration of air quality. In addressing these and many other problems, cities across the world are adopting different solutions within smart cities concepts. Smart City is an approach to the development of cities and urban regions, their management and planning aiming to provide the urban quality of life. By 2013, more than 140 cities around the world had launched their Smart City strategy. At the beginning of 2014, 240 European cities with more than 100 000 inhabitants had such a strategy, and this growth continues. In 2017, already almost all Western European cities applied comprehensive solutions of their own Smart City concept. Despite the fact that the concept of smart city has been alive for almost 20 years, in recent times many places have been moving from theory to reality, i.e. to the applications of individual models. This is also the case in Slovakia, where the issue of smart cities has long been in the background. It must be emphasized that the speed of response to ongoing global urban change also depends to some extent on the size of the city. However, smart city is not just a concept of big cities, although we perceive the mentioned problems more intensively in these.

The presented article focuses on the adoption of smart city initiatives in the capital of Slovakia, Bratislava. Specifically, it deals with one of the city's most serious problems, and that is air quality. Even with regard to the current pandemic, it has been shown that air quality has improved significantly in most cities, mainly as a result of reduced traffic - especially passenger traffic. On the other hand, anti-pandemic measures and lockdowns have required an increase in local government spending and changed the focus on critical areas. Our goal is to find out the progress in the adoption of intelligent solutions in connection with the improvement of air quality in Bratislava in the context of the current pandemic.

2 LITERATURE REVIEW AND THE CHARACTERISTICS OF BRATISLAVA

Just as there is no doubt that still no single acceptable definition of smart city exists (Ristvej, Lacinák and Ondrejka, 2020), there is no doubt that most of the literature agrees that the concept of smart city can be identified with the adoption of smart technologies to improve and enhance city life. Smart city is strongly related to urban growth. The issue of urban growth had been addressed in the literature before we encountered the concept of smart city. Smart city concept thus naturally followed up on theories of urban growth (Caragliu, Del Bo and Nijkamp, 2011). It consists of six main dimensions which form a unified image of a modern and sustainable city – namely smart economy, smart mobility, smart environment, smart people, smart living and smart governance (Moura and de Abreu e Silva, 2019). Other authors also add a seventh dimension – smart architecture (Giffinger et al. 2010, Stübinger et. al. 2020, Cantuarias-Villessuzanne et. al, 2020). Many of the approaches are bottom-up and they arise from experience with certain problems (Dameri, 2017). Smart city is moreover a multidisciplinary paradigm (Betis et al., 2018). Even the concept of smart city has not

been without criticism, especially as far as ICT is concerned. Hollands (2008) for example points out criticism for the dominance of the entrepreneurial version of smart city concepts, relying blindly on ICT instead of people. Today, therefore, academic research is beginning to place much more emphasis on a people-centered approach, because smart city has primarily served to improve the quality of life of people in cities.

One of the dimensions of the smart city concept is the smart environment (Orlowski and Rosinka, 2018). Green technologies can have a direct impact on the urban environment when actively cooperating with people (Radovic et al, 2021). Within the smart city concept, smart environment uses ICT to manage natural resources of the urban area – air quality, green spaces, natural resources, urban biodiversity. The state of the urban environment is the result of many factors, as a city or urban area is an ecosystem which is an interactive organism involving various interdependencies. Smart environment usually tries to cope with the most negative impacts on human life in the city, such as increasing level of carbon emission and worsening the air quality (due to growth of citizens and the transportation); increase of produced waste (and the problems of recycling problem and waste management) and the worsening of water resources quality (illegal dumping, an ageing infrastructure of water pipes) (Thorpe, 2018).

In bigger cities, air pollution is mostly caused by PM2.5 and PM10 particles. Both particles are part of the traffic exhaust gases, street du, asphalt, tires and brakes of cars or results from burning the wood. In addition, these particles are transportable through long distances. It is already scientifically proven that the high concentration of these ultra-fine particles, especially long-term exposure to this pollution, for example in city life, causes several diseases of civilization – allergies, cardiovascular diseases and lung diseases, including cancer. These particles can also carry other contaminants or allergens. As most of this pollution comes from transport, the solution to improving air quality is precisely measures that seek to reduce transport. Here we see a clear intertwining of the individual dimensions of a smart city, which cannot be separated from each other. Smart transport – i.e. measures to make transport more efficient, which is to become more pleasant for the population, is also an indirect tool of the smart environment dimension.

2.1 Main characteristics of Bratislava

The capital of Slovakia, Bratislava, lies in the west of the country in the Danubian Lowland, on the border with Austria. Its strategic location lies at the crossroads in good transport accessibility and close to other world capitals, especially Vienna (65 km), Budapest (200 km) and Prague (330 km). The number of citizens represents 432 864 (Statistical Office, 2020), but together with the suburbs, the number increases up to 600 000 citizens. If we count the daily commuters, we get to the number 730 000. The population density is about 1 163,53/km^2. Green area represents 13 000 ha. Bratislava is the center of job offers in Slovakia. Their sufficiency causes many people to come to the capital for the so-called weekly shifts, as significant regional differences in Slovakia do

not allow people to work in some parts such as the south of central Slovakia or the east Slovakia. Although the concentration of labor supply in the capital is not unusual, it is undesirable to the existing extent, because in addition to the pressure on the real estate market, transport, air pollution also creates the problem of depopulation of some areas. In addition to several key industrial companies that belong to the critical infrastructure in Slovakia (such as the oil company Slovnaft, power plants, waterworks, the Volkswagen car concern), there are also 41 Shared Service Centers in Bratislava (out of 65 in Slovakia) (SARIO, 2019).

2.1.1 Traffic

As for the traffic characteristic, there are 322 753 cars and 880 public transport vehicles registered in Bratislava (Statistical Office, 2020b). Of the public transport vehicles, 524 buses have the largest share, followed by 162 trolley buses and 194 trams. The high share of bus transport and the low share of rail transport is an important milestone in improving public transport in the capital, as buses are also among the vehicles which, together with passenger cars, are the main air pollutants in terms of transport. Bratislava does not have a built metro. One of the busiest arteries is the intersection of Trnavské mýto and Krížna street in the city center. Measurements of the Slovak Hydrometeorological Institute regularly show alarming air quality here.

2.1.2 Environment

There are 2 national nature reserves and 9 natural reserves in Bratislava. Protected areas (14), natural monuments (4) are also important natural resources. The most important watercourses include the Danube and Little Danube rivers and the Morava river. Lakes, gravel pits and natural reservoirs as well as wetlands of a rare protected area of floodplain forests are important water features. Bratislava has 6 water reservoirs, which are used for recreation and relaxation.

2.1.3 Air quality

The most polluting substances in the capital are emissions of sulfur dioxide, nitrogen oxides, carbon monoxide and solid pollutants. The average value of emissions of sulfur dioxide in tones for 2020 was 3 332, emissions of nitrogen oxides 2 624, and emissions of carbon monoxide 660 tones. As for the solid pollutants, the total amount represented 129 tones (Statistical Office, 2020b). In addition to emission values, the concentration of ultra-fine particles concentration is also important. The pollution in Bratislava is mostly caused by PM2.5 particles. This is due to the fact, that Bratislava region is quite heavily industrialized. Slovnaft, or Volkswagen are among the biggest polluters. However, the main cause of current air pollution is emissions from domestic heating and transport emissions as well as high background concentrations (pollution where it is not possible to directly determine the source of emissions). PM10 particles, which represent street dust, are also significant polluter in Bratislava, especially on the main roads.

2.1.4 Housing

As for 2020, there were 223 394 apartments in Bratislava, out of which 11 321 were under construction (Statistical Office, 2020a). Housing construction in Bratislava is quite stagnant, there is a shortage of flats, demand is higher than supply, which keeps flat prices at a multi-year maximum. For comparison, in 1975, 22 flats per 1000 inhabitants were completed in Bratislava; in 1985, 14 flats per 1000 inhabitants; and in 2019, this number represented 6.5 flats per 1000 inhabitants (Statistical Office, 2020b). The most densely populated parts of the city are Staré mesto, Karlova Ves, Dúbravka, and Petržalka followed by Ružinov, Nové Mesto and Vrakuňa.

2.1.5 Economic activity

There are currently 71 038 companies operating in Bratislava, of which 32 478 are self-employed (Statistical Office, 2020b). In terms of establishment, limited liability companies make up the highest percentage. In terms of focus, professional, scientific and technical activities (i.e. work with higher added value), wholesale and retail trade, information and communication technologies, real estate activities, construction and industrial production predominate. Micro enterprises and small enterprises with up to 50 employees have the largest representation. As of 31 December, a total of 354 155 natural persons were employed in Bratislava. The average nominal monthly wage was 1 713 euros for men and 1 474 euros for women. However, it should be noted here that many employees do not even reach this gross wage. For perfuming, the average nominal monthly wage in Slovakia was 1 113 euros. The highest earnings are achieved by employees in the information and communication technology sector.

2.1.6 Tourism

The tourist capacity represents 279 accommodation facilities, which together provide 8 427 rooms. 1 395 896 tourists visit Bratislava every year, of which up to 69% are foreign tourists. The capacity of accommodation occupancy in 2019 was just over 40%. Unfortunately, the coronavirus pandemic has hit tourism in Bratislava very significantly (several cultural and social events and traditional Christmas markets have not taken place) – however, the processed statistical data are not yet available.

2.2 Bratislava smart city ranking

The smart city ranking was developed by International Institute for Management Development (IMD). In 2019, Bratislava ranked on the 76th place out of 102 rated cities. It´s overall rating is CC (out of the range AAA-D; Bratislava belongs to the 3rd quartile) (IMD, 2020). This result is, of course, extremely unsatisfactory for the capital of Slovakia. The ranking consists of five main components – health, mobility, activities, opportunities and governance. However, estimates of a year-round decline in tourist visits reach more than 50%. Bratislava lags behind especially in air quality, low-quality transport and persistent traffic jams as well as weaker digital services for the population, thus lacking the active involvement of the population in the process of creating a smart city.

3 METHODS

The purpose of this research is to find out the progress in the adoption of intelligent solutions in connection with the improvement of air quality in Bratislava in the context of the current pandemic. The methodology of the research considers three steps. In the first two chapters we introduce the literature review on the concept of smart city with the relevance to smart environment dimension of smart city. We characterize Bratislava in the context of traffic, environment, air quality, housing, economic activity and tourism because knowledge of these basic parameters is a key starting point for understanding the position of the city in the Slovak economy as well as for understanding the problems that the capital has been facing for a long time and cannot yet solve them effectively.

In the following sections we focus on the empirical research, specifically, the second step in the methodology is the analysis of the current state of air pollution with respect to the most common polluters, namely nitrogen dioxide $PM_{2,5}$ and PM_{10} particles. We compare the change in air quality with the period before the pandemic. Data from the European Environmental Agency (measured by the Slovak Hydrometeorological Institute) were used, which measures air quality in the capital at 4 measuring stations. In our analysis, we compare the development of the concentration of monitored pollutants, specifically NO_2, $PM_{2,5}$ and PM_{10} particles. We focus on weekly daily values in 2020, which we compare with daily average values measured in 2019. Our objective is to answer the basic question, namely whether and how the established lockdown affected the air quality. We determined the significance in differences in concentration of selected pollutants in 2019 and 2020 by conducting a pairwise t-test with normalized log-transformed data. The null hypothesis assumed that the true mean difference between the paired samples was zero, while the alternative hypothesis assumed that the true mean difference between the paired samples was not equal to zero. We chose $\alpha = 0.001$ to determine statistical significance. For each pollutant, we focused on the five standard periods during the year – pre-lockdown, 2 lockdown periods, 2 post-lockdown periods, namely:

1. pre-lockdown period; 1 January–12 March 2019 / 1 January–12 March 2020;
2. lockdown 1 period;13 March–5 May 2019 / 13 March–3 June 2020;
3. post-lockdown period; 6 May June–23 October 2019 / 6 May June–23 October 2020;
4. lockdown 2 period; 24 October – 30 November 2019 / 24 October – 30 November 2019;
5. post-lockdown 2 period; 1 December – 31 December 2019 / 1 December – 31 December 2020.

In terms of the dispersion of pollutants in the air, the most relevant meteorological parameters are wind speed, humidity and thermal stratification of the atmosphere. We considered these parameters when comparing the weather condition in 2019 and 2020 to be able to distinguish air quality analysis from possible meteorological impacts. Comparison of indicators between years did not show statistical significance at the $\alpha = 0.05$.

In the third part we apply the method of key informant interview. The key informant interview is a method of data collection that involves interaction (verbal) between the researcher and the specialist in the field of study (Allen, 2017). The purpose of the conducted key informant interview was to collect valuable data and information regarding the application of smart environment solution in order to reduce the air pollution and thus to improve the quality of environment in Bratislava. The questions of the informant interview were designed to take into account information on already implemented projects, projects that are currently being implemented as well as planned projects. The aim of the interview was to determine the effects of the pandemic on the municipal budget for the implementation of these projects and the perception of changes in air quality due to traffic reduction, which came naturally as a result of several lockdowns.

Below are the questions of the key informant interview that we asked the City of Bratislava in February 2021:

1. What does the discussion and priorities of Bratislava in the field of air quality within the concept of smart city look like?
2. Do you see any changes in these priorities due to the ongoing coronavirus pandemic?
3. Have certain projects been suspended due to the pandemic? What is the expected date of their recovery?
4. Does the capital have any air quality solutions within the smart city concept? Have they already been implemented? At what stage of implementation are the planned ones?
5. What steps does the city plan to take in order to ensure the ecological and sustainable mobility of the population? In what time horizon? Have the approximate costs been quantified?
6. How does the municipality plan to motivate citizens to move from cars to public transport?
7. Does the capital intend to promote the concept of smart city more in order to raise citizens' awareness of its (not only) environmental aspects?

4 RESULTS

Limit values of polluting particles in Slovakia are regulated by Decree 244/2016 Coll. (as amended by No. 296/2017 Coll., 32/2020 Coll.). Limit values for the protection of human health and the dates of their achievement are given in Table 1.

Table 1: Limit values for pollutants

Pollutant type	***Period***	***Limit value***
PM_{10}	1 day	50 µg / m3 must not be exceeded more than 35 times per calendar year
	1 year	40 µg / m3
$PM_{2,5}$	1 year	until 1 January 2020: 25 /g / m3 from 1 January 2020: 20 /g / m3
NO_2	1 hour	200 µg / m3 must not be exceeded more than 18 times per calendar year
	1 year	40 µg / m3
CO	The highest daily 8-hour mean	10 mg/m3
SO_2	1 hour	350 µg / m3 must not be exceeded more than 24 times a calendar year
	1 day	125 µg / m3 must not be exceeded more than 24 times a calendar year

Source: Decree 244/2016 Coll.

Although the concentration of harmful substances regularly increases in the winter months and vice versa, in the summer months it reaches the lowest concentration, in 2020 there is a decrease to some extend in the concentration of measured pollutants in the air that can be observed at all measuring stations in Bratislava.

4.1 NO_2

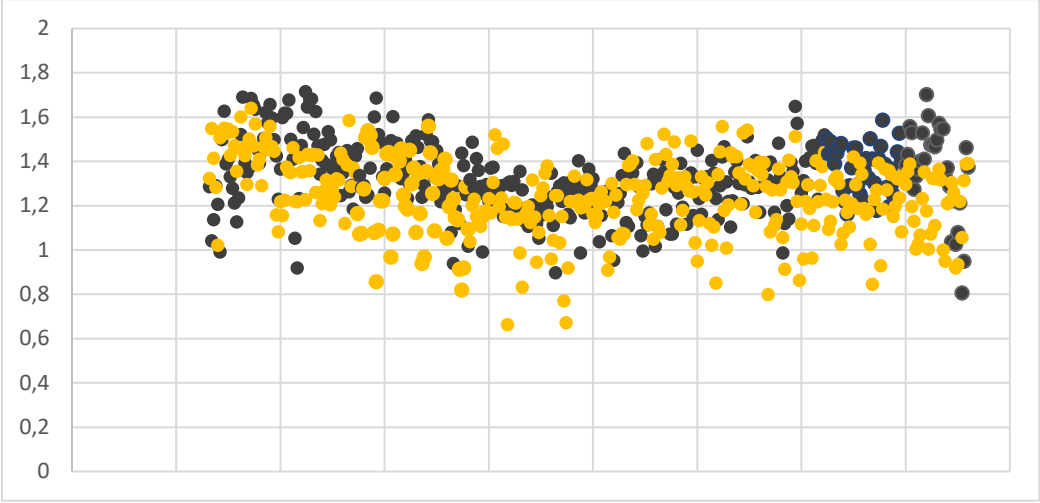
As for NO_2 concentration, comparing 2019 and 2020, changes in concentration for the pre-lockdown period are not statistically significant at the $\alpha = 0.001$. However, the statistical significance was confirmed for the rest four periods- lockdown, post-lockdown, lockdown 2 as well as post-lockdown 2. When monitoring the NO_2 concentration indicator, it can be stated that in 2020, compared to 2019, the value of the indicator decreased in the 10 monitored months (average month values). The results of the two-sample test for NO_2 are presented in Table 2 and Figure 1.

Table 2: Output of the two-sample t-test for NO_2 in µg / m3 in Bratislava

Period	*Mean 2019*	*Mean 2020*	*P value*
1. pre-lockdown	26.3	23.44	0.046
2. lockdown 1	22.9	16.98	0.0003
3. post-lockdown	18.19	16.21	0.0021
4. lockdown 2	23.44	16.21	<0.0001
5. post-lockdown 2	22.9	15.48	0.0002

Source: authors' own processing in STATA/MP 16.0.

Figure 1: Scatter chart of the two-sample t-test for NO2 in µg / m3 in Bratislava, 2019 and 2020



Source: authors' own processing.

4.2 PM2,5

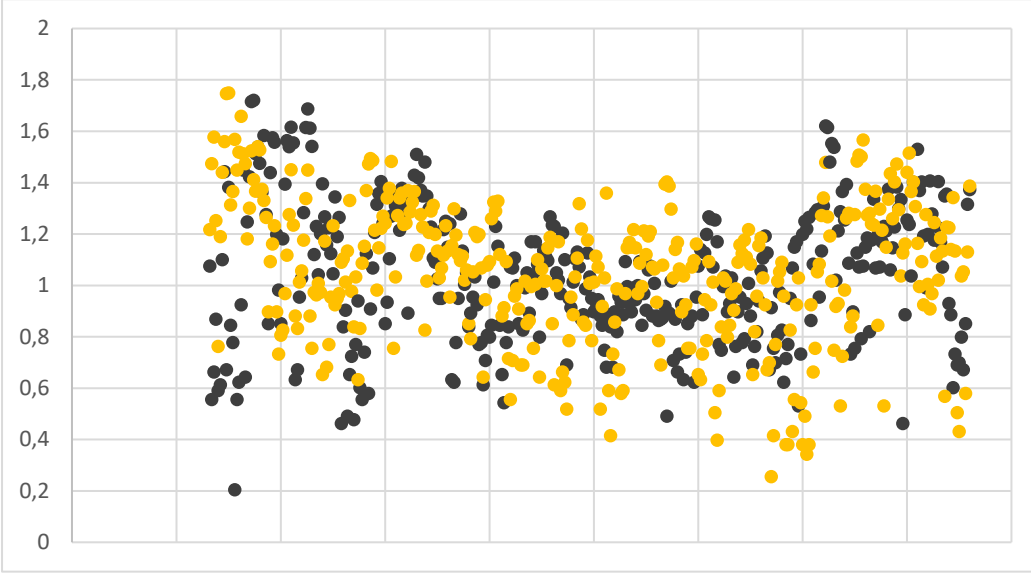
As for $PM_{2,5}$ concentration, comparing 2019 and 2020, changes in concentration for all of the monitored five periods are not statistically significant at the $\alpha = 0.01$. In the case of $PM_{2,5}$ particles, we observe a slight decrease only in 5 monitored months during the whole year (average month values). The results of the two-sample test for $PM_{2,5}$ are presented in Table 3 and Figure 2.

Table 3: Output of the two-sample t-test for $PM_{2,5}$ in µg / m3 in Bratislava

Period	*Mean 2019*	*Mean 2020*	*P value*
1. pre-lockdown	12.88	14.79	0.26
2. lockdown 1	13.18	14.79	0.2
3. post-lockdown	8.7	8.5	0.46
4. lockdown 2	14.12	14.45	0.93
5. post-lockdown 2	13.18	12.3	0.52

Source: authors' own processing in STATA/MP 16.0.

Figure 2: Scatter chart of the two-sample t-test for PM2,5 in µg / m3 in Bratislava, 2019 and 2020



Source: authors' own processing.

4.3 PM_{10}

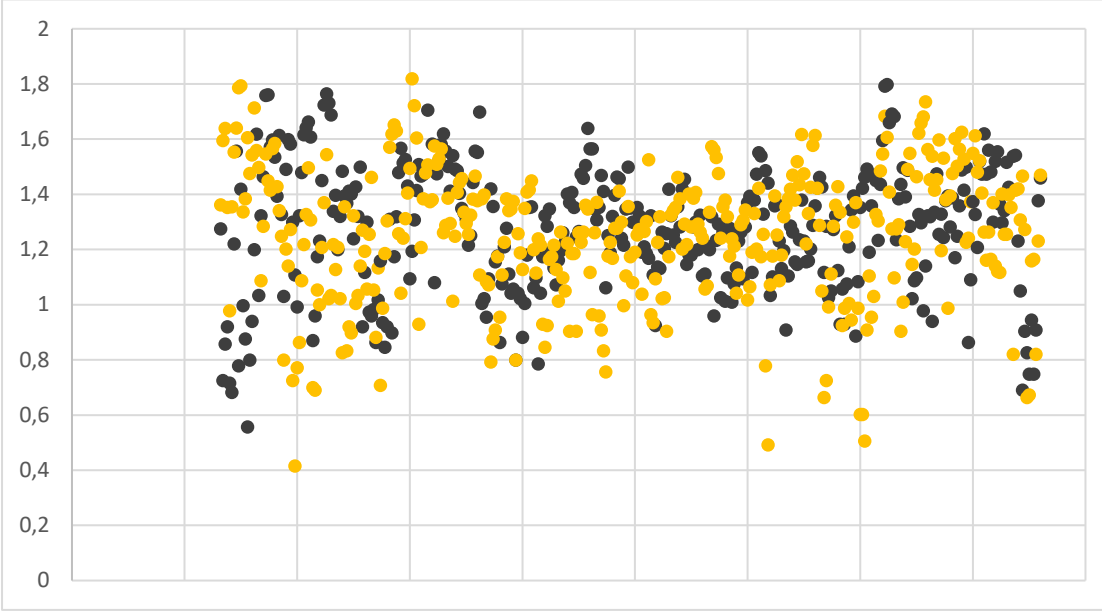
In the case of PM_{10} particles it is 6 monitored months, when we monitored a slight decline in average month values. However, there is no statistical significance as a result of two-sample t-test for these particles. In other months, on the contrary, the value in 2020 exceeds the value from 2019. The results of the two-sample test for PM_{10} are presented in Table 4 and Figure 3.

Table 4. Output of the two-sample t-test for PM_{10} in µg / m3 in Bratislava

Period	*Mean 2019*	*Mean 2020*	*P value*
1. pre-lockdown	18.62	16.98	0.41
2. lockdown 1	21.87	20.41	0.59
3. post-lockdown	17.37	15.84	0.03
4. lockdown 2	20.89	25.11	0.13
5. post-lockdown 2	19.05	17.37	0.3

Source: authors' own processing in STATA/MP 16.0.

Figure 3: Scatter chart of the two-sample t-test for PM_{10} in µg / m3 in Bratislava, 2019 and 2020



Source: authors' own processing.

It seems that at the beginning of 2020 the declared rapid improvement in air pollution in Slovakia is not fully supported by data as far as Bratislava is concerned. One of the reasons for the capital is the rapid decline in the use of public transport and suburban transport to satellites around Bratislava and their exchange for transport by car, especially due to the fear of the pandemic. Another reason, especially for the particles $PM_{2,5}$ concentration is the presence of the biggest industry polluters in the area of Bratislava. The biggest industrial polluter in the city is the Slovnaft refinery. Another major polluter is the Volkswagen factory, but also city´s waste management and heating solutions play a major role in air pollution in Bratislava.

In the following third part of our research, we focused on the key informant interview with the representatives of the City of Bratislava. The aim was to find out to

what extent the city of Bratislava is implementing or planning to implement intelligent solutions to reduce air pollution, which is, in some parts of the city, alarming. Due to the lockdown in place when writing this paper, the key informant interview, originally planned as an in-person encounter, had to be conducted online. The team from the environment department of the City of Bratislava informed us about important discussions and working groups to take place in 2021, the purpose of which will be to reflect on a new law proposal concerning the air. Currently, the most critical problems regarding air quality are linked to the traffic and dust. In accordance with the amendments to the new law, competencies of the municipalities should be strengthened. Hence, the City is expecting qualitative improvements in comparison to the previous law. Many measures aimed at air quality improvement are already being implemented. An example is the project 10 000 trees; activities focusing on growing plants; reconstruction of parks. Moreover, the City is attempting to strengthen public transportation, however, this is being challenged by the ongoing pandemic. As for public transportation, the objective is to design new bus lanes, tram routes, cycling routes, and similar. All relevant information will be made available to the public as well as to experts. The presented research has been limited by the announced legislative changes to be made by the end of 2021. Therefore, further monitoring of the situation is needed, as well as subsequent evaluation of the impacts of the implemented amendments. Our intention is to reflect on this development in our next paper.

The disappointment that the interview brought is the fact that the municipality was currently unable to provide a specific answer to any of the questions asked. On the other hand, this fact did not surprise us so much, as all the measures so far that we could call "smart" were planned and applied rather unconceptually. The result is only partial success and chaos, which is also related to changes in city management. The solutions that have been adopted so far are rather fragments of a comprehensive concept of a smart city. Although the current situation of the pandemic creates enormous pressure on local governments, which are forced to provide comprehensive testing at their own financial expense, in the case of Bratislava it also reflects how little has been done so far in connection with the implementation of smart solutions. Bratislava ranks last in the global rankings of smart cities and cannot compete with other European capitals in any way. A summary of the measures taken within the smart environment is given in Table 5.

Table 5: Smart environment solution adopted by the City of Bratislava as of February 2021

Initiative	*Solution*	*Goal*	*Results*
10 000 trees	Plating greenery	10 000 trees by 2022	2020 – 1339 trees and 4598 shrubs planted 2019 – 531 tress and 738 shrub shrubs planted
Bus lanes	creation and extension of reserved bus lanes of two types – type I. with the prohibition of entry of any vehicle and type II. with the possibility of use for taxis	encourage the use of public transport and reduce time spent in traffic jams	construction of new bus lanes continues
New tram lane	construction of a new tram line presupposes the connection of the city center with the most populous part of Bratislava-Petržalka and thus significantly reduces the use of passenger car transport	4,2 km	01/2021 planned termination of public procurement 09/2021 beginning of construction
Bike paths	15 new bike paths	71,8 km 25 km until 2022	construction of new bike paths continues

Source: key informant interview.

5 DISCUSSION AND CONCLUSION

The COVID pandemic has brought with it, in addition to difficult times, the hope of improving the air quality on the planet. Similar assumptions prevailed in Slovakia. While initial researches focusing on the data from the first lockdown in March-April 2020 showed a significant improvement in air quality, the analysis we performed with the paired t test in the STATA program at a significance level of 0.001 did not show

a significant improvement in all pollution parameters. The only significant improvement was observed for the NO_2 pollutant. However, our results suggest that the decline in vehicle-related NO2 has not coincided with a significant reduction in $PM_{2.5}$ and PM_{10} particles. These results are correspondents with the findings of several other studies, e.g. with the (Donzelli et. al, 2020) or (Dobson and Semple, 2020). However, we believe that this situation is the result of the presence of major polluters in the area of Bratislava, namely Slovnaft and Volkswagen.

Nevertheless, these are serious findings. The health effects of the particles are very well described and are very serious, in the long run including cardiovascular disease, pulmonary illness and stroke. All the more important is the evaluation of the city's approach to improving air quality. As mentioned in the methodology, Bratislava has four air quality monitoring stations, some of which (of course for relevant reasons) are located on the busiest arteries of the city. These areas are highly polluted by air pollution. The concentration of pollutants here is often higher than the norms set by law during rush hour on a working day. Therefore, the city has long announced various solutions that should be part of a larger concept of smart city.

It was the implementation of smart air quality solutions that we dealt with in the next part of the research, where we used the key informant interview method. The aim of the paper was to determine the status of adoption of smart city initiative in Bratislava, capital of Slovakia, in relation to the air quality in the context of the current COVID-19 pandemic. It was the insufficient significance of the improvement of air quality that indicated that even in times of a pandemic, the implementation of such smart solutions cannot be forgotten. Unfortunately, the interview brought disappointment. Insufficient funding, inconsistencies in policies, changes in city management, the complexity of managing a pandemic associated with constant testing resulted in a failure to fully implement the plans intended for 2020. The city announces a change in 2021, but whether it will actually take place is questionable. In addition, the proposed solutions require a longer period of time for their implementation. What we are currently seeing in Bratislava is the implementation of various small sub-projects, which cannot be described as bad, but from the point of view of creating an intelligent environment, they are only small steps. Thus, in the time sequence of several proposed smart plans, it seems that Bratislava has made almost no progress. A more significant element, the longer it will lighten the first time, is only the completion of electric tracks.

The pandemic has shown us that reducing air pollution is not impossible, but it is not easy. Despite the reduced mobility, Bratislava faces the presence of important polluters, and therefore it will be crucial that the solutions to reduce significant pollution start to be implemented as soon as possible. The question remains to what extent this implementation will be possible at a time when the money in the city budget is restricted.

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