A study into city pollution and methane levels

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ABSTRACT

Ranked in the 11th spot în a mid-2015 study[1] and 6th spot in a 2018 Numbeo.com study for pollution[2], there is no doubt when saying Bucharest is one of the most polluted cities in Europe. However, how true does this statement stand taking into consideration the pandemic and all other factors that might have affected Bucharest's pollution in the last 4 years.

This paper analyses current pollution levels both in the centre and outskirts of Bucharest taking into account carbon dioxide(CO2)[3], carbon monoxide(CO)[4] and sulphur dioxide(SO2)[5] levels. Moreover, previous levels of pollution in the city will be compared to current ones in order to draw a thorough conclusion on the topic. Furthermore, methane levels will also be accounted for, seeing whether or not they correlate with the amount of life expected to exist in the area.

Firstly, we used a rover including all needed sensors controlled remotely using a laptop which collected all the necessary data for our study.

In the second phase of the study we compared the data we collected with data from past years seeing whether or not there has been a change in Bucharest pollution levels for better or for worse.

To sum up, we arrived at an interesting unexpected conclusion proving that Bucharest is on the right track of becoming a less polluted city and a better place for its citizens.

Keywords:

Sensors
Pollution
Methane
Rover
Pandemic

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1. INTRODUCTION

In this project, we set ourselves three major objectives. First, we will measure the level of pollution in Bucharest. Although pollution has been an important topic on European cities' agenda for a long time, in Bucharest this problem has been neglected in the past due to more significant problems which had to be addressed first. Still, in the last decade this problem has been brought up to a stature of big importance in the city's agenda, therefore we expected to see a significant drop in pollutant levels. Taking this into consideration, we devised a project which compares data we collected using a rover equipped with multiple sensors in order to see whether Bucharest’s pollution has been effectively lowered.

Figure 1.1

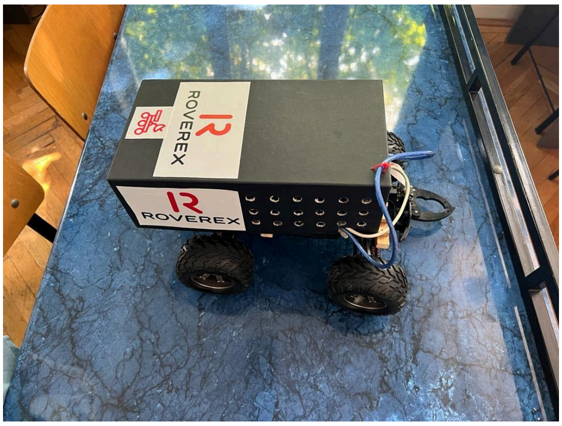

Figure 1.2

Our hypothesis is that the pandemic has had a big impact on the city, making more people choose to work from home, therefore lowering car exhaustion in the city. Therefore, in order to achieve our second goal, we will observe the difference between pre-pandemic and post-pandemic levels of pollution, after all data is collected. In order to achieve this we measured the inner city’s level of pollution and the outside’s level, seeing whether or not both were lowered. This was accomplished using a small agile rover that can easily reach places inaccessible to humans.

The rover has both carbon dioxide sensors that can easily detect fires, and methane sensors that can tell us if life is present.

We also use sulphur dioxide and carbon monoxide sensors to detect the level of pollution in Bucharest. We were able to take measurements in isolated areas inside the forest by taking advantage of the rover’s network connection in order to have a clearer picture of how the outskirts compare. This is an interesting method of addressing the problem, the standard usually being a weather station which may give inaccurate interpretations of measurements in uninhabited areas due to their size and need for space.

Our third goal for this project is to study methane. According to an ESA study more than 90% of Earth’s methane is of biological origin[6]. This shows that methane, even though other explanations could also be possible, can be used as an indicator for the quantity of life. If our rover is to succeed in detecting the small differences in its levels, it would prove our rover suitable for exploration on other planets in order to discover primitive life forms which are the cause of the methane abnormality.

That being said, using a small rover is very useful for research purposes, being both cheaper to operate and build, and more accurate in certain situations.

2. RESEARCH METHOD

In the first stage of our project we needed to find a method of monitoring pollution in Bucharest. However, this couldn't have been done easily using a traditional approach. This being said, we decided to make a rover equipped with all needed sensors for data gathering which could be controlled remotely and therefore be used for missions unfeasible on foot.

Firstly we built our rover structure out of wood, consequently assuring its durability. Moreover, a cardboard layer was added on top in order to further protect the sensors required for the study.

In order to ensure sensors work properly and that there is no overheating in the main body of the project, cooling holes have been drilled both in the rear and back. Moreover the raspberry pi-arduino[7] and raspberry pi - IR(infra red) [8] camera cables exit the rover interior due to the camera's position which makes it impractical to keep everything on the inside.

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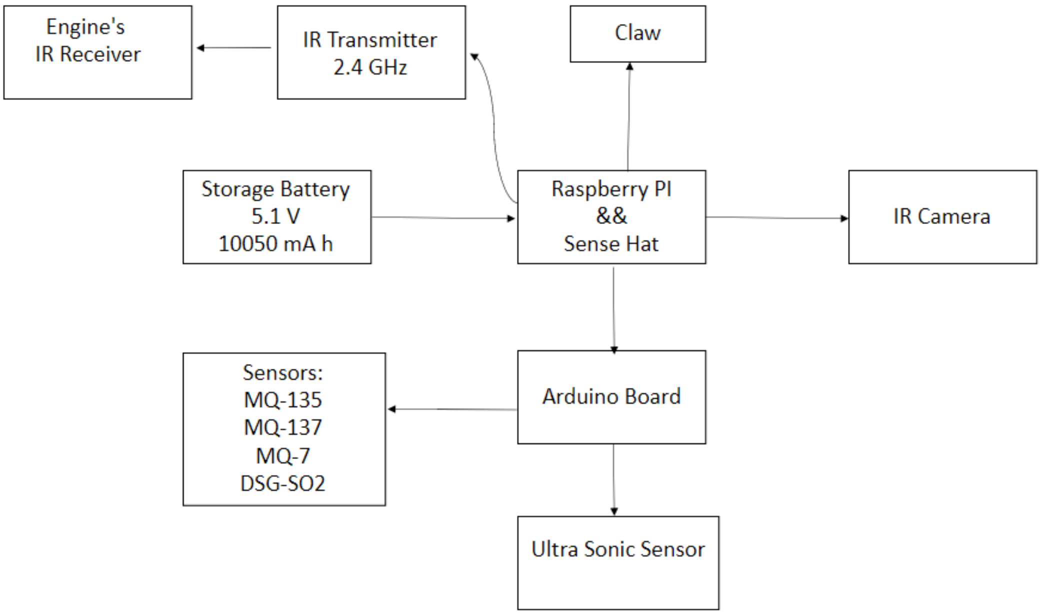

Figure 1. Rover electrical design

Secondly, our rover is placed on a set of high performing wheels, enabling it to traverse harsh terrain and collect data from places we could not reach otherwise. This way we achieve more accurate measurements, also letting us detect fires from afar using our CO_2 detector[9].

Before going out to take the measurements we needed to be sure our rover is capable of carrying out missions. We tested the sensors both indoors and outdoors, making sure harsh terrain will not be a problem for the project. After calibrating the sensors and making measurements using some of them we decided our rover is prepared for taking the tests:

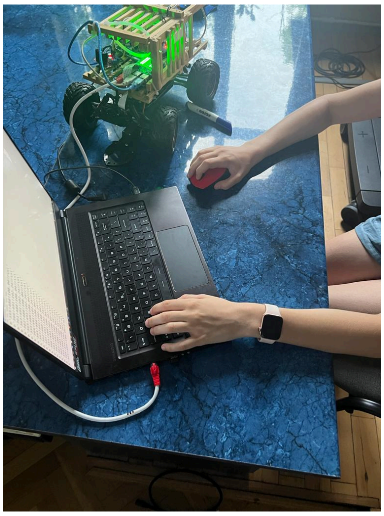

Figure 2.1

CO_2 [µg/m³]	CH_4 [µg/m³]	Distance [cm]
390.89	424.989	9.71
410.56	425.123	9.66
405.69	423.569	9.79
418.32	420.985	9.82
410.74	419.978	9.39
456.87	421.059	9.50
418.94	422.421	9.64
420.436	418.891	9.75
399.471	421.954	9.69
408.677	423.861	9.7

Table 2.1

In the second stage of the project we went and measured all CO_2(carbon dioxide), CO(carbon monoxide), SO_2(sulphur dioxide) and CH_4(methane) levels[10]. Using these indicators we devised graphs comparing the metrics between different areas in Bucharest[11]. For our test sample we chose to measure these metrics in the centre of the city (University), in our high schools' courtyard (next to Kiseleff park) and on the outskirts of Bucharest (Baneasa forest)[12]. This way we were able to effectively estimate Bucharest's pollution[13] and draw lines between pre-pandemic levels and current ones.

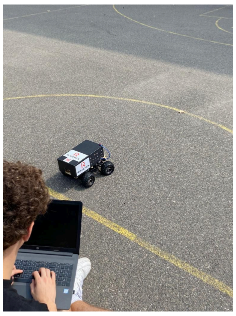

Figure 2.2

Figure 2.3

Figure 2.4

Figure 2.5

In order to have an accurate picture on the matter we measured during a 3 hour period the air a total of seven times, each one being done in different days during the workweek from 4 pm to 7 pm. During these measurement we found the following results:

School	SO_2	CO_2	CO	CH_4
Hour	Value [$\mu g/m^3$]	Value [$\mu g/m^3$]	Value [$\mu g/m^3$]	Value [$\mu g/m^3$]
16:00	5.51	390.89	648.68	424.989
16:30	5.48	410.56	670.86	425.123
17:00	5.41	405.69	620.51	423.569
17:30	5.38	418.32	650.29	420.985
18:00	5.29	410.74	660.34	419.978
18:30	5.26	456.87	705.26	421.059
19:00	5.22	418.94	656.51	422.421

Table 2.2

Periphery	SO_2	CO_2	CO	CH_4
Hour	Value [$\mu g/m^3$]	Value [$\mu g/m^3$]	Value [$\mu g/m^3$]	Value [$\mu g/m^3$]
16:00	3.97	350.86	542.45	425.985
16:30	5.11	352.95	541.80	428.587
17:00	3.2	352.26	530.94	427.679
17:30	3.75	354.84	576.58	428.852
18:00	3.67	354.26	550.98	427.542
18:30	3.68	353.89	561.35	425.694
19:00	3.71	353.09	549.89	425.314

Table 2.3

City center	SO2	CO2	CO	CH4
Hour	Value [µg/m³]	Value [µg/m³]	Value [µg/m³]	Value [µg/m³]
16:00	7.92	480.89	697.52	424.598
16:30	7.26	525.98	702.59	425.352
17:00	6.88	470.59	685.96	430.987
17:30	7.63	508.26	700.13	420.234
18:00	7.42	512.38	732.96	424.534
18:30	7.19	525.68	704.14	425.142
19:00	6.98	510.84	706.51	425.023

Table 2.4

In the next part of the project we made comparisons between levels from 2022 and one's from 2019. These comparisons were made using our data, as well as data from a study of a local station[14]:

Periphery 2019 vs 2022 CO emissions and SO2 emissions

Hour	CO[µg/m³] 2019	CO[µg/m³] 2022
16:00	651.75	542.45
16:30	674.64	541.80
17:00	635.96	530.94
17:30	689.06	576.58
18:00	664.13	550.98
18:30	662.82	561.35
19:00	660.46	549.89

Table 2.5

Hour	SO2[µg/m³] 2019	CO[µg/m³] 2022
16:00	5.87	3.97
16:30	5.94	5.11
17:00	5.78	3.2
17:30	5.65	3.75
18:00	5.69	3.67
18:30	5.94	3.68
19:00	5.77	3.71

Table 2,6

City centre 2019 vs 2022 CO emissions and SO2 emissions

Hour	CO[μg/m³] 2019	CO[μg/m³] 2022
16:00	1199.37	697.52
16:30	1242.38	702.59
17:00	1316.6	685.96
17:30	1365.55	700.13
18:00	1338.9	732.96
18:30	1344.33	704.14
19:00	1378.54	706.51

Table 2.7

Hour	SO2[μg/m³] 2019	SO2[μg/m³] 2022
16:00	10.76	7.92
16:30	13.16	7.26
17:00	16.07	6.88
17:30	15.93	7.63
18:00	13.06	7.42
18:30	11.92	7.19
19:00	10.97	6.98

Table 2.8

School 2019 vs 2022 CO emissions and SO2 emissions

Hour	CO[μg/m³] 2019	CO[μg/m³] 2022
16:00	803.93	648.68
16:30	800.92	670.86
17:00	624.37	620.51
17:30	829.65	650.29
18:00	885.53	660.34
18:30	854.73	705.26
19:00	828.43	656.51

Table 2.9

Hour	SO2[μg/m³] 2019	SO2[μg/m³] 2022
16:00	9.52	5.51
16:30	9.46	5.48
17:00	10.27	5.41
17:30	10.41	5.38
18:00	9.5	5.29
18:30	9.36	5.26
19:00	9.25	5.22

Table 2.10

The last step of our research was to analyse collected methane level data and to see whether or not it corresponds to our estimates or not:

Place	School	Periphery	City centre
Hour	Value [μg/m³]	Value [μg/m³]	Value [μg/m³]
16:00	424.989	425.985	424.598
16:30	425.123	428.587	425.352
17:00	423.569	427.679	430.987
17:30	420.985	428.852	420.234
18:00	419.978	427.542	424.534
18:30	421.059	425.694	425.142
19:00	422.421	425.314	425.023

Table 2.11

3. RESULTS AND DISCUSSIONS

Taking into consideration all collected data, there are some interesting results to be discussed, taking advantage of graphs which will illustrate emission differences.

3.1. Pollution in Bucharest 2022

Our results show how polluted Buchraest is at the moment[15]. The following graphs show different levels of pollution when evaluating 3 distinct areas:

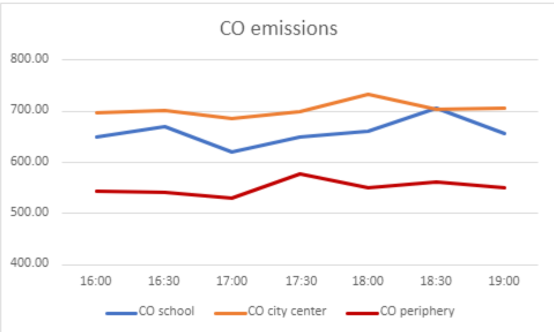

Figure 3.1

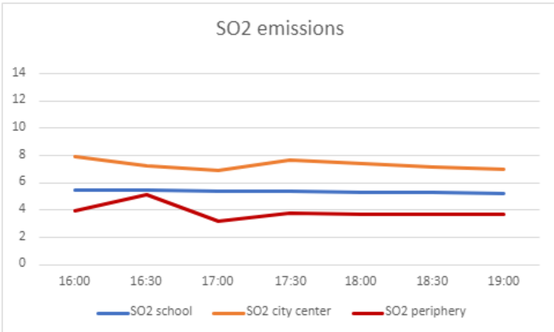

Figure 3.2

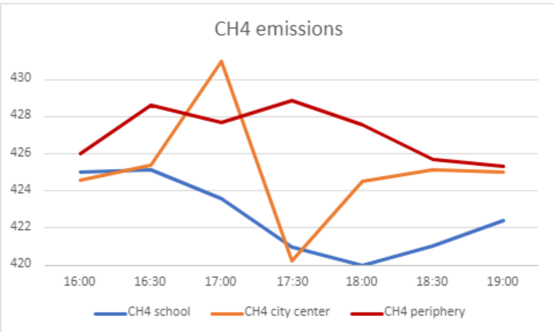

Figure 3.3

These results reassure our hypothesis that Bucharest's pollution is getting better. However, the difference between the outskirts and the centre of the city has not been getting less visible suggesting that the change has been caused by a general drop in overall emissions rather than from measures aimed to lower pollution in the middle of the city[16][17]. This was most probably caused by the pandemic which has left its impact on businesses around the city as well as people's lifestyles.

3.2. Pollution now compared to 2019

Moreover when comparing procured data to data measured in weather stations in 2019 a significant drop in the cities' pollution can be observed in the graphs below:

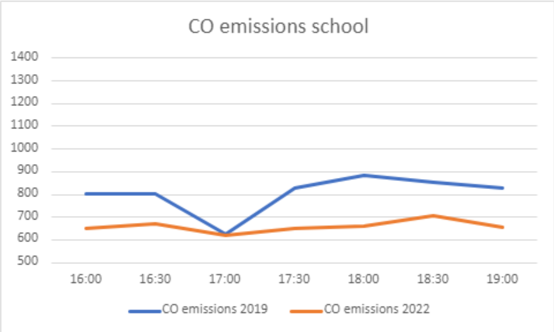

Figure 3.4

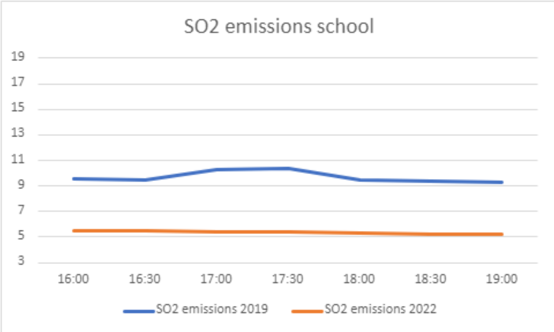

Figure 3.5

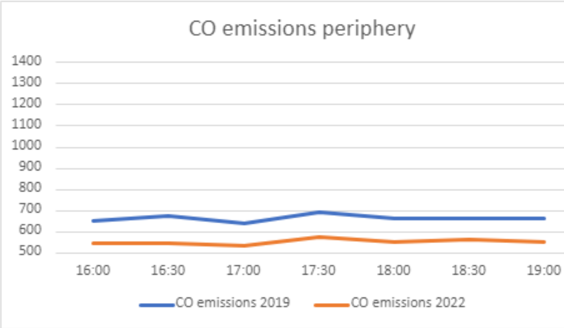

Figure 3.6

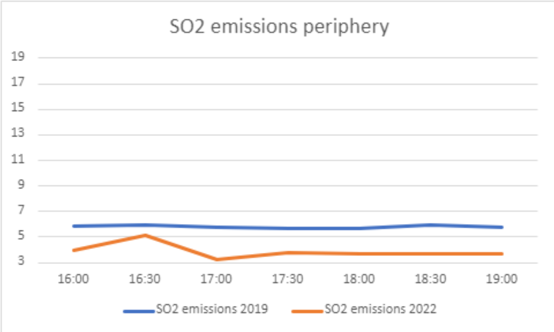

Figure 3.7

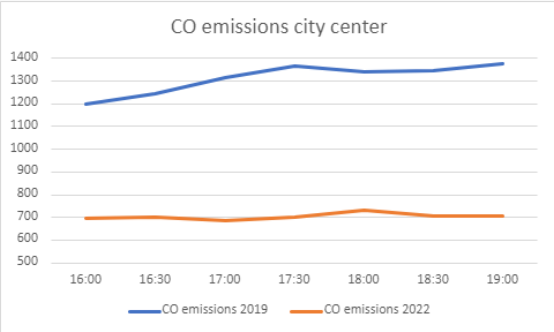

Figure 3.8

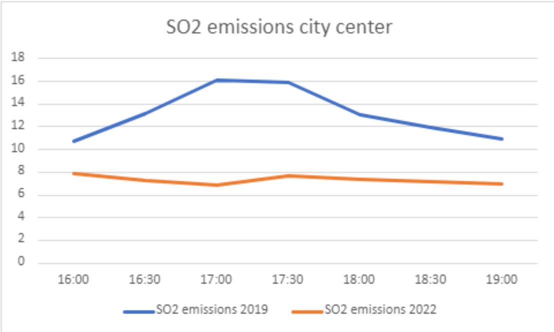

Figure 3.9

These scars left in the industry affected pollution significantly, ultimately leading to a healthier life for their cities population.

3.3. Methane within the city

This part of the experiment was also in concordance with our expectation, the forest having the most methane[18], closely behind being our school located near a park and less than both the city centre full of buildings and with little green space as seen in the graphs below.

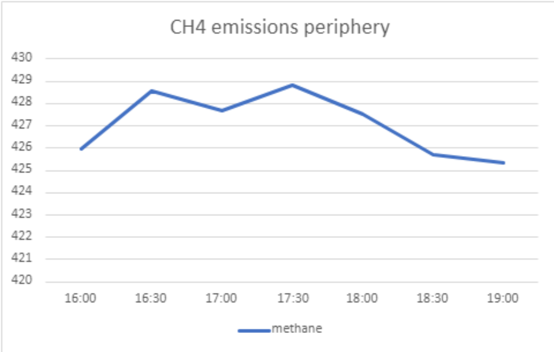

Figure 3.10

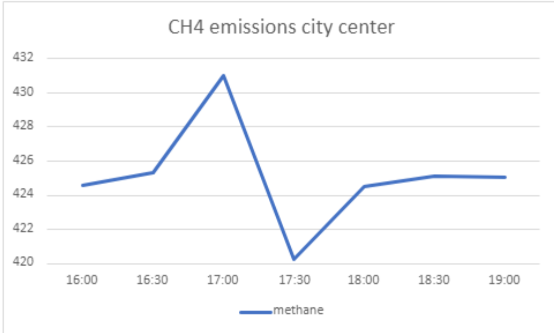

Figure 3.11

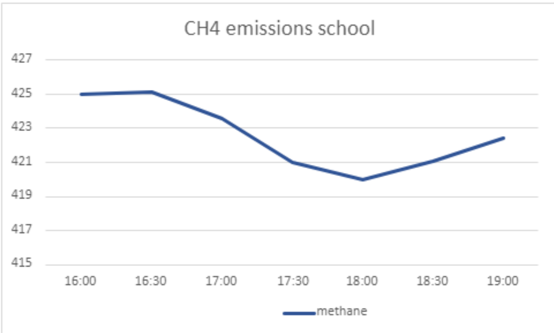

Figure 3.12

4. CONCLUSION

Given the data presented above, we can say with certainty that pollution has decreased after the pandemic. The effects of the lockdown are felt in greenhouse gas emissions, so SO2 and CO emissions are much lower than in the pandemic[19][20]. Therefore it is clear that the pandemic has indefinitely changed the working in the office requirement[21], more people gravitating towards online alternatives. This combination with reduced industrial production caused by low demand are very influential when it comes to city pollution. Moreover, this study showed us the possibility for life methane monitoring which proves that our rover would be suitable for planet explorations.

Further developments for our rover include the programming of a mewon sensor[22] which would help monitor solar energy[23]. Furthermore, adding a black and white infrared camera[24] which would help with path finding using a ML algorithm[25].

ACKNOWLEDGEMENTS

To begin with, we would like to express our sincerest thanks to the Indonesian Scientific Society for organising the International Research Project Olympiad.

By working on this project, we gained knowledge on amazing topics we used to know little about, we developed our coding skills and team spirit, and, we dare say, got a small insight on what it's like to be a scientist.

Last but not least, we would like to show our immense gratitude to our physics teacher Ioana Stoica for providing us with useful materials and suggestions, and encouraging us to participate in such a prestigious competition.

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