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Assessment of Some Air Pollutants in Erbil, Kurdistan Region - Iraq

4th class Research Project

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Abstract

Clean air is the basic requirement of all living organisms. Ambient air quality is one of the most serious environmental concerns in urban areas around the world, particularly in developing countries. This study aims to assess the concentrations of gaseous air pollutants to examine and monitor air quality in Erbil's ambient air for the year 2024. Air quality monitoring data was recorded from the Air Quality Monitoring Device which is called (Oizom Polludron). In the present study, gaseous pollutants (SO_2, NO_2, CO, and O_3) were assessed in 2024 in Erbil city Kurdistan region -Iraq, Erbil's (30-meter, 60-meter, 120-meter) roads. The mean values of CO were highest measure presented in 30-meter (7.013 µg/m³), NO_2 was the highest measure presented in the 120-meter highway (61,392 µg/m³, SO_2 was highest measure in 60-meter (109.77 µg/m³), (O_3) was highest measure in 120-meter (70.792µg/m³), in 2024, respectively. The mean concentration of pollutants was found within the acceptable range according to US EPA standards (except the level of CO) and found a little higher than EPA standards for air pollutants in March 2024. Furthermore, precaution measures and management strategies to minimize the outcome of gaseous pollutants have also been suggested for achieving its ambient levels in Erbil.

Key words: Air Pollutants, Assessment, Air Quality Index, Erbil.

1. Introduction

Air pollution in big cities throughout the world has emerged as a significant environmental problem, with anthropogenic activities emitting a significant percentage of gases and particles (Sicard et al., 2021) Air pollution is the presence of unwanted impurities in the air in large quantities to produce negative impacts. From sources currently beyond human control, many of these dangerous substances enter the atmosphere. However, the primary sources of these pollutants are human activities in the most densely inhabited parts of the globe, especially in industrialized countries (De Nevers, 2010). One such gas that is produced when fuels based on carbon have not completely burned is carbon monoxide, which is a significant air pollutant. Both the central nervous system and the circulation's capacity to carry oxygen have been impacted. As the major source of NOx in transportation facilities, diesel engine combustion is the main human source of NOx emissions (Mawlood, and Sultan, 2022). Nitrogen dioxide (NO2) is very harmful and can irritate the eyes, throat, and respiratory system in kids. Oxygen (O3) is produced when nitrogen oxides from vehicle exhaust combine photochemically with hydrocarbons in the presence of sunshine. Human health has been demonstrated to be negatively impacted by ozone inhalation, especially in children. Additionally, it has detrimental effects on ecosystems and plants (Chaichan, 2015 a, Chaichan, 2015b, Voskamp et al., 2018). Ozone is a strong oxidizer and a molecule of unstable oxygen. The World Health Organization (WHO) states that low levels of ozone in the environment can cause headaches, coughing, and chest pain, as well as irritating the nose, eyes, and throat. Asthma and bronchitis sufferers are especially susceptible (Mawlood, and Sultan, 2022)

In Iraq, air pollution levels surpass World Health Organization guidelines, leading to higher rates of premature mortality and cancer due to environmental pollutants. According to the Iraq Air Quality Index 2022, Iraq is second globally for poor air quality. Specifically, on May 19, 2022, the air quality index in Erbil ($PM_{2.5}$) was recorded at 162. Using geographic information systems (GIS) combined with aerial imagery from the Sentinel-5P satellite plays a vital role in monitoring global air quality variations. This satellite effectively captures data on numerous air pollutants, including, SO_2, CO, NO_2, and O_3 (Ali et al.,2023). This study is to assess and measure air gas pollutants such as (CO, NO_2 O_3, and SO_2) to determine the quality of the air that we breathe. This study is concerned with analyses and evaluation of our air quality in gas pollutants and then compares the concentrations of these gases with the allowable limits.

2. Materials and Method:

2.1. Study area

The governorate of Erbil (or Hawler in Kurdish) located in the northern Kurdistan region of Iraq. Erbil covers about 18175 square kilometers (Figure 1). The average rainfall in Erbil city is around 440mm (Zohary, 1950). The summer season is hot and dry, while the winters are cold and wet. It is bounded to the north- east by the greater Zab River and to the South East by the lesser Zab River. It lies between the latitude (45, 35- 37), and the two longitudes 43 and 45 (Toma, 2013).

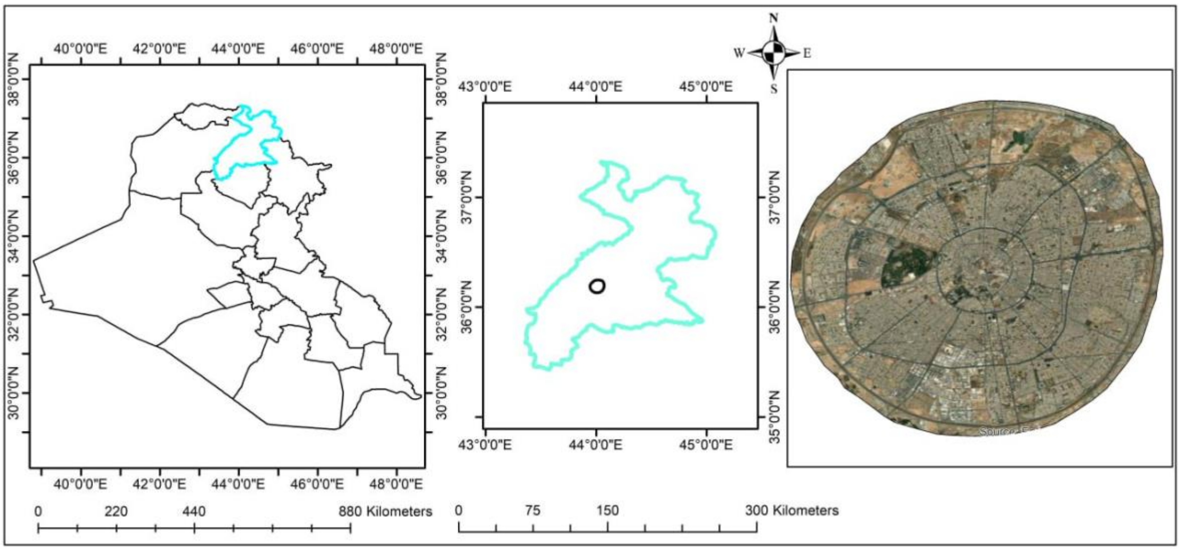

Figure 1: Map of Iraq (left), Erbil governorate (center) and the study area (right)

2.2. Measurements of gaseous air pollutants

This study is to assess the concentrations of gaseous air pollutants in Erbil ambient air in the year 2024, gaseous air pollutants CO, NO_2, CO_2, SO_2, and O_3 in Erbil City Kurdistan region-Iraq Measured by using the air quality monitoring device called (Oizom-Polludron) (Figure 2). Several sites were selected within Erbil City for measuring gas pollutants (Table 1). Air survey of Erbil's city streets (30 meters, 60 meters, 120 meters), some points taken from each street, air quality monitoring data hourly measurements of CO, NO_2, CO_2, SO_2, and O_3 were obtained and recorded. These recorded data were assessed to determine the temporal characteristics of gaseous air pollutants in Erbil's ambient air.

Figure 2: Air quality monitoring device – Oizom Polludron

Table 1: Several sites selected within Erbil city for measuring air gases pollutants.

Location code	Location name	Longitudinal	Latitudinal
30-meters			
A1	UKH	44.00703526	36.18190135
A2	key makers	44.01548966	36.18227997
A3	Federally bank	44.01715077	36.1953007
A4	Erbil view hotel	44.00198535	36.19696287
A5	Tafser library	44.00030197	36.18838771
60-meters			
A6	Today restaurant	44.01119327	36.17419445
A7	Par hospital	44.02544916	36.18257283
A8	Home marka	44.02166973	36.20055151
A9	Ministry of Justices	44.0021156	36.20153958

Location code	Location name	Longitudinal	Latitudinal
A10	Erbil silhouette	43.99413837	36.1839916
120-meters			
A11	Kirkuk road intercepts	43.95106456	36.17199229
A12	Mousl road intercepts	43.95106536	36.17199088
A13	Ankawa road intercepts	43.99038863	36.24002736
A14	Kasnazan road intercepts	44.05565	36.232233

2.3: Air Quality Index (AQI)

The Air Quality Index (AQI) gauges the daily pollution level of specific pollutants regulated by the EPA's National Ambient Air Quality Standards (NAAQS). This index merges the NAAQS with an epidemiological formula to ascertain a representation of the health impacts on humans from brief exposure (24 hours or less) to each pollutant. The AQI is a simple, color-coded, unitless index that is an effective way to communicate air pollution concentrations to the general public. It provides an indication of the quality of the air and its health effects. The calculation of the pollutant's index involves a mathematical equation, as outlined by the EPA (2016). The AQI were calculated using the following equation:

Air Quality Index Equation Using US EPA Method

$$\mathbf{I_P = \frac{I_{Hi} - I_{Lo}}{BP_{Hi} - BP_{Lo}} (C_P - BP_{Lo}) + I_{Lo}} \ldots\ldots\ldots.(\mathbf{1})$$

where:

I_P = the index for pollutant P

C_P = the truncated concentration of pollutant P

BP_{Hi} = the concentration breakpoint that is greater than or equal to C_p

BP_{Lo} = the concentration breakpoint that is less than or equal to C_p

I_{Hi} = the AQI value corresponding to BP_{HI}

I_{Lo} = the AQI value corresponding to $BP_{\mathbf{LO}}$

Table 2: Proposed breakpoints for AQI scale 0-500 units (μg/m³ unless mentioned otherwise)

AQI Category	AQI	Concentration Range*							
		PM_{10}	$PM_{2.5}$	NO_2	O_3	CO	SO_2	NH_3	Pb
Good	0-50	0-50	0-30	0–40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory	51 - 100	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.5-1.0
Moderately Polluted	101-200	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor	201-300	251-350	91-120	181-280	169-208	10-17	381-800	801-1200	2.1-3.0
Very Poor	301–400	351-430	121-250	281-400	209-748*	17-34	801-1600	1200-1800	3.1-3.5
Severe	401-500	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

* CO in mg/m^3 and other pollutants in $\mu g/m^3$; 24-hourly average values for PM_{10}, $PM_{2.5}$, NO_2, SO_2, NH_3, and Pb, and 8-hourly values for CO and O_3.

2.3. Statistical Analysis

The data were statistically analyzed by using SPSS and Microsoft Excel. Data were checked for normality distribution before carrying out any statistics. ANOVA was used to check if there are any significant differences between the pollutant's concentration among main roads. Maps were produced using GIS ArcMap (v. 8.1).

3. Results and Discussion

In the present study, gaseous air pollutants CO, NO_2, CO_2, SO_2, and O_3 were assessed in the year 2024 in Erbil, Kurdistan region -Iraq mean concentrations of gaseous air pollutants are presented in Table 3. The descriptive statistics of the studied five main air pollutants in Erbil are presented in Table 3. Maximum CO_2 was recorded at 120-meter road (611.275 ppm) whereas maximum CO was recorded at 60-meter road (7.013 mg/m^3). Highest mean concentration of NO_2 and O_3 were recorded at 120-meter road with 61.392 and 70.792 $\mu g/m^3$, respectively. Moreover, only SO_2 with an average concentration of 1097.736 $\mu g/m^3$, recorded at 60-meter road.

Mean concentrations and ANOVA results are presented in (Figure 3) ANOVA results show that there were no significant differences ($p < 0.05$) between CO concentrations in 60 Meter (Mean = 6.46 $\mu g/m^3$) and 120 Meter (Mean =5.454 $\mu g/m^3$), while there were significant differences ($p < 0.0001$) between 30 Meter (Mean =7.013 $\mu g/m^3$) and 120 Meter (Mean=

5.454µg/m³); and between 30 Meter (Mean = 7.013µg/m³) and 60 Meter (Mean= 6.46µg/m³) ($p < 0.05$). (Figure 4) ANOVA result shows that there were no significant differences ($p < 0.05$) between CO_2, concentrations at 60 Meters (Mean = 530.24 µg/m³) and 120 Meters (Mean =611,275 µg/m³), and also between 30 Meter (Mean =509.36 µg/m³) and 120 Meter (Mean= 611,275µg/m³); while there was a significant difference between 30 Meter (Mean = 509.36µg/m³) and 60 Meter (Mean= 530.24µg/m³) ($p < 0.0001$). (Figure 5) ANOVA results shows that there were no significant differences ($p < 0.05$) between NO_2 concentrations in 60 Meter (Mean = 21.917 µg/m³) and 120 Meter (Mean =61,392 µg/m³), while there were significant differences ($p < 0.0001$) between 30 Meter (Mean =18.458 µg/m³) and 120 Meter (Mean= 61.392µg/m³); and between 30 Meter (Mean = 18.458µg/m³) and 60 Meter (Mean= 21.917µg/m³) ($p < 0.05$). (Figure 6) ANOVA results show that there were no significant differences ($p < 0.05$) between SO_2 concentrations in 60 Meter (Mean = 109.77 µg/m³) and 120 Meter (Mean =53.99 µg/m³), between 30 Meter (Mean =89.76 µg/m³) and 120 Meter (Mean= 53.99µg/m³); and between 30 Meter (Mean = 89.76µg/m³) and 60 Meter (Mean= 109.77µg/m³) ($p < 0.05$). Figure 7 shows the ANOVA result that there were no significant differences ($P < 0.05$) between O_3 concentrations in 60 Meter (Mean =40.946 µg/m³) and 120 Meter (Mean =70.792µg/m³), while there was a significant difference between 30 Meter (Mean=52.598 µg/m³) and 120 Meter (Mean= 70.792µg/m³); and between 30 Meter (Mean = 52.598µg/m³) and 60 Meter (Mean= 40.946µg/m³) ($P < 0.0001$).

Table 3: The descriptive statistics of the studied air pollutants in Erbil.

Roads	Statistics	CO_2 (ppm)	CO (mg/m³)	NO_2 (µg/m³)	O_3 (µg/m³)	SO_2 (µg/m³)
30m	Mean	509.36	7.013	18.458	52.598	897.689
	SD	78.949	0.84	22.714	20.527	1093.995
	Min	443	4.53	0	0	305.84
	Max	808	7.36	62.46	83.06	4406.99
60m	Mean	530.24	0.653	21.917	40.946	1097.736
	SD	80.624	0.653	37.457	30.128	91.251
	Min	466	4.71	0	0	201.98
	Max	758	7.34	139.05	84.34	4408.8
120m	Mean	611.275	5.454	61.392	70.792	539.966
	SD	162.733	1.771	14.746	20.838	412.577
	Min	476	2.73	40.76	10.37	227.34
	Max	1190.5	6.92	90.19	94.27	1458.31

Table 4: Calculated Air quality index for Erbil's streets – Kurdistan regional of Iraq

Air quality index (AQI)				
Location	**CO (mg/m^3)**	**NO_2 ($\mu g/m^3$)**	**O_3 ($\mu g/m^3$)**	**SO_2 ($\mu g/m^3$)**
30-meter	162	23	52	68
60-meter	159	27	40	78
120-meter	143	76	70	72

The result shows that. The Air quality index for (CO) from all Erbil roads the highest measure presented at 30m road which was (AQI=162, scale 101-200) lies in the moderately polluted air category, that were assessed in (pink color), CO (Carbon Monoxide) is a colorless, odorless gas that can be harmful when inhaled in large amounts. CO is released when something is burned. The greatest sources of CO to outdoor air are cars, trucks, and other vehicles due to human activity(Environmental Protection Agency,2023), and also the result shows that the air quality index for (NO_2) from all Erbil roads is the highest measure presented at 120m highway which was (AQI=76, scale 51-100) lies in satisfactory air category, that was assessed in (green color) safely quality of the air that we breathe, NO2 is one of the harmful greenhouse gases, nitrogen dioxide, forms when fossil fuels such as coal, oil, methane gas (natural gas) or diesel are burned at high temperatures (Schlesinger, & Lippmann, 2020).On the other hand, High levels of nitrogen dioxide are also harmful to vegetation damaging foliage. Nitrogen dioxide can reduce visibility, and react with surfaces (Hakeem et al., 2017). also, the same result shown in the air quality index for (SO2) from all Erbil roads the highest measure presented at 60m which was (AQI=78, scale 51,100) lies in the satisfactory air category, that was assessed in (green color) safely quality of the air that we breathe, SO2 is greenhouse gases, Sulfur dioxide (SO2) composed of sulfur and oxygen. SO2 forms when sulfur-containing fuel such as coal, petroleum oil, or diesel is burned (Chu, Chen, & Lu, 2008). On the other hand, Sulfur dioxide can damage trees and plants, inhibit plant growth, and damage sensitive ecosystems and waterways. It also can contribute to respiratory illness and aggravate existing heart and lung conditions (Cao, Garbaccio, & Ho, 2009).and the result shows that the air quality index for (O3) from all Erbil roads, the highest measure presented at 120m highway which was (AQI=70, scale 51-100) lies in satisfactory air category, that also were assessed in (green color) safely quality of the air, Ozone is an odorless, colorless gas made up of three oxygen molecules (O3) and is a natural part of the environment. It occurs both in the Earth's upper atmosphere, or stratosphere, and at ground level in the lower atmosphere, or troposphere (da Silveira Petrucci et al., 2022). However, Ozone exposure reduces the overall productivity of plants, damaging cells and destroying leaf tissue. and all this assessment of gaseous air pollutants accorded to (table 2: proposed breakpoints for AQI scale 0-500).

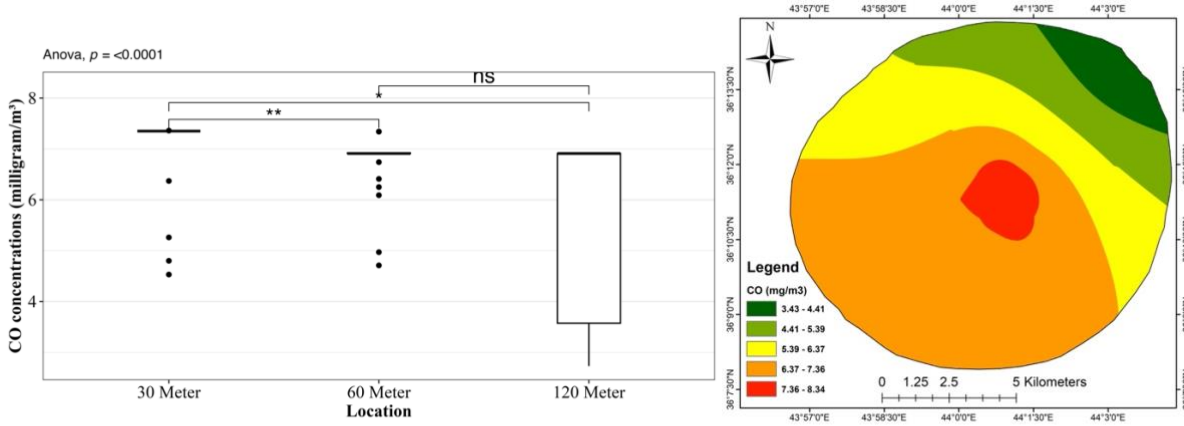

Figure 3: ANOVA results of mean concentration of CO between the main roads in Erbil (left) and their spatial distribution in the studied area (right). ****=p<0.0001; ***=p<0.001; **=p<0.01; *p<0.05; ns=p>0.05.

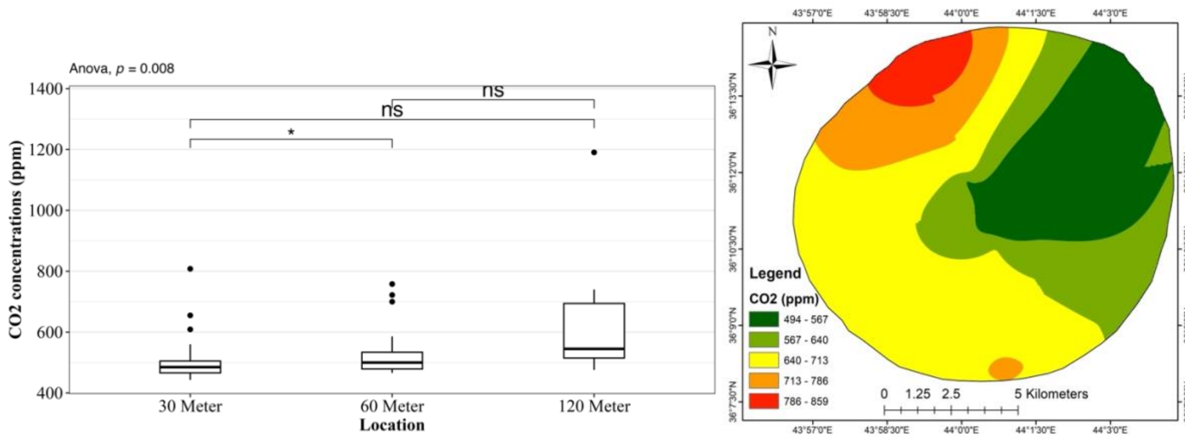

Figure 4: ANOVA results of mean concentration of CO_2 between the main roads in Erbil (left) and their spatial distribution in the studied area (right). ****=p<0.0001; ***=p<0.001; **=p<0.01; *p<0.05; ns=p>0.05.

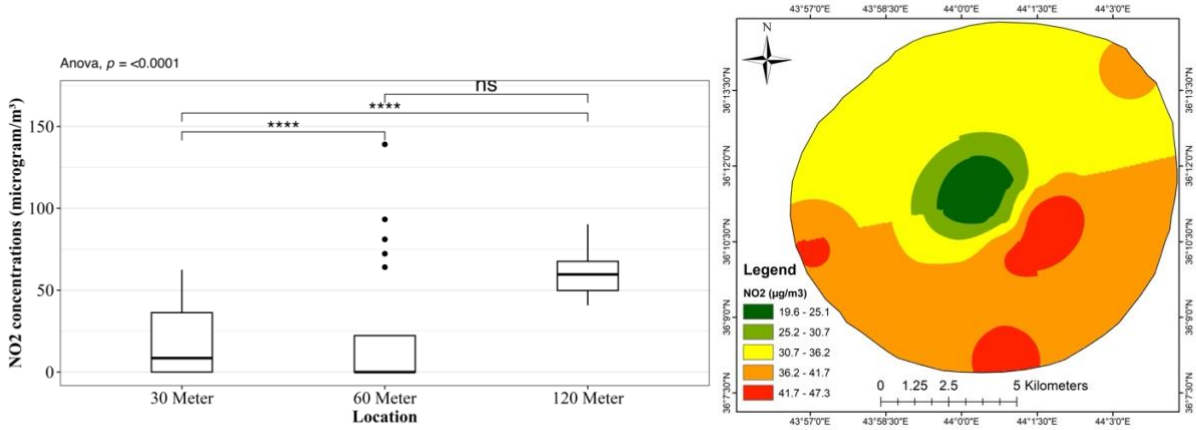

Figure 5: ANOVA results of mean concentration of NO_2 between the main roads in Erbil (left) and their spatial distribution in the studied area (right). ****=p<0.0001; ***=p<0.001; **=p<0.01; *p<0.05; ns=p>0.05.

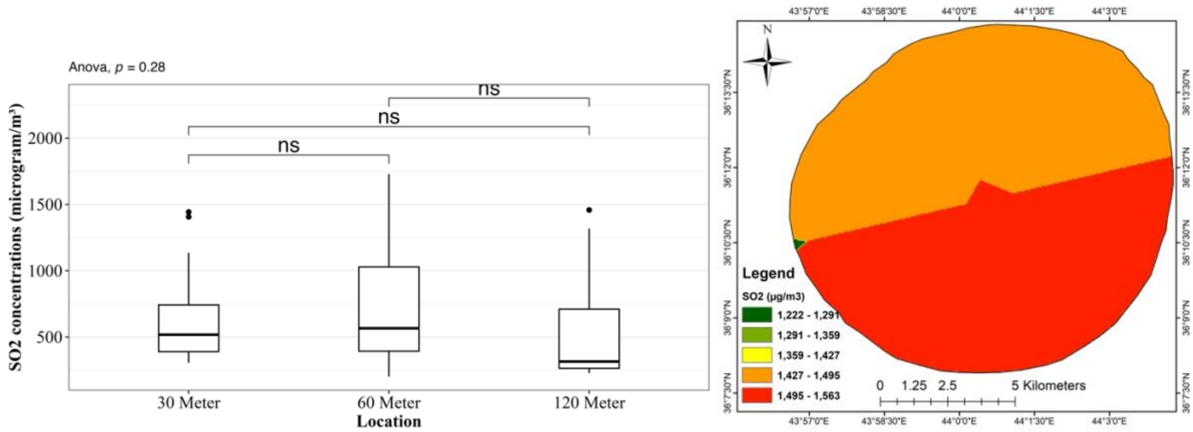

Figure 6: ANOVA results of mean concentration of SO_2 between the main roads in Erbil (left) and their spatial distribution in the studied area (right). ****=p<0.0001; ***=p<0.001; **=p<0.01; *p<0.05; ns=p>0.05.

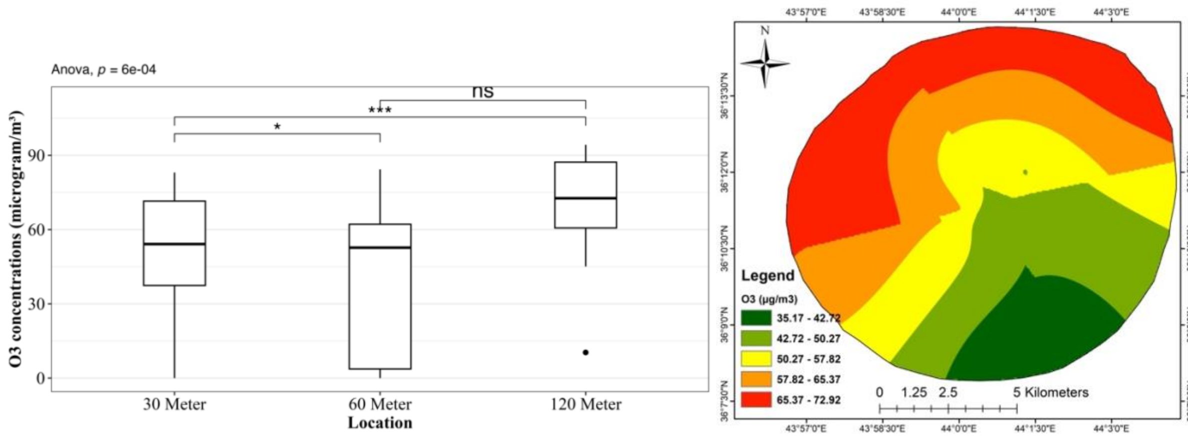

Figure 7: ANOVA results of mean concentration of O_3 between the main roads in Erbil (left) and their spatial distribution in the studied area (right). ****=p<0.0001; ***=p<0.001; **=p<0.01; *p<0.05; ns=p>0.05.

4. Conclusion

Gaseous pollutants (CO, SO_2, NO_2, and O_3) are well within the permissible limits when compared with US EPA standards for 2024. Nevertheless, the level of CO was found to be a little higher than EPA standards for air pollutants in March 2024. Measures like limiting the number of vehicles, conducting public attention campaigns about the harmful effects of air pollution, and educating drivers to be more eco-friendly are to be implemented. Furthermore, regulatory authorities must confirm that industries obey their moral and social responsibilities to protect the environment. Generally, the level of gaseous air pollutants in Erbil's ambient air is in satisfactory condition (except for minor threats of CO), which could be ameliorated by implementing the above-mentioned managerial steps and strategic plans to live a safer and healthier life. The writers propose the periodic assessment of some air pollutants at frequent intervals to check the level of such obnoxious pollutants in Erbil, Kurdistan.

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