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# Assessment of the Ambient Gaseous Pollutants in the Crowded Traffic Crossroad in Baghdad City

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**ABSTRACT**

Exposure to ambient gaseous components is a significant issue for people's health. This study aims to check the modification effect of seasonal temperature variation on the association of ambient air pollutants in the selected traffic crossroads in Baghdad city. The study continued for around 180 calendar days from the winter of 2020 to the summer of 2021; during this period, seven major gaseous parameters, including volatile organic compounds (VOCs), nitrogen dioxide ($NO_2$), carbon monoxide (CO), carbon dioxide ($CO_2$), hydrogen sulfide ($H_2S$), sulfur dioxide ($SO_2$), and ground ozone ($O_3$), were tested via using the devices of GIG6 and GIG2. The results showed that the high temperature significantly affected the dispersion of air pollutants, whereas the increase in air temperature from 10 °C to 48 °C led to an increase in the concentration of $H_2S$ about ten times, and an increase in emission of CO around three times, while there are varying increases for the rest of the other air pollutants.

**Keywords:** ambient air, gaseous pollutants, automobiles exhaust, environmental legislation.

## INTRODUCTION

Humans can dispense with food for several days and water for two to three days, while they cannot dispense with air for several minutes, so researchers are interested in preparing research and scientific reports on air quality, whether inside or outside doors and studying gaseous pollutants and comparing them with global standards. These air contaminants may take the shape of solid particles, liquid or gas droplets, or both. Additionally, it might be generated by human activities or be natural (EPA, 2015). Baghdad is the capital of Iraq, located in the center of the country; the geographic location coordinates are (33° 20' 19" North, 44° 23' 38" East) (Maplandia, 2022). Its climate is characterized by being hot and dry in summer, cold and little rain in winter (Spark, 2022). Hot, dry weather is considered a good atmosphere for the dispersion of gaseous pollutants (GPs) due to the increased rate of dispersal in the air, especially with the presence of wind movement resulting from the movement of vehicles near traffic intersections (Dholakia et al., 2014; Agrawal et al., 2021; Brewer, 2021), and sometimes these pollutants may be transmitted on a larger scale in the city if there are winds carrying them (Vallero, 2008; Fath and Jorgensen, 2021). According to the reports of the General Traffic Directorate in Iraq (Iraqi-GTD, 2021), after 2003, there was an unplanned increase of vehicles imported into Iraq, especially in Baghdad. In addition, many of these vehicles have poor technical specifications, as well as the production of diesel and gasoline with low specifications encouraged us to study the air quality in selected major traffic intersections in Baghdad to investigate the levels of gaseous pollutants emitted from vehicle exhaust, especially with the exacerbation of the problem of traffic jam at these intersections, where citizens may take more than half an hour to cross the intersection. Figure 1 shows the increase in the number of cars imported to Baghdad during the past years (Iraqi-GTD, 2021).

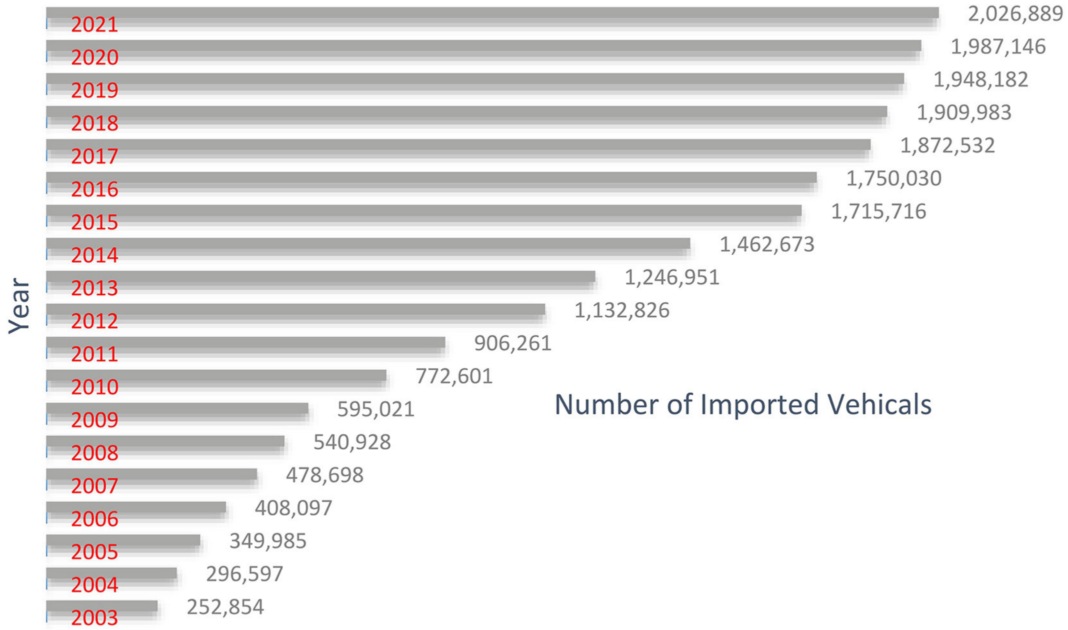


**Figure 1.** The increasing number of vehicles in Baghdad in the last two decades

There is a noticeable difference in the ambient temperature between the seasons in Baghdad city, where the weather reports indicate that the temperature reaches 1 °C on some winter days, while it may reach half the boiling point of water in the summer (Spark, 2022). Figure 2 demonstrates the variation of the ambient weather temperature during the study period, which lasted about 180 days from December 2020 to May 2021.

Many researchers have pointed out a relationship between fluctuations in air temperatures and the spread of gaseous pollutants resulting from vehicle exhaust emissions, especially in large cities. There are also many studies that have examined air quality variance during the Covid-19 pandemic and the effect of closure periods on reducing the rates of air pollutants emitted (Sulaymon et al., 2021; Zaib, Lu et al., 2021). Given that air quality is closely related to human and animal health, the importance lies in providing all technical capabilities and scientific expertise in monitoring the spread of air pollutants and controlling air quality (Hampel et al., 2011; He et al., 2016; Qiu et al., 2018). Agrawal et al. (2021) investigated the transmission of $PM_{10}$ and $PM_{2.5}$ and have been documented for one year in three small cities in India with the aim of achieving sustainable development goals (SDGs) that has direct relevance to people's health. The researchers concluded that the air pollutants they studied had exceeded the permissible limits in the NAAQS in India (MEFCC 2020; NAAQS-EPA 2021), while far exceeding the maximum limits set by the WHO (WHO, 2000), which indicates

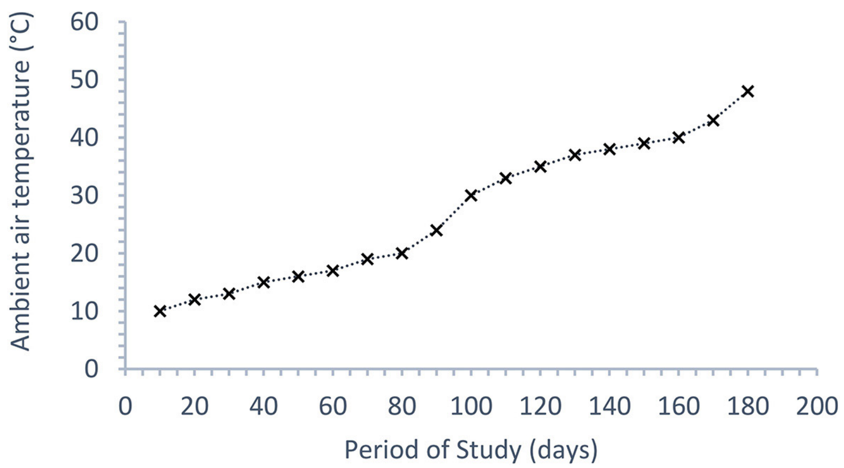


**Figure 2.** Ambient air temperature (°C) during the period of research

that the air quality is not monitored in many villages and even in urban areas. The researchers recommended the need to monitor the quality of gaseous emissions as well as polluting particles in order to achieve the SDGs 3.9, 11.6, and 11.b.

Ajeel et al. (2021) studied the variation in the concentrations of asbestos fibers in the air at four traffic intersections in Baghdad in the fall of 2019. Using energy-dispersive X-ray equipment and a scanning electron microscope (SEM), the number of asbestos fibers on the filters was measured. The average concentration of asbestos in the ambient air for the four zones was 0.0718 f/mℓ, which exceeds WHO regulations for air equal to 0.0022 f/mℓ (WHO, 1986; Ajeel, Fleeh et al., 2021). This could occur as a result of the city's close proximity to industry and its excessive traffic. Thus, plans such as traffic administration, industrial relocation, and product replacement can be effective in reducing airborne fiber concentrations.

In 2021, Allu et al. (2021) confirmed the link between $O_3$ levels and other contaminants using the Pearson correlation coefficient (EPA, 2015). Along with monitoring CO, $NO_X$, and $O_3$, environmental variables like temperature, relative humidity, and sun radiation (Allu et al., 2021). It was noted that the decrease in CO and NOx concentration caused the $O_3$ concentration to rise from 26 ppb to 56.4 ppb during the pre-and closure periods, respectively. Additionally, throughout the closing time, concentrations of $NO_2$, NO, and CO decreased by 33.7%, 53.8%, and 27.25%, respectively (Allu et al., 2021). Analysis of variance ANOVA was employed to ascertain the parameters' statistical significance. By analyzing the concentration of pollutants during COVID-19 lockdown and pre-lockdown periods, this study sought to determine the impact of COVID-19 lockdown on air quality in Hyderabad, India (Allu et al., 2021).

Shihab (2022) has applied the principal component analysis (PCA) as a tool to determine the main causes underlying variations in air pollution in a part of the Iraqi metropolis of Mosul, where a temporal overall air standard evaluation index was created using PCA to determine when the air quality was at its best throughout the year. The information was gathered using a substation housed in a public library close to a traffic light intersection and an extremely congested motorway in Mosul city. The information comes from data measured over a year of $O_3$, NO, NOx, $SO_2$, CO, $CO_2$, CH4, TH, NMHC, and $PM_{10}$. PCA was used to examine the air quality metrics on a seasonal and annual basis. According to the study, there was a significant variation in the pollutants created by vehicles, ranging from 56.91 to 73.75%. The gases CO, NO, NOx, $O_3$, THC, and $CO_2$ serve as evidence. The monthly air quality temporal evaluation revealed that March and April had the cleanest air, while January had the worst air quality conditions. The research found that using PCA to analyze air quality data effectively identified the factors influencing air quality variance and its underlying causes. Additionally, the researcher demonstrated that the PCA findings might be useful in designing the measurement program for the station located.

Theyab et al. (2021) deal with how the transportation system affects contamination at urban crossroads, with the primary goal of this research being to look at how traffic flow affects the amount of pollution at a particular crossroad in Kerbela city. Consequently, a video camera was set up for three days to track the changes in traffic flow during a 24-hour period. The researcher was then employed to look into the quantity of $CO_2$ and CO released during the peak times. For the crossroad analysis, a well-known SIDRA 8.0 was used. The results showed that the $CO_2$ levels surpassed the allowable threshold with inferior roadways at the two junctions that were chosen.

Indeed, strict attempts to measure, such as lockdowns forced in countries around the world to control the extent of the spread of COVID-19 have affected ecological standards significantly. When it comes to the influence of transport systems on air quality, crossroads are primarily regarded as crucial components. Their control type and physical arrangement may have a big impact on vehicle emissions. The current experiment presents a vision of the spread of seven gaseous pollutants (i.e., $SO_2$, $NO_2$, CO, $CO_2$, $H_2S$, VOCs, $O_3$, and beside of percentage of lower explosive limits (% LEL)) in the selected traffic intersections and the effect of seasonal temperature variation in the city of Baghdad by measuring these gaseous via using specialized devices and comparing the results with the global standard of air quality (WHO, 1986; WHO, 2000; EPA, 2015; EPA, 2015; EPA, 2015; EPA, 2015; EPA, 2015; NAAQS-EPA, 2021), in order to help researchers and decision-makers to develop the necessary plans to control air quality and thus reduce air pollution.

## THE EXPERIMENTAL WORK AND FIELD INVESTIGATION

In this research, the work was divided into two main parts: the experimental and field works and the second part was analyzing and comparing the results with Global Standard. Three crowded traffic intersections have been selected in Baghdad city, two at Alresafa sector (Bab Almuadham and Almasbah intersections) and another one at Alkarkh sector (Alliqaa Cycle intersection) as shown in the Fig. 3a, 3b, and 3c, respectively; these plates were captured from Google Earth website 2022 (Google, 2022). Where these sites are characterized by high traffic jams, and the passage of different types of vehicles with gasoline and diesel fuel. In order to examine a wide range of ambient air pollutants (AAP) throughout the period of study, GIG-6 and GIG-2 gases GFG devices made in Germany (as shown in Fig. 3d) were used to achieve the experimental purpose of this research. Prior the starting the tests, and to get an acceptable result, the calibration of the devices was carried out in the Manufacturing Directorate of the Iraqi Ministry of Industry and Minerals according to other researchers' recommendations (Al-Sultan et al. 2019). GIG-6 device was utilized to measure the pollutants $NO_2$, CO, $CO_2$, $H_2S$, $SO_2$, and %LEL (%LEL: Low Exclusive Limited, it revealed the lowest intensity of burn for the Volatile Gases, that is maybe sung (↑↑) to convey the potential for the expulsion or (↓↓)), and GIG-2 was used for detect of $O_3$, VOCs. The sampling was conducted at the peak flow of the traffic volume between (1:00 PM - 2:00 PM) since the peak period when there is the most traffic, and the maximum daily temperature is the worst situation for the spread of GPs. As the ambient air temperature is the primary factor affecting the multiplicity inspected the air contaminants (Maplandia, 2022; Saxena and Sonwani, 2019; Shihab, 2022; Spark, 2022), the investigation was done throughout six months, from December 2020 to May 2021.

## RESULTS AND DISCUSSION

AAP (i.e., VOCs, CO, $CO_2$, $SO_2$, $NO_2$, $H_2S$, and $O_3$) are regarded as among the major byproducts of the combustion of gasoline and diesel fuel, and their release from vehicle exhaust has a direct, immediate impact on the quality of the air (KIANO, 2018; Saxena and Sonwani, 2019; Rao and Sharma, 2020). The spread of AAP under this study was investigated at the selected traffic intersections, as shown in the experimental and analyzing details below.

### VOCs release

There are several non-burning causes of VOCs emission, but the use of solvents, particularly those released from paints, is the most significant one. VOCs are one of the principal byproducts of the burning of vehicle fuel and are used to define organic material in the vapor phase, excluding methane. During storage and distribution, evaporative gasoline losses are very substantial (Rao and Sharma, 2020). Figure 4 shows the typical seasonal fluctuation of VOCs in the chosen traffic signal; it is evident that the concentrations of VOCs significantly rise as the temperature rises. High concentrations of VOCs are present in automobiles at the crossroad traffic signal, and the pace of the resulting VOCs is directly proportional to the rise in temperatures. The rising levels of VOCs have a detrimental effect on human health, and they also contribute to the formation of ground-level of $O_3$ that is accompanied by sunshine. The VOC emission results were in the range of 0.500 ppm in the winter and 2.850 ppm in the summer. Although this compound is a concern for human health, significantly harming the lungs, especially teens and children under of 15 years (Dai et al., 2015), the concentrations that were read during the study period were within permitted limits by EPA Standard (EPA, 2021), and the reason for this may be due to the dispersal of the compound during the movement of cars at traffic intersections in addition to the movement of winds in the study area.

### CO and $CO_2$ emissions

One of the primary sources of CO is automotive exhaust, an odorless, colorless gas that does not irritate anything that breaths it (WHO, 2000; EPA, 2015). Figure 5 describes the seasonal variation of CO concentrations over time; there is a significant CO concentration jump when the ambient air temperature increases. As can be seen, the range of CO concentrations rose from (9.95–30.20 ppm) when the seasonal ambient air temperature changed during winter, spring, and summer days. The reason for this, according to previous studies, is that the

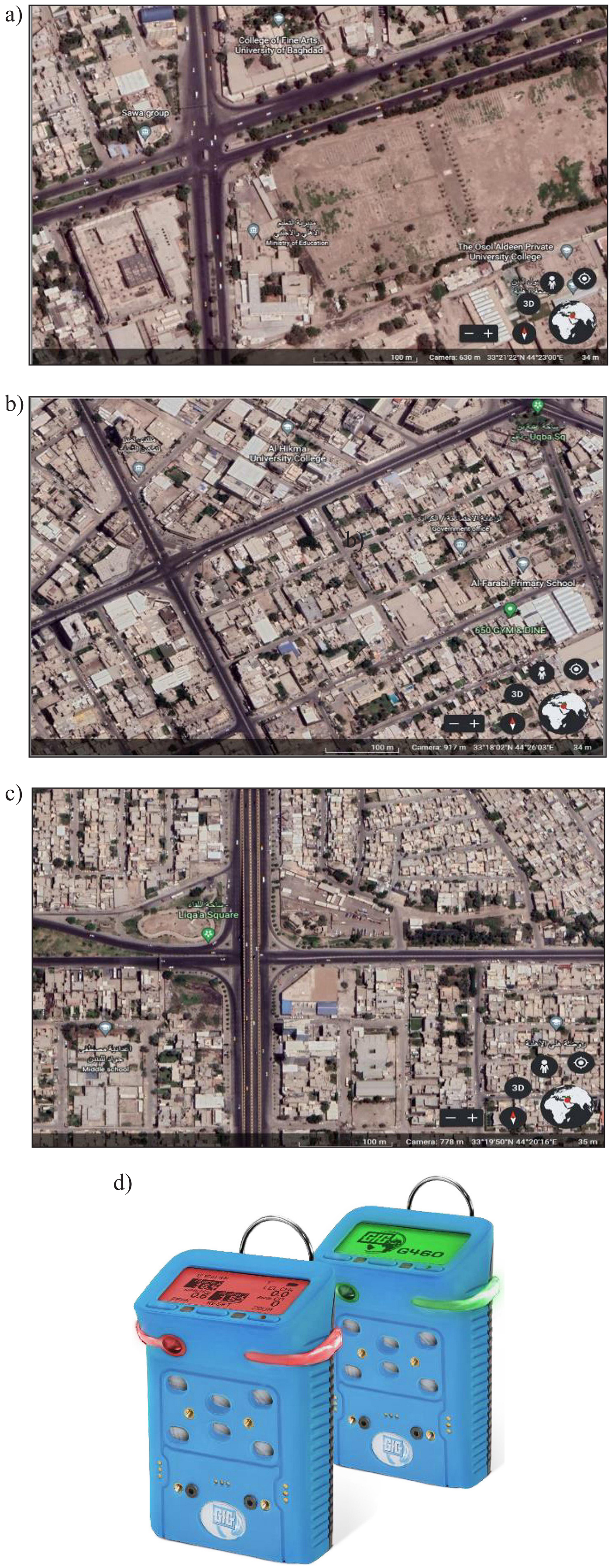


**Figure 3.** a) Bab Almuadham traffic intersection; b) Almasbah traffic intersection; c) Alliqaa cycle traffic intersection; d) GIG-6 and GIG-2 air pollutants detector

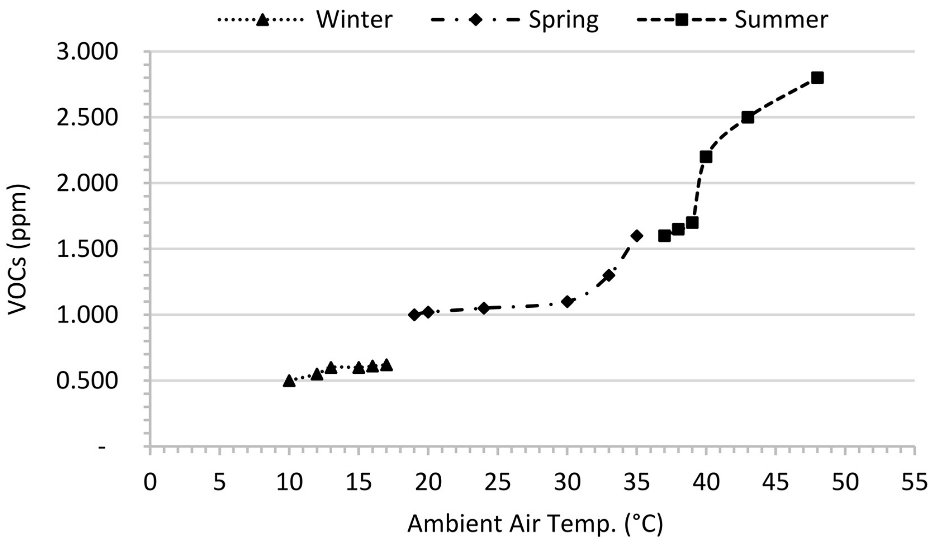


**Figure 4.** Seasonal fluctuation of VOCs

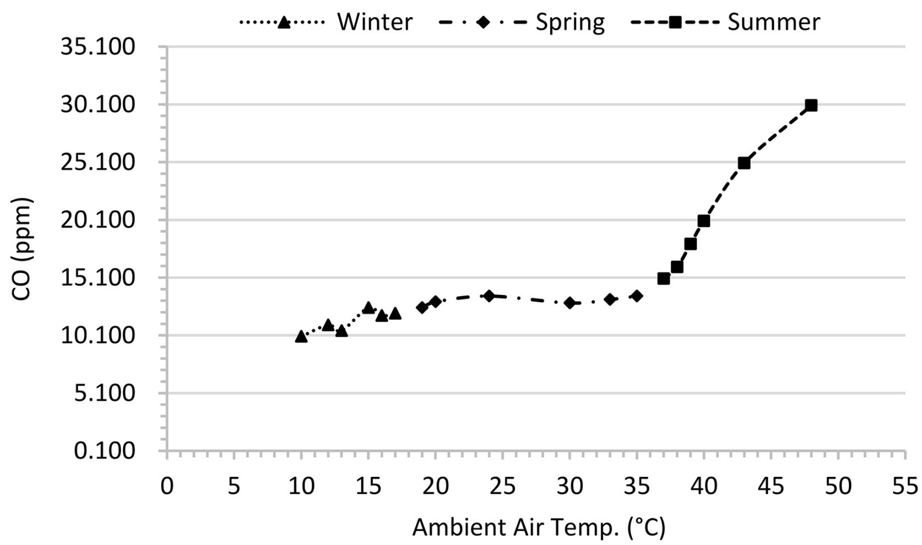


**Figure 5.** Seasonal variation of CO

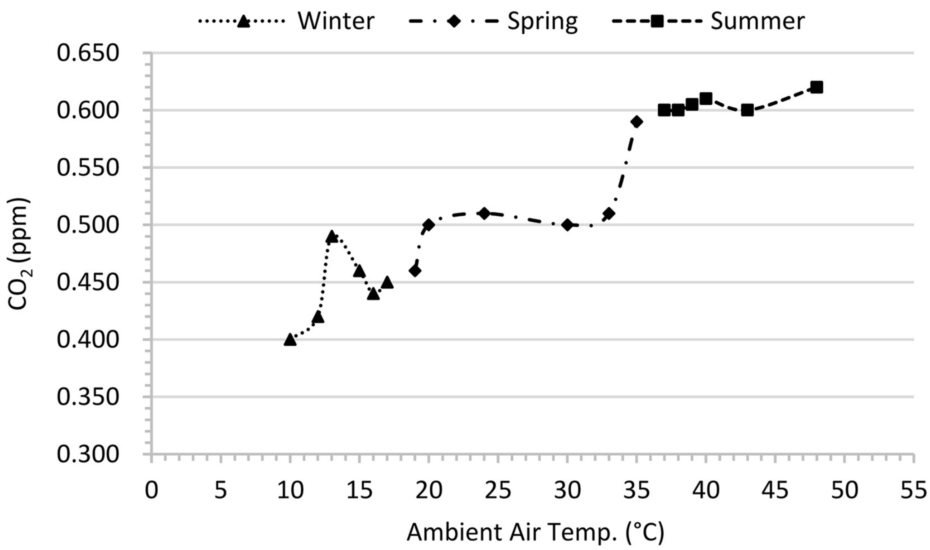


**Figure 6.** Seasonal variation of $CO_2$

increase in air temperature leads to the dissolution of carbon dioxide into carbon monoxide and free oxygen in the air (Rao and Sharma, 2020; Brewer, 2021); in addition to the incomplete combustion of poor-quality fuels, as well as old vehicle engines, can produce carbon monoxide. From GIG-6 detector readings, the maximum CO concentration was reported to be around 30.21 ppm, this is less than the maximum daily 1-hr mean = 52.238 $mg/m^3$ or (35 ppm) based on the EPA limitations (EPA, 2015), but this value was more significant than the standard maximum daily 8-hour mean (9.00 ppm) conducted by EPA (EPA, 2015).

$CO_2$ is one of the gases available in the atmosphere and is necessary for the life of plants, but if it exceeds the permissible concentrations, it is considered harmful to the ozone layer (WHO, 2000). This gas results from the combustion of fossil fuels, forest fires, and various industrial activities (Austin et al., 2002). Figure 6 demonstrates the findings it captured from GIG-6, and $CO_2$ concentrations varied during the research period. It is noticeable that the increase in temperatures from 4 °C to 48 °C doubled the spread of $CO_2$ concentrations from 0.398 ppm to 0.610 ppm; as well, $CO_2$ concentrations were less than CO concentrations as a result of the high seasonal temperatures and their effect on the splitting of $CO_2$ into CO and free oxygen.

## $NO_2$ and $SO_2$ emission

Industrial activities and the explosion of volcanic craters lead to the production of many gases, the most important of which are $NO_2$ and $SO_2$, which can also be produced from the combustion of vehicle fuels. Additionally, these gases cause the creation of acid rain, which has a variety of negative impacts, such as the acidity of lakes and streams, rapid corrosion of structures, and reduced vision (Wang, 2005). Among the various NOx emitted from fragment combustion, NO, $N_2O$ and $NO_2$ are stable, and NO dominates. $NO_2$ may irritate the lungs and eliminate barriers to respiratory infections in terms of health impacts (Sugathan, 2021).

As shown in Figure 7, the readings of the GIG-6 device showed an evident rise in $NO_2$ emissions, as the lowest reading was recorded at 0.200 ppm in the winter season at 9 °C, while the maximum concentration was reached at 0.272 ppm in the summer season at 46 °C, which mean that the maximum value was more than the normal normal conducted by the WHO (1- hr mean 200 $\mu g/m^3$ = 0.134 ppm) (WHO 2000). Then again, and according to the reported device readings sketched in Figure 8, the release of $SO_2$ was around range values of (0.008–0.651 ppm) during the seasonal temperature variation (9–49 °C). As can be observed, the winter season's lowest value was lower than the typical emission value, while the season's highest value was higher than the WHO permitted limit (10 minutes mean, 500 $\mu g/m^3$ = 0.335 ppm) (WHO, 2000). These data pertain to how the detrimental effects of $SO_2$ increase as temperature rises. The levels of $NO_2$ and $SO_2$ demonstrate the relative rise in high pollution at the chosen road crossings, which has an immediate impact on the human respiratory system.

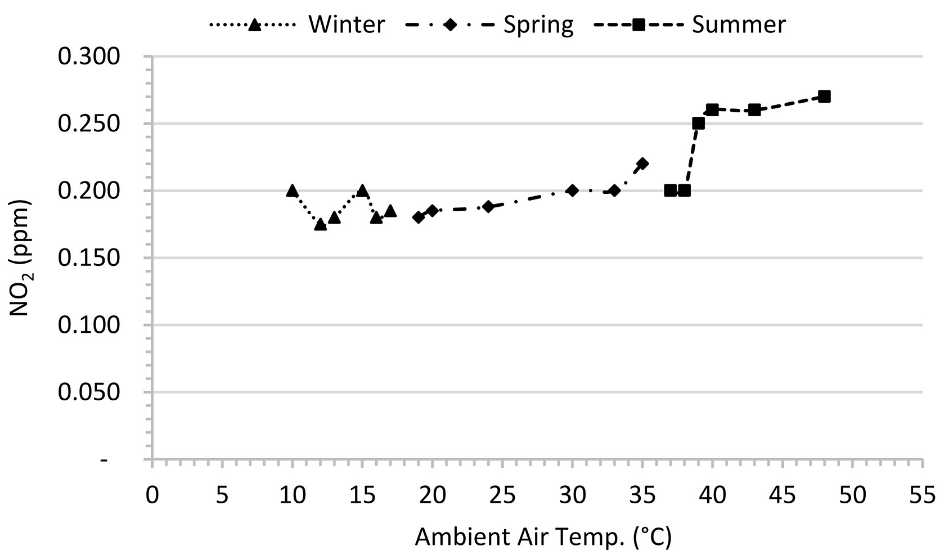


**Figure 7.** Seasonal fluctuation of $NO_2$

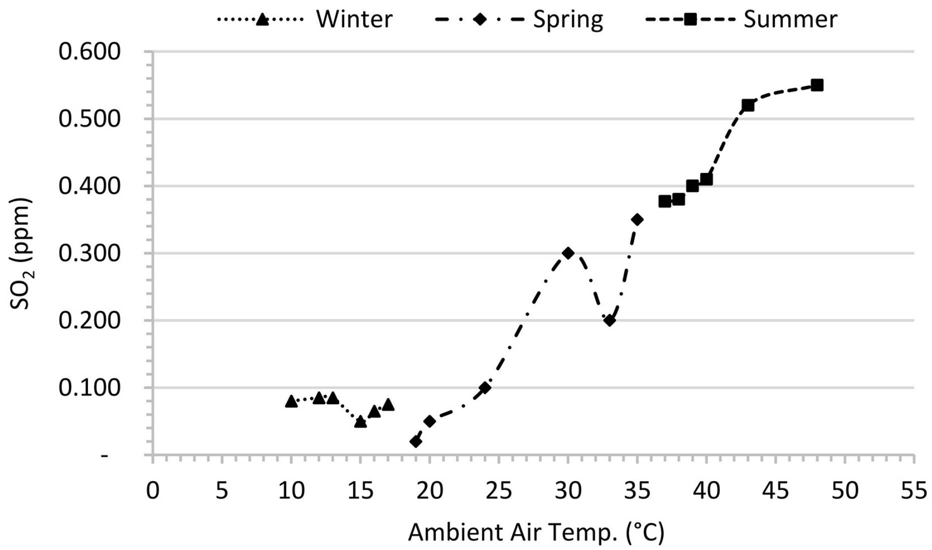


**Figure 8.** Seasonal variation of $SO_2$

## $H_2S$ emission

$H_2S$ is a colorless hydrocarbon gas that may be dissolved in a variety of liquids, such as water and alcohol. (WHO, 2000). $H_2S$ is a gas that may be produced by saline marshes and is found near sulfur springs and lakes as well as in the air in geothermally active regions. People can often detect hydrogen sulfide, combustible gas with an unpleasant odor like rotten eggs, in the air at low quantities of 0.0005 to 0.3 ppm (ATSDR, 2016). $H_2S$ causes itching in the skin and eyes when it is in low concentrations, while it may lead to suffocation and death if it spreads in high concentrations (WHO, 2000).

The emission of $H_2S$ was investigated in the study areas, where it was noted in Figure 9 that the increase in temperatures from 9 °C to 45 °C led to an increase in $H_2S$ emissions resulting from the combustion of vehicle fuel, where the lowest concentration of $H_2S$ was recorded at 0.0005 ppm, while the value of the highest concentration of $H_2S$ was reached to 0.005 ppm that consider more minor than the normal limit of emission (10 ppm) placed by WHO (WHO, 2000).

## $O_3$ gas release

$O_3$, a supplementary pollutant created by photolysis that may be harmful to human health and cause respiratory issues, is produced when NOx and VOCs combine, and one of the crucial elements of the atmosphere's troposphere is $O_3$ (WHO, 2000; EPA, 2015). Numerous chemical activities in the atmosphere day and night are governed by the

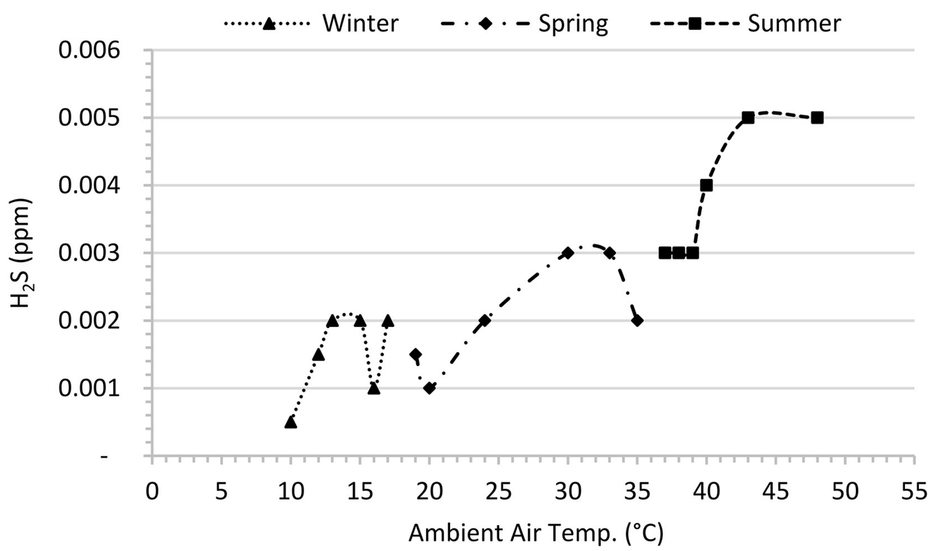


**Figure 9.** Seasonal fluctuation of $H_2S$

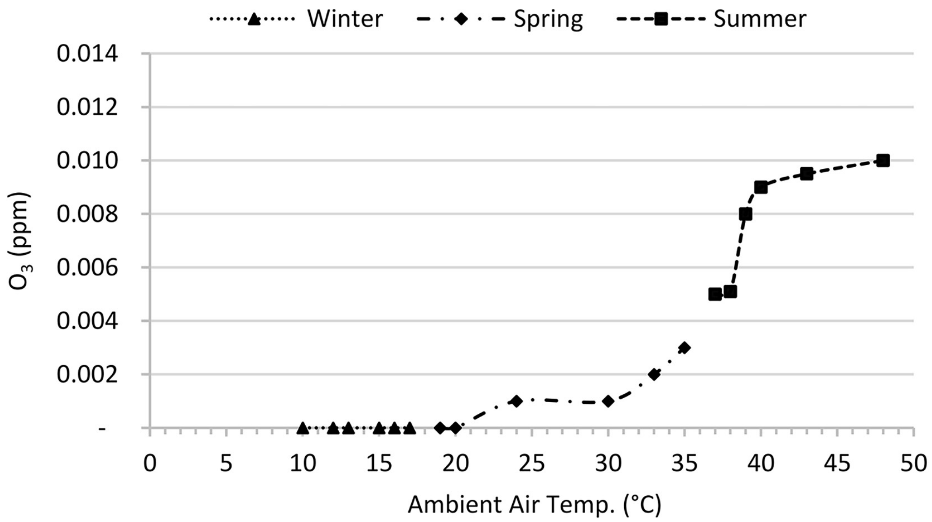


**Figure 10.** Seasonal variation of $O_3$

chemical reactions connected with this optical gas (Prabhu et al., 2022). $O_3$ is one of the components of smog, and when $O_3$ concentrations grow significantly due to human activities that help burn fossil fuels, a significant amount of it becomes an air pollutant (Dhanya et al., 2022).

The concentrations throughout the winter and spring days (0.000–0.0028 ppm), which were fewer than the standard limit (112 mg/m$^3$ or 0.075 ppm), are shown in Figure 10 to illustrate the seasonal change for the $O_3$ for 180 days based on the air quality limitations placed by EPA (EPA, 2015). $O_3$ concentrations varied from 0.008 ppm to 0.01 ppm in the summertime, particularly towards the end of May; these levels are higher than the EPA's standard limit. Numerous studies have shown that high temperatures are to blame for the high $O_3$ concentrations at the start of the summer because it broke some of the bonds in VOCs and combined with NOx to produce ground-level $O_3$ (WHO, 2000; Dhanya et al., 2022).

## CONCLUSIONS

In this research, one of the environmental issues that Baghdad city suffers from is highlighted, where the emission of gaseous pollutants from vehicle exhaust as a result of fuel combustion at critical traffic intersections was evaluated for 180 days. This paper has been conducted to harness the knowledge and practical and theoretical possibilities in environmental engineering to reveal the causes of this problem and try to help decision-makers find solutions. The results of the tests obtained from air quality sensors confirmed that there is a close relationship between temperature increases and the spread of gaseous pollutants. In comparison, the rise in temperature from 4 °C in the winter to 46 °C on some days of summer doubled the emission of VOCs, $NO_2$, $SO_2$, $H_2S$, CO, $CO_2$, and $O_3$. In May 2021, the readings of the examination devices indicated that the concentrations of each CO, $NO_2$, and $SO_2$ were exceeded the permissible standards placed by WHO and EPA, as well as the release of $O_3$ in the summer times was larger than WHO's limitations, while the rest of the readings for other gaseous pollutants during the study period were within the permissible limits. In addition, the devices did not detect the %LEL during the study period.

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