Evaluation the role of plant fences in reducing the level of some spread gases and oxides in the northwestern part of Baghdad

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Abstract

The study was applied in the city of Baghdad by choosing the northwestern part of the city on the Karkh side, represented by the highway linking the northwestern entrance to Baghdad (Taji district) to (Darwish Intersection) and administratively named (Salah Al-Din Highway). The study area was divided into five sites that differed in the quality, quantity and distribution of plants used as fences in the middle and sides of the road as well as the density and distance of residential buildings and other human activities from the approaches to the road.

The concentrations of gases and oxides were measured in the field, represented by (CO2), (H2S), (CO), (HCHO) and (O2), in addition to some environmental factors such as temperature, humidity and wind speed. The study ran from July to September 2022, with an average of four visits per month and took concentration rates at morning and afternoon peaks for each site.

(CO2) concentrations ranged from 523.9 ppm to 574.5 ppm and were above acceptable limits for WHO standards and Iraqi determinants of 250 ppm. (CO) concentrations ranged from 0.5 ppm to 113.4 ppm and were also above the acceptable limits of WHO standards at site (A) and site (E) for the study area of 9 ppm, and concentrations of (H2S) ranged between (0 - 62.82) ppm, which exceeded the acceptable limits of WHO standards of 0.047 ppm in all sites except site (C). Formaldehyde concentrations were between (0.03 - 0.128) mg per cubic meter and recorded the lowest concentration rate in site (A) and highest in site (E).

Keywords: *Green fencing; Air quality; Gas and oxides; Vegetation; Pollution; Urban environment*.

1. INTRODUCTION

Air quality in the urban environment is a major health concern because about 54% of the world's population lives in urban areas, and this proportion is expected to rise to 66% by 2050 (United Nations, 2014).

In the Iraqi urban environment, according to statistics from the Ministry of Planning and Human Development, the urban population constitutes about 69.9% of the total population. Studies show that in addition to their impact on climate change and the environment, transportation emissions significantly degrade air quality, especially for people living on or near busy streets and highways, as these emissions cause increases in the incidence of asthma and other allergic diseases, some cancers and heart attacks.

Emissions of various modes of transportation are the main source of air pollution in cities around the world (Kumar et al., 2013). The movement and intensity of traffic is the main source of air pollution through its emissions and wastes that pollute the urban environment. (Kumar, P. et al., 2018; Abhijith, K. V. et al., 2017) These pollutants are characterized by a group of harmful gases and oxides, such as carbon monoxide and dioxide (CO, CO2), nitrogen oxides (NOx), and particulate matter - PM10 (Particulate matter ⩽ 10μm) and PM2.5 (PM ⩽2.5μm) and ultrafine particles (UFP<100 nm), in addition to vehicle exhaust emissions and other transport-related pollution factors. (Dean et al., 2011; Nowak et al., 2014; Tzoulas et al., 2007; Pérez et al., 2014; Younis and Alsalman, 2018; Aljewari and Alsalman, 2023)

These emissions of particulate matter, hydrocarbons, carbon monoxide and other pollutants harm human health, as these cause skin and eye irritation, allergies and very fine particles can accumulate in the lungs, where they cause respiratory problems. As hydrocarbons react with nitrogen dioxide and sunlight and form ozone, which is beneficial in the upper atmosphere but harmful at ground level, ozone leads to inflammation of the lungs, causing chest pain, coughing and making it difficult to breathe, carbon monoxide, an exhaust gas, is especially dangerous for infants and people with heart disease because it interferes with the blood's ability to transport oxygen. (Rabee, 2014; Ajeel, et al., 2021)

Therefore, many attempts and means have been made to mitigate the impact of these pollutants, including the adoption of the concept of green infrastructure in the built environment, especially in large cities, and considering it as a solution for appropriate urban planning to improve the environment of cities and air quality (Althwainy et al., 2017), in addition to enhancing the sustainability of these cities to be able to accommodate the escalating population growth in urban areas (Irga et al., 2015; Salmond et al., 2016).

Green solutions include increasing the planting of street trees, creating vegetation barriers (including hedges), green walls, green roofs, hydroponics, and others. Within these infrastructures, plant species act as porous bodies that affect the patterns of dispersion, absorption and on-site adsorption of different pollutants depending on the structural, morphological and volumetric nature of these plants (Nowak, 2006; Escobedo and Nowak, 2009; Yin et al., 2011; Fantozzi et al., 2015; Janhall, 2015; Jasim, 2018; AlObaidy and Rabee, 2018; Abozaid, et al., 2021; Khayoon and Alsalman, 2023).

Apart from reducing potential air pollution, urban green infrastructure also provides benefits such as urban mitigation of heat islands, better storm and storm water management and climate change mitigation (Czemiel Berndtsson, 2010; Roy et al., 2012; Chen et al., 2014; Gago et al., 2013; Matthews et al., 2015; Al-hesnawiand Alsalman, 2015)

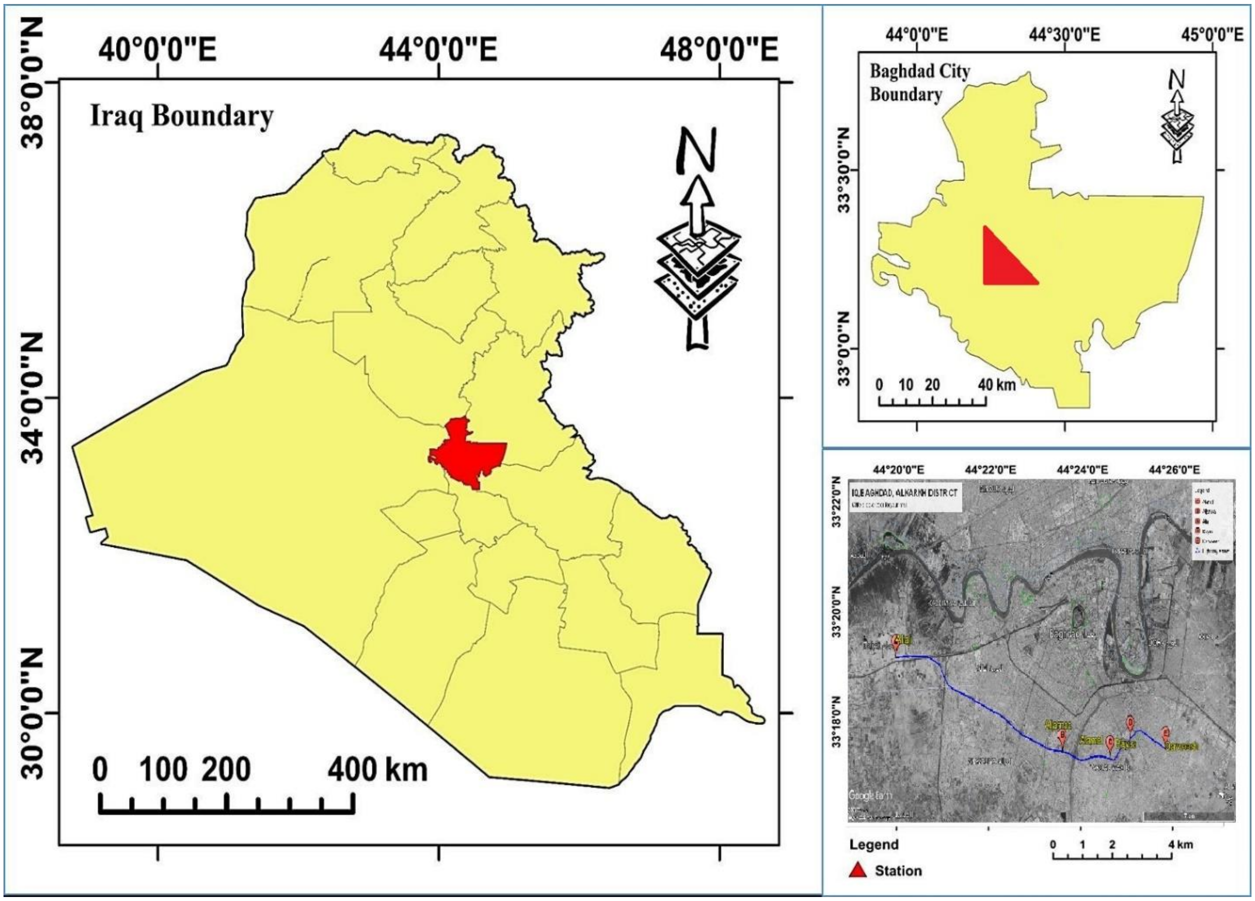
For the air pollution reduction performance of different types of green infrastructure, either individually or in combination, in different urban environments the majority of studies focused on pollutants such as CO (Chen et al., 2011; Bigazzi and Figliozzi, 2015), which have adverse health effects. Green urban infrastructure can be implemented as a passive air pollution control measure to control air pollution in cities through limited modifications in the constructed environment (McNabola, 2010).

Therefore, this study was designed to find out the level of performance and conformity of green fences and green infrastructure in the city of Baghdad with international standards and standards on the one hand and their efficiency in reducing the levels of air pollutants on the other hand.

2. Study Area

The study area is on the Karkh side of Baghdad, Iraq's capital, which is bordered on the eastern side by the Tigris River and is astronomically located between latitude (33) north, longitude (44) east and as in Figure (1).

Figure 1. Study Area, Baghdad city, Iraq.



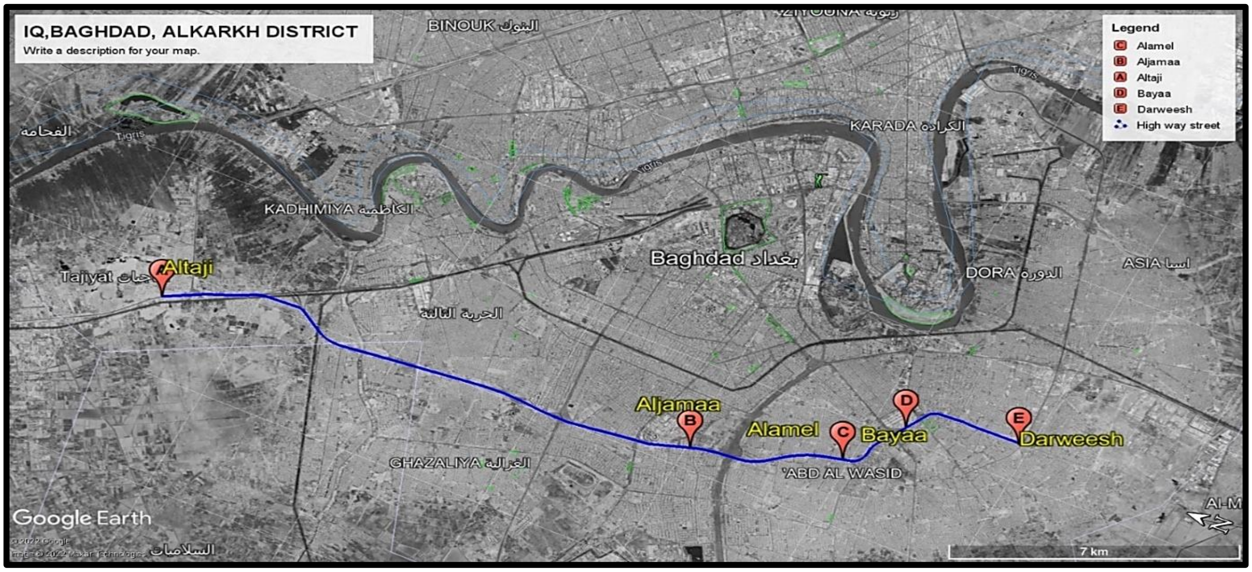
2.1. Sites of study

The study area was divided into five sites where the highway passes and included the following areas, the first site (A) Taji area, (B) Aljamaa district, (C) Alaamil district, (D) Al-Bayaa garage and (E) Darwish intersection distributed over a distance of about 22 km and as shown in Figure (2) and Table (1). Where the division depended on the presence and absence of plant fences on both sides of the road and the middle islands, and whether the site is residential or non-residential near and far from the road and as in the Satellite image of these sites from (1-5).

Table 1. Locations and their coordinates.

No.	Site Name	North Coordinate	East Coordinate
1	Site (A) Altaji	33°25'09.7"N	44°17'27.1"E
2	Site (B) Aljamaa district	33°17'57.6"N	44°18'25.2"E
3	Site (C) Alaamil district	33°16'05.9"N	44°19'15.6"E
4	Site (D) Albayaa Garage	33°15'35.3"N	44°20'15.1"E
5	Site (E) Darwish intersection	33°14'09.3"N	44°20'42.0"E

Figure 2. Study sites within the Karkh side - Baghdad Governorate. Source: (Google Earth)



Satellite image 1. Location of (A) Taji area

Satellite image 2. Location (B) Aljamaa district

Satellite image 3. Location (C) Al-Aamel District

Satellite image 4. Location (D) Al-Bayaa Garage

Satellite image 5. Location (E) Darwish Intersection

3. Experimental part

After determining the coordinates of each site, the center point of each site was chosen for measurement within each site. Portable measuring devices were used to measure the concentration of various gases in the atmosphere of the study area such as (CO, CO2, HCHO, O2, H2S) using devices (WT8811-Wintact), (GM8802-Benetech) and (WT87B-Wintact) as the devices were installed at a height of one and a half meters above the ground to avoid dust flying due to wind movement, and the measurement was made with the direction of the prevailing winds in the region during the implementation of the experiments and as stated in (IPCS, 1995).

The samples were taken simultaneously for a period of exposure (one hour) and at a rate of four readings per month for each site (two readings during the morning peak and two readings during the afternoon peak interchangeably between sites). The rates of the four readings for each site were taken for three months during the summer (July, August and September) of 2022. Some basic atmospheric factors affecting the distribution of the gases targeted in the study were also measured, represented by temperature, relative humidity and wind speed, as well as the number of passing vehicles during the measurement process.

4. Results

By following up the results of field measurements of the studied factors of gases (CO, CO2, HCHO, O2, H2S), in addition to some climatic factors such as temperature, relative humidity and wind speed, in addition to calculating the number of cars passing during the measurement times, we find that all sites have recorded varying values and when following the path of change of each gas or oxide, we find that it has taken its own behavior in line with the nature of the region, the density and quality of vegetation cover, the number and quality of passing vehicles, the time of sample collection, wind intensity and quantity. Humidity as shown in Table (1).

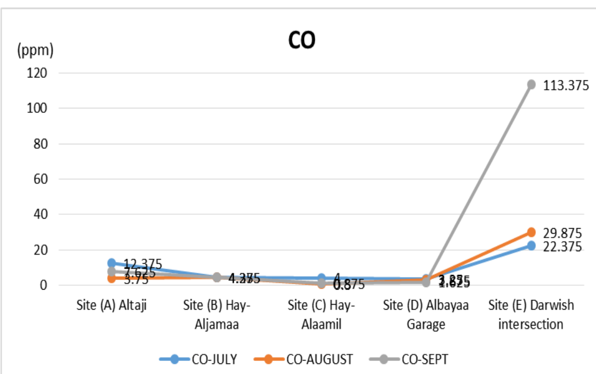
Table 2. The average of (CO, CO2, H CHO, O2, H2S and metrological parameter, wind, temperature, RH) in sites of study compared with WHO standards.

Sites	Months	CO (ppm)	CO_2 (ppm)	HCHO mg/m3	O_2 % vol.	H_2S (ppm)	Wind Sp. Km/h	Temp C° Average	RH % Average	cars per Hour
Site (A) Al-Taji	July	12.4	533.8	0.03	20.23	0.7	12.6	45.7	18	4782
	August	3.8	523.9	0.043	20.71	0.87	5	43	21.7	5548
	September	7.6	539.3	0.045	20.85	1.57	3.7	41.4	20.4	5700
Site (B) Al-Jamaa District	July	4.3	536.4	0.053	21.01	0.45	6.6	46.1	19	8064
	August	4.4	574.5	0.035	21.03	1.33	3.3	40.1	24.7	8050
	September	4.4	541.5	0.071	21.12	0.52	3.7	42	18	8669
Site (C) Al-Aamil District	July	4	526.9	0.038	20.98	*N	8	48.2	17.4	4175
	August	0.5	570.4	0.053	21.73	*N	5.7	42.5	21.7	4313
	September	0.9	556.8	0.067	21.1	0.5	5.4	41	17	3903
Site (D)	July	3.3	524.8	0.033	22.21	0.35	7.5	45.5	17.4	6222

Al-Bayaa Garage	August	2.9	545	0.107	21.05	0.32	5.7	45.4	18.9	5785
	September	1.6	548.6	0.032	21.1	0.05	4.9	43	15.9	6938
Site (E) Darwish intersection	July	22.4	526.4	0.075	21.28	62.82	7.7	46.1	17.3	4200
	August	29.9	544.4	0.128	20.95	13.18	3.8	44.1	19.5	4705
	September	113.4	551.3	0.088	20.97	35.08	4.9	42.4	16.4	6620
WHO level		9	250			0.047				
EPA level		35				0.011				
Iraqi National Limits		35	250							*N: nondetectable

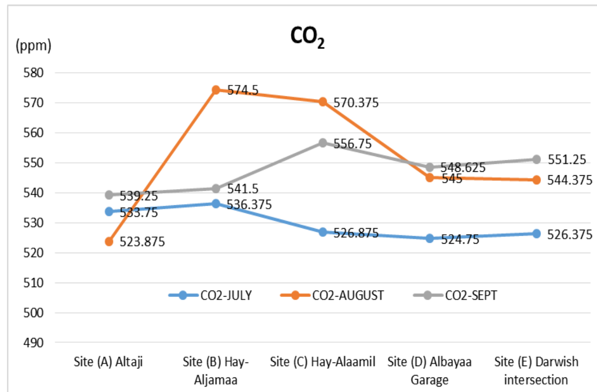
When analyzing the path of change in carbon monoxide gas values, we find that its values ranged between (0.5-113.4) ppm, where the highest concentration was recorded at site (E) Darwish intersection in September, while the lowest concentration was recorded at site (C) Al-Aamel district in August, as shown in Table (1) and Figure (2).

Figure 2. Chart of carbon monoxide distribution over the study sites.



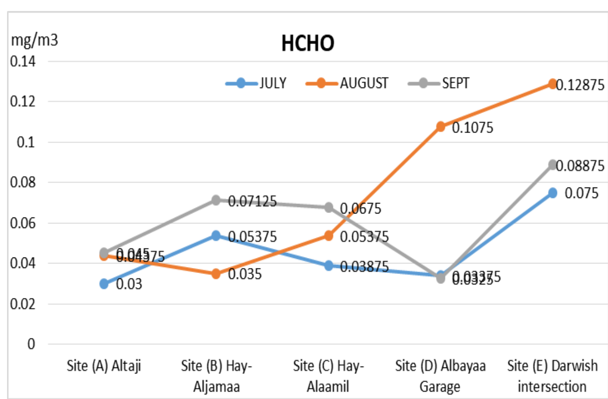
And when reviewing the values of carbon dioxide gas. It was found that the highest concentration was recorded at site (B) Al-Jamaa District in August at a rate of (574.5) ppm, while the lowest concentration was recorded at site (A) Taji area in August as well at a rate of (523.9) ppm as shown in Table (1) and Figure (3).

Figure 3. Chart of carbon dioxide distribution over the study sites.



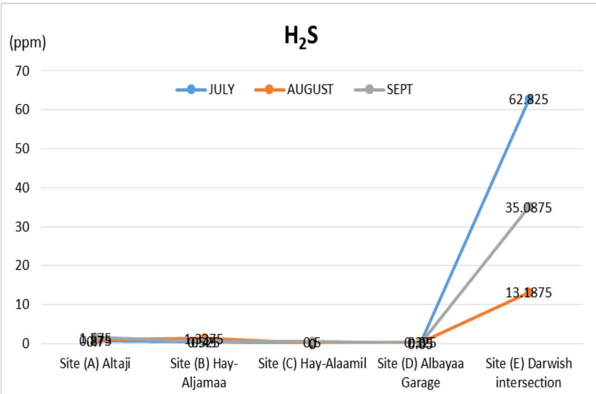
And found that the highest concentration of hydrocarbons (formaldehyde) was recorded at site (E) at the Darwish intersection in August (0.128) ppm and that the lowest concentration of the same gas was recorded at site (A) Taji area in July at a concentration of (0.03) ppm as shown in Table (1) Figure (4).

Figure 4. Chart of formaldehyde distribution over the study sites.



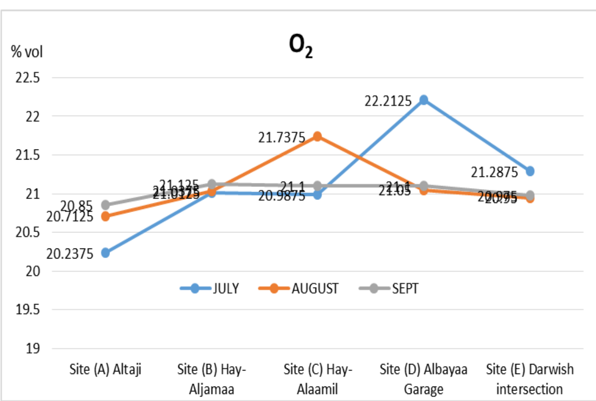
While by observing the H2S gas values, The highest concentrations were (62.82) ppm, at site (E) Darwish intersection in July, while its values were nondetectable - N, at site (C) Al-Aamel District in July and August, Table (1) and Figure (5).

Figure 5. Chart of hydrogen sulfide distribution over the study sites.



During measuring the O2 gas levels, it was found that the site with the highest percentage is (D) Al-Bayaa garage was at a rate of (22.21) percent in July, while the lowest concentration was recorded at site (A) Al-Taji area at a rate of (20.23) percent volume in July as well, Table (1) and Figure (6).

Figure 6. Chart of Oxygen distribution over the study sites.



5. Discussion

When analyzing the relationship between the studied gases and oxides and the climate factors represented by temperature, humidity and wind speed, we find that the relationship was positive between temperature and the values of carbon monoxide, formaldehyde hydrogen sulfide gas and oxygen, while the relationship with carbon dioxide was negative, while the relationship with relative humidity was positive only with carbon dioxide and negative with the rest of the gases and oxides. The relationship with wind speed was positive with carbon dioxide and oxygen gas, while the relationship was negative with carbon monoxide, hydrogen sulfide and formaldehyde, as in Table (2).

Table 3. Correlation analysis between (CO, CO2, H2S, HCHO, O2) concentration and metrological parameter (Temperature, Relative Humidity (RH) and Wind).

Air pollutant	Temp.	RH	Wind Sp.
CO	0.276	-0.400	-0.201
CO2	-0.270	0.161	0.997
H2S	0.313	-0.444	-0.058
HCHO	0.438	-0.597	-0.165
O2	0.597	-0.662	0.945

Through tracking and analyzing the results obtained from the study, we find that most of the values of the factors studied during the summer have exceeded the permissible limits specified by the WHO organization and the Iraqi national determinants regarding air quality and concentrations of pollutants in general and gases (CO, CO2, H2S, HCHO) in particular, and this is mainly due to the weakness of green infrastructure and the application of environmental sanitation rules required in the environment of cities, especially large and crowded ones (Jassim et al., 2021).

Among these indicators is the high values of the gas dangerous to human health and animal organisms in particular, represented by carbon monoxide CO, as this gas has a rapid and great ability to combine with hemoglobin and form a compound (carboxyhemoglobin) about 200 times faster than oxygen, This gas is produced from the exhaust of cars, especially with dilapidated engines or with poor combustion, as it can result from the burning of waste, especially organic ones, in uncontrolled conditions, and this is what has been observed in the field at sites A and E, as there are many random burning operations at the first site and in the second high traffic density and adjacent to relatively high buildings of the highway, and these conclusions are in line with what researchers who have studied similar cases worse in the Iraqi environment or in cities Other scientists, including (Omran, et al., 2010).

Carbon dioxide levels it has exceeded twice the allowable limits at all sites. This indicates a weakness in the distribution of vegetation cover in all its forms in general and green plant fences in the study sites in particular, and even if some of them were found, they were not subject to the conditions and engineering, environmental and agricultural standards required in organizing these barriers and their heights on the one hand and in choosing plant species to suit the nature and size of pollutants on the other hand, and the high values of this gas give an environmental indicator of high temperatures and high indicators of global warming and the impact on climate characteristics and drought factors, and this is what suffers Including the Iraqi environment in general, especially in the central and southern regions, including the location of the city of Baghdad in question, as temperatures exceeded the barrier of 50 degrees Celsius, this is consistent with the researchers' view (Al-temimi, 2016; Hashim, et al., 2016) in their studies on different locations of cities and regions of Iraq and the city of Baghdad.

Formaldehyde was found in all study sites. Although its concentrations were within the environmentally permissible limits, with the exception of site (E), which recorded 0.128 ppm, but at the same time, studies indicate to researchers and scientific institutions that continuous exposure to such concentrations, as we have shown in Table (1) and Figure (4).

Formaldehyde is an organic compound formed by natural processes and released during metabolism, this volatile organic compound is part of the group of the most dangerous substances that can be found in the air (Lund et.al. 2006) this happened were people regular exposure for a longer period to affected concentration of this compound which can lead to health issues. Health issues that can occur to Irritation of the nose, A headache and Irritation of the eyes and respiratory tract and other allergic diseases, especially in stressful environment in the summer, as in the environment of the city of Baghdad, and these opinions are in line with (Piccinini et al., 2007, Salthammer. et al,2010, Airvital, 2023, InspectAPedia, 2023)

The limit for Formaldehyde is at home 0.08 and construction /industry 0.10 mg/m3. In some literature gas exposure limits in a building (.05 ppm), but the range of human response (also widely variable individually) may be summed as follows in table (3): (Australian Competition and Consumer Commission, 2015).

Table 4. Health Effects of Exposure to Formaldehyde (ACCC, 2015)

Health Effects of Exposure to Formaldehyde		
HCHO Level in Air	**Expected Health Effects**	**Comments**
> .01ppm	mild irritation or allergic sensitization in some people	[> 0.0123 mg/M^3]
> 0.5ppm	irritation to eyes & mucous membranes	[> 0.615 mg/M^3]
> 1.0 ppm	possible nasopharyngeal cancer	[> 1.23 mg/M^3]
3.0 ppm	respiratory impairment and damage	[3.684 mg/M^3]

While the results of hydrogen sulfide in the atmosphere of the study area, we find that it recorded high values except for site (C) for the months of July and August, as the values were below the level of sensitivity of measuring devices, while its rates in the rest of the sites and months exceeded the environmentally permissible limits (0.047-0.011) by several times, as the lowest at site (C) was 0.5 and the highest at site (E) was 62.82 in July, and the presence of these concentrations in the city's atmosphere leads to many environmental and health problems as indicated by studies & Research.

The dangerous nature of hydrogen sulfide is reflected in its ability to affect every organ in your body. According to the Agency for Toxic Substances and Disease Registry (ASTDR), prolonged exposure could cause eye irritation, fluid in the lungs, and eventual loss of consciousness. Your prognosis is usually determined by the amount of H2S that you were exposed to, especially if you’re wondering about your long-term outcome (GDS, 2020). OSHA has set a permissible exposure limit for H2S gas of 10 ppm over an 8-hour period. Anything higher than that could cause extensive injuries or death.

It is noticeable from the results that the values of this gas may be more related to the quality of the means of transport, especially large trucks, the type of fuel, the nature of combustion, and to a certain degree with the high temperature and wind flow, but it is noted that the role of vegetation, the density and quality of trees, the width of the cultivated area, the proximity of buildings, slow traffic and the congestion of transportation at traffic intersections were the most influential factors in the high concentrations of this gas in each site, and what confirms the results obtained at the site (E) These conclusions are consistent with what researchers (Lakey, et al., 2016; Edwards, et al., 2022; Gobo, et al., 2012) in their studies applied in different cities exposed to pollution by this gas.

The oxygen gas rates were calculated and monitored in the study, not as an environmental pollutant, but as an environmental indicator to monitor pollution with oxides, which were referred to because there is an environmental relationship between its natural values in the air and its decrease with the levels and quality of pollution, as the researchers Lakey et al., (2016) indicate the following: present chemical exposure-response relations between ambient concentrations of air pollutants and the production rates and concentrations of reactive oxygen species (ROS) in the epithelial lining fluid (ELF) of the human respiratory tract. In highly polluted environments, fine particulate matter (PM2.5) containing redox-active transition metals, quinones, and secondary organic aerosols can increase ROS concentrations in the ELF to levels characteristic for respiratory diseases.

Researchers (Edwards, et al., 2022) emphasized that Reactive oxygen species (ROS) and environmentally persistent free radicals (EPFR) play an important role in chemical transformation of atmospheric aerosols and adverse aerosol health effects.

The researchers (Tong et al., 2017) also point out Mineral dust and secondary organic aerosols (SOA) account for a major fraction of atmospheric particulate matter, affecting climate, air quality and public health.

From the follow-up of oxygen values at the study sites, we find that they fluctuated somewhat up or down depending on the nature of the site, plant fences, density of means of transportation, temperatures and wind movement, which makes it a good environmental indicator to monitor the quality and levels of different pollution.

6. Conclusions

- The influence of the composition, shape and density of plant fences was evident in the values and rates of Gases and oxides studied when comparing sites B and C with the rest of the sites.
- The values of the studied gases and oxides varied during the months of the year

and the study sites, and this variation was related to environmental variables and traffic density (transportation density).

• All gases and oxides studied were above the limits allowed by the World Health Organization and the Iraqi limits.

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