

**AN EXPERIMENTAL STUDY ON THE DETERMINATION OF AIR POLLUTANT  
CONCENTRATIONS RELEASED FROM SELECTED OUTDOOR GASEOUS  
EMISSION SOURCES IN BASRA CITY, SOUTHERN IRAQ**

**SHUKRI I. AL-HASSEN<sup>1</sup>**  
**EMAD H. AL-QARRONI<sup>2</sup>**  
**MUAYAD H. QASSIM<sup>3</sup>**  
**HAMID T. AL-SAAD<sup>4</sup>**  
**ABDULZAHRA ALHELLO<sup>4</sup>**

<sup>1</sup>Environmental Analysis and Research Lab, Dept. of Geography, College of Arts, University of Basra, Iraq

<sup>2</sup>Dept. of Biology, College of Education for Pure Sciences, University of Basra, Iraq

<sup>3</sup>Education Department, Basra, Iraq

<sup>4</sup>Dept. of Environmental Chemistry, Marine Science Center, University of Basra, Iraq

**ABSTRACT**

This experimental study aims to determine the concentrations of air pollutants directly released from selected outdoor gaseous emission sources. This experiment carried out during 2013 at Basra City, Southern Iraq. Air pollutant concentrations were measured by using the portable detection instrument Drager CMS. The measured air pollutants were CO, CO<sub>2</sub>, NO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, HCs, and H<sub>2</sub>S. The selected emission sources divided into a variety of stationary and mobile sources. The obtained results indicated that mean concentrations for CO, CO<sub>2</sub>, NO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, HCs, and H<sub>2</sub>S were  $\geq 150$ , 2426,  $\leq 0.5$ , 12.6, 0.7, 42.0, and  $\leq 0.2$  ppm, respectively. Most of these concentrations exceeded the maximum permissible limits for National Emission Standards in Iraq. As well, some of the recorded emission concentrations at this experimental study are higher than those that at other studies which dealt with ambient air pollution, because effect of diffusion and dispersion on the ambient air pollutants. The recorded values of gaseous pollutants in this study can be used as the background level for the next studies.

**KEYWORDS:** Air pollution, Air pollutant, Gaseous emission, Stationary source, Mobile source.

**INTRODUCTION**

Air pollution is a phenomenon by which particles (solid or liquid) and gases contaminate the environment. Such contamination can result in health effects on the population, which might be either chronic (arising from long-term exposure), or acute (due to accidents). Other effects of pollution include damage to materials (e.g., the marble statues on the Parthenon are corroded as a result of air pollution in the city of Athens), agricultural damage (such as reduced crop yields and tree growth), impairment of visibility (tiny particles scatter light very efficiently), and even climate change (certain gases absorb energy emitted by the earth, leading to global warming) (Christoforou, 2004). An air pollutant is any gas or

particulate that, at high enough concentration, may be harmful to life, the environment, and/or property. A pollutant may originate from natural or anthropogenic sources, or both. Pollutants occur throughout much of the troposphere; however, pollution close to the earth's surface within the boundary layer is of most concern because of the relatively high concentrations resulting from sources at the surface (Matthias et al, 2006). The term of gaseous emission means the total amount of gases, expressed in m<sup>3</sup>/h or metric ton/day, emitted from a given anthropogenic and natural source into the atmosphere (Vallero, 2008). The gaseous emission consists of a one or more of air pollutants, which their concentrations depend mainly on the total mass of pollution emitted into the atmosphere, together with the atmospheric conditions that affect its fate and transport (Matthias et al, 2006).

Air pollutants can be classified as either primary or secondary air pollutants. Primary air pollutants are made up of constituents emitted directly into the air from a stationary source (a source contributor) such as a factory smokestack. Secondary air pollutants, however, are made up of elements emitted from sources that then form into new substances in the atmosphere as a result of complex chemical reactions involving the primary pollutants and sunlight, such as non-methane VOCs conversion to ozone (O<sub>3</sub>) (Spellman, 1999).

Primary air pollutants may also be categorized by being either stationary (e.g., power plants) or mobile (e.g., automobiles) sources. Indoor and outdoor (or ambient) air pollutants are other frequently used classifications. Pollutants with a predominantly outdoor source may be reduced to rather low levels indoors due to the high surface area/volume ratios indoors leading to extremely efficient dry deposition of pollutants such as ozone and sulfur dioxide. (Harrison, 2001).

In the UK, for example, the relative contribution made by transport, industrial, and domestic sources to the total national emission of the pollutants such as CO, NO<sub>x</sub>, and SO<sub>2</sub> ranged from 3% to 90%. These figures do not necessarily reflect the relative contribution of these sources in any particular area of the country, or any particular 'hot spot'. There are great variations between urban and rural areas, and between residential, commercial and industrial areas (Gittins, 1999).

In Basra City, Southern Iraq (the study area), as Al-Hassen (2011) reported, the most important source for gaseous emissions is the anthropogenic. This anthropogenic source divided into stationary and mobile sources. The stationary sources in Basra includes major industrial plants such as Petrochemical Complex, Steel and Iron Plant, Oil Refinery, Fertilizer Factory, Gas Liquefier Plant, Hartha and Najebia Thermal Power Stations, and minor

industrial plants such as gas-fueled power stations, asphalt plants, gypsum factories, gas flames, etc. As well, there are many of workshops, bakehouses, restaurants, electrical generators, and incinerators. These sources, in total, emit from their smokestacks into local atmosphere thousands of metric tons of gases in every day. Recently, the automobile exhausts become the predominant mobile source of gaseous emissions, because largely increase in traffic. Garabedian (2010), for example, estimated that CO and NO<sub>x</sub> emissions released from the automobile exhausts in Basra City are about 6370 and 956kg/year, respectively.

Although there are several studies (Al-Asadi, 1996; Al-Mayahi, 2005; Al-Saad, 2005; Al-Imarah et al., 2007; Al-Hassen, 2011; Qassim, 2011; Douabul et al., 2013; Karmalla et al., 2013; Sultan et al., 2013; Al-Hassen et al., 2013) which dealt with gaseous pollutants in ambient air of the study area and its surrounding, yet a study to measure the concentrations of those pollutants released from direct emission sources is not available almost. This study aims to directly determine the concentrations of air pollutants emitted from both stationary and mobile outdoor sources in Basra City. An experimental work was carried out for this purpose. The obtained data may serve as background levels of gaseous pollutant for further studies dealing with air pollution. Therefore, the present study is a one of the first attempts in this respect.

## **MATERIALS AND METHODS**

This experiment has been designed to determine the concentrations of air pollutants released from outdoor gaseous emission sources which are commonly existing and affecting in the ambient air, particularly those which in contact with everyday living of people in the study area. These emission sources divided into stationary and mobile. Five emission sources were selected from both categories. The stationary sources being selected in this experiment include an electrical generator 10A (commonly used in houses), electrical generator 50KV (commonly used for power supply to residential, commercial, municipal areas, etc.), restaurant's smokestack, bakehouse's smokestack, and incinerator. The mobile sources involve an old and new saloon cars, truck vehicle, motorcycle, and motorboat. The place and period of experiment was at Basra City, Southern Iraq, and during 2013.

Concentrations of gaseous pollutants released from emission sources were determined by using the portable detection instrument Drager CMS (Dragerwerk AG & Co, Lubeck, Germany). This instrument consists of the analyzer and gas-specific chips. Drager CMS is designed for short-term measurement of various hazardous gases and vapors in ambient air.

Ten measurements can be performed with each chip. The measuring principle is based on the chemical reaction between the gas in question and a gas-specific reagent system. The reagent system is encapsulated in a glass capillary; the air sample to be investigated is drawn through the reagent system with constant flow. The hazardous gas or vapor under test reacts with the reagent system. This chemical reaction is detected optoelectronically. The complete reaction basically takes place within a very much shorter period of time at higher concentrations than at lower concentrations. The measuring time for higher concentrations of hazardous gas is consequently shorter than for lower concentrations. The measured gas result is evaluated automatically and displayed directly on the LC display of the analyzer as a concentration.

In the present experiment, seven gas-specific chips were chosen. These chips and its specifications are shown in Table 1. The concentrations were measured by installation the gas inlet of the employed instrument on a distance about one meter from the outlet of an emission source in working. The smog emitted from a given gaseous source, however, may be varied in diffusion and density to a large extent; thus for keeping on a regular course of smog flow and for controlling on its quantity, a tube of 4inch diameter and 1meter length joining the emission exhaust to the gas inlet of the instrument has been installed. The displaying result for each gas-chip, then, has been recorded.

The measurements have been carefully conducted in uniform weather conditions in the terms of wind speed and directions, temperature, and humidity. Such uniformity in weather provides an approximative reading for every gas-chip, without experimented to the various meteorological influences. This point is very important for validly determine the concentrations of gaseous pollutants. Again, the tube above mentioned has been played a role in reduce the likely impact of weather conditions. Therefore, the recorded values represent, to a large extent, the *valid* concentrations of air pollutants released from gaseous emission sources in question. This is the main purpose of the present experimental study.

**Table 1. Specifications of the measurement chips being employed in the present work.**

Measurement Chip of Pollutant	Measuring Range (ppm)	Measuring Time (seconds)	Accuracy	Reproducibility (SD)
Carbon Monoxide (CO)	5 to 150	Approx. 80s at 150 ppm Approx. 150s at 30 ppm Approx. 300s at 5 ppm Approx. 210s at 0 ppm	± 12% of the measured value over the measurement range.	± 10%

Carbon Dioxide (CO <sub>2</sub> )	200 to 3000	Approx. 60s at 3000 ppm Approx. 120s at 1500ppm Approx. 260s at 200 ppm Approx. 180s at 0 ppm	± 7% of the measured value over the measurement range.	± 10%
Nitrogen Dioxide (NO <sub>2</sub> )	0.5 to 25	Approx. 20s at 25 ppm Approx. 70s at 3 ppm Approx. 330s at 0.5 ppm Approx. 200s at 0 ppm	± 10% of the measured value over the measurement range.	± 8%
Nitrogen Fumes (NO <sub>x</sub> )	10 to 200	Approx. 20s at 200 ppm Approx. 70s at 30 ppm Approx. 100s at 10 ppm Approx. 120s at 0 ppm	± 8% of the measured value over the measurement range.	± 12%
Sulfur Dioxide (SO <sub>2</sub> )	0.4 to 10	Approx. 40s at 10 ppm Approx. 100s at 2 ppm Approx. 300s at 0.4ppm Approx. 180s at 0 ppm	± 12% of the measured value over the measurement range.	± 12%
Petroleum Hydrocarbons (HCs)	20 to 500	Approx. 150s at 100 ppm Approx. 330s at 20 ppm Approx. 225s at 0 ppm	± 9% of the measured value over the measurement range.	± 15%
Hydrogen Sulfide (H <sub>2</sub> S)	0.2 to 5	Approx. 40s at 5 ppm Approx. 120s at 1 ppm Approx. 450s at 0.2 ppm Approx. 225 at 0 ppm	± 15% of the measured value over the measurement range.	± 25%

Source: Drager, instructions for use.

## RESULTS AND DISCUSSION

The gaseous pollutants being tested in this study have a many of properties. These properties as follows:

Carbon monoxide (CO) is a colorless, odorless, and tasteless gas that is slightly lighter than air. It can be toxic to humans and animals when encountered in higher concentrations, although it is also produced in normal animal metabolism in low quantities, and is thought to have some normal biological functions (Hill, 2004). The elevated levels of carbon monoxide in this study are due to incomplete combustion of fuels employed in the selected emission sources. Carbon monoxide is produced from the partial oxidation of carbon-containing compounds; it forms when there is not enough oxygen to produce carbon dioxide (CO<sub>2</sub>), such as when operating a stove or an internal combustion engine in an enclosed space.

Carbon dioxide (CO<sub>2</sub>) is a naturally occurring chemical compound composed of two oxygen atoms covalently bonded to a single carbon atom. Carbon dioxide also results from the complete combustion of fossil fuels; thus the recorded higher concentrations in this work are related to gaseous emissions for fuel combustion from the selected sources. As Vallero (2008) reported, CO<sub>2</sub> is toxic in higher concentrations: 1% (10,000 ppm) will make some people feel drowsy. Concentrations of 7% to 10% cause dizziness, headache, visual and hearing dysfunction, and unconsciousness within a few minutes to an hour.

Nitrogen dioxide is the chemical compound with the formula NO<sub>2</sub>. It is one of several nitrogen oxides. NO<sub>2</sub> is an intermediate in the industrial synthesis of nitric acid, millions of tons of which are produced each year. This reddish-brown toxic gas has a characteristic sharp, biting odor and is a prominent air pollutant. Nitrogen dioxide is toxic by inhalation. However, as the compound is acrid and easily detectable by smell at low concentrations, inhalation exposure can generally be avoided. One potential source of exposure is fuming nitric acid, which spontaneously produces NO<sub>2</sub> above 0 °C. Symptoms of poisoning (lung edema) tend to appear several hours after inhalation of a low but potentially fatal dose. Also, low concentrations (4 ppm) will anesthetize the nose, thus creating a potential for overexposure. There is some evidence that long-term exposure to NO<sub>2</sub> at concentrations above 40–100 µg/m<sup>3</sup> may decrease lung function and increase the risk of respiratory symptoms (Hill, 2004).

Nitrogen oxides (NO<sub>x</sub>) produces from the excess air required for complete combustion of fuels in these processes introduces nitrogen into the combustion reactions at high temperatures. Direct exposure to NO<sub>x</sub> gases irritates the lungs, aggravates asthma, and lowers resistance to infection. Nitrogen dioxide is poisonous to plant life. Converted to the

aerosols, nitric acid and nitrate, there can be major deleterious effects. The tiny aerosols can be deeply inhaled into, and cause inflammation of, the lungs (Hill, 2004).

Sulfur dioxide (SO<sub>2</sub>) is a colorless gas with a sharp irritating odor. It accounts for about 18% of all air pollution, making it second only to CO as the most common urban air pollutant. Direct exposure to the gas, SO<sub>2</sub>. The SO<sub>2</sub> gas reacts with moisture in the eyes, lungs, and other mucous membranes to form strongly irritating acid. This reaction removes about 90% of the SO<sub>2</sub> in the upper respiratory tract. Exposure can trigger allergic-type reactions and asthma in sensitive individuals. Exposure also aggravates pre-existing respiratory or heart disease (Hill, 2004).

Petroleum hydrocarbon gases are comprised of predominantly one to four carbon atom hydrocarbons, and may contain asphyxiant gas components such as hydrogen, nitrogen, and carbon dioxide. Several petroleum hydrocarbon gases also contain benzene and/or 1,3-butadiene. Emissions of petroleum hydrocarbon gases to the atmosphere would not likely result in acutely toxic concentrations in adjacent water bodies because such emissions will tend to remain in the atmosphere (The Petroleum HPV Testing Group, 2009).

Hydrogen sulfide (H<sub>2</sub>S) a colorless gas with a strong odor of rotten eggs; Sense of smell becomes rapidly fatigued and cannot be relied on to warn of its continuous presence. It is hazardous to the respiratory system and eyes and is toxic through inhalation, ingestion, and contact. Symptoms of exposure include apnea, coma, convulsions, eye irritation, conjunctivitis, pain, lacrimation, photophobia, corneal vesiculation, dizziness, headache, fatigue, irritability, insomnia, gastrointestinal distress, and respiratory system irritation (Koran, 2005).

The results obtained from the present experiment are shown in Table 2, which listed the gaseous pollutant concentrations measured from selected emission sources. Obviously, the results indicate that concentrations of CO are higher than 150 ppm at the all of selected emission sources. The concentrations of CO<sub>2</sub> are higher than 3000 ppm at the all of gaseous emission sources, with the exception of bakehouse smokestack, incinerator, and motorboat exhaust, which their concentrations were 1025, 1120, and 1123 ppm, respectively. The NO<sub>2</sub> concentrations were less than 0.5 ppm at the all of selected sources. The concentrations of NO<sub>x</sub> were varied; it ranged from 10.2 to 19.0 ppm at some emission sources, and less than 10.0 ppm at other sources. SO<sub>2</sub> concentrations are less than 0.4 ppm at the all of selected sources, whereas the emission source of incinerator records 3.70 ppm. HCs concentrations

ranged from 20.0 to 96.0 ppm, while concentrations of H<sub>2</sub>S were less than 0.2 ppm at the all of selected emission sources.

**Table 2. Gaseous pollutant concentrations measured from selected emission sources in the present study.**

No.	Emission Source	Gaseous Pollutant Concentration (ppm)						
	Stationary Source	CO	CO <sub>2</sub>	NO <sub>2</sub>	NO <sub>x</sub>	SO <sub>2</sub>	HCs	H <sub>2</sub> S
1	Electrical Generator 10A Exhaust (Benzene-fueled engine)	≥ 150	≥ 3000	≤ 0.5	10.2	≤ 0.4	38.0	≤ 0.2
2	Electrical Generator 50KV Exhaust (Gasoline-fueled engine)	≥ 150	≥ 3000	≤ 0.5	12.0	≤ 0.4	44.0	≤ 0.2
3	Restaurant Smokestack (Wood coal fuel)	≥ 150	≥ 3000	≤ 0.5	≤ 10.0	≤ 0.4	21.0	≤ 0.2
4	Bakehouse Smokestack (Kerosene fuel)	≥ 150	1025	≤ 0.5	≤ 10.0	≤ 0.4	20.0	≤ 0.2
5	Incinerator	≥ 150	1120	≤ 0.5	≤ 10.0	3.70	20.0	≤ 0.2
No.	Mobile Source	CO	CO <sub>2</sub>	NO <sub>2</sub>	NO <sub>x</sub>	SO <sub>2</sub>	HCs	H <sub>2</sub> S
1	Old Saloon Car Exhaust (Benzene-fueled engine)	≥ 150	≥ 3000	≤ 0.5	14.0	≤ 0.4	96.0	≤ 0.2
2	New Saloon Car Exhaust (Benzene-fueled engine)	≥ 150	≥ 3000	≤ 0.5	15.0	≤ 0.4	34.0	≤ 0.2
3	Truck Vehicle Exhaust (Gasoline-fueled engine)	≥ 150	≥ 3000	≤ 0.5	≤ 10.0	≤ 0.4	37.0	≤ 0.2
4	Motorcycle Exhaust (Benzene-fueled engine)	≥ 150	≥ 3000	≤ 0.5	19.0	≤ 0.4	65.0	≤ 0.2
5	Motorboat Exhaust (Gasoline-fueled engine)	≥ 150	1123	≤ 0.5	16.0	≤ 0.4	45.0	≤ 0.2
<b>Mean</b>		<b>≥ 150</b>	<b>2426</b>	<b>≤ 0.5</b>	<b>12.6</b>	<b>0.7</b>	<b>42.0</b>	<b>≤ 0.2</b>

Source: Fieldwork.

Some gaseous pollutant concentrations recorded in this experiment indicates that they highest when compared to the National Emission Standards (MoE), as shown in Table 3. For example, CO, NO<sub>x</sub>, HCs, and H<sub>2</sub>S concentrations from most of emission sources, were considerably exceeded the National Emission Standards. This means that the selected sources may consider as major cause of air pollution in the area study. The concentrations of NO<sub>2</sub> and SO<sub>2</sub> were less than the recommended values of MoE Standards.



**Table 3. Maximum permissible concentrations (ppm) for air pollutants from specific emission sources according to National Emission Standards (MoE).**

Air pollutant	Emission source	Maximum permissible concentration (ppm)
Carbon Monoxide (CO)	All of sources	5
Nitrogen Oxides (NOx)	Combustion sources	10
	Manufacturing industries	10
Sulfur Dioxide (SO <sub>2</sub> )	Combustion sources	5
	Manufacturing industries	20
	Other sources	10
Petroleum Hydrocarbons (HCs)	All of sources	20
Hydrogen Sulfide (H <sub>2</sub> S)	Manufacturing industries	0.10
	Other sources	0.05

Ref.: MoE (2012)

The concentrations recorded in this study when compares with the results of previous studies which have been dealt with measuring concentration of gaseous pollutants in the ambient air, as shown in Table 4, there are significant differences in both cases. The present values for CO, CO<sub>2</sub>, NOx, and HCs were considerably higher than those that recorded in the previous studies; these highest values may due to the low rate of dispersion for gases as close as the emission source, but the dispersion and diffusion factor is usually increased in ambient air. However, SO<sub>2</sub> and H<sub>2</sub>S values were lower those that measured in the ambient air; this may partly refers to the difference in brands of the measurement instruments used between the present experiment and previous works.

**Table 4. Comparison between the results (mean concentration) of present work and those of previous studies.**

CO (ppm)	CO <sub>2</sub> (ppm)	NOx (ppm)	SO <sub>2</sub> (ppm)	H <sub>2</sub> S (ppm)	HCs (ppm)	Ref.
12.5	-	-	1	-	3	Al-Asadi, 1998
52.5	0.19	-	22.5	4	15	Al-Mayahi, 2005
10	0.04	-	10	2.5	10	Al-Saad, 2005
-	174	-	-	-	-	Al-Imarah et al, 2007
27.3	270	2.51	0.57	11	22.0	Al-Hassen, 2011
7.37	280	0.35	0.36	-	-	Qassim, 2011
11	255	0.9	0.65	-	0.8	Douabul et al, 2013
25.40	221.87	1.49	3.67	2.45	18.97	Sultan et al, 2013
≥ 150	2426	12.6	0.7	≤ 0.2	42.0	<b>The present work</b>

## CONCLUSION

Most of the concentrations measured in the experimental study exceeded the maximum permissible limits for National Emission Standards. As well, some of the recorded emission concentrations at this experimental study are higher than those that at other studies which dealt with ambient air pollution, because effect of diffusion and dispersion on the ambient air pollutants. The recorded values of gaseous pollutants in this study can be used as the background level for the next studies.

## REFERENCES

1. Al-Asadi, K.A.W (1998) The influence of climatic factors on the major industries in Basra and their reflections on the environmental pollution, Ph.D. thesis, College of Arts, University of Basra: 197. (in Arabic)
2. Al-Hassen, Sh.I. (2011) Environmental pollution in Basra City, Ph.D. thesis, College of Arts, University of Basra: 232. (in Arabic)
3. Al-Hassen, Sh.I., Al-Saad, H.T., and Al-Rubaiay, D.J. (2013) An analytical study on petroleum hydrocarbons contamination in the urban environment of Basra City, Southeast Iraq, Proceedings of the first international scientific symposium for strategic studies of the environmental impacts caused by petroleum activities in southern Iraq, 14-15/Apr./2013, Basra.
4. Al-Imarah, F.J.M., Al-Mohameed, R.Sh,J, and Ibraheem S.I. (2007). Extent of atmospheric pollution by some industrial emissions released from petrochemicals and gas liquefier industries in Khor Al-Zubair, *J. of Kerbala*, Special Issue on the Annual Environment of Meeting of Babylon University, Mar.:1-6.
5. Al-Mayahi I.K. (2005) An environmental analysis on the factors affecting the air pollutants quality at Basra Province, M.A. thesis, College of Education, University of Basra: 240. (in Arabic)
6. Al-Saad, H.T. (2005) Basrah environmental survey: final report, Marine Science Center, University of Basra: (unpublished).
7. Christoforou, C. (2004) Air pollution, in Richard M. Stapleton (Editor in Chief), *Pollution A to Z*, Vol. 1, Macmillan Reference, New York: 30-38.
8. Douabul, A.A.Z., Al-Maarofi, S.S., Al-Saad, H.T., and Al-Hassen, Sh.I. (2013) Gaseous pollutants in Basra City, Iraq, *Air, Soil and Water Res.* (6): 15–21.
9. Garabedian, S.A.K. (2010) Study of the main pollutants of air caused by transportation in Basra, Proceedings of the scientific conference of marine science center and the national specialized workshop on oceanography, on 23-24/12/2008: 125-136.
10. Gittins, M.J. (1999) Air pollution, in W.H. Bassett (ed.), *Clay's Handbook of Environmental Health*, 18th ed., E & FN Spon, London: 729-776.
11. Harrison, R.M. (2001) Air pollution: sources, concentrations and measurements, in Roy M. Harrison (ed.), *Pollution: Causes, Effects and Control*, 4<sup>th</sup> ed., RSC., Cambridge: 169-192.
12. Hill, M.K. (2004). *Understanding Environmental Pollution*, Cambridge University Press, Cambridge: 468.
13. Karmalla, H.A., Al-Hassen, Sh.I., Adam, R.S., and Qassim, M.H. (2013) A Cartographic representation to levels and impacts of carbon monoxide pollutant in Basra City, Southern Iraq, (under consideration) (in Arabic)
14. Koren, H. (2005) *Illustrated Dictionary and Resource Directory of Environmental and Occupational Health*, CRC Press, New York: 701
15. Matthias, A.D, Comrie, A.C. and Musil, S.A. (2006) Atmospheric pollution, in Ian L. Peeper, Charles P. Gerba, and Mark L. Brusseau, *Environmental and Pollution Science*, 2<sup>nd</sup> ed, Elsevier, San Diego: 377-394.
16. MoE (Ministry of Environment/ Iraq) (2012) Suggested national ambient air quality standards in Iraq, Factsheet.
17. Qassim, M.H. (2011) A Geographic analysis for air pollution problem in AzZubayr City and its healthy effects, M.A. thesis, College of Arts, University of Basra:180. (in Arabic)
18. Spellman, F.R. (1999) *The Science of Environmental Pollution*, Taylor & Francis Routledge, Pennsylvania: 245.

19. Sultan, A.W.A, Al-Hassen, Sh.I, Ateeq, A.A., and Al-Saad, H.T. (2013) Ambient air quality in the industrial area of Khor AzZubayr, Southern Iraq, Proceedings of the first international scientific symposium for strategic studies of the environmental impacts caused by petroleum activities in southern Iraq, 14-15/Apr./2013, Basra.
20. The Petroleum HPV Testing Group (2009) Petroleum hydrocarbon gases category analysis and hazard characterization, report submitted to the US EPA: 145.
21. Vallero, D.A. (2008) *Fundamentals of Air Pollution*, 4<sup>th</sup> ed., Elsevier Inc., London: 942.