Assessment of air quality for Kerbala city using field survey

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Abstract. The main objectives of this work are monitoring and analyzing air pollutant gases in Karbala city like (O₃, SO₂, H₂S, VOCs, TSP, CO, CO₂, NO₂, PM₁, PM_{2.5}, PM₇ and PM₁₀). In this study, 11 deferent locations with 22 monitoring site has been selected to measuring the concentrations of air pollutants. The measuring period was six months starting from December (2015) to May (2016). The concentration results of TSP were more than Iraqi and world standard during April and May. The concentrations of CO recorded high values at the north of the city. The maximum concentration of NO₂ was exceeding (1.5 ppm) at April 2016, while the minimum value was reached to (0.1 ppm) in many locations. The values of O₃ were within international and Iraqi standard limits while the SO₂ concentrations were above the International standard limits. High concentration of CO₂ were founded in the north site of Karbala. There were high H₂S concentrations in all sites, H₂S values were between (0.006 ppm – 1.81 ppm) during the period study, which were exceeding acceptable limits value of the international. There is variation in the volatile organic compounds (VOCs), the highest concentration for VOCs was about (20 ppm) at December 2015. The minimum concentrations of VOCs were recorded during March 2016. In all sites the concentrations were within the acceptable limits (3 ppm). The results of field tests of air sites show that the highest pollutants concentrations were in December, April and May months, whereas lower concentrations of pollutants are observed during the remainder of the study, especially in March.

1. INTRODUCTION

Throughout the world, air pollution is a matter of concern at all levels. The worldwide epidemiological study on the effect of air pollution had revealed that gaseous pollutants and particulate matter had enough potential to cause severe health effect like respiratory, cardiovascular diseases and cardio pulmonary mortality [1, 2]. Being a serious matter of concern now-a-day, a systematic monitoring program all over the world especially in urban cities are urgently needed as the level of air pollution is increasing rapidly in many areas of mega cities of the developing world [3]. It was found that the modernization and industrialization of developing countries had led to the increase use of fossil fuels and their derivatives. As such, developing countries were confronted with the great challenge of controlling the atmospheric pollution especially in the rapidly growing mega cities. Concern about air pollution in urban regions is receiving increasing importance worldwide, especially pollution by gaseous and particulate trace metals [4, 5]. The urban centers might be viewed as dense sources of enormous anthropogenic emissions of pollutants, which could alter the atmospheric composition, chemistry and life cycles in its downwind regimes, extending over several

hundred kilometers [6]. It had been found that world motor vehicle population growth had reached 700 million in the year 2000 [7]. Petrol and diesels engines of motor vehicles were found to emit a wide variety pollutants, principally, oxide of nitrogen (NO_x) which had an increasing impact on urban air quality [8].

2. OBJECTIVE

The main objective of this work are measuring and analyzing air pollutant gases in Karbala city like (*O₃, SO₂, H₂S, VOCs, TSP CO, CO₂, NO₂, O₃, SO₂, H₂S, VOCs, TSP, PM₁, PM_{2.5}, PM₇ and PM₁₀*)

3. STUDY AREA

Karbala is an Iraqi city, located about 100 km southwest of Baghdad. Karbala is the capital of Karbala Governorate, the geographic location of the city is **32.61°N, 44.08°E**, and has an estimated population of (1,151,200) people (Statistical Center Organization in Karbala, 2014). Karbala was one of Iraq's wealthiest cities, profiting from both religious visitors and its agricultural produce, especially dates. It split into two districts, "Old Karbala", the religious center, and "New Karbala", the residential district containing Islamic

schools and government buildings. Figures (1,2) below show the location of Karbala city to Iraq and the map of Karbala city.

Figure (1): Map of Iraq show the location of Karbala governorate

Figure (2) the map of Karbala city

4. METHODOLOGY AND SAMPLING

In this study, 11 deferent locations with 22 monitoring site has been selected to measuring the concentrations of air pollutants. The distribution of selected sites was to cover nearly all the area of Karbala city, including the mainly crowded intersections and different land classifications (residential, commercial, vegetation, barren and industrial areas). The measurement of concentrations has been done by using different devices to monitoring the concentrations of air pollutants such as (AEROCET 531, GIG450 devices, NOVA600 devices, MiniRAE 3000, Eco Sensors UV-100) as shown in Figure (3), which measure (TSP, PM₁, PM_{2.5}, PM₇, PM₁₀, H₂S, NO₂, SO₂, CO₂, CO, VOCs, O₃). The site locations were located by using Garmin GPS72. The measuring period was six months starting from December (2015) to May (2016).

5. RESULTS AND ANALYSIS

The results of this study deals with air pollutants (TSP, PM₁, PM_{2.5}, PM₇, PM₁₀, H₂S, NO₂, SO₂, CO₂, CO, VOCs, O₃) for six months starting from December 2015 to May 2016 and analysis their results. The average gases, TSP and PM concentrations measurements of air in the sites of the study area for six months are shown in Table (1).

Figure (3): The equipment used in the fieldwork to measure the concentrations of air pollutants in Karbala city

Table (1): Average gases, TSP and PM concentrations measurements of air in the sites of the study area for six months

Site Name	Site No.	RH %	Temp. °C	VOCs ppm	H ₂ S ppm	CO ₂ ppm	O ₃ ppm	NO ₂ ppm	SO ₂ ppm	CO ppm	PM ₁ µg/m ³	PM _{2.5} µg/m ³	PM ₇ µg/m ³	PM ₁₀ µg/m ³	TSP µg/m ³
المركز	Site 1	35.7	22.1	2.14033	0.61	211.22	0.00483	0.89667	0.64667	6.0275	0.808	1.74033	5.88	14.88	67.1
المركز	Site 2	35	22.6	1.79967	0.22833	201.8	0.00775	0.63	0.47	4.78033	0.34	2	6.81667	14.0667	47.6667
المركز	Site 3	35.7	23	1.62833	0.225	194.833	0.00652	0.34667	0.41	3.37	0.36167	2.116	6.69833	12.316	40.3333
المركز	Site 4	32.8	23	1.288	0.2	186.167	0.00438	0.33	0.3	2.23667	0.24833	0.75667	9.89	16.8217	34.6
المركز	Site 5	33	23.2	1.34333	0.39967	214.833	0.00883	0.40667	0.3425	3.90667	0.21	3.73333	10.3633	18.275	43.8333
المركز	Site 6	40	24	1.858	0.37833	221.24	0.00133	0.43417	0.38167	3.03667	0.26667	3.138	8.63167	18.688	45.1667
المركز	Site 7	39	24.1	1.17867	0.40833	211.35	0.0038	0.49	0.34667	4.21167	0.34667	3.64	9.26333	18.77	85.3333
المركز	Site 8	38.3	24.1	1.64167	0.40833	224.233	0.0032	0.25667	0.37833	0.89167	0.77167	4.25333	9.08233	19.4433	84.6667
المركز	Site 9	37	24.2	2.49833	0.30867	229.667	0.00232	0.43	0.38167	0.60333	1.42833	4.838	12.4083	24.3333	62.38
المركز	Site 10	37	24.4	2.46867	0.34217	211.667	0.0024	0.27167	0.1386	3.16833	0.78167	2.246	7.78167	16.8633	88.4
المركز	Site 11	34	25	1.36	0.24787	214.833	0.00383	0.33833	0.09433	4.28833	0.258	1.4	7.258	16.8533	87.4333
المركز	Site 12	35.7	26.4	1.29	0.37333	212.333	0.004	0.36167	0.44533	6.72333	0.27333	2.35667	7.08833	15.41	65.3
المركز	Site 13	33.8	26.6	2.76067	0.36833	219.667	0.0068	0.338	0.4118	6.47	0.28667	1.83333	7.898	16.698	66.7833
المركز	Site 14	40.7	27	2.66833	0.334	207.333	0.01817	0.31333	0.83483	5.77833	0.48167	1.07667	6.818	16.5417	85.86
المركز	Site 15	38.6	27.3	0.12167	0.8636	244.46	0.00888	0.66333	0.38167	9.12667	1.19	3.33	9.78333	24.8667	69.2667
المركز	Site 16	37.4	27.4	3.808	0.25317	205.667	0.0031	0.488	0.4588	8.26667	0.838	1.31	6.79	21.5417	77.5667
المركز	Site 17	36.4	27.6	2.448	0.408	231.36	0.007	0.3078	0.38767	6.07667	0.28667	0.86	6.868	16.3883	66.8
المركز	Site 18	36	27.6	1.82667	0.29283	224.833	0.00248	0.27667	0.28333	3.72333	0.39	1.108	7.6	18.9783	89.6
المركز	Site 19	34.3	28.1	2.18833	0.291	206.833	0.00277	0.41	0.2468	3.08333	0.21667	1.08833	7.898	18.3233	63.78
المركز	Site 20	36.3	28.3	3.08833	0.89	227.167	0.00788	0.36833	0.2118	2.58833	0.62333	0.88833	13.42	28.36	104.98
المركز	Site 21	36.6	28.4	2.88867	0.888	224.167	0.0091	0.36867	0.2588	1.998	0.36833	0.81167	13.6167	30.37	104.28
المركز	Site 22	38.8	28.8	3.888	0.63417	229.667	0.00888	0.73333	0.22483	1.86667	0.82167	7.438	11.7333	26.168	83.8333

5.1 Total Suspended Particulate (TSP)

The concentration of total suspended particulate (TSP) from (22) locations were obtained as shown in **Figure (4)** below. The figure demonstrate high values of TSP above WHO standards in the April and May due to the increase the numbers of the cars.

5.2 Particulate Matter (PMs)

There is appositve relationship between (TSP) and particular matter **Figures (5a and 5b)** shows the concentrations of PM10 and PM2.5 were within the WHO standards.

5.3 Carbon Monoxide (CO)

It was notice that highest concentrations of CO was in the north of city at locations No. (10, 11, 12, 13, 14, and 15) during the study period as shown in **Figure (6)** below. Although these value are high but within acceptable limits of Iraqi standards that is (35 ppm) and exceeding international standards, which is (9 ppm). The remaining sites ranging between (0.15 ppm – 14 ppm) and were within acceptable standards.

The increase in the car number and using bad-quality of benzene led to increase the CO emission which generates carbon monoxide gas instead of carbon dioxide gas, and the high temperature increase the value of CO.

High values of CO were founded in locations (No.12, 14) with values (9 ppm and 14 ppm respectively) during February 2016 to March 2015 due to the traffic volume and the presence of garage and petrol station. minimum concentration was (0.11 ppm) at (No.22) In December and January, as shown in **Figures (6)**, this location is in the west north of city and conceder as agriculture area with low traffic volume.

5.4 Nitrogen Dioxide (NO₂)

Figure (7) shown that the concentration of NO₂ was higher than International limits which is about (0.11 ppm).

site (No.16) shows maximum concentration of NO₂ with value exceeding (1.5 ppm) at April 2016, While many locations through several months shows the minimum value reaching to (0.1 ppm).

Graphically, It can noticed that in December 2015, the maximum value of NO₂ was (1.35 ppm) which detected in site (No.20), while the minimum value was (0.1 ppm) in site (No.10). In the next two month, the values were gradually decrease in the most of the sites. While in April and May gradually increase in concentrations for all locations of the study area.

Rising NO₂ concentrations shown in the north and middle of city. Which represented by locations No. (1, 2, 3, 15, 16, 17, 18, 19, and 20).

5.5 Ozone (O₃)

Figure (8). Showed that the concentrations of O₃ ranging between (0.01-0.08 ppm) not exceeded the Iraqi and international standard, which are (0.08 ppm), and (0.12 ppm) high values of O₃ were in site (No.14) measured in December While the minimum value of ozone gas was in many locations through different periods.

5.6 Sulfur Dioxide (SO₂)

The concentrations of SO₂ were exceeding the International standard limits in almost locations for the city as shown in **Figure (9)**.

In December, the minimum value (0.18 ppm) was founded at location (No.20) south of city. On the other hand, the maximum value of (0.9 ppm) founded in the location of (No.16). While the remaining sites, their concentrations ranging between (0.18 -0.8 ppm).

Finally, it can be notice that the concentration of SO₂ increased due to industrial activity in this area.

5.7 Carbon Dioxide (CO₂)

the values of CO₂ were highly recorded in the north and the middle of city due to the main road that connect with Baghdad, also the main intersection in Karbala city. High concentrations were resulting from passing a significant number of big trucks that produce a large quantities of carbon dioxide and contaminated the surrounding air.

The highest concentration was in December 2015 (380 ppm) and this value was above the WHO limits (250 ppm) as shown in **Figure (10)** at site No.6 and the lowest concentration was (300 ppm) in site No.3 during study period.

The minimum concentrations during the study period were during March that witnessed decreasing in concentrations in all sites during this month. The next two months witnessed gradually increase in CO₂ concentrations.

5.8 Hydrogen Sulfide (H₂S)

The concentrations of H₂S ranging between 0.006-1.81ppm and these values above the acceptable limits 0.047ppm, as shown in **Figures (11)**.

highest concentration recorded at May 2016 in all sites with concentrations ranging between (0.3 ppm) to (1.81 ppm). While the lowest concentration was (0.004 ppm) at many locations during several months as shown in **Figures (11)**.

The lowest concentration of H₂S was founded at almost months while The high concentrations of H₂S recorded in the north of the city at may 2016 due to industrial activity in the area ,destruction of sewer networks.

5.9 Volatile Organic Compounds (VOCs)

Figure (12) show, the highest concentration for VOCs was in site No.14 with value about (20 ppm) at December 2015, due to high traffic volume in this area and the proximity from petrol station and textile factory. While the lowest values of VOCs measured to be zero ppm in many sites during several periods.

The concentrations of VOCs at locations (No.14, 18, 19, 20, 21, and 22) exceeding the acceptable limit standards. The presence of petrol stations in middle and north of the city is the main source to increase the values of VOCs.

Figure (4): Concentration of TSP in the air of Karbala city for Six months.

Figure (5, A): Concentration of PM₁₀ in the air of Karbala city for Six months.

Figure (5, B): Concentration of PM_{2.5} in the air of Karbala city for Six months.

Figure (6): Concentration of CO in the air of Karbala city for Six months.

Figure (7): Concentration of NO₂ in the air of Karbala city for Six months.

Figure (8): Concentration of O₃ in the air of Karbala city for Six months.

Figure (9): Concentration of SO₂ in the air of Karbala city for Six months.

Figure (10): Concentration of CO₂ in the air of Karbala city for Six months.

Figure (11): Concentration of H_2S in the air of Karbala city for Six months.

Figure (12): Concentration of VOC_s in the air of Karbala city for Six months.

6. CONCLUSIONS

- High pollution by gases has increased in summer seasons for all gases while decreased in wintertime.
- The results of field tests of air sites show that the highest pollutants concentrations were in December, April and May months, whereas lower concentrations of pollutants are observed during the remainder of the study and especially in March. The study took into consideration the rainfall and its impact on the air clearness of pollutants, as well as the effect of wind direction and speed in the transfer of pollutants.
- values of (TSP) were above the permissible limits during April and May and high concentrations of PMs was founded in the same sites contain high values of TSP.
- highest concentrations of CO was in the north of city at locations No. (10, 11, 12, 13, 14, and 15). the concentration of NO_2 was higher than International limits
- The concentrations of SO_2 were exceeding the International standard limits in almost locations for the city. the concentrations of O_3 ranging between (0.01-0.08 ppm) not exceeded the Iraqi and international standard.
- the values of CO_2 were highly recorded in the north and the middle of city. The concentrations of H_2S

ranging between 0.006-1.81ppm and these values above the acceptable limits and the highest concentration for VOCs was in site No.14 with value about (20 ppm) at December 2015.

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