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Research paper

Study and evaluation the air pollution around the thermal power plant of Zebadiah city, Wassit province, Iraq

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Abstract

This study focused on gaseous pollution caused by exhaust gas from AL-Zubaydiah thermal power plant. Study gases included sulfur dioxide (SO2), nitrogen oxide (NO), carbon oxide (CO) and hydrocarbon (HC). The concentration of gas measurement is conducted during six months from January until June 2017. Nova 600 series portable devise and G450 confined space gas detector was used for measuring gas concentration, which emitted from the chimney of the thermal power station with an interval of 100m and into the path of smoke for a distance of 1400 m. The prevailing wind direction and temperature were taken into consideration during the study and their impact on the gas distribution. Four readings have been taken in each station during each month for all gases under study. The results showed that less gas concentrations were near the power station and then getting more gas concentration away from the station and higher concentrations are obtained at a distance of 900 m from the power station at ground level. Results indicated that sulfur dioxide concentrations recorded were higher than allowed in the Iraqi and American standards in most locations around the station. The highest concentration recorded at 900 m from the power station with value 597.3968 µg/m3, which is higher than the limitation of Iraqi and international specifications (150 µg/m3). This high concentration of SO2 is due to the crude oil from the Ahdab field with high rates of Sulphur that used as fuel in the generation process. These high concentrations of sulfur dioxide cause problems on the growth of plants and human health and viability of the soil in the coming years. Nitrogen oxide gas concentrations also were high and outside the upper limits allowed and were worth 131.38 µg/m3. The rest of the gas concentration (CO and HC) were acceptable and within the Iraqi standard. To preserve the environment in the region and within the limits of the allowed values globally requires a search for another source of fuel with a low percentage of sulfur and using modern technology for burning to reduce emissions of nitrogen oxides.

Keywords: *Air; Pollution; Power; Plant; Thermal*

1. Introduction

Gases have received considerable investigation, because of their impact on the atmosphere, animals, vegetation and human health. Approximately 90% of human emissions in the atmosphere are gaseous [1].
Rapidly growing population has led in conjunction with high rate of urbanization, industrialization and increase in motorized transport have resulted in an increased concentration of various air gaseous e.g. hydro-carbons, carbon monoxide, nitrogen dioxide and sulfur dioxides [2, 3, 4].
Know numerous researchers have studied the emission of pollutants from power plants in several countries in the world. Pratil and Patil, 1990 have estimated the degree of quantitative impact assessment of air quality for a thermal power station [5].
Nitrous oxide emissions from power plants in England and USA have been measured and discussed by Laird and Slon, 1993[6] and Duncan et al., 1995[7]. Emission factors and annual emissions of bulk and trace elements from Environ Monti Assess Oil-Shale-fueled power plants investigated by Hasanen et al., 1997 [8]. Lopez et al., 2005[9] have studied the health impact of power plant emissions in Mexico.
Rodriguez et al., 2006 [10] has studied the air quality effect of distributed power generated in South Coast air basin of California, USA. Their study focused on two main objectives: (1) the systematic characterization of distributed power generated installation in urban air basins, and (2) the simulation of potation air quality effect using a state-of-the art three-dimensional computational model. Wind speed, rainfall, temperature and relative humidity affect the concentration of air pollutants in the atmosphere and therefore changes in climatic and environmental atmosphere.
Elements of the atmosphere such as the temperature and relative humidity, wind speed and amount of rainfall play a key role in controlling the spread of various air pollutants [11].
The aims of the present work are concentrated on the study and evaluation of four pollutants (Hydrocarbons, Carbon oxides, Nitrogen dioxides and Sulfur dioxides), that emitted from Zubydiah thermal power plant including concentration and distribution of these gases at different zones on the basin area during six months and its impact on city.

2. Study area

Al-Zubaydiah thermal power plant is located in the north of Al-Zubaydiah city, Wasit province, Iraq. Figure (1) shows the thermal power station and the direction of the pollution that result from the chimneys of the plant. The chimneys of the station bordered by latitude (32° 45' 38.6" N) and longitude (45° 10' 22.3" E). The area around the power station has transitional climate between the Mediterranean climate and desert climate. Warm and dry in summer, as well as cool with low rainfall in winter. According to (General Meteorological Organization and Seismology / Baghdad), the average monthly air temperature of the area differs from 30 ^{0}C to about 45 ^{0}C in summer. While during winter the average monthly air temperature, differ from 16 ^{0}C to about 24 ^{0}C. Relative humidity ranges throughout the year with average monthly values from 37% to 54% in summer and from 55% to 81% in winter. The average annual rainfall was 110 mm over period (2000 - 2014). The annual prevailing winds in the study area are mainly northerly and northwesterly winds with average speed of 20 km/hr. They are blowing from the northwest towards the southeast, and usually accompanied by dust storms and dust, especially in the summer

Fig. 1: Al-Zubaydiah Thermal Power Plant.

3. Methodology and sampling

In this study, the location of Al-Zubaydiah thermal power plant are determined by using GPS device and then insert the site's coordinate into the Aerial photograph to describe the location of thermal power plant.

The locations had been chosen depend on many considerations such as the direction and speed of wind. Wind direction and their speed have an effective impact on the distribution of air pollution concentrations, as well as the wind direction of the study area mainly northwesterly as demonstrated by Figure (1) and Figure (2) that shows the direction of smoke's plume that result from the chimneys. The height of chimneys also has an effective impact on diffusion of pollutants.

Air pollution concentrations measured in the direction of smoke's plume from (42) location distributed at (14) different zones, each zone have three sampling point as shown in Figure (3) below.

The pollutants measured in this study were (SO_2, NO_X, CO, and HC) during a period of six months starting from (January 2017) to (Jun 2017) by using the devices shown in Figure (4) below.

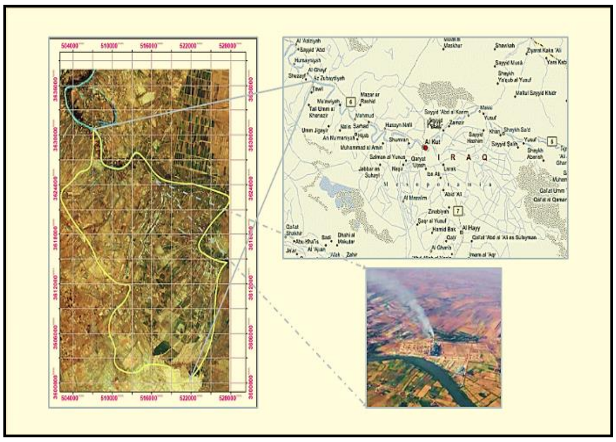

Fig. 2: Thermal Power Plant Location and the Border of Al-Zubaydiah City.

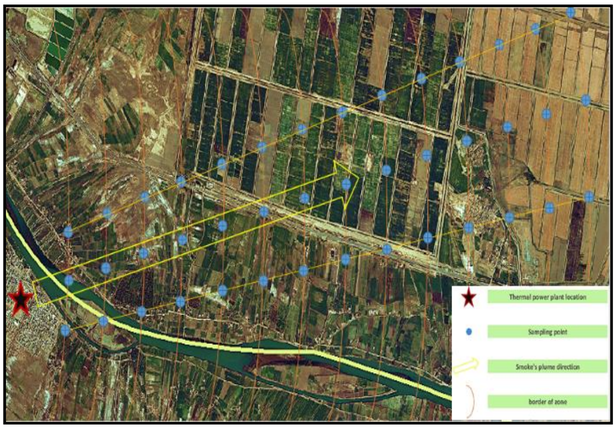

Fig. 3: Location of Thermal Power Plant and Sampling Sites.

NOVA 600 Series Portable Devices	Measuring (CO_2, CO, NO, NO_2, SO_2, and LEL Combustibles)	
G450 Confined Space Gas Detector	Measuring (CO, H_2S, O_2, O_3, VOCs, NO_2, SO_2 and percent LEL combustible gas	

Fig. 4: The Devices Used in the Fieldwork.

The monthly concentration of pollutants calculated by taking the average of four readings per concentration (one reading per week). Measurements were performed at varying distances ranging from (100 m) to (1400 m) from the center of the thermal power station as described in Figure (3) previously.

4. Results and discussions

Tables (1, 2, 3, 4, 5, and 6) and figures (5, 6, 7, and 8) shown below illustrated the concentration of air pollutants (sulfur dioxides, nitrogen dioxides, carbon monoxide, and hydro carbons) at the ground level with different and various places from Al-Zubaydiah thermal power station during a period starting from January 2017 to June 2017.

Results obtained by fieldwork have shown that concentrations of sulfur dioxides range from (0.621403 μg/m^{3}) to (597.3968 μg/m^{3}). The emissions levels for sulfur dioxides indicated poor air quality category around the thermal power plant from distance 300m to 1400 m away from the chimney of power station, and maximum at 900m. These values are more than 100 μg/m^{3}. The acidification is or may in future be a significant problem. The sulfur dioxide emissions from the power plant or unit should be less than 0.2 metric tons per day (t/d) per MWe of capacity for the first 500 MWe, plus 0.1 t/d for each additional MWe of capacity over 500 MWe (Tavoulareas et al., 1995).

The concentrations of nitrogen dioxides varying from (0.115246 μg/m^{3}) to (131.3834 μg/m^{3}). The EA pay particular attention to levels of nitrogen oxides before and after the completion of the project. Provided that the resultant maximum ambient levels of nitrogen dioxide are less than 150 μg/m^{3}.

The key issues to control the sulfur dioxide and nitrogen oxides emissions from power plant are demonstrated of choosing the cleanest fuel economically available, and use of low – NO_x and other combustion modifications to reduce emissions of nitrogen oxides.

Carbon monoxide and hydrocarbons concentrations ranging from (0.009804 μg/m^3) to (6.1022 μg/m^3) and (0.007789 μg/m^3) to (1.7332 μg/m^3) respectively throughout this study, it was found that the lowest concentrations of contaminants observed near the thermal power station at a distance (0 – 200 m). The highest concentrations level of contaminations founded at a distance of (900 m) from the stack of the thermal power station.

The lowest concentration of contaminants was near the thermal station due to two main reasons: chimneys height and wind effect, while the highest pollutant concentration obtained at a distance of (900 m) from the chimneys because the pollutants become falls to the ground-surface. After a distance of (1000 m).

The concentrations of all contaminations gradually decrease due to random distribution and wind effect. Temperature and rainfall have an effective effect on pollutant concentrations as shown in the tables below. The concentration of pollutant concentrations has gradually increased from month to month due to temperatures increasing and low rain fall.

Table 1: Ground Level Concentrations (Mg/M^3) of the Pollutants at Different Distances from the Chimney, (Jan. 2017)

NO.	Distance from chimney	Pollutants			
		SO_2	NO_X	CO	HC
1	100	0.621403	0.115246	0.009804	0.001189
2	200	1.987605	0.881975	0.028669	0.009573
3	300	182.3514	35.6328	1.6501	0.3395
4	400	254.5246	47.2854	1.8906	0.5543
5	500	312.5428	56.1905	2.0684	0.6485
6	600	372.8746	70.3726	3.6421	0.7951
7	700	435.9158	82.7851	4.7014	0.8132
8	800	484.0432	94.4956	4.9625	0.9961
9	900	558.1736	109.0697	5.2581	1.5624
10	1000	498.0102	101.5127	4.1212	1.0698
11	1100	490.5214	92.3698	4.0208	0.8562
12	1200	419.7231	84.1254	3.782	0.7146
13	1300	392.8412	71.9856	3.0125	0.6425
14	1400	360.2546	49.4785	2.4452	0.5734

Table 2: Ground Level Concentrations (Mg/M^3) of the Pollutants at Different Distances from the Chimney, (Feb. 2017)

NO.	Distance from chimney	Pollutants			
		SO_2	NO_X	CO	HC
1	100	0.538411	0.125245	0.018523	0.003265
2	200	2.154932	0.945201	0.045201	0.012584
3	300	192.8965	42.95148	1.71	0.4201
4	400	287.3327	50.26957	1.9201	0.5602
5	500	310.4521	60.35825	2.1057	0.6521
6	600	378.7854	73.56984	3.7625	0.8115
7	700	445.5698	85.36987	4.8214	0.8224
8	800	485.4587	96.21457	5.1202	1.0121
9	900	561.1125	112.9876	5.3054	1.5721
10	1000	508.0852	98.25698	4.2398	1.0423
11	1100	494.5542	89.32154	4.0158	0.9214
12	1200	411.7016	81.25489	3.6432	0.7228
13	1300	388.9513	60.25496	2.9125	0.6526
14	1400	365.8751	52.32547	1.8635	0.5854

Table 3: Ground Level Concentrations (Mg/M^3) of the Pollutants at Different Distances from the Chimney, (Mar. 2017)

NO.	Distance from chimney	Pollutants			
		SO_2	NO_X	CO	HC
1	100	0.542157	0.134255	0.092511	0.004125
2	200	2.162589	0.948236	0.098208	0.014238
3	300	192.9522	43.75212	1.7547	0.4311
4	400	289.4952	50.93654	1.9425	0.5701
5	500	313.3215	60.89683	2.1952	0.6635
6	600	388.1014	77.13427	3.7887	0.8232
7	700	454.3698	85.95866	4.8425	0.8378
8	800	487.4587	98.85238	5.1336	1.04
9	900	562.0998	115.3261	5.5289	1.6354
10	1000	509.0622	98.29852	4.2485	1.0555
11	1100	495.5003	90.36254	4.02	0.9472
12	1200	413.8231	81.85201	3.7802	0.7852
13	1300	390.2288	61.22325	3.1022	0.6863
14	1400	370.9513	53.45872	2.2364	0.6118

Table 4: Ground Level Concentrations (Mg/M^3) of the Pollutants at Different Distances from the Chimney, (Apr. 2017)

NO.	Distance from chimney	Pollutants			
		SO_2	NO_X	CO	HC
1	100	0.551248	0.242121	0.102313	0.005236
2	200	2.168652	1.232365	0.138296	0.028954
3	300	193.6527	43.96366	1.8417	0.4454
4	400	292.3569	51.98527	2.1035	0.5965
5	500	323.3112	63.82313	2.3956	0.7235
6	600	388.9865	77.98658	3.9987	0.9632
7	700	458.3828	88.25856	4.9325	0.9978
8	800	487.9636	100.2128	5.8985	1.5036
9	900	573.0128	120.3285	5.9969	1.7538
10	1000	509.8959	99.29821	4.7255	1.6032
11	1100	495.9635	90.8596	4.1005	0.9561
12	1200	438.3693	82.8283	3.9632	0.8224
13	1300	392.1254	63.2896	3.2389	0.7112
14	1400	375.8542	51.9865	2.5055	0.6507

Table 5: Ground Level Concentrations (Mg/M^3) of the Pollutants at Different Distances from the Chimney, (May 2017)

NO.	Distance from chimney	Pollutants			
		SO_2	NO_X	CO	HC
1	100	0.675858	0.365984	0.112024	0.006268
2	200	2.545866	1.852142	0.139658	0.029875
3	300	195.9987	45.32568	1.8611	0.4466
4	400	295.8593	53.02201	2.1257	0.6121
5	500	381.6358	65.95684	2.4256	0.7278
6	600	405.6584	78.96533	4.1252	0.9952
7	700	469.1973	90.36501	4.9989	0.9994
8	800	496.3476	101.2169	5.9941	1.6034
9	900	588.3214	125.3396	6.1211	1.7789
10	1000	512.3652	100.2923	4.7854	1.6454
11	1100	501.3288	91.2357	4.1023	0.9765
12	1200	438.9513	84.3658	3.9725	0.8334
13	1300	398.1101	65.3972	3.2936	0.7787
14	1400	382.8596	53.8957	2.6303	0.6917

Table 6: Ground Level Concentrations (Mg/M^3) of the Pollutants at Different Distances from the Chimney, (Jun 2017)

NO.	Distance from chimney	Pollutants			
		SO_2	NO_X	CO	HC
1	100	0.712458	0.465903	0.18654	0.007266
2	200	2.785245	1.880205	0.14858	0.039201
3	300	198.8524	45.98637	1.9274	0.4587
4	400	299.2587	55.02931	2.3562	0.6333
5	500	388.1328	67.99634	2.7856	0.7987
6	600	415.6854	79.79531	4.3654	1.0001
7	700	474.3581	93.36684	5.1285	1.1054
8	800	501.7536	111.2936	6.1022	1.7332
9	900	597.3968	131.3834	6.5369	2.0121
10	1000	514.3396	105.8543	4.8961	1.7852
11	1100	509.3228	98.2307	4.3602	0.9939
12	1200	448.9032	86.3631	4.1243	0.8586
13	1300	401.1901	68.3003	3.5496	0.7931
14	1400	383.8087	58.8087	2.5378	0.7019

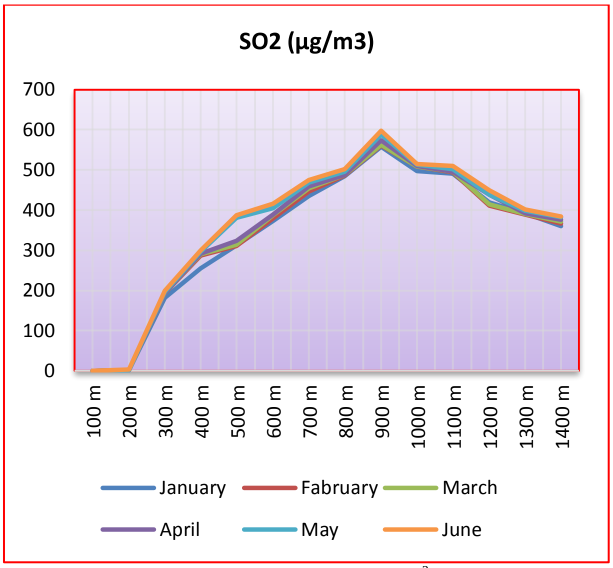

Fig. 5: SO_2 Concentration at Ground Level (Mg/M^3) at Different Distances from the Chimney during Six Months.

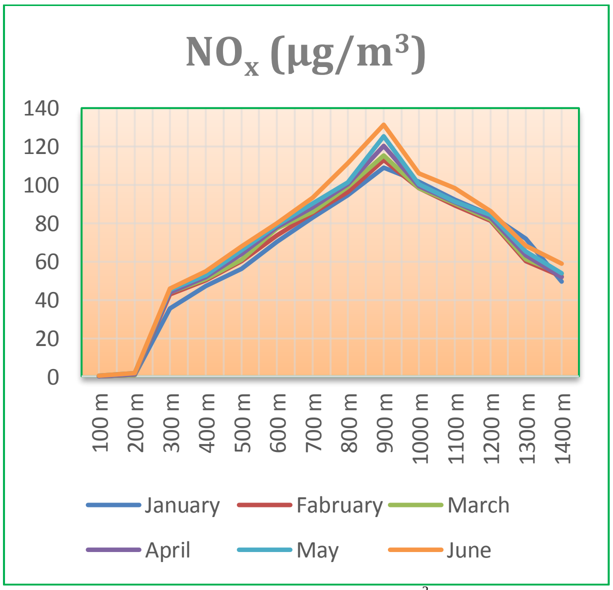

Fig. 6: No_x Concentration at Ground Level (Mg/M^3) at Different Distances from the Chimney during Six Months.

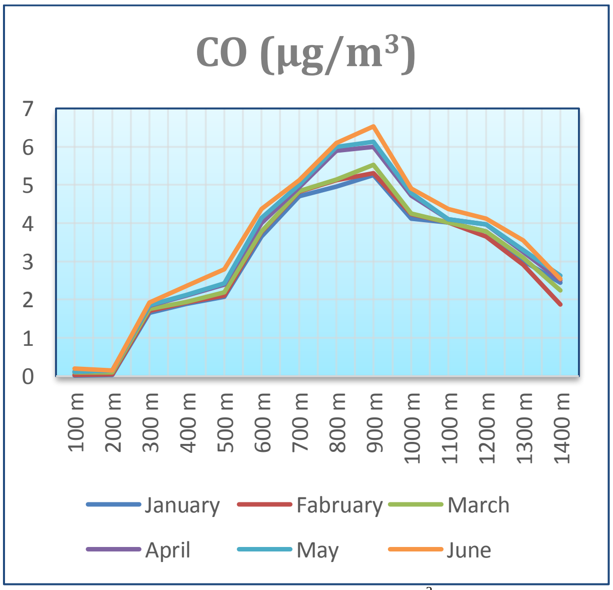

Fig. 7: CO Concentration at Ground Level (Mg/M^3) at Diferent Distances from the Chimney during Six Months.

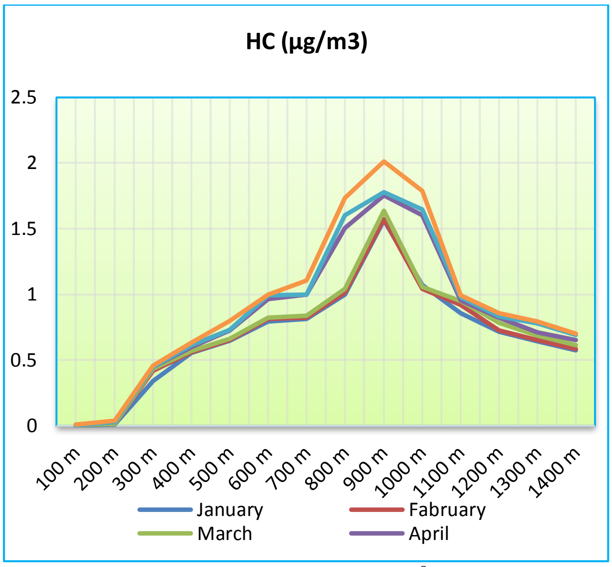

Fig. 8: HC Concentration at Ground Level (Mg/M^3) at Different Distances from the Chimney during Six Months.

5. Conclusions

The air pollution in the Al-Zubaydiah City is very serious, especially during winter time, in term of the smoke problem. Pollutants such as SO_2 and NO_X are much higher than international standards, which damage the environment and are highly responsible for deterioration of health of human beings. Emission of gases disperse over large area and case respiratory and related aliments when inhaled by people. In addition, the spreading and deposition of these gases on soil, disturb the soil strata thereby the land become less productive. Structures and building get affected due to corrosion reaction of large amount of $SO_{X,}$ NO_X emission. Therefore, stricter emission standards are urgently needed to reduce current emissions to acceptable levels.

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