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Study the Concentration of SO2 Emitted from Daura Refinery by using Screen View Model

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Abstract

In this study, the concentrations of sulfur dioxide (SO2) were emitted from the Daura oil refinery units and their effect on the surrounding areas of the refinery were investigated, and also, study the atmospheric stability effective by using the Screen View model, and check the effect of the wind speed and direction on the spread of pollutants.
As indicated during this study, the physical factors of the sources of pollution, such as the height of the chimney, its diameter and the surrounding environmental conditions, contributed to the increase in the concentration of contaminants. It was generally observed that the concentration of SO2 increased by increasing the rates of airflow and ambient temperature. This work was prove the influences of weather conditions in the transmission and spread of pollutants such as wind speed, wind direction, atmospheric stability and ambient temperature, but the effect of ambient air temperature was lower than others variables.
When the distance increases between the plume and the source of pollution, a heat exchange takes place with the surrounding atmosphere, the difference between the temperature of the emitted gas and the surrounding atmosphere decreases and the buoyant force increases. This leads to a lack of vertical movement that disperses the contaminants. In addition, the concentration of the pollutants decreases with the distance increases from the source of the pollution. In the present work, emission rate of SO2, and stack gas exit velocity calculated for all stacks (point sources) of the twelve production units during August 2013, and February 2014 by using the actual amounts of fuel consumed in Daura refinery in this period.

Keywords: SO2, Screen View Model, Pollutants, Plume.

الخلاصة

في هذه الدراسة تم تحليل تراكيز ثاني أكسيد الكبريت (SO2) المنبعثة من الوحدات الانتاجية التابعة لمصفاة الدورة، وقد تم دراسة تأثيرها على المناطق المحيطة بالمصفاة ، وكذلك تم دراسة استقرارية الغلاف الجوي باستخدام الموديل (Screen View Model)، و تأثير سرعة الرياح واتجاهها على انتشار الملوثات. كما تم تحديد العوامل الفيزيائية لمصادر التلوث ، مثل ارتفاع المدخنة وقطرها والظروف البيئية المحيطة بها،والتي ساهمت في زيادة تراكيز الملوثات. ولوحظ بشكل عام أن تركيز ثاني أكسيد الكبريت يزداد بزيادة معدلات تدفق الهواء ودرجة الحرارة المحيطة. وقد أثبت هذا العمل تأثير الظروف الجوية في انتقال وانتشار الملوثات مثل سرعة الرياح واتجاه الرياح والاستقراريةالجوية ودرجة الحرارة المحيطة ، ولكن تأثير درجة حرارة الهواء المحيط كان أقل من غيرها من المتغيرات.عندما تزداد المسافة بين غمامة الدخان(Plume) ومصدر التلوث، يحدث التبادل الحراري مع الغلاف الجوي المحيط به ، ويقل الفرق بين درجة حرارة الغاز المنبعث والجو المحيط وتزداد قوة الطفو، وهذا يؤدي إلى نقص الحركة العمودية التي تشتت الملوثات. أيضا، يبدأ تركيز الملوثات في الانخفاض مع زيادة المسافة بعيدا عن مصدر التلوث..

Introduction

Air pollution has previously defined as a situation in which the atmosphere contains certain substances whose concentrations cause undesirable results on human health and environment [8].

Environmental pollution is one of the most important problems faced by humans in recent times. Air pollution comes at the forefront of these environmental problems, because of the inability to control the air and determine its spread from one place to another.

The atmosphere of the Earth is composed of a mixture of several gases in a balanced manner. Therefore, any imbalance in these ratios can be considered as pollution, the most important of which is oxygen and nitrogen gas, which account for about 21% and 78% of the air weight respectively, Such as carbon dioxide in the air by 0.003% and some other inert gases such as helium, neon, argon, and crepton, which are present in the Earth's atmosphere in very small proportions, and the air mixture with its previous structure is very vital.

Air is polluted if injected with any of the industrial gaseous compounds and the recognized air pollutants are gases such as carbon oxides, NOx, SOx, non-burnt hydrocarbons, particles such as dust, smoke, smog, mist Aerosols. These pollutants emitted from various sources such as; transportation, power generation, fuel combustion in homes and factories [4].

Air pollutants defined as substances in the air that are at certain concentrations harmful to humans, animals, plants or substances (corrosion of materials). These include various formulations of substances with natural or industrial components that carried by air and at certain concentrations that lead directly or indirectly to the pollution of the environment and sometimes important changes occurs in the values of concentrations of pollutants. Wind or thermal inversion leads to high levels of pollutants caused of disease or death called the ring of air pollution.

Area Study

Daura oil refinery is located in the Daura area, which is located south of Baghdad and overlooks the Tigris River.

Urban areas with few palm trees situated around the refinery. Small factory for liquid gas filling, and Al-Imam Al-Hassan quarter located at east side, Al-Jamaia quarter in the westerly and south-westerly side, the residence of employers lying very close to the border of the refinery at the west side. Daura express highway and palm trees are lying in the east, south-east, and south side, and finally in the north side a small flat area is extended across Tigris River where located one of the biggest city in Baghdad named Al-Karada [7].

Al-Daura Refinery is an integrated oil industry complex, one of Iraq's oldest oil refineries, located in the southern part of Baghdad. Its foundation laid in 1953, and began operation in 1955. Its production is 140,000 barrels per day and is located on an area of 2,500,000 square meters. Oil transported from Kirkuk and Khanaqin oilfields. The refinery produces gasoline, gas, jet fuel, gas oil, diesel, crude oil, grease, wax, asphalt, etc. It also contains a manufacture of plastic cans to fill the oil produced.

Materials and Methods

This section includes the application of the Screen View Model to study the spread of pollutants from different sources of emission and to study the effect of weather variables and factors related to the source of pollution in the urban area around the refinery.

In addition, the effect of all types of weather stability and wind speed will investigated on the spread of pollutants to a distance of ten Kilometers, when the air temperature surrounding the chimney is 293 K.

The model used includes several variables related to the characteristics of the stacks and the surrounding atmosphere. This model characterized by a wide range of aerobic conditions and included all stability cases with a range of accompanying wind speed. The source of the meteorological data is the General Board Meteorological of Iraq.

The Input Data for Screen View Model includes; Emission Rate (ER) (g/sec),Stack Height (SH) (m), Stack inside Diameter (SD) (m),Stack Gas exit Velocity (GV) (m/s), Stack Gas exit Temperature (GT) (k), Ambient air temperature (k), Receptor height above ground (m), Nature of the place Urban or Rural, Complex terrain Option, Building downwash. Table 1 below shows these variables.

Table 1: Characteristics of the point sources in Daura refinery

PS	NS	SH (m)	SD (m)	GT (K)	ER (g/s)	GV (m/s)
C1	1	46	2.4	640	27.74	2.42
C2	1	46	2.7	612	32.26	1.88
R1	4	30	1	643	45.24	5.48
KH	2	20	1	593	42.14	9.11
R2	5	30	1.5	548	197.3	5.86
C13	3	30	2	573	3.611	0.15
P1	4	30	2	673	245.3	8.3
P3	1	36	2.5	493	139.5	8.3
L1	3	30	1	573	8.09	1.10
L2	5	30	1	673	10.17	0.95
L3	5	30	3	632	54.89	3.82
P2	1	30	3	673	214.9	12.1

Results and Discussion

This section includes the application of the Screen View Model to study the diffusion of pollutants from different sources of emission in the area around the Daura refinery, and the impact of weather factors. In order to know these effects; we will apply the model through a two sides.

1. Study the spread of pollutants from the point source (Daura refinery), and to design schemes to study the effect of; emission rate, stack height, stack diameter, the speed of the gas emitted from the stack, the temperature of the gas emitted from the stack.
2. Investigate the effects of variance in the categories of air stability on the spread of pollutants of this source (Daura refinery) for a distance about 10 km around the refinery.

It has generally observed that the concentration of pollutants increases with increasing emission rates of pollutants. In addition, the higher wind speed leads to the less of the concentration of the pollutants, because the increases in the speed of the wind lead to the dispersion of pollutants and then decrease in concentration.

As the distance increases and the source of pollution is removed, heat exchange with the surrounding atmosphere is achieved. The difference between the temperature of the emitted gas and the ambient air temperature lead to the buoyancy force increases, leading to a lack of vertical movement that disperses the pollutants. The concentration of pollutants begins to decrease with increasing distance to get away from the source of pollution as in the following Figures. The first twelve Figures for the summer, August 2013, and the last elven Figures for the winter, February 2014.

Summer, August 2013

The analysis of the Figures 1, 2, 3, 4, 5, and 11 showed that the high values of pollutants concentration in the first two hundred meters, then it's decrease along the distance. While in the Figures 6, 9, and 10 were the high values in the distance less than 100m from the point source, then decrease to very low concentration through it is moving. Figures 7, 8, and 12 illustrated the deferent scenario, were the high values continued along the distance 10 km, this is the result of the higher values of emission rates of spices for these units compare with other units.

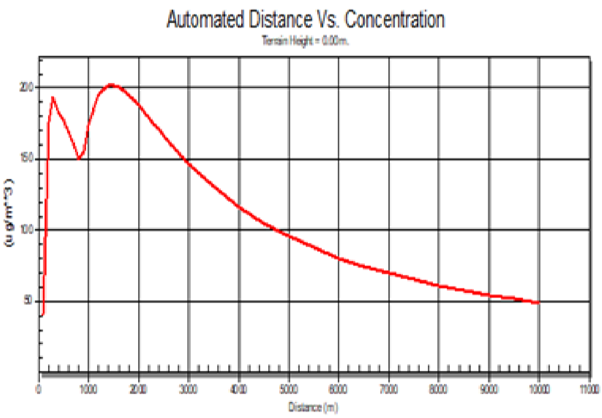

Figure 1: SO_2 dispersion for the C1 unit

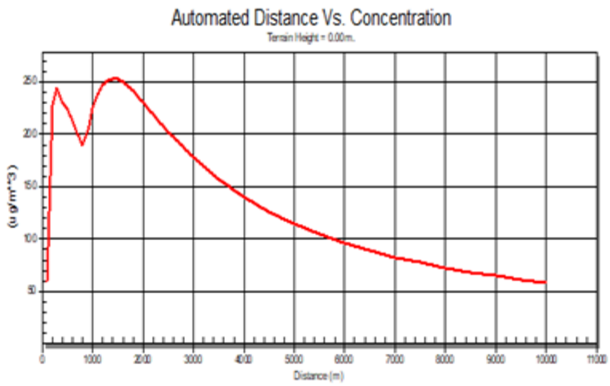

Figure 2: SO2 dispersion for the C2 unit

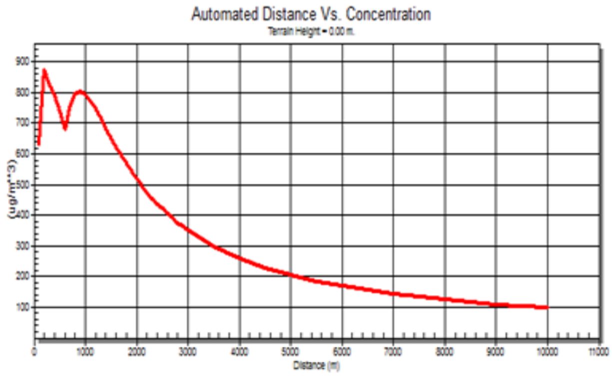

Figure 3: SO2 dispersion for the R1 unit

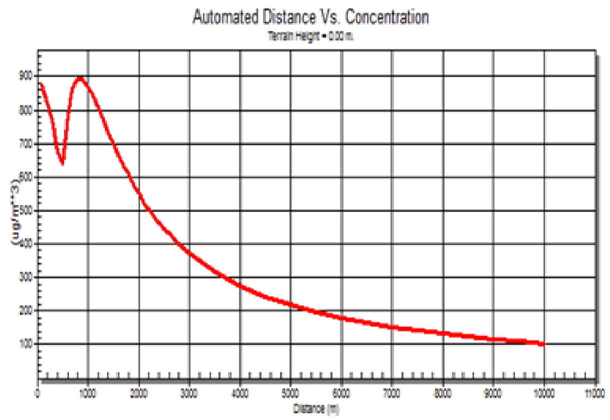

Figure 4: SO2 dispersion for the KH unit.

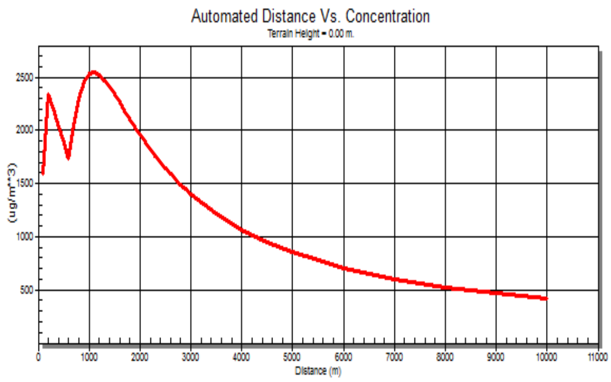

Figure 5: SO2 dispersion for the R2 unit

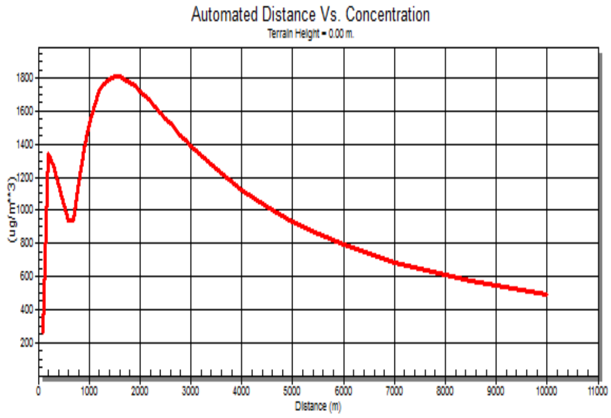

Figure 6: SO2 dispersion for the C13 unit.

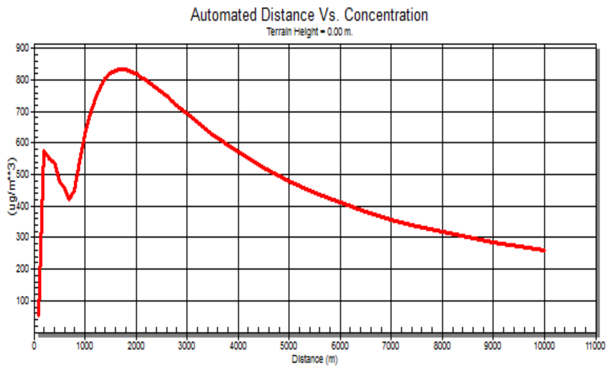

Figure 7: SO2 dispersion for the P1 unit

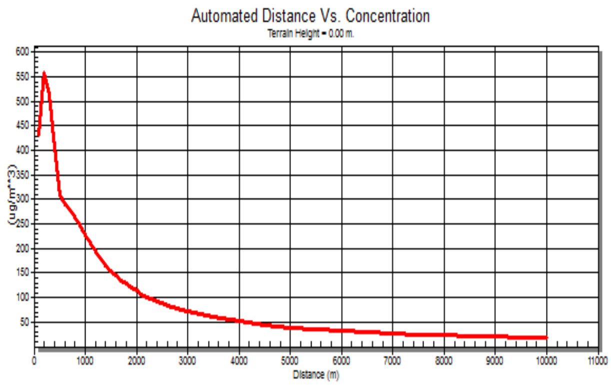

Figure 8: SO2 dispersion for the P3 unit.

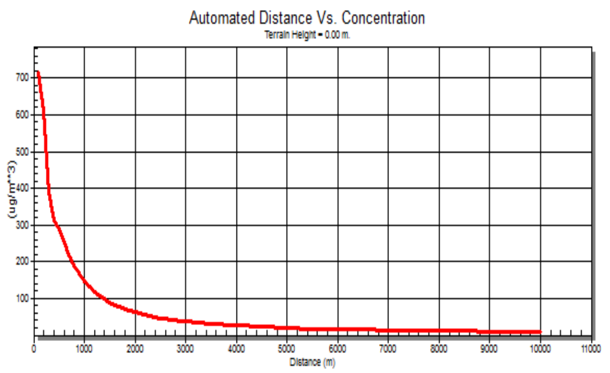

Figure 9: SO2 dispersion for the L1 unit

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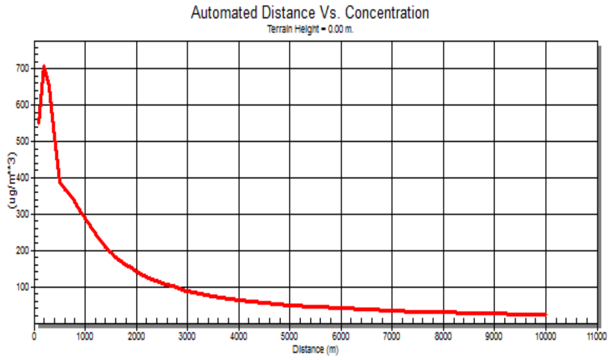

Figure 10: SO_2 dispersion for the L2 unit.

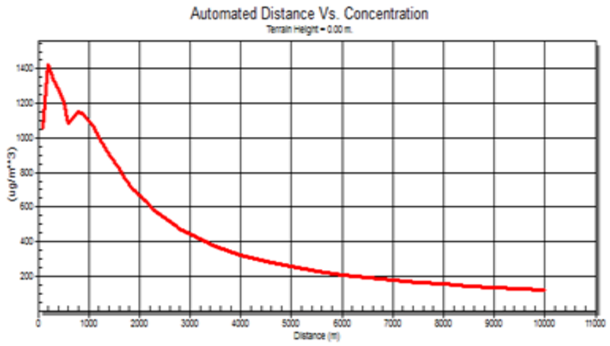

Figure 11: SO_2 dispersion for the L3 unit.

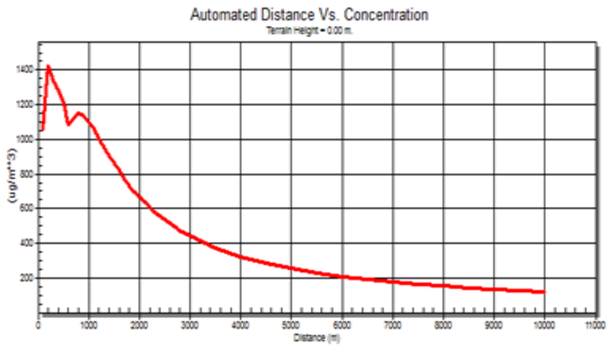

Figure 12: SO_2 dispersion for the P2 unit

Winter, February 2014

The dispersion of pollutants on February, for winter season, gives similar relationship between the concentrations with distance. The Figures 13, 14, 15, 16, and 17 showed the high values in the beginning 200 meters, and then it has started to decrease a long distance. On the units C13, L2, and L3 for the Figures 18, 21, and 22 respectively, the diffusion were started with high values until less than 100 meters, then its decrease to very low values of concentrations, were started from 200 meters. P1, P3, and P2 in the Figures 19, 20, and 23 were illustrated the diffusion of high values of SO_2 along the total distance of 10 km, this because the high values of emission rates of SO_2, compare with other units.

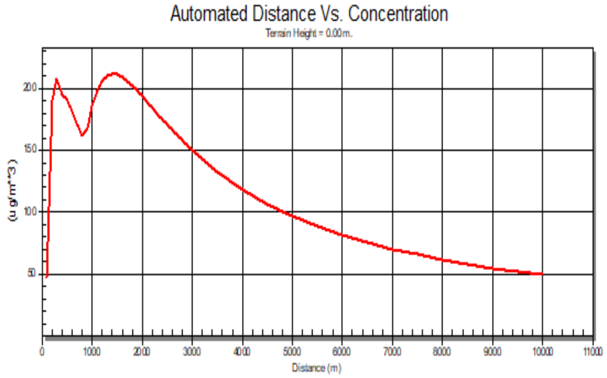

Figure 13: SO_2 dispersion for the C1 unit.

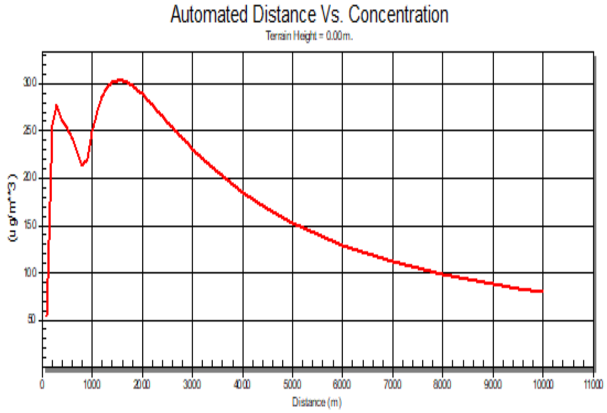

Figure 14: SO_2 dispersion for the C2 unit.

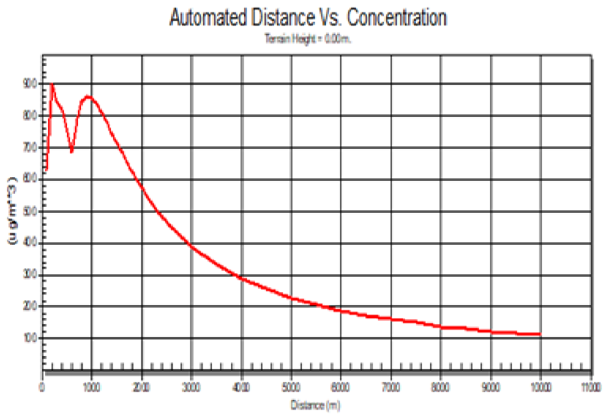

Figure 15: SO_2 dispersion for the R1 unit

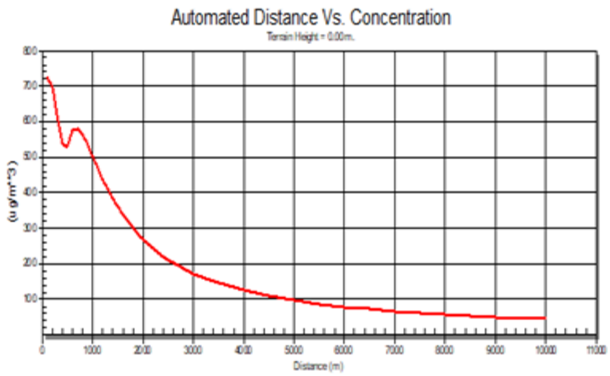

Figure 16: SO2 dispersion for the KH unit

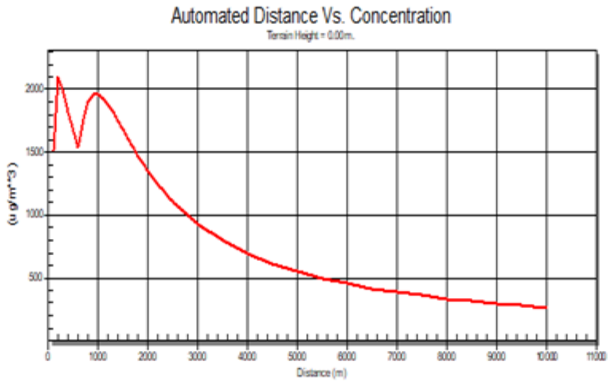

Figure 17: SO2 dispersion for the R2 unit

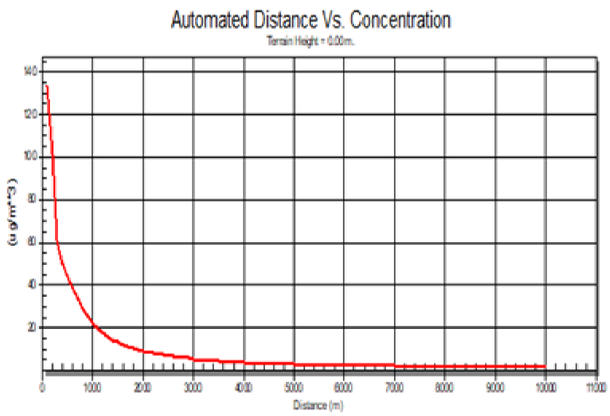

Figure 18: SO2 dispersion for the C13 unit

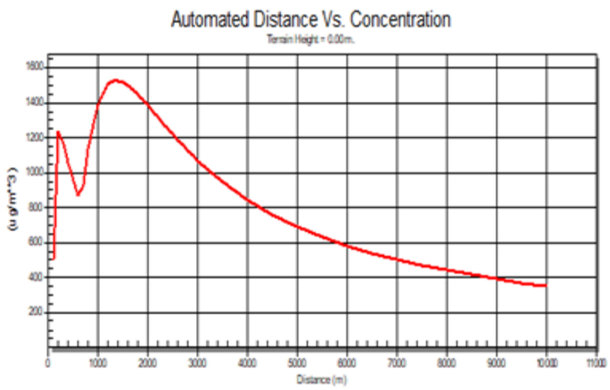

Figure 19: SO2 dispersion for the P1 unit

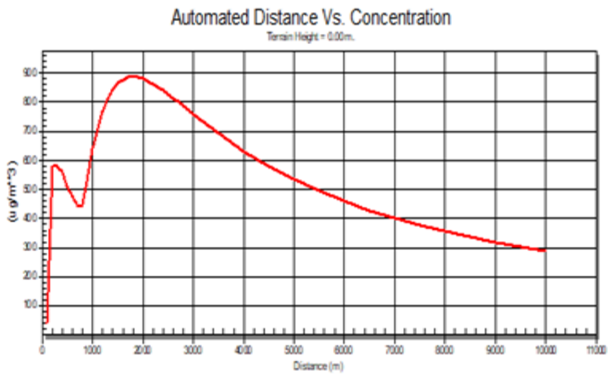

Figure 20: SO2 dispersion for the P3 unit

(LO1 unit is shutdown in this month)

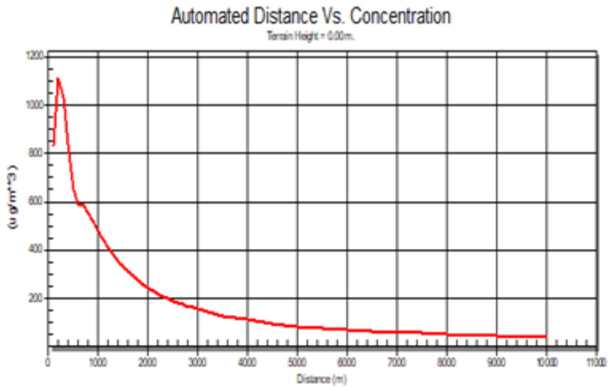

Figure 23: SO2 dispersion for the P2 unit

Effect of atmospheric stability on pollutant concentrations

The Figures below showed the effect of the atmospheric stability on the concentration of the pollutant along the distance, for the August 2013 respectively. It observed that the concentration of pollutants decreases when the atmosphere is unstable class (A, B, C). Because the vertical movement is active, which leads to the dispersion of pollutants and thus lead to a reduction in the concentration of pollutants, were in unstable weather condition the temperature of the rising air is hotter than the ambient air temperature, the air masses rises and the cold air moves below it. Under these cases, the vertical motion is active (disturbance), so the pollutants mixed and dispersed and then the concentration of pollutants is low, as shown in Figures 24, 25, and 26, when the atmosphere is stable. The stability class (E, F) shows that the concentration of pollutants increases. This is because in stable weather conditions, the temperature of the rising air is cooler than the

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ambient air temperature. Horizontal movement is active, so, there is no disturbance and mixing of contaminants, therefore, there is no dispersion and thus the concentration is high, as illustrated in Figures 28, and 29.

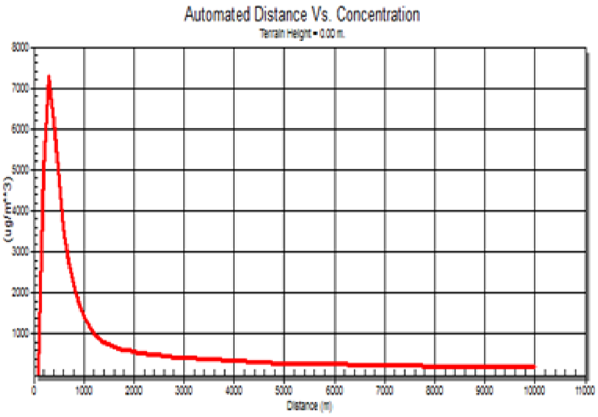

Figure 24: Represents the stability A (very unstable)

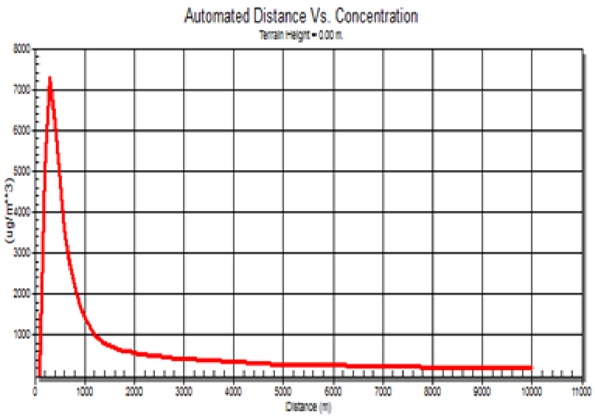

Figure 25: Shows the stability B (unstable)

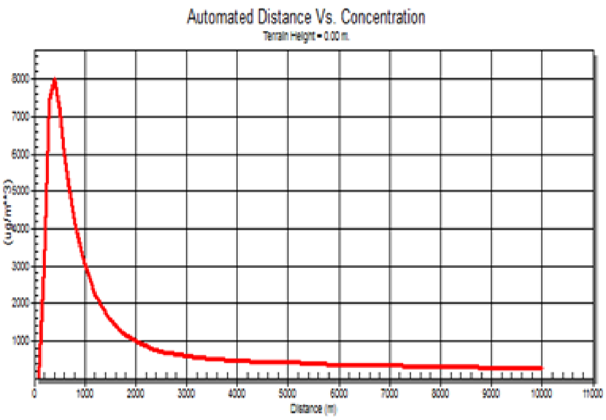

Figure 26: Illustrates the stability C (Slightly unstable)

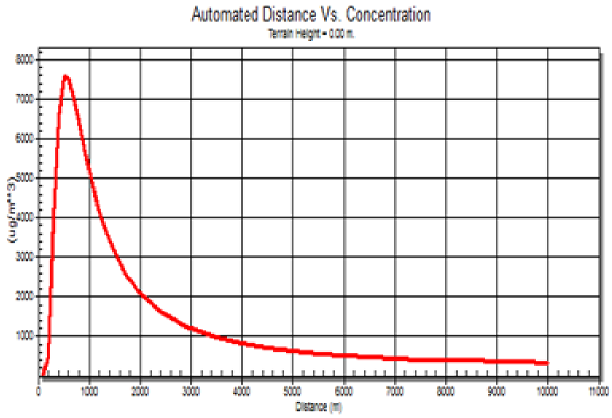

Figure 27: Shows the stability D (Neutral)

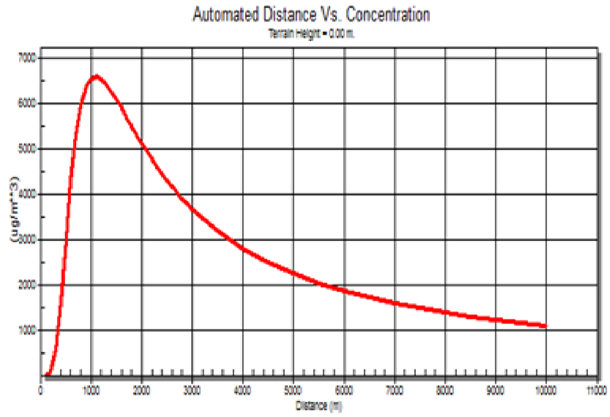

Figure 28: Illustrates the stability E (Slightly stable)

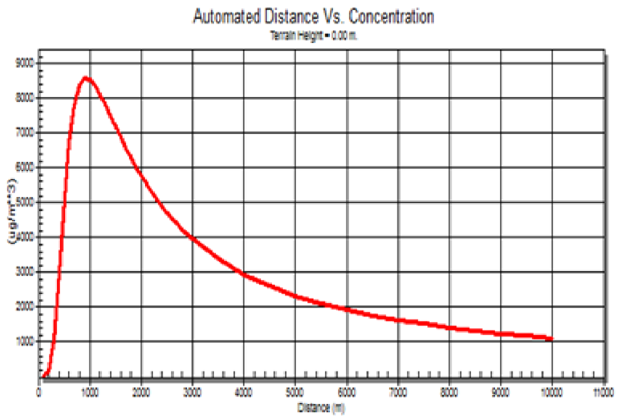

Figure 29: Represents the stability F (Stable)

Effect of wind velocity and direction on the spread of pollutants

In this section, we will discuss the impact of wind speed and direction on the movement and spread of pollutants by drawing the wind rose for the August 2013 and February 2014.

In the Figure 30 of the wind rose, the prevailing wind direction is northwesterly. In the summer, the northwesterly wind which represents the dominate wind, with a lowest wind values from north and east direction. The high concentration values of the species dispersed in the west, southeast, and east direction.

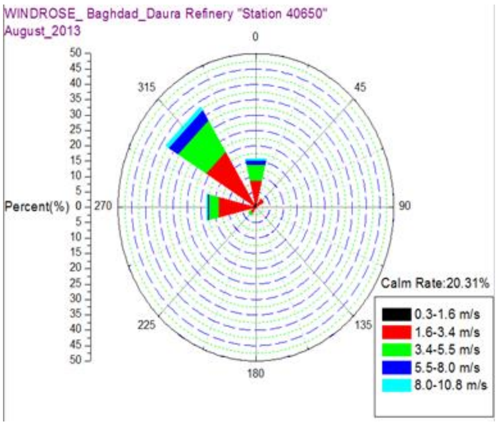

Figure 30: Wind rose for the August 2013.

Figure 31 shows the wind rose from one to 28 February 2014. The strong wind blown from northwesterly, northerly, southeasterly and westerly directions, therefore, the high values of pollutants formed in the southern and northern regions of the refinery site.

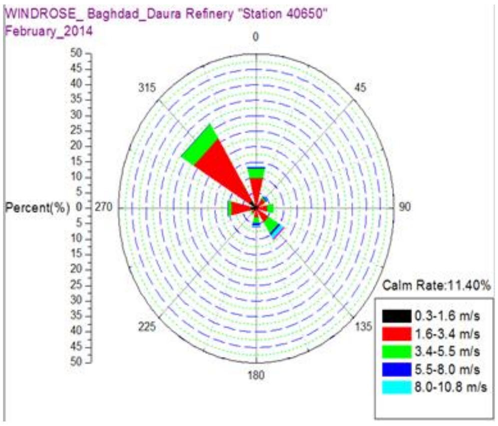

Figure 31: Wind rose for the February 2014

Conclusions

The following conclusions can draw from the present study:

1. The concentration of pollutants increased by increasing the emission rate and increasing the ambient air temperature, on the other hand, it is decreasing by increasing the height and diameter of the stack, and increasing the velocity and temperature of the gas emitted.
2. The effects of the flue velocity and stack diameters for the emitted gas, is similar in the behavior of the plume movement, for the units of refinery.
3. There is a pattern of variation between the plume and the concentration of contaminants, which causes a rise in the plume and a decrease in the concentration of pollutants in all cases.
4. The increase in the emission rate does not indicate a change in the height of the plume, while the increase in the speed of the emitted gas, and the increase in the chimney height lead to an increase in the height of the plume.
5. The calm wind in the winter is fewer, therefore lead to increase the speed of wind, which lead to the spread of pollutants and significantly reduced its concentrations. While in the summer the calm wind is higher which lead the wind speed is low and the spread of pollutants is decrease due to increase the concentrations of pollutants and possible to occur dust storms.

Recommendations

1. When choosing an industrial site for the establishment of any industrial project should be studied the weather variables in the region, especially the stability condition of the air.
2. We recommend finding models include the impact of more atmospheric factors such as, rain and humidity to get more accurate for the pollutants investigated.
3. The selection of plants sites must be far from the city, and also the stacks must be higher and relatively large diameters, to ensure the pollutants move away from the urban areas which the people lived there.
4. The industrial area such as Daura refinery should be in the outside of the Baghdad city center at 30 kilometers at least to ensure healthier and safety for the people lived there.

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References

[1] M. H. K. Al-Jiboori, Atmospheric Pollution, Ministry of Higher Education and Scientific Research, Mustansiriyah University, College of Sciences, Department of Atmospheric Sciences, 2015.
[2] R. K. Al-Kubaisi, Study on concentration of certain contaminants in the air of the session area. First National Conference on environmental pollution and methods of protection, Atomic Energy Organization, Baghdad, 2000.
[3] I. W. Al-Tamimi, PhD Dissertation, Model for the estimation of air pollutants in the city of Baghdad, Department of Atmospheric Sciences, College of Science, Mustansiriyah University, 2006.
[4] H. N. N. Fathallah, Master Thesis, Assessment of air pollution in some LPG filling stations in Baghdad, Department of Atmospheric Sciences, College of Science, Mustansiriyah University, (2004).
[5] R. E. Luna, and H. W. Charch, A comparison of Turbulence Intensity and Stability Classes. J. Appl. Meteor. 1972, V.11, P.663-669.
[6] D. H.McIntosh, and A. S. Thom, Essentials of Meteorology. Taylor and Francis LTD, London, 1981.
[7] R. M. J. Shubbar, PhD Dissertation, Numerical Simulation of air pollutants using CALPUFF model at an urban area in Baghdad, Iraq,Environmental Atmospheric Sciences, Pukyong National University, South Korea, 2017.
[8] N. J. Snell, Industrial Pollution Control, Van Nostrand Reinhold Company, New York, 1981.

Appendix – A

Acronyms/ Abbreviations

C1	Crude Distillation Unit_70000 barrel_1
C2	Crude Distillation Unit_70000 barrel_2
C13	Distillation of Crude oil Units_1, and 3
ER	Emission Rate of pollutants
GT	Stack Gas exit Temperature
GV	Stack Gas Exit velocity
KH	Kerosene Hydrogenation.
L1	Lube Oil_1
L2	Lube Oil_2
L3	Lube Oil_3
NS	Number of Stack
P1	Power Unit_1 (boiler_1, 2, 3, 4, 5, 6, 7, and 8).
P2	Power Unit_2 (boiler_9 and 10).
P3	Power Unit_3 (boiler_11 and 12).
PS	Point Source
R1	Catalytic Reformer_1
SD	Stack Diameter
SH	Stack Height
R2	Catalytic Reformer_2