Iraqi Journal of Science, 2025, Vol. 66, No. 1(SI), pp: 499- 506
DOI: 10.24996/ijs.2025.66.1(SI).7

ISSN: 0067-2904

Assessment of the Emission and Circumnavigation Pollution of Sulfur Oxide, Nitrogen Oxide, and Total Petroleum Hydrocarbons in the North of Thi-Qar Province, Al Rifaee City, Iraq During 2015-2018 and 2023.

Jamal S. Abd Al Rukabie
Department of Science, College of Basic Education, university of Sumer, Thi - Qar, Iraq

Received: 26/11/2023 Accepted: 11/11/2024 Published: 15/2/2025

Abstract

Air pollution caused by gas emission dispersion leads to damage of the environment and is harmful to humans. In this article, we study and analyze the gas emissions of nitrogen oxide (NO_X), sulfur oxide (SO_X), and Total Petroleum Hydrocarbons (TPHs) in Al Rifaee City. The feedback and main source of pollution was due to the production of crude oil from the Gharraf oil field (GOF), located in the northwest direction of Al Rifaee City. The highest monthly total emission rate for all years was for TPHs (79499.8685 MMSCF); it was 6483.69, and 1560.73 tons) for NO_X and SO_X, respectively. The value of correlation factor R^2 for NO_X was equal to 0.190, which is higher than SO_X and TPHs. In the second part of this article, the concentrations of the above pollutants were measured in the laboratory in September 2023, and the maximum value was for TPHs 610 µg/kg in the soil sample of the northwestern area of Al-Rifaee city center due to crude oil production from the Gharraf oil field (GOF).

Keywords: Gases emission, pollution, Nitrogen oxide, Sulfur oxide, TPHs

تقييم الانبعاثات والتلوث المحيطي بأكسيد الكبريت وأكسيد النيتروجين والهيدروكربونات النفطية الكلية في شمال محافظة ذي قار، مدينة الرفاعي ، العراق خلال الاعوام 2015–2018 و2023 .

جمال سهيل عبد الركابي
قسم العلوم ، كلية التربية الاساسية ، جامعة سومر، محافظة ذي قار ، العراق

الخلاصة

يؤدي تلوث الهواء الناتج عن انتشار انبعاثات الغازات إلى الإضرار بالبيئة والإنسان. في هذا المقال تم دراسة وتحليل انبعاث غازات أكسيد النيتروجين (NOx) وأكسيد الكبريت (SOx) واجمالي الهيدروكربونات البترولية (TPHs) في مدينة الرفاعي. وكان المصدر الرئيسي للتلوث وتغذيته يعود لإنتاج النفط الخام من حقل الغراف النفطي الواقع في الاتجاه الشمالي الغربي لمدينة الرفاعي. كانت اعلى قيمة لإجمالي المعدلات الشهرية لجميع السنوات هي قيمة الهيدروكربونات البترولية (79499.8685 مليون قدم مكعب قياسي)، أقل قيمة أكاسيد النيتروجين وأكاسيد الكبريت (6483.69، 1560.73 طن) على التوالي. وكانت قيمة معامل الارتباط R^2 لأكاسيد النيتروجين تساوي (0.190) وهي أعلى من SO_X وTPHs. في الجزء الثاني من هذا البحث، تم قياس تراكيز الملوثات المذكورة أعلاه مختبرياً خلال شهر ايلول 2023، وكانت القيمة القصوى لتركيز TPHs تساوي 610 ميكروغرام / كغم في عينة التربة) في المنطقة الشمالية الغربية من مركز مدينة الرفاعي، وذلك بسبب إنتاج النفط الخام من حقل الغراف النفطي..

*Email: suheel77@yahoo.com

1.Introduction

Pollution is the introduction of harmful substances (so-called pollutants) into the environment at concentrations beyond the permissible limits. Pollution has far-reaching impacts; it can cause damage and adverse effects on the environment, living organisms, and human health. Pollutants can be solid, liquid, or gaseous (World Health Organization, WHO 2021). They can come from various sources, including industrial activities, transportation, agriculture, domestic waste and the use of fossil fuels, which lead to the emission of greenhouse gases that cause atmospheric pollution and climate change [1]. There is a relationship between the economy and the environment; gas emissions increase depending on industry, crude oil production, and used energy sources (fossil fuels) [2]. Pollution can occur in different environmental media, such as air, water, and soil. Change in the concentrations of gases that make up the air, as well as the presence of hazardous and harmful substances in the ecosystem, such as carbon oxides, sulfur dioxide, nitrogen oxides, particulate matter, hydrocarbons, and volatile organic compounds , is referred to as air pollution. This sort of pollution can be caused by industrial emissions, automobile exhaust, the use of fossil fuels, and other factors. It harms human health and the planet as a whole. According to (WHO), large numbers (nearly 7 million) of people die annually due to air pollution [3].

Water bodies, such as rivers, lakes, oceans, and groundwater, can get contaminated with pollutants, such as chemicals, heavy metals, sewage products, fertilizers, and oil spills. Water pollution occurs when unwanted materials enter the water changing water quality. Contaminated water is harmful to the environment and human health. It can occur due to industrial discharges, improper waste disposal, agricultural waste, and inadequate wastewater treatment. Water quality issues are a major challenge that humanity is facing at present [4]. Pollutants, including heavy metals, pesticides, hazardous compounds, and industrial waste, can contaminate soil, resulting in soil pollution. Groundwater quality, ecological health, and agricultural output can all be negatively impacted by soil pollution [5].Preserving the environment, including air quality, is one of the major issues facing our society. The most important is reducing the proportion of emissions of air-polluting gases, including NOx, because they cause serious risks to the Earth's climate, ecosystems, and human health by using clean energy instead of fossil fuel energy [6]. Air pollution is one of the most important environmental problems facing the world, as it is one of the three most important global risk factors for disease and death. It is worth noting that environmental pollutants emitted into the air, such as particulate matter, carbon monoxide, ozone, nitrogen oxides, sulfur oxides, hydrocarbons, etc., pose major public health concerns (WHO, 2021). Inhaling air containing a high percentage of sulfur dioxide leads to serious health consequences such as respiratory problems and suffocation [7]. Human activities have a significant and effective impact on the accumulation of petroleum hydrocarbons (PHs) in various regions. Crude oil production has led to an increase in total petroleum hydrocarbons [8]. Increased petroleum production and crude oil play an important role in affecting the environment [9]. Types of pollution have their sources and effects, but they are often interrelated and can have cumulative effects on the environment. Industrial emissions, car exhaust, inappropriate waste management, chemical spills, and fossil fuel combustion are examples of common sources of pollution. Particulate matter, hazardous chemicals, heavy metals, greenhouse gasses, and other pollutants are released into the air, water, or soil as a result of these operations. Pollutants come in several forms: multi-source pollutants (aerosol extinction coefficient (AEC)), formaldehyde (HCHO) and glyoxal (CHOCHO)), secondary pollutants (ozone), and primary pollutants (NOx, SOx, etc.) [10]. Different methods and approaches are used to treat environmental pollution. This requires setting international rules, using clean technology, encouraging sustainable habits, increasing awareness of the requirements and importance of environmental protection, and

holding more international agreements and conferences to study the reduction of gas emissions through the use of renewable energy.

Given that climate change has become a large and widespread issue, sustainable development, anti-pollution measures, and switching to renewable energy sources are essential to reducing pollution and protecting the world for future generations. There is an increasing desire to use renewable energy due to the rising costs of fossil fuel energy, which has caused increased global warming and climate change [11]. Wind speed and direction play a major role in the transporting and dispersion of pollutants to other regions; other influencing factors include the atmospheric stability and topography of the region [12]. The research aimed to analyze and study pollutant emissions in Al Rifaee City in Iraq, and to identify their sources. Pollutant concentrations were measured in the laboratory using different methods, and dispersion was determined.

2. Study area

The study area extending from north and northwest to the south of the Al Rifaee city center, located about 85 km north of Thi-Qar province, south of Iraq. The longitude and latitude of the area are (46.1088035°E and 31.7203291°N) respectively. The population of Al Rifaee city is about (200000 capita). The Gharraf oil field (GOF) is near Al-Rifaee city center, and the Gharraf integrated facilities terminal (GIFT) area is about 4 km in the northwest.

3. Materials and Methodologies

The data used in this research, which included the monthly rates of gas emissions (NO_X, SO_X, and TPHs), were obtained from Thi-Qar Oil Company (TOC). The Microsoft Excel 2010 program was used to plot the figures and calculate the annual rates of gas emissions, and curve equations were used. All samples (soil, plant, and water) were carefully taken from different regions of Al Rifaee City. In the laboratory, to measure NOx and SOx concentrations, the water sample was placed in a device consisting of a flask (round-bottom); a thermal heater was used to heat the water sample to the boiling point. The released emitted gases were passed through a tube connected to a gas testing device for measuring each gas concentration by using a kit (chip) that contains ten tests. The plant and soil samples were mixed with an amount of water of previously calculated concentration of gases in it; the new sample was stirred well to make a solution, which was then heated, and the concentration of its released gases was measured using the same method. These measurements were done in accordance with Environmental Protection Agency EPA Method 8015. (SiteLAB. UVF-3100) kit, which uses the ultraviolet fluorescence (UVF) technology, was employed to measure the concentrations of TPHs in the samples (soil, plant, and water).

4. Results and discussions

This research studied and analyzed the pollution caused by (NO_X, SO_X, and TPHs) gas emissions in Al-Rifaee City. The main source of these gases is the production of crude oil, which is considered a feedback to emissions. The burning of fossil fuels used in vehicles and electric generators represents the second source of gas emissions; Figure 1 shows the monthly rates of TPHs emissions during 2015-2018; the maximum value was found to be (1917.4 MMSCF) in January 2017. This is because of the increase in oil production and pollutant transport by the wind. The wind speed and direction affect pollutant dispersion throughout Al-Rifaee City; the conditions of stability in the atmospheric boundary layer cause an increase in dispersion of air pollutants, especially in the winter season. The lowest value of hydrocarbon emission was (1186 MMSCF) in February 2015, while the highest value of the monthly rate during 2018 was (1850 MMSCF) in January. The correlation factor R^2 value was (0.0446), which is considered small. This result refers to the fact that the values are uncorrelated. The equation of the curve was ($Y = -4.7773X + 1725.8$), as emphasized in Figure 2.

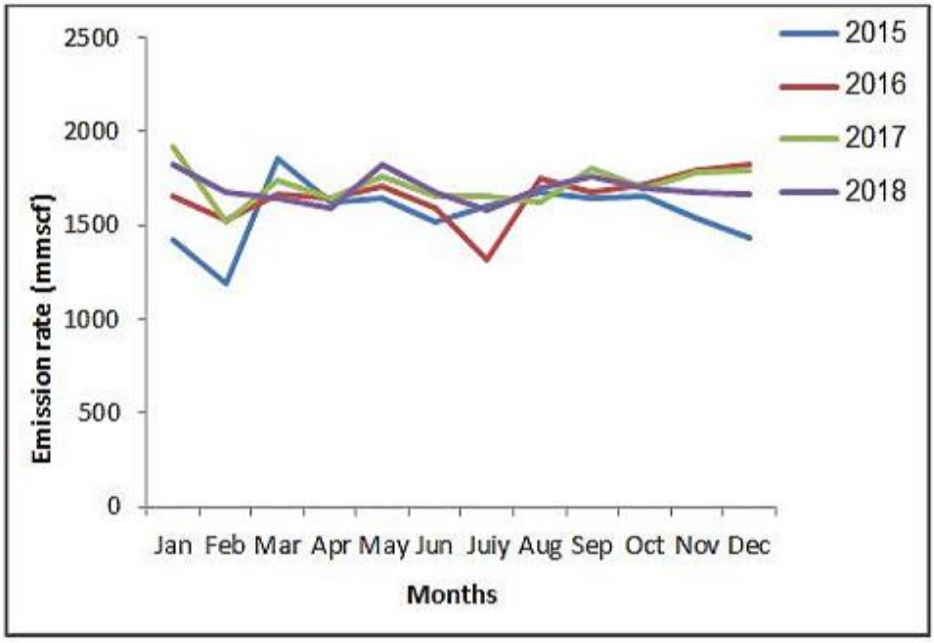

Figure 1: Monthly Rates of TPHs emissions during 2015-2018

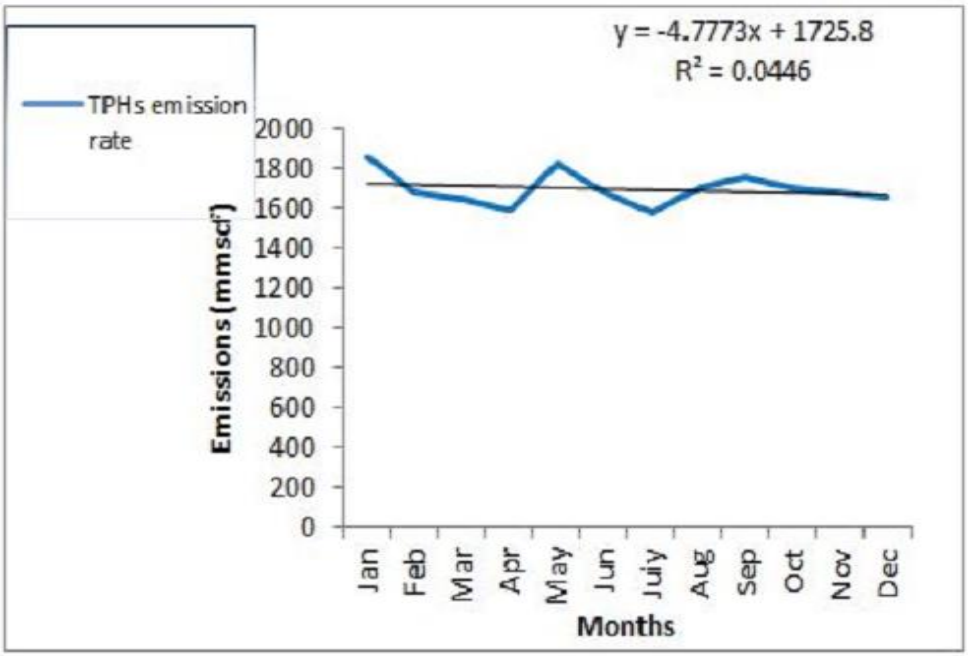

Figure 2: Monthly Rates of TPHs emissions during 2018.

Figure 3 shows the monthly rates of NO_X emissions (Ton) during 2015-2018. The maximum value of NO_X was 183 tons in August 2015, and the lowest was 122 tons in April 2018. The total value (higher value) during 2016 was 1829 tons because of the increased oil production from GOF, and due to the gas emission from vehicles, electric generators and the like. The value of R^2 was 0.190, and it was higher than R^2 for TPHs, whose values have weak correlations. The curve equation was ($Y = 1.1332X + 129.34$), Figure 4 shows this behavior.

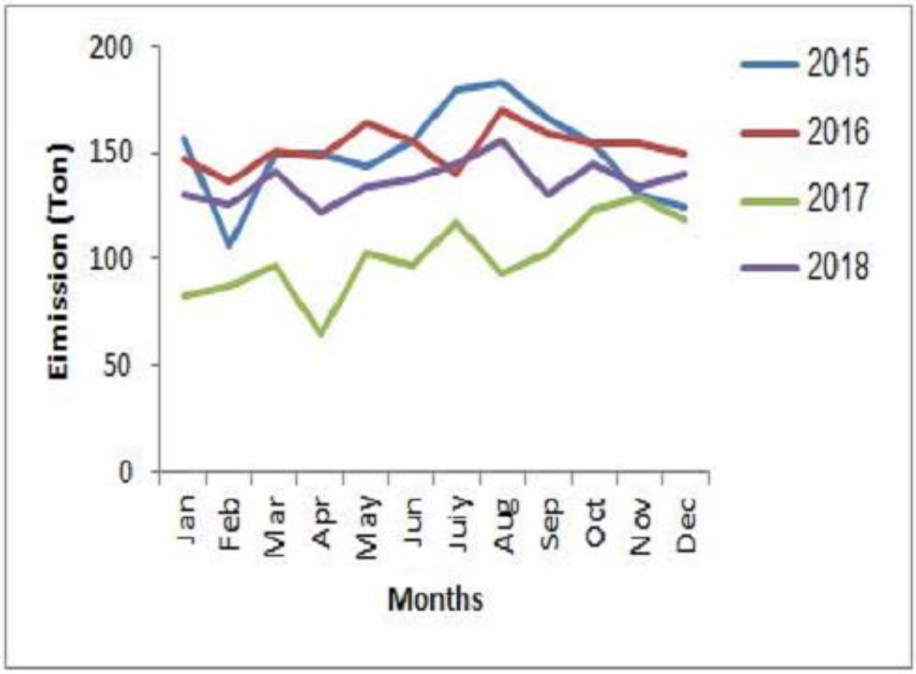

Figure 3: Monthly Rates of NO_X emissions (Ton) during 2015-2018.

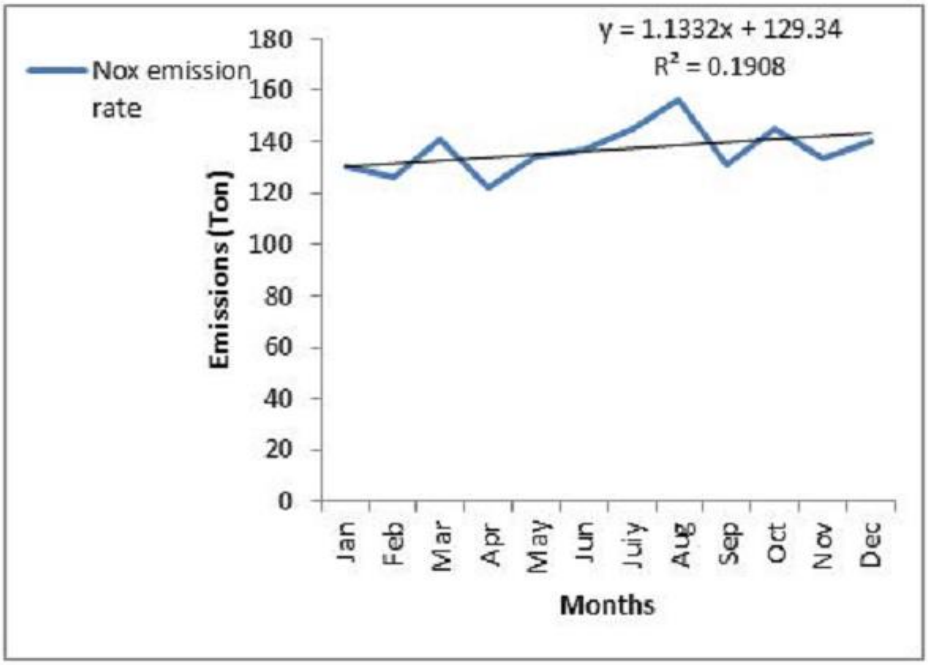

Figure 4: Monthly Rates of NO_X emissions (Ton) during 2018

Figure 5 shows the monthly rates of SO_X emissions (Ton) during 2015-2018. The lowest value of SO_X emission was 3.71 tons in Apr. 2017, while the highest was 64 tons in March 2015; gas emissions were lower in 2017 and 2018 due to the decrease in crude oil production from the GOF during that period, which is the primary source of emissions. The emission values in some months were high because of the high use of electric generators. The total value emission of SO_X for all years was 1560.73 tons. The value of R^2 was 0.118, and the equation curve was ($Y = 0.222X + 10.265$), as shown in Figure 6.

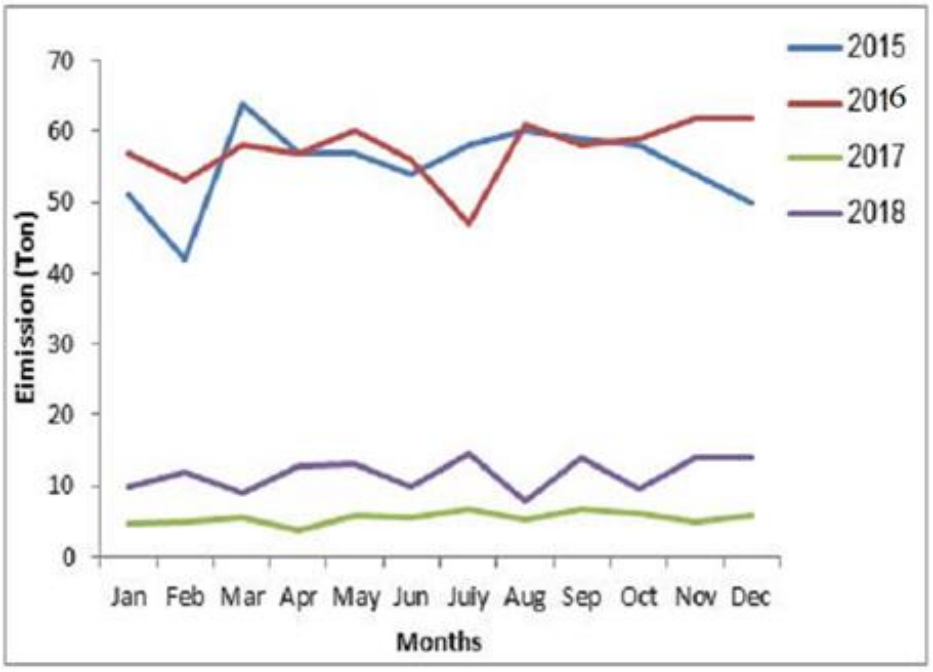

Figure 5: Monthly Rates of SO_X emissions (Ton) during 2015-2018

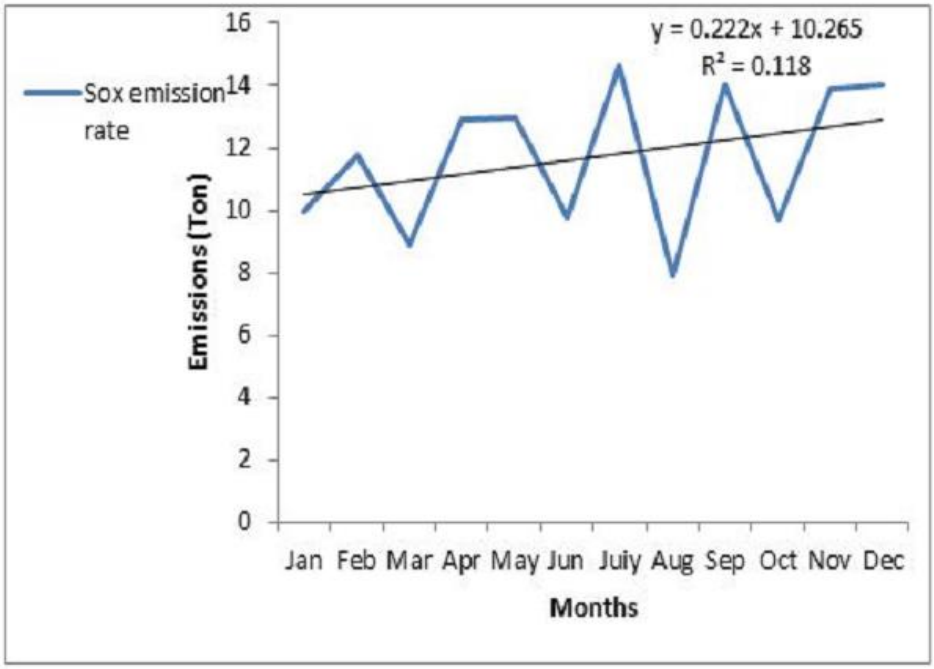

Figure 6: Monthly Rates of SO_X emissions (Ton) during 2018

The annual emission rates were calculated, as shown in Figure 7; the highest values of NO_X, SO_X, and TPHs were 152.4 tons, 55.33 tons, and 1713.9 MMSCF, respectively, and the total annual rates were 540.30 tons, 130.08 tons, and 6624.9 MMSCF, respectively. Generally, these gas emission values are considered high, which may cause damage and a polluted environment. The rapidly increased of pollution gas emissions certainly caused an increase these gases as global averaged concentrations in atmosphere. In Al-Rifaee City, the emission of gases may cause many health effects, such as cancer, asthma, and allergies.

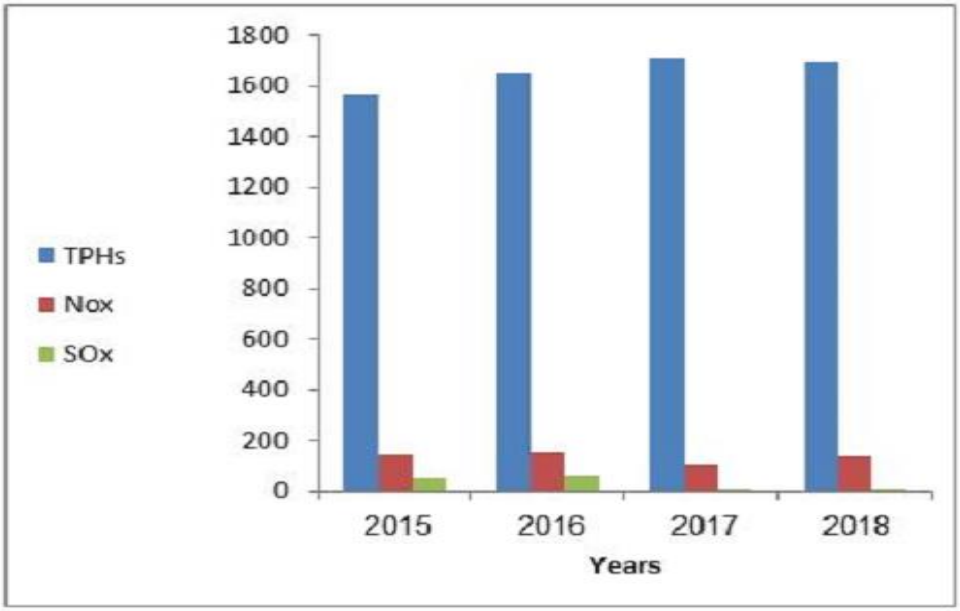

Figure 7: Annual Rates of NO_X, SO_X and TPHs emissions during 2015- 2018.

In the second part of this research, the samples were collected and their pollutants were measured in the laboratory for 2023. It was found that the maximum values for all pollutants in the samples were those of the northwestern side of Al-Rifaee city (sample B) because the northwestern winds transport the pollutants to it and that the minimum values were for the eastern side of the city (sample D), as shown in Table 1. The other sources of pollutants in this study are the combustion and use of fossil fuels. The results were compared with the maximum limits in the Iraqi regulations as well as the United States Environmental Protection Agency (US EPA) values, and the results were within permissible limits.

Table 1: The pollutants concentration studied in Al Rifaee city during 2023.

samples	Coordinates	direction	pollutants	Concentrations		
				Water µg/L))	Plant µg/Kg))	**Soil µg/ Kg))**
A	Longitude 46.11139678 Latitude 31.73221435	North	NOx	11.1	3	**371**
			SOx	130	19.1	**410**
			TPHs	190	35	**601**
B	Longitude 46.102438 Latitude 31.72362607	northwestern	NOx	12.8	4.2	**380**
			SOx	138	21.8	**420**
			TPHs	210	43	**610**
C	Longitude 46.10366909 Latitude 31.70692076	South	NOx	9.3	2.8	**350**
			SOx	120	20.3	**400**
			TPHs	168	24	**590**
D	Longitude 46.11525165 Latitude 31.71314325	East	NOx	7.2	2.1	**290**
			SOx	112	16	**371**
			TPHs	140.3	18.4	**560**

5. Conclusions

This study and its analysis showed that the gas emissions values were high. The primary source of feedback pollution in Al-Rifaee City comes from GOF, while the second source is the burning of fossil fuels by vehicles and electric generators. Wind direction and speed played a big role in the transport of pollutants and dispersion towards the Al-Rifaee city center. TPHs have the highest annual rate, followed by NO_X, and SO_X had the lowest annual rate. After measuring pollutant concentrations in the laboratory, it was discovered that they did not exceed Iraqi standards and US EPA.

References

[1] J. S. A. Al Rukabie., A. S., Hassan, and J. H. Kadhum, "Assessment CO_2 Emission Intensity of Crude Oil Production in Iraq," *IOP Conference Series: Materials Science and Engineering*, vol. 928, no. 7, pp. 072-048, 2020.

[2] J. S. A. Al Rukabie, A. S. Hassan, and J. H. Kadhum, "Empirical analysis of CO_2 emission using EKC model in Iraq," *Int. J. Adv. Sci. Technol*., vol. 29, no. 3 Special Issue, pp. 557–564, 2020

[3] S., Zikirillo, and I. M. Ataboyev, "air pollution and control engineering and technology," *Proceedings of International Conference on Modern Science and Scientific Studies*, vol. 2, no. 5, pp. 155-159, 2023.

[4] S. N. Kuchangi, M. H. Mruthunjayappa, and N. S. Kotrappanavar, "An overview of water pollutants in present scenario," *3D Print. Technol. Water Treat. Appl*., pp. 83–105, 2023.

[5] C. Wei, M. Lei, T. Chen, C. Zhou, and R. Gu, "Method on site-specific source apportionment of domestic soil pollution across China through public data mining: A case study on cadmium from non-ferrous industries," *Environmental Pollution*, vol. 295, p. 118605, 2022.

[6] K. Ś. Da Costa, G. Delahay, A. Zaki, K. Adil, and A. Cadiau, "Facile modifications of HKUST-1 by V, Nb and Mn for low-temperature selective catalytic reduction of nitrogen oxides by NH3," *Catalysis Today*, vol. 384, pp. 25-32., 2022.

[7] M. M. X. Lum, K. H. Ng, S. Y. Lai, A. R. Mohamed, A. G., Alsultan, Y. H Taufiq-Yap, M. K. Koh, et al. "Sulfur dioxide catalytic reduction for environmental sustainability and circular economy: A review," *Process Safety and Environmental Protection*, vol. 176, pp. 580-604, 2023.

[8] H. Wu, L. Xie, Y. Wu, L. Chen, B. Jiang, X. Chen, and Y. Wu, "Improving cleaner production of human activities to mitigate total petroleum hydrocarbons accumulation in coastal environment," *Marine Pollution Bulletin*, vol. 186, pp. 114473, 2023.

[9] H. Gao, M. Wu, H. Liu, Y. Xu, and Z. Liu, "Effect of petroleum hydrocarbon pollution levels on the soil microecosystem and ecological function," *Environmental Pollution*, vol. 293, pp. 118-511. 2022.

[10] S. Zhang, S. Wang, R. Xue, J. Zhu, S. He, Y. Duan, J. Hue, and B. Zhou, "Impacts of Omicron associated restrictions on vertical distributions of air pollution at a suburb site in Shanghai," *Atmospheric Environment*, vol. 294, pp. 119-461, 2023.

[11] M., Thirunavukkarasu, Y., Sawle, &, H. Lala, "A comprehensive review on optimization of hybrid renewable energy systems using various optimization techniques," *Renewable and Sustainable Energy Reviews*, vol. 176, pp. 113-192. 2023.

[12] J. S. A. Al Rukabie., A. S., Hassan, & J. H. Kadhum," Evaluation of carbon dioxide emissions dispersion from crude oil production of Garraf oil field in Iraq," *AIP Conference Proceedings*, vol. 2839, no. 1, pp 080014-1-080014-7, 2023.