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RESEARCH ARTICLE

Air Pollution Assessment Around Al-Rumaila Combined Cycle Power Plant, Basrah Governorate Under Dry Climatic Conditions

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ABSTRACT

The paper addresses the potential air pollution levels resulting from the combustion of natural gas in the Rumaila combined cycle power plant in Basrah city. The study aims to evaluate the concentrations of pollutants (carbon monoxide, sulfur dioxide, nitrogen oxides, and particulate matter) at distances of 100, 500, and 1000 meters from the plant using a Gaussian dispersion model. This includes calculating the emission rates of pollutants from the stacks and estimating atmospheric stability based on data from the Iraqi Meteorological Authority. The study also determines the Turner-Pasquill stability classes for August 2023 and the wind speed and direction at the height of the stack. The results indicate that the concentrations of pollutants in the exhaust gas from the five stacks are well below the national ambient air quality standards, indicating that the power plant has no negative impact on the local climate and air quality.

Keywords: Air pollutants concentration, Gaussian model, Rumaila combined cycle power plant, Basrah City, Iraq

Introduction

There is a fundamental relationship between the fuels used in electric power plants and the greenhouse gases (GHG) produced by electricity generation, especially when they are extracted from fossil fuels such as coal, oil, and natural gas. This contributes significantly to GHG emissions and exacerbates the harmful effects of climate change.[1,2]

Iraq has been identified as one of the most vulnerable nations to climate change due to rising temperatures, less precipitation, more frequent sand and dust storms, increased frequency of droughts and water scarcity, and flooding.[3] There are two major reasons for this phenomenon: air pollution and water scarcity[3] and the most dangerous is air pollution, which is the result of uncontrolled emissions from a variety of sources, including factories, car exhausts, electric generators, and oil refineries. These emissions often exceed the acceptable limits set by international standards.[4] Unfortunately, Basrah is at the forefront of climate change in Iraq, experiencing high temperatures exceeding 50 °C in the summer and little rainfall.[5] As a result, Basrah faces some very difficult challenges accordingly, such as climate change, as drought, heat waves, sea level rise, and salinity threaten the city and its surroundings.[5] It has a serious pollution problem particularly because the region is rich in oil fields, the main source of air pollution. For example, Basrah, Iraq's most populous governorate, suffers from health problems, particularly respiratory diseases and cancer, declining agricultural productivity and loss of biodiversity.[6,7]

Natural gas (NG) is a prominent contemporary clean energy source, demonstrating cost-effectiveness and having a lower carbon content than coal or oil.

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NG has the potential to reduce the environmental impacts associated with other fossil fuels, contributing to the mitigation of climate change caused by carbon dioxide (CO_2) emissions while fostering sustainable development.[8] However, many studies have been conducted on using natural gas in industrial processes and its impact on environmental, health, and economic aspects, and we present some of these studies in this section.

Hannun and Razzaq[9] concluded that natural gas represents a viable solution to mitigate the environmental impact of fossil fuels (coal, oil, and gas) used in generating electrical power. This conclusion stems from its significantly lower contribution to air pollution and greenhouse gas GHG emissions compared to coal and oil electric power plants. In their study, Ghosh et al.,[10] evaluated the potential environmental impact of generating power from natural gas (NG) in the area surrounding a gas-fired power plant. The results showed that the EPP used NG as fuel and did not contain any greenhouse gases and particulate matter (PM) and its properties were well below National Ambient Air Quality Standards (NAAQS). Jaafar and Kadhum,[11] highlighted using NG purification procedures and hybrid NG purification processes, emphasizing how these methods can make NG the cleanest fossil energy source. Because NG consists mainly of methane (CH_4), when burned, it primarily produces water vapor (H_2O) and CO_2, releasing less carbon dioxide per unit of energy produced and fewer pollutants such as sulfur dioxide (SO_2) and nitrogen oxides (NOx), which results in less acid rain. It's important to note that NG cannot be considered a renewable energy source. Al Muhy and Aleedani,[12] their study emphasized the flaring of NG in Basrah Governorate and its impact on the environment and climate change. They found that burning NG adds heat to the atmosphere and produces amounts of gaseous pollutants, which means that it plays a role in the climate change problem during a critical condition that the governorate suffers from, represented by high temperatures exceeding 52 °C and an increase in the number of cancer patients. Fetisov et al.[13] presented data on man-made emissions from the oil and gas industry and direct emissions from transport and energy processing that were used to investigate how volatile organic compounds (VOCs) affect the environment around the world and how far they spread. They found that patterns of VOC emissions show the importance of controlling VOCs during the production, processing, transport and storage of oil and gas, and the importance of creating a single research base on emissions for each industry sector and on sources of greenhouse gas absorption. Mirrezaei and Orkomi[14] assessed the health risk of benzene, toluene, ethylbenzene and xylenes (BTEX), which are a few forms of VOCs associated with the combustion of gas, which are known as hazardous air pollutants because of their harmful effects and the carcinogenic properties of some of them. The results of this study found that the relative contribution of gas burning in assessing the health risks of BTEX is less than the permissible limit, but the cumulative effects of all potential sources of BTEX, including gas burning, cause health problems.

The purpose of the study

The Rumaila Combined Cycle Power Plant (RCCPP) was chosen for this study because it is a newly established project and therefore needs to be evaluated environmentally, especially in light of Basrah's pollution. This research is considered the first research for this power plant in terms of evaluating air pollution. So, the main objectives of the paper are as follows:

1. Assessment of emission rates, produced by RCCPP for gaseous (CO, SO_2, NO) and particulate matter pollutants.
2. To investigate atmospheric stability based on wind speed and solar radiation area related to pollutant transport.
3. Estimating the concentration of the above pollutants using the simple Gaussian model at several distances from the stacks of RCCPP.
4. Plotting the wind rose depends on the direction of the wind speed, which is used to determine the direction of pollutants.
5. To present current rose pollution to predict the predominant pollution trend area.

Materials and methods

Study site

RCCPP is a modern electric power plant built by the Ministry of Electricity, constructed in June 2018 and a 2,180 MW gas fired power project. It has dimensions of 1000 m by 900 m and is located about 50 km from the center of Basrah in the northern Rumaila region, at latitude 30.54° North and longitude 47.40° East Fig. 1. The power plant is situated in a desert area rich in oil fields, bordered to the northwest by the Rumaila oil field, one of the largest oil fields in Iraq, and surrounded by several industrial facilities, including an electric power station under construction. The RCCPP project consists of five gas units (turbines), which rely on natural gas to generate electricity, and two thermal units (turbines).

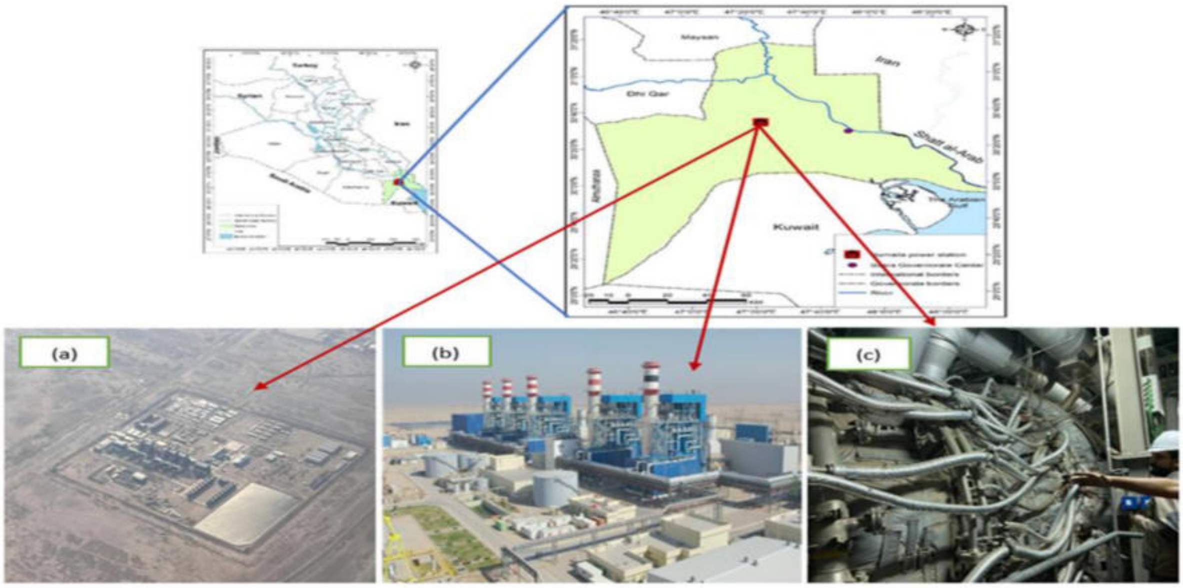

Fig. 1. Location of RCCPP, (a) electricity power plant location from satellite, (b) RCCPP photo with its five stacks, (c) one of the combustion chambers (gas turbine).

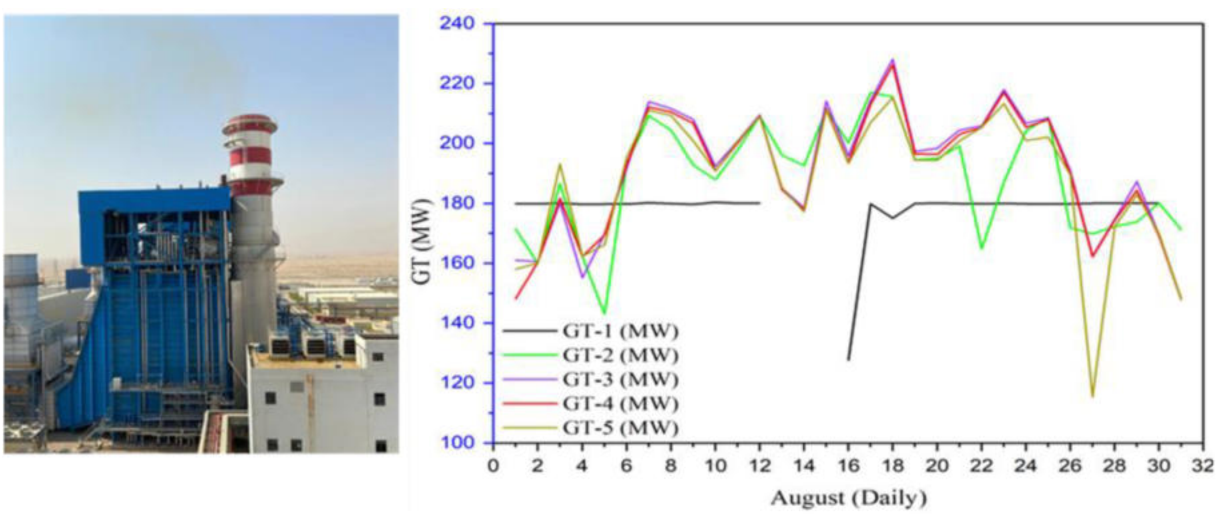

Fig. 2. RCCPP, electricity production using gas units (5-turbines). August, 2023.

RCCPP electric production

The RCCPP operates 24 hours a day, and very large quantities of NG are flaring to produce electricity by its Five Gas Units (5 GT). The daily gas consumption rate is approximately 4500 m^3/s. The rate of electric production is between 150 and 230 MW as a daily average, with 3 missing days of GT-1 working, as shown in Fig. 2.

Emission rate

Emission rate, a mathematical tool used to predict pollutant concentrations downwind of a source (the amount of a pollutant released into the atmosphere per unit of time).[15] It is usually measured in grams per second (g/s), kilograms per hour (kg/h) or tons per year (t/y). The emission rate is a fundamental input to air quality modeling and plays a central role in the Gaussian plume model as it determines the strength of the source and influences the predicted downwind concentration.[16]

For each of the five stacks of the power plant (which are 60 m high and 7.5 m in diameter) in August 2023, data on the gas exit velocity from the stack is available. Using the following equation, ascertain the emission rates of the four pollutants (SO_2, CO, NO_2, and PM):[17]

$$E_s\left(\frac{m^3}{sec}\right) = V_s * A = V_s * \frac{\pi * D^2}{4} \quad (1)$$

Es = Volumetric gas flow rate inside the chimney in m^3/sec, Vs = exit velocity from the stack in m/s, A = area of the stack, and D = stack diameter in m.

As both the temperature and pressure inside the chimney differ from the values observed in the surrounding air, adjusting for the flue gas flow rate is necessary by considering the impact of moisture content and the standard conditions. This is achieved by utilizing the equation presented below.

$$E_{s.dry}\left(\frac{m^3}{sec}\right) = E_s * \frac{273.15}{T_{actual}} * \frac{P_{actual}}{1_{atm}} (1 - \text{fracction water vapour}) \quad (2)$$

T_{actual} and P_{actual} are the pressure and temperature inside the stack in units of Kelvin and atmosphere. By knowing the concentration rate of a certain gas inside the chimney, we get the emission rate in units g/s. The emission rate (Q_s) for any pollutant released from a source located at the origin, in μg/s, can be calculated using the following equation:[17]

$$Q_s = E_{s.dry}\left(\frac{m^3}{s}\right) * C_0\left(\frac{g}{m^2}\right) \quad (3)$$

where C_o = the concentration at the stack.

Dispersion gaussian model

The Gaussian atmospheric dispersion model is a mathematical tool used to predict the concentrations of pollutants in the atmosphere after their release from the point sources, and ensuring public safety. This model is based on the assumption that the pollutant plume can be predicted by relying on meteorological conditions.[18] In other words, it is the description of a continuous point, starting from the source in a uniform (homogeneous) turbulent flow.[19] To apply the simplified Gaussian equation, several factors must be calculated. The first is to calculate the pollutant emission rate. The second is to determine the wind speed at the stack nozzle, and the third is to calculate atmospheric stability,[15] which depends on the change of days and seasons.

Modified Gaussian equation Eq. (4) below was to estimate a certain pollutant concentration (C), in $\mu g/m^3$, at the receptor near the Earth's surface:[20]

$$C\ (x.\ 0.0) = \frac{Q_s}{2\pi\ U\ \sigma y \sigma z} \quad (4)$$

where U is the wind speed at the height of the stack in (m/s). In the lower part of the earth's boundary layer (i.e., the surface layer), the wind speed increases with height and exhibits a strong gradient near the ground. Thus, to describe the wind speed at the top of the stack, it's often calculated by a simple power law.[15]

$$U\,(z) = U_r * \left(\frac{z}{zr}\right)^{\alpha} \quad (5)$$

where U_r: wind speed at a reference height (z_r), in which the actual wind speed is measured. The exponent (α) is variable according to surface roughness and atmospheric stability. When the air reaches neutral conditions for non-rough surfaces, it is 1/7 and increases 0.25 in urban areas. So, we employed the value of 1/7 for the height of 60 m (stack height) in the study.

The dispersion coefficients, denoted by σy (sigma-y) and σz (sigma-z) in Eq. (4), are crucial parameters in Gaussian plume models used to estimate the concentration of pollutants downwind from a source. These coefficients quantify the horizontal (σy) and vertical (σz) spread of the pollutant plume as it travels through the atmosphere. So, the dispersion coefficients represent the standard deviations of the spread of the divergent and transverse winds of the concentration distribution. Depending on the stability class curve shown in Fig. 3, the dispersion coefficients σy and σz could be derived by projecting any horizontal downwind distance found on the x-axis.

Atmospheric stability

Atmospheric stability is defined as the response of air parcels to vertical movement, which depends largely on vertical changes in wind speed and solar radiation, such that these elements are considered indicators used to calculate atmospheric stability.[19] The vertical movement of air that increases or decreases atmospheric turbulence across the atmospheric boundary layer is known as "atmospheric stability", where any movement of atmospheric constituents such as water vapor, aerosols, etc. is affected by atmospheric stability.[21] Stable conditions lead to high concentrations of pollutants, which means that air quality in a particular area deteriorates,[22] because pollution events with low winds and very stable conditions trap pollution on a very shallow vertical scale.[23] In contrast, unstable atmospheric conditions are often associated with sunny days, which further

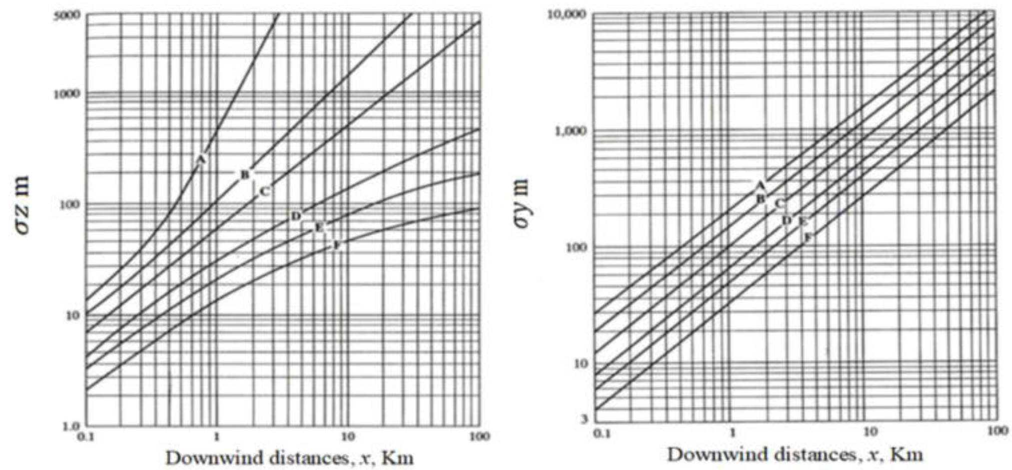

Fig. 3. Dispersion coefficient curve for σz and σy.[17]

facilitate high vertical mixing of air. In summer, for example, high levels of solar radiation and long day lengths cause surface air temperatures to rise, leading to mixing and dispersion of pollutants.[24] There is no physical law that specifically defines atmospheric stability, but there are a wide range of schemes such as the Pasquill classification, Richardson number, Monin-Obukhov length, etc.[25] It can be determined in different ways or parameters depending on the data available, and in this study, we have used the Pasquill stability classification.

Pasquill-Gifford (PG) chart was adopted from Turner-Pasquill stability classes. It is a classification scheme for atmospheric stability based on wind, solar radiation, and clouds. It mainly consists of six classes of atmospheric stability classified as (A) very unstable, (B) unstable, (C) slightly unstable, (D) Neutral, (E) slightly stable, and (F) very stable. It was used with the meteorological data available, such as solar radiation and wind speed in the study area, as daily averages, as shown in the procedure in Table 1.[26]

Table 1. Pasquill-Gifford (PG) day time classification scheme.[26]

Wind Speed (at 10 m) (m/s)	Day Time Solar Insolation (W/m^2)			Radiation
	Strong > 600	Moderate 300–600	Slight < 300	Overcast
<2	A	A-B	B	C
2–3	A-B	B	C	C
3–5	B	B-C	C	C
5–6	C	C-D	D	D
>6	C	D	D	D

Wind and pollutant roses

A wind rose for pollutants is a diagram that shows the frequency and intensity of wind directions at a particular location and how pollutants are distributed depending on wind direction and speed. It can identify the dominant wind direction (i.e., prevailing wind), indicating the most frequent wind direction. This is where the wind most often blows from and is critical in determining the direction in which pollutants from a source may primarily travel. Also, from different wind speeds, it can assess the impact of wind speed on the dispersion of pollutants, whereas higher wind speeds can disperse pollutants more widely, while lower wind speeds might result in higher concentrations near the source.

However, the general diagram of the methodology is given in Fig. 4.

Results and discussion

Daily variations of pollutants (CO, SO_2, NO, and PM)

Continuous monitoring systems for emissions resulting from the operation of RCCPP with burning NG within 24 hours provide hourly records of the taken pollutant concentrations of carbon monoxide, sulfur dioxide, nitrogen oxide and particulate matter to be measured directly from the inside of smokestacks for August 2023. Regarding daily pollutant levels (see Fig. 5), it was observed that in August 21, the highest concentration of CO reached 94,525 $\mu g/m^3$, and

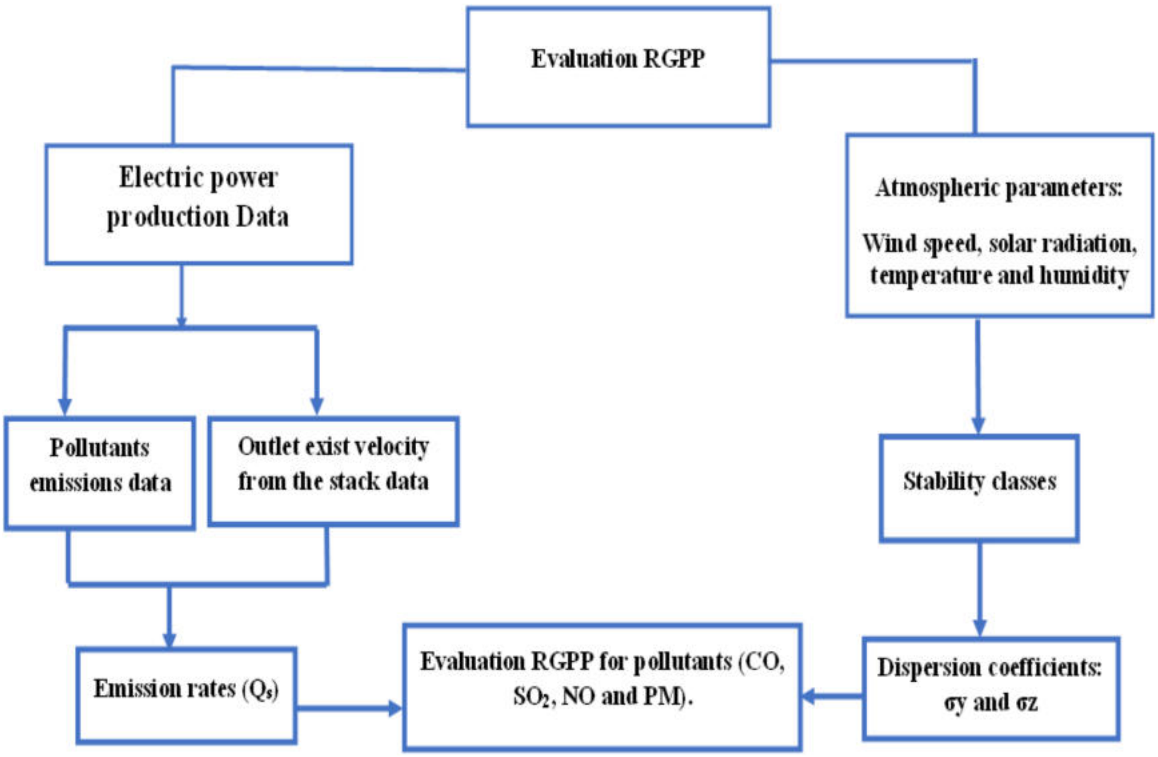

Fig. 4. Diagram for the methodology in the current study.

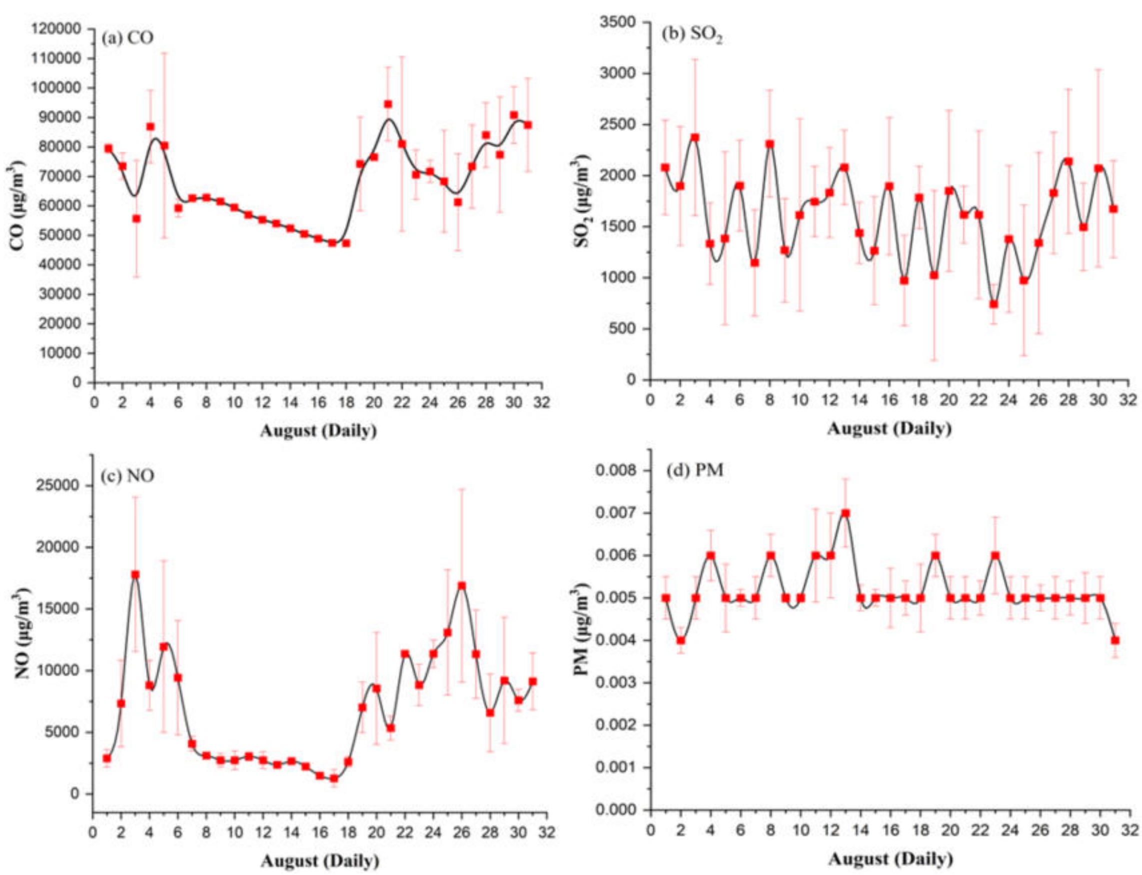

Fig. 5. Daily average concentration of pollutants (a) CO, (b) SO_2, (c) NO, and (d) PM within August month, 2023.

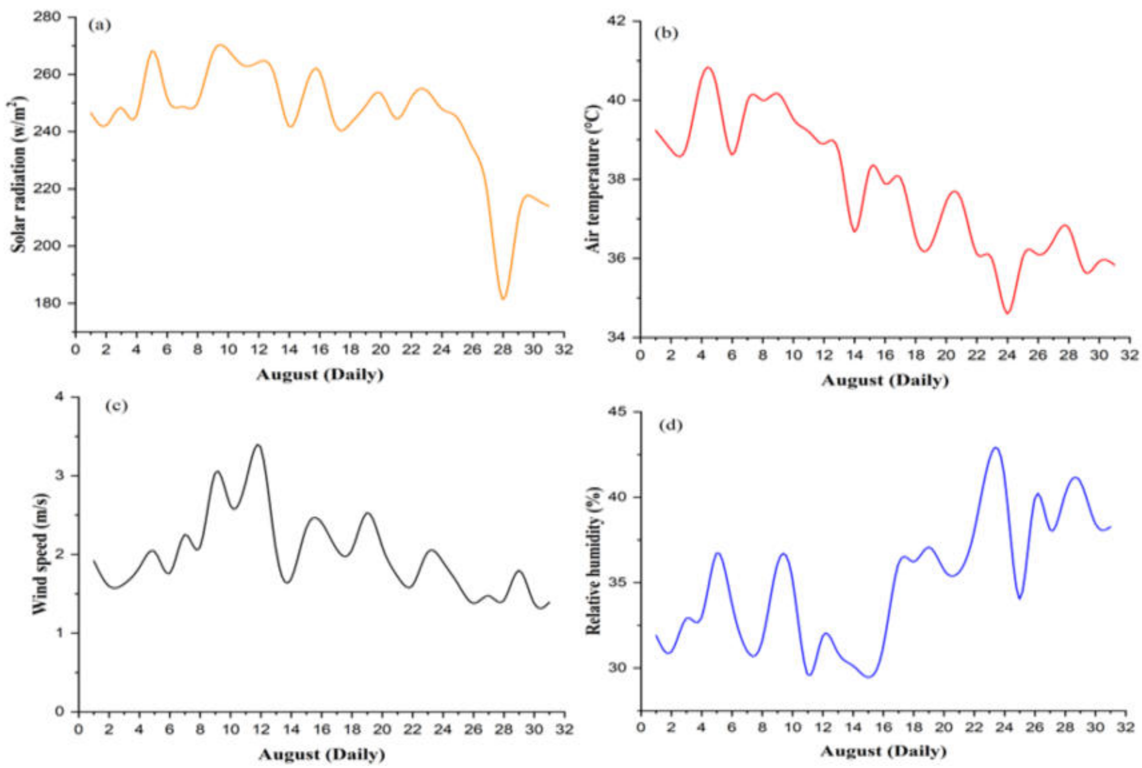

Fig. 6. Atmospheric elements, (a) solar radiation, (b) air temperature, (c) wind speed, (d) relative humidity, in August, 2023.

its lowest concentration was between 40,000–50,000 $\mu g/m^3$ in the middle of the month due to the cessation of one of the turbines (GT-1). The average concentration of CO in August, with moderate gas combustion conditions at the station, ranged between 70,000–80,000 $\mu g/m^3$. The daily averages of sulfur dioxide measurements directly from stacks in August ranged between 740–2500 $\mu g/m^3$, and the daily averages of NO measurements showed that the highest concentration on days 3 and 26 in August was 17800 and 16890 $\mu g/m^3$ with a roughly constant. The lowest concentration rate for NO was for 10 days, from day 7 until day 18, at a rate ranging between 1200–4000 $\mu g/m^3$ due to the shutdown of the turbine (GT-1), and daily measurements of PM between 0.004–0.007 $\mu g/m^3$. These elevated levels of pollutants released from the stacks indicate poor gas combustion efficiency, as shown in Fig. 5.

Daily meteorological variables

To estimate the spread of pollutants in the atmosphere around an electric power plant, it was necessary to collect daily weather measurements, including solar radiation, air temperature, wind speed and direction, and relative humidity. These data were obtained from the Basrah Meteorological Station located at Basrah Airport, which is about 20 km away from the RCCPP. This clearly displays the variation behavior of the above elements as shown in Fig. 6. Meteorological data showed the following: Brightness rates ranged between 240–270 W/m^2, with a sharp decrease on August 28 to 190 W/m^2. Followed by temperatures in the same month, which ranged between 36–41 °C, where the lowest was on the 28th (36 °C). The decrease coincided with a dust storm that obscured the sun and affected temperatures. As for wind speeds, they ranged between 1–3.5 m/s, and finally, humidity levels ranged between 29–44%.

Wind rose analysis

Wind data at a stack height of 60 meters show that the prevailing wind direction during August is between the northwest and the southwest. The most prevalent wind direction was from the west, with speeds ranging from 3 to 6 m/s, followed by the southwesterly direction, with speeds ranging from 2 to 4 m/s, as illustrated in Fig. 7. Therefore, the direction of the pollutants will be mostly east.

Estimation of gaseous CO, SO_2, NO, and PM concentrations

The power plant RCCPP is situated in a flat, sandy desert area in North Rumaila, approximately 50 km

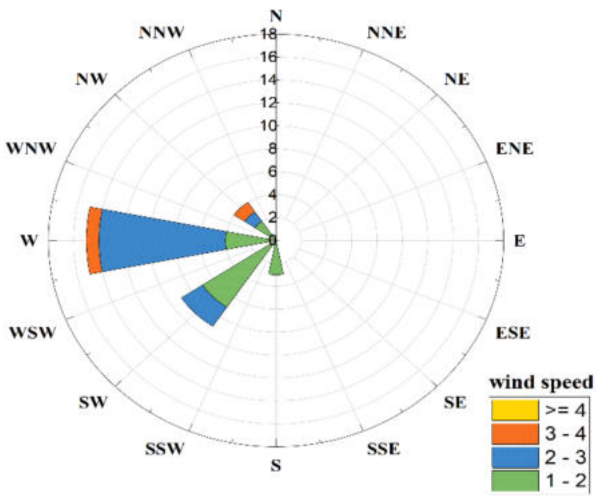

Fig. 7. A wind rose, daily wind speed and direction, August 2023.

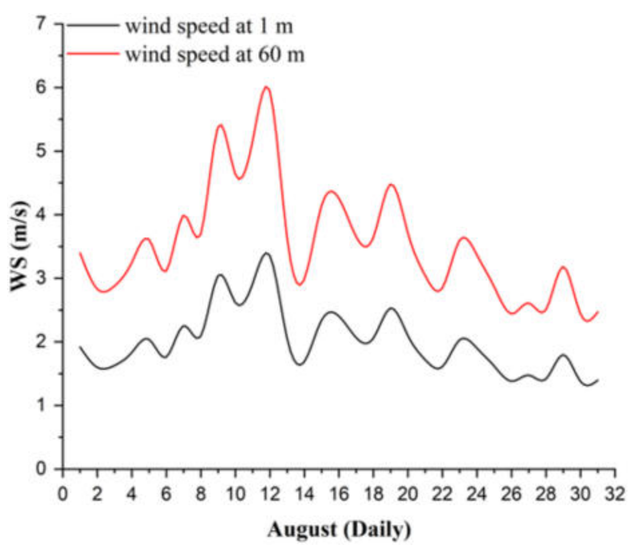

Fig. 8. Wind speed calculated at stack height according to power law.

northwest of the center of Basrah Governorate. Therefore, the wind speed at the stack height (60 m) was determined using the exponential engineering wind law as defined in Eq. (5). Fig. 8 shows the wind speed at 1 m observed and 60 m calculated at the stack exit according to the energy drop, where the highest gusts were. The wind in the days (9, 10, 11, 12) of August, where the highest temperature rise was usually occurred in this month and the lowest value was for the 27th and 28th. Perhaps it was a cloudy day or the presence of a dust storm that obscured the sun and this affected the winds. The end of the eighth month is also considered to be the end of the season, in which the dry conditions will be accompanied by high levels of humidity. Temperatures begin to fall.

Dispersion coefficients (σz and σy)

In this research, according to Table 1, based on the daily wind speed and solar radiation, the atmospheric stability class was estimated as (C: slightly unstable conditions). Using the curves for C in Fig. 3, we calculated the vertical and lateral dispersion coefficients (σz and σy) through interpolation for three distances: 100, 500, and 1000 m. The results are presented in Table 2, showing that the values of σz and σy increase with distance from the RCCPP.

Table 2. σz and σy for three distances (100, 500, 1000 m).

Distance	σz (m)	σy (m)
100	8	13
500	45	60
1000	70	110

Emission rate for pollutants: CO, SO_2, NO, and PM

The average rates of emission were separately calculated for each pollutant (i.e., CO, SO_2, NO) and PM) during this month. The results were displayed in Fig. 9a-9d, respectively. In Fig. 9a, emission rates were between (0.2–0.8) g/s for CO, 0.04–0.08 g/s for SO_2 Fig. 9b, (0–0.15) g/s for NO Fig. 9c, and (1–5) $\times 10^{-8}$ g/s for PM Fig. 9d. CO has the highest emission rate compared to other pollutants owing to two reasons. The first is the incomplete combustion that can occur when there is not enough oxygen or when the combustion temperature is too low. Secondly, the poor ventilation in systems using natural gas can also contribute to higher CO emissions.

Application of a simplified Gaussian model

The concentrations of the pollutants CO, SO_2, NO, and PM were estimated in daily rates at different distances from the single stack of RCCPP in August 2023. Using Eq. (4), the dispersion coefficients (σz and σy) gen in Table 2, and the emission rates for each pollutant, their concentrations were calculated at distances of 100, 500, and 1000 m near the ground in the eastern direction of the plant. Then, these concentrations were multiplied by 5 to include the five stacks in RCCPP, which are considered as one point source. The results of the daily concentrations at these distances for all pollutants released from RCCPP are presented in Figs. 10 to 13, respectively. In general, all concentrations have higher values at 100 m, gradually decrease at 500 m, and are lower at 1000 m distance. The high CO concentrations of 365,

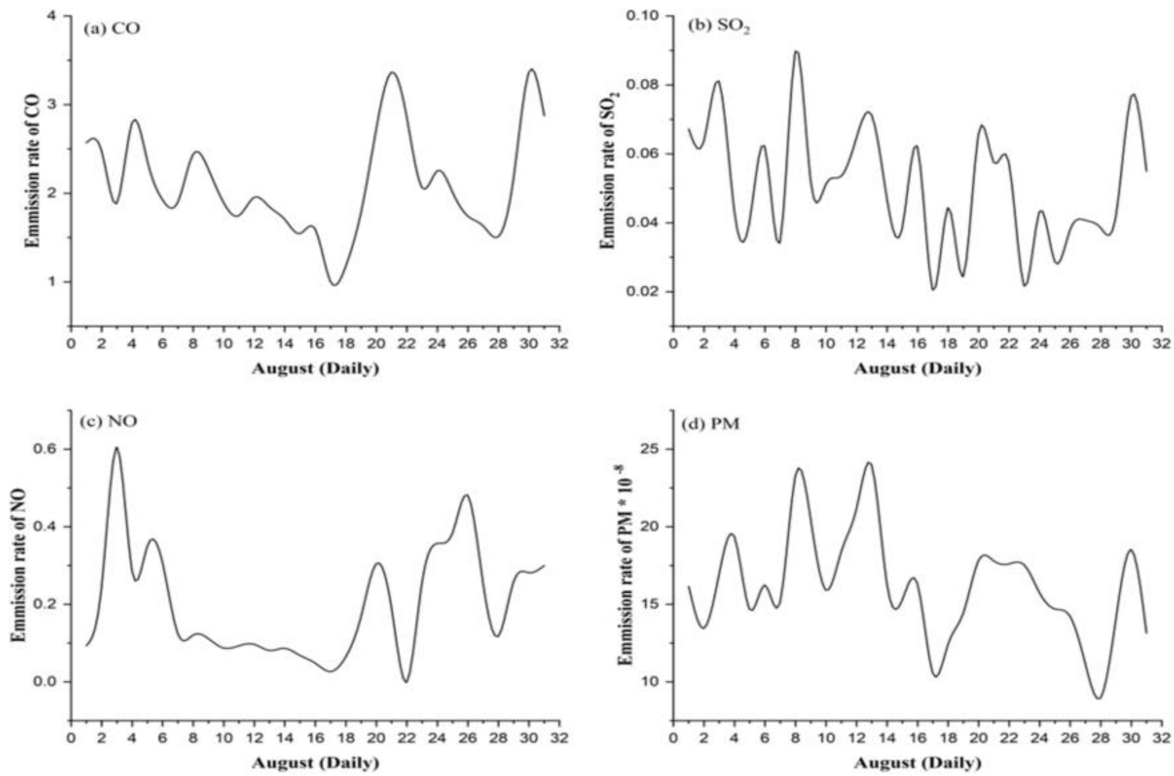

Fig. 9. Emission rates for CO, SO_2, NO, and PM, calculated according to Eq. (1).

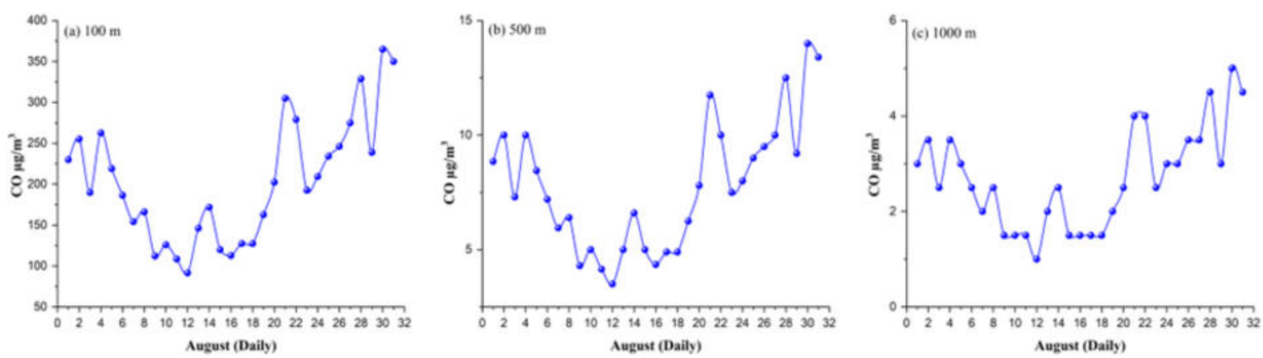

Fig. 10. Daily predicted concentration of CO with distances, (a) 100, (b) 500, and (c) 1000.

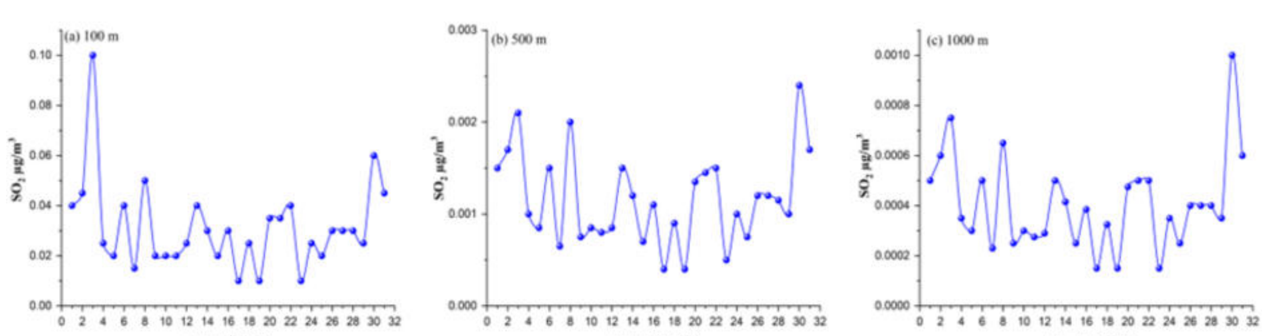

Fig. 11. Daily predicted concentration of SO_2 with distances, (a) 100, (b) 500, and (c) 1000 m.

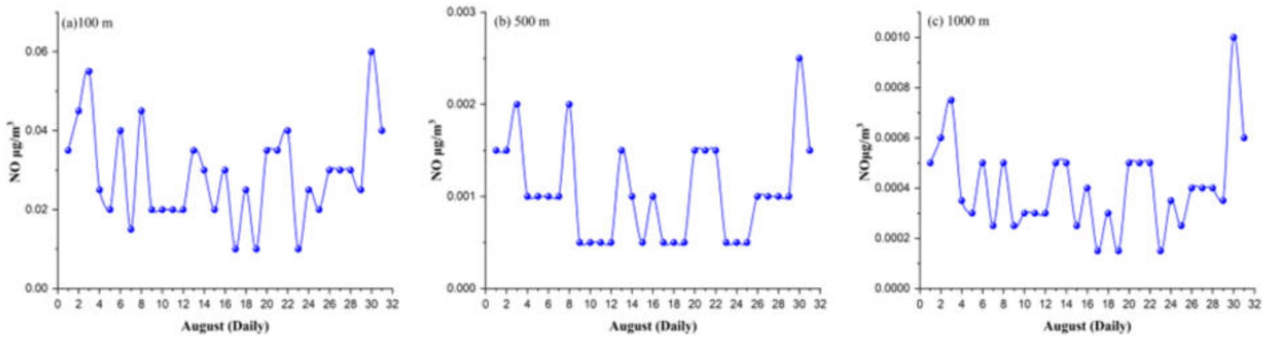

Fig. 12. Daily predicted concentration of NO with distances, (a) 100, (b) 500, (c) 1000 m.

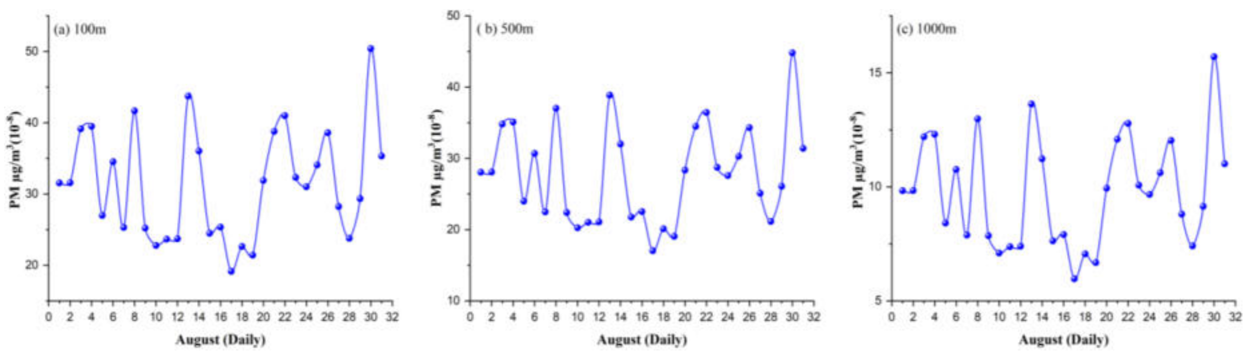

Fig. 13. Daily predicted concentration of PM with distances, (a) 100, (b) 500, and (c) 1000 m.

14, 5 $\mu g/m^3$ occurred at the end of the month for the three distances, respectively. Overall, most of the CO concentrations are lower than the national ambient air quality standard, which is 960 $\mu g/m^3$ for a day.[17]

Concentrations of SO_2 values at distances (100, 500, 1000 m) from RCCPP point area using Eq. (4) were 0.1, 0.002, 0.001 $\mu g/m^3$, respectively. Also, the concentration of SO_2 is lower than the national ambient air quality standard, which is 150 $\mu g/m^3$ for a day[17] as shown in Fig. 11.

NO gas concentration in days, according to the simplified Gaussian model for the distances (100, 500, and 1000 m) from the power plant, were 0.06, 0.002, 0.001 $\mu g/m^3$, respectively, which are under the limits of 4800 $\mu g/m^3$ for a day,[17] as shown in Fig. 12.

Results of PM particles using Gaussian model for the distances from the power station 100, 500 and 1000 m. The concentrations were $5*10^{-7}$, $46*10^{-8}$, $15.5*10^{-8}$ $\mu g/m^3$. According to these values resulting from mathematical averages, in the reality of the distances studied, this indicates that there is no PM, only inside the stack, because NG combustion does not generate significant PM emissions, but some technical processes such as cooling towers, which are used to expel excess heat, often create a visible plume of water vapor that can resemble PM, especially from a distance. This PM is not formed due to the burning of the natural gas, but from water evaporating from the cooling process, as shown in Fig. 13.

Pollutants rose analyses

The relationship between the concentration of pollutants and the direction of the wind makes it possible to deduce the direction of the pollutants (CO, SO_2, NO) for concentrations calculated at a distance of approximately 100 m from the stack (emission source), since this is the area affected by the workers, by examining the direction of the wind. The direction of the wind is important when investigating how pollutants affect workers because it determines where the pollutants are likely to travel. For example, in the current study, if the RCCPP is upwind of a work area, workers downwind will be more exposed to these pollutants. As shown in Fig. 7, the prevailing wind at the RCCPP site was west-south, which means that the direction of the pollutants will be east-south. The stacks are oriented in an east-south direction and, as shown in Fig. 14, we can also conclude that the concentrations of pollutants taken from the continuous measurements of pollutants increase only in the vicinity of the stack.

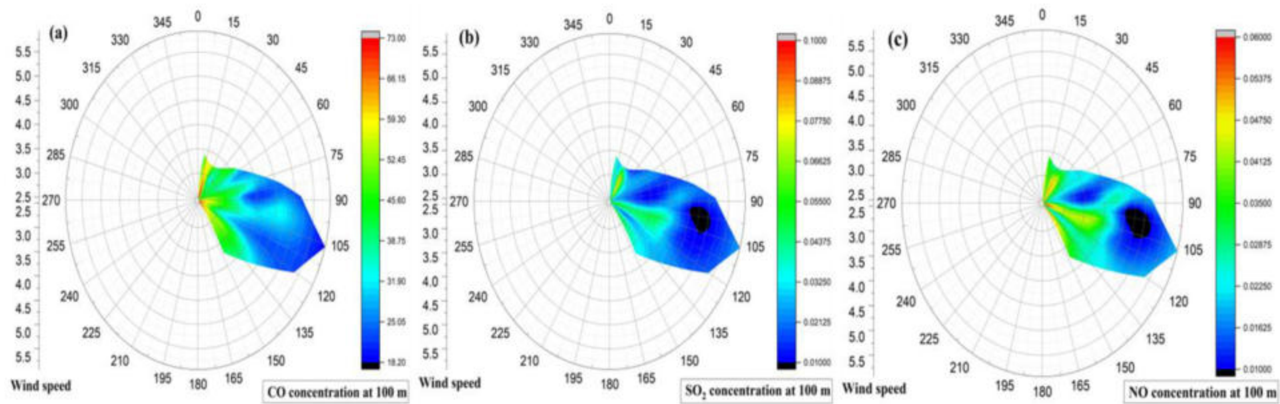

Fig. 14. Concentrations of (a) CO, (b) SO_2, and (c) NO with wind direction in the vicinity of the power plant.

Conclusion

Rumaila Combined Cycle Power Plant is a modern power plant that was established in 2018. The Rumaila Power Plant operates continuously and uses natural gas to generate electricity. It consumes about 4,500 cubic meters per second of gas per day. On average, it produces between 150 and 230 megawatts of electricity per day. The combustion waste is discharged through five stacks, each 60 meters high. Our study is the first since the plant started production to assess the concentration of gases that are considered air pollutants and are typically released from power plants that burn gas as fuel to generate power. Based on the concentrations measured at different distances from the five stacks, it is clear that there is no significant pollution of the environment surrounding the plant based on comparing the results with the permissible rates in the National Ambient Air Quality Standards (NAAQS). We believe that this is due firstly to the newness and efficiency of the plant, and secondly to the location of the plant in an open desert area where winds cause the gases to spread quickly and not to concentrate locally. We recommend that long-term monitoring be conducted in the future to assess the impact of climatic conditions on the dispersion of gaseous pollutants from the station so that we can maintain its low impact on air pollution in the area.

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Authors' declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for republication, which is attached to the manuscript.
- No animal studies are present in the manuscript.
- No human studies are present in the manuscript.
- Ethical Clearance: The project was approved by the local ethical committee at University of Baghdad.

Authors' contribution statement

This study was designed by M.S., M.H., and J.A. Data collection and analysis were performed by M.S and J.A. The manuscript was drafted by M.H. and M.S. with contributions from all authors.

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تقييم تلوث الهواء حول محطة كهرباء الرميلة ذات الدورة المركبة في البصرة في ظل الظروف الجافة

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الخلاصة

تتطرق الورقة البحثية إلى تحليل مستويات التلوث الجوي المحتملة الناتجة عن احتراق الغاز الطبيعي في محطة كهرباء الرميلة ذات الدورة المركبة في مدينة البصرة. تهدف الدراسة إلى تقييم تركيزات الملوثات، بما في ذلك ثاني أكسيد الكربون(CO_2) ، وثاني أكسيد الكبريت (SO_2)، وأكاسيد النيتروجين (NO)، والجسيمات الدقيقة (PM)، على مسافات 100 و500 و1000 متر من المحطة، باستخدام نموذج التشتت الغاوسي.تشمل الدراسة حساب معدلات انبعاث الملوثات من المداخن وتقدير الاستقرار الجوي بناءً على البيانات المتاحة من هيئة الأرصاد الجوية العراقية. كما تحدد الدراسة فئات استقرار تيرنر-باسكويل لشهر أغسطس 2023، بالإضافة إلى قياس سرعة الرياح واتجاهها عند ارتفاع المدخنة.تشير النتائج إلى أن تركيزات الملوثات في غاز العادم المنبعث من المداخن الخمسة تقل بشكل ملحوظ عن معايير جودة الهواء الوطنية، مما يدل على أن محطة الطاقة لا تؤثر سلباً على المناخ المحلي وجودة الهواء.

الكلمات المفتاحية: تركيز الملوثات الجوية، النموذج الغاوسي، محطة كهرباء الرميلة ذات الدورة المركبة، مدينة البصرة، العراق.