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Assessing the Impact of Gas Flaring Activities in Ebedei, Southern Nigeria

***Akpoyibo, O. and Vwavware, O. J.**

Department of Physics, Dennis Osadebay University, Asaba, Nigeria

*Corresponding author's email: akpofavo@gmail.com

ABSTRACT
The study looked at how gas flaring affects development and sustainable growth. While the availability of natural gas and crude oil is expected to serve as a socioeconomic stimulus for faster, more sustainable growth, the current situation in Nigeria's oil-producing regions is significantly worse than expected. Eleven (11) experimental locations, including Obinomba (control site), which lacks a gas flaring station, provide data for the collections. The air quality indices concentrations and various temperatures were measured. At a starting location that was 50 meters distant from the flare's bund wall, assessments of the location temperature and also air quality in Ebedei were taken at intervals of 50 meters. The statistics indicate that both the temperature and the quantity (content) of gases (CO, NO_2, SO_4, and CH_4) have increased. Thus, a rise in temperature is proportional to a rise in flared gases. It is imperative that no agricultural crops be planted in this area that react adversely to high temperature variation, such as cassava, palm trees, rubber trees, bananas, and other crops. It can be suggested that the extracted gas be liquefied and bottled for usage in home and industrial settings, as well as being heavily utilized by a gas turbine to generate electricity. Residential buildings should be constructed at least 0.5 kilometers away from the flare point, and water samples should be analyzed to determine the level of contamination and water portability. To maintain adherence and keep the blessed environment, it is totally crucial to urge that FEPA continuously track and assess the degree of damages attributed to gas flaring.

Keywords:
Gas Flaring,
Temperature alterations,
Pollution,
Ebedei,
Ukwuani.

INTRODUCTION

The uncontrolled burning of surplus hydrocarbons collected in an oil/gas flow of production station is known as gas flaring, and natural gases are frequently flared following the extracting and refining of crude oil. By using combustion to get rid of waste and noxious gases, flaring serves as a safety mechanism or device to prevent pipelines or vessels from becoming over-pressurized as a result of unforeseen disruptions (Anomohanran, 2012). The burner and igniters are positioned at the top of a pipe or stack, through which the combustion occurs (Anomohanran, 2012). Gas flaring has developed into a custom that is currently followed by practically all Nigerian oil companies and is an essential component of the country's oil-producing towns in the Niger Delta when considered with Canada and other developed nations (Penner, 1999). According to reports, around 75% of Nigeria's gas production is flared, making the country responsible for roughly 19% of the world's total gas flared (Kindzierski, 2011). It is impossible to downplay the danger pollution resulting from gas flaring poses to human life. In addition to deteriorating corrugated metals (aluminum) roofs, gas flaring adds acidic rain, which acidifies the soil, reducing fertility levels and harming crops. Thermal pollution results from the unrestrained disposal of gas via flaring, which produces a great deal of heat that is felt across an average diameter of 800 meters (Ikelegbe, 1993, Anomohanran, 2012). There are concerns about gas flaring's effects on a local and global level. The poisonous cocktail of materials released during flares that contain particles of benzene causes communities exposure to grievous and and serious health risks.

These massive gas deposits are connected to crude oil in Nigeria's oil reserves. The high temperature has a significant physiological effect on crops cultivated close to the flare (Oseji, 2009, Anomohanran, 2012). The main factor influencing how quickly plants grow is temperature, and plants are known to react to temperature constantly. Temperature variations can have an impact on grain yield since most plants, including corn, wheat, sorghum, and beans, become stressed when temperatures rise and their pace of crop development slows down. Between 15 and 25 degrees Celsius, the relationship between soil temperature and corn output is essentially linear. The yield drops over 25^0C (Anomohanran, 2012). Increased surface air temperature causes physical effects such as stunted growth, defoliation, wrinkling, withered leaves, and premature ripening of fruits (Oseji, 2009). The result of this flaring is the emission of methane gas, carbon dioxide, and other associated gases, which release pollutants into the atmosphere, including carbon (C), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), and lead (Pb) (Okoh, 2000). These associated gases are a by-product of the nation's vital petroleum exploration activities; they are separated from the oil at flow station, and more than 95% of the oil is flared overall. Environmental preservation is vital to sustainable development and poverty reduction (Ojeh, 2012). The major and common greenhouse gasses linked to gas flaring operations are carbon dioxide and methane; as a result, it has been proven and established that this process has raised the mean global (world) temperature by roughly 0.5°C over the past century (Ojeh, 2012). These gasses cause disruptions in the photosynthetic process, which lowers growth and leads to low agricultural yields (Ossai et al., 1997; Anomohanran, 2012). According to Nwaogu and Onyeze (2010), the environmental impacts (effects) of gas flaring in the communities of Ebocha and Egbema show that the mean pH of soil samples taken from these two communities is highly acidic. Plants and soil microorganisms may be harmed by the chemical and biological conditions that high soil acidity produces.

Blame for the flames and smoke that poison the atmosphere and soil (vegetation) in the environmentally vulnerable region and add to world greenhouse gas emissions falls on the flaring station in the Ebedei. The research area's environmental health issues may be exacerbated by heat and toxic gasses. The temperature of the flare up, the velocity at which gas flows, and the geometric configuration of the flare stack have all contributed to the timely and rapid warming observed at Ebedei. Simply put, the heat from gas flares has an impact on the population of microbes (Benka-Coker and Ekundayo, 1997). Humid (topsoil) divisions, microbial populations, nutrients accessibility and availability, and fertile soil are all impacted by this process, which contributes to the decay of organic material and the development of nitrogen. The significant cause of heat pollution in Ebedei is flare-ups of gases, which creates a unique microclimate in the area around the activity. It is convenient to define environmental laws and regulations as inadequate and bad, given that the government prioritizes earnings (profits) over the well-being of its population and the precious environment. Consequently, the investigation of temperature fluctuations and gas flares are essential to this research. Due to the prevalence of flaring of gas and incessant oil drilling operations (activities) in the vicinity, Ebedei will receive special attention. The implication on burning gases in the Ebedei community is what this research aims to deliver.

Study Area

Ebedei is in the abundantly gas-and oil-rich Niger Delta. With latitudes of 5°52'N and 6°12'N and longitudes of 5°11'E and 5°49'E, it is situated within the Ukwuani (Figure 1). The distinguishing characteristic of Ebedei is its soils, which are composed of a blend of coarse fluvial and colluvial strata. The area (region) is watered by the River Ethiope, one of its tributary rivers, and the Orogodo stream, which joins it after the wet season (Akpoyibo et al. 2022; Esi and Akpoyibo 2024). The area has a tropical equatorial climate with an average yearly temperature of 27.32°C, a mean normal relative humidity of 60%–80%, and 4205 mm of rainfall. Two primary wind systems mainly affect the environmental conditions of Ukwuani. They are the cold trade winds out of the northeast from the hot Sahara and the observed southwest wind releases and blows cold dampish air from the Atlantic. The North-East trade wind is in charge of the cold dry period (Harmattan), which affects the region for around four months (November–February), whereas the South-West wind is predominant virtually all year long, from March to October. As a result, there are two distinct seasons in a year: the rainy and the dry. The dense vegetation cover of the tropical rainforest belt is made up of tall, evergreen forests with climbing plants growing in the understory along streams and creek channels. This type of vegetation is typically known as primary vegetation, while the presence of grasslands with sporadic trees and shrubs is known as secondary vegetation within the vegetation belt. The Niger-Delta region's geology has been thoroughly described in detail by Short and Stauble (1967), Molua, (2012), Okolie and Akpoyibo (2012), Ofomola et al., 2017, Esi and Akpoyibo (2023), Anomohanran et al., 2023 and Esi et al., 2023, Akpoyibo et al., 2023.

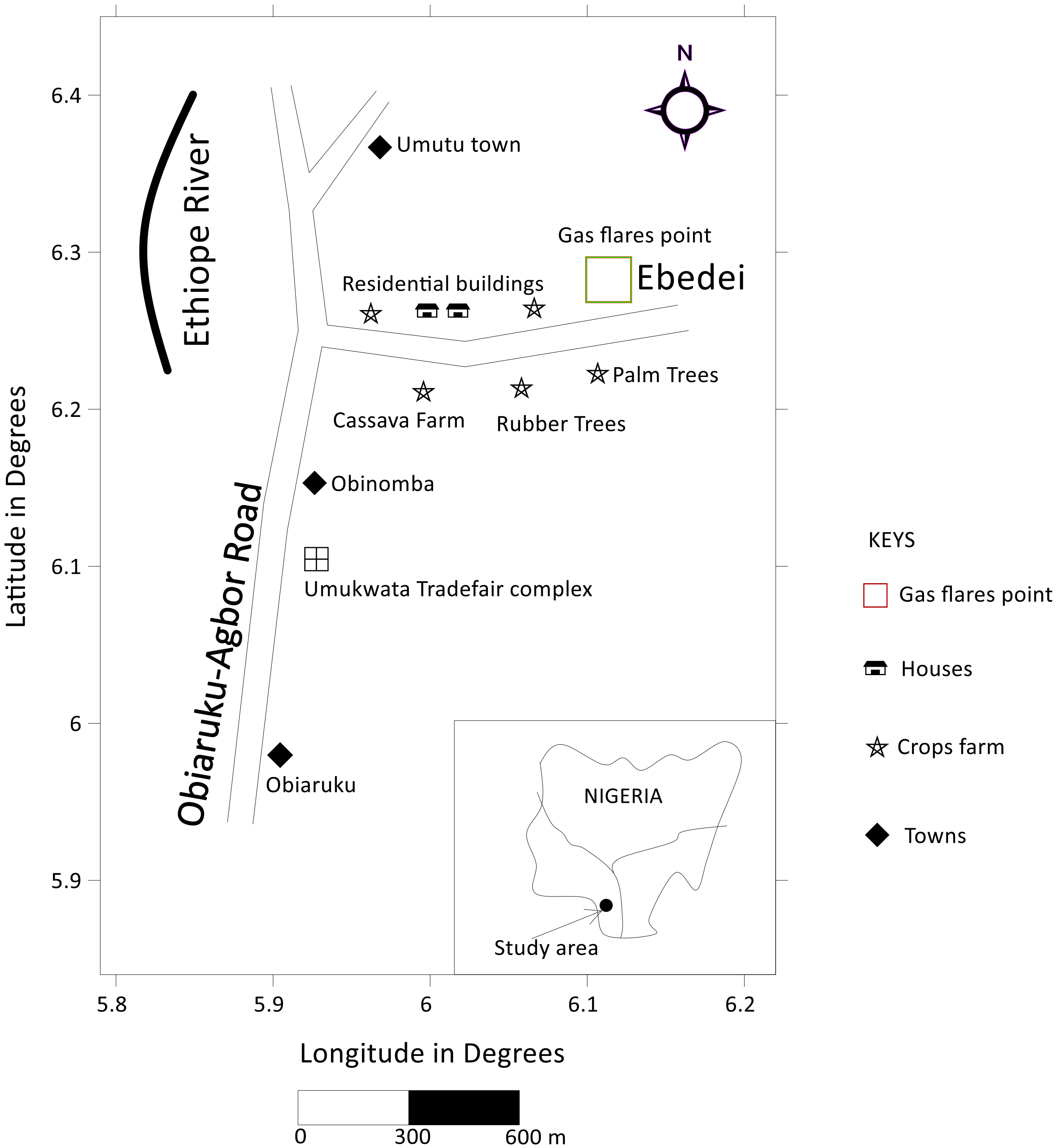

Figure 1: Map of study area showing the Ebedei gas stack point

MATERIALS AND METHODS

Air quality properties (indices) and flare temperature were taken in a time frame of three-month (January to March) as part of the research approach that the study used. The mean was calculated.

Sample Gathering

Eleven (11) testing locations were carefully selected to be equally spaced apart from the Ebedei outburst site. The equivalent distances were 50, 100, 150, 200, 250, 300, 350, 400, 450, and 500 meters. The flare boundary wall was 1800 meters (1.8 km) away from a control point at Obinomba. The control site's distance selection, according to Onuorah (2000) and Ojeh (2012), reflects an insignificant statistical effect, which is outside the 16 and 21-km flared site radius. Again, the study and control sites featured similar soils and climates; but, since the control location (site) is not in an area where gas flares are present. Therefore, any variations in separation from the flare place that are noticed could be caused by gas flaring. A good thermometer was utilized to measure the temperature. To reduce the impact of the vertically temperature slope and to ensure weather homogeneity, the temperature readings were obtained at a height of 1.5 meters for all measures conducted between 8 and 10 a.m. GMT. A gas meter was used to test the air quality index in the early morning (6:30 am) and late evening (6:30 pm). The fact that the gasses are volatile led to the selection of this time frame. Records of the specified distances from flares wall wraps (bunds) were used to average the data on the surrounding temperatures and the air purity (quality) index. Suphur dioxide (SO_2), nitrous oxide (NO_2), methane (CH_4), and carbon dioxide (CO_2) are the principal constituents of flared gases. The Nigerian flare stack's low combustion efficiency (60–80%) causes methane, which has a higher global warming potential, to make up a vital amount of the gases released. To obtain the study area's coordinates, a unique GPS receiver was employed.

RESULTS AND DISCUSSION

The temperature in the surroundings against distance toward the flare location was revealed in Table 1. The temperature drops as one gets farther away from the flare point. The research area's mean (average) temperature is 28.6 °C. As a result, within 300 meters of the flare point, the surface temperature along the distances normalized at 28.6 °C. When a place's recorded air temperature deviates from its average ambient temperature and this rise in temperature has an unfavorable impact on people, it is considered thermal air pollution (Ojeh, 2012; Vwavware et al., 2024). The volume or amount of gases emitted from various flare distances is shown in Table 2. Nearly all of the metrics (CO, NO_2, SO_2 and CH_4) that were acquired from Ebedei had values that were higher above the FEPA standard or permitted limit for normal and fresh air environment and were noticeably greater than those for the Obinomba community. However, due to their volatility, sulfur dioxide (SO_2) gas has the largest concentration (Figure 2, 3). According to Ojeh (2012), the mean values of all the air quality indices dropped with increasing distance from the flaring location, suggesting that gas diffusion increased with increasing distance. Although the mean values for both CO and CH_4 are below FEPA requirements, indicating a lower concentration of the pollutants at greater distances, this observation is attributable to the high pollution level caused by gas flaring in Ebedei. This may be explained by the fact that the dispersion of the contaminants and other components is causing them to react in different ways. Table 2 shows that the 50–300 m radius surrounding the flare station is the most risky area. However, depending on the amount of gas flared, wind speed, ambient temperature, discharge velocity, and stack height, the impacts of the flared gas are felt within a 400-meter radius from the flaring source. The results showed that as the volume of gas flared grows, so does the concentration of pollutants at ground level, and vice versa. Industrial activities are to blame for this increase in gas concentrations (Yusuf and Oyewunmi, 2008; Ojeh, 2012; Ikegu et al. 2024).

Table 1: Temperature deviation along distance from Ebedei flare bund wall point

Distance (m)	50	100	150	200	250	300	350	400	450	500	1800
Temperature (^{0}C)	30.0	29.2	29.0	28.9	28.7	28.6	28.5	28.4	28.3	27.9	27.3

Table 2: Gas flare out distances and flared (gushed) gases

Distance (m)	**Gas flared(10^{-6}g/m^3)**			
	CO	**SO_2**	**NO_2**	**CH_4**
50	12.01	33.05	30.76	15.40
100	11.89	33.04	30.18	14.25
150	11.46	33.01	29.56	13.26
200	11.44	30.59	29.43	7.99
250	11.02	25.08	30.15	6.84
300	10.89	26.12	25.16	6.66
350	9.80	35.09	22.45	5.27
400	6.19	30.16	22.05	5.12
450	5.86	19.25	20.19	4.98
500	4.89	18.52	19.81	4.69
1800	2.88	14.75	16.37	2.08
FEPA	10	20	20	10

Federal Environmental Protection Agency (FEPA) air quality standards

Figures 2 and 3 demonstrate that the gases flared are, respectively, SO_2, NO_2, CH_4 and CO in decreasing order. This suggests that since the gases are happening at extents (levels) higher or over the permissible limits of FEPA, the health of the individuals in the research area is significantly impacted, especially those who live very close to the flare site (50-300 m). For example, when properly extracted, sulfur dioxide (SO_2) can be used as a fumigant, bleaching agent, and food preservative. On the other hand, nitrogen dioxide (NO_2), a poisonous brown gas that is hazardous to human health, can be used as a catalyst and to produce compounds made of oxidized cellulose. All of these chemical compounds can be used for a variety of purposes since it serves as an intermediary in the production of nitric acid. In contrast to carbon monoxide (CO), which is used to make detergents and is a reagent for the synthesis of aldehydes and phosgene, methane, or CH_4, is used to generate electricity, serves as rocket fuel in its refined and pure liquid form, is required to sanitize items, and is also valuable as an antifreeze ingredient. All of these gasses from air pollutants are dangerous to aquatic (if a fish pond is mentioned nearby) and arboreal life in addition to humans, even though they are useful. Anomohanran (2012) and Ojeh (2012) conducted experiments that support these findings, demonstrating rising trends in gas emissions from gas flaring in the Ebedei area. Additionally, residential buildings near the flared bund point are experiencing elevated temperatures and amounts of flared gases, posing a threat to nearby crops and residents alike, as the gases are occurring at levels that exceed the allowable limits of FEPA for most observations.

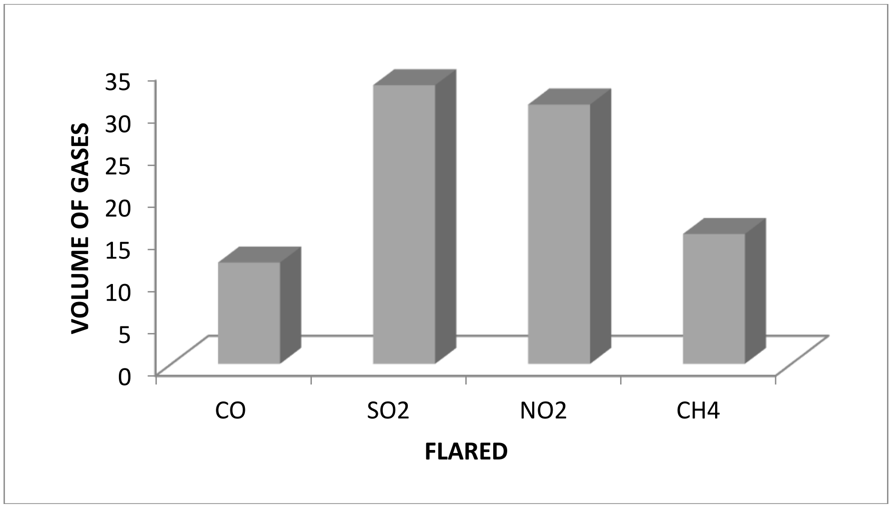

Figure 2: Volume quantity of flared gas at 50m distance from the gas bund

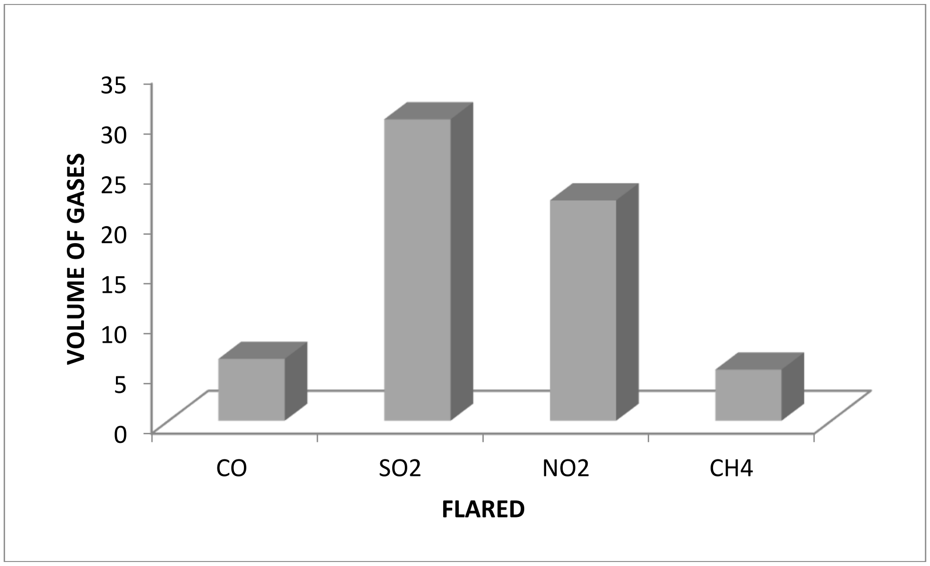

Figure 3: Volume amount of gas flared at 400m distance from the gas point bund

Figures 4 and 5 illustrate how the temperature rises in proportion to the distance from the gas flare point. The temperature is affected by these gasses. In comparison to other distances, the temperature recorded is highest at 50 m from the flare's bund wall and is lowest at 1800 m at Obinomba. The majority of the crops grown in the region are unlikely to yield correctly, given the increase in temperature values caused by gas flares over the average daily temperature. This is consistent with research by Orimoogunje et al. (2010), which showed that yields of crops like as corn, wheat, sorghum, beans, rice, cotton, and peanuts will all decline with even little temperature rises. The findings of the International Protocol on Climate Change (IPCC) are also supported by this data, which shows that temperature increases of 1 to 2^0C are likely to have a detrimental impact on the yield of major cereals and tubers like wheat, yam, cassava, maize, and rice. These effects are also evident in the color changes of the leaves of different crops (IPCC, 2007). On the other hand, growers of crops that thrive in the heat, like okra and melon, would like this. Pathogenic bacteria that are beneficial to humans and promote soil fertility will also be impacted by the heat radiation brought on by this temperature increase. It has the potential to make local residents uncomfortable with its extreme heat. Due to its extreme development and ability to produce acid rain, it can potentially have an impact on nearby structures. In addition, gas flaring greatly increases greenhouse gas emissions, which fuel global warming. Additionally, there is a migration of locals, particularly farmers, to neighboring towns for settlement, including Agbor, Obiaruku, Umutu, and Umuaja.

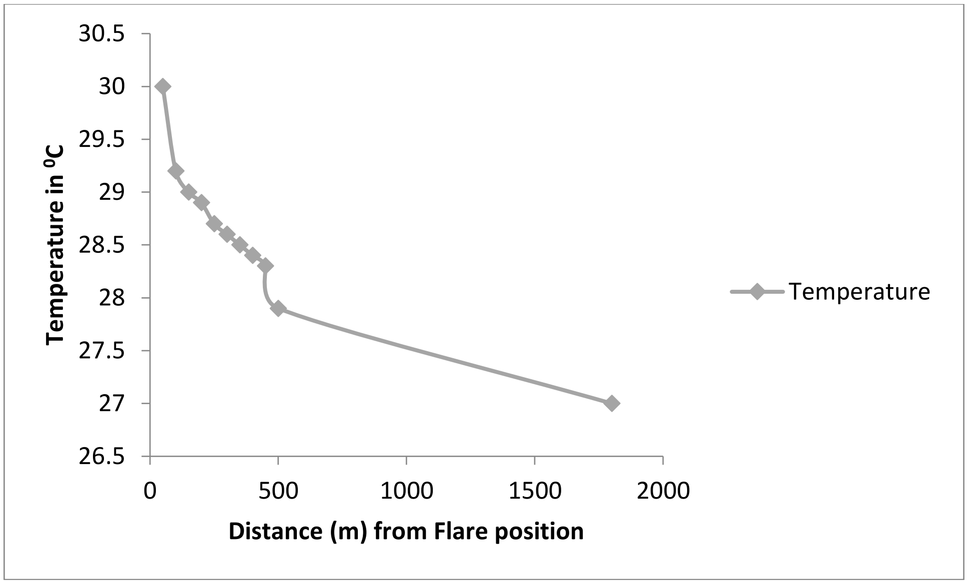

Figure 4: Plot of Temperature against distance from the situated flared point

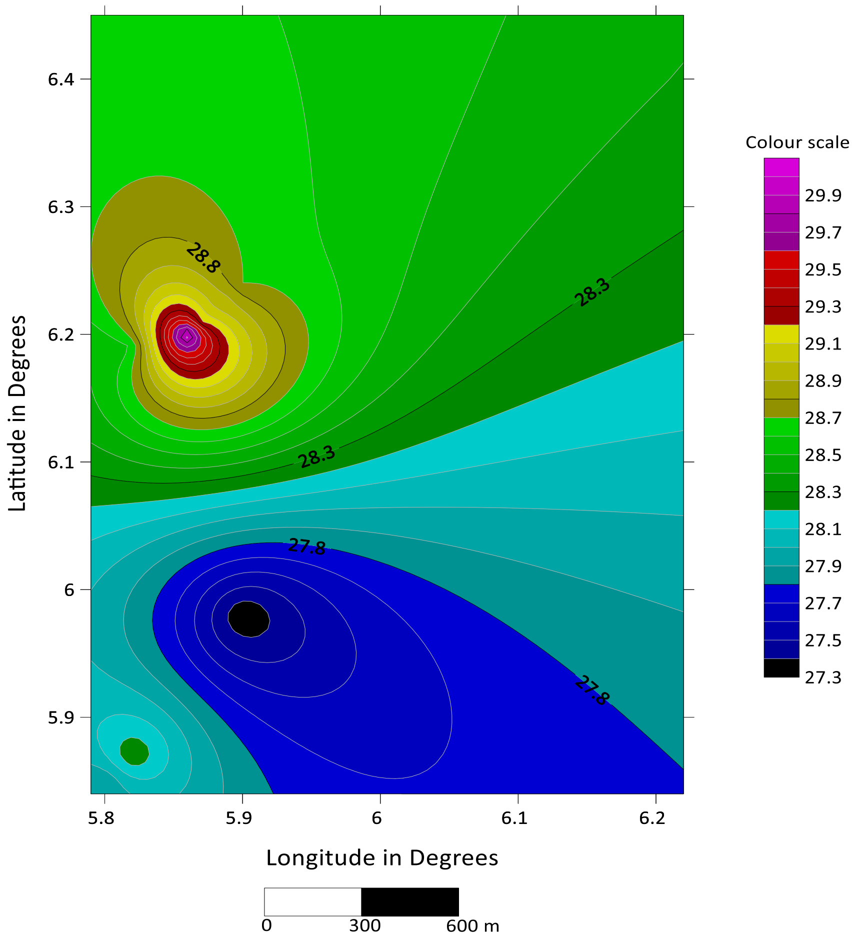

Figure 5: Temperature Distribution of Ebedei gas flare area

CONCLUSION

In the Ebedei area, our study has shown that temperatures are rising in tandem with increases in gas combustion and flare (flame) distances. As a result, the presence of gas in the studied region causes a thermal effect or a temperature rise in temperature. It is reasonable to draw the conclusion that gas flaring and erupting not only generates excessive heat that changes the environment's temperature and also releases gaseous harmful substances into the atmosphere, which could harm local populations and jeopardize the long term and sustainable development. The environment's temperature returns to its normal level approximately 500 meters from the flared stack. As a result, residential structures ought to be situated within this distance range. It is advised that oil companies be forced to cease gas flaring in order to lessen the harmful effect of these greenhouse gases on the health and well-being of the residents of areas harboring the gas flare stations, given the situation with regard to the negative socio-economic impacts on the environment caused by the gas flaring at the Ebedei gas plant. Instead of being flared, gas should be used to generate energy by means of a gas turbine. In relation to the Ebedei gas plant, residential areas are to be located at least 500 meters away from the flare point.

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