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Thermal Effects of Gas Flaring Activities at Gbarain Clan, Bayelsa State, Nigeria

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ABSTRACT

This investigative research work on thermal effects of flared gasses in Gbarain Cluster Communities of Bayelsa State, Nigeria where ambient temperature gradients was measured at a minimum distance of about 200km away and above from the flare stack, for wet and dry seasons. The analysed result is an indication that thermal pollution occurred within a radius of 2.15 km for the wet season and 2.06 km for the dry season portraying uncomfortable range of heat dispatch. Thus, adequate precautionary measure should be put in place to forestall higher-ups emissions of heat since agricultural crops and most animals could not strive positively to higher temperature variation. Wherein, they should not have been grown in a hazardous atmosphere such as this. In conglomeration, regulatory agencies like the Ministry of Petroleum Resources Department in conjunction with local and international bodies should urgently swing into action to end this menace of open gas flaring in Nigeria.

Keywords: Gbarain, thermal effects, gas flare, environment, comfortable, heat

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INTRODUCTION

Gas flaring is the conditions of burning off unwanted flammable gas via combustion in an open atmosphere (Jike, 2004, Osang et al., 2013) it include the emission of hydrocarbons as much as greenhouse gasses. The continued unabated Environmental degradation of air, water, soil, food and valuable constituents had negativity pose severe health consequence to the continued existence of most animals and plants habitants and will definitively impede human race (Nwaichi and Uzazobon, 2011). This research intend to address salient issues to invigorate the dearth information on the health impacts of gas flaring on host communities and in a nutshell the entire population dwelling within the Niger Delta Region (Avwiri, 2003., Oseji, 2009).

Recent developments has showcase gas flaring being at the epicenter and remote causes of ozone layer depletion as a result of excessive emissions of carbon dioxide and methane gas at a global scale, a common reoccurrence during industrial activities on oil rigs, refineries, chemical and coal plants. These unhealthful flaring of excessive amount of gases into the atmosphere will utterly deplete the Ozone layer, cause acid rain and global warming if not nip in the board (Abdulkareem et al., 2010, Ellen and Barry, 2005). Heat produced from gas flaring activities on the averaged kills surrounding plants, impede the growth rate of most flowering plants, thus generally decrease crop yield, increase soil pollution, impair aquatic biota and degrade agricultural output (Oculi and Oronto, 2007). The effects of acid rain, Green House Gas Emissions (GHGE) would ultimately impact unfavorable economic and unhealthy consequences to residents of these area (Oseji, 2007) Ellen and Barry (2005).

The 2022 Global Gas Flaring Tracker Reported an annual publication witness abrupt increment of flared gas in their findings at the World Bank’s GGFR, comprising of governments, IOCs, and other international institutions working to end routine gas flaring at oil production terminals around the world. GGFR, in partnership with the US NOAA and The Payne Institute for Public Policy at the Colorado School of Mines, has successfully developed global gas flaring estimable device with its observations drawn from the launched of a satellites in 2012 and 2017 respectively. The advanced sensors of this satellite detect the heat emitted by gas flares as infrared emissions at global upstream oil and gas facilities. This report x-rayed top 10 countries including, Russia, Iraq, Iran, United States, Venezuela, Algeria, Nigeria, Mexico, Libya and China in 2021 accounting for 75% of all gas flared and 50% of global oil production, while the flared amount of gas was left at 144 billion cubic feet for just 2021.

The rise in global gas flared was attributed to the increased production of shale oil in the United States. In the United States liquid natural gas, production jumps at 20% from 1.9 trillion cubic feet (tcf) to 2.3 tcf, whereas gas flared rise by only 2.8% from 142 tcf to 144 tcf. Back where, in Nigeria it had proven gas deposits of 208.53 trillion cubic feet (tcf) in African and 9th largest in the worlds list (as at 2021) with 209.5 trillion cubic feet (tcf) of natural gas as reported by DPR 2021 yet the ratio of gas production remains very low and unstable. Noticeably, the ratio of gas flared to gas production has decline drastically.

This could be adjourn with recent improvement in gas production as against it complete flaring years back. Growing environmental awareness and regulations had push and compelled international oil companies in Nigeria to cut down their emissions rate due to global outcry (Oseji, 2010). This may have informed the recent shift by Nigeria indigenous and international oil company’s massive investment on gas commercialization projects under the Nigeria Gas flare commercialization programmed (NGFCP). In the nutshell, this research attempt to explore credible avenue for wealth generation by the Nigerian Government rather than outright emissions of noxious gas into the atmosphere which causes intense heat as out rightly canvas for by the German Chancellor, Olaf Scholz. His words "If more Nigerian states offered gas on the global market, prices would decrease" Olaf Scholz while expressing his country's interest by investing in Nigeria natural gas. Nigeria lost about N843bn to gas flaring between January 2022 and August 2023, data obtained from the National Oil Spill Detection and Response Agency (NOSDRA) as shown in its latest gas flare report, disclosed that oil and gas companies operating within the corridor of Nigeria landscape between January and August 2022, flared 147.1 billion SCF of gas, valued at $514.9m, about N390bn (using Central Bank of Nigeria's current exchange rate of N757.5 to a dollar.). Affirmatively, between January and August 2023, a total of 171.1 billion standard cubic feet of gas valued at about $599m (N453bn) was flared. Thus giving a total of about N847bn lost between January and August last year and the same period this year (Figure 1).

Temperature

Defines how hot or cold an object is and can be measured in degrees Fahrenheit (F) or Celsius (C). Temperature is the principal issues that determines how fast plants grow and quick response to temperature variation. It developed faster as temperature increases, and grows slowly as temperature decreases (Challinor et al., 2005). Whereas, at an elevated temperature plants began to experience stress and the rate of crop development begins to decrease drastically, thereafter affect grain yield. Kalra et al. (2008) acknowledge that winter crops are more vulnerable to high temperature during their reproductive stages and differential response of temperature change (rise) to various crops has been witness under several production environments. Thus, corn yield increasingly almost linearly as a function of soil temperature between 15°C and 25°C. Above 25°C, the yield decreases (IPCC, 2007). Hence, Oseji (2009) proved beyond reasonable doubt that the physical effects of extremely high surface air temperature causes; stunted growth, defoliation of leaves, wrinkling of leaves, withered leaves and premature ripening of fruits.

Figure 1: Burning of Natural gas

Atmospheric temperature

This is a measure of temperature at various levels of the Earth's atmosphere. It is governed by many factors, including incoming solar radiation, man induced radiation, humidity and altitude.

Ambient temperature

This is the average temperature of an environment and can be any temperature. Room temperature refers specifically to the temperature range in which the average person feels comfortable. Ambient temperature also refers to the average temperature of an environment. It might vary depending on the location, time of year, or even time of day.

Effects of temperature on crop production

Crops grow best under acceptable temperate conditions. The Intergovernmental Panel on Climate Change predicts that subjecting crops to temperatures above 30 °C for a long time can have a range of negative effects on crops production. The minimum soil temperatures for planting common crops are as follows: spring wheat – 37°F (3°C); soybeans – 59°F (15°C); spring canola and sugar beet – 50°F (10°C); sunflower and millet – 60°F (16°C); dry beans are the most demanding, requiring 70°F (21°C) for their successful germination and rooting. Whereas, the optimal soil temperature for growing vegetables varies from 65 to 75°F (18-24°C). These effects can reduce production in crop yields in the future, Alameddine et al. (2005).

Soil temperature

This refers to the measurement of the ground's inherent warmth. It controls the chemistry and biology of the ground and the atmospheric-ground gas exchange. Though one could often come across the term "soil surface temperature," which is the measurement of warmth/coldness in the top 4 inches (10 cm) of the ground. Seasonal and daily changes in the land warmth degrees might cause variations in radiant energy and energy shifts at the ground surface. The ground's warmth affects numerous plant processes, leading to nutrient and water uptake and root growth. Experimentally it has been proved that nitrogen uptake varies both in quantity and form depending on the thermal conditions of the ground (Abu-Hamdeh, Nidal, 2003). Therefore, the ground's temperature is even more influential on plant growth than air warmth. The importance attached to soil temperature in agriculture is believed to qualitatively improve farming mechanisms. Soil solarization process is anchored on ground's warmth and moisture levels. Ground's thermal conditions are precautionary measures for achieving 70-

100% progress in fertilizing and weed management of plants.

Factors affecting soil temperature

Soil temperature is not an acceptable universal variable and as such relies on different mechanisms such as color, slope, vegetation cover, compaction, moisture, and, naturally, the amount of sunlight available. In the nutshell understanding physical and chemical properties like correlations between soil moisture and temperature, guarantee improve crop yield forecasting Adebayo (1991). Soil temperature is anchored on the ratio of the energy absorbed to that lost. It relies on the temperature of the surrounding atmosphere. Soil temperature regulates seed germination, plants and roots growth and the availability of nutrients. Soil temperature undulates seasonally, monthly and daily. These fluctuations in soil temperature are much lower with increasing soil depth. Heavy mulching (a type of soil cover) that reduce the warming of soil on the contrary slow undulating in surface temperature. Varieties of impediments negates soil temperature like; water content, soil color, and relief (slope, orientation, and elevation), and soil cover (shading and insulation). The color of the ground cover and its insulating properties had a strong influence on soil temperature. Whiter soil tends to have a higher albedo than blacker soil cover, which encourages whiter soils to have cooler soil temperatures, Awosika (1995).

Acceptable temperature limits for human existence/comfort

There are ranges of temperature within which humans can live comfortably. Temperatures above and below this range brings various degrees of discomfort (Table 1). For a given temperature, the temperature increases as the relative humidity (moisture content) of the air becomes higher. The following table gives ranges of temperature for various degrees of thermal effect on people in the environment, (Vereecken et al., 2008; Emoyan et al., 2008, Adrienne, et al., 2023). Always keep in mind that optimal ground's warmth varies substantially depending on the stage of plant growth. For instance, pre-emergent herbicides grow best under 10-13°C (50-55°F). The optimum soil temperature for seed germination ranges between 68 and 86°F (20-30°C).

The combined influence of temperature, humidity, winds, and human comfort

Around the human body, energy is produced by the metabolism of foods. Approximately 1800 kilocalories of energy per day is metabolized by the average person when at rest and greater measure while doing strenuous work, although over half of this energy is converted to heat. But without good concrete mechanism to remove this internally-produced heat energy, the body temperature would increase indefinitely. Under certain atmospheric conditions (high temperature and high humidity), it becomes apparently difficult for the body to remove this excess heat. Contrarily some problems might arise when the body loses heat too rapidly under conditions of cold temperatures and strong winds.

Thermoregulation

This refers to the processes by which the human body regulates internal heat generation and external heat exchange so that its core temperature varies by no more than 2°C from its average of 37°C. "Core" refers to vital organs such as the brain, heart, kidneys, etc. If the body's core temperature moves outside of this range, essential life functions do not work properly. Surprising to many, exposure to extreme heat and cold are responsible for more human deaths per year than all other weather disasters (e.g., thunderstorms, tornadoes, hurricanes, blizzards) combined. The ideal conditions for a resting human body fall into a range called the thermal neutral zone, where the air temperature is between 20°C - 25°C (68-77 °F), with little wind and moderate relative humidity. Under these conditions, a resting body can easily maintain its core temperature. Outside of this narrow range, the body's thermoregulation responses take over.

Biological control systems

Living organisms, just like mechanical engines, required supervision to effectively function. The monitoring of living organisms is known as biological control systems. Numerous homeostatic biological control systems are at operation in the body (Figure 2). Homeostasis is the stable operation of physiological activities (Figure 2). Control systems maintain a balance in the biophysical and biochemical functioning of the body. An important system is thermoregulation, which stabilizer the internal body temperature at a fixed level in all kinds of weather. More than half of all energy from food and other sources elude the body as heat. Hence, the body required a proper functioning homeostatic control system for thermal regulation. Whereas, Enzyme-controlled biochemical reactions in the body are basically much efficient at around 98°F (37°C). This temperature gradient is the minimum fixed gage for the inner body temperature of mammals. On the contrary the average soil temperatures for bioactivity range from 50 to 75°F (10-24°C). These values are favorable for the normal life functions of the ground biota that ensure proper organic matter decomposition, increased nitrogen mineralization, uptake of soluble substances, and metabolism. Below is a flow diagram indicating how the body adjusts to heat-related stresses.

Table 1: Acceptable temperature limits for human comfort.

Cool Temp (°C)	Warm Temp (°C)	Degrees of Comfort
24-26°C (75-79 °F)	28-30°C (82-86 °F)	Comfortable
30-32°C (83-88 °F)	34-36°C (95-99 °F)	Uncomfortable
42-44°C (107-112°F)	46-48°C (114-118°F)	Abnormally high temperature

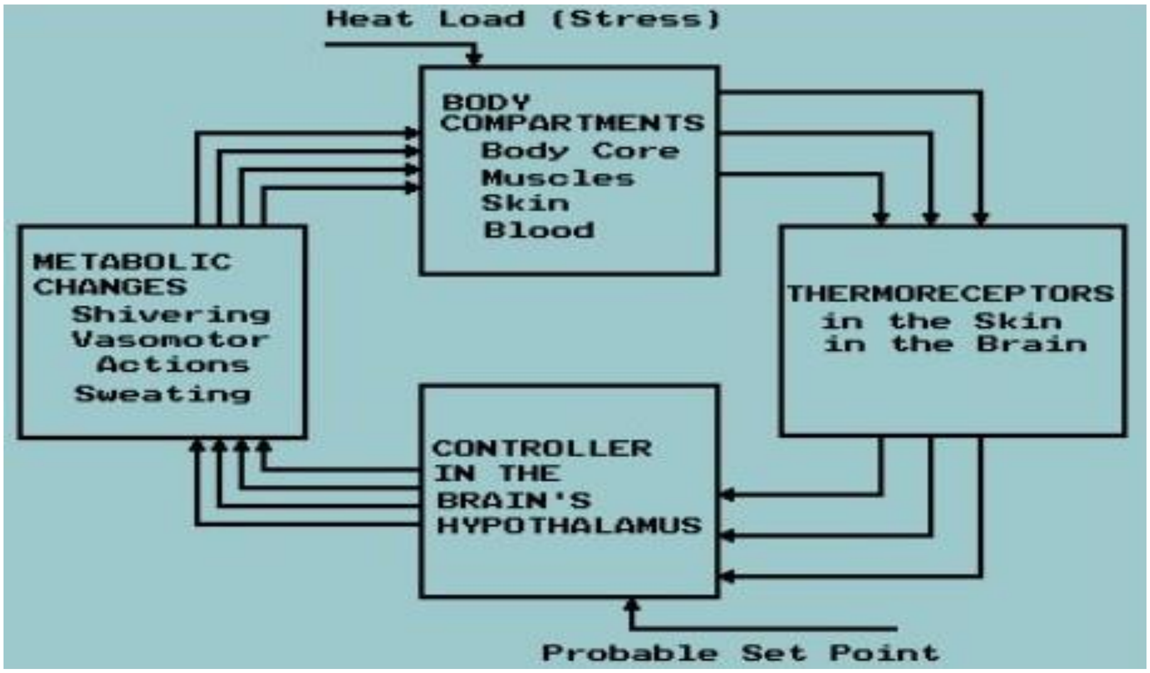

Figure 2: Diagram showing biological control systems.

Physical properties

Increased soil temperatures induce the dehydration of clay and cracking of sand particles, eventually reducing their content and increasing the concentration of silt. The warmer the earth is, the more carbon dioxide it releases. Heat is the reason for land cracking due to evaporation and, thus, insufficient water penetration into the ground profile.

Chemical properties

Due to decomposed organic matter, high soil temperature durations show higher cation exchange capacity. The warmer the ground, the more water-soluble phosphorus it contains for plants. Vice versa, low-heated earth is poor in phosphorus available for vegetation. As to pH levels, the acidity rises to a greater degree due to organic acid saturation.

Ideal soil temperature for planting

Either being too low or high thermal degrees kill soil-dwelling organisms and plants. In particular, crops develop slowly at 32°C (90 °F), while 140°F 60°C (140°F) is critical because bacteria in the ground can't survive the heat (Table 2). At 38°C (100°F), plants cannot absorb enough water in as much that over 85% of soil moisture is lost due to evapotranspiration. Irrigation at exceeding air heat is extremely undesirable, as most water inputs would turn into waste due to excessive evaporation rates. Besides, refracted water drops acting as magnifying glasses will burn vegetation. Below is the ideal temperature chart for planting.

MATERIALS AND METHODS

The area of study LNG Gbarain as shown in (Figure 3) is a Cluster of several Communities located in Yenagoa Local Government Area of Bayelsa State, Nigeria. It lies within Latitude 4° 48' 0'' N, and Longitude 5° 54' 0'' E, It is bounded in the South by Taylor Creek which flows from Orashi River in Rivers State; in the North by Amassoma Community; in the West by Okutukutu Community and in the East by Zarama Community. The main occupation of the people of Gbarain Clan is fishing and farming,

Table 2: Ideal soil temperature chart for plant growth.

Plant species	Minimum Temp. Range	Plants species	Maximum Temp. Range
Sugar beat	10 °C (50 °F)	Cucumbers	16 °C (60 °F)
Spring canola	10 °C (50 °F)	Tomatoes	16 °C (60 °F)
Soybeans	15 °C (59 °F)	Sweet corn	18 °C (65 °F)
Sunflower	16 °C (60 °F)	Watermelons	21 °C (70 °F)
Millet	16 °C (60 °F)	Peppers	21 °C (70 °F)
Dry beans	21 °C (70°F)	Okra	21 °C (70 °F)

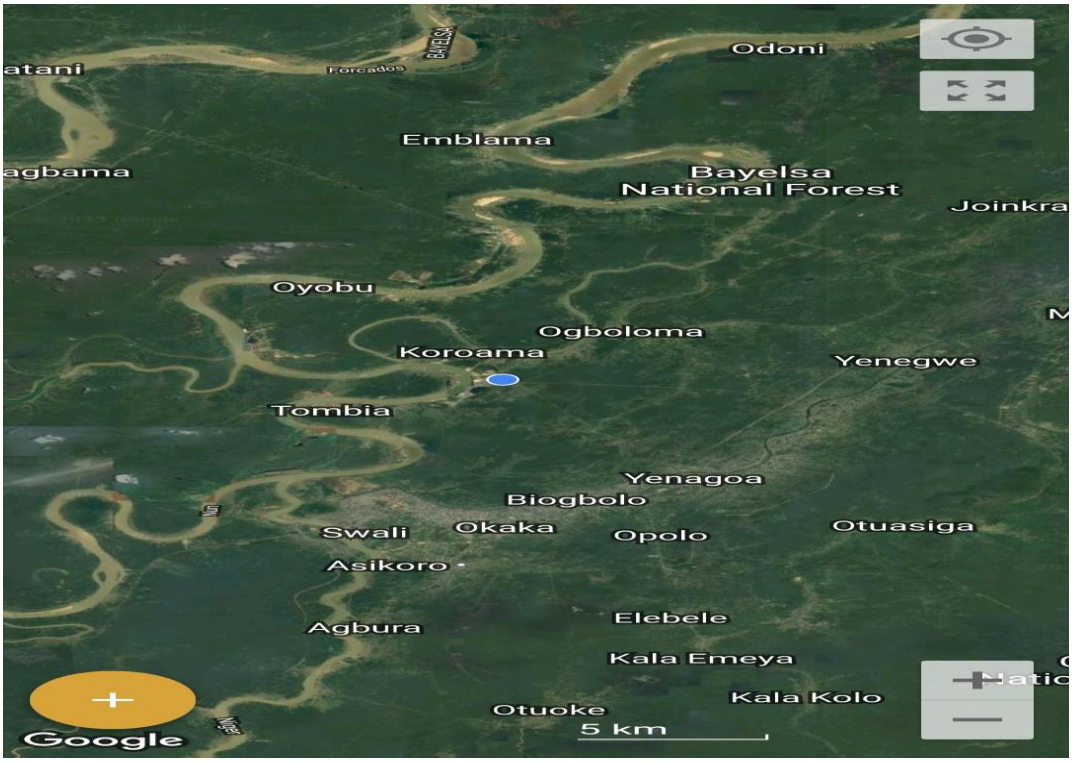

Figure 2: Map of study area

although some are gainfully employed by the Oil Companies operating within their clan.

Sample collection

LNG Gbarain flare station situated in Bayelsa State was pick and subsequently visited to guarantee a holistic experimental reportage that is effective and reliable. Measurement was conducted within the radius of 200m part from the flare stack for precautionary measures. The application of a metal tape was highly prohibited within the context of this study to prevent determinate errors which could have occur through expansion and contraction of the metal tape owing to high temperature of the surrounding between the timeframe of this study, temperature reading were measured using a thermometer and distance measured by a fibrous tape. Temperature measurement was performed at a constant height of 1.68m from the ground level and between the 9:00h and 11:00h GMT to completely reduce the effect of vertical temperature gradient and for accurate weather conditions respectively. The parameter measured at each sampling sites was as follows:

Atmospheric temperature measurement

Atmospheric temperature for each sampling location was determined with Mercury-in-glass thermometer. The thermometer was left for about 1 minute to stabilize and read before withdrawal. This procedure was done at the site of data collection.

Soil temperature measurement

Soil temperature for each sampling location was determined with Mercury-in-glass thermometer placed in

Table 3: Observed values of Atmospheric Temperature Ta (°C) at LNG GBARAIN Cluster Communities of Bayelsa State for Dry Season (October - December, 2023).

Temperature (°C)										
Operational Months	**200m**	**400m**	**600m**	**800m**	**1000m**	**1200m**	**1400m**	**1600m**	**1800m**	**2000m**
October	44	44	43	42	41	41	49	39	38	37
November	46	45	44	43	43	42	41	40	40	39
December	48	48	47	47	46	45	44	43	41	40

Table 4: Observed values of Soil Temperature Ts (°C) at LNG GBARAIN Cluser Communities of Bayelsa State for Dry Season (October - December, 2023).

Temperature (°C)										
Operational Months	**200m**	**400m**	**600m**	**800m**	**1000m**	**1200m**	**1400m**	**1600m**	**1800m**	**2000m**
October	31	39	30	31	30	30	29	28	28	26
November	32	32	31	30	30	29	28	27	26	26
December	35	34	33	33	32	32	31	30	29	28

Table 5: Observed values of Atmospheric Temperature Ta (°C) at LNG GBARAIN Cluser Communities of Bayelsa State for Raining Season (April - September, 2023).

Temperature (°C)										
Operational Months	**200m**	**400m**	**600m**	**800m**	**1000m**	**1200m**	**1400m**	**1600m**	**1800m**	**2000m**
April	49	50	49	48	47	46	44	39	38	36
May	48	48	47	49	45	43	41	40	39	36
June	47	45	44	43	45	40	39	39	38	34
July	46	44	42	40	40	39	37	36	35	32
August	44	43	42	42	41	38	37	34	33	33
September	44	42	41	40	42	40	39	39	36	34

Table 6: Observed values of Soil Temperature Ts (°C) at LNG GBARAIN Cluser Communities of Bayelsa State for Raining Season (April - September, 2023).

Temperature (°C)										
Operational Months	**200m**	**400m**	**600m**	**800m**	**1000m**	**1200m**	**1400m**	**1600m**	**1800m**	**2000m**
April	31	30	30	29	29	28	28	27	27	26
May	32	30	31	30	30	30	29	29	28	28
June	33	32	32	31	31	31	30	30	29	28
July	33	33	31	32	31	31	31	39	29	29
August	33	32	32	32	31	31	30	30	28	29
September	31	30	31	30	30	30	29	29	28	27

2-3 cm beneath the soil. The thermometer was left for about 5 minutes to stabilize and read before withdrawal. This procedure was done at the site of collection.

Data analysis

After the collation of data, a simple descriptive analytical method was employed to unravel the degree of gas flaring at LNG Gbarain in Bayelsa State, Nigeria.

RESULTS AND DISCUSSION

After the collation of data for Atmospheric and Soil Temperature at LNG Gbarain Cluster Communities, the observed lines indicate a decrease in temperature with increasing distance further from the flare stack. The decrease in temperature with further distance is in tandem with the theory of temperature distribution mixed with heat transfer over a temperature gradient. The atmospheric temperature is evidentially higher at the direction of the flare stack at LNG Gbarain Cluster Communities when compared with the accepted temperature value for overall plants growth. The minimum permissible limits for ideal planting soil temperature for crops is given as 10 °C (50 °F) -21 °C (70°F) whereas, the acceptable temperature limits for human comfort during Cool Temperature is (°C) is 24-26°C (75-79 °F) and Warm Temperature is (°C) 28-30°C (82-86 °F) (Tables 3-6). Moreover, this intense flaring of noxious gasses had invaded the Ozone layer causing unpredictable heat flow within our surrounding. The abrupt increase in atmospheric temperature has negatively impact our socio-economic lives and wellbeing as a people. Most of this invasive health hazards cause by gas flaring in LNG Gbarain is; stunted growth and reddish leaves observed with cassava, plantain, palm trees, yam, cocoyam, and several other crops that were planted around the radius of 200m off the flare stack. It is pertinent to note the near absent of large scale farming within a given area of 200m away from the flare stack due to low productivity, while the larger population preferred cultivating their crops outside this vicinity for safety.

Conclusion

Putting a stop to routine gas flare in the Niger Delta Region of Nigeria would expand the frontier on the easy of doing business and revenue generation; triple the usage of compress natural gas (CNG), infrastructural development, power generation and create thousands of job opportunity for our teaming youths seeking for employment; thereby improve the economic and health conditions of the peoples of the oil-rich region, and cut down the emission of CO_2 into the atmosphere. Hence, complete stoppage of flared gas by way of enacting appropriate law and proper monitoring by regulatory agencies should be of utmost importance with regard to its hazardous impact on air quality, physical infrastructure, biodiversity compositions that negates plants and animals survival mostly insects, effects on human health over a prolong period of time and water sources mostly rainwater. In conglomeration acid rain formation had been globally adjourned to be the epicenter and remote causes of flared gas in the Niger Delta Region of Nigeria. These flare undoubtedly impact noxious consequences on soil, air and water qualities, whereas in aspect of vegetation, it causes loss of vegetation cover, reduced crops growth and productivity as a result of the rise in Atmospheric and Soil Temperature.

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