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IMPACT OF GAS FLARING ON CLIMATE CHANGE
(A CASE STUDY OF NIGER DELTA REGION OF NIGERIA)

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ABSTRACT

Gas flaring is the burning of natural gas and petroleum hydrocarbons in flare stacks by upstream oil companies in oil fields during operations. Gas flaring is the most common source of global warming and contributes to emissions of carbon monoxide (CO), nitrogen (II) oxide (NO) and methane (CH_4) which have the propensity of causing climate change and ecological disturbances or destruction. The study assessed the impact of gas flaring on climate change using both primary and secondary data. The primary data was obtained through administration of one hundred and fifty (150) questionnaires which focused mainly on the impact of gas flaring on farm activities; adaptation to gas flaring effects; farmer's perception on gas flaring and climate change and crop performance; etc. coupled with intensive fieldwork. The secondary data were gotten by collection of different samples at various proximities from the gas flare locations, measurements and experimentations were meticulously carried out. The data were presented in form of tables showing frequencies and percentages. The result obtained in this research shows a marked trend as all the parameters considered showed a gradient away from the flare point in all the flow stations such as soil pH changing from acidic (4.0-4.2) to near neutral (6.4-6.6) faraway from the flare points and the average low soil moisture content of (17% - 23%) as against 40% for the (50m and 100m) and control distance. These values portray a bad signal for the affected communities. This study recommends that gas flaring should be seen as violet action against the people and that the flared gas should be channeled to meeting the ever increasing demand for energy in the industrial sector of the economy.

1.0 INTRODUCTION

One of the environmental problems associated with crude oil exploration and exploitation in Niger Delta region is linked to gas flaring *(ERA/FOE Nigeria, 2005); (Obioh, 1999)*. When crude oil is brought to the surface from several kilometers below, the gas associated with such oil extraction usually comes to the surface as well. If the oil is produced in those areas of the world that lack gas infrastructure or a nearby gas market, a significant portion of the associated gas may be released into the atmosphere either un-ignited (vented) or ignited (flared). Flaring or burning of gas is widely used to dispose of natural gas liberated during oil production and processing where there is often no infrastructure to make use of the gas. The key environmental issues in the Niger Delta of Nigeria relate to its petroleum industry

1.1 Background of the study

Although climate change is scientifically accepted, its cause is still disputed. *(Nordell, 2003)* suggested a most natural explanation; that this change is a result of heat emissions from the climate consumption of non-renewable energy. Climate change means that heat has been accumulating in air, ground, and water. During the same period heat is released into the atmosphere by heat dissipation from the global use of fossil fuel and nuclear power. Any such thermal pollution must contribute to the change. A comparison of accumulated and emitted heat show that heat emissions explains 55% of the climate change. Moreover, the amount of emitted heat is underestimated, since the non-commercial use of fossil fuel is not included, e.g. gas flares, underground coal fires, oil used in production of plastics, and also biofuel (wood) consumed at a greater rate than the growth. Here, the task is to estimate the heating caused by one of the non-commercial energy sources, the flaring of gas.

1.2 Significance of the study

Nigeria as a nation is reputed to as a major oil producer. In addition, the nation's hydrocarbon reserve features more gas than crude oil. Estimated at 185 trillion cubic feet, Nigeria's natural gas reserves are rated as the seventh in the world and the largest in Africa, *(EIA, 2006*). The nation's gas reserve is distributed between associated gases (AG) and non-associated gas (NAG). Gas flaring started at the end of the colonial rule. Flaring of associated gas is the process of burning of surplus combustible vapours from an oil well, either as a means of disposal or as a safety measure to relieve well pressure. Gas flaring contributes to emissions of carbon monoxide, Nitrogen (II) oxide and methane which are estimated between 1 to 4%, of the total emissions from all sources of noise, unwanted heat and light, affecting nearby communities and surroundings flora and fauna. Nigeria flares 50% of her total associated gas produced which is about 850 billion cubic feet per year (Bcf/y). Because of an undeveloped Internal Gas Market; about 52% of current Gas production of 6bscf/d is flared. Nigeria flares the second largest volume of gas behind Russia, which account for about 11% of the world's total flared volume. The volume of gas flared by Nigeria per annum is more than enough to power the nation's energy demand. Despite Nigeria's huge gas reserves, the country still suffers chronic energy shortages. Gas flaring expends huge amount of energy and causes health and environmental degradation. The environmental and human health of the people in the Niger Delta region has frequently been a tertiary consideration for the oil companies. Neither the Federal Environmental Protection Agency (FEPA) nor the Department of Petroleum Resources (DPR) has implemented anti flaring policies for excess associated gases nor have they monitored the emissions to ensure compliance with standards since 1988, *(Manby 1999)*. Nigerian gas flares emit as many greenhouse gases as 18 million metric tons, and release toxic substances in the areas, damaging both the environment and the health of the people in the Niger Delta. It causes acid rain, which acidifies lakes and streams and also damages the environment, *(Watts, 2001).* The World Bank report towards the development of an environmental action plan for Nigeria in 1990 highlighted the environmental cost of the present unsustainable practices in the development activity of the country. The report estimated that over US $ 5 billion is lost annually in the long term due to activities whose negative impact could have been avoided if environmental impact assessment was carried out. It should be noted that these losses are virtually irreversible and beyond mere economic calculation. *(Chilaka, 2009),* from his study stated that the Nigeria gas market lacked adequate infrastructure to produce natural gas and that a considerable quantity of the produced gas is flared. He submitted that 94.9% of produced gas was flared in 1978 and about 79.2% was flared in 1984. Currently, Nigeria is flaring about 40% of produced gas and re-injecting 12% to enhance oil recovery, *(Onyekonwu, 2008*)

2.0 THE NIGER DELTA REGION OF NIGERIA

The Niger delta covers 20,000 km² within wetlands of 70,000 km² formed primarily by sediment deposition. Home to 20 million people and 40 different ethnic groups, this floodplain makes up 7.5% of Nigeria's total land mass. It is the largest wetland and maintains the third-largest drainage basin in Africa. The Niger Delta's environment can be broken down into four ecological zones: coastal barrier islands, mangrove swamp forests, freshwater swamps, and lowland rainforests. This incredibly well-endowed ecosystem contains one of the highest concentrations of biodiversity on the planet, in addition to supporting abundant flora and fauna, arable terrain that can sustain a wide variety of crops, lumber or agricultural trees, and more species of freshwater fish than any ecosystem in West Africa. The region could experience a loss of 40% of its inhabitable terrain in the next thirty years as a result of extensive dam construction in the region. The carelessness of the oil industry has also precipitated this situation, which can perhaps be best encapsulated by a 1983 report issued by the NNPC, long before popular unrest surfaced: We witnessed the slow poisoning of the waters of this country and the destruction of vegetation and agricultural land by oil spills which occur during petroleum operations. But since the inception of the oil industry in Nigeria, more than twenty-five years ago, there has been no concerned and effective effort on the part of the government, let alone the oil operators, to control environmental problems associated with the industry'. *("Niger Delta Human Development Report". UNDP. 2006)*

2.1 Gas Flaring

flaring contributes to climate change, which has serious implications for both Nigeria and the rest of the world. Nigeria is one of the highest emitter of greenhouse gases in Africa and among the highest CO_2 emitters in the world *(GGFR, 2002); (Iyayi, 2004*). The burning of fossil fuel, mainly coal, oil and gas, has led to the warming up the environment through the emissions of carbon dioxide (CO_2) as the main greenhouse gas *(Ellen and Barry, 2005)*. Atmospheric contaminants from gas flaring include oxides of Nitrogen, Carbon and Sulphur (NOx, CO_2, CO, SOx), particulate matter, hydrocarbons and ash, photochemical oxidants, and hydrogen sulphide (H_2S) (Obioh, 1999); *(Kindzierski, 2000)*. The flares also contribute to acid rain, which, apart from corroding corrugated aluminium roofs, acidify the soil, thereby causing soil fertility loss and damaging crops. For instance, studies have shown that in cassava, there is a decrease in length, weight, starch, protein, and ascorbic acid (Vit.C) content *(Imevbore and Adeyemi, 1981)*, while okra plants and palm trees around the flares do not flower, and therefore, do not fruit. It is apparent that the issue of gas flaring is a serious problem to environmental sustainability. Therefore, this study focused on the assessment of the impact of gas flaring on the crop performance and yield in the study area, especially where gas flaring is dominant. Agricultural activity has always included adaptation to a number of diverse stresses and opportunities. Climate and weather conditions are a good example of factors that require on-going adaptations, which are even more significant with climate change. These changes in weather and climate conditions have been recognized as key determinants for success in the agricultural-food sector. Variations in such conditions as length in growing season, changes in rainfall, changes in temperature, all influence crop production. Therefore, sustainable agriculture is not just a set of practices, but a process requiring skills of adaptability *(Milestead and Darnhofer, 2003); (Ellen and Barry, 2005),* the presence (or absence) of which is a fundamental determinant of how vulnerable a specific system is, to external or internal stresses, such as climate change. The development of such adaptation projects which focus on reducing vulnerability, or increasing adaptive capacity of communities to climate change and variability has the potential to help maintain the environment *(Kindzierski, 2000)*. Thus, this study finds relevance as a means of enlightening the public on strategy for proper understanding of changes in climate and adaptability to ensure a good health.

2.2: Gas Flaring: Major Cause of Climate Change

The Deepwater Horizon oil spill isn't a direct cause of climate change. However, one of the methods being used to deal with it is a large source of carbon emissions in developing countries that could easily be reduced. BP recently inserted a pipe into the leaking well. In addition to oil, the pipe BP is sending gases such as methane and natural gas to the surface as well. Rather than capturing them along with the oil, they're being burned in a process called gas flaring. It represents a major global and local environmental problem. Flaring is a wasteful process. Almost 5.5% of the world's natural gas production is wasted due to flaring. In financial terms, that's over $40 billion a year. That alone should be enough to make the companies responsible for the flaring reconsider the process. It's also an incredibly harmful to the local and global environment and public health locally, gas flaring produces a plethora of byproducts harmful to health. These include fine particulate matter and carbon monoxide. Particulate matter is particularly (no pun intended) problematic for people who have asthma or other respiratory problems. The chemical benzene is also released. Benzene is linked to leukemia and possibly cancer, in addition, there are local environmental problems caused by gas flaring. Though the connection isn't definite, some evidences points to flaring causing the release of Sulphur dioxide and nitrous oxide which in turn cause acid rain. Flaring also produces black carbon, which will prevent vegetation from growing. Intense heat from the flaring site itself also limits vegetation. Of course, the biggest environmental problems come from the extraction of oil that is associated with flaring. The oil spill in the Gulf is a prime example of those impacts. Globally, gas flaring is a major source of greenhouse gas emissions. Over 400 million tons of carbon dioxide are emitted annually. The carbon emissions from gas flaring fall right between the emissions of Belgium and the Czech Republic. Nigeria is the largest gas flaring country in the world behind Russia. Its carbon emissions from flaring alone are actually higher than the rest of sub-Saharan Africa combined. Black carbon produced by flaring also has strong implications for climate change. Its considered an aerosol, though it doesn't act exactly like other ones. Aerosols generally have cooling properties by reflecting incoming sunlight, but black carbon is actually a short-lived but strong warming agent that can cause climate change. It contributes to warming in three ways. For one, when black carbon is in the atmosphere, it absorbs sunlight rather than reflecting it like other aerosols. It also increases low-level clouds, which have further warming properties. Finally, when it leaves the atmosphere, it can land on snow. There, it also absorbs sunlight, thus warming the snow around it, sometimes weeks faster than clean snow. Melting snow reduces the Earth's reflectivity, known as albedo, which leads to still more warming. The Arctic is warming twice as fast as the rest of the Earth, in part because of black carbon. Just how much is black carbon contributing to climate change? James Hansen of NASA has estimated that black carbon accounts for a quarter of observed warming. Because black carbon only sticks around for a few days, reducing black carbon emissions is one of the only ways in which we can immediately mitigate the effects of climate change. Reducing black carbon could provide immediate benefits for maintaining snowpack, sea ice, and permafrost, all of which could pass dangerous tipping points if we continue to pursue business as usual. It will also buy time while the slow process of reducing carbon emissions moves forward. So gas flaring is bad for the local and global environment and the economy. And fixing it would provide immediate benefits to mitigate climate change. And the technology to eradicate the practice is there. So why does it happen? The majority of it happens in remote areas or in countries that don't have the technical capacity to use natural gas for energy. It's also energy-intensive to separate natural gas from crude oil. There are a few initiatives operated by international entities including the World Bank and the UN to reduce gas flaring. However, technology isn't being adapted as fast as it could be in part because it's still more profitable to burn the gas rather than store and use it. In major gas flaring countries, ineffective and even obstructionist governments also hamper public opposition (though hopefully this is changing in Nigeria, whose government has set a deadline for December 2010 to end gas flaring). The keys to reducing gas flaring are to hold corporations who use the process accountable for the damage they cause to the local and global environments and also facilitating technology transfers to the countries where gas flaring is a major problem. This means energy technology that can burn natural gas and/or technologies that can reinject natural gas into the ground rather than flaring it. In the long term, we'll need to move towards energy sources that have zero carbon emissions. However, in the short term, finding ways to reduce gas flaring will provide tangible benefits that will hopefully inspire those longer term fixes, *(Onyekonwu, 2008)*

2.3 Environmental Implications of gas flaring

2.3.1 Climate Change

Gas flaring contributes to climate change, which has serious implications for both Nigeria and the rest of the world. The burning of fossil fuel, mainly coal, oil and gas-greenhouse gases-has led to warming up the world and is projected to get much, much worse during the course of the 21st century according to the intergovernmental panel on climate change (IPCC). This scientific body was set up in 1988 by the UN and the World Meteorological Organization to consider climate change. Climate change is particularly serious for developing countries, and Africa as a continent is regarded as highly vulnerable with limited ability to adapt. Gas flaring contributes to climate change by emission of carbon dioxide, the main greenhouse gas. Venting of the gas without burning, a practice for which flaring seems often to be treated as a synonym, releases methane, the second main greenhouse gas. Together and crudely, these gases make up about 80% of global warming to date.

2.3.2 Acid Rain

Acid rains have been linked to the activities of gas flaring, *(Medilinkz, 2010).* Corrugated roofs in the Delta region have been corroded by the composition of the rain that falls as a result of flaring. The primary causes of acid rain are emissions of Sulphur dioxide (SO_2) and nitrogen oxides (NO) which combine with atmospheric moisture to form sulfuric acid and nitric acid respectively. Size and environmental philosophy in the industry have very strong positive impact on the gas-flaring-related CO_2 emission, *(Hassan, and Konhy, 2013*). Acid rain acidifies lakes and streams and damages vegetation. In addition, acid rain accelerates the decay of building materials and paints. Prior to falling to the earth, SO_2 and NO_2 gases and their particulate matter derivatives, sulfates and nitrates, contribute to visibility degradation and harm public health

2.3.3 Agriculture

The flares associated with gas flaring give rise to atmospheric contaminants. These include oxides of Nitrogen, Carbon and Sulphur (NO_2, CO_2, CO, SO_2), particulate matter, hydrocarbons and ash, photochemical oxidants, and hydrogen Sulphide (H2S), *(Obioh, I1991*). These contaminants acidify the soil, hence depleting soil nutrient. Previous studies have shown that the nutritional value of crops within such vicinity are reduced, (Imevbore, and Adeyemi, 1981). In some cases, there is no vegetation in the areas surrounding the flare due partly to the tremendous heat that is produced and acid nature of soil pH, *(Ubani, and Onyejekwe, 2013).* The effects of the changes in temperature on crops included stunted growth, scotched plants and such other effects as withered young crops*, (Orimoogunje, et al., 2010).* Orimoogunje, et al., concluded that the soils of the study area are fast losing their fertility and capacity for sustainable agriculture due to the acidification of the soils by the various pollutants associated with gas flaring in the area.

2.4. HEALTH IMPLICATIONS

2.4.1. Adverse Effects

The implication of gas flaring on human health are all related to the exposure of those hazardous air pollutants emitted during incomplete combustion of gas flare. These pollutants are associated with a variety of adverse health impacts, including cancer, neurological, reproductive and developmental effects. Deformities in children, lung damage and skin problems have also been reported, *(Ovuakporaye, et al, 2012)*

2.4.2. Haematological Effects

Hydrocarbon compounds are known to cause some adverse changes in hematological parameters. These changes affect blood and blood-forming cells negatively. And could give rise to anemia (aplastic), pancytopenia and leukemia, *(Kindzierski, 2000).*

2.5 Other Effects

2.5.1. Economic Loss

Aside from the health and environmental consequences of gas flaring, the nation also loses billions of dollars' worth of gas which is literally burnt off daily in the atmosphere. Much of this can be converted for domestic use and for electricity generation. By so doing the level of electricity generation in the country could be raised to meet national demand. Nigeria has recorded a huge revenue loss due to gas flaring and oil spillage, *(Effiong, and Etowa, 2012*). Though more than 65 % of governmental revenue is from oil, *(Arowolo, and Adaja, 2011)*, it is estimated that about $2.5 billion is lost annually through gas flaring in government revenues

2.5.2. Pollution

Drilling mud and oil sometimes find their way to the streams, surface waters and land thus making them unfit for consumption nor habitable by man or animal. This problem has been produced by a range of international oil companies which have been in operation for over four decades. The economic and environmental ramifications of this high level of gas flaring are serious because this process is a significant waste of potential fuel which is simultaneously polluting water, air, and soil in the Niger Delta.

3.0 METHODOLOGY

First, comprehensive lists of all gas flare locations were made. Several visitations were made to most of the various under listed gas flare locations in a bid to achieve my mentioned objectives. Data was gathered through a well-designed and articulating oral and written questionnaires, direct and first-hand observation of their environment (landed and water bodies) were made. Different samples at various proximities from the gas flare locations were taken and measurements and experimentations meticulously carried out. The parameters monitored at each sampling location included: Rain water from the flares, Soil temperature, Noise level, Soil pH, and Soil moisture content. Standard measurements for each parameter were carried out as follows: The study was carried out in Rivers State, Delta state Bayelsa state and Akwa Ibom state. One hundred and fifty (150) structured questionnaires were issued to residents of Mkpanak and Iko communities in Ibeno and Eastern Obolo Local Government Areas located in the Qua Iboe River basin of Akwa Ibom State, one of Nigeria's major oil producing communities situated in the Niger Delta Region of Nigeria.

3.1 Rain Water Analysis

Clean acid-free glass bottles were used to collect bulk samples of rain that had fallen during the preceding week. The bottles were Placed at distances of 50m, 100m, and 150m from the flare point. A funnel was covered with a plastic net to prevent collection of windblown debris from the bottles. Each bottle was placed on a stand 1.3-1.5m above ground level. The collected samples were analyzed in accordance with cations anions and trace metals (as recommended by Department of Petroleum Resources, DPR and Federal Ministry of Environment, FME.)

3.2 Soil Temperature Measurements

The temperature of each soil sample was determined with Mercury-in-glass thermometer, which was placed 2-3 cm into the soil. The thermometer was left for 5 minutes to stabilize and read before withdrawal. This was done at the site of collection.

3.3 Soil Moisture Content Measurement

The APHA (1985) method was used to determine the moisture content of each soil sampled. 10g of each soil sample was heated in a hot air for 8-12hrs at 80°C until a constant weight was obtained. The difference between the initial weight and the consistent final weight obtained was taken as the weight of the moisture

3.4 Soil pH Measurement

The pH of the various soil samples was determined from supernatant obtained after 1:1 (W: V) mixture of the soil samples were made with sterile distilled de-ionized water. The pH was determined using a PYE UNICAM model 291mkz pH meter with a combined glass electrode.

3.5 Noise Level

Noise levels at the various distances from the flare tip were measured using a weighted scale of a decibel meter. Measurements were taken for 5 minutes at each and the range of the noise level was noted and the true mean was computed. Various operational processes that contributed to the noise level at each flow-station and/or gas plants were noted. Measurements were carried out upwind, downwind, and crosswind of the flare. Noise levels were also measured near pumps and power generators at the flow stations and/or gas plants.

4.0 RESULTS AND DISCUSSION

4.1 Results Out of the 150 structured questionnaires issued to residents of Mkpanak and Iko communities, 115 responded to the questions and returned them.

Below are the tables of the summary of the research work.

Table 4.1: The pH (average) of rain water samples taken from various gas flare locations and W.H.O limit

Company	Distance from flare point (M)	pH (Average)	W.H.O maximum pH limit
A	50m	3.04	5.6
	100m	6.06	5.6
	150m	6.81	5.6
B	50m	4.82	5.6
	100m	5.09	5.6
	150m	6.19	5.6
C	50m	4.82	5.6
	100m	5.26	5.6
	150m	5.31	5.6
D	50m	3.81	5.6
	100m	5.32	5.6
	150m	6.25	5.6

Table 4.2: Temperature, pH and Moisture contents (MC) of various soil samples taken from various locations

Distance from flare point (M)	Company A pH	Company A Tem ^0C	Company A M.C. (%)	Company B Ph	Company B Tem ^0C	Company B M.C (%)	Company C pH	Company C Tem. ^0C	Company C M.C. (%)	Company D pH	Company D Tem ^0C	Company D M.C (%)
50	4.2	45	18	4.0	48	18	5.1	42	26	4.2	44	25
100	6.0	38	26	5.5	40	25	5.7	36	31	5.1	35	28
150	6.2	31	34	6.5	33	30	6.3	31	40	6.4	30	30
Control	6.6	30	45	6.7	29	41	6.6	30	40	6.7	29	35

Table 4.3: Mean Noise level from the gas flares (dBA) from various locations

Company	Distance from flare point (M)	Mean Value	DPR Limit (lower-upper)
A	50	814	80 – 100
	100	70.8	80 – 100
	150	74.3	80 – 100
B	50	83.4	80 – 100
	100	76.4	80 – 100
	150	68.0	80 – 100
C	50	84.3	80 – 100
	100	73.5	80 – 100
	150	70.1	80 – 100
D	50	85.3	80 – 100
	100	78.1	80 – 100
	150	71.3	80 – 100
			80 – 100

Table 4.4: Distance of farm from gas flare point

Distance (km)	Frequency	Total (%)
Less than 1	3	2.6
1 – 2	34	29.6
3 – 4	53	46.1
5 – 6	25	21.7
Total	115	100

Table 4.5: Effects of gas flares on plants

Distance (km)	Effects of gas flares on plants	Frequency	Total (%)
Less than 1	Defoliation	28	29.3
1 – 2	Withering	15	13.1
3 – 4	Stunted growth	37	32.2
5 – 6	Wrinkling leaves	35	30.4
Total		115	100

Table 4.6: Effects of temperature change on farming

Effect of temperature	Frequency	Total (%)
Not applicable	104	90.4
Stunted growth	3	2.6
Scorched plants	4	3.5
Others	4	3.5
Total	115	100

Table 4.7: Effects of change in rainfall pattern on crops

Effects of rainfall	Frequency	Total (%)
Change on crops	60	52.17
Not applicable	45	39.10
Delays planting season	2	1.74
Late harvest	4	2.61
Low harvest	5	4.35
Others	-	-
Total	115	100

Table 4.8: Quantity of crops produced last year

Quantity (bags)	Frequency	Total (%)
1 – 3	10	8.70
4 – 6	40	34.78
7 – 0	30	26.10
More than 10	35	30.43
Total	115	100

4.2 DISCUSSION

4.2.1 Rain Water Sample

The results on the analysis carried out on rain water to determine the effect of gas flaring are shown on Table 4.1. The results show that the pH values were generally below 5.6 (WHO 200 limit for rain acidity) for many of the gas flare locations, hence a water-borne diseases prevalence and massive destruction in aquatic life recorded in these communities. However, on a few occasions, pH values were greater than 5.6 for rainwater samples collected from various distance of 50m, 100m and 150m respectively. Rainwater samples collected during dry seasons will be more acidic than those collected during rainy seasons. This can be explained by the fact that acids formed in the atmosphere with pollutants ($NO_x + H_2O \rightarrow HNO_3$ & $SO_x + H_2O \rightarrow H_2SO_4$) are likely to be more diluted during the rainy season than dry season.

4.2.2 Soil Sample

The results on the investigation carried out on soil temperature, pH and moisture content measurement are shown on Table 4.2

4.2.2.1 Soil Temperature

The result from Table 4.2 shows that the closer a sampling point was to the flare, the higher the soil temperature. This high temperature affects the survival of microbes and germination of plants. Beyond 100m from the flare tip, the soil temperature was more strongly influenced by vegetation cover and the moisture content, rather than the presence of the flare or even insulation. The soil temperature taken in the morning was approximately 1^0C lower than that taken late afternoon or evening. Effect of vegetation cover was found to lower the soil temperature by as much as 4^0C.

4.2.2.2 The Soil pH

The results from Table 4.2 shows that pH values, changed from acidic (3.04 – 4.82) to near neutral (6.19 – 6.81) away from the flare point. The low pH values at the flare points could be attributed to the acidic oxides produced by the flaring. Both the lower pH and higher aluminum concentrations in surface water that occur as a result of acid rain can cause damage to fish and other aquatic animals. At pHs lower than 5 most fish eggs will not hatch and lower pHs can kill adult fish. As lakes and rivers become more acidic biodiversity is reduced. Acid rain has eliminated insect life and some fish species over the years due to these gas flaring and dangerous gaseous emissions.

Table 4.1: The pH (Average) of rainwater sample taken from various gas flare locations and the W.H.O limit.

4.2.2.3 Moisture Content

The results from Table 4.2 above show that moisture content also increased away from the flare site. The lowest soil moisture content was observed at 50m distance from the flare site and 150m having at least higher percent while the control had the highest percent of moisture in the soil. As expected, the hottest spot was nearest to each flare jet and it gradually decreased away from the flare point. The heat produced from the flaring point is highest at the flare point as expected. The low moisture content close to the flaring point is a direct effect of the heat. All the soil samples examined had the least moisture content in soil at 50m followed by 100m. The 150m soil samples and controls had higher moisture content.

4.2.3. Noise Level

The noise levels at all the locations were monitored and the result presented on table 3 as shown above. Noise levels at most facilities were generally very close to the DPR/FEPA limit. However, exceptional cases are the noise levels at 50m and 150m flow station and gas plant (86.5) and noise levels measured at distances very close to pumps and generators (93.6-96.1 dBA). These values are however lower than the upper limit of the Nigerian regulatory body (DPR). Continuous exposure to noise at such levels eventually leads to hearing loss unless protective equipment is used, and unfortunately, indigenes don’t put on Personnel Protective Equipment (PPE).

Analyses of the effects of gas flaring in the two communities were done separately because of the fact that in Mkpanak, gas is still being flared, while in Iko, gas flaring was forcefully stopped about 10 years ago, by the youth militants. Thus, the analyses in this section compared the environment of the two communities to see the differences and similarities (if any). As regards the number of gas flaring points, distances of farms from the point and effects of the flares on the farms, in Mkpanak, there is only one gas flaring point at Mobil Producing Nigeria (MPN) terminus. The other flare points are offshore. Table 4.4 shows the distance of farm lands of respondents to this flare point. From the table, the average distance of the farms from a gas flare point is about 3-4km as indicated by the greater number of the respondents (46.1%). 29.6% of the farmers have their farms within 1-2km from the flare point, 21.7% of the farmers have their farms located within 5-6 km from the flare point, while 2.6% of them have their farm lands located less than 1 km from the flare point.

In Iko, this parameter i.e. distance of farm from a former flare point was not analyzed for farmers because gas flaring was stopped in the area. However, in a personal interview with some of the elderly ones in the community, it was gathered that the effects of gas flaring on crop were quite similar to those observed in Mkpanak, but since the flaring had stopped, there seem to be a measure of improvement with time as effects of the flares gradually wear away. As in Mkpanak, there was only 1gas flare point in Iko town while the other 32 points were offshore. Effects on crops according to the respondents included, stunted growth, defoliation of leaves, wrinkling of leaves, withered leaves and premature ripening of fruits due to the heat from the flare.

In respect of the impact of gas flaring on climate change and its attendant effects on farming, the results indicate that in Mkpanak, the effects of the changes in temperature on crops included stunted growth, scotched plants and such other effects as withered young crops, in Iko, the changes in temperature tend to enhance general crop performance (for instance, greener leaves), as opposed to when gas was still being flared.

Table 4.6 shows the effects of temperature change in Mkpanak. Even though gas flaring may have contributed to high temperatures through the emission of the various greenhouse gases (GHGs), especially CO_2 which might formed a blanket in the atmosphere, preventing the long wave radiation from the earth’s surface returning back to space, and thus increasing both the atmospheric and soil temperatures; yet from the table, it can be said that the temperature change does not affect farming in Mkpanak, as confirmed by 90.4% of the respondents. About 2.6%and 3.5% of the respondents believed that the effects of temperature change on farming in Mkpanak are stunted growth and scotched plants respectively, while about3.5% of the respondents were of the view that temperature changes have some other side-effects on farming, apart from those already mentioned.

With respect to rainfall, Table 4.7 shows the responses to changes in rainfall pattern and its effects on crops. The responses were similar in the two communities; hence the variable was analyzed for the two communities together. Of the total respondents, 60 (52.17%) said they did not notice any change in rainfall pattern, while the remaining 47.83% noticed changes in rainfall pattern. Hence, the analysis of this parameter was based on the 47.83% that noticed changes in rainfall pattern. The major effect of changes in rainfall was the delay in planting season as noted by most of the respondents (43%), which perhaps led to late harvest, low harvest, and other effects such as crop failure due to retreating of the rains after the first two rains.

In respect to crop yield, Table 4.8 shows that on the average harvest are 4-6 bags of crops as recorded by 34.78% of the respondents. 26.10 % of the farmers recorded a yield of 7-10 bags, 30.43% recorded more than 10 bags and 8.70% recorded 1-3 bags. From the low percent that recorded more than 10 bags of crops, it can be inferred that the yield per farm is rather on the low side. This may probably be due to the fact that the farmers do not have very large farm lands, or due to the effects of the gas flares on the soils, which have rid the soil of its fertility, thus the soils no longer produce optimally.

Generally, the respondents in Iko indicated an increase in their yield in the last 10 years, while those in Mkpanak indicated a decrease in their yield in the last 10 years. By inference, the increase in Iko is likely to be due to the fact that gas flaring had stopped in Iko, and the soils have begun to be rejuvenated as the effects of the flares are gradually wearing away, thereby enhancing better crop performance.

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Gas is being increasingly seen as a viable source of energy to speed up developmental needs in Africa. In Nigeria, while gas is wasted through the air, creating harmful air pollutants, biomass is still the mainstay of cooking and other heating. As a matter of fact, the natural gas currently flared in Nigeria can serve the cooking needs of 320 million people not served by modern fuels. Petroleum exploitation and production in the Niger Delta over the years have resulted in a number of environmental, socio-economic and political problems in the region. Oil spillage and gas flaring have caused severe environmental damages, loss of plants, animals and human lives, and loss of revenue to both the oil producing companies and the government. Petroleum exploration, exploitation, production, storage, distribution and transportation activities affect the environment in a conspicuously negative manner. Vegetation are removed to make way for seismic lines and sites. Storage, distribution and transportation of oil and gas using Tankers and pipeline network result in some quantities of petroleum products being released into the environment. Oil exploration causes a range of environmental problems. These include: contamination of both surface and ground water by benzene, xylene, toluene, and ethylbenzene; contamination of soil by oil spill and leaks; increased deforestation; as well as the economic loss and environmental degradation stemming from gas flaring. In order to address the problems of gas flaring, it is necessary to understand why the natural gas is being flared. Because oil and natural gas are mixed in every oil deposit, the natural gas called “associated gas” (AG) must be removed from oil before refining. Gas flaring is simply the burning of this associated gas. Gas flaring is currently illegal in most countries of the world, where gas flaring may only occur in certain circumstances such as emergency shutdowns, non-planned maintenance, or disruption to the processing system. Though the draft Petroleum Industry Bill (PIB) stipulates that "natural gas shall not be flared or vented after 31st December, 2012, in any oil and gas production operation, block or field, onshore or offshore, or gas facility, except under exceptional and temporary circumstances", this draft is yet to be passed into law. Legislative backing and governmental bureaucracy still remains a stumbling block.

5.2 Recommendations

These difficulties faced by local communities from gas flares are a sufficient justification for ending gas flaring practice. Government should as a matter of urgency, make stringent laws and take drastic action against defaulting companies not just by payment of fines. Fines for defaulting companies should be so exorbitant so as to deter them. Furthermore, the gas can be processed and produced into cooking/domestic gas. Environmentalists and human right activists should continue in their quest to end this act. Gas flaring should be brought to an end because of the monumental waste of resources especially in a country like Nigeria where energy demand surpasses supply and where over 70% of the population still lives in abject poverty. In addition, the extent of environmental degradation that gas flaring causes is enormous and therefore stopping gas flaring will reduce the environmental and health effects.

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