Spatial and Temporal Variations of Acid Rain Formations in Selected Oil Producing Communities in Akwa Ibom State, Nigeria

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Abstract: *In developing countries like Nigeria, incessant gas flaring is creating serious environmental problems due to acid rain formations. Based on the problem, the study aim at looking at spatial and temporal variations of acid rain formations in selected parts of oil producing communities in Akwa Ibom State in order to know the impacts of gas flaring on acidity and its effects on ecosystem. For the study, rainwater was harvested directly from the atmosphere between March, July and November 2008-2010 and tested for pH to determine spatio-temporal variability. The results revealed that in March pH levels ranged between (5.1 -6.5), with the mean value of pH of 5.7, July having pH values ranging between 5.5-6.8, with mean values of 6.01 and in November, pH values ranging between 5.4 – 6.7, with the mean value of 5.7. The results indicated that atmospheric rainwater is more acidic in the months of March and November than July due to variation in rainfall intensity. The southern parts having very low pH values indicated acid rain formations with worse situation in Ibeno, while the northern parts as control with high pH values in atmospheric rainwater approaching alkalinity. Acid Rain formation was observed to be influenced by locations, rainfall frequency, wind direction and gas flaring by Mobil Oil Producing Company which affects man and his environment. This then suggested that gas flaring should be checked in the southern Akwa Ibom State by gas re-injection and gas revolution to boost sustainable growth and development.*

Key words: Acid rain, Atmospheric rainwater , Gas flaring, WHO STD

1. INTRODUCTION

As atmospheric CO_2 dissolves in water to form carbonic acid, rain is naturally acidic. Normal rain has a pH of about 5.6. It has been generally considered that rain whose pH is lower than 5.6 to be acid rain because this is the pH value of carbon dioxide in equilibrium with distilled water [21; 22]. The main cause of acid rain is the presence of strong mineral acids, mainly sulfuric (H_2SO_4) and nitric (HNO_3) acids, derived from the atmospheric oxidation of sulfur dioxide (SO_2) and nitrogen oxides (NO_X). These gases are emitted from both natural and anthropogenic sources [2 ; 12; 17] . In some places in the developing world, the results showed that the atmospheric rainwater samples were acidic when judged from the pH scale where a pH of 7 is neutral while a pH above 7 is alkaline and that below 7 is acid Clean or unpolluted rain is slightly acidic because carbon dioxide (CO_2) and water (H_2O) in the air react together to form carbonic acid, a weak acid [2,17]. Sulphur related compounds include SO_2 and SO_3 that cause acid rain tha has a pH of 5.6. This acidity in water predominantly contains H_2SO_4. The SO_3 dissolves in rainwater to H_2SO_4 resulting in acid rain :

$$S + O_2 \rightarrow SO_2 \quad (1)$$

$$SO_2 + O_3 \rightarrow SO_3 + SO_2 \quad (2)$$

$$SO_3 + H_2O \rightarrow H_2SO_4 \quad (3)$$

However, estimates show that more than 100 billion cubic meters of gas is still flared or vented worldwide annually with Nigeria flaring the highest constituting 18% [18]. In the oil producing areas of Nigeria, gas flaring has led to increased levels of acid precursors like SO_2 and NO_x occasioning acidic atmospheric moisture and corrosion of galvanized iron roofing sheets [21]. According to [6], gas flaring by oil companies in Nigeria as a major cause of acid rain, and about 460 km from Abuja that acid rain could only fall within the Niger Delta region

because of the huge quantity of sulphuric dioxide and methane in the air as a result of gas flaring. "Acid rain is not new to those living in areas in Niger Delta where there has been oil exploration for years" [6]. Ultimately, in Akwa Ibom State gas flaring was found to affects the soil thereby reducing the microbial populations [3], due to Mobil Producing Unlimited that flares and average of 42.8 million standard cubic feet (MSCF) of natural gas per day at Qua Ibo Terminal and several nearby onshore and offshore oil fields [4].

Based on the uncertainty and denial of acid rain formations in the lower atmosphere in developing countries like Nigeria were gas is constantly flared by oil companies, the study then seek to investigate the occurrence and possibility of acid rain in Akwa Ibom State in space and time of the year for scientific proof.

11. MATERIALS AND METHODS

(a) Study Area

Akwa Ibom State is located between latitude 4^0 32' and 5^0 5' North and longitude 7^0 2'and 8^0 25. It has total population of 2,395,756 (87.89% rural and urban 12.11%), spread across landmass of 8,412 km^2. The rainfall varies from more than 3000 mm along the coast to about 2000mm inland, and the mean temperature varies between 25 – 28 ^OC. The state holds some of the largest reserves of oil and gas, both on- and offshore and these accounts for 28 percent of Nigeria's total crude oil export [5].

(b) Atmospheric Rainwater Sampling:

Atmospheric rainwater was collected between from 10 local Government Areas of Akwa Ibom State between 2008 – 2010 during the month of March, July and November. These were as follows: In March which is the early rainy season, in July when the rain had attained some degree of frequency or regularity and November when rainwater intensity gradually reducing . Eket , Ikot Abasi , Onna , Ibeno , Eastern Obolo , and Mbo coded study rainwater harvesting (SRWH) as study locations were chosen at the windward side of the gas flaring along the coastline of Akwa Ibom State. Simultaneous studies were also conducted at the four Local Government Areas as controls, where it is assumed that gas flares has little or no influence on atmospheric and coded controlled rainwater harvesting (CRWH)- Control Rainwater) as follows: Essien-Udim Ini and Uruan in November , when the intensity of rainfall reducing rainy season when rainfall becomes very infrequent (Fig.1). Amount of hydrogen ion was measured in-situ and expressed in pH, and the HACH MODEL 148600 digital pH meter was used for the measurement. ARCVIEW Version 9 was used as geographical information system's tool for designing the chloropleth maps. The classification of pH into the possibility of acid rain formation was done according to [25] : 5.1 - 5.5 as acidic, and 6.5- 8.5 as potable water and 6.4 – 6.8 as an unpolluted water [7].

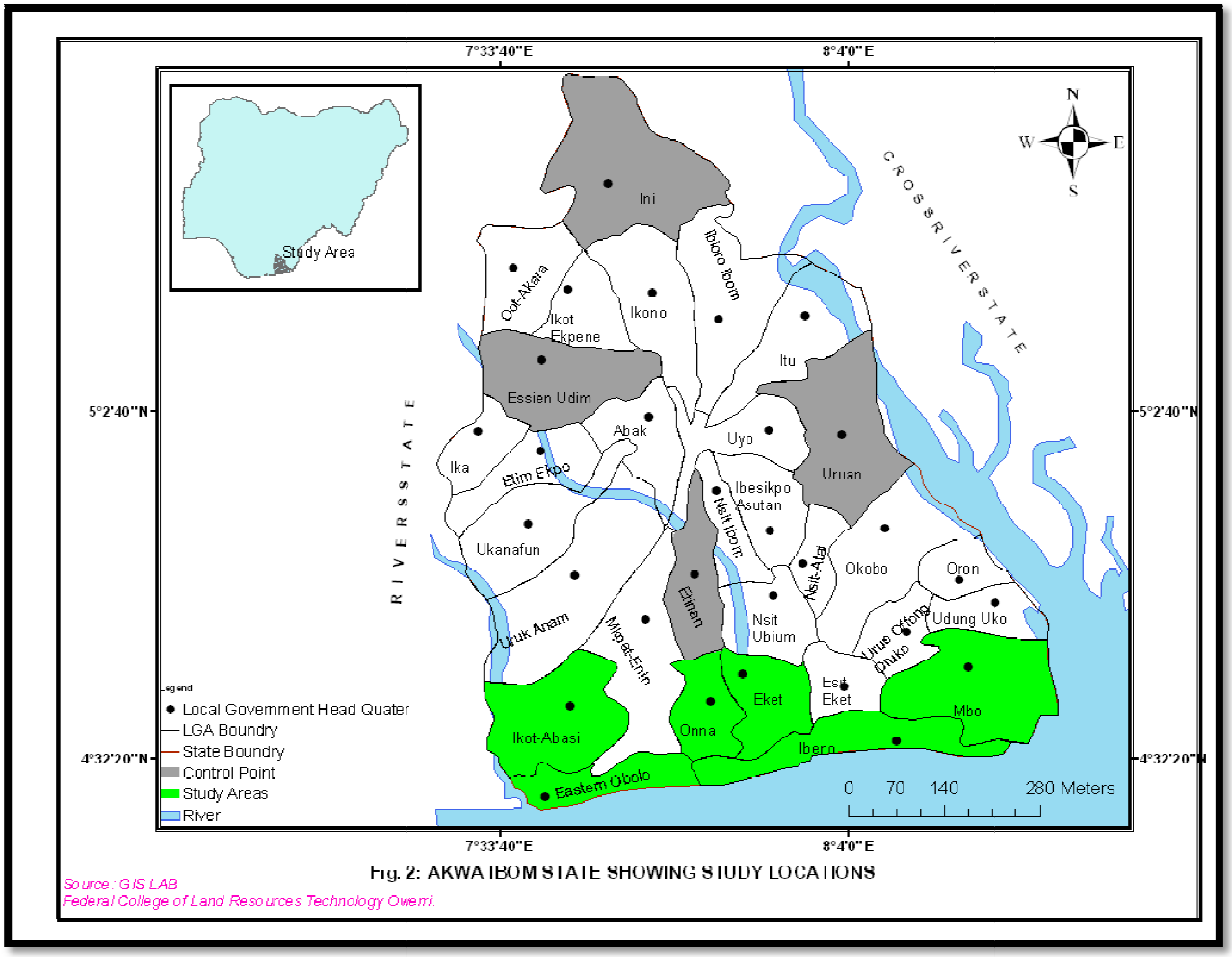


Fig. 1 : Akwa Ibom State Showing Control and Study Locations

111.RESULTS AND DISCUSSIONS

The results of mean values pH in atmospheric rainwater harvested directly from the atmosphere in different between the month of March, July and November 2008- 2010 in the study locations are presented in Table 1.

TABLE 1: Mean Values of pH in Atmospheric Rainwater in Selected Parts of Akwa Ibom State (2008 -2010)

ATMOSPHERIC RAIN (MARCH)				ATMOSPHERIC RAIN (JULY)				ATMOSPHERIC RAIN (NOVEMBER)			
SN	LGA	pH		SN	LGA	pH		S/N	LGA	pH	
1	Etinan	5.4	ACID RAIN	1	Etinan	6.4	UNPOLUTED WHO	1	Etinan	5.5	ACID RAIN
2	Eket	5.4		2	Mbo	5.6		2	Eket	5.5	
3	Ikot Abasi	5.5		3	Eket	5.6		3	IkotAbasi	5.5	
4	Onna	5.5		4	IkotAbasi	5.7		4	Ibeno	5.4	
5	Ibeno	5.1		5	Onna	5.7		5	Eastern-Obolo	5.5	
6	Eastern-Obolo	5.4		6	Eastern-Obolo	5.6		6	Mbo	5.5	
7	Mbo	5.4		7	Essien –Udim	6.8		7	Onna	5.6	UN WHO
8	Ini	6.5	WHO	8	Ini	6.7		8	EssienUdim	6.7	
9	Uruan	6.5		9	Uruan	6.5		9	Ini	6.6	
10	Essien –Udim	6.6		10	Ibeno	5.5	ACID	10	Uruan	6.6	

Source: Fieldwork, 2008/2010

1V.SPATIAL AND TEMPORAL VARIATIONS OF pH IN ATMOSPHERIC RAINWATER

From the results in Table 1, the results show that, during the month of March, July and November pH levels of rainwater harvested from atmosphere in the four control locations (CRWH) and the six study locations (SRWH) varied considerably**.** The graphic presentation of temporal variability of pH values in atmospheric rainwater harvested during the months of March , July and November are shown in Figures 2, 4, and 6. The spatial variablities are shown in Figures 3,5 and 7. The results are described as follows:

(c) pH in in Atmospheric Rainwater in the month of March:

During the month of March, rainwater harvested recorded pH ranging between 5.1- 5.5 signifying acid rain formation in the atmosphere in Etinan,Eket, Ikot-Abasi, Onna, Ibeno, Estern-Obolo, and Mbo . The month of March reflects early rain where rain intensity is low and atmospheric pollutants are high due to accumulation of organic and inorganic pollutants during dry seasons. Also the result further indicated that, Ibeno which where Exxon Mobil practiced both upstream and down stream oil activities reccorded the lowest pH (5.1) that experienced highest acid rain formation (Fig. 3). Also Etinan (pH 5.4) that serves as control is affected by acid rain due to influence of South West Trade Wind and proximity to oil producing areas. While Ini, Uruan and Essien-Udim recorded pH levels ranging between 6.5 -6.6 that meets the WHO STD for potable rainwater (Fig. 2). Also, there is an indication that acid rain is found in the southern part of the state, in which areas that are within southern axis are bound to experience the same act.

The results of pH values in atmospheric rainwater samples in Ibeno during the month of March is worst than those obtained by authors such as [13] with pH value of 5.3 in Haifa, Israel [12] with pH value of 5.2 in Minnesota, USA; [15] with pH of 5.3 in Hartwood , Scotland. In contrast, the results of pH in Ibeno is better than temperate countries, where much lower pH has been reported; 5.01 at Amsterdam Island (remote marine site) [15], and 4.9 at Chile, Pacific Ocean [9].

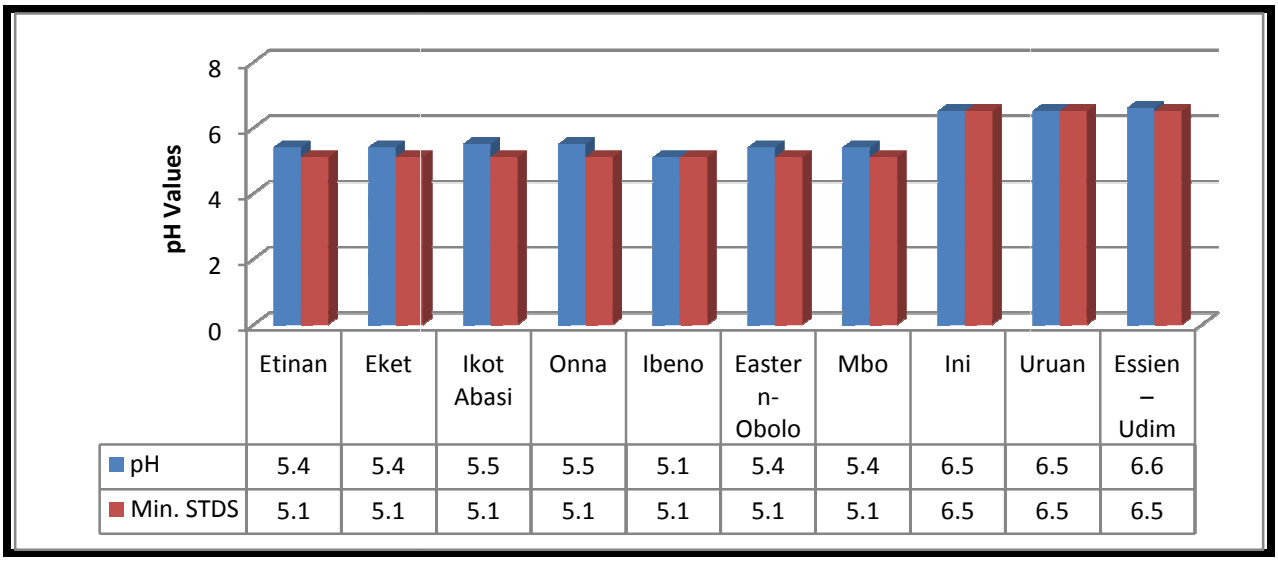


Fig.2: Comparison of Atmospheric Rainwater with the minimum STDS During the month of March

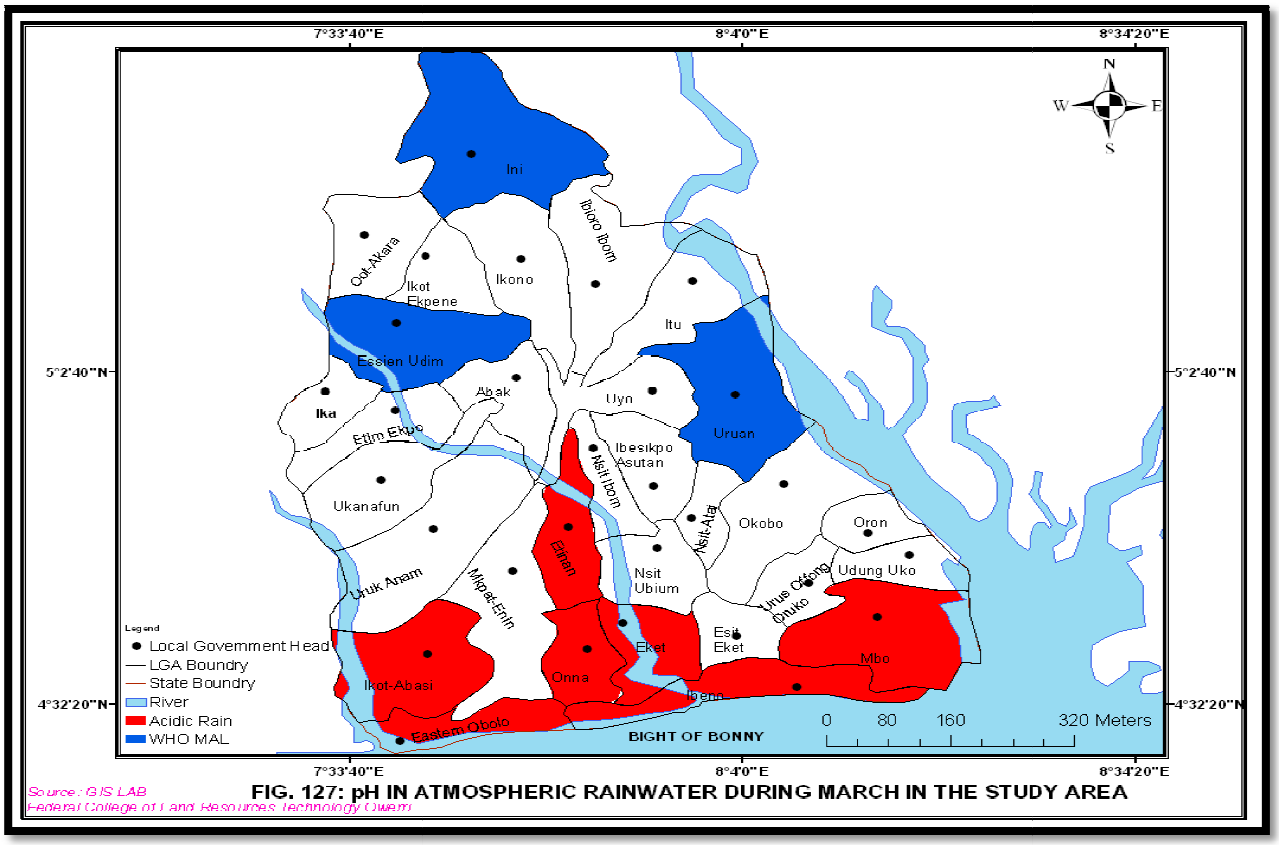
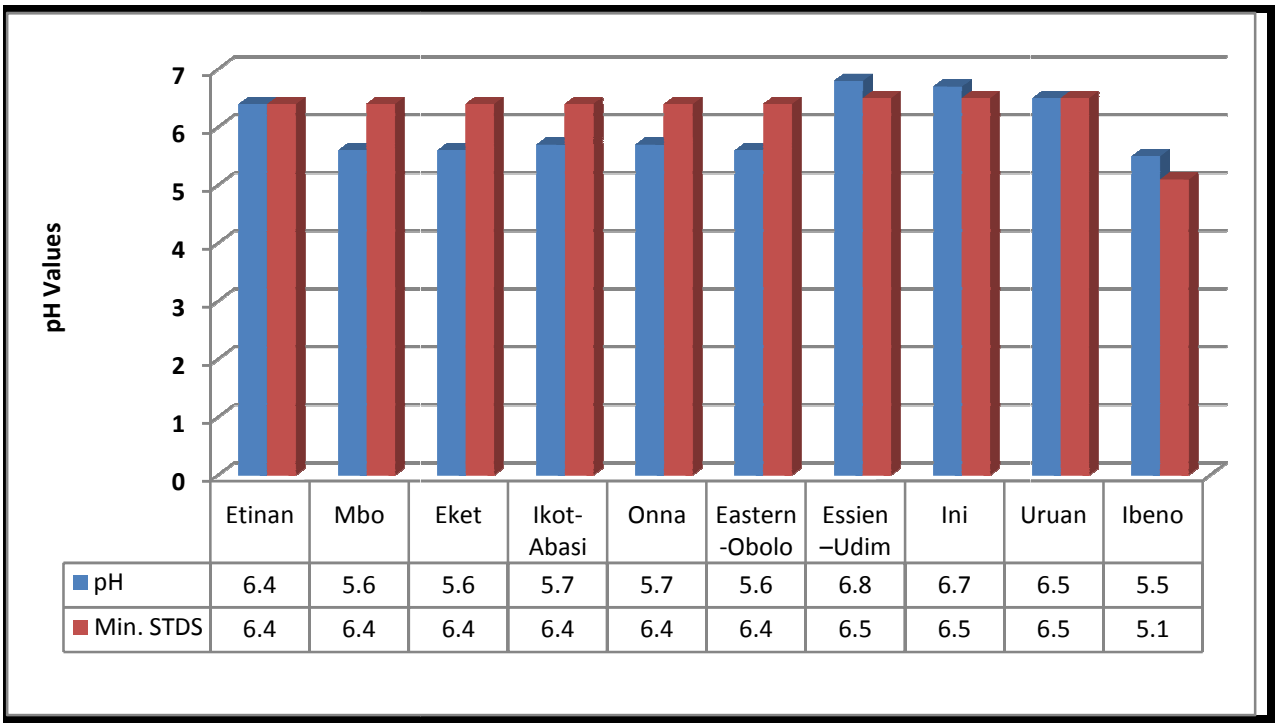


Fig.3: Spatial Variations of pH in Atmospheric Rainwater during the month of March

(d) pH in in Atmospheric Rainwater in the month of July:

This is the period where rainfall intensity is very high that washes atmosphere and reduce ambient air to cleaner environment. During the month of July , Etinan, Mbo, Eket, Ikot-Abasi, Onna, and Eastern-Obolo have pH level in rainwater harvested from atmosphere ranging between 5.6 – 5.7 as unpolluted rain (Fig. 5). This is suspected to be as a result of high rainfall intensity during the month of July, with Etinan having the best unpolluted rainwater, suspected to influenced by the distant from the gas flare areas and rainfall intensity. During the same month of July, Ini and Uruan as control points have pH level as 6.7 and 6.5 indicating that rainwater quality in terms of hydrogen ion is within 6.5 – 8.5 the WHO standard expected for water consumption. Also Ibeno has pH of 5.5 (Fig.4). This is suspected be the result of constant rainfall that cleanses the atmosphere.



	Etinan	Mbo	Eket	Ikot-Abasi	Onna	Eastern-Obolo	Essien –Udim	Ini	Uruan	Ibeno
pH	6.4	5.6	5.6	5.7	5.7	5.6	6.8	6.7	6.5	5.5
Min. STDS	6.4	6.4	6.4	6.4	6.4	6.4	6.5	6.5	6.5	5.1

Fig.4: Comparison of pH of Atmospheric Rainwater With the Minimum STDS During the month of July

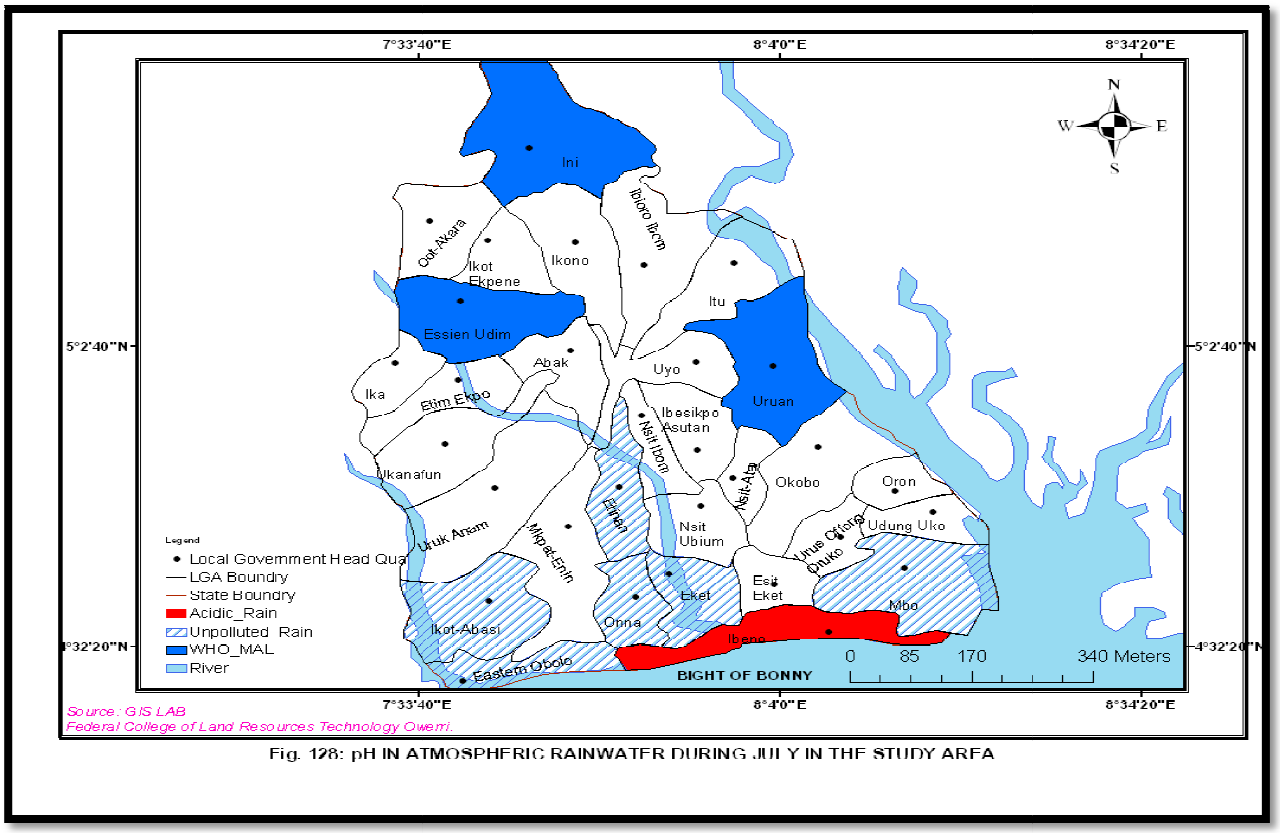
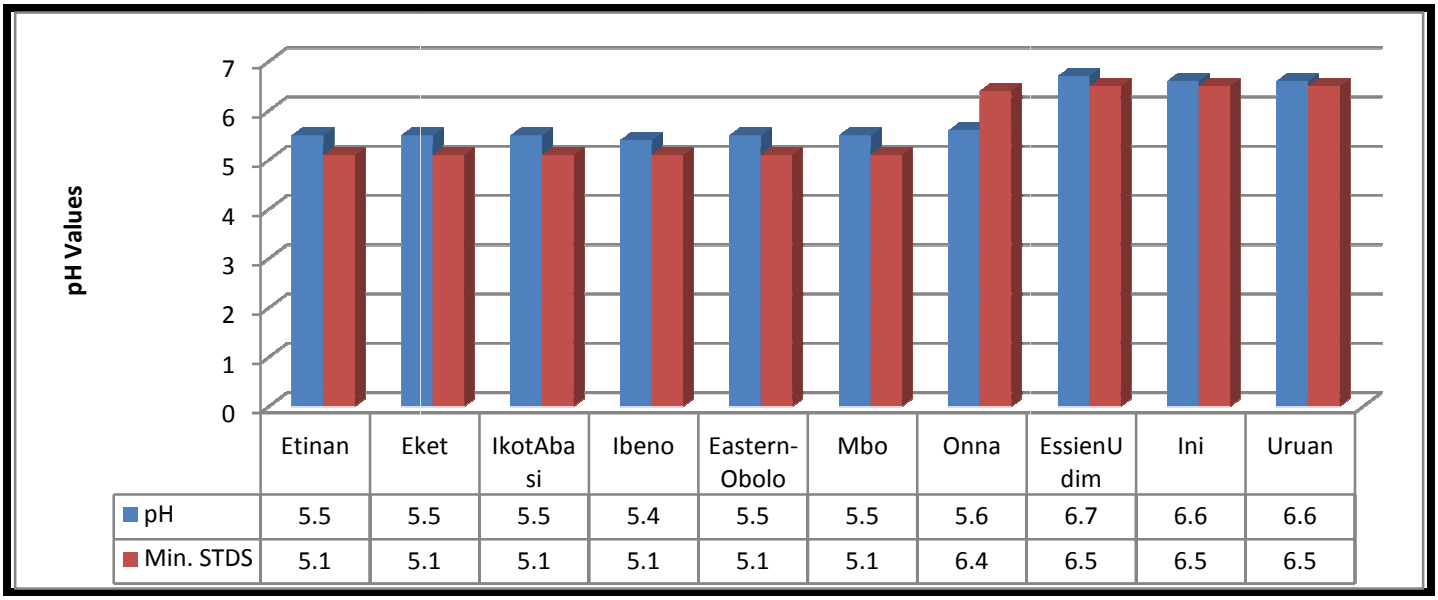


Fig. 128: pH IN ATMOSPHERIC RAINWATER DURING JULY IN THE STUDY AREA

Fig. 5 : Spatial Variations of pH in Atmospheric Rainwater during the month of July

(e)pH in in Atmospheric Rainwater in the month of November:

This is the month where rainfall intensity started reducing leading to re-accumulation of atmospheric pollutants to the former stage of March. In November where the intensity and volume of rainfall is reducing , places like Etinan, Eket, Ikot-Abasi, Ibeno, Eastern-Obolo and Mbo have pH concentrations in rainwater from the atmosphere ranging between 5.4 - 5.5, with Ibeno having the lowest pH value in the atmospheric rainfall during November (Fig.8). This results then signifies heavy pollution of the atmospheric rainwater, suspected to be build up of obnoxious gases in the atmosphere by gas flaring leading to formation of acidity in rainwater. The result is consistent with the findings of [19; 11], who observed that, pH levels in rainwater at different locations in Eboacha of River State during the month of November is an indication of build-up of pollutants in the atmosphere as rain intensity reduces and the atmospheric cleansing is low. Also Onna has pH level of 5.6 as unpolluted rain, Essien-Udim, Ini and Uruan have pH levels ranging between 6.6 - 6.7 indicating WHO standards (Fig 6). This is suspected to be controlled by the locations , rainfall intensity and wind speed and direction; because these areas are outside the vicinity of gas flaring and have little or no industry. And variability of pH values among the months of March, July and November show that acid rain intensity was high during the month of march, reduces by July and gradually built up during the month of November(Fig.8). This variation is suspected to the result of rainfall intensity.



	Etinan	Eket	IkotAbasi	Ibeno	Eastern-Obolo	Mbo	Onna	EssienUdim	Ini	Uruan
pH	5.5	5.5	5.5	5.4	5.5	5.5	5.6	6.7	6.6	6.6
Min. STDS	5.1	5.1	5.1	5.1	5.1	5.1	6.4	6.5	6.5	6.5

Fig.6: Comparison of pH of Atmospheric Rainwater With the Minimum STDS During the month of November

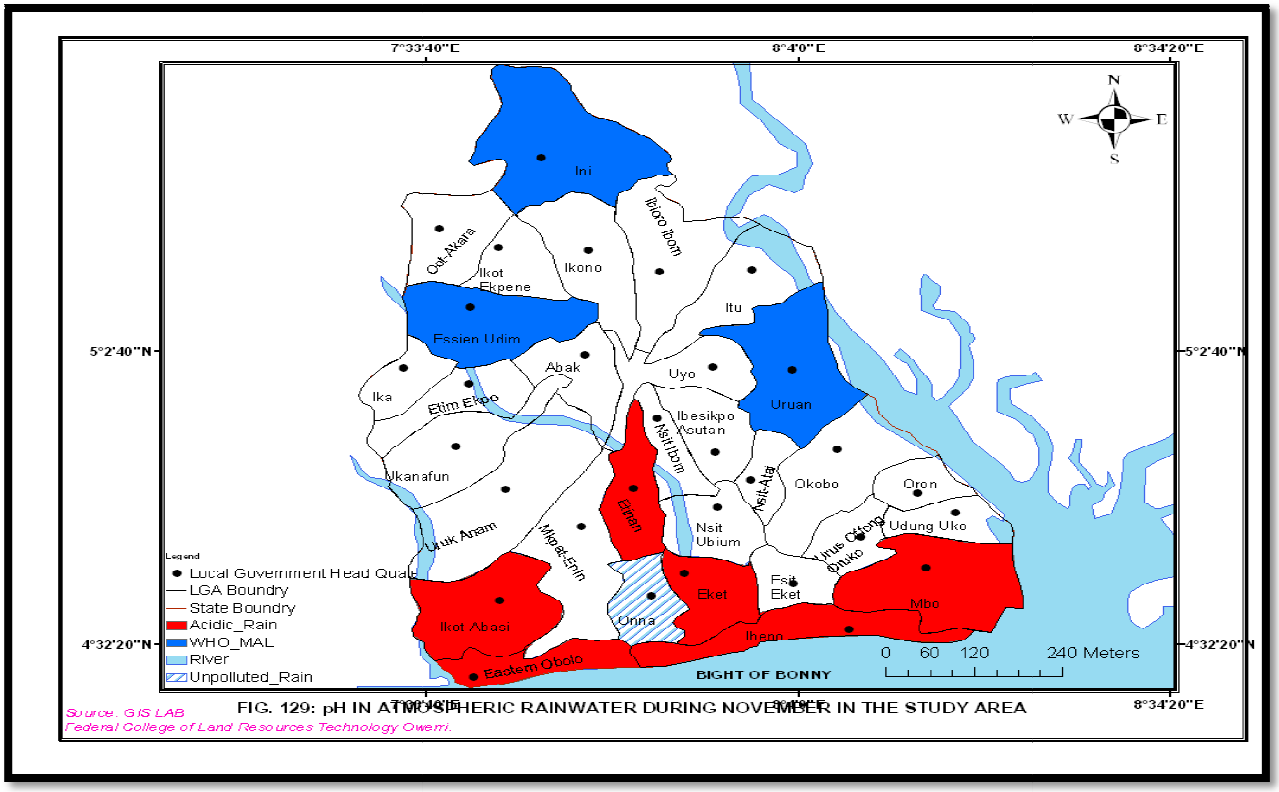
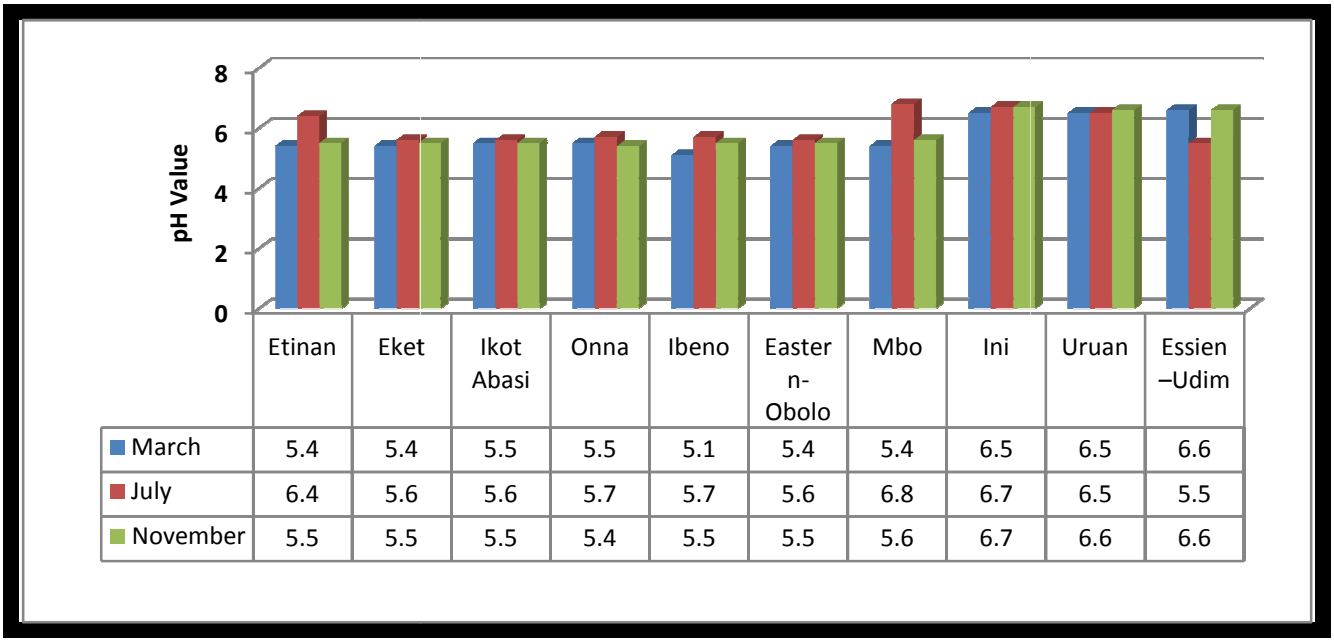


FIG. 129: pH IN ATMOSPHERIC RAINWATER DURING NOVEMBER IN THE STUDY AREA

Fig. 7: Spatial Variations of pH in Atmospheric Rainwater during the month of November



	Etinan	Eket	Ikot Abasi	Onna	Ibeno	Eastern-Obolo	Mbo	Ini	Uruan	Essien–Udim
March	5.4	5.4	5.5	5.5	5.1	5.4	5.4	6.5	6.5	6.6
July	6.4	5.6	5.6	5.7	5.7	5.6	6.8	6.7	6.5	5.5
November	5.5	5.5	5.5	5.4	5.5	5.5	5.6	6.7	6.6	6.6

Fig. 8: Temporal Variation of pH in Atmospheric Rainwater in Selected Locations in the Study Area

(f) Implications of the Acid Rain Formation in the Study Area:

The flares also contribute to acid rain. There are many problems and effects caused by acid rain which, apart from corroding corrugated iron roofing sheets [23] it acidify the soil, thereby causing soil fertility loss and damaging crops (20 ; 16]. For instance, studies have shown that in cassava, there is a decrease in length, weight, starch, protein, and ascorbic acid (Vit.C) content [10] , 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. This study has clearly shown that gas flaring contributed significantly to environmental degradation in the area. Acid rain caused by gas flaring [14] has altered the vegetation of the area [1], replacing the local vegetation with "stubborn" elephant grasses (*Penisetum purpureum*), as called by the local people, a grass plant that thrives in very harsh environment. It is obvious that the people of this area are dependent on the environment for their source of livelihood. Microorganisms are affected due gas flaring , hence acid rain [24].The findings of [1] showed that gas flaring has indeed brought about degradation in the soil quality of the area. The once lush forest is almost completely gone due to acid rain, corrugated sheets used for roofing have given way, the onetime area known for its fish now barely has enough, and now tend to depend on imported frozen fish as spillage has either killed or poisoned the aquatic life of the area. Diseases related to gas flaring include asthma, bronchitis, cancers, blood disorders and skin diseases. [14] corroborates the findings of this study and maintained that gas flaring in the area has resulted in health problems- mainly respiratory- as well as damage to wildlife, homes and vegetation. Crop yield has reduced to the barest minimum as the land can no longer sustain cultivation after several years of acidification from the flares [10]. Due to acid

rain formation rainwater quality is highly acidic with pH level of 5.6 [21] which the rural populace depend on for drinking. The study has implication in that a lot of people in this area depend on climate sensitive sectors, mainly fishery and agriculture [8], which has led to extinction of crayfish and fishes in bakassi, Ibeno, Mbo, Utan-Effiong, Mbe-Ndoro and it environ. Acid rain from gas flaring in the study area has raised the ambient temperature which impacts could lead to changes in the patterns of acid rainfall, rainstorms, rise in sea level, flooding that erodes the beaches and wetlands and inundates low-lying areas like Ibeno, Okposo, Mbo, Utan-Effiong and Mbe-Ndoro along the coastline of Akwa Ibom State.

V.SUMMARY AND CONCLUSION

(g) Summary:

Analysis of atmospheric rainwater from control and study locations revealed low pH in oil producing communities with Ibeno having the lowest (pH 5.1- 5.5) during the months of March , July and November, and Etinan being control experiencing low pH 5.4 in March due to its proximity to oil producing. Except Ibeno with (pH 5.5), the pH which later increased with the frequency of the atmospheric rainwater that indicated unpolluted and WHO STD of 6.5 – 8.5 during the month of July. And the decreased pH was observed during the month of November, with Onna (pH 5.6) as unpolluted and Essien-Udim, Ini and Uruan with pH 6.7 and 6.6 respectively indicating WHO STD. The results further indicated that atmospheric rain has lower pH in the southern parts which is mainly acidity indicating heavy pollution above WHO STD, while the northern parts recorded high pH approaching alkalinity during the three months interval reflecting unpolluted rainwater that meets World Health Organization Standard (WHO) . It is then concluded that acid rain formation is real in oil producing communities of Akwa Ibom State where Mobil Oil Company operates with the spill over effect found in the nearby communities where gas is not flared. And this is by aided South West Trade Wind (SWTW) across the Atlantic Ocean that carried aerosols toward hinterland , with rainwater producing relatively strong acid (H_2SO_4 , and HNO_3), hence acid rain that destroys man and his environment.

(h)Conclusion:

From the result, it is concluded operation of Mobil Oil Nigeria Unlimited is directly responsible for incessant gas flaring in the southern Akwa Ibom state that has led to decreased in pH levels, hence acid rain formations. It is then an established fact that acid rain formation in the study area varied between space ant time due to seasons . This observation then called on Akwa Ibom State in particular and Nigerian government in general to stop the Mobil Oil company from gas flaring and encourage the building of gas re-injection plants as well was gas revolution to boost the economy for environmental sustainability as obtained in the western parts of the world.

(i)Recommendations:

1. Nigerian government should stop oil companies from gas flaring and encourage the building of gas re-injection plants as was obtained in the western parts of the world.
2. Gas revolution should be implemented or to store it for use as an energy source for electricity, small scale industries, fertilizer plant etc. If properly harnessed, the gas could also be utilized by households for cooking which will in turn checkmate de-vegetation for fuel wood .
3. Above all, environmental laws and regulations should be fully implemented for compliance.

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MEMBERSHIP OF PROFESSIONAL SOCIETIES AND AN AWARD

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(ii) Member – Nigerian Geographical Association (**NGA**)

(iii) Member _ Nigerian Environmental Society (**MNES**)

(iv) Associate Fellow – Institute of Industrial Administration (**FIIA**)

(v) Member – Academic Staff Union of Colleges of Agriculture (**ASUCA**)

(vi) Soil Science Society of Nigeria (**SSSN**)

(vii) Educational Leadership Award by Institute of Industrial Administration (**FIIA**), 31st, July 2010