# LEVELS OF ACID RAIN AND ITS IMPACT ON SOME COMMUNITIES IN AKWA IBOM STATE, NIGERIA.

ISSN: 2141 – 3290
www.wojast.com

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**ABSTRACT:** The levels of acid rain and its impact on some communities in Akwa Ibom State were examined to determine the degree of acidity of rain water collected from the roofs, atmosphere, industrial and non-industrial areas. The results of the analysis revealed the mean pH range of rain water collected from the roofs and from the atmosphere varied from 5.97 ± 0.47 to 7.57 ± 0.85 and from 6.18 ± 0.43 to 7.57 ± 0.86 respectively. At 5% level of significance, there was no difference in the degree of acidity of rain water collected from the roofs and the atmosphere in the study area. However, the acidity of rain water collected from industrial area (Ibeno) and non-industrial areas of the State were significantly different. The ranges in the levels of nitrite ion ($NO_2^-$), nitrate ion ($NO_3^-$), and sulphate ion ($SO_4^{2-}$) determined in the rain water were 0.001 - 0.065mg/l, 0.100 - 0.0760mg/l and 0.620 - 19.02mg/l respectively. The results also revealed that rain water collected in the state was fit for drinking with respect to its pH, and levels of $NO_2^-$, $NO_3^-$, and $SO_4^{2-}$, which fell below minimum levels set by World Health Organization for drinking water. Exception was the rain water collected in Ibeno whose mean pH of 5.97 ± 0.47 made it too acidic and unfit for human consumption. Swam Brand roofs in the State corrode as a result of aging with exception to those seen in Ibeno Local Government Area and its environs which corroded before their expiring date of 30 years. These results imply that acid rainfall due to gas flaring is impacting negatively on our environs.

## INTRODUCTION

Acid rain describes rainfall that has a pH level of less than 5.6 (Lazarus *et al*; 2006). Also, acid rain refers to the deposition of wet (rain, snow, sleet, fog and cloud water, dew) and dry (acidifying particles and gaseous) acid compounds (Liken *et al;* 2002). Distilled water, which contains no carbon (iv) oxide, has a pH of 7. Liquids with a pH less than 7 are basic. The two primary causes of acid rain are sulphur (iv) oxide ($SO_2$) and oxides of nitrogen ($NO_x$). Automobiles are the source of nitrogen oxide emissions (DeHayes *et al*; 2001). These gases evaporate into the atmosphere and then oxidized in clouds to form nitric or nitrous acid and sulphuric acid. When these acids fall or precipitate to the earth, they cause damage to the environment and human health (Committee on Environment Health, 2004).

The pollutants in acid rain cause problems in human respiratory system. They attack humans indirectly through the foods they consume. Governments of various countries have passed laws to reduce emission of sulphur (iv) oxide and nitrogen oxides, but it is no use unless people start to work together in stopping the release of these pollutants. If acid rain destroys our environment, eventually it will destroy us as well. This study highlights the level of acid rain and its impacts on some communities in Akwa Ibom State.

## MATERIALS AND METHODS

Rain water samples were collected separately from Swan Brand corrugated iron roofs and direct from the atmosphere at five different locations each in five Local Government Areas (LGA) selected for the study in each of the three Senatorial Districts (Uyo, Ikot Ekpene and Eket) in Akwa Ibom State, Nigeria. This was done between May-November 2010. The rain water samples were collected into clean dried plastic containers with lids and were taken to the Central Laboratory of the Akwa Ibom State Water Corporation, Uyo, Nigeria for the determination of pH and levels of nitrite ion ($NO^-_2$), nitrate ion ($NO^-_3$) and sulphate ion ($SO_4^{2}$).

### Chemical Composition of Rain Water

The pH of the samples was determined with a pH meter and the levels of nitrite ion ($NO_2^-$), nitrate ion ($NO_3^-$) and sulphate ion ($SO_4^{2-}$) were determined with a portable dataloging spectrophotometer according to the methods of analysis of Association of Official and Analytical Chemists (AOAC, 1985).

### Determination of Impacts of Acid Rain

Two methods were employed. First, the assessment of the durability of Swan Brand corrugated iron roofing sheets used in the State and the second was testing for fitness of rain water collected in the area for drinking. In the first method, oral interview of residents living under heavily corroded buildings with a question, "what is the age of your roof?" was done. However, the ages of the heavily corroded Swan Brand roofing sheets obtained during the interview were compared with the life span of the roofing material used to ascertain whether or not the corrosion were caused and/or accelerated by acid rain.

In the second method, "fitness for drinking" the rain water collected in the area was done through comparism of the pH and the levels of $NO_2$), $NO_3$, and $SO_4^2$ determined in the rain water samples analyzed with those in the current drinking water standards set by the World Health Organization (WHO, 2006).

## RESULTS AND DISCUSSION

Table 1: Mean pH levels of rain water collected from the roof in the three Senatorial Districts in Akwa Ibom State.

| Sample from Uyo Senatorial District. | Mean pH | Sample from Eket Senatorial Districts. | Mean pH | Sample from Ikot Ekpene Senatorial Districts | Mean pH |
|---|---|---|---|---|---|
| Uyo | 6.20 ± 0.50 | Eket | 6.97 ± 0.92 | Ikot Ekpene | 7.34 ± 0.85 |
| Ibiono Ibom | 7.56 ± 0.49 | Ibeno | 5.97 ± 0.40 | Ikono | 7.52 ± 0.57 |
| Nsit Ubium | 7.41 ± 0.39 | Ikot Abasi | 6.39 ± 0.51 | Etim Ekpo | 7.57 ± 0.85 |
| Ibesikpo | 6.69 ± 0.41 | Oron | 7.46 ± 0.53 | Abak | 7.13 ± 0.83 |
| Etinan | 7.01 ± 0.36 | Mbo | 7.07 ± 0.68 | Obot Akara | 7.18 ± 0.75 |

Data are mean of five samples (±) standard error

The present study has shown the level of acid rain and its impacts on some communities in Akwa Ibom State, Nigeria. Table 1 revealed a mean pH levels of rain water collected from the roof in the three Senatorial Districts, of Uyo, Eket and Ikot Ekpene, in Akwa Ibom State. The mean pH range for the rain water collected from the roof in Uyo, Eket and Ikot Ekpene Senatorial Districts were 6.20 - 7.56, 5.97 - 7.46 and 7.13 - 7.57 respectively. Eket Senatorial District recorded the most acidic mean pH for rain water collected from the roof, while rain water collected from the roof in Uyo and Ikot Ekpene Senatorial Districts recorded no level of acidity. The level of acidity of rain water recorded in Eket Senatorial District and in Ibeno LGA in particular may have resulted from gas flaring in the LGA by Exxon Mobil Oil Company situated there.

These findings are in agreement with the report that occasional pH readings in rain and fog water of well below 2.4 (the acidity of vinegar) had been reported in industrialized areas of the world where gases are flared from oil refineries and where hydrocarbons from automobile engines and generating plants are burnt (McCormack, 2000; Rodhe, 2004 and Rose, 1994).

Table 2: Mean pH levels of rain water collected from the atmosphere in the three Senatorial Districts.

| Sample from Uyo Senatorial District. | Mean pH | Sample from Eket Senatorial District. | Mean pH | Sample from Ikot Ekpene Senatorial District | Mean pH |
|---|---|---|---|---|---|
| Uyo | 6.29 ± 0.50 | Eket | 7.24 ± 0.91 | Ikot Ekpene | 7.36 ± 0.87 |
| Ibiono Ibom | 7.54 ± 0.56 | Ibeno | 6.18 ± 0.43 | Ikono | 7.52± 0.55 |
| Nsit Ubium | 7.50 ± 0.47 | Ikot Abasi | 7.05 ± 0.75 | Etim Ekpo | 7.57± 0.86 |
| Ibesikpo | 6.69 ± 0.44 | Oron | 7.49 ± 0.58 | Abak | 6.76± 0.89 |
| Etinan | 7.05 ± 0.54 | Mbo | 7.13 ± 0.65 | Obot Akara | 7.17± 0.70 |

Data are mean of five samples (±) standard error.

Table 2 shows the mean pH of rain water collected from the atmosphere in Uyo, Eket and Ikot Ekpene Senatorial Districts in Akwa Ibom State. Their respective mean pH range were 6.29-7.54, 6.18-7.49 and 6.76-7.57. At 5% level of significance, there was no significant difference in the mean pH levels of rain water collected from the roof and the ones collected from atmosphere in these study areas.

This is in agreement with the report that rain water collected from the roof and atmosphere are the same in content at any location in the world with respect to the nature and conditions of roofing material and environmental conditions of the area (Weather and Likens 2006). Meanwhile, the mean pH range of rain water collected in Eket Senatorial District remained most acidic in the three study areas with respect to the results of the research.

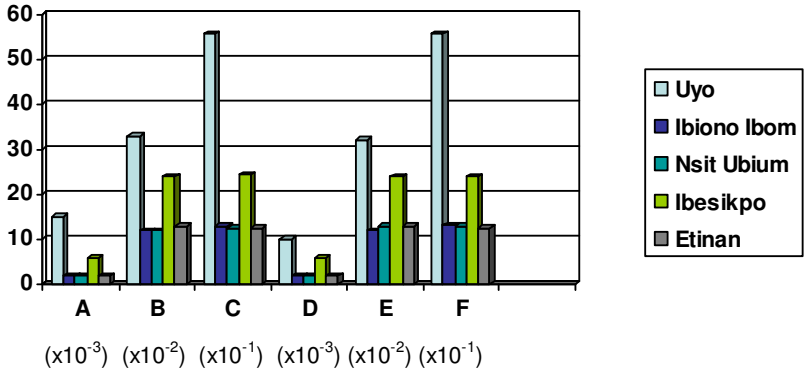


Figure 1: Mean concentration (mg/l) of Nitrite ion, Nitrate ion and Sulphate ion in rain water collected from the roof (A-C) and from the atmosphere (D-F): A and D – Nitrite ion, B and E – Nitrate ion, C and F – Sulphate ion.

Mean concentration of nitrite ion, nitrate ion, and Sulphate ion in rain water collected from the roof and from the atmosphere in Uyo Senatorial District are presented in Figure 1. The concentrations of these ions were measured in mg/l and the data were recorded as mean of five samples. A, B and C represent mean concentration of nitrite ion, nitrate ion and Sulphate ion, approximated to $x10^{-3}$, $x10^{-2}$ and $x10^{-1}$ respectively in samples collected from the roof in Uyo Senatorial District. D, E and F represent mean concentration of nitrite ion, nitrate ion and sulphate ion, approximated to $x\ 10^{-3}$, $x10^{-2}$ and $x10^{-1}$ respectively in samples collected from the atmosphere in Uyo Senatorial District.

The mean range for Nitrite ion, Nitrate ion and Sulphate ion concentration in samples collected from the roof were $2x10^{-3}$ -$15x10^{-3}$ mg/l, $12x10^{-2}$ – $33x10^{-2}$ mg/l and 12.5x $10^{-1}$ -$55.5x10^{-1}$mg/l respectively. But, the mean range for nitrite ion, nitrate ion and sulphate ion concentration in samples collected from the atmosphere were $2x10^{-3}$ -$10x10^{-3}$ mg/l, $12x10^{-2}$ - $32x10^{-2}$ mg/l and 12.6x $10^{-1}$ -$55.5x10^{-1}$ mg/l respectively. At 5% level of significance, there was no significant difference in the mean concentration of $NO_2^-$, $NO_3^-$, and $SO_4^{2-}$ in samples collected from the roof and those collected from the atmosphere in Uyo Senatorial District.

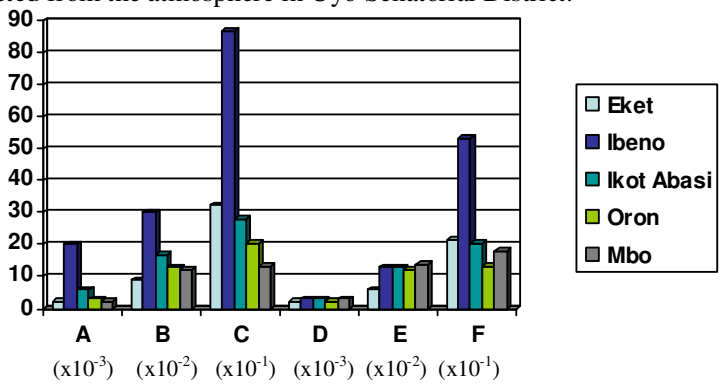


Figure 2: Mean concentration (mg/l) of Nitrite ion, Nitrate ion and Sulphate ion in rain water collected from the roof (A-C) and from the atmosphere (D-F): A and D – Nitrite ion, B and E – Nitrate ion and C and F – Sulphate ion.

Presented in Figure 2 are the mean concentrations of Nitrite ion, Nitrate ion and Sulphate ion, in rain water collected from the roof and from the atmosphere in Eket Senatorial District in Akwa Ibom state. Represented as A, B, and C are mean concentration of Nitrite ion, Nitrate ion and Sulphate ion approximated to $x10^{-3}$, $x10^{-2}$ and $x10^{-1}$respectively in samples collected from the roof and D, E and F represent mean concentration of Nitrite ion, Nitrate ion and Sulphate ion, approximated to $x10^{-3}$, $x10^{-2}$ and $x10^{-1}$ respectively in samples collected from the atmosphere in Eket Senatorial District. The mean range for nitrite ion, nitrate ion and sulphate ion concentration in samples from the roof were $2x10^{-3}$ – $6x10^{-3}$ mg/l, 9 $x10^{-2}$ -$30x10^{-2}$mg/l and $13.5x10^{-1}$ – $86.8x10^{-1}$ mg/l respectively. But the mean range for nitrite ion, nitrate ion and sulphate ion concentration in samples collected from the atmosphere were $2x10^{-3}$ – $3x10^{-3}$ mg/l, $6x10^{-2}$ -$14x10^{-2}$mg/l and $13.5x10^{-1}$ – $53.2x10^{-1}$ mg/l respectively. There was no significant difference between the mean concentration of samples collected from the roof and from the atmosphere at 5% level of significance.

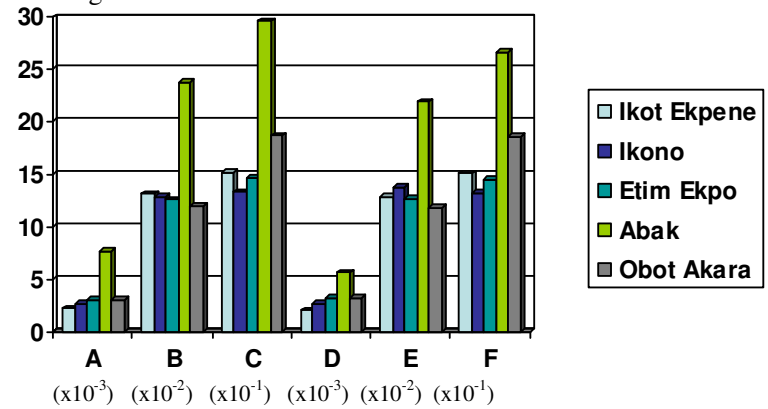


Figure 3: Mean concentration (mg/l) of Nitrite ion, Nitrate ion and Sulphate ion in water collected from the roof (A-C) and from the atmosphere (D-F): A and D – Nitrite ion, B and E – Nitrate ion, and F – sulphate ion.

Figure 3 shows the mean concentration of Nitrite ion, Nitrate ion and Sulphate ion in rain water collected from the roof and from the atmosphere in Ikot Ekpene Senatorial District in Akwa Ibom State. Represented as A, B and C are mean concentrations of Nitrite ion, Nitrate ion and Sulphate ion, approximated to $x10^{-3}$, $x10^{-2}$ and $x10^{-1}$ respectively in samples collected from the roof and D, E and F represent mean concentration of Nitrite ion, Nitrate ion and Sulphate ion, approximated to $x10^{-3}$, $x10^{-2}$ and $x10^{-1}$ respectively in samples collected from the atmosphere. The mean range for nitrite ion, nitrate ion and sulphate ion concentrations in samples from the roof were $2.2x10^{-3} – 7.6x10^{-3}$ mg/l, $11.9x10^{-2}$ -$23.8x10^{-2}$ mg/l and $13.3x10^{-1} – 18.7x10^{-1}$ mg/l respectively.

However, the mean range for nitrite ion, nitrate ion and sulpahte ion concentration in samples collected from the atmosphere were $2x10^{-3} – 5.6x10^{-3}$ mg/l, $11.8x10^{-2}$ -$13.7x10^{-2}$ mg/l and $13.2x10^{-1} – 26.6x10^{-1}$ mg/l respectively. At 5% level of significance there was no significant differences between the mean concentration of Nitrite ion, Nitrate ion and Sulphate ion in rain water collected from the roof and from the atmosphere in Ikot Ekpene Senatorial District. This still agrees with the report that rain water collected from the roof and atmosphere are the same at any location in the world with respect to the nature and conditions of roofing material and environmental conditions of the area (Weather and Likens2006; Botkin and Keller 1998).

Table 3: Ages of heavily corroded swan brand corrugated iron roofs in three Senatorial Districts in Akwa Ibom State.

| Study Area | Location of building | Age of heavily corroded building (years). |
|---|---|---|
| Uyo Senatorial District | Uyo | 45 |
| | Ibiono Ibom | 36 |
| | Nsit Ubium | 40 |
| | Ibesikpo Asutan | 43 |
| | Etinan | 37 |
| Eket Senatorial District | Eket | 26* |
| | Ibeno | 20* |
| | Ikot Abasi | 28* |
| | Oron | 47 |
| | Mbo | 26* |
| Ikot Ekpene Senatorial District | Ikot Ekpene | 39 |
| | Ikono | 51 |
| | Etim Ekpo | 35 |
| | Abak | 49 |
| | Obot Akara | 38 |

* Ages of Swan brand corrugated iron roofs that were heavily corroded below their life span of 30years.

Table 3 shows ages of heavily corroded Japanese swan brand zinc which is a type of roofing material predominantly used. To find the effect caused by acid rain on this roofing material, the life span of this corrugated iron roofing sheet which is 30 years (Akpan, 2003; Liken *et al,* 2002) were compared with the ages of these corroded corrugated roofs. It revealed that most of the Swan brand corrugated iron roofs in Ibeno LGA and its environs corroded and depreciated before their expiry date of 30 years. This proved that acid rainfall caused by pollutants emitted from the oil refinery in Ibeno is implicated in the early corrosion of the roofing material in the area. This finding was in agreement with the report by Akpan (2003) that acid rainfall is affecting buildings and the inhabitants of Niger Delta region of Nigeria.

Table 4: Current drinking water standards by World Health Organization (WHO)

| Parameters | Units | WHO guidelines |
|---|---|---|
| pH | - | 6.5-9.2√ |
| Aluminum (AL) | mg/l | 0.200 |
| Ammonia ($NH_3$) | mg/l | 1.500 |
| Antimony (Sb) | ” | 0.200 |
| Arsenic (As) | ” | 0.010 |
| Barium (Ba) | ” | 0.700 |
| Boron (B) | ” | 0.500 |
| Cadmium (Cd) | ” | 0.003 |
| Chromium (Cr) | mg/l | 0.050 |
| Copper (Cu) | mg/l | 1.500 |
| Cyanide ($CN^-$) | ” | 0.070 |
| Fluoride (F) | ” | 1.500 |
| Iron (Fe) | ” | 1.000 |
| Lead (Pb) | mg/l | 0.050 |
| Manganese (Mn) | ” | 0.400 |
| Mercury (Hg) | ” | 0.006 |
| Molybdenum (Mb) | ” | 0.070 |
| Nitrate ($NO_3^-$) | ” | 50.000√ |
| Nitrite ($NO_2^-$) | mg/l | 3.000√ |
| Nickel (Ni) | ” | 0.020 |
| Selenium (Se) | ” | 0.010 |
| Sulphate ($SO_4^{2-}$) | ” | 42-50.000√ |
| Uranium (U) | ” | 0.015 |
| Zinc (Zn) | ” | 3.000 |

Source: WHO, (2006).

Table 4 shows the current drinking water standards by World Health Organization. The mean pH range of rain water collected from the roofs and from the atmosphere in the State were 5.97 ± 0.47 – 7.57 ± 0.85 and 6.18 ± 0.43 – 7.57 ± 0.86 respectively and the ranges in the levels of nitrite ion, nitrate ion and sulphate ion determined in the rain water analyzed were 0.001 -0.065 mg/l, 0.100-0.0760mg/l and 0.620 -19.02 mg/l respectively. Though the levels of $NO_2^-$, $NO_3^-$ and $SO_4^{2-}$ measured in milligramme per litre of the rain water collected in Ibeno LGA fell below the minimum levels of WHO, the mean pH of the rain water is less than its standard range making it more acidic for human consumption. Moreso, the mean pH and the levels of $NO_2^-$, $NO_3^-$ and $SO_4^{2-}$ in the rain water collected in all other LGAs under the study fell below the minimum levels set in the guidelines.

Therefore, rain water collected in Akwa Ibom State is fit for human consumption, except the ones collected in Ibeno LG A which is contaminated by acid precipitation in the area.

## CONCLUSION

The present study investigated acid rain and its impacts on communities in Akwa Ibom State. The levels of pH, and concentrations of $NO_2^-$, $NO_3^-$ and $SO_4^{2-}$ in rain water collected from the roof and from the atmosphere were not different. But the level of pH in rain water collected in Ibeno LGA, an industrial area of the State where oil exploration and exploitation is done is low, signifying some level of acidity. It was established that the high degree of acidity in rain water collected in Ibeno and its environs may have led to early corrosion and depreciation in the life span of Japanese swan brand zinc used in the area. It was established that rain water collected in Akwa Ibom State is fit for drinking, except the ones collected in Ibeno which was slightly

more acidic compared with its standard in the World Health Organization guidelines for drinking water.

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