

Corrossitivity of Pollutants from Gas Flares on Galvanised Roofing Sheets in Idu, Rivers State, Niger Delta of Nigeria

Happy Wilson Abali^{1,*}, Ongoebi M. Etebu², Tambari G. Leton^{1,*}

¹Centre of Occupational Health, Safety & Environment, University of Port Harcourt, Nigeria

²Faculty of Engineering, University of Port Harcourt, Nigeria

*Corresponding author: hwabali@yahoo.com

Abstract The rate of corrosion of roofing sheets especially those made of galvanized sheets is very high in the Niger Delta of region Nigeria. This could be due to the high level of atmospheric pollutants emitted mainly from gas and other industrial activities. To determine the impact of atmospheric pollutants, two shades were constructed at Idu, an oil bearing community with three gas flares. The shades were installed windward to provide maximum exposure to atmospheric pollutants and the rate of corrosion monitored nine-month period. The first shade was inclined at 30° while the second was inclined at 70°. A sheet was removed from each of the shades monthly and comparison made with its original characteristics and corrosion rate noted. The rate of corrosion is the speed at which any metal in a specific environment deteriorates. The corrosion of galvanized corrugated iron sheet is the deterioration of galvanized corrugated iron sheet as a result of air pollutant reactions. Pollutants act faster in dry season than rainy season when acid rain is diluted beyond pH of 5.3 which is more than its corrosion strength. Besides at the inclination of 70° does not allow pollutants to settle on the roof and therefore corrosion is minimal.

Keywords: air pollutants, atmospheric corrosion, roofing sheets corrosion

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1. Introduction

The menace of conventional gas flaring, indiscriminate and unchecked burning of bushes and hydrocarbons have made particulate pollution reach an alarming level in the Niger Delta of Nigeria. The change in the level of particulate matter pollution is affected by various sources of emission mainly industrial emission from convectional gas flaring. Other sources are power plants, vehicles and biogenic sources like indiscriminate burning of hydrocarbons and windblown dust. The change in atmospheric concentration of any pollutant is however affected by source strength or emission rate and meteorological factors such as rain, sunlight, geography, cloud cover, moisture, and weather patterns.

Air pollution is a concern to many people as it directly influences the quality of human health, especially respiratory problems, heart and lung diseases, and may in extreme cases cause death. Children are at greater risk as they are generally more active outdoors and their lungs are still developing, while elderly people are also sensitive to some serious types of air pollution [1].

Flare gas refers to the gases that are disposed of and flared into the atmosphere. Flare gas could contain sulfide and different contaminants like H₂S and sulfur dioxide and must therefore be treated before being released. However

luckily, Nigerian crude has less than 5% sulfur and sulfur treatment is unnecessary. Since flare gas emissions are often toxic or corrosive, they can contribute to the formation of acid rain especially because of its NO₂ dioxide content. NO₂ is an acid rain precursor as it reacts with moisture to form corrosive nitric acid. Acid rain is rainfall made so acidic by atmospheric pollution that it causes environmental harm, mostly to vegetation and stationary water bodies. The main cause in the Niger Delta of Nigeria is burning of fossil fuels, the waste gases which contain nitrogen oxides combine with atmospheric water to form acids.



Figure 1. Major particulate matter pollution in Idu Ogba/Egbema/Ndoni Rivers State, Nigeria

Table 1. Critical pollutants in Niger Delta of Nigeria

Pollutants	Description	Sources	Effect
Particulate Matter	PM _{2.5} and PM ₁₀	Residues from burning of hydrocarbons – gas flaring etc	increase respiratory symptoms, aggravate asthma, and cause premature death.
Carbon Monoxide (CO)	Poisonous gas	incomplete combustion from vehicles and gas flaring.	affect mental function, alertness, and worsen cardiovascular diseases. Harmful even in low concentrations.
Nitrogen Dioxide (NO ₂)	Reactive gas. Part of smog formation	Vehicles and power plants, gas flaring	Respiratory illness (short term). Lowers resistance to respiratory infection (long term).
Ozone (O ₃)	Reactive gas. Main chemical in smog formation	Sunlight reacting with exhaust from motor vehicles and refineries	significantly decrease lung function, increase respiratory symptoms, aggravate asthma

Pollution studies carried out in the Niger Delta in the last five years, found these to be the critical air pollutants sulfur dioxide (SO₂), nitrogen oxide (NO₂), carbon monoxide (CO), ground level ozone (O₃), lead (Pb), fine particles less than 10 micrometers (PM₁₀) and nitric acid (HNO₃) [2,3].

2. Materials and Methods

Monitoring the corrosivity of pollutants on galvanized roofing sheets require a sequence of activities as described herewith. Two shades of galvanized roofing sheets 0.5mm thick were constructed windward in January 2017. This study was carried out for nine months. Four months of dry season being from January to April and five months of rainy season May to September were covered in the study. While Shade A was roofed at inclination angle of 30°

which represents the angle of most of the buildings in Idu, Shade B was roofed at 75°. Weights of the sheets were taken before construction. At the end of each of the nine months of monitoring, a sheet was removed each from Shade A and Shade B, inspected and reweighed. The following Table 2 shows the rate of corrosion and progressive weight loss throughout the period of study.

Table 2. Co-ordinates of flaring site and pollutant monitoring locations

S/N	Location	Co-ordinates	
		NORTHING	EASTING
1	Idu flow station	5° 14' 33.00" N	6° 36' 5.22" E
2	Idu Obosi Ukwu	5° 14' 44.35" N	6° 15' 00.11" E
3	Idu Osobile	5° 14' 12.13" N	6° 35' 13.12" E
4	Obagi	5° 14' 44.50" N	6° 36' 31.56" E
5	Oboburu	5° 13' 49.63" N	6° 36' 06.62" E

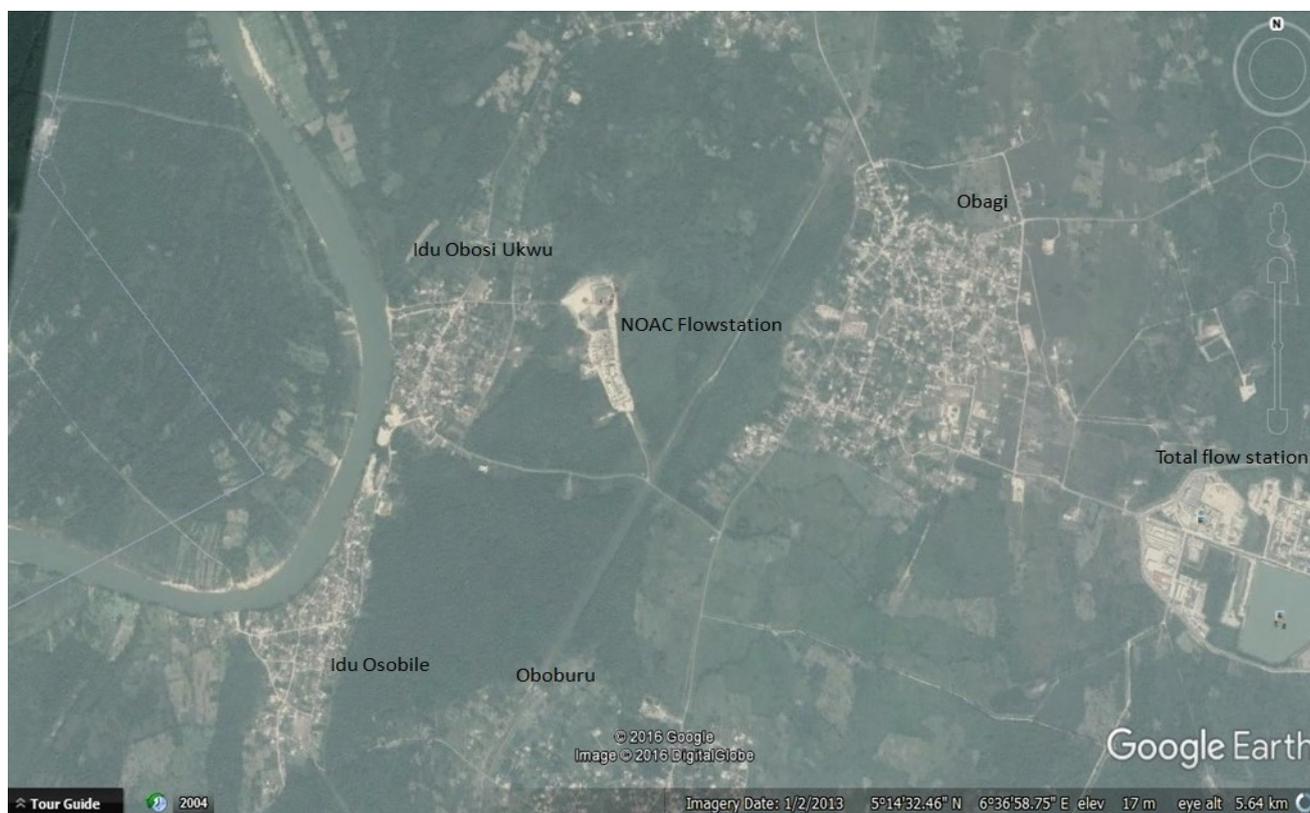
**Plate 1. Satellite location of Idu and environs**

Table 3. Data obtained from Shade A (30°)

Month	Average Ambient Monthly Temp °C	Average Monthly Humidity %	Initial weight (g)	After x days	New weight (g)	Weight loss (g)	Progressive weight loss
Jan	30.3	75	2190	30	2189.992	0.008	0.008
Feb	29.9	78	2223	60	2222.981	0.019	0.011
Mar	29.8	88	2075	90	2074.966	0.034	0.015
April	28.9	89	2138	120	2137.947	0.053	0.019
May	28.3	90	2253	150	2252.924	0.076	0.026
June	27.3	91	2149	180	2148.89	0.110	0.035
July	26.7	94	2219	210	2218.851	0.149	0.030
Aug	27.2	95	2117	240	2116.832	0.168	0.019
Sept	27.0	96	2236	270	2235.827	0.173	0.005

Table 4. Data obtained from Shade B (70°)

Month	Average Monthly Temp °C	Average Monthly Humidity%	Initial weight (g)	After x days	New weight (g)	Weight loss (g)	Progressive weight loss
Jan	30.3	75	2280	30	2279.993	0.007	0.005
Feb	29.9	78	2318	60	2317.99	0.010	0.003
Mar	29.8	88	2278	90	2277.984	0.016	0.006
April	28.9	89	2380	120	2379.979	0.021	0.005
May	28.3	90	2240	150	2239.974	0.026	0.005
June	27.3	91	2190	180	2189.968	0.032	0.006
July	26.7	94	2220	210	2219.962	0.038	0.006
Aug	27.2	95	2180	240	2179.957	0.043	0.004
Sept	27.0	96	2260	270	2235.827	0.045	0.002

2.1. Rate of Corrosion

Rate of Corrosion is the speed at which any metal in a specific environment deteriorates. It is also the amount of corrosion loss per year in quality and value of the material specimen. The speed or rate of deterioration depends on the environmental conditions and the type and condition of the metal under reference.

The rate can be expressed mathematically as follows:

$$R = KW / (\beta AT)$$

Where K = constant

W = total weight loss

T = time taken for the loss to occur

A = the surface area of the exposed metal

β = the metal density in g/cm^3

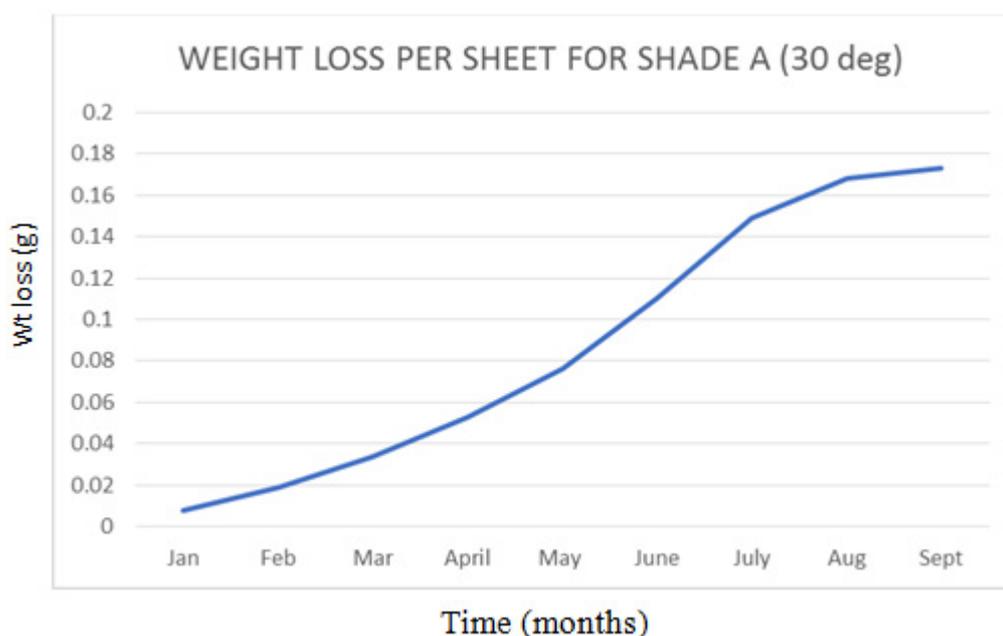


Figure 2. Weight loss per sheet for Shade A

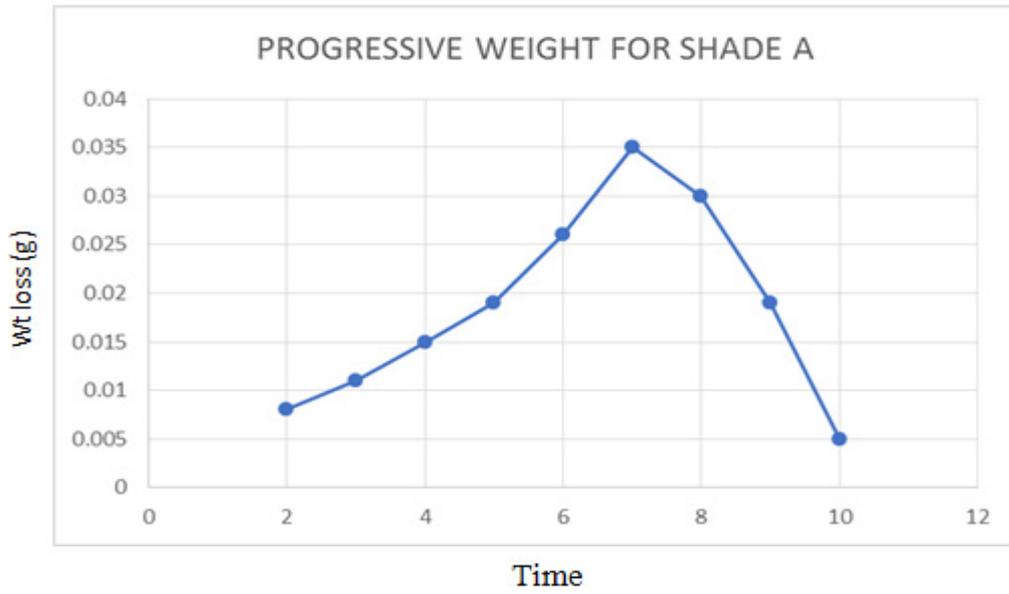


Figure 3. Progressive weight loss for Shade A

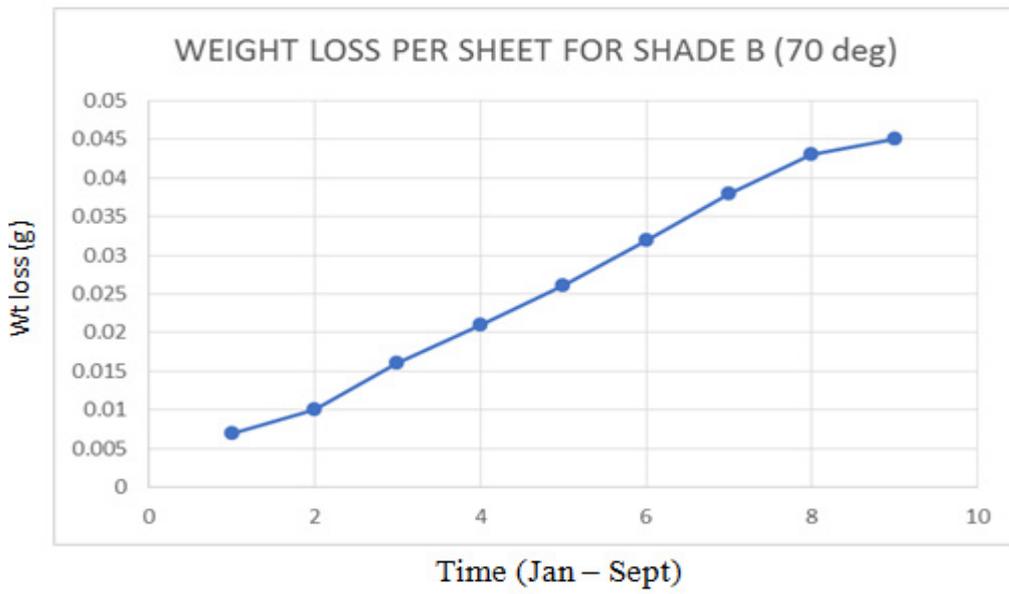


Figure 4. Weight loss per sheet for Shade B

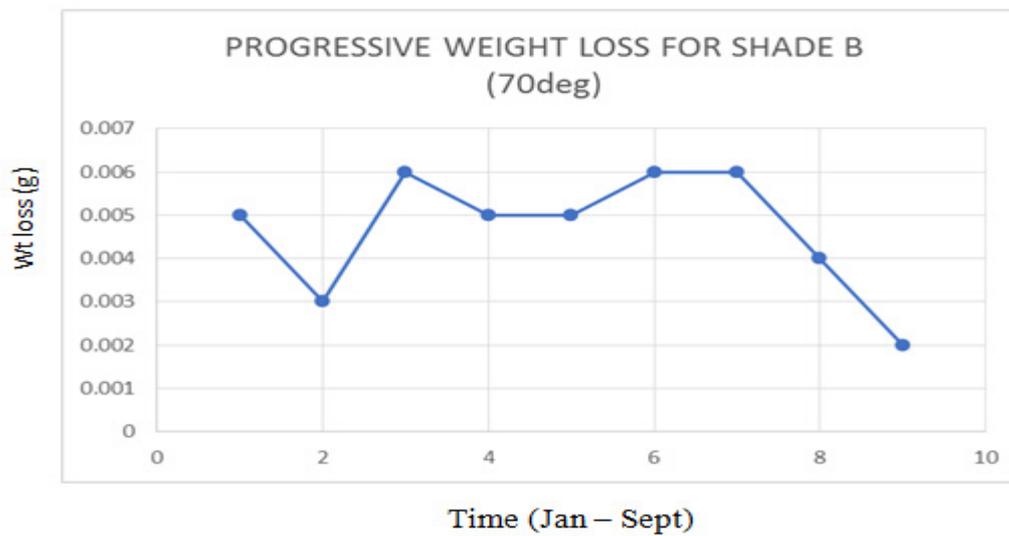


Figure 5. Progressive weight loss for 70° inclined roof

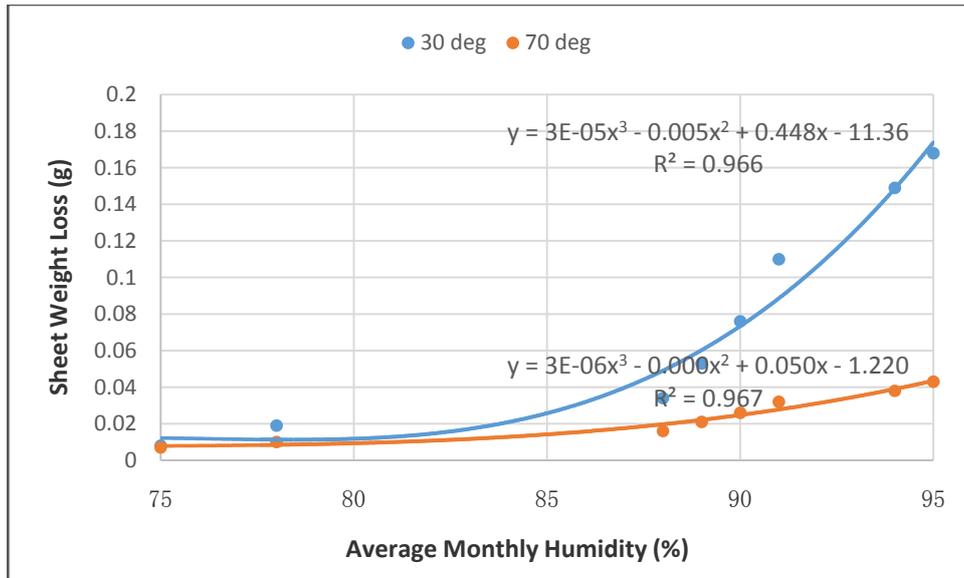


Figure 6. Humidity effect on weight loss for Shades A and B

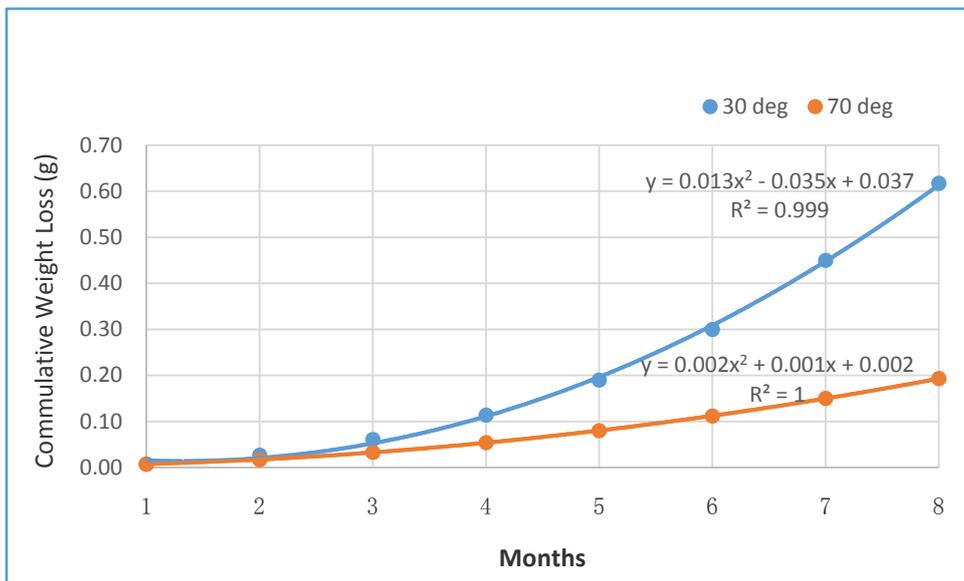


Figure 7. Monthly Cumulative Weight Loss for Shades A and B

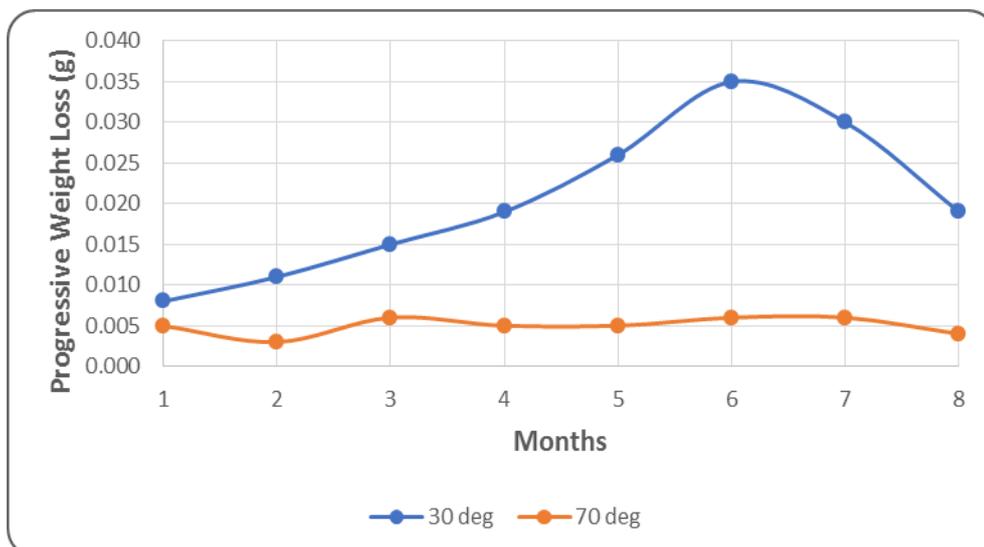


Figure 8. Monthly Progressive Weight Loss

After June when the rains have fully come, the progressive weight loss started to decline.

The reason for this decline is the continual increase in rainfall that diluted nitric acid to more than pH 5.3 which is beyond its corrosivity. The progressive weight loss continues to decline for the rest of the study period.

Weight loss per sheet was steadily on the increase throughout the study period.

However, the progressive weight loss as shown in Figure 5 was low to 0.003g in February from 0.005 in January because of the occasional rainfall observed in February. This value went up again for the dry month of March to about 0.006g. It was more or less steady during the months of April and May at 0.005g before increasing to a steady level of 0.006g during the months of June and July and plunged down to 0.004g in August and 0.002g in September as the rains increased.

3. Discussion of Result

Meteorological parameters monitored include Temperature at ground level, wind speed and humidity at ground level. Air pollutants monitored include NO₂, PM_{2.5}, PM₁₀ and CH₄. Average daily pH of the humidity was taken during the dry season on 5th March 2017, when the rains started setting on May 19th 2017, June 27th 2017 and 3rd Sept 2017. There was a steady increase of daily average pH from 3.9 in March, 4.2 in May, 4.8 in June and 5.3 in September. This pH record with the average monthly humidity average (75% for January, 78% for February, 78% for March, 80% for April, 83% for May, 85% for June, 90% for July and 95% for September) and air pollutants which were all above permissible exposure limits could contribute to wet and dry acid deposition. Acid deposition on metals lead to corrosion as observed sheet weight loss.

It was discovered that pollutants action mainly that of Nitrogen Dioxide (NO₂) causing Nitric Acid (HNO₃) rain when reacted with moisture and particulates matter which forms nitrates when settled on roofs. Galvanized roofing sheet physically went from loss of gloss (loss of galvanization) within the first few months of study to actual rusting of the roofing sheets as Nitrogen Dioxide (NO₂) is reacted with atmospheric moisture to form corrosive nitric acid. Besides, by inclining the roof at 75° Shade B, the rate of corrosion was reduced as nitric acid making contact only with small surface area and shorter time. During rainy season active pollutants are scrubbed from the air and further diluted to a near neutral state (pH 6.5) so that their corrosive ability is reduced to minimum. House roofs in Idu and environs are inclined at between 25° and 30°. With higher humidity as in the months of April, May, June and July corrosion rate continuously increased until the months of higher precipitation when dilution of nitric acid is prevalent.

4. Conclusion

“The expected lifespan of a metal roof is 30 to 45 years in Florida. The most common metal roof material

we see in this area is galvalume, which is a steel sheet with an electrolytically-applied coating of a combination of zinc and aluminum to extend the lifespan” (www.mcgarryandmadsen.com/.../16_What_is_the_average_lifespan_of_a_metal_%2... Dec 16, 2014.) At an average roof life maximum of 15years (Idu residents 2017) these buildings with galvanized roof (coated with zinc) are reroofed because of pollutant caused corrosion which roofs in Florida USA quoted above are not exposed to. By inclining the roof at 70° life of these buildings can achieve the expected life span above because the rate of corrosion is greatly reduced. Alternatively, stone coated roofing sheets can be employed as they are manufactured to withstand corrosion than ordinary galvanizing or zinc coating. Second alternative is galvalume or aluminum roofing sheets which corrodes slower than galvanized and the other non-aluminum roofing sheets.

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