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Atmospheric Corrosion of Roofing Sheets Due To Gas Flaring In The Vicinity of Kwaleiokpai Gas Plant, Delta State, Nigeria

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Abstract

The roofing materials used in most buildings in Nigeria and Delta State in particular are the Asbestos, Galvanized Iron, Long span Aluminum and oil Painted Galvanized Iron sheets respectively. The atmospheric corrosion of these roofing sheets in gas flaring (Polluted Industrial) atmosphere of Kwale/Okpai environs in Delta State has been studied. The weight loss method was applied in the study. In this method, specimen of roofing sheets were exposed to the polluted atmosphere within Kwale/Olcpai environs (Experiment) and another at Ndemili (Control) while some of the mechanical properties were examined before and after exposure at 20 days intervals and for a maximum of 140 days. Results obtained revealed high corrosion rate for galvanized iron roofing sheets whereas the long span aluminum and asbestos sheets were relatively resistance to corrosion. Furthermore, the corrosion rates at Ndemili and Kwale/Okpai environs are within 0.4 x 10^{-6} mm per day and 2.2 x 10^{-6} mm per day for galvanized Iron sheet respectively. The major aim of any scientific research is to improve the living condition of the immediate communities and suggest possible ameliorating ways. In the study area, the roofing sheets are easily attacked by rust, hence it is pertinent to recommend the best roofing sheet within the said environment and publish same for public consumption and for those who could not afford an EIA (Environmental Impact Assessments) report before erecting buildings.

***Keywords*:** corrosion, Gas Flaring, Roofing Sheets, Atmosphere.

1.0 Introduction

The economic loss associated with the corrosion of roofing materials largely depend on the nature of the environment in which the materials are exposed to. Roofing sheets are used under industrial, urban, marine and rural atmospheric conditions. The climate of the study area is influenced by the Southwest and the Northeast trade winds that blow across the Sahara desert. The mean maximum and minimum air temperatures vary between 28 – 34 ^{O}C and 20.6 — 23.5 ^{O}C respectively. However, the thermal gradient within Kwale/Okpai gas plant has been altered by 3.7 ^{O}C [1]. The mean annual rainfall varies between 100 -160 inches. The maximum and minimum relative humidity ranged between 89 — 98 % and 51 — 82 % respectively. The P_H, which is a measure of the acid base equilibrium, is controlled by the carbon dioxide, bicarbonate and carbonate equilibrium system [2]. The P_H of the rainwater lies between 7.11 — 7.63. The increased concentration of atmospheric gas and weather conditions are controlled by the carbon dioxide, bicarbonate and carbonate equilibrium system [2]. The P_H of the rainwater lies between 7.11 — 7.63. The acid rain contains weak acid solutions of HCL, H_2S0_4 and H_3C0_3, which are very hash on the human body as well as the environment {10}. In Oyigbo area of River State, it was observed that the P_H value of rainwater was 4.25 when compared to the normal P_H range of about 5.8-6.2. This P_H value of 4.25 suggests that the rainwater in Oyigbo area is highly acidic with the general physical environment of the gas flaring. Trees and a virtually semi-savannah vegetation characterized by grassland and shrub [3] the practice release a number of combustion products into the atmosphere and this constitutes potential land, water and air pollutants. The major impact of gas flaring on the environment comes in the form of acidic precipitation that is highly corrosive and therefore accelerates the corrosion of roofing sheets used in such environment [4]. Corrosion is a natural phenomenon and could be defined as an unintentional attack or spontaneous destructive oxidation of metals due to its environment with a tendency to return the metal back to the ore it was derived from [5 -6]. Naturally, metal occur in the combined state as ores. After extraction and processing, they become unstable as they are left in uncombined form. Throughout their service life they strive to revert to their combined state. Thus corrosion can also be seen as a reversion or partial reversion from the metallic state to the more stable mineral

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state with an accompanied reduction in the free energy of the system [7 – 8]. The energy required by the metal to revert to the mineral states varies from metal to metal by reason of the differences in their physiochemical properties. Corrosion is an economic and engineering problem. It is a major agent of waste and affects engineered structures by reducing their utility values, quality, safety, Strength, efficiency and length of service [9]. Corrosion tests can be done either by service tests or laboratory tests. The service tests are carried out for the purpose of evaluating specific materials in a service condition. The main purpose of such test is to determine the best material for use in service [10]. Such tests usually involve placing specimen or coupons of known dimensions and weight into the environment for a specific length of time and then retrieving to take the final condition relative to the starting conditions from which the rate of corrosion is calculated [6]. Laboratory tests may be divided into a number of categories, which include immersion, stimulation, accelerated and electrochemical tests. Such tests are usually useful in the industries where mixtures of solutions that have not been evaluated are encountered. The key benefit of this paper amongst others is to find out the environmental and socioeconomic impacts associated with gas flaring and to recommend the best roofing sheets for environmental sustainability.

2.0 Research Methodology

A wooden exposure rack of dimensions I .5m by I .5m was constructed and placed at a height of I .7m above the ground. Corrosion specimens of dimensions 10cm by 5cm were prepared from the following types of roofing sheets.

i. Galvanized iron roofing sheets (Swan China brand).
ii. Long span aluminum-roofing sheets (Goken Aluminum).
iii. Painted galvanized iron roofing sheets and
iv. Asbestos sheets (Eternit).

The specimens were thoroughly cleansed of all previous corrosion products by using not only various grades of silicon carbide abrasive paper but degreased in acetone and later washed in warm water containing detergent and scrubbed with a soft brush. The specimens were further degreased in methylated spirit and dried. Atmospheric corrosion test were carried out with seven coupons of each specimen. The coupons were mounted in an exposure rack at an angle of 500 at Ndemili (Control) and 600 m south of Kwale/Okpai gas plant respectively. Each coupon of the various specimens were retrieved at every 20 days interval and evaluated for weight loss, maximum force required to break it and the hardness respectively. This was carried out for a maximum of 140 days. The rate of corrosion is obtained by dividing the weight lost from a test specimen by the exposed time and the area of the specimen.

Mathematically, rate of corrosion = the rate of Weight loss

Area x time of exposure = $\dfrac{\Delta W}{A.\Delta T}$ (1)

Where ΔW = Weight loss, ΔT = Time of exposure, A = Area of specimen = 5000 mm^3.

The tensile strength and hardness tests of the specimen were carried out using a hydraulic Tensometer and an Avery Denison machines respectively. These mechanical properties were determined before and after exposure. The Ultimate Tensile Stress (UTS) was calculated using the maximum force required to break an effective area of the specimen that was reshaped to a size of 10 mm by 5 mm with punched holes at the ends, so that the Tensometer can grip it easily [5],

Ultimate Tensile Stress = $\dfrac{F_{MAX}}{a_{EFF}}$ (N/rnm2) (2)

Where F_{max}. = Maximum force (N) and a_{eff} = Effective area (mm^2) 50 mm^2.

The hardness of the specimens was read directly from the Avery Denison machine.

3.0 Results and Discussion

Uniform specimens of galvanized iron, long span Aluminum, Painted galvanized iron and Asbestos-roofing sheets weighed 15.79g. 13.84, 15.92g and 92.35g respectively before exposure, after every 20 days interval, the new weights for each specimen were recorded and this was used to determine the weight loss, for the experiment and for the control. The maximum force that breaks the pre-exposed specimens was also determined and this was used to calculate the utility tensile stress. Finally, the graphs of rate of corrosion against exposure time for the four rooting sheets are as shown in figures 1 and 2 for experiment and control respectively. The visual estimation of the specimens revealed that there was a general corrosion of the surface of galvanized iron sheets in the first 20 days of exposure, as well as progressive discoloration and roughening of the surfaces at the experimental specimen than the control. The highest value of corrosion at Ndemili is within 0.4 x 10^{-6} mm whereas that within Kwale/Okpai gas plant is as high as 2.13 x 10^{-6} mm. On the other hand there were no significant changes in all other specimens. Effective degradation started from the 60th day of exposure. The corrosion may have been enhanced by the onset of the raining season (acid rain phenomenon). The increased concentration of atmospheric gas and weather condition which are partly caused by the gas flared at Kwale/Okpai gas plant may have created the Conducive environment for the atmospheric degradation of iron roofing sheets as manifested by the selective attack leading to the formation of pits on the sheets. The long span aluminum-roofing sheets were resistant to atmospheric corrosion. The corrosive resistance of this material makes it very suitable for roofing and other applications in the region within Kwale/Okpai gas plant. The painted galvanized iron sheets show some measure of corrosion resistance, as the painting seems to have slowed down corrosion attack considerably. Asbestos would make very good roofing material, as it is totally resistant to atmospheric corrosion but for its high cost and poisonous nature. It has been reported [2] that rain collected from asbestos roofing sheets is poisonous and carcinogenic. The major disadvantage is the cost involved, which is beyond the reach of the indigenes of the area due to their poor socio-economic disposition.

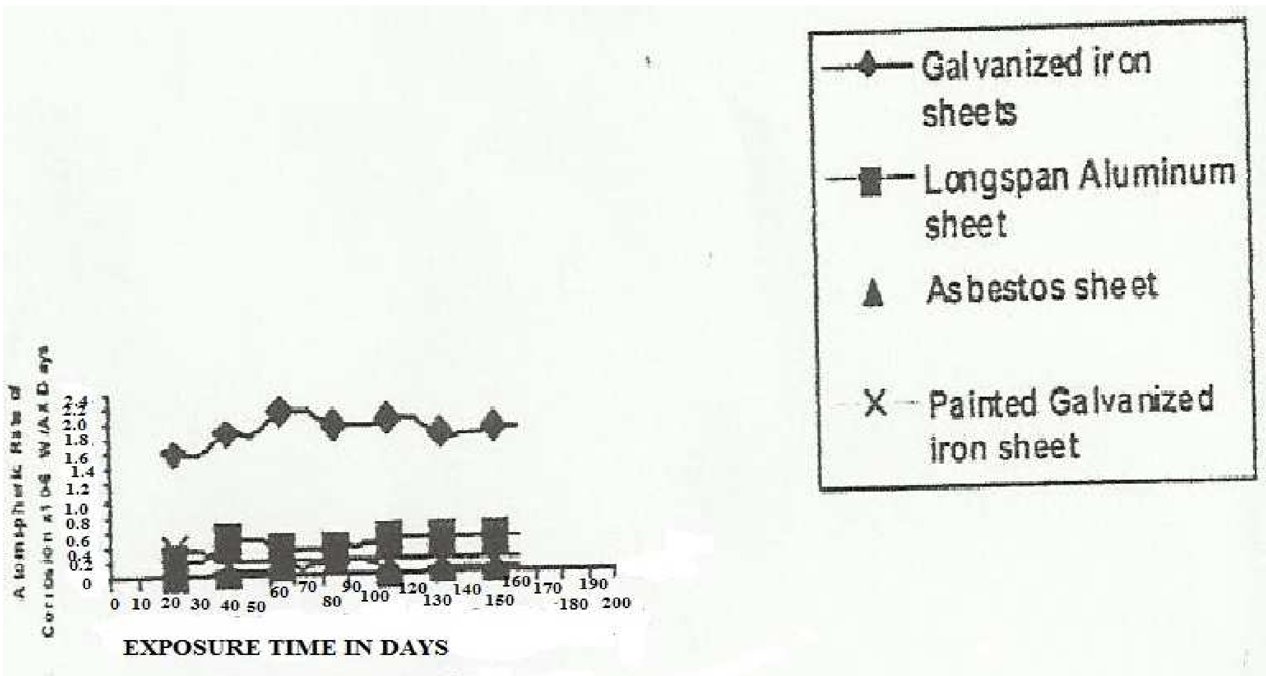

Figure 1: The graph of rate of corrosion against exposure time in days for the for roofing sheets within Kwale/Okpai Gas Plant **(EXPERIMENTAL)**

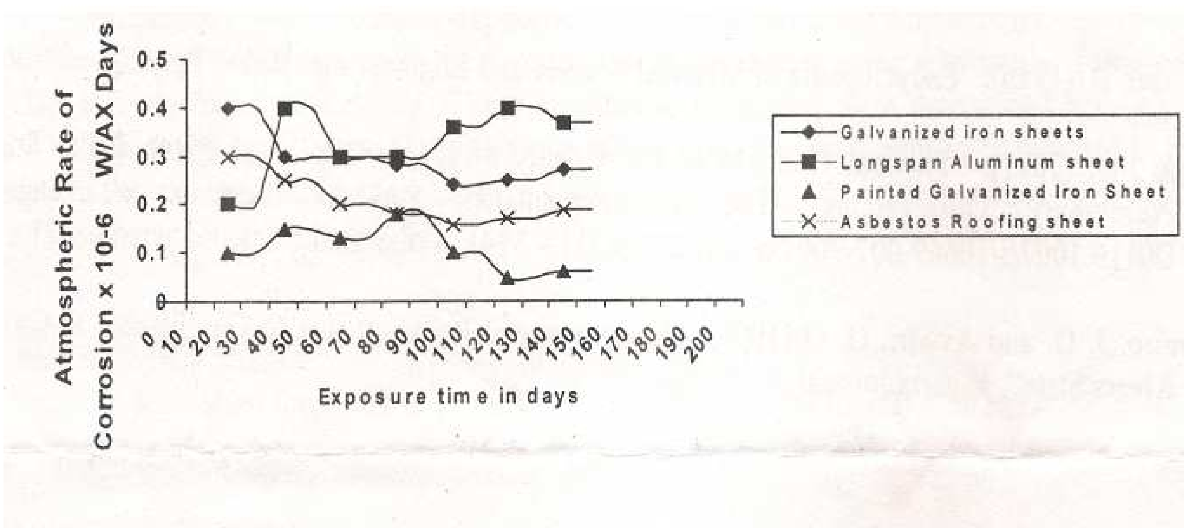

Figure 2: The graph of rate of corrosion against exposure time in days for the four Roofing Sheets at Ndemili **(CONTROL)**

4.0 Conclusion

The research work has shown that galvanized iron sheets are rapidly corroded in the gas-flaring atmosphere than every other roofing sheet. The corrosion rate at Ndemili is within 0.4 x 10^{-6} mm per day whereas that within Kwale/Okpai environs is as high as 2.2 x 10^{-6} mm per day for galvanized Iron sheets.

Corrosion in oil and gas operational area should be seen as not only an economic but also an engineering problem. It is a major agent of waste. It affects engineering structures and reduces their strength, efficiency and length of service. Corrosion In reinforced concrete can suddenly result in failure of a section of highway, collapse of electric towers and buildings and this leads to significant repair and costs thereby endangering public safety. The corrosive effects induced by the gas-flaring activities have no short-term effects on the mechanical properties of the roofing sheets [5]. We therefore recommend the use of long span Aluminum roofing sheets and limited use of asbestos roofing sheets within Kwale/Okpai gas plants and environs. Furthermore, oil companies should provide comprehensive welfare packages for their host communities to compensate for the damages caused by their operational activities.

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