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Performance Characteristics of various Corrugated Roofing Sheets in Nigeria

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ABSTRACT:

This Paper is based on an experiment carried out on different roofing sheets namely aluminum, galvanized steel, plastic and asbestos of various grades. The aluminum samples were obtained from two different companies in Nigeria namely First Aluminum and Tower Aluminum; the Asbestos was obtained from Emenite while the Steel and Plastic samples were bought from the market. The samples were cut into a particular size (8cm by 5cm) and immersed in various media namely acidic **(H_2SO_4)**, *alkaline* **(NaOH)**, **Sea water** *and* **Rain water** *in 2litres plastic beakers. The Rain water was used as the control medium for the experiment. The experiment was carried out for 70days and each grade was cut into 14 pieces of the same dimension. The samples were washed, weighed and tagged before immersion in the media. Each sample was removed every 5 days, washed thoroughly, dried and re-weighed. Some of the samples corroded while some resisted corrosion. The differences in the weights of the samples, and hence their respective rates of corrosion were obtained depending on the reacting media. The values that were obtained, the weight loss and weight gain were used to determine the corrosion rates per unit area per unit time. Graphs of specific weight loss/gain against time were plotted for each medium and each sample. Based on our graphs and observations, we can say that the coated samples are more resistant to corrosion, and therefore more durable.*

KEYWORDS: *Roofing Sheets, Aluminum, Galvanized Steel, Corrosion, Asbestos.*

I. INTRODUCTION

It is an indisputable fact that the roofing of one house turns reddish or brownish after awhile while another doesn't change or react at the same rate under the same environmental condition though they may be roofed with the same or different corrugated roofing sheets.

This aroused our interest to investigate the effect of different media on the corrosion kinetics of different types of corrugated roofing sheets in Nigeria.

Corrosion is defined in different ways, but the usual interpretation of the term is "an attack on a metallic material by reaction with its environment". **[1]** The material is progressively destroyed by the chemical action of the environment on it.

The concept of corrosion can also be used in a broader sense, where this includes attack on nonmetallic materials. Corrosion does occur in polymers and ceramics, but the mechanisms are quite different from those of metals, and are more often known as degradation. **[2]**Metallic systems are the predominant materials of construction, and as a class, are generally susceptible to corrosion. Consequently the bulk of corrosion science focuses on metals and alloys.

With a few exceptions, metals are unstable in ordinary aqueous environments. Certain environments offer opportunities for these metals to combine chemically with elements to form compounds and return to their lower energy levels, which is more stable and non-reactive. **[3]**

Generally, this destruction takes place on its surface in the form of material dissolution or re-deposition in some other form. Corrosion may occur over an entire exposed surface, more or less uniformly corroding the surface or may be localized at micro or macroscopic discontinuities in the metal to form pits or cracks. **[4]**

The most familiar example of corrosion is the rusting of iron, a complex chemical reaction in which the iron combines with both oxygen and water to form hydrated iron oxide. The oxide is a solid that retains the same general form as the metal from which it is formed but, porous and somewhat bulkier, and it is relatively weak and brittle, and still allows the corrosion effect of the environment to get to through to the uncorroded underlying metal. **[5]**

Because corrosion is a diffusion controlled process, it occurs on exposed surfaces. As a result, methods to reduce the activity of the exposed surface, such as passivation, galvanizing, chromate-conversion, etc can increase a material's corrosion resistance. However, some corrosion mechanisms are less visible and less predictable. **[6]**

Corrosion affects our Nation’s force effectiveness and readiness levels through the diminished safety and reliability of structures, mechanisms and electronics.

In many cases, corrosion is the life-limiting factor of a component. Corrosive failures can occur unexpectedly and at the worst possible moment.

Metallurgical factors that affect corrosion are chemical composition, material structure, grain boundaries, alloying elements, mechanical properties, heat treatment, surface coating, welding and manufacturing conditions. Understanding these factors are of great importance to decrease and control corrosion problem in many industrial applications. **[7]**

Corrosion testing can consume enormous blocks of time, particularly in the case of outdoor atmospheric tests. Unfortunately, the timescales involved in such tests preclude the opportunity for proper materials selection. In typical circumstances, new systems may be halfway through their lifecycle before real data on the fielded system would indicate any corrosion problems. **[8]**

The serious consequences of the corrosion process have become a problem of worldwide significance. Managing corrosion in structural components and critical systems to extend service life and ensure reliability is paramount. **[9]**

Corrosion resistance and control is a process by which humans employ the application of sound principles and try to regulate the rate of corrosion in different materials and for different environments, keeping it acceptable or at least predictable limits for the life of the structure. **[10]**

Effective corrosion control requires meaningful test data in a reasonable time frame such that it may be employed to influence materials selection and protection efforts.**[11]**

Corrosion control is achieved by recognizing and understanding corrosion mechanisms, by using corrosion- resistant materials and designs, and by using protective systems, devices, and treatments**.[12]**

The control of corrosion through the use of coatings, metallurgy, and nonmetallic materials for constructions, cathodic protection and other methods has evolved into a science in its own right and has created industries devoted solely to corrosion control.

Major corporations, industries, and government agencies have established groups and committees to look after corrosion-related issues, but in many cases the responsibilities are spread between the manufacturers or producers of systems and their users.

II. MATERIALS AND METHOD

This study consists of series of tests and experiment carried out over a period of seventy (70) days on the samples:

- First Aluminum brand
- Tower Aluminum brand
- Double Hand Steel brand
- Swan Milligram Steel brand
- Plastic sheets
- Asbestos sheets

The samples were tested in different environments, to find out and observe the effect of the media on the sample, the rate of corrosion by weight loss or weight gain, weight loss or gain per unit area.

The media which the tests were carried out in are:

Acid Medium: Tetraoxo Sulphate VI acid, H_2SO_4

- Alkali Medium: Sodium Hydroxide, NaOH
- Sea water Medium
- Rain water Medium

2.1 Sample Sourcing

The materials used for this study are: aluminum roofing sheets, obtained from First Aluminum and Tower Aluminum, asbestos roofing sheets obtained from Emenite, galvanized steel roofing sheets, swan milligram and double hand brand and plastics roofing sheets were all obtained from Eke Awka Market, Awka in Anambra state of Nigeria.

2.2 Sample Preparation

The samples were arranged and named as follows:
Aluminum sample 1: First Aluminum (Al 1, coated)
Aluminum sample 2: Tower Aluminum (Al 2, uncoated)
Aluminum sample 3: Tower Aluminum (Al 3, coated)
Steel sample 1: Swan Milligram (St 1, uncoated)
Steel sample 2: Double hand (St 2, uncoated)
Steel sample 3: Coated brand (St 3, coated)
Plastic sample 1: colored (Pl 1)
Asbestos sample 1: plain (Ab 1)
Asbestos sample 2: colored (Ab 2)

2.2.1 Cutting

The samples were cut to the same dimension of 8cm by 5cm. The cutting was done with a pair of scissors and was marked out with the aid of a meter rule.

2.2.2 Washing

The cut samples were washed thoroughly, to remove all traces of dirt, oil or grime, and were then dried thoroughly before weighing. This was to make sure the weight gotten was accurate, and to prevent reactions with impurities.

2.2.3 Tagging

All the samples were individually tagged and labeled using masking tape, for easy identification and recognition, to avoid mistakes of mixing the samples up. The beakers we used were perforated in preparation for hanging in the samples for immersion in the medium; these were also properly tagged and named.

2.2.4 Weighing

The samples were all weighed using an electronic digital meter. These weights make up the initial weights of the samples.
The thickness of each sample was equally obtained with the aid of a micro meter screw gauge.

2.3 Media/Solution Preparation

The solution used was 0.01M (mole) of tetraoxosulphate VI acid H_2SO_4, 0.01M sodium hydroxide NaOH, Sea water obtained from Atlantic Ocean and Rain water.

2.3.1 Acid Concentration Preparation

Amount to produce 0.01 molar concentration of H_2SO_4
=molecular weight/ (specific gravity x percentage purity)
=98.08/ (1.84 x 0.98) = 54.4ml
= 0.01 X 54.4 = 0.544ML
0.544ml of H_2SO_4 was needed to make up 1dm^{3}of deionized water to obtain 0.01 molar concentration of acid.

2.3.2 Alkali Concentration Preparation

Amount to produce 0.01 molar concentration of NaOH
= 40g of NaOH in 1dm^3 of deionized water make up I molar NaOH
i.e. 40g/L = 1M
Therefore, 0.01M = 0.4g of NaOH
0.4g of NaOH was weighed and 1dm^3 of water was poured in to make 0.01 molar concentration of sodium hydroxide.
The various PHs of the environments were taken before the samples were immersed. They are:
Acidic medium: pH of 2.0
Alkaline medium: pH of 11.0
Sea water medium: pH of 6.0
Rain water medium: pH of 6.0

2.4 The Trial Test

This trial test was carried out on the samples in the acidic and alkaline media. The molar concentration used was 2.5 M, for both the acid and base solutions. This was done to determine the time it would take for each of the samples to completely deteriorate. This helped us choose the molar concentration we eventually used, and the interval for the withdrawal of the samples from the solutions.

The rate of reaction of the samples in the 2mole solution of both the acid and base was very spontaneous, and within 24 hours, all the samples had deteriorated.

This led us to use a molar concentration (0.01) that was not so far from the ambient condition (0.001), but still capable of yielding results in the given duration of our experiment.

2.5 Sample Immersion

The prepared samples were then immersed in 1.5dm³ of each of the solutions listed above. The different samples, 14 pieces each for each sample were immersed in each of the environments for seventy (70) days.

After every 5-day interval, one sample from each environment is removed from solution, washed thoroughly in deionized water, to remove all residual traces of the solution it was removed from, and to stop further reactions. The washed samples were hung to effect quick drying, and then reweighed to get their final weights.

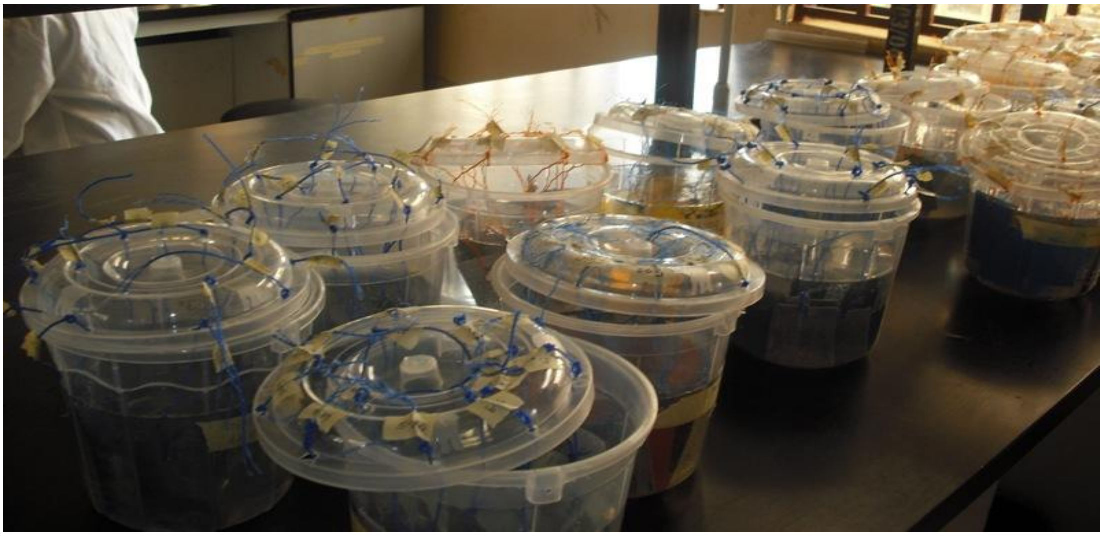

Fig. 1 The Experimental Set-Up

III. RESULT AND DISCUSSIONS

3.1 Presentation of Results

The results we obtained from this experiment carried out for seventy days are presented in tables and graphs, for ease of presentation and analysis.

3.2 Tables

Table 1: Aluminum sample 1: First aluminum (coated). Thickness – 0.58mm in 0.01 mole H_2SO_4

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)²)
5	4.15	4.15	0.00	0.00000
10	4.17	4.17	0.00	0.00000
15	4.20	4.20	0.00	0.00000
20	4.20	4.19	0.01	0.00025
25	4.21	4.20	0.01	0.00025
30	4.24	4.23	0.01	0.00025
35	4.24	4.23	0.01	0.00025
40	4.27	4.26	0.01	0.00025
45	4.28	4.26	0.02	0.00050
50	4.28	4.26	0.02	0.00050
55	4.30	4.28	0.02	0.00050
60	4.31	4.29	0.02	0.00050
65	4.34	4.31	0.03	0.00075
70	4.36	4.33	0.03	0.00075

Table 2:Aluminum sample 1: First aluminum (coated) Thickness – 0.58mm in 0.01 mole NaOH

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)^2)
5	4.20	4.20	0.00	0.00000
10	4.20	4.20	0.00	0.00000
15	4.21	4.20	0.01	0.00025
20	4.22	4.21	0.01	0.00025
25	4.23	4.22	0.01	0.00025
30	4.23	4.22	0.01	0.00025
35	4.23	4.22	0.01	0.00025
40	4.25	4.24	0.01	0.00025
45	4.26	4.25	0.01	0.00025
50	4.26	4.24	0.02	0.00050
55	4.27	4.24	0.03	0.00075
60	4.28	4.25	0.03	0.00075
65	4.28	4.24	0.04	0.00100
70	4.30	4.25	0.05	0.00125

Table 3: Aluminum sample 1: First aluminum (coated) Thickness – 0.58mm in Sea water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)^2)
5	4.14	4.14	0.00	0.00000
10	4.14	4.14	0.00	0.00000
15	4.15	4.14	0.01	0.00025
20	4.16	4.15	0.01	0.00025
25	4.18	4.17	0.01	0.00025
30	4.19	4.18	0.01	0.00025
35	4.20	4.19	0.01	0.00025
40	4.20	4.19	0.01	0.00025
45	4.22	4.20	0.02	0.00050
50	4.23	4.21	0.02	0.00050
55	4.24	4.21	0.03	0.00075
60	4.24	4.21	0.03	0.00075
65	4.29	4.26	0.03	0.00075
70	4.31	4.28	0.03	0.00075

Table 4:Aluminum sample 1: First aluminum (coated) Thickness – 0.58mm in Rain water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)^2)
5	4.18	4.18	0.00	0.00000
10	4.18	4.18	0.00	0.00000
15	4.19	4.19	0.00	0.00000
20	4.21	4.20	0.01	0.00025
25	4.21	4.20	0.01	0.00025
30	4.24	4.23	0.01	0.00025
35	4.25	4.24	0.01	0.00025
40	4.25	4.24	0.01	0.00025
45	4.26	4.25	0.01	0.00025
50	4.29	4.27	0.02	0.00050
55	4.31	4.29	0.02	0.00050
60	4.31	4.29	0.02	0.00050
65	4.32	4.30	0.02	0.00050
70	4.32	4.30	0.02	0.00050

Table 5:Aluminum sample 2:Tower aluminum (uncoated) Thickness: 0.57mm in 0.01 mole H_2SO_4

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)^2)
5	3.12	3.11	0.01	0.00025
10	3.12	3.11	0.01	0.00025
15	3.14	3.13	0.01	0.00025
20	3.15	3.14	0.01	0.00025
25	3.17	3.15	0.02	0.00050
30	3.18	3.16	0.02	0.00050
35	3.19	3.16	0.03	0.00075
40	3.20	3.17	0.03	0.00075
45	3.20	3.17	0.03	0.00075
50	3.22	3.18	0.04	0.00100
55	3.23	3.19	0.04	0.00100
60	3.23	3.19	0.04	0.00100
65	3.24	3.19	0.05	0.00125
70	3.25	3.20	0.05	0.00125

Table 6:Aluminum sample 2:Tower aluminum (uncoated) Thickness: 0.57mm in 0.01 mole NaOH

Time (days)	**Initial weight (grams)**	**Final weight (grams)**	**Weight loss (Iw-Fw) (grams)**	**Specific weight loss (g/(cm)²)**
5	3.16	3.26	-0.10	-0.00250
10	3.16	3.28	-0.12	-0.00300
15	3.17	3.30	-0.13	-0.00325
20	3.18	3.32	-0.14	-0.00350
25	3.18	3.32	-0.14	-0.00350
30	3.19	3.31	-0.14	-0.00350
35	3.21	3.35	-0.14	-0.00350
40	3.21	3.35	-0.14	-0.00350
45	3.22	3.37	-0.15	-0.00375
50	3.22	3.39	-0.17	-0.00425
55	3.24	3.46	-0.22	-0.00550
60	3.25	3.48	-0.23	-0.00575
65	3.25	3.48	-0.23	-0.00575
70	3.26	3.51	-0.25	-0.00625

Table 7:Aluminum sample 2:Tower aluminum (uncoated) Thickness: 0.57mm in Sea Water

Time (days)	**Initial weight (grams)**	**Final weight (grams)**	**Weight loss (Iw-Fw) (grams)**	**Specific weight loss (g/(cm)²)**
5	3.11	3.11	0.00	0.00000
10	3.13	3.13	0.00	0.00000
15	3.14	3.13	0.01	0.00025
20	3.15	3.14	0.01	0.00025
25	3.15	3.14	0.01	0.00025
30	3.17	3.16	0.01	0.00025
35	3.18	3.16	0.02	0.00050
40	3.19	3.17	0.02	0.00050
45	3.21	3.18	0.03	0.00075
50	3.22	3.19	0.03	0.00075
55	3.22	3.18	0.04	0.00100
60	3.23	3.18	0.05	0.00125
65	3.24	3.18	0.06	0.00150
70	3.24	3.18	0.06	0.00150

Table 8:Aluminum sample 2:Tower aluminum (uncoated) Thickness: 0.57mm in Rain Water

Time (days)	**Initial weight (grams)**	**Final weight (grams)**	**Weight loss (Iw-Fw) (grams)**	**Specific weight loss (g/(cm)²)**
5	3.12	3.11	0.01	0.00025
10	3.12	3.11	0.01	0.00025
15	3.14	3.13	0.01	0.00025
20	3.15	3.13	0.02	0.00050
25	3.18	3.16	0.02	0.00050
30	3.19	3.17	0.02	0.00050
35	3.19	3.16	0.03	0.00075
40	3.18	3.15	0.03	0.00075
45	3.20	3.17	0.03	0.00075
50	3.21	3.17	0.04	0.00100
55	3.21	3.17	0.04	0.00100
60	3.23	3.18	0.05	0.00125
65	3.23	3.17	0.06	0.00150
70	3.25	3.19	0.06	0.00150

Table 9: Steel sample 1: Swan Milligram (uncoated) Thickness: 0.19mm in 0.01 mole H_2SO_4

Time (days)	**Initial weight (grams)**	**Final weight (grams)**	**Weight loss (Iw-Fw) (grams)**	**Specific weight loss (g/(cm)²)**
5	5.80	5.80	0.00	0.00000
10	5.82	5.81	0.01	0.00025
15	5.83	5.82	0.01	0.00025
20	5.83	5.81	0.02	0.00050
25	5.85	5.83	0.02	0.00050
30	5.86	5.83	0.03	0.00075
35	5.89	5.86	0.03	0.00075
40	5.90	5.86	0.04	0.00100
45	5.92	5.86	0.06	0.00150
50	5.94	5.86	0.08	0.00200
55	5.94	5.85	0.09	0.00225
60	5.95	5.85	0.10	0.00250
65	5.97	5.87	0.10	0.00250
70	5.99	5.87	0.12	0.00300

Table 10: Steel sample 1: Swan Milligram (uncoated) Thickness: 0.19mm in 0.01 mole NaOH

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss $(g/(cm)^2)$
5	5.78	5.78	0.00	0.00000
10	5.81	5.80	0.00	0.00000
15	5.83	5.80	0.01	0.00075
20	5.83	5.80	0.01	0.00075
25	5.85	5.81	0.01	0.00100
30	5.86	5.81	0.02	0.00125
35	5.87	5.80	0.02	0.00175
40	5.88	5.80	0.03	0.00200
45	5.92	5.84	0.03	0.00200
50	5.94	5.85	0.03	0.00225
55	5.95	5.85	0.06	0.00250
60	5.98	5.87	0.06	0.00275
65	6.00	5.87	0.07	0.00325
70	6.01	5.87	0.08	0.00350

Table 11: Steel sample 1: Swan Milligram (uncoated) Thickness: 0.19mm in Sea Water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss $(g/(cm)^2)$
5	5.79	5.78	0.01	0.00025
10	5.82	5.81	0.01	0.00025
15	5.83	5.81	0.02	0.00050
20	5.84	5.82	0.02	0.00050
25	5.85	5.83	0.02	0.00050
30	5.86	5.83	0.03	0.00075
35	5.89	5.86	0.03	0.00075
40	5.90	5.86	0.04	0.00100
45	5.92	5.88	0.04	0.00100
50	5.94	5.89	0.05	0.00125
55	5.94	5.89	0.05	0.00125
60	5.95	5.90	0.05	0.00125
65	5.96	5.90	0.06	0.00150
70	5.98	5.91	0.07	0.00175

Table 12:Steel sample 1: Swan Milligram (uncoated) Thickness: 0.19mm in Rain water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss $(g/(cm)^2)$
5	5.82	5.82	0.01	0.00000
10	5.82	5.82	0.01	0.00000
15	5.83	5.82	0.04	0.00025
20	5.84	5.83	0.05	0.00025
25	5.85	5.83	0.06	0.00050
30	5.87	5.83	0.07	0.00100
35	5.89	5.85	0.07	0.00100
40	5.90	5.86	0.07	0.00100
45	5.92	5.88	0.07	0.00100
50	5.94	5.89	0.08	0.00125
55	5.94	5.89	0.08	0.00125
60	5.95	5.90	0.09	0.00125
65	5.97	5.91	0.10	0.00150
70	5.98	5.92	0.10	0.00150

Table 13: Steel sample 2: Double hand (uncoated). Thickness: 0.22mm in 0.01 mole H_2SO_4

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss $(g/(cm)^2)$
5	5.98	5.97	0.05	0.00125
10	5.99	5.97	0.03	0.00075
15	6.01	5.98	0.02	0.00050
20	6.03	5.99	-0.01	-0.00025
25	6.04	5.98	-0.01	-0.00025
30	6.06	5.99	-0.03	-0.00075
35	6.06	5.95	-0.04	-0.00100
40	6.08	5.94	-0.05	-0.00125
45	6.09	5.92	-0.06	-0.00150
50	6.11	5.92	-0.07	-0.00175
55	6.12	5.92	-0.09	-0.00225
60	6.14	5.91	-0.11	-0.00275
65	6.14	5.90	-0.14	-0.00350
70	6.16	5.89	-0.15	-0.00375

Table 114: Steel sample 2: Double hand (uncoated). Thickness: 0.22mm in 0.01 mole NaOH

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)²)
5	6.00	6.00	0.00	0.00000
10	6.00	6.00	0.00	0.00000
15	6.01	6.00	0.01	0.00025
20	6.03	6.02	0.01	0.00025
25	6.04	6.03	0.01	0.00025
30	6.05	6.03	0.02	0.00050
35	6.06	6.04	0.02	0.00050
40	6.07	6.05	0.02	0.00050
45	6.09	6.07	0.02	0.00050
50	6.10	6.07	0.03	0.00075
55	6.12	6.09	0.03	0.00075
60	6.14	6.11	0.03	0.00075
65	6.16	6.12	0.04	0.00100
70	6.17	6.12	0.05	0.00125

Table 15: Steel sample 2: Double hand (uncoated). Thickness: 0.22mm in Sea Water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)²)
5	5.97	5.97	0.00	0.00000
10	5.99	5.98	0.01	0.00025
15	6.01	5.98	0.03	0.00075
20	6.03	6.00	0.03	0.00075
25	6.04	6.00	0.04	0.00100
30	6.05	6.00	0.05	0.00125
35	6.06	6.01	0.05	0.00125
40	6.08	6.02	0.06	0.00150
45	6.09	6.03	0.06	0.00150
50	6.11	6.05	0.06	0.00150
55	6.13	6.07	0.06	0.00150
60	6.14	6.07	0.07	0.00175
65	6.14	6.06	0.08	0.00200
70	6.15	6.07	0.08	0.00200

Table 16: Steel sample 2: Double hand (uncoated). Thickness: 0.22mm in Rain Water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)²)
5	5.99	5.99	0.00	0.00000
10	5.99	5.98	0.01	0.00025
15	6.01	5.99	0.02	0.00050
20	6.03	5.99	0.04	0.00100
25	6.04	5.99	0.05	0.00125
30	6.06	5.99	0.07	0.00175
35	6.06	5.98	0.08	0.00200
40	6.08	6.00	0.08	0.00200
45	6.09	6.00	0.09	0.00225
50	6.11	6.02	0.09	0.00225
55	6.12	6.03	0.09	0.00225
60	6.13	6.03	0.10	0.00250
65	6.14	6.04	0.10	0.00250
70	6.18	6.07	0.11	0.00275

Table 17: Plastic Sample 1 in 0.01 mole H_2SO_4

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)²)
5	3.40	3.40	0.00	0.00000
10	3.45	3.44	0.01	0.00025
15	3.45	3.44	0.01	0.00025
20	3.46	3.45	0.01	0.00025
25	3.52	3.51	0.01	0.00025
30	3.52	3.51	0.01	0.00025
35	3.57	3.56	0.01	0.00025
40	3.57	3.55	0.02	0.00050
45	3.61	3.59	0.02	0.00050
50	3.63	3.61	0.02	0.00050
55	3.68	3.65	0.03	0.00075
60	3.71	3.68	0.03	0.00075
65	3.72	3.68	0.04	0.00100
70	3.76	3.72	0.04	0.00100

Table 18: Plastic Sample 1 in 0.01 mole NaOH

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)^2)
5	3.41	3.41	0.00	0.00000
10	3.43	3.42	0.01	0.00025
15	3.44	3.43	0.01	0.00025
20	3.44	3.43	0.01	0.00025
25	3.46	3.45	0.01	0.00025
30	3.47	3.46	0.01	0.00025
35	3.49	3.48	0.01	0.00025
40	3.51	3.49	0.02	0.00050
45	3.51	3.49	0.02	0.00050
50	3.52	3.50	0.02	0.00050
55	3.53	3.50	0.03	0.00075
60	3.54	3.51	0.03	0.00075
65	3.55	3.52	0.03	0.00075
70	3.55	3.51	0.04	0.00100

Table 19: Plastic Sample 1 in Sea Water

Time (days)	Initial weight (grams)	Final weight (grams)	Weight loss (Iw-Fw) (grams)	Specific weight loss (g/(cm)^2)
5	3.36	3.36	0.00	0.00000
10	3.38	3.38	0.00	0.00000
15	3.40	3.40	0.00	0.00000
20	3.41	3.41	0.00	0.00000
25	3.42	3.41	0.01	0.00025
30	3.45	3.44	0.01	0.00025
35	3.47	3.46	0.01	0.00025
40	3.49	3.48	0.01	0.00025
45	3.50	3.48	0.02	0.00050
50	3.51	3.49	0.02	0.00050
55	3.51	3.49	0.02	0.00050
60	3.53	3.50	0.03	0.00075
65	3.55	3.52	0.03	0.00075
70	3.58	3.55	0.03	0.00075

Table20: Asbestos sample 1: (colorless) in atmospheric environment

Time (days)	Initial weight (grams)	Final weight(Fw) (grams)	Weight gain (Fw-Iw) (g)
5	12.00	12.57	0.57
10	12.85	13.57	0.72
15	12.95	13.70	0.85
20	13.20	14.25	1.05
25	13.40	14.57	1.17
30	13.65	14.96	1.31
35	13.80	15.30	1.50
40	14.05	15.77	1.72
45	14.25	16.11	1.86
50	14.50	16.51	2.01
55	14.70	17.02	2.32
60	14.78	17.33	2.55
65	14.90	17.50	2.60
70	14.98	17.69	2.71

Table 21: Asbestos sample 2:(colored) in atmospheric environment

Time (days)	Initial weight (grams)	Final weight (grams)	Weight gain (Fw-Iw) (grams)
5	12.35	12.79	0.44
10	12.48	12.99	0.51
15	12.63	13.27	0.64
20	12.77	13.47	0.70
25	12.86	13.81	0.95
30	13.09	14.16	1.07
35	13.21	14.37	1.16
40	13.35	14.58	1.23
45	13.48	14.90	1.42
50	13.65	15.14	1.49
55	13.72	15.25	1.53
60	13.95	15.57	1.62
65	14.20	15.91	1.71
70	14.58	16.61	2.03

3.3 Graphs

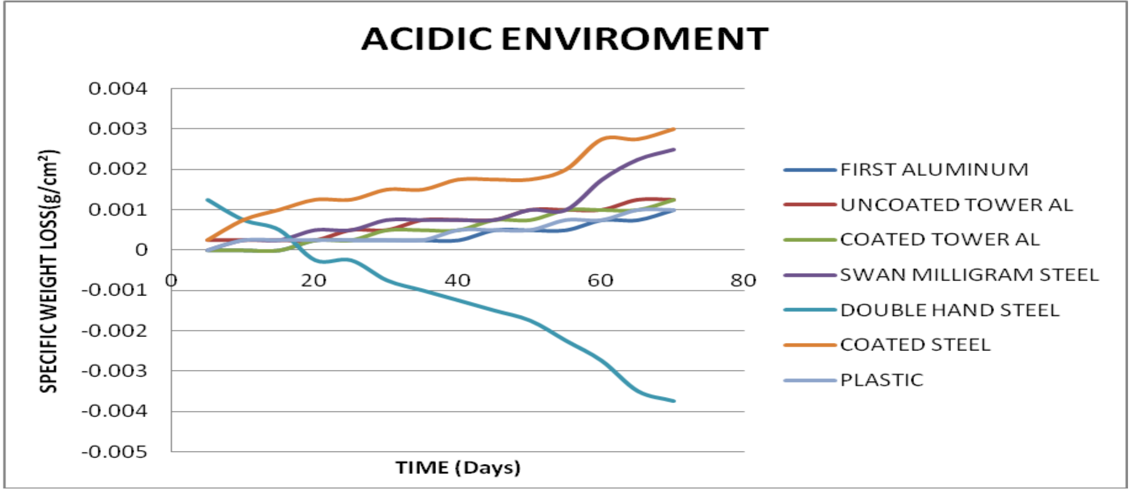

Fig.2: Rates of corrosion of the different samples in the acidic environment, 0.01 mole H_2SO_4.

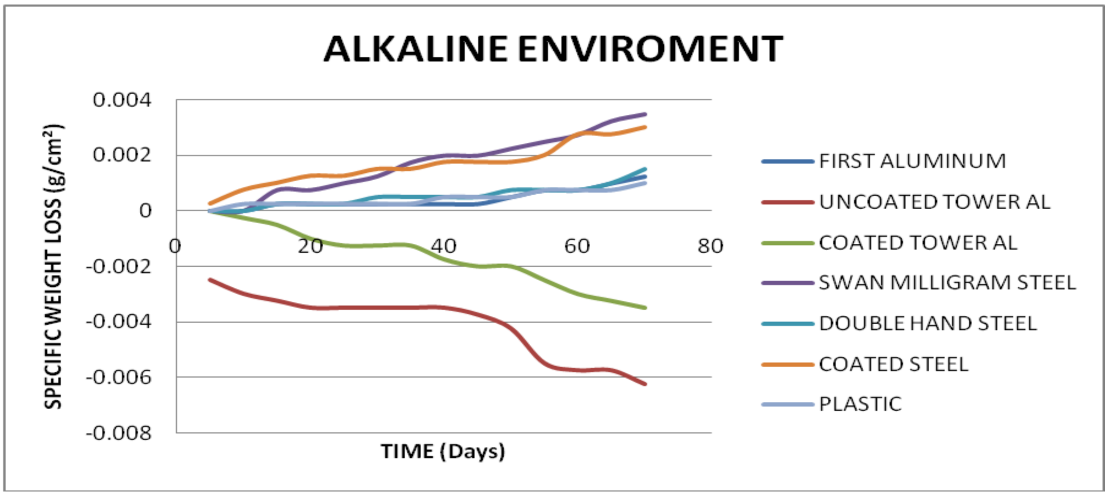

Fig.3: Rate of corrosion of the different samples in alkaline environment, 0.01 mole NaOH.

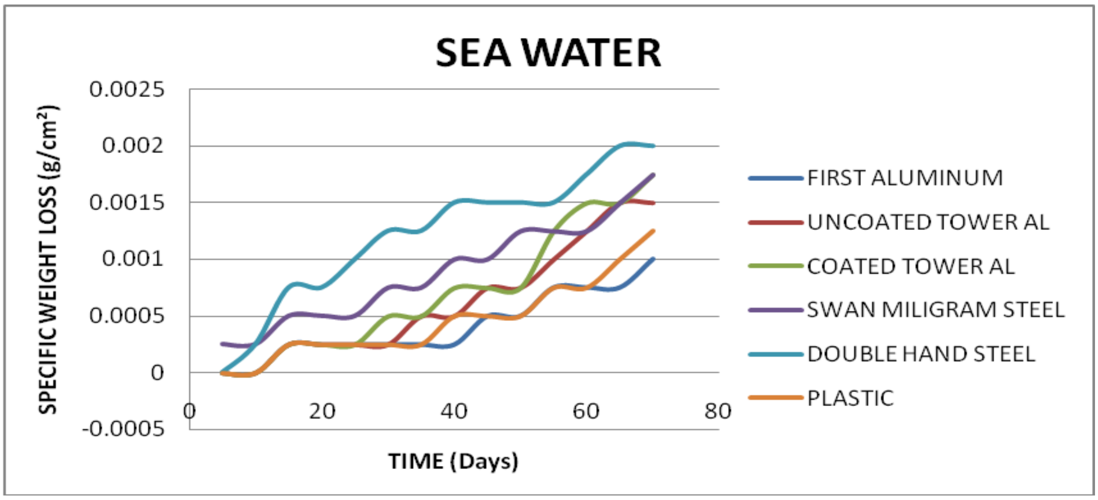

Fig.4: Rate of corrosion of the different samples in sea water environment.

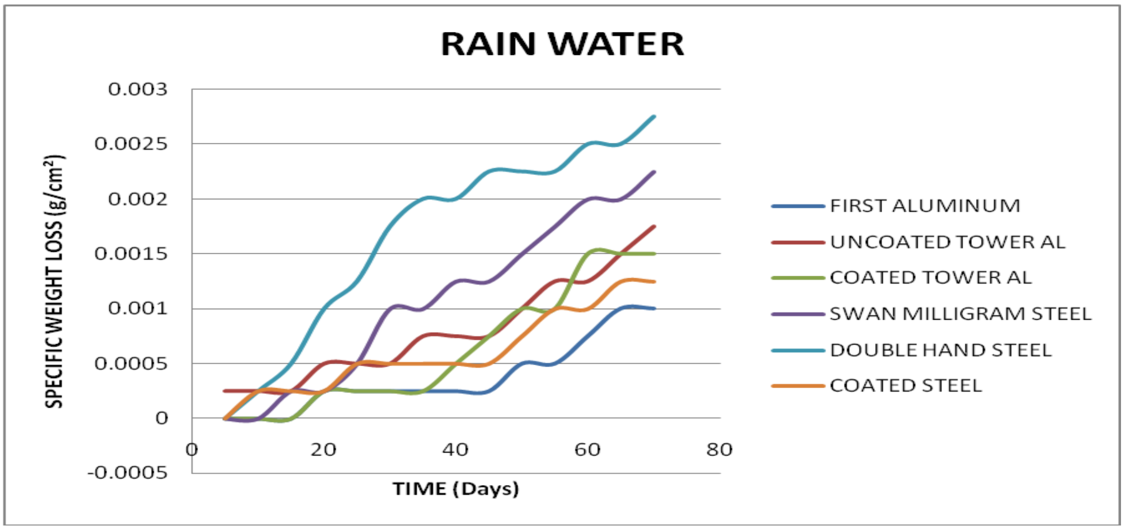

Fig.5: Rate of corrosion of the different samples in rain water environment.

IV. DISCUSSIONS AND OBSERVATIONS

4.1 Acidic Environment

At the beginning of the experiment, the pH of the acidic medium was 2, but it increased gradually to 4 as the experiment progressed. This was due to the formation of corrosion films in the medium.

4.1.1 First Aluminum Sample: It was observed that there was minimal weight loss which may be as a result of the presence of a high amount of aluminum in the sample. The elements the sample was alloyed with increased its strength and caused it to resist corrosion to a reasonable extent.

4.1.2 Tower Aluminum (Uncoated) Sample: There was a visible change in appearance. However the alloying materials may have induced corrosion and given rise to the formation of intermediate products.

4.1.3 Tower Aluminum (Coated) Sample: It progressively deteriorated in the course of the experiment. There was no weight gain rather we observed insignificant weight loss. It is possible that this sample maybe purely aluminum and hence is known to resist rusting. Though rusting did occur but the level was insignificant.

4.1.4 Swan Milligram Sample: Weight loss was observed, it is possible that the thickness of the galvanizing material (zinc) was very small. The chemical content of the medium (sulphur oxide) has been known to increase in galvanized steel. [35]

4.1.5 Double hand Sample: Initially this sample experienced weight loss and then weight gain. It may be an alloy containing some other elements which induce electrolysis which brought about deposition and formation of heavier or intermediate compounds deposited on the sample.

4.1.6 Green coated Sample: There was irregularity in weight loss and this can be attributed to changes in weather and atmospheric condition of our environment.

We observed that the acid attacked the paint used in coating the sheet, therefore, we suspect that the paint used for the coating is inferior, and could not properly protect the metal from corrosion.

Steel is a heavy metal and as acid reacts with it, it forms oxides and chlorides of the metal which pull out of the metal and go into the solution. Hence giving rise to weight loss.

4.1.7 Plastics: There was little or no significant weight loss. Plastics do not encourage microbial degradation that promotes rusting or degradation. They equally react with environmental acid but the level of the reaction is low, perhaps due to the unsaturated nature of the polymer.

4.2 Alkaline Environment

The pH of this medium reduced from 11 to 8 as the experiment progressed. This is due to the formation of oxide films that dissolved in the medium, thereby making the pH of the solution tend towards neutral.

4.2.1 First Aluminum Sample: There was insignificant loss in weight but as of the 60th day of the experiment, it was observed that sheet has lost its shiny appearance and there was very little powdery substance on the surface of the metal. This didn't give rise to weight loss because it was in minute quantities.

4.2.2 Tower Aluminum Uncoated Sample: There was significant weight gain as a result of the reaction of aluminum with NaOH.

$2Al_3 + 9NaOH \rightarrow 3Al_20_3 + {}^{9/}{}_2H_2 + 9Na$

Aluminum oxide is an intermediate that is formed and it is heavier than the base metal. This can be due to electrolytic reaction as sodium metal is more reactive than aluminum which turns deposit on the aluminum samples.

4.2.3 Tower Aluminum Coated Sample: There was significant weight gain as a result of the reaction of aluminum with NaOH.

$2Al_3 + 9NaOH \rightarrow 3Al_20_3 + {}^{9/}{}_{2}H_2 + 9Na$

Aluminum oxide is an intermediate that is formed and it is heavier than the base metal.

4.2.4 Swan Milligram Steel Sample: There was a progressive weight loss observed in this sample with deposits in the alkaline solution. This may have been as a result of intermediates formed but maybe they weren't heavier than the base metal.

4.2.5 Double Hand Steel Sample: Weight loss was observed but wasn't significant. This could be as a result the trace elements present in the sample, which helped to reduce the rate of corrosion.

4.2.6 Green Coated Steel Sample: There was a progressive weight loss observed in this sample with brownish deposits in the alkaline solution but not as much as that in the swan milligram. This may have been as a result of intermediates formed but maybe they weren't heavier than the base metal.

4.2.7 Plastic: There was little or no significant weight loss. Plastics don't encourage microbial degradation that promotes rusting or degradation. They equally react with environmental acid but the level of the reaction is low, perhaps due to the unsaturated nature of the polymer.

4.3 Sea Water Environment

The pH of this medium was 6, which was constant throughout the period of the experiment.

4.3.1 First Aluminum Sample: The rate of corrosion of this sample was insignificant. The salt in the medium was deposited on the metal surface.

4.3.2Tower Aluminum (Uncoated) Sample: The weight loss observed in this medium was not significant. The sample deteriorated visibly with time.

4.3.3Tower Aluminum (Coated) Sample: The uncoated side of the sample was experienced more attached than the coated side. Thus the rate of attach was insignificant when compare with uncoated tower aluminum.

$Al + 3NaCl \rightarrow AlCl_3 + 3Na$

The sodium metal formed from the reaction above attaches the surface of the aluminum sample.

4.3.4 Swan Milligram Steel: During the period of this experiment this sample experienced more attack than the aluminum sample this is due to the fact that oxidation of iron is more rapid than aluminum.

4.3.5 Double Hand Steel Sample: Weight loss was observed but wasn't significant. This could be as a result the trace elements present in the sample, which helped to reduce the rate of corrosion.

Some metals have naturally slow reaction kinetics, even though their corrosion is thermodynamically favorable. These include such metals as zinc, magnesium, and cadmium. While corrosion of these metals is continuous and ongoing, it happens at an acceptably slow rate. This is the why these metals are used as alloying element.

V. CONCLUSION

Generally, coated or painted samples are preferred to uncoated samples in most of the media. This is the reason why most coated samples did not corrode in their respective media. Based on the results of our experiment, First Aluminum (Al sample 1) was recommended as the best roofing sheet in Nigeria. This is due to fact that, the sample retained its shiny appearance in control medium (rain water) throughout the 70days of the experiment. The rate of weight loss in acidic and alkaline media was highly insignificant. Although plastic sample did not corrode during the period of our experiment, its low temperature resistance makes it not suitable for roofing because it becomes brittle on continuous expansion and contraction and it is not fireproof. In conclusion, aluminum samples are highly reactive in alkaline medium and thus it is not advisable to use them in alkaline-prone environments. The steel samples are highly reactive in acidic environments, care should be taken to ensure that they are always coated and crack free at all times, to avoid exposure of the surface to the acids.

Though galvanizing with zinc protects it from corrosion, in the presence of sulphur compounds, which are present in highly industrial urban areas, the presence of the zinc aids corrosion. Therefore, galvanized products have a shorter life span in urban industrial areas than in rural unindustrialized areas.

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