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VALIDATION OF CORROSION STATUS OF SOME ROOFING SHEETS UTILIZED IN GOMBE METROPOLIS

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ABSTRACT

The study was aim at investigation the level of corrosion on roofing sheets utilized in Gombe where acid and alkaline medium immersion test of 25 days showed that light zinc (0.15 mm) sample decreased in weight from 0.03g to 0.04 g while the 2.0mm zinc decreased in weight range of 0.01g to 0.04 g in the alkaline solution. Samples of thick aluminum (5.5 mm) and light aluminium(4.5mm) showed insignificant weight range 0.0g to 0.03 g after immersion in alkaline. In acidic medium both light and thick zinc showed greater weight lost 0.05g to 0.08g. However both the thick and light aluminium showed loss of their shiny appearance only with no renowned significant corrosion throughout the twenty-five days of immersion. XRF analysis of the oxides on the corrosion samples of 0.15mm zinc showed decreasing pattern of: Fe2O3 > SiO2.> Na2O >Al2O3 > MnO > CaO respectively. The decreasing order of the percentage of oxides on 2.0mm zinc: Fe2O3 > SiO2 .>Al2O3 > CaO > MnO oxides on 4. 5mm. Aluminium is in decreasing order of; Al2O3 > SiO2.> Fe2O3 > CaO > K2O . On the other side percentage of the oxides of 5.0mm Aluminium is Al2O3 > SiO2 > MnO respectively. Aluminium samples are more durable and resistant which indicates suitability for roofing than zinc sheets.

Keywords: Corrosion, Oxides, Weight, Alumium, Zinc

INTRODUCTION

Roofing sheets act as a very vital tools as building materials required for human shelter, it also a provides beautiful and elegance structures that serves as a form of covering to a building. Shelter acquisition is a first mandatory skill of Man among most vital components that protected him from environmental and other complicated hazards of conflict risks. High demands of roofing sheets in the market for constructions of social amenities constituting a Roofing sheets of various types, sizes, colors, strength, durability, quality as reported by Abdulkarim *et al.*, (2009). However, some of these roofing sheet are constantly affected by Corrosion, which is a natural deterioration or destruction of a substances mostly metals as a result of the chemical and electrochemical interaction with various environment.

Corrosion imminent severe unfavorable effect in our environment and ecosystems, which constitutes environmental pollution, economical losses, corrosion form rusting of roofing sheets surfaces and machines parts which require greater repairs or replacement thereby incurring high cost. Corrosion environmental effects is synonymous to the deterioration of oil tanks, pipelines etc. which leads to water and land pollution. Several measures that may reduce corrosion on metallic surfaces includes plant extract inhibition in aggressive media, electroplating and also painting of the metal. The corrosion rate is generally high during the first year of exposure after which it decreases with prolonged exposure period. On a time scale it usually reaches an almost constant level. High corrosion rates can be attributed to high concentrations of air pollutants such as SO_2 , NO_2 , and O_2 in the atmosphere (Ubuoh *et al*., 2017).

Corrosion also occurs in acidic substances in contacts with metals such as iron, rusting will occur instantly as iron is oxidized after being exposed to oxygen and water. When iron is exposed to water its particles are lost to the water acidic electrolytes, the iron then becomes oxidized. The process of corrosion reaction is divided into an anodic portion and cathodic portions occurring simultaneously at discrete points on metallic surfaces through flow of electrons from anodic to the cathodic area by redox reaction. (Abdulkarim *et al*., 2009)

MATERIALS AND METHODS

Sample collection

Zinc and Aluminum roofing sheets samples were purchase from Gombe main market, Gombe State Nigeria. The sample are categorized as; Zinc sample A1(light), Zinc sample A2 (Thick), Aluminum sample A1 (4.5mm), Aluminum sample A2 (4.5mm), Asbestos sample as adopted by Joseph *et al.*, (2021).

Sample Preparations

The four samples of roofing sheets adopted for this research work were arranged, identified and classified as follows: -The samples obtained were cut in the same dimension of 4 cm by 4cm using a pair of scissors and measured out using a meter rule. The slices of roofing sheets samples were washed properly to ensure no dirt or oil stain was coated at their surfaces and then dried.

The samples were labelled using a masking tape for easy identification, the beakers used for immersion rest were also properly tagged to avoid mixing the reagent. The samples were then weighed accurately using an electrical digital weighing balance and the values of their initial weight were recorded as adopted by Abdulkarim *et al*., (2009).

Media Preparation

The samples for analysis were soaked in the solution of 0.5 M Tetraoxosulphate (VI) acid and 0.5M Sodium Hydroxide Then the solution were left to stand for 25 days for corrosion to take place.

The acidic solution of this experiment was prepared by dissolving 1.5 ml of sulphuric acid using 250 ml of deionized water and pH of 3.0 was obtained.

The alkaline medium was also prepared by dissolving 16 grams of sodium hydroxide in 250 ml of deionized water and pH of 10 was obtained as adopted by Ujam *et al*., (2014).

Sample immersion

The roofing sheets samples prepared were immersed individually into the acidic and alkaline solutions as mentioned above, four pieces of each samples under investigation were placed in the different containers of the prepared solutions that was kept for 25 days. After every five days one sample from each of the medium was removed and rinsed thoroughly with deionized water to remove residue of the solution in order to avoid further reactions and then reweighed to get the final weight. All reactions were also observed and recorded as adopted by Ujam *et al*., (2014) with few modification.

Study Area

Gombe State is located in northeastern part of Nigeria that shared border with the state of Borno and Yobe, to the south by Taraba state, to the southeast by Adamawa State, and to west by Bauchi State. Gombe, is located at Nigeria country who's Cities was placed in category with the GPS coordinates of *10° 16' 59.9988'' N and 11° 10' 0.0012'' E*.

Gombe State is among the 21 largest and Populated States in Nigeria and also among the 32nd most viable economic and populous state with an estimate population of about 3.26 million as of 2016 population census. The state exhibits rapid development due to patriotism of the indigenes to develop their state to interact with other states of the federation of Nigeria. Hence viable buildings require roofing sheets were Aluminium and Zinc are constantly utilized.

Figure 1: Map of Gombe State showing Gombe Metropolis

X-Ray Fluorescence Analysis

Powdered form of the samples of the roofing sheets of about 2 g was accurately weighed as samples from mine site and it was separately placed in crucibles and taken to furnace then it was heated for 30 minutes at 970 ^{OC} which removed moisture and other impurities. The content was then allowed to cool and 1g of sample roofing sheet was weighed and mixed in a platinum crucible with 8 small spatula spoon of Flux crystals containing 80% lithium tetra borate, 20 % lithium meta-borate was added with 1cm^3 of 4 % lithium bromated solution in a platinum crucible. All the contents of additives were poured into the burner with the help of crucible that instantly turned them into a mold, which was then placed into a fusion machine that analyzed the oxides percentage displayed on screen of computer.

Other required items are Acetylene and other composite with oxygen compressor sources was applied to the machine at 4bar, 0.8bar and 6bar pressures respectively. The compressor bottom nozzle was open to discharge water contaminants, and then XRF burner was switch on and regulated that made the fused beat within 15 minutes. Crucible contents were drained into the oppositely placed platinum mold automatically after frequents shaken by the machine which was allowed to cool for 10 minutes. The fused glass galena samples or pellets was made from the burner, which was removed and placed in a XRF detector machine that automatically detected the compositions of the sample metallic oxides with their respective concentrations in percentage on the computer screen attached to the machine, as adopted by Usman *et al., (*2020)

RESULTS AND DISCUSSION

Corrosion on Zinc in Alkaline Medium

The results obtained by the immersion of light zinc sample (0.15 mm) was carried out for the period of twenty-five days, immersion period showed observable features of the corrosion effects on the zinc samples. Figure 2 showed that Zinc sheet sample which is the light zinc was observed to decrease in weight from 0.03 g to 0.04 g in the alkaline solution and no significant or visible appearance of corrosion sign were was observed, this is because rusting of iron do occur in the presence of H^+ and alkaline medium neutralizes the H^+ ions and inhibits the corrosion process.

Thick Zinc (0.2 mm) was observed to have a very slight decrease in weight ranging from 0.01g to 0.04 g on the different samples analyzed and no change in visible appearance of corrosion was observed. The result obtain was slightly greater than 0.03 g decrease in weight loss Abdulkarim *et al.*, 2009 in the study of Roofing Sheets to Acid Rain Water in Eleme Rivers, Nigeria.. This is because alkaline medium does not corrode zinc easily due to their basicity, Oxide layers are formed over zinc sheet surface thus causing resistance to corrosion.

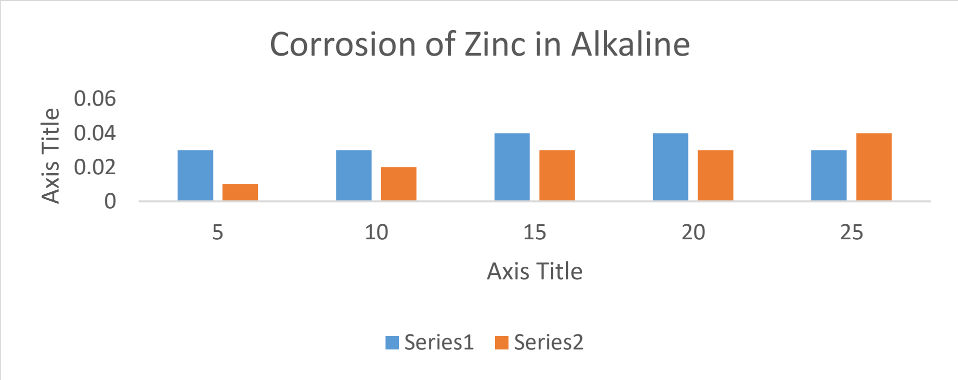

Figure 2: Zinc corrosion in Alkaline Medium

Corrosion on Aluminium in Alkaline Medium

Aluminum sheet sample which is light Aluminum (4.5mm) in alkaline media showed insignificant weight loss of 0.02 to 0.05 g within 25 day of immersion and white powdered particles adhere on the surface of the sheets as illustrated in Figure 3, however the change in weight lost fluctuated with change due to exposure time. Also the coating on Aluminum sheets was perceived to be wearing off a little which implies that the presence of high OH concentration increases the corrosion susceptibility in this environment. This sample is resistance to corrosion in alkaline medium because the hydroxides causes dissolution of metals, a higher alkaline pH will lead to higher corrosion rates, the pH was 9 for this media.

The result obtain indicated that Aluminum sheet sample (5.5mm) in alkaline medium showed decreased in weight ranging from 0.00 g in 5 days to 0.003 g in 25 days where weight lost occurred ranges from 10 to 25 day on exposure to the alkaline. Emission of white powdered particles on the surface of sample was observed this reaction was not pronounced as compare to the light aluminum sample (4.5mm) in the same alkaline medium. The result obtained showed the corrosion efficacy has occurred due to moisture and ambient temperature and other atmospheric conditions as related to the findings of Marat *et al*., (2018)

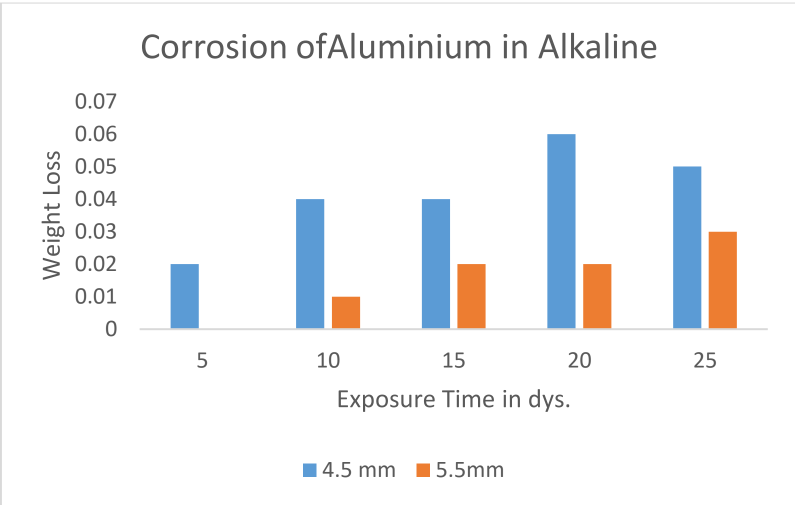

Figure 3: Aluminium corrosion in Alkaline

Corrosion of Zinc in Acidic Medium

Figure 4 shows Zinc sheet sample Light Zinc (0.15mm) with a weight loss in the sample being significant and fast ranging from 0.05g at 5 days' exposure time increases up to 0.1 g in 15 days. At 20 days' exposure time it reduced to less than 0.1 g and finally increased to 0.15 g within the 25 days exposure time. This indicated that the sample 0.15 mm zinc showed a high rate of corrosion than the other. Observations showed that immersing this samples into 0.5M sulphoric acid solution produced tiny bubbles of gas when this solution was reacting.

On the other hand, Thick Zinc 2.0 mm sample showed insignificant weight loss ranging from 0.00 g to 0.04 g, when subjected to exposure from 5 days to 25 days indicating slow corrosion rate compared to the 0.15 mm Zinc, This implied that corrosion rate decreases with increasing thickness of sheets. Thicker zinc coatings are more resistance to corrosion than lighter ones in acidic medium. The result obtained showed that corrosion efficacy in both zinc samples due to moisture and ambient temperature effects and the atmospheric conditions as related to the findings of Marat *et al*., (2018)

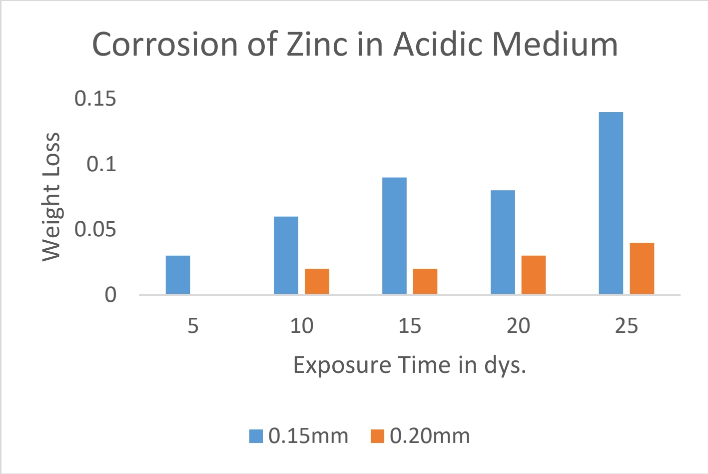

Figure 4: Zinc in Acidic Medium

Corrosion of Aluminium in Acidic Medium

Figure 5 showed light Aluminum sheet sample (0.45mm) immersed in the acidic medium exerted insignificant weight loss. However a mild colour fading was rarely prominent on this sample. Thus, this Aluminium sheets sample lost only their shiny appearance, no significant corrosion was noted throughout the twenty-five days in the acidic medium. This implies that corrosion on both samples of aluminium detected showed slight changes.

Aluminum sheet sample 5.5mm in acidic media also showed variation of sample weight loss which was very insignificant, no detrition or color change was observed, this sample did not corrode as a result of the increased coating on the sheet. The result showed that acid is readily soluble in water as it dissociates into respective ions and free hydrogen, which initiate high reactivity rate with metallic compositions. Sulphor oxides (SO_2), nitrogen oxides (NO_2) and carbon oxides (CO_2) are precursor gases, which causes increase corrosion reaction on roofing sheet from anthropogenic releases as stated by Daniel *et al*., (2021)

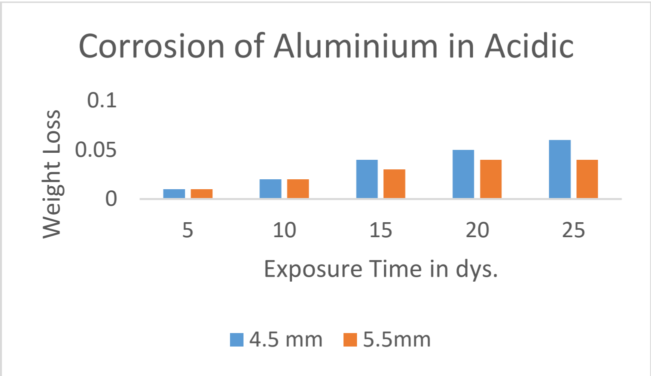

Figure 5: Aluminium in Acidic Medium

Oxides Content of Light Zinc 0.15mm

The XRF result revealed on Figure 6 showed the presence of the following oxides and their composition Na_2O (1.53 %), Al_2O_3 (0.913 %) and Fe_2O_3 (93.6 %), the Fe_2O_3 composition is the highest in percentage which explains why this sample has the highest corrosive rate, this sample will rust when it reacts with oxygen and water. The amount of ZnO obtain in light zinc sample was too negligible contradicted to the Zn metal value of 0.020 to 0.027 mg/l as obtain by Sulaiman *et al*., (2024).The result obtained showed lower corrosion effect in 0.15mm of ZnO in Zinc samples was contrary to the findings of Ubouh *et al*., (2017) which stated that formation of oxides such as ZnO from rooftop does not occurred as corrosion particles are due to effects of atmospheric conditions.

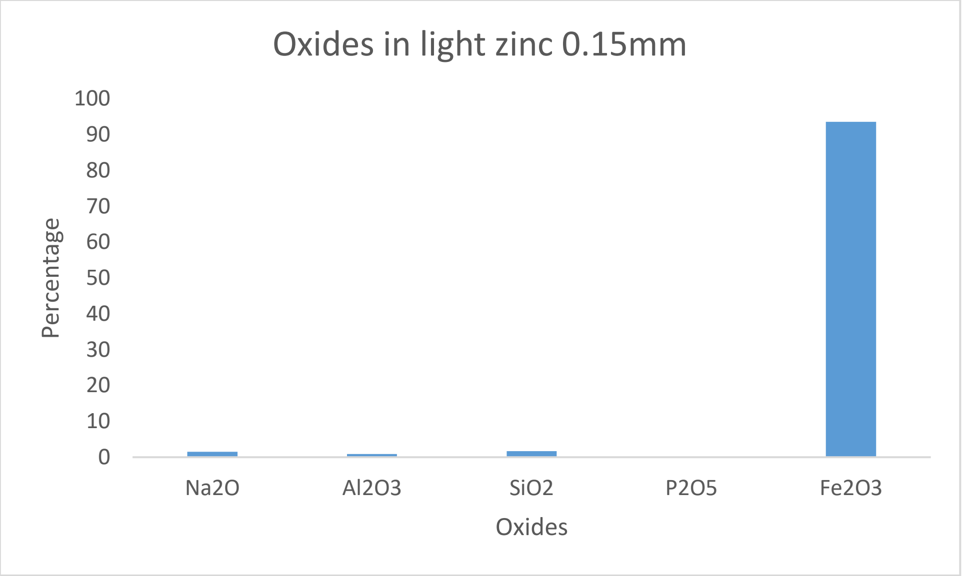

Figure 6: Oxides n Light Zinc 0.15mm

Oxides Content of Thick Zinc 0.20mm

The oxides present in the thick zinc as illustrated on Figure 7 are Al_2O_3 (1.09 %), SiO_2 (1.69 %), P_2O (0.0016%), CaO (0.138 %), MnO (0.00091 %,) and the Fe_2O_3 (31.8 %) where Fe_2O_3 has the highest percentage of oxides content which explains why the thick zinc did not show any visible change or corrosion within the immersion period unlike the light zinc because the zinc 0.20 mm has a lower percentage of Fe_2O_3 oxides content. The amount of ZnO obtained in the light zinc sample was too negligible contrary to the Zn metal value of 0.020 to 0.027 mg/l as obtained by Sulaiman *et al*., (2024). The result obtained showed greater corrosion effect in the 2.0 mm Zinc samples was similar to the findings of Ubouh *et al*., (2017) which stated that formation of phases oxides such as Fe_2O_3 and ZnO from rooftop occurred simultaneously in the corrosion on the surface of the samples which are due to effects of atmospheric conditions, but contradicted Daniel *et al*., (2012) were SO_2, NO_2, and CO_2 were absent as precursor gases, which causes increase corrosion reaction on roofing sheet from anthropogenic atmospheric released.

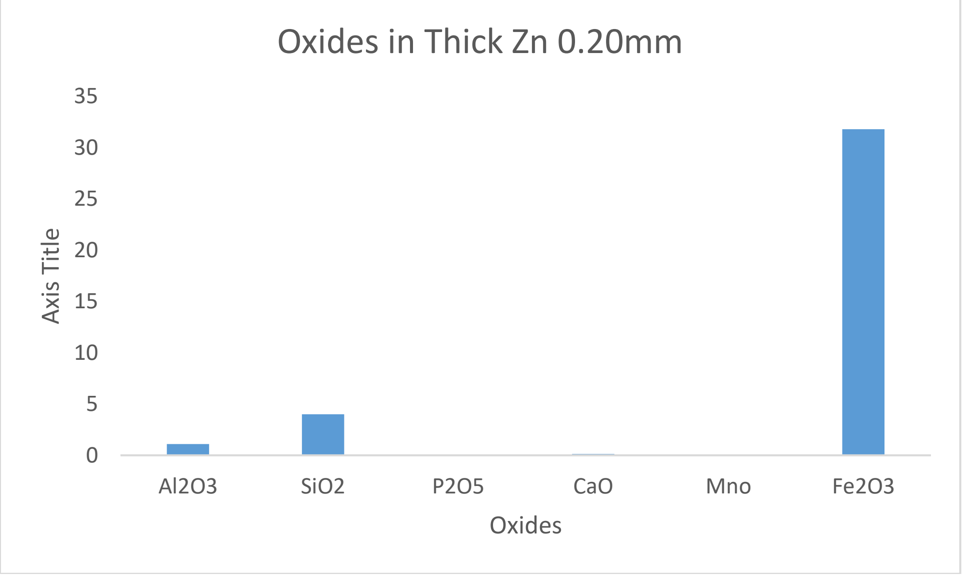

Figure 7: Oxides n Thick Zinc 0.20mm

Oxides Content of Light Aluminum 4.5mm

The XRF analysis revealed the presence of oxides on Figure 8 are; Al_2O_3 (94.1 %), SiO_2 (2.75 %), K_2O (0.0492 %), CaO (0.509 %), Fe_2O_3 (1.52 %) and Chlorine ions with 11.5 %. The chlorine ions displayed the highest percentage which assisted in corrosion process of the light Al. The result obtained indicated lower corrosion effect in 4.5 mm Aluminium samples contrary to the findings of Ubouh *et al*., (2017) which stated that formation of oxides such ZnO was absent on the rooftop and does not occur on the surfaces of corrosion samples are due to none effects of atmospheric changes. The result obtained was also contrary to the work of Daniel *et al*., (2012) were SO_2, NO_2, and CO_2 were absent as precursor gases, which causes increase corrosion reaction on roofing sheet from anthropogenic atmospheric released

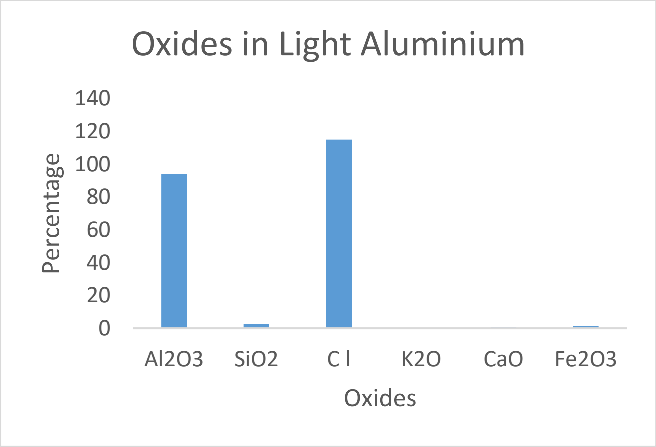

Figure 8: Oxides in Light Aluminum 4.5mm

Oxides Content of Thick Aluminum 5.5mm

The XRF result of 5.5 mm Aluminium oxides was shown in Figure 9 with the presence of SiO_2 (0.304 %), MnO (0.0038 %), Fe_2O_3 (0.178 %) and Al_2O_3 (98.8 %) has the highest percentage composition unlike for the 0.45 mm Aluminium sheet sample which explained the low corrosion rate. This indicated that result obtained with lower corrosion effect in 5.5 mm Aluminium samples was synonymous to the findings of Ubouh *et al*., (2017) which stated that formation of phases oxide such as ZnO was absent from rooftop. Corrosion occurred in minute proportion as powdered particles at the surfaces of this sample were not affected samples by atmospheric reactions. The result obtain was also contrary to Daniel *et al*., (2012) were SO_2, NO_2, and CO_2 were absent as precursor gases, which causes increase corrosion reaction on roofing sheet from anthropogenic atmospheric released

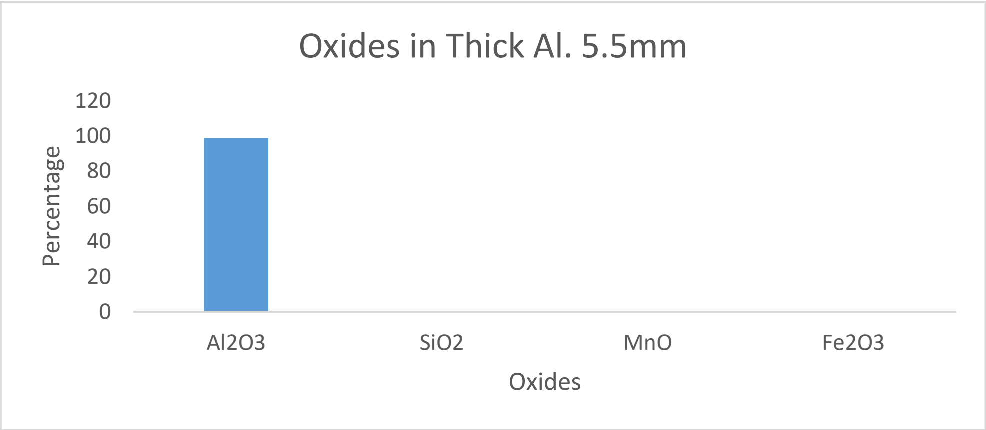

Figure 9: Oxides in Thick Aluminum 5.5mm

Comparative concentrations of Oxides in Zinc Samples

The Oxides of Light Zinc sample (0.15 mm) compositions are represented in Figure 10 whereby Fe_2O_3 = 93.6 % in 0.15 mm Zinc while Fe_2O_3 = 31.8 % in 2.0mm zinc. Al_2O_3 showed 0.913 % in 0.15 mm zinc as compared with Al_2O_3 = 1.09% in 2.0mm zinc. SiO_2 = 1.69 %, in 0.15 mm zinc (Light Zinc), while it showed SiO_2 = 4.0 % in 2.0mm (Thick zinc). P_2O_5 = 0.0016 % in 0.15 mm zinc (Light Zinc) while P_2O_5 = 0.54 % in 2.0mm (Thick zinc). Then, CaO has no value in 0.15 mm zinc (Light Zinc) while CaO = 0.14% in 2.0 mm (Thick zinc), MnO = 0.071 % in 0.15 mm zinc (Light Zinc) while MnO = 0.00091 % in 2.0mm zinc (Thick zinc). Finally, Na_2O showed only 1.53 % in 0.15mm (Light Zinc) zinc with no value in 2.0mm zinc (Thick Zinc).

The decreasing order of percentage of oxides in 0.15mm zinc (Light Zinc) is; Fe_2O_3 > SiO_2.> Na_2O >Al_2O_3 > MnO > CaO respectively. On the other side order of oxides in the 2.0mm (Thick zinc) is: Fe_2O_3 > SiO_2 .>Al_2O_3 > CaO > MnO respectively. The percentage of the oxides obtained in this study contradicted the oxides ranges from 0.024% t0 78.30% in rocks because rock served as rawmaterial more consolidated materials than roofing sheets as reported by Raliya Aminu Hayatu,(2024) also the result obtained showed greater corrosion effect in both 0.15mm and 2.0mm zinc samples was dissimilar to the findings of Ubouh *et al*., (2017) which stated that formation of phases of oxide such as ZnO from rooftop are presence as residues of corrosion that supported the atmospheric reactions. Also the result obtain contradicted the findings of Usman *et al.*, (2020) were sediments and mineral showed 1.54% and 0.13% of ZnO oxides.

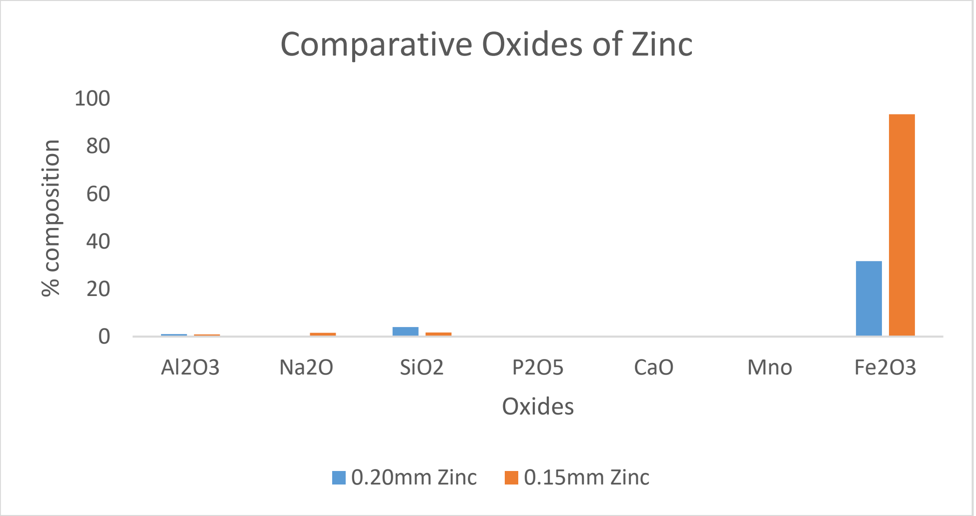

Figure 10: Comparative Oxides of Zinc Samples

Comparative Concentrations of Oxides in Aluminium Samples

The result of XRF of two Aluminium samples roofing sheets was illustrated in Figure 11 where light Aluminium (4.5 mm) are: where Fe_2O_3 = 1.52 % while Fe_2O_3 has zero or no value in Tick Aluminium (5.5mm). Al_2O_3 = 94.1 % in Light Aluminium (4.5mm) as compared with Al_2O_3 = 98.8 % in Thick Aluminium (5.5mm). SiO_2 = 2.75 %, in light Aluminium (4.5mm) while SiO_2 = 0.304 % in thick Aluminium (5.0 mm). P_2O_5 showed zero or absent in both light Aluminium (4.5 mm) and thick Aluminium (5.5mm). Then CaO = 0.509 % in light Aluminium (4.5 mm) while CaO has no value or absent in thick Aluminium(5.5 mm), MnO was absent in light Aluminium (4.5 mm) while MnO= 0.0038% in thick Aluminium (5.5 mm). Finally, K_2O = 0.05% in light Aluminium (4.5 mm) but showed no value or absent in thick Aluminium (5.5 mm).

The percentage of oxides composition obtained in decreasing order of light Aluminium showed; Al_2O_3 > SiO_2.> Fe_2O_3 > CaO > K_2O respectively. On the other side percentage of oxides in decreasing order pattern of thick Aluminium showed Al_2O_3 > SiO_2 > MnO respectively. The oxides values obtained in Aluminium roofing sheets contradicted the oxides in rocks which ranges from 0.024% t0 78.30% as reported by Raliya Aminu,(2024).The result of oxides obtained in both Aluminium samples showed lower corrosion effect also the deficiency of ZnO in both samples was contrary to the findings of Ubouh *et al*., (2017) which stated that formation of phases of oxides such as ZnO from rooftop occurred was insignificant and less prominent, thus lesser effects on atmospheric reactions also the result obtain was opposing to Usman *et al*., (2020) were the oxides of ZnO showed 1.5% and 0.13% in both sediments and Galena mineral.

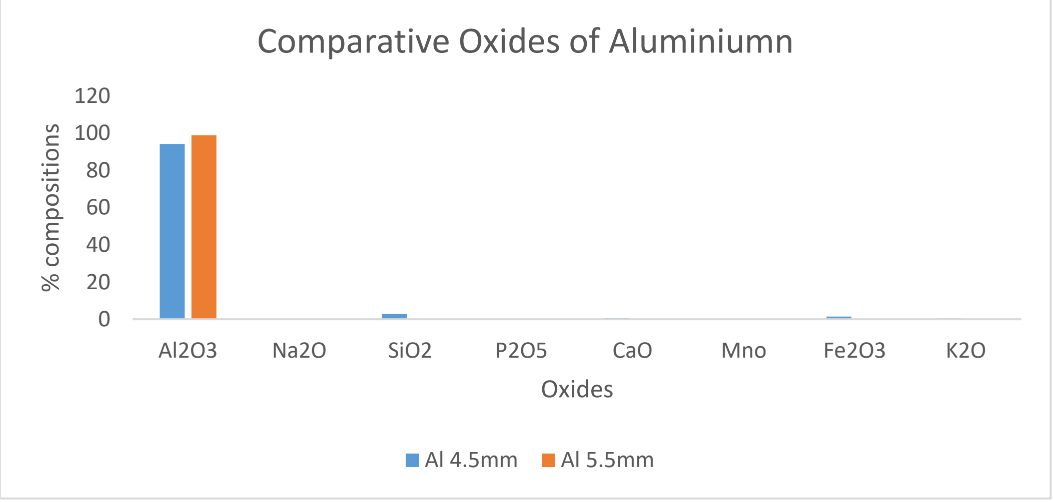

Figure 11: Comparative Oxides of Aluminium Samples

CONCLUSION

Investigations on this study showed the impact of corrosion on four sampled roofing sheets in acidic and alkaline medium of commonly utilized and sold in Gombe, Nigeria and discovered that the light zinc (0.15 mm) and light Aluminium (4.5 mm) roofing sheets are sustainable to corrosion than their counterpart of thick zinc (2.0 mm) and thick aluminum (5.5mm) respectively. Their oxides have increased deposited particles with grey and brown coloration in zinc while white powdered particle appears on the surfaces of Aluminium sheets after several days of immersion. Statistical model on the result obtained by assessment of student test showed $p < 0.05$ which indicated significant effect.

Level of corrosion was more pronounce in light zinc (0,15 mm) than in thick zinc (2.0mm) and also the same changes was showed by light Aluminium (4.5mm) than thick

Aluminium (5.5 mm) which was attributed to atmospheric climate and other pollutants. Oxides of Fe_2O_3 revealed high concentration in both samples analyzed but are more frequent as the product of substantial redox reaction occurring than other oxides analyzed at surface of roofing sheets that reduces the durability and protective covering power of roofing sheets.

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