INTERNATIONAL JOURNAL OF NATURAL AND APPLIED SCIENCES (IJNAS), VOL. 6, NOS.1& 2 (2011); P. 9 – 13, 1TABLE, 4 FIGS.

Comparative study of the atmospheric corrosion of zinc- coated iron sheets in the south- eastern part of the Niger delta, Nigeria

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ABSTRACT

The investigation on the atmospheric corrosion of zinc coated iron sheets at three stations (Iko, Berger Camp and Utaewa) in the South South Geopolitical zone of Nigeria was carried out for a period of 12 months. A fabricated sampling stand with a newly purchased and pre-cleaned zinc coated iron roofing sheet was used from which direct rainwater (DRW) and roof rainwater (RRW) samples were collected. Zinc coated roofing sheet coupons were mounted and placed at each location. The coupons were exposed in order to determine corrosion rates using their weight losses. Physicochemical parameters like pH, Cl-, electrical conductivity and others were determined in the rainwater samples. The corrosion rates of the coupons exposed to the atmosphere were as follows: Iko (6.37×10^{-3}mgdm^{-1} day^{-1}), Utaewa (6.07×10^{-3}mgdm^{-2}day^{-1}) and Berger Camp (4.08×10^{-3}mgdm^{-2}day^{-1}). Similarly the level of acidity of rainwater samples from the pH levels determined followed the same trend: Iko > Utaewa > Berger camp.

INTRODUCTION

Acidification is one of the most serious environmental problems. Among the effects of acid deposition, corrosion of structures exposed to the atmosphere mainly by sulphur pollutants is a well known problem (Lucera and Matson 1988). Economic losses caused by atmospheric corrosion are tremendous and therefore account for the disappearance of a significant portion of metal produced. The quest to improve atmospheric corrosion resistance of galvanized steel structures and other steel materials has been one of the major study subjects since the beginning of the 20th century. Zinc coating on galvanized steel products developes a protective formation of the $ZnSO_4$ surface film as a result of natural weathering. This provides the elongavity of performance. However, in a polluted environment, the existing SO_2 and CO_2 in the atmosphere react under ambient conditions with zinc coating producing zinc salts which finally terminate the formation of the $ZnSO_4$ and $ZnCO_3$ phases (Vourlisa et al, 2004). Thus rainwater flowing over galvanized roofing material may dissolve small amount of materials and salts from the surface. This dissolution promotes and maintains the protective film and enhances the corrosion resistance. However, when rainwater flows over unpainted galvanized steel roof, accelerated corrosion can occur. Efforts have been made to improve on the steel corrosion resistance (Hou and Liang, 2004).

Quantitative estimation of prediction of atmospheric corrosion of any material can be done by considering the chemical composition of the material involved and the environmental factors (Morcillo et al,2000 & Roberge et al, 2002).

Many factors contribute to the corrosion of zinc roofing sheets depending on the specific atmospheric environment, the nature and the chemical composition of the pollutant (Hou and Liang, 2004 Dugstad et al, 1994; Townsend, 2001; Seinfeld, 1986; Syed 2006 and Vashi and Kadiya 2009). In natural atmosphere, zinc corrosion resistance is more than that of steel. The galvanized roofing sheet owes its high degree of resistance to the insoluble basic carbonate film that is always formed and so the environmental condition that interferes with the formation of the carbonate film contributes to the rapid corroding of zinc. Falk et al (1998) reported the influence of CO_2 and NaCl on atmospheric corrosion of zinc structures. CO_2 in the presence of NaCl results in heavy pitting of the metal. There is also a combined influence of CO_2 and temperature on the atmospheric corrosion of zinc in the presence of NaCl (Rakel et al, 2000).

Significant progress has been achieved in understanding the general composition of galvanized steel structures. Zinc roofing sheets which are galvanized steel structures are normally protected with chromate compounds for passivity.

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Upon exposure to the atmosphere, the chromate compound is first destroyed, and then the metal gets oxidized. Sevenson and Johansson(1998) reported that further reaction occurs as a result of contribution by pollution agents. Askey et al,1993) reported his observation of an increase in the surface electrolyte when galvanized structures are exposed to particular contaminants.

Along the coastal region of the Niger Delta, rapid degradation of the galvanized roofing sheets has led to constant changing of the roofing sheets. This is an economic waste to the people of the region. Also the corroding materials are washed off the roof during rain events, thus polluting the rainwater if harvested. This may also be a precursor to some health problems in the region.

Having seen the devastation of zinc roofing sheets, it became necessary to determine the anthropogenic inputs to the corrosion of zinc- coated roofing sheets in the area. Also of interest, were the rate of corrosion of the zinc- coated roofing sheets and the corrosivity of the environment. These determinations were carried out at three locations in Akwa Ibom State on the southeastern Niger Delta. The location selected for this study are Iko, Berger Camp, and Utaewa (Fig.1)

Area description

Iko is an Atlantic coastal town located in Eastern Obolo Local Government Area of Akwa Ibom State, Nigeria. Shell has its facilities in Iko and gas is being flared there. Berger Camp and Utaewa are located in Ikot Abasi Local Government Area of the state and the Aluminum Smelting Industry (ALSCON) is situated at Berger Camp. Utaewa,on the other hand is a coastal town of Imo River. The study area consisting of these three cities in the Niger Delta coastal region is spread over from latitude 4º30'19" N to 4º34'12"N and 7º32'27"E to 7º35'57"E (Fig.1). The study area is located in the subequatorial south climatic region and has a high vegetation type (Iloeje, 1991).

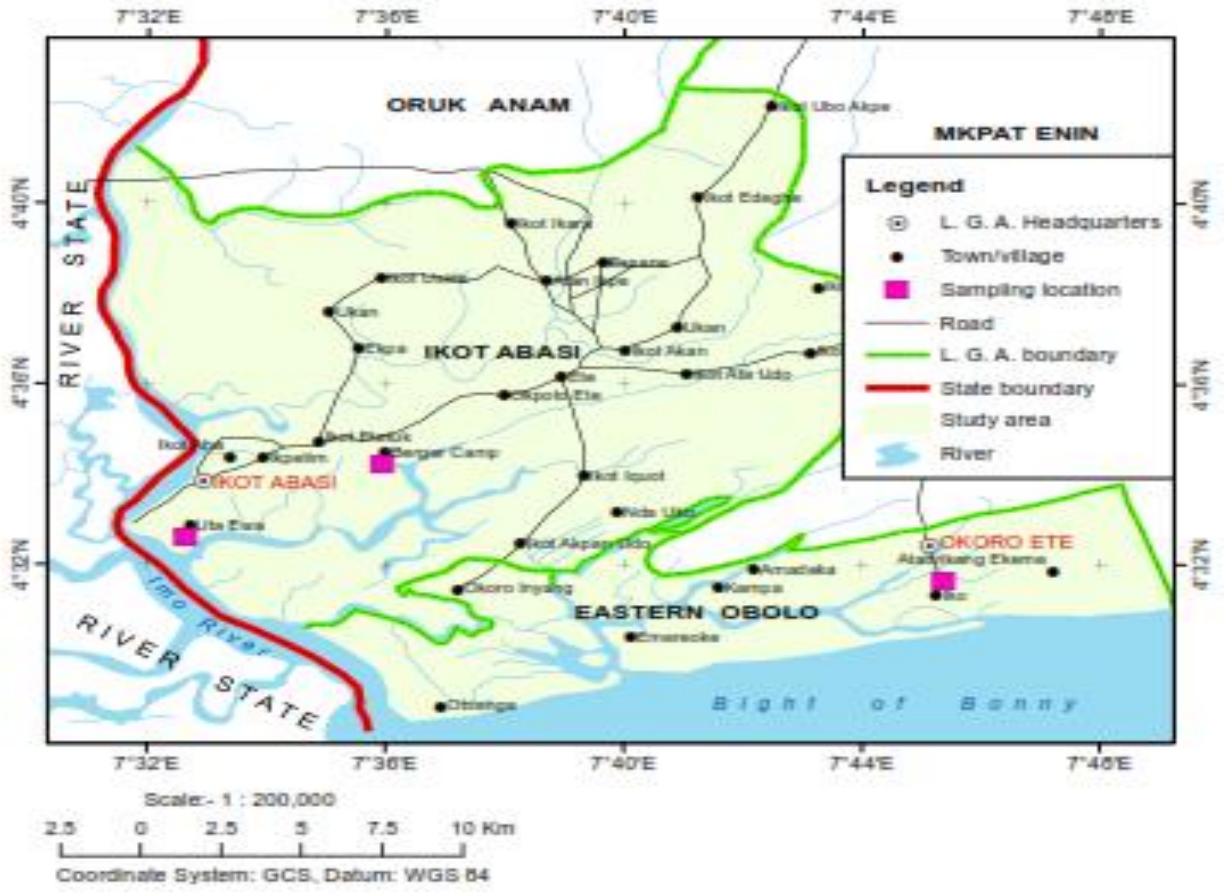

Fig.1. Map of study location showing sampling stations

MATERIALS AND METHODS

Three towns, Iko, Berger Camp and Utaewa were chosen for the monitoring process. A fabricated iron stand was fitted with a roof made of galvanized zinc material and constructed to hold some 2L polyethylene containers for both the direct rain (DR) and the roof rain (RR) water samples. The newly purchased galvanized zinc roofing sheet was washed thoroughly with deionized water, degreased in absolute ethanol and dried using acetone before mounting it on the stand. Coupons made from the same zinc material were also given the same pretreatment before they were exposed to the atmosphere. Rainwater samples were collected once every month after a heavy rain event.

Experimentals

Physicochemical parameters were determined using standard procedures (Andrew et al, 1995). Coupons were exposed at each location (Iko, Berger Camp and Utaewa) for twelve months. The initial weights of the coupons were taken. The size of all the coupons was 15 × 10 × 0.2 cm. and were mounted at an angle of 45^0 towards the horizontal plane. The coupons were removed and tested for weight loss after every three months (90 days) (Heuer and Stubbing, 1999). The corrosion products were removed by using a soft brush to scrub. After thoroughly cleaning the metal coupons, their weights were taken to determine the loss in weight. Coupons were placed back for another three months. This process was repeated for every three months.

RESULTS AND DISCUSSION

Weight loss of the zinc coupons exposed to the atmosphere in the three study areas is presented in Table 1. A regression graph of the corrosion rate with respect to time is presented in fig 2.The figure shows the corrosivity of each study area. From the figure it is seen that the rate of corrosion of the metal coupons is higher at Iko and Utaewa as compared with Berger Camp. These three study areas were chosen based on their different types of environments. The corrosion rate was calculated from the equation adopted from Syed,(2006) which is represented below:

$$\text{Corrosion Rate (CR)} = \frac{w \times k}{d \times A \times t}$$

where w = weight loss (g)

k is a conversion factor and is given as 87.6 for zinc

d = alloy density (g/cm^3)

A = exposed area (cm^2)

t = time (in hrs)

Table 1 Weight loss data for zinc coated roofing sheet coupons at the different locations

Location	Corrosion rate x 10^{-3} ($mgdm^{-2}day^{-1}$)			
	0 – 3 months	0 – 6 months	0 – 9 months	0 – 12 months
Iko	4.64	4.76	6.12	6.37
Utaewa	5.46	5.90	5.70	6.08
Berger Camp	0.76	1.20	1.87	4.08

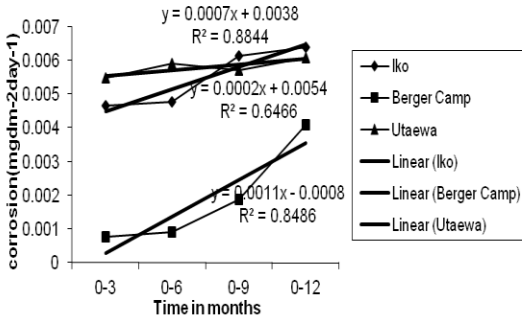

Fig. 2 Regression graph of corrosion rate with time

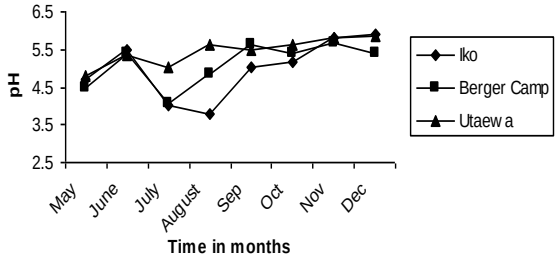

Fig. 3 pH variation at Iko, Berger Camp & Utaeawa

Figure 3 represents the variation in pH of the direct rainwater samples in the three stations. Comparing Figs 2 and 3, the rate of corrosion of the zinc coated metal sheets correlates significantly with the level of acidity of the harvested rainwater samples. The corrosion rate trend is as follows: Iko > Utaewa > Berger Camp, while the acidity of the harvested rainwater follows the trend: Iko > Berger Camp > Utaewa. pH value in rainwater has been implicated as one of the major factors responsible for increase in corrosion rate of zinc structures.(Bernarie and Lipfert, 1986; Mendoze and Corro, 2000 and Koster, 2003). Figure 4

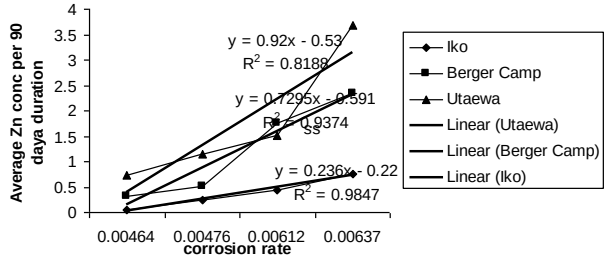

Fig. 4 Average Zn conc versus corrosion rate

A similar trend is observed when the mean concentration of zinc is plotted against corrosion rate (fig.4). Same is observed in the case of copper at Iko but the correlation is negative between copper and corrosion rate at both Berger Camp and Utaewa. Nickel correlates negatively with corrosion rate in all the stations while Cl^- correlates positively with corrosion rate in the three stations.

CONCLUSION

Evaluation of the zinc coated coupons' weight difference showed a change in material loss with respect to time when exposed to the atmosphere. The high corrosion rate with time for Iko and Utaewa as compared with Berger Camp (Fig 2) may be attributed to both anthropogenic activities (like gas flaring in Iko) as well as the nearness of Iko and Utaewa to the Atlantic and Imo River respectively. This is in agreement with Ossch (2004) that loss in weight of zinc coated products when exposed to the atmosphere depend on the atmospheric conditions. In such environments where the water droplets present in the air and with their high relative humidity most commonly serve as electrolytes, zinc roofing sheets will corrode faster than cities in the hinterland (Jones, 1996)

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