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CORROSIVE EFFECT OF GAS FLARING ON METALS (Stainless Steel and Aluminium)

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Abstract- ***This work investigated the effect of gas flaring on the rate of corrosion of metals. Surface water which has been exposed to gas flares, was taken from within Ogbogu flow station in Ogba/Egbema/Ndoni Local Government Area of Rivers State Nigeria, and was used for this experiment. The procedure involved soaking one set of various coupons of Aluminium and Stainless steel, in the water taken from within the gas flare zone and another set in distilled water and kept for 14 days; after which the metals were removed and weighed for weight loss as a result of the corrosive effect of both water. This process was repeated for 56 days and various data obtained was analyzed using empirical corrrelation. Matlab was used for computation and simulation. At the 42nd day, corrosion rate for the flare zone water and distilled water were for Aluminium 6.739cm/days and 4.813cm/days and Stainless steel 2.289cm/days and 1.308cm/days respectively. The result obtained showed a higher rate of corrosion for water taken from within the gas flare zone of Ogbogu flow station than distilled water. Thus, gas flaring encourages corrosion.***

Keywords: Corrosion, Gas flaring, Metals, Distilled water, Matlab, Aluminium, Stainless Steel

I. INTRODUCTION

In Nigeria, the oil and gas sector accounts for about 35 per cent of Gross Domestic Product (GDP), and petroleum exports revenue represents over 90 per cent of total exports revenue. Apart from petroleum, Nigeria's other natural resources include natural gas, tin, iron ore, coal, limestone, niobium, lead, zinc and arable land [1]. Nigeria has one of the ten largest natural gas reserves in the world and roughly 50% of the deposits are discovered in association with oil. It possesses the largest deposits of natural gas in Africa, most of which are located in and around the Niger Delta region.Natural gas supply in Nigeria comes in two streams - gas in isolated wells (or non-associated gas), and gas discovered together with oil (associated gas) [2]. These two sources exist in roughly equal proportions. While non-associated gas can be left underground until needed, associated gas is unavoidably lifted together with crude oil, and must either be harvested or disposed on-site as an unwanted by-product

The issue of gas flaring in Nigeria has become a topical one in view of the devastating effect gas flaring has in the socio-economic lives of the people in the affected areas. [3]. Historically, it is said that gas flaring is as old as oil production in Nigeria. Oil exploratory activities of oil companies in Nigeria have caused gas flaring resulting in loss of lives and properties in the affected communities where gas is flared. There is no specific legal framework that prohibits gas flaring in Nigeria inspite of the environmental problems associated with it. [4]. The existing law that appears to regulate gas flaring in Nigeria is not effective as it does not completely prohibit gas flaring but only provide monetary penalties for continued flaring of gas by oil companies in Nigeria.Gas flaring is the burning of natural gas that is associated with crude oil when it is pumped up from the ground. In petroleum-producing areas where insufficient investment was made in infrastructure to utilize natural gas, flaring is employed to dispose of this associated gas. [5,6]

Gas flaring in oil rigs and wells contribute significantly to greenhouse gases in our atmosphere. These greenhouse gases in the atmosphere pollute the environment and the marine habitat. [7,8]. Flares are common because they are used industrially for quick disposal of continuous flow of excess gases and for disposal of large surge of gases in an emergency calls. Other disposal system in use include atmospheric discharge (venting) disposal to a lower pressure. The principal harmful substances that are discharged into the atmosphere when crude (solid fuels) or other substances that are combusted are: carbon dioxide, carbon monoxide, hydrogen sulphide, sulphur dioxide, ammonia and fluoride compounds. Acid rain has been linked to the activities of gas flaring. This occurrence takes place when the discharged gases released during combustion comes in contact with matter/moisture in the atmosphere forming acid rain which are very corrosive to metals when they rain on them. [9,10,11]

Corrosion can affect metals in a variety of ways depending on its nature and the precise environmental conditions prevailing. Therefore, in the process of gas flaring at high temperature, oxide of nitrogen in the atmospheric (mainly during geological activities) does not recycle by airy transfer. The flared gases and gaseous pollutants contributed to the distribution and deterioration of metallic properties as a result of corrosive action taking place. Corrosion simply refers to the undesirable deterioration or degradation of metal components or metallic alloys, [11, 12, 13]. This is due to the reactions of the metals/environmental reaction which results to adverse consequences on the properties of the metals. Most metals corrode on contact with water (and moisture in the air), acids, bases, salts, oil, aggressive metal polishes and other solid and liquid chemicals. Metals will corrode when exposed to gaseous materials like acid vapours, formaldehyde gas, ammonia gas, and sulphur containing gases. Hence, any substance or environmental factor that causes disintegration of metals or any other material and subsequently corrodes the metals (in this case, rusting it), such is said to be corrosive. The environment can be polluted by hydrocarbon gases when some of the intermediate end products of petroleum processing plants are flared off upon production in the absence of demand. [14,15,16,17]

II. MATERIALS AND METHODS

A. Materials

1. Two coupons of aluminum of size 30 x 50mm with thickness 1mm
2. Two coupons of stainless steel of size 30 x 50mm with thickness 2mm
3. Water exposed to gas flaring from Ogbogu Gas Flow Station
4. Distilled water

B. Apparatus

Electric (digital) weighing balance, saw blade, and micrometer screw guage.

C. Experimental Procedures

Two (2) rectangular coupons of different metals (aluminium and stainless steel) whose initial weight were taken was soaked in distilled water and flare zone water and kept in the laboratory separately. The coupons were allowed for the period of 14 days (two weeks) before being removed from the waters and weighed and the weight of each metal was recorded after which the coupons were washed from the previous corrosion and soaked again. These processes were repeated for the period of 56 days.

D. Corrosion Rate Calculation

The rate of corrosion is related to the weight loss as:

$$C_R = \frac{\Delta m * 3.45 * 10^6}{A * \rho * t} \qquad (1)$$

where C_R = corrosion rate in (cm/day), A= cross sectional area of coupon in (cm^2), P = Density of coupon in (g/cm^3), Δm = weight loss in (g), T = period of exposure

III. RESULTS AND DISCUSSIONS

A. Analysis of Water from Flared Zone

p^H = 6.63,

Electrical conductivity ($\mu s/cm$) = 151,

Chloride ion, Cl^-, (mg/l) = 18.22,

Total hardness, (mg/l) = 600,

Total suspended solid (g/l) = 2.04,

Total dissolved solid (g/l) = 560,

Fe^{2+} (ppm) = nil,

Zn^{2+} (ppm) = 0.426,

Total heterotrophic bacteria, (cfl/ml) = $0.07*10^4$,

Total caliform bacteria, (mpn/index/100ml) = 0.10,

Facial caliform bacteria, (mpn/index/100ml) = $12.4*10^1$

B. Properties of Distilled Water

Electrical conductivity (μs/cm) = <50,

Chloride ion, Cl^-, (mg/l) = 250,

Total hardness, (mg/l) = 500,

Total suspended solid (g/l) = 2 to 5,

Total dissolved solid (g/l) = 500,

Fe^{2+} (ppm) = 0 to 0.30,

Zn^{2+} (ppm) = 3.0,

Total heterotrophic bacteria, (cfl/ml) = <100/100ml,

Total caliform bacteria, (mpn/index/100ml) = 0 to 2,

Facial caliform bacteria, (mpn/index/100ml) = nil

The results of the weight loss and the rate of corrosion of different metals in the distilled water and water from flared zone (Ogbogu gas flow station) in the course of the experiments are as represented in Tables 1a,1b, 2a, and 2b, below.

C. Aluminium

From Tables 1a and 1b and Figure 1, it can be seen that the corrosion rate in the distilled water was lowest within the 42 day-period. It was observed that the aluminium coupon corrode faster with a higher corrosion rate in the flare zone water than in the distilled water. In both environments the corrosion rate dropped after 42 days.

TABLE 1 (a): Corrosion Rate of Aluminium Soaked in Distilled Water

Period of exposure (days)	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Initial weight (g)**	**Final weight (g)**	**Weight loss (g)**	**Corrosion rate (cm/days)**
14	5	3	0.1	3.97	3.969	0.001	2.888
28	5	3		3.97	3.967	0.003	4.332
42	5	3		3.97	3.965	0.005	4.813
56	5	3		3.97	3.965	0.005	3.610

TABLE 1(b): Corrosion Rate of Aluminium Soaked in Water from Flare Zone (Ogbogu gas flow station)

Period of exposure (days)	**Length (cm)**	**Width (cm)**	**Thickness (cm)**	**Initial weight (g)**	**Final weight (g)**	**Weight loss (g)**	**Corrosion rate (cm/days)**
14	5	3	0.1	3.88	3.878	0.002	5.776
28	5	3		3.88	3.875	0.005	7.220
42	5	3		3.88	3.873	0.007	6.739
56	5	3		3.88	3.873	0.007	5.054

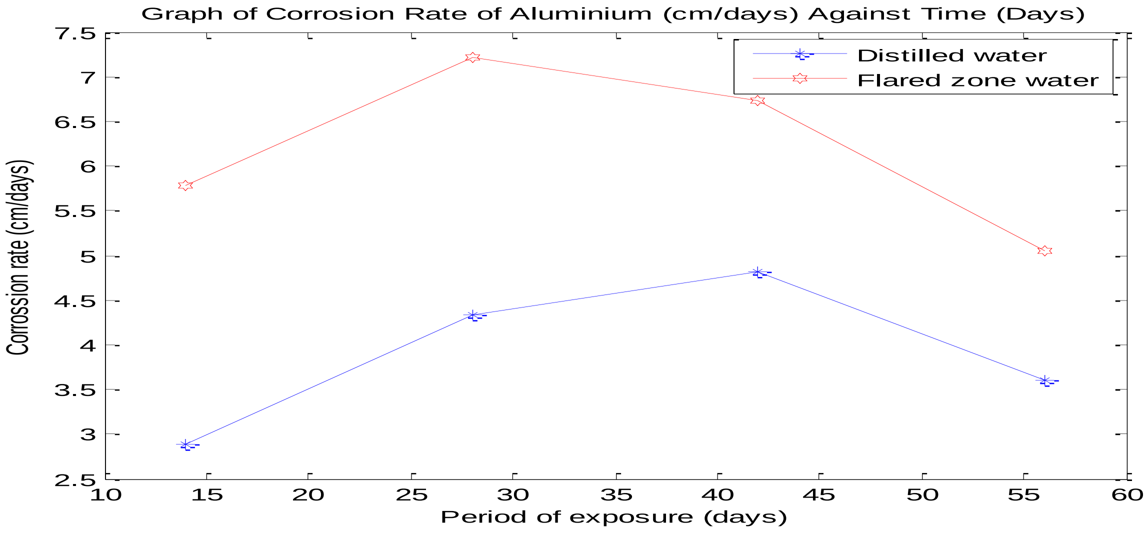

Fig 1: Variation of corrosion rate of Aluminium soaked in distilled water and water from flare zone (Ogbogu gas flow station)

D. Stainless Steel

From Tables 2a and 2b and Figure 2, it can be seen that the corrosion rate in the distilled water and in flare zone water were highest within the 42 days period. It was observed that the stainless steel coupon corroded faster with a higher corrosion rate in the flare zone water than in the distilled water. In both environments the corrosion rate dropped after 42 days.

TABLE 2(a): Corrosion Rate of Stainless Steel Soaked in Distilled Water

Period of exposure (days)	Length (cm)	Width (cm)	Thickness (cm)	Initial weight (g)	Final weight (g)	Weight loss (g)	Corrosion rate (cm/days)
14	5	3	0.2	26.56	26.56	0	0
28	5	3		26.56	26.558	0.002	0.981
42	5	3		26.56	26.556	0.004	1.308
56	5	3		26.56	26.556	0.004	0.999

TABLE 2(b): Corrosion Rate of Stainless Steel Soaked in Water from Flare Zone (Ogbogu gas flow station)

Period of exposure (days)	Length (cm)	Width (cm)	Thickness (cm)	Initial weight (g)	Final weight (g)	Weight loss (g)	Corrosion rate (cm/days)
14	5	3	0.2	24.34	24.338	0.002	1.903
28	5	3		24.34	24.336	0.004	1.963
42	5	3		24.34	24.333	0.007	2.289
56	5	3		24.34	24.333	0.007	1.749

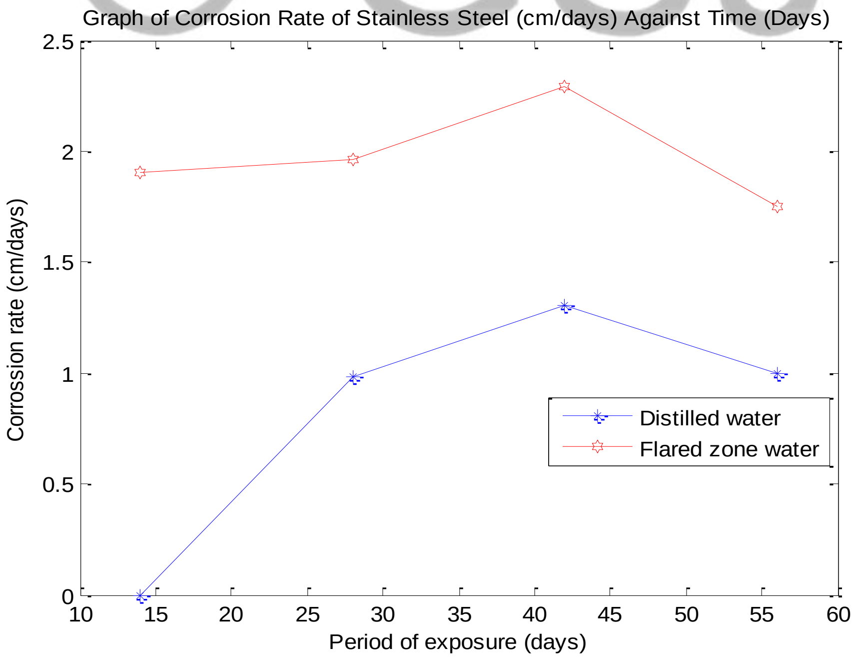

Fig 2: Variation of corrosion rate of stainless steel soaked in distilled water and water from flared zone

IV. CONCLUSION

The results of this work show that exposed water from the flare zone of Ogbogu flow station has a higher corrosive effect on metals as a result of gas flaring which is mainly the primary cause of the high corrosive effect of the water on metals. The flared gas which is as a result of drilling activities going on within the Egi area releases poisonous gases to the atmosphere, such gases includes: Carbon dioxide (CO_2), Sulphur dioxide (SO_2), Hydrogen sulphide (H_2S) etc. From the work, it is seen that rate of corrosion of aluminum and stainless steel in the flare zone environment was higher than that in the distilled water environment. Thus, gas flaring encourages corrosion.

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