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Corrosive Effect of Gas Flaring on Metals in Egi Kingdom
(Galvanized Iron and Brass)

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Abstract— *This work investigated the effect of gas flaring on the rate of corrosion of metals in the Egi Kingdom of Rivers State, Nigeria. Surface water which has been exposed to gas flaring taken from Ogbogu gas flow station within the Egi kingdom in Ogba/Egbema/Ndoni Local Government Area of Rivers State Nigeria, was used for this experiment. The procedure involved soaking one set of various coupons of galvanized iron and brass in the water taken from within the gas flow station 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 simulations. At day 42, corrosion rate for the flared zone water and distilled water were for Galvanized Iron 2.431cm/days and 1.651cm/days, and Brass 2.382 cm/days and 1.786 cm/days respectively. The result obtained showed a higher rate of corrosion for water taken from the Ogbogu gas flow station than distilled water. The results thus confirm that gas flaring activities increases the rate of corrosion in the environment and explains the reason for the high rate of corrosion within the Egi Kingdom.*

Keywords— *Corrosion, Gas flaring, Metals, Distilled water, Matlab, Galvanized Iron, Brass.*

I. Introduction

Corrosion is a natural process, which converts a refined metal to a more chemically - stable form, such as its oxide, hydroxide or sulphide. It is the gradual destruction of materials (usually metals) by chemical and electro-chemical reaction with their environment. In the most common use of the word, this means electrochemical oxidation of metal in reaction with an oxidant such as oxygen or sulphur. Rusting, the formation of iron oxides, is a well known example of electrochemical corrosion (Breakell *et al.,* 2005).

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 (Aigbedion, and Iyayi, 2007). 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) Ajugwo, (2013). 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 (Abdulkareem, 2006). 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 (Arowolo *et al*, 2011). 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 (Effiong *et al*, 2012; Julius, 2011). 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.

Gas flaring in oil rigs and wells contribute significantly to greenhouse gases in our atmosphere. (Hassan *et al*, 2013; Ibitoye, 2014). These greenhouse gases in the atmosphere pollute the environment and the marine habitat. 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 (Kindzierski, 2000; Nkwocha, 2010).

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

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(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. (Amadi *et al*, 2009; Obia *et al*, 2011; Obia, 2010). Corrosion simply refers to the undesirable deterioration or degradation of metal components or metallic alloys. 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, Obia, (2009): 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. This flared gas initiates corrosion in the environment which degrades the useful properties of materials and structures including strength, appearance and permeability to liquids and gases. (Ayoola, 2011; Ekpoh *et al* 2010, Manby, 1999).

II. MATERIALS AND METHODS

2.1 Materials

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

2.1.1 Apparatus

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

2.2 Experimental Procedures

Two (2) rectangular coupons of the two metals (galvanized iron and brass) whose initial weight were taken was soaked in distilled water and in the water from the flared zone and kept in the laboratory separately. The coupons were allowed for the period of 14 days (two weeks) and the various coupons were removed from the water and weighed and the weight of each metal were recorded after which the coupons were washed from the previous corrosion and soaked again. These processes were repeated for the period of 56 days.

2.3 Corrosion Rate Calculation

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

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

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

3.1 Analysis of Water from Flared Zone

pH = 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) = $12.4*10^1$

3.2 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 the two metals in the distilled water and water from flared zone (Ogbogu gas flow station) in the course of the experiment are as represented in tables 1a,1b, 2a, and 2b, below.

3.3 Brass

From Tables 1a, 1b and Figure 1, it can be seen that the corrosion rate in the distilled water and in flared zone water was highest within the 42 day period. It was observed that the brass coupon corroded faster with a higher corrosion rate in the flared zone water than in the distilled water. In both environment the corrosion rate dropped after 42 days

TABLE 1(a). Corrosion rate of Brass 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	32.32	32.319	0.001	0.893
28	5	3	0.1	32.32	32.317	0.003	1.309
42	5	3	0.1	32.32	32.314	0.006	1.786
56	5	3	0.1	32.32	32.314	0.006	1.339

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TABLE 1(b). Corrosion rate of Brass soaked in water from flared 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	32.30	32.398	0.002	1.786
28	5	3	0.1	32.30	32.396	0.004	1.731
42	5	3	0.1	32.30	32.392	0.008	2.382
56	5	3	0.1	32.30	32.392	0.008	1.786

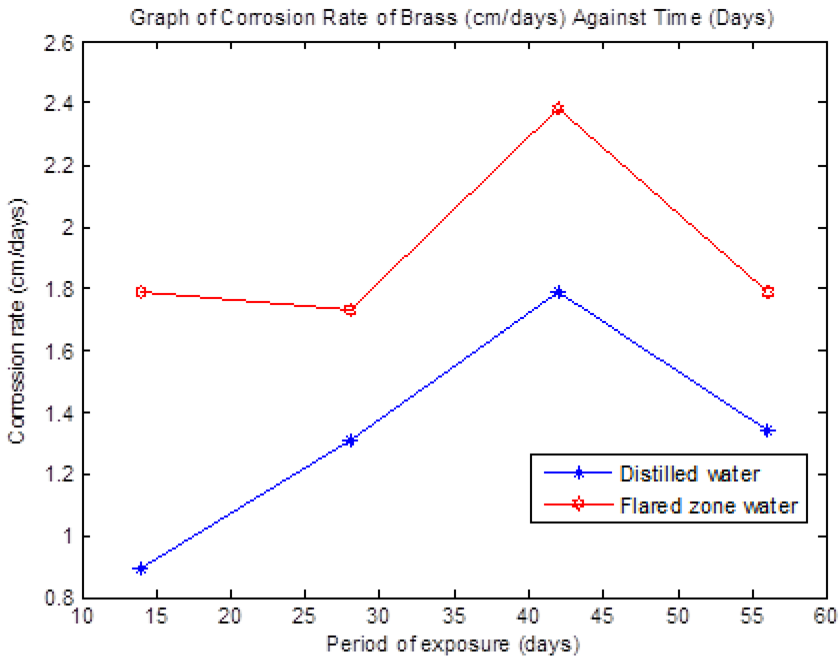

Fig. 1. Corrosion rate of Brass soaked in distilled water and water from flared zone (Ogbogu gas flow station).

3.4 Galvanized Iron

From Tables 2a, 2b and Figure 2 it can be seen that the corrosion rate in the distilled water was higher within 42 days period while that in flared water within 14 days period. It was observed that the iron coupon corroded faster with a higher corrosion rate in the flared zone water than in the distilled water. In both environments the corrosion rate dropped after 42 days.

TABLE 2(a). Corrosion rate of Iron (Fe) 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	9.47	9.489	0.001	0.999
28	5	3	0.1	9.47	9.487	0.003	1.486
42	5	3	0.1	9.47	9.485	0.005	1.651
56	5	3	0.1	9.47	9.485	0.005	1.238

TABLE 2(b). Corrosion rate of Iron (Fe) soaked in water from flared 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	9.93	9.927	0.003	2.972
28	5	3	0.1	9.93	9.925	0.005	2.477
42	5	3	0.1	9.93	9.923	0.007	2.431
56	5	3	0.1	9.93	9.923	0.007	1.734

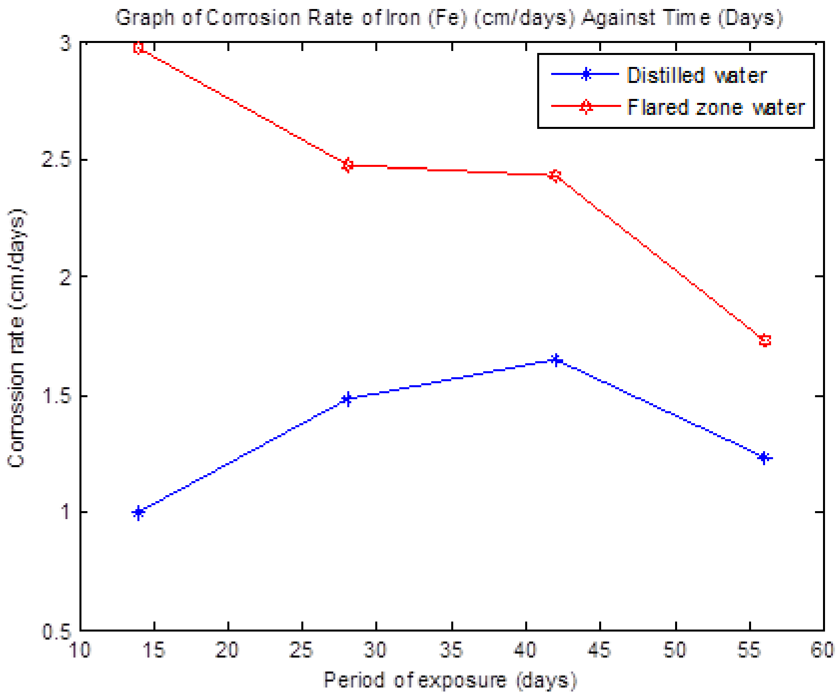

Fig. 2. Corrosion rate of Iron (Fe) soaked in distilled water and water from flared zone (Ogbogu gas flow station).

IV. CONCLUSION

The results of this work shows that water from 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 Egi area release poisonous gases to the atmosphere, such gases includes: Carbon dioxide (CO_2), Sulphur dioxide (SO_2), Hydrogen sulphide (H_2S) etc. From this work, it is seen that rate of corrosion of brass and iron in the flared zone environment was higher than that in the distilled water environment. Thus, gas flaring increases the rate of corrosion and explains the reason for the high rate of corrosion within the Egi Kingdom.

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