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Prevention and Control of Corrosion in Pipelines using monkey sugarcane (*Costus afar*) Juice in the Niger Delta Region of Nigeria

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Abstract *— This study is aimed at evaluating the physiochemical parameters of soil with their impact in corroding pipelines using a weight loss analysis method and deducing preventive measures using monkey sugarcane (Costus afar) juice as green yard inhibitor. Low carbon steel was cut to coupons size and one set covered with the monkey sugarcane (Costus afar) juice and the other set without the said juice and all buried in three different samples of soil all gotten for test from the Niger delta region. Results obtained were the fast rate of corrosion of carbon steel in different soil medium without inhibitor such as swampy soil, clay soil, sandy-loamy soil and comparing it with the inhibitors efficiency having a magnitude such as swampy soil, sandy-loamy soil, clay soil, all computed using a corrosion rate model and inhibition efficiency model to achieve results. In conclusion, the results obtained clearly demonstrates the significance of monkey sugarcane (Costus afar) juice in preventing and controlling pipeline corrosion to the barest minimum if applied adequately.*

Keywords— Prevention, Control, Corrosion, Pipeline, Monkey sugarcane (Costus afer) Juice

1. INTRODUCTION

For centuries, pipelines offered the safest, most efficient and reliable method for transporting oil and gas. Mostly, these pipelines are installed underground to protect them from damage and to minimize the threat to the environment from spillage, which can result in an ecological disaster. Currently in the Niger Delta region of Nigeria, it is a major problem to the soil water and environment.

The global demand for a sustainable supply of oil and gas dictates an effective pipeline system. Therefore, economical and effective techniques to minimize the deteriorating effects such as corrosion and coating failure are critical for the lifetime of pipeline systems. Corrosion is considered the major reason behind most pipeline failure. Actually, over the years, corrosion has been the cause for many incidents including pipeline and tank explosions, bridge collapses.

Oil spills occur as a result of vast number of reasons which amounts to sabotage 25% of oil spills, oil production operations 20% of oil spills and 5% for inadequate and non-functional equipment and the corrosion of pipelines materials amounts to 50% of its regular occurrence [1]. Corrosion occurs as a result of many different reasons such as man's activities on metals, soil and microbial activities on metals, concentration of fluid or gases been transported through the pipes, and inadequate maintenance.

Various conceptual views have been given concerning on corrosion and its effect on oil pipelines by several authorities and taught individuals who holds different views. Also Corrosion is defined as the gradual deterioration of materials by chemical interaction with their environment, it is also applied to the degradation of plastics, concrete and wood but generally refers to metals. As well defined as corrosion as the spontaneous destruction of metals in the course of their chemical, electrochemical or biochemical interactions with the environment, thus it is exactly the reverse of extraction of metals from ores. Also Ukpaka [2] defines corrosion as the gradual destruction of materials (usually metals) by chemical reaction with their environment. It is as a result of the metallic reaction with its environment to form metallic oxides thereby causing the metal to deteriorate. The pipeline integrity manual [3] defines corrosion as the natural degradation of metals in the environment through electrochemical or chemical processes. Generally corrosion in pipeline is the spontaneous degradation of metals and non-metals with reaction to its environment thereby causing an undesirable deterioration of metals through natural or man influenced processes. Researchers such as Idibiye [1]; Baker [4]; Ukpaka and Amadi [5]; and Enani [6] have made diverse suggestions concerning measures to adopt to reduce pipeline/metals corrosion issues to the barest minimum.

Idibiye [1] suggested that adequate corrosion monitoring and prevention techniques can help in reducing pipeline corrosion to the barest minimum. According to Baker [4] coating and cathodic protection for external corrosion in pipelines, and also the need for huge investment in continous pipeline monitoring to identify affected areas to take pro-active measures. Also, Ukpaka & Amadi [5] reported that effective anti-corrosion agents can be used and proper investigation of the soil characteristics and compositions before laying pipeline through any soil environment will help in reducing this corrosion issue of national interest. As well, it has been in literature recommended that material selection for Coatings Inhibitors, Cathodic protection Design methods will help

towards corrosion control in any region. Furthermore, Enani [6] contributed in the need to engage in constant monitoring which aims at identifying the presence and extent of corrosion.

Considering all the suggested means above will help to mitigate/reduce the corrosion problem to an extent but if government/companies can set up a corrupt free panel to scrutinize the materials to be used in constructing the pipeline and ensure their proper use in the field will help reduce this corrosion issues ravaging the country oil and gas sector. Because some contractors usually demonstrate corrupt practices in the field while constructing thereby causing early joint fractures and leakages as a result of their inability to checkmate welded joints, coating processes, soil composition analysis before pipe laying process.

It is convenient to classify corrosion by the forms in which it manifest itself, although some forms of corrosion are unique and distinct, all of them are interrelated and can be identified visually. *Costus afer* Ker Gawl of the Zingiberaceae family, commonly called bush sugar cane or monkey sugar cane [7, 8] is a monocot and a relatively tall, herbaceous, unbranched tropical plant with creeping rhizome. It is commonly found in moist and shady forest of West and tropical Africa [7, 8]. *C. afer* is a perennial, rhizomatous herb that can attain a height of up to 4 m, and is often planted in home gardens for medicinal purposes as well as widely used for ceremonial and religious purposes [7, 8]. The aim of study is to evaluate the effects of monkey sugarcane (*Costus afar*) juice as the green yard inhibitor in prevention and control of corrosion in pipelines.

2.0 MATERIALS AND METHODS

2.1Sample Collection

Soil samples were extracted from different locations of which sandy-loamy soil was gotten from Efeke-Ama in Ammassoma, swampy soil was extracted from the swamp regions of Niger Delta University (NDU) all in Southern-Ijaw Local Government of Bayelsa State, Nigeria and clay soil was gotten from the shores of Odi in Kolokuma/Opokuma Local Government Area of Bayelsa State. Metal for examination (carbon steel) was gotten from Ebisco group of company fabrication yard located at km 12 DSC road Warri, Delta State, Nigeria. Carbon steel was transported to NDU for cutting into pieces (coupons) that was used for the weight loss analysis. The monkey sugarcane *(Costus afer*) was harvested from the farms of Mr. Adone Egbe from Amassoma community.

2.2 Experimental Procedure

The soil samples were sent to the Department of Chemical Sciences Research Laboratory NDU to determine their properties such as soil pH, conductivity, and temperature using the essential standard operation procedure. Monkey sugarcane (*Costus afer*) was duly sorted out, washed and crushed to extract the concentrated juice and it was analysis using a prescribed standard operation procedure to determine its chemical composition. The juice was used to test on the various soil mediums on the prevention and control test of corrosion in pipelines. A Control was also set up, without the plant extract. A piece of the pre-weighed coupons was then introduced into each of the soil samples containing various concentrations of the plant extract respectively. The medium was sterilized with a spatula at room temperature. The temperature of the medium was maintained at 37°C throughout the duration of the experiment. The rate of corrosion was then determined using weight loss method and was calculated using the corrosion rate model.

Carbon steel was cut into various sizes (coupons) (Plate 1). Each sample of soil such as swampy soil clay and sandy-loamy soil were divided into two portions each to be used on the test and control reactors placed in batch reactors. One part of each of the soil samples were mixed with concentrated monkey sugarcane (*Costus afar*) juice for testing purpose. Coupons (carbon steel) were weighed using a weighing balance. One coupon was immersed to each soil sample in the batch reactor. These samples were kept for a period of 15 days to determine weight change, pH and conductivity. Metals are thoroughly washed and scrubbed before new weight is determined. After determining the weight change and soil pH, temperature and conductivity the carbon steel coupon is placed back on batch reactors to repeat process for 4 times (60 days) for serial evaluation. A weighed sample (coupon) of the metal or alloy under consideration is introduced into the process, and later removed after a reasonable time interval. The coupon is then cleaned of all corrosion products and is reweighed. The weight loss is converted to a corrosion rate (CR).

Plate 1: Coupons Used for the Test

2.3 Determination of Inhibitor Efficiency in the Soil Media

The inhibitor efficiency was determined using (3.1) [9]

$$Inhibitor\ efficiency\ (IE) = \frac{W_o - W}{W_0} \times 100 \quad (3.1)$$

Where
IE = Inhibition Efficiency
Wo = Average corrosion rate without inhibitor
W = Average corrosion rate with inhibitor

2.4 Determination of average corrosion rate at each medium

The average corrosion rate at each medium was determined using equation 3.2.

$$Average\ corrosion\ rate = \frac{Summation\ of corrosion\ rate}{Number\ of\ repeated\ experimental\ times} \quad (3.2)$$

3.0 RESULTS AND DISCUSSION

3.1 Composition of Monkey Sugarcane (*Costus afer*)

Table 1 shows the chemical composition of monkey sugarcane (*Costus afar*) using ethanol and aqueous extracts. This agreed with Nyananyo [7] and Etukudo [8] that stated that monkey sugarcane (*Costus afar*) stem contains Alkanoids, flavonoid, phenols, tannins, and saponins.

Table 1: Composition of Monkey Sugarcane (Costus afer)

Composition	Ethanol Extract	Aqueous Extract
Alkaloids	ND	4.6
Flavonoids	17	29
Saponins	0.12	2.6
Tanins	0.0	2.54
Phenols	0.17	0.18

3.2 Data for Experimental Parameters

Table 2 and 3 depict the data for experimental parameters such as weight, pH, temperature and electrical conductivity and density before coupon test.

Table 2: Data for Experimental Parameters

Soil samples	weights (g)	pH	Soil temperature (°c)	Soil Conductivity(μsm)
Clay soil	67.30	3.90	26.5	0.8
Swampy soil	65.50	6.40	26.5	1.0
Sandy-loamy soil	68.50	6.55	26.5	0.3

Table 3 Density of Low Carbon Steel

Metal	Density (g/cm^3)
Carbon steel	7.85

3.3 Comparison between Corrosion Rates and Time of Exposure

Figure 1 shows the corrosion rate and time of exposure in different soil medium – swampy, soil, clay soil, sandy loamy soil.

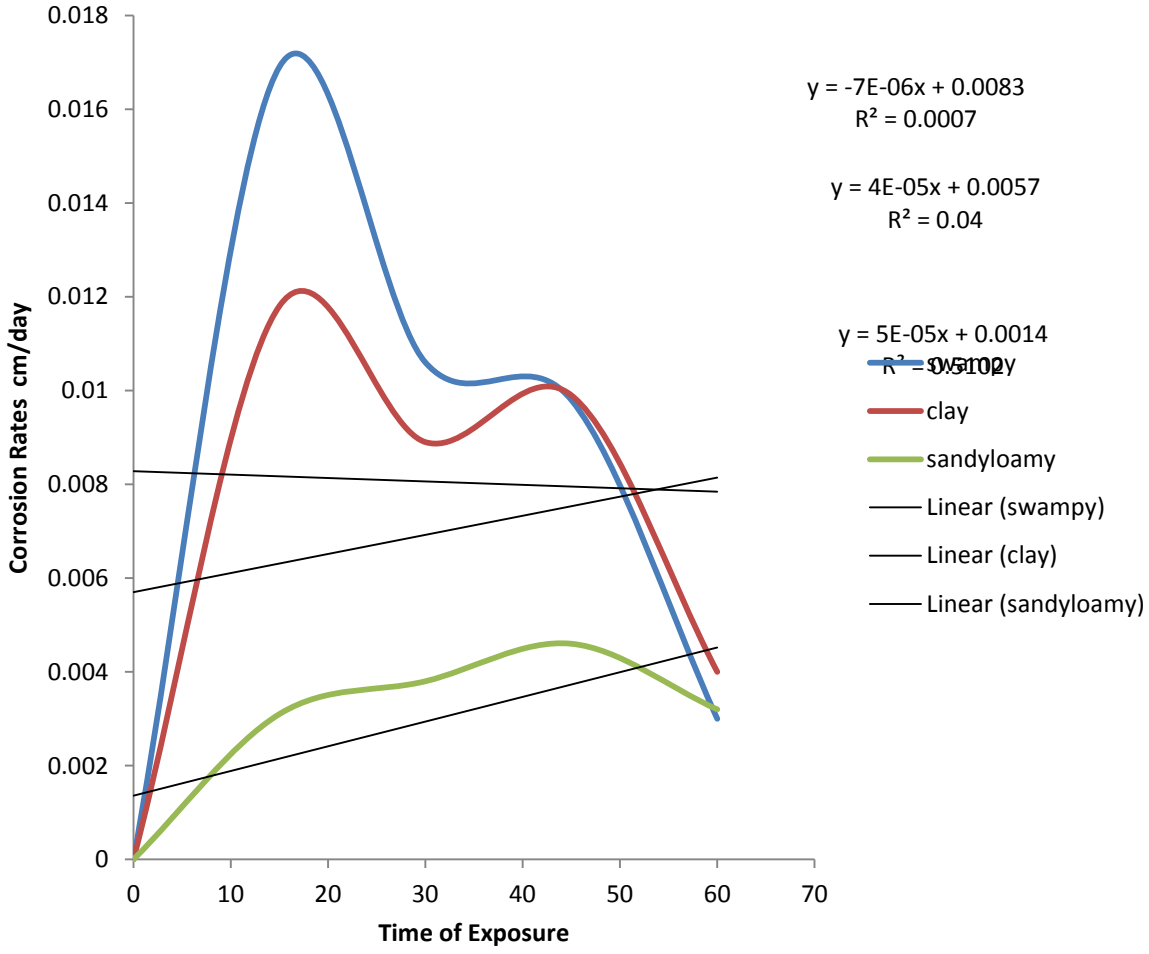

Figure 1: Comparison of Corrosion Rate Trend

3.4 Discussion

From the results, it showed that the trend of low carbon steel undergo corrosion in different soil mediums. The inhibiting efficiency observed proceeded swampy soil, sandy-loamy, and clay soil while the trend experienced in the normal soil mediums

preceded swampy soil, clay soil, and sandy-loamy soil. Results obtained from the test at the various soil mediums mixed with concentrated monkey sugarcane (*Costus afer*) juice showed that the trend low carbon steel undergo corrosion in different soil mediums. The inhibiting efficiency observed proceeded swampy soil, sandy-loamy, and clay soil while the trend experienced in the normal soil mediums preceded swampy soil, clay soil, and sandy-loamy soil.

Comparing the corrosion rate trend experienced in the three soil samples graphically. It is clear that corrosion rate preceded from swampy soil, clay soil, sandy-loamy soil. Coupon in Swampy soil experienced a high level of detoriation compared to the other soil samples examined. Comparing the inhibitors efficiency, it was discovered that the inhibitors efficiency is excellent in the swampy soil medium, thereby expressing the significance of the monkey sugarcane (*Costus afer*) juice in preventing and controlling corrosion in pipelines.

Finally the results obtained from this research work clearly showed the significance of monkey sugarcane (*Costus afer*) juice in the prevention and control of corrosion in pipelines especially in the swampy soil mediums where corrosion is high thereby stating the ability of monkey sugarcane (*Costus afer*) juice to work actively as a corrosion inhibitor in any soil mediums disregarding the amount of water content found on the soil mediums.

4.0 CONCLUSIONS

The following conclusions were drawn from the research:

1. The investigation showed that the physiochemical parameters of the soil that induced corrosion were inhibited by the monkey sugarcane (*Costus afer*) juice used in the preventive and control test.
2. The inhibitors efficiency was found to be excellent at the swampy soil medium where large amount of water is in it, thereby making it obvious that it is better active in a swampy medium.
3. The trend in corrosion shows that the corrosion rate was higher in swampy soil, clay, and sandy-loamy soil and compared to the inhibiting trend swampy soil, sandy-loamy, and clay soil.
4. Monkey sugarcane (*Costus afer*) juice can be applied to any corroding metałic surface to reduce corrosion.
5. The existing corrosion rate model was used to deduce the computations of the corrosion rate values and trends as presented on the research work.
6. The inhibitors efficiency model was also used to compute the mathematical efficiency of the inhibitors at various soil samples examined.
7. It was observed that soil and other environmental factors greatly influence corrosion and there is need for proper investigations on soil characteristics and composition before installing pipelines on the ground

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