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INHIBITING EFFICIENCY OF LOCALLY DEVELOPED INHIBITORS (Amaranthusspinosus, Euphorbia heterophylla, Imperatacylindrica and Panicum maximum) ON LOW CARBON STEEL IN ACIDIC AND SALINE MEDIA

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Abstract: The inhibiting efficiencies of acid and saline extract of Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica and Panicum maximum leaves for the corrosion of low carbon steel was assessed using corrosion rate and inhibiting efficiency. The results showed that the inhibiting efficiency increased with increase in the concentration of inhibitor for the acid extract. Acid extract had Euphorbia heterophylla showing maximum inhibiting efficiency of 88.73% at 4% concentration. For the saline extract, most of the leaves showed a low corrosion rate.
Keywords: Inhibiting efficiency, Low carbon steel, Acid extract, Saline extract, Inhibitor

1. INTRODUCTION

In recent years, plant juice extracts as inhibitor is of high interest due to its nature (eco-friendly and cost); it is believed that there are some active inhibiting chemicals and chemical compounds in plants that inhibit corrosion in aqueous or acidic environment.

Large numbers of inorganic corrosion inhibitors such as chromates and nitrates have been studied and are still being studied to assess their corrosion inhibition potential. However, most of these substances (inhibitors) are not only expensive but also pose health and environmental hazards [1] prompting the search for their replacement.

The use of natural products of plant origin as corrosion inhibitors has been widely reported by several authors [2,3].Plants have been recognized as sources of naturally occurring compounds that are generally referred to as green inhibitors or organic inhibitor: contain substances that are biocompatibility in nature, environmentally acceptable, readily available and renewable source [4].

The application of inhibitors has been said to be among the most practicable ways for protection of metals against corrosion, especially in acidic media [5, 6]. The inhibitive reactivity of inhibitors is fundamentally affected by the molecular structure of the inhibiting molecules [7,8]. Most prominent corrosion inhibitors are organic compound containing nitrogen, sulphur, oxygen, phosphorous in their functional groups [8].

Carbon steel, the most widely used engineering material, accounts for approximately 85%, of the annual steel production worldwide. It is used in large tonnages in marine applications, nuclear power and fossil fuel power plants, transportation, chemical processing, petroleum production and refining, pipelines, mining, construction and metal-processing equipment [7]. However, the concern of the engineers over the years has been the susceptibility of steels to several environmental degradations of which the major one observed has been the corrosion of steels [9-11].

In this research work, the inhibiting efficiency of juice extracts from Amaranthusspinosus, Euphorbia heterophylla, spear grass (*Imperatacylindrica*) and guinea grass (*Panicum maximum*) on the corrosion of mild steel in acidic and saline environments was investigated. This study is expected to contribute meaningfully to the present interest in elucidating the corrosion inhibition efficiency of plants.

2. MATERIAL

The mild steel used for the research was procured from a local vendor. It was sectioned 10 x 15 mm in the Agricultural Engineering workshop of The Federal University of Technology, Akure, before carrying out corrosion test on them. Materials and equipment include *Euphorbia heterophylla*, *Amaranthusspinosus*, *Panicum maximum*, and *Imperatacylindrica* leaves, water bath, hydrochloric acid, distilled water, sodium chloride salt, beakers, volumetric flask.


Euphorbia heterophylla Amaranthusspinosus


Imperata cylindrical Panicum maximum

Table 1. Elemental composition of the low carbon steel using spectrometric analyzer.

%C	%Si	%Mn	%P	%S	%Cr	%Mo	%V	%Cu	%Ni	%Al	%Fe
0.271	0.184	0.613	0.038	0.063	0.205	0.020	0.005	0.227	0.112	0.004	98.20

3. METHODS

Extracts fromPlant

The leaves of the plants (*Euphorbia heterophylla*, *Amaranthusspinosus*, *Panicum maximum*, and *Imperatacylindrica*) were sun dried and ground to powder form. Hydrochloricacid and sodium chloride solution were both used to extract the active constituents in the leaves that were responsible for corrosion inhibition. Acid extraction was carried out by method of Saratha and Vasudha, (2010). 10g of the pulverized leaves was weighed into reagent bottles each containing 100ml of 0.5M HCl, placed inside a water bath at 90^{0}C for 3hours. It was allowed to stay overnight and filtered. The extracts were kept as stock solution. The saline extraction was carried out just as the acid extraction method using 0.5M NaCl.

Phytochemical Analysis

The phytochemical analysis was conducted using the UV spectrophotometer to reveal the composition of the leaves. The table 2 represents the composition of the leaves (Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica and Panicum maximum).

Corrosion Evaluation – Gravimetric Test

The concentration of the extracts was varied from 1% to 5% in 0.5M HCl and 0.5M NaCl simultaneously. Each coupon whose initial weight was already taken was immersed inside respective environment; the weight of each coupon was taken and weight loss calculated for each reading taken. From the weight loss, the corrosion rate and inhibiting efficiency were calculated using the equations given below:

$$CR = \frac{W}{AT} \quad (1)$$

where CR = Corrosion rate (mgmm^{-2}r^{-1}), W = Weight loss, A = Total surface area of the specimen and T = time in days.

$$\text{I.E. } (\%) = \frac{CRblank - CRinh}{CRblank} \times 100 \quad (2)$$

whereI.E = Inhibiting Efficiency, CR_{blank} = corrosion rate in absence of inhibitor, CR_{inh} = corrosion rate with inhibitor.

Table 2. Composition of the Leaves Extract

Phytochemical Analysis				
	Euphorbia	Amaranthus	Spear grass (Imperatacylindrica)	Guinea grass (Panicum maximum)
Alkaloid	-	-	-	+
Saponnin	+	+	-	+
Taniin	+	-	+	-
Phlobatanin	-	-	-	-
Steriod	+	-	+	-
Antraquinone	+	-	-	-
Terpenoid	+	+	-	-
Flavonoid	+	+	+	+
Cardiac Glycoside				
Legal Test	+	+	+	-
Lieberman Test	+	-	-	+
Salkwoski Test	+	+	-	+
Keller Killiani	+	+	+	+

4. RESULTS

The results of the corrosion rate and inhibiting efficiency versus exposure time plots of low carbon steel immersed in 0.5M HCl and NaCl in the presence and absence of varying percentage of inhibitors (Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica, Panicum maximum) are presented below.

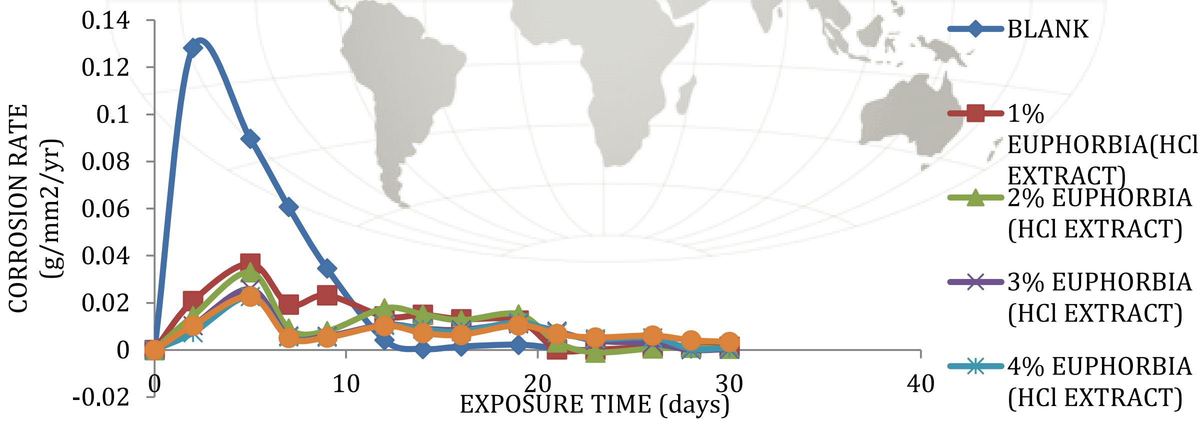

Figure 1. Variation of corrosion rate of low carbon steel in 0.5M HCl acid in presence and absence of acid extract of Euphorbia heterophylla

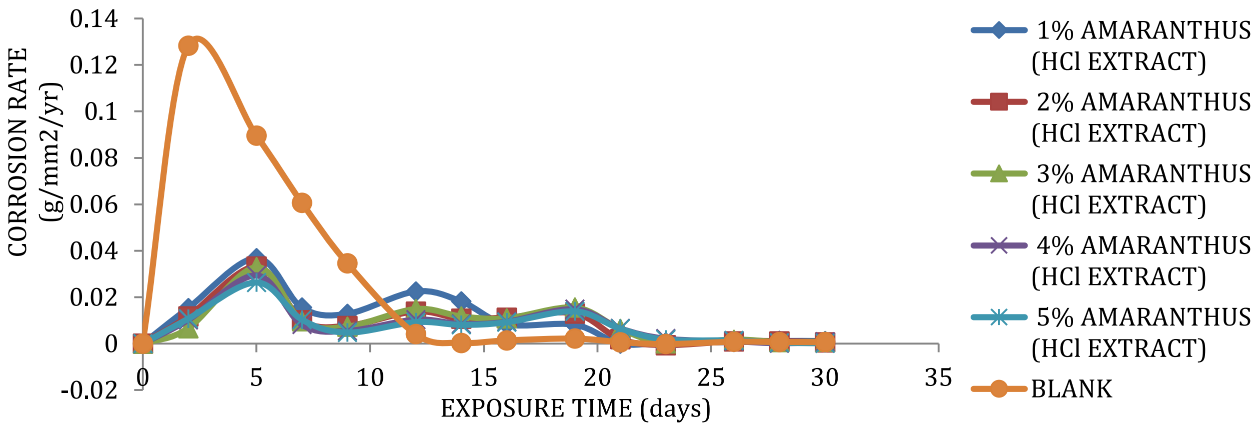

Figure 2. Variation of corrosion rate of low carbon steel in 0.5M HCl acid in presence and absence of acid extract of Amaranthusspinosus

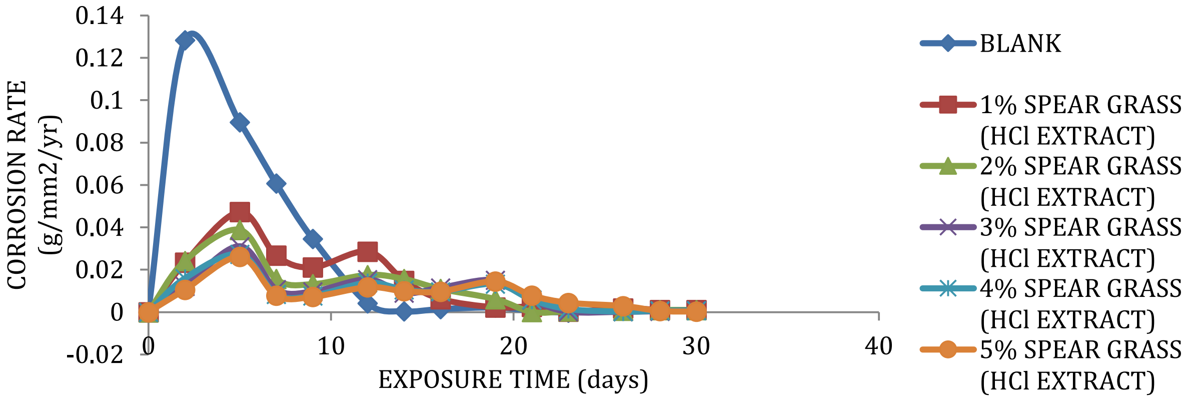

Figure 3. Variation of corrosion rate of low carbon steel in 0.5M HCl acid in presence and absence of acid extract of Imperatacylindrica

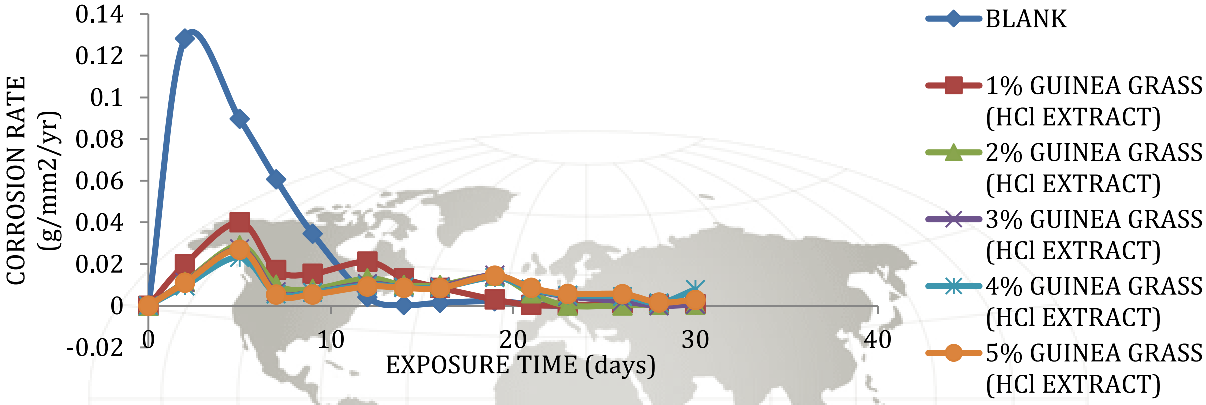

Figure 4. Variation of corrosion rate of low carbon steel in 0.5M HCl acid in presence and absence of acid extract of Panicum maximum

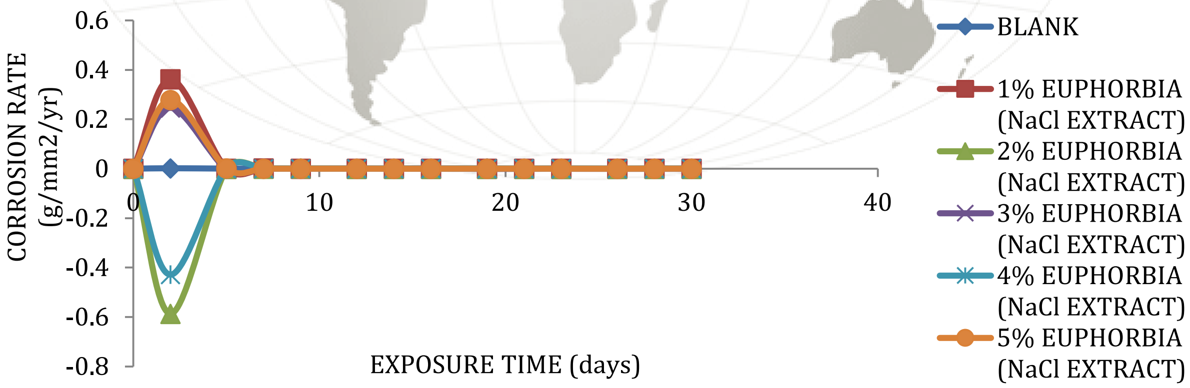

Figure 5. Variation of corrosion rate of low carbon steel in 0.5M NaCl solution in presence and absence of saline extract of Euphorbia heterophylla

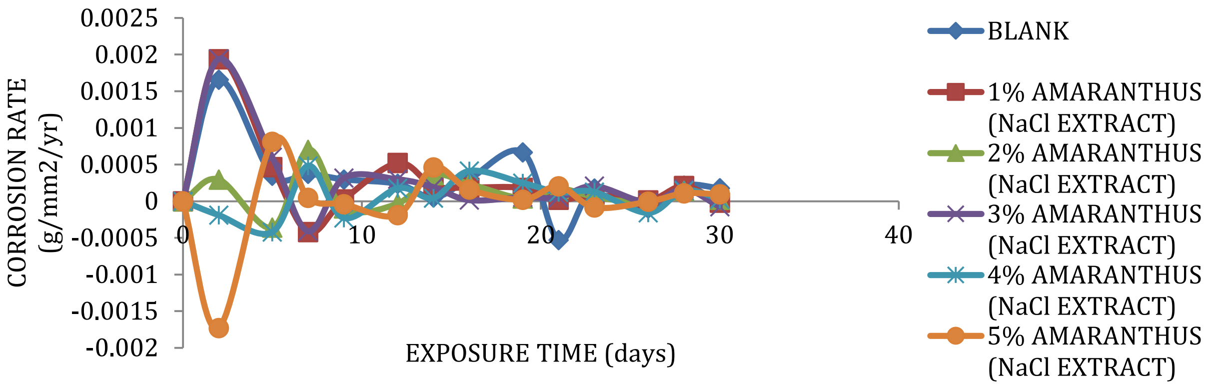

Figure 6. Variation of corrosion rate of low carbon steel in 0.5M NaCl solution in presence and absence of saline extract of Amaranthusspinosus

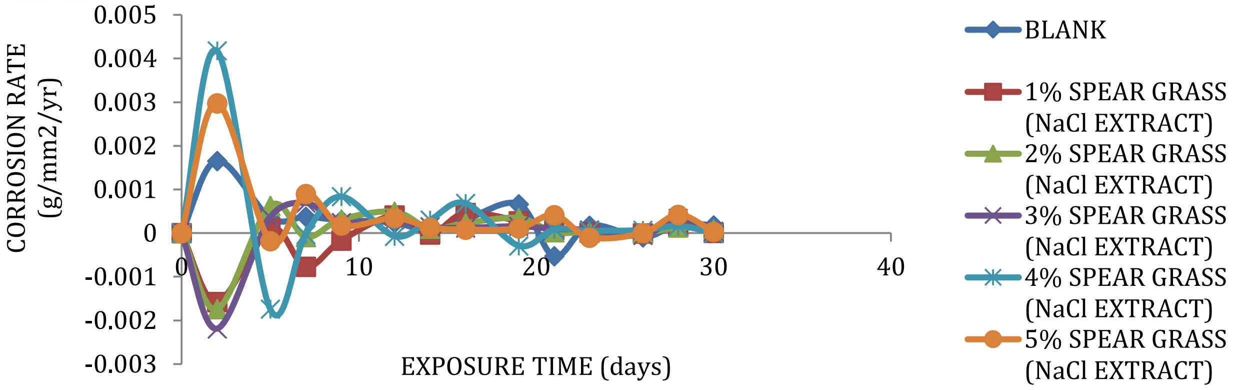

Figure 7. Variation of corrosion rate of low carbon steel in 0.5M NaCl solution in presence and absence of salt extract of Imperatacylindrica

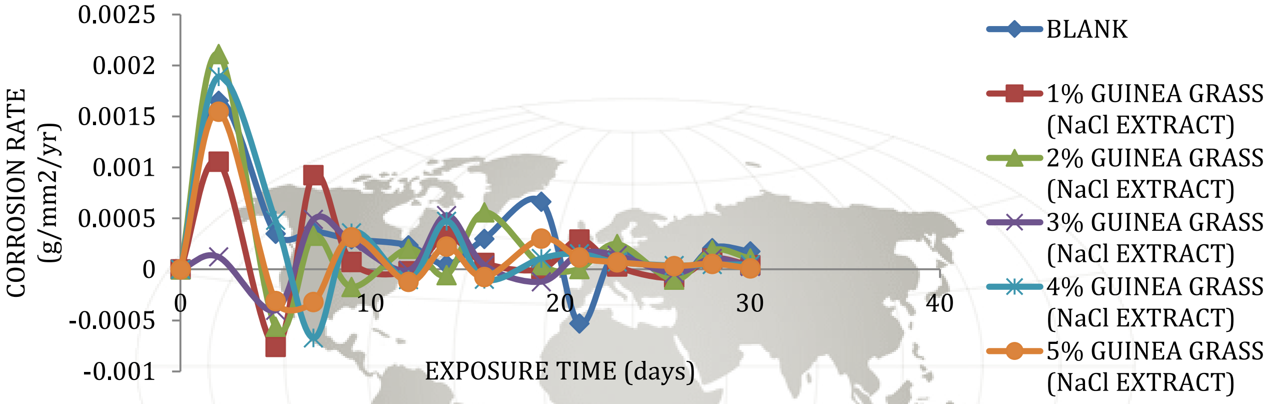

Figure 8. Variation of corrosion rate of low carbon steel in 0.5M NaCl solution in presence and absence of saline extract of Panicum maximum

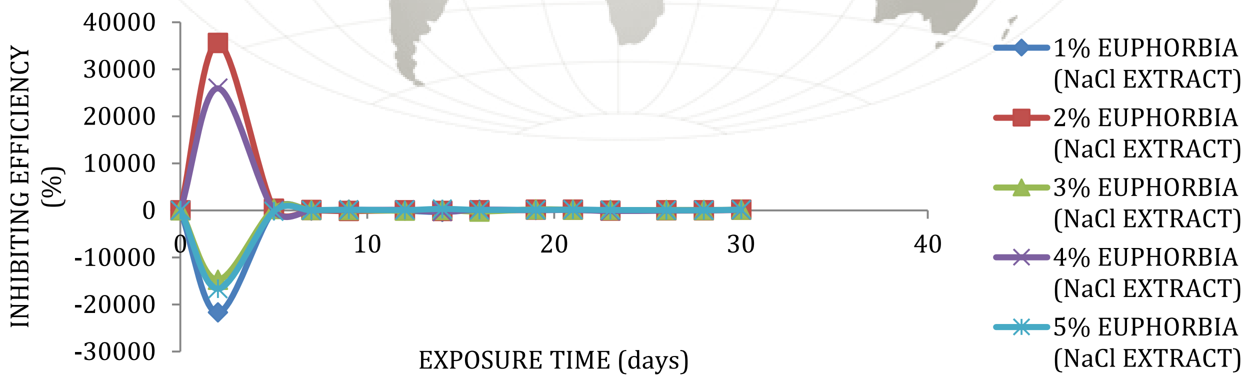

Figure 9. Variation of inhibiting efficiency of saline extract of Euphorbia heterophylla on low carbon steel in 0.5M NaCl solution

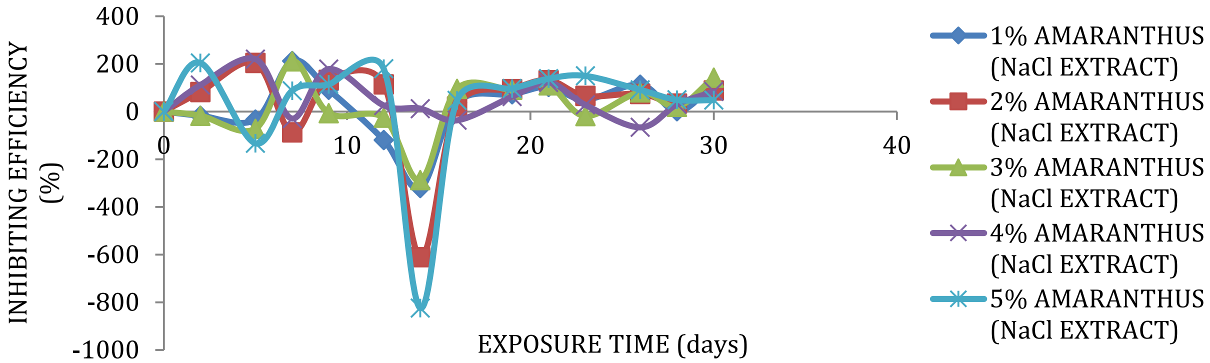

Figure 10. Variation of inhibiting efficiency of saline extract of Amaranthusspinosus on low carbon steel in 0.5M NaCl solution

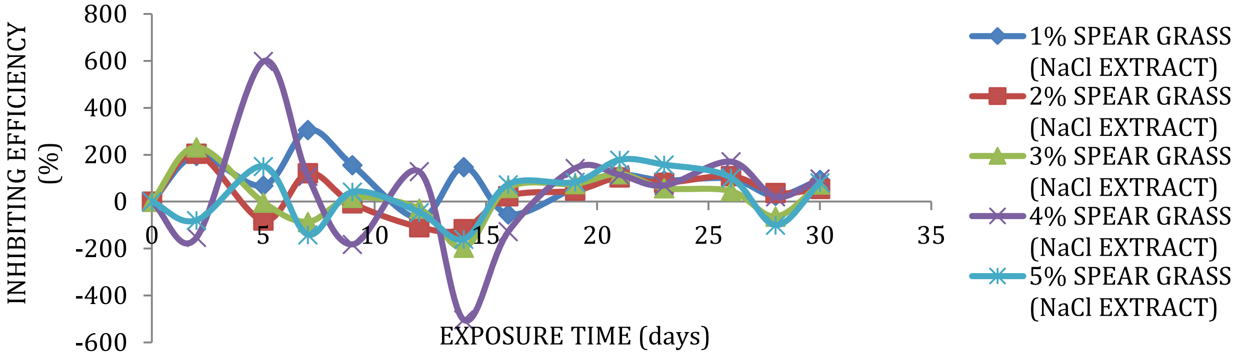

Figure 11. Variation of inhibiting efficiency of saline extract of Imperatacylindrica on low carbon steel in 0.5M NaCl solution

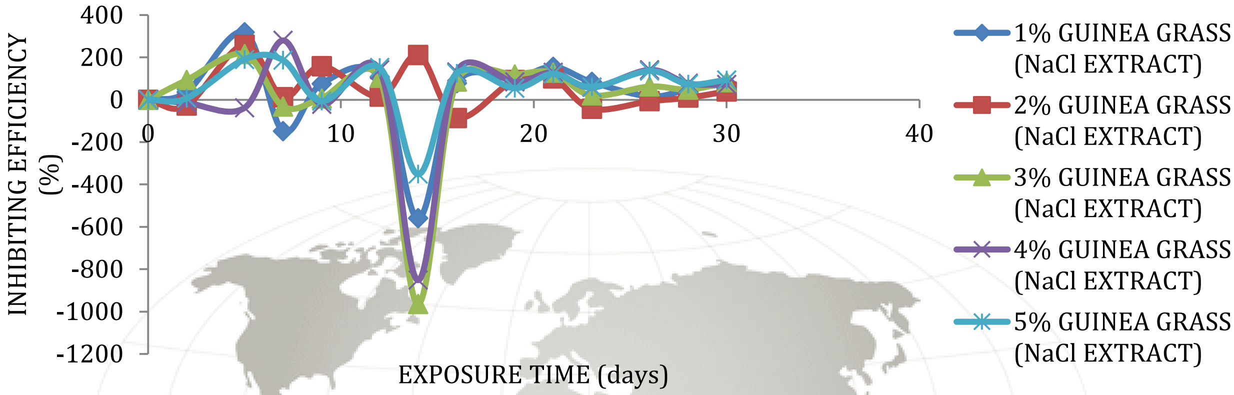

Figure 12. Variation of inhibiting efficiency of saline extract of Panicum maximum on low carbon steel in 0.5M NaCl solution

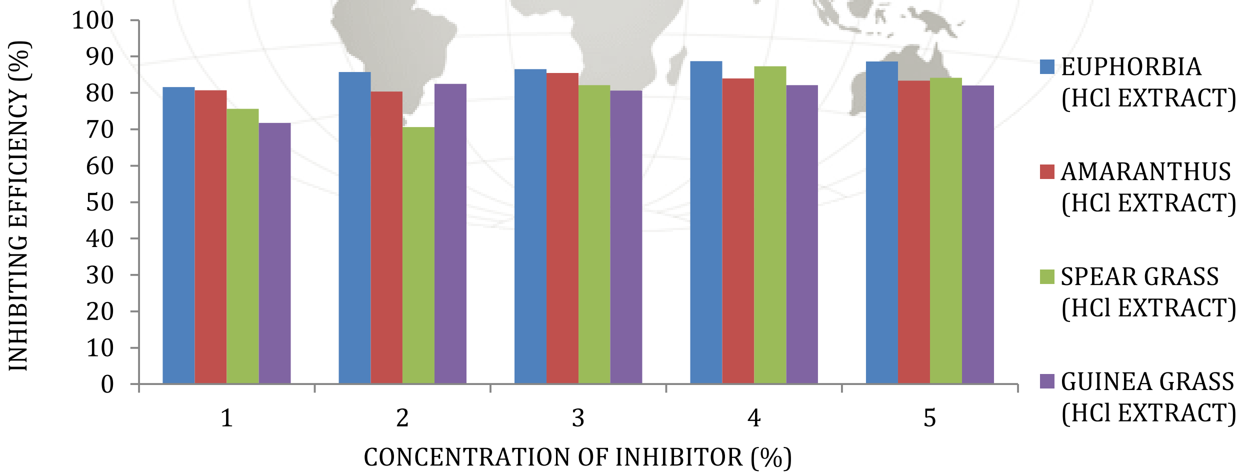

Figure 13. Variation of inhibiting efficiency of acid extract of Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica, and Panicum maximum with extract concentration

5. DISCUSSION

Pyhtochemical Constituents

The results of the phytochemical analysis of the acid extract of the leaves are presented in Table 2. The table presents some of the compounds that are responsible for the inhibitive action of the leaves (Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica and Panicum maximum) extract. The presence of Tannin, Flavonoid and Triterpenoid in the leaves extract has proven that the leaves' extract could actually inhibit the mild steel[12]. From the result, all the leaves contain flavonoid. Extract of Amaranthusspinosus contains alkaloid while tannin is present in Euphorbia heterophylla and Imperatacylindrica. Also, the presence of saponin is notable in Imperatacylindrica.

The inhibitive properties of tannins have been attributed to the reaction of the polyphenolic fraction of the tannins moieties, which ensures effective protection of the metal surfaces [13]. The flavonoid and other constituents also possess functional groups which are capable of chelating with metal ions and thus facilitate strong coordination on the surface of the steel [14].

Effect of Extract Concentration on Corrosion Rate

Figure 1 to 8 is the variation of corrosion rate of low carbon steel in 0.5M HCl and 0.5M NaCl solution in the absence and presence of various concentrations of leaves (Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica and Panicum maximum) extracts. The result showed that the corrosion rate of low carbon steel in 0.5M HCl decreased with increase in concentration of extracts. This suggests that as the concentration of extracts increases, there is an increase in the number of adsorption of the extract constituents on the surface of the low carbon steel which prevent rapid dissolution of Fe^{2+} into the solution [15]. On the other hand, the corrosion rate of low carbon steel in 0.5M NaCl solution showed a fluctuating trend. Similar results have been reported in atmospheric corrosion of stainless steel [16,17].

Effect of Concentration on Inhibiting Efficiency

It can be seen from the Figure13 that the inhibition efficiency of the inhibitors increases with increasing concentration of inhibitors. When the extract concentration was at 1%, the inhibiting efficiency for euphorbia, amaranthus, spear grass and guinea grass were 81.52%, 80.76%, 75.59%, 71.79% respectively but when the concentration increased to 2%, the inhibiting efficiency for euphorbia and guinea grass increased to 85.71% and 82.44% while there were decrease in inhibiting efficiency for amaranthus and spear grass. With increase in extract concentration to 3% and 4%, there were also increased in their inhibiting efficiency of all the extracts, but at extract concentration of 5%, there were slight decrease in their inhibiting efficiency.

6. CONCLUSIONS

The following conclusions can be drawn from the results obtained in carrying out the research Euphorbia heterophylla, Amaranthusspinosus, Imperatacylindrica and Panicum maximum act as efficient inhibitors in acidic medium for the reduction in corrosion attack on low carbon steel. More so, the weight loss decreased significantly in the presence of the extracts.

Acid extract of Euphorbia heterophylla has the highest inhibiting efficiency of 88.73% at 4% concentration which shows that the extracts concentration at 4% of all the inhibitors will be enough while extract of Imperatacylindrica has the least inhibiting efficiency of 70.63% at 2% concentration.

References

[1.] Raja PB, Sethuraman MG.(2008). Natural products as corrosion inhibitor for metals in corrosive media - A review. Materials Letters, 62(1), 113-116.

[2.] Saedah R. Al Mhyawi,: Inhibition of mild steel corrosion using juniperus plants as green inhibitor, African journal of pure and applied chemistry, vol. 8,(1) pp. 9-12, 2014

[3.] Uwah I.E, Okafor P.C and Ebiekpe V.E,: Inhibitive action of ethanol extracts from Nauclealatifolia on the corrosion of mild steel in H_2SO_4 solutions and their adsorption characteristics, Arabian journal of chemistry, vol. 6 issue 3, pp. 285-293,2013.

[4.] Abdel-Gaber AM, Abd-El-Nabey BA, Sidahmed IM, El-Zayady AM, Saadawy M. (2006**)** Inhibitive action of some plant extracts on the corrosion of steel in acidic media, Corr. Sci. 48(9): 2765 - 2779.

[5.] Desia P.S and Kaporara S.M.: Inhibiting effect of anisidines on corrosion of aluminium in hydrochloric acid, Indian journal of chemical technology, vol 16, pp 486 – 491, 2009.

[6.] Ramananda M, Singh. 2008, "The inhibitory effect of dicthanolamine on corrosion of mild steel in O.S.M sulpuric medium", Portugaliae Electrochemical Acta, vol. 26, pp. 479 -492

[7.] Fonda A.S., Elewandy G.Y, and El-Haddad M.N., "Corrosion inhibition of carbon, steel in acidic solution using some azodyes", Canadian journal on specific and industrimistral research, vol 2, no. 1, pp 1-18, 2011.

[8.] Sachin H.P., M.H.M. Khan and N.S. Rhujangaiah: Surface modification of mild steel by orthophenylendiamine and its corrosion study, International Journal of Electrochemical Science, vol. 4, no. 1, pp 134 – 143, 2009

[9.] Higgins, R. A, Engineering Metallurgy, Sixth Edition, Viva Books, Private Limited, pp 158, 2004.

[10.] Lebrini, M, Robert, F and Roos, C, Alkaloids Extract from PalicoureaguianensisPlant as Corrosion Inhibitor for C38 Steel in 1 M Hydrochloric Acid Medium, International journal of electrochemical science, Vol. 6, pp 847-59, 2011.

[11.] Abdulrahman A. S and Mohammad, Evaluation of corrosion inhibiting admixtures for steel reinforcement in concrete. International journal of the physical sciences Vol. 7, No 1, pp. 139 – 143, 2012.

[12.] Shanab SMM, Ameer MA, Fekry A M, Ghoneim AA, Shalaby EA. Corrosion Resistance of Magnesium Alloy (AZ31E) as Orthopaedic Biomaterials in Sodium Chloride Containing Antioxidantly Active Compounds from Eichhorniacrassipes. International Journals of Electrochemical Science, 6: 3017 – 3035, 2011

[13.] Nnanna L.A, Onwuagba B.N, Mejeha I.M, Okeoma K.B. Inhibition effects of some plant extracts on the acid corrosion of aluminium alloy. African Journal of Pure and Applied Chemistry, 4(1) 11-16, 2010.
[14.] Oguzie E. Evaluation of the inhibitive effect of some plant extracts on the acid corrosion of mild steel. Corrosion Science. 50: 2993-2998, 2008.
[15.] Nutan K, Alok C, Rajesh K. U. Comparative Study of Corrosion Inhibition Efficiency of Naturally Occurring Ecofriendly Varieties of Holy Basil (Tulsi) for Tin in HNO_3Solution. Journal of Metal, 2, 68-73, 2012
[16.] Wang B.B.; Wang Z.Y.; Han W. and Ke W. ; Atmospheric Corrosion of Aluminium Alloy 2024-T3 Exposed to Salt Environment in Western China,Journal of Corrosion Science, Volume 59, Pp. 63-70, 2012.
[17.] Liang C.F., Hou W.T.; Twelve year Atmospheric Exposture of Stainless Steels in China, in; H.E. Townsent (Ed.). Outdoor Atmospheric Corrosion,ASTM STP 1421, American Society of Testing and Materials, Philadelphia,Pp. 358-367, 2002.

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