Uniport Journal of Engineering and Scientific Research (UJESR)

Vol. 8, Issue 2, 2024, Page 322-326
ISSN: 2616-1192

(www.ujesr.org)

Combating Subsea Pipeline Corrosion Using Vernonia Amygdalina

Cookey, D[1], Uzoigwe, N[2]* and Odutola, T[3]
[1] Department of Petroleum and Gas Engineering. University of Port Harcourt, Rivers State.
[2] Department of Petroleum Engineering. Rivers State University, Rivers State.
[3] Department of Petroleum and Gas Engineering. University of Port Harcourt, Rivers State.
*Corresponding author's email: ndidi.uzoigwe@ust.edu.ng

Abstract
This study investigated the potential of Vernonia amygdalina extract as an eco-friendly corrosion inhibitor for aluminium, mild steel, and galvanized steel in subsea pipeline applications. Recognizing the limitations and environmental concerns associated with synthetic inhibitors, this research explored Vernonia amygdalina, a plant known for bioactive compounds with antioxidant and antimicrobial properties. Experimental tests were conducted in seawater to observe the effects of varying Vernonia amygdalina concentrations (8 ml, 12 ml, and 16 ml) on corrosion rates. Results indicated that Vernonia amygdalina significantly reduced corrosion, with higher concentrations offering increased protection across all metals. Aluminum exhibited the highest initial corrosion rates but showed notable improvement at higher Vernonia amygdalina levels. Mild steel displayed the best overall resistance, achieving optimal protection at 12 ml Vernonia amygdalina, while galvanized steel demonstrated moderate reduction, preserving both zinc coating and underlying steel. These findings support Vernonia amygdalina's potential as a sustainable, cost-effective alternative for corrosion control in the oil and gas industry.

Keywords: Vernonia Amygdalina, Corrosion inhibition, Mild steel, Aluminium coupon

Received: 31st October, 2024 *Accepted: 31st December, 2024*

1. Introduction

Subsea pipelines are essential for transporting hydrocarbons across the ocean floor, but they face severe corrosion risks due to the saline, high-pressure environment and microbial activity (El-Shafei et al., 2012). This degradation undermines pipeline integrity, causing leaks, environmental harm, and sometimes loss of life (IEA, 2019). The materials commonly used in these pipelines are highly vulnerable, creating both economic and ecological burdens (Amutha et al., 2015). Corrosion costs the oil and gas sector billions annually and poses significant risks to marine ecosystems and coastal economies if corrosion related issues emanate (Fouda et al., 2020).

Traditional corrosion control relies on synthetic inhibitors, which, although effective, are costly, require regular reapplication, and pose environmental concerns due to potential toxicity and bioaccumulation (Abdel-Gaber et al., 2006). Consequently, sustainable alternatives like Vernonia amygdalina (VA), commonly known as bitterleaf, have drawn interest. VA's bioactive compounds, such as saponins and terpenoids, possess antioxidant and antimicrobial properties, which may inhibit corrosion. Being biodegradable and widely available, VA offers an eco-friendly and cost-effective solution, though more research is needed to assess its long-term stability and compatibility with pipeline systems (Arockia and Rajendran, 2009). This study explores VA's potential as a corrosion inhibitor.

2. Materials and methods

This study examined the corrosion inhibition properties of Vernonia amygdalina. The materials used included dried leaves of Vernonia amygdalina, concentrated tetraoxosulphate (VI) acid (98% pure), acetone, ethanol, distilled water, and metal coupons made from aluminium, mild steel, and galvanized steel. The experiment began with cutting the coupons to size and drilling holes for suspension. After smoothing the surfaces with abrasive paper, the coupons were rinsed, degreased in acetone, and air-dried before weighing to determine their initial mass.

The dried Vernonia amygdalina leaves were ground into a fine powder, and their active compounds were extracted using ethanol in a 4:1 ratio. The extract was collected for use in subsequent tests. Control beakers containing 200 ml of seawater (pH 7.6) with 1 ml H_2SO_4 were prepared for each metal type. Additionally, nine beakers with varying concentrations of the VA extract (8 ml, 12 ml, and 16 ml) were set up. Each coupon was suspended in its respective solution and monitored for 24 hours. The weight loss was calculated daily to determine the corrosion rate using Equation (1).

$$CR = \frac{(K*W)}{(A*T*D)} \quad (1)$$

where w is the mass loss, k is the rate of corrosion, A is the area of the specimen, D1 is the aluminium density, T is the time of exposure, and D2 is the mild steel density.

3. Results

Table 1 compares the weight loss and corrosion rate of aluminium coupons under different concentrations of *Vernonia amygdalina* (VA) extract. The table provides critical insights into the effectiveness of VA as a corrosion inhibitor by showcasing the progressive reduction in corrosion rates as inhibitor concentration increases. By analyzing the data in Tables 1, 2 and 3, we can assess the dose-dependent impact of VA extract and its potential in mitigating aluminium, mild steel and galvanized steel corrosion in aggressive environments.

Table 1: Effect of vernonia amygdalina extract on the corrosion of aluminium coupon

Time (hour)	0ml Weight Loss (g)	8ml Weight Loss (g)	12ml Weight Loss (g)	16ml Weight Loss (g)	0ml Corrosion Rate (mm/yr)	8ml Corrosion Rate (mm/yr)	12ml Corrosion Rate (mm/yr)	16ml Corrosion Rate (mm/yr)
24	0.676	0.439	0.109	0.333	70.4046	45.7213	11.3522	34.6816
48	0.983	0.739	0.249	0.461	51.1892	38.483	12.9665	24.0063
72	1.044	0.929	0.349	0.686	36.2438	32.2514	12.116	23.8154
96	1.131	1.069	0.569	0.811	29.4481	27.8338	14.8152	21.1162
120	1.131	1.099	0.579	0.956	23.5585	22.8919	12.0604	19.9133

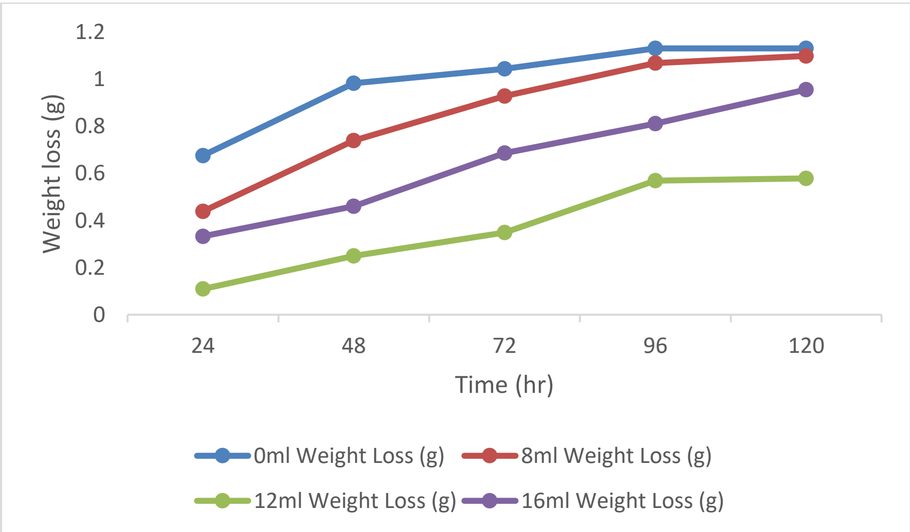

Fig. 1: Weight loss vs time plot for aluminium coupon

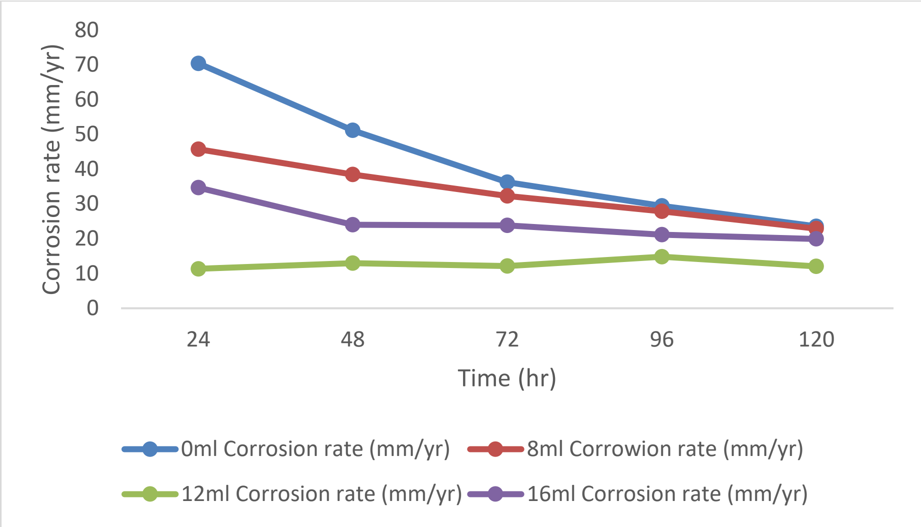

Fig. 2: Corrosion rate vs time plot for aluminium

Table 2: Effect of vernonia amygdalina extract on the corrosion of mild steel coupon

Time (hour)	0ml Weight Loss (g)	8ml Weight Loss (g)	12ml Weight Loss (g)	16ml Weight Loss (g)	0ml Corrosion Rate (mm/yr)	8ml Corrosion Rate (mm/yr)	12ml Corrosion Rate (mm/yr)	16ml Corrosion Rate (mm/yr)
24	0.02	0.27	0.006	0.017	0.7155	9.6596	0.2147	0.6082
48	0.115	0.268	0.011	0.027	2.0571	4.794	0.1968	0.483
72	0.166	0.257	0.02	0.029	1.9796	3.0648	0.2385	0.3458
96	0.179	0.248	0.028	0.031	1.601	2.2181	0.2504	0.2773
120	0.184	0.298	0.039	0.033	1.3166	2.1323	0.2791	0.2361

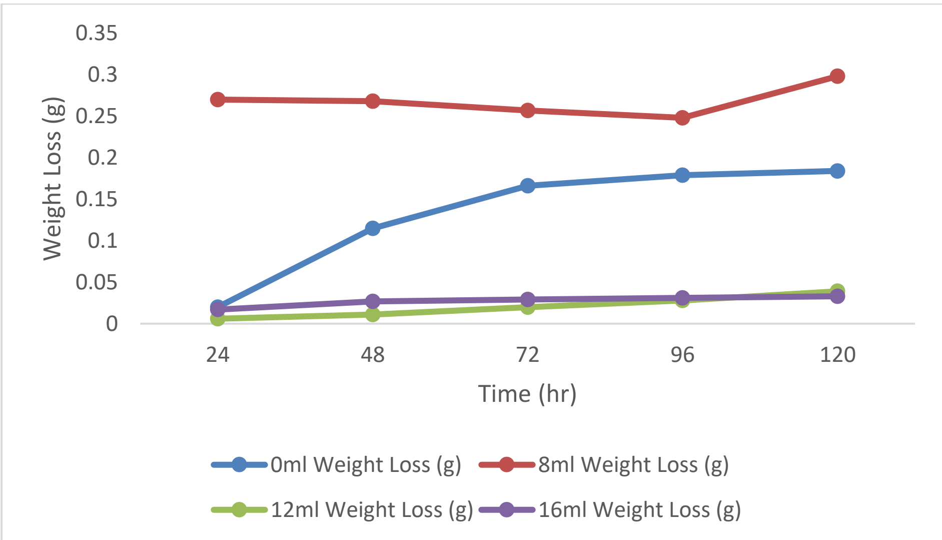

Fig. 3: Weight loss vs time plot for mild steel

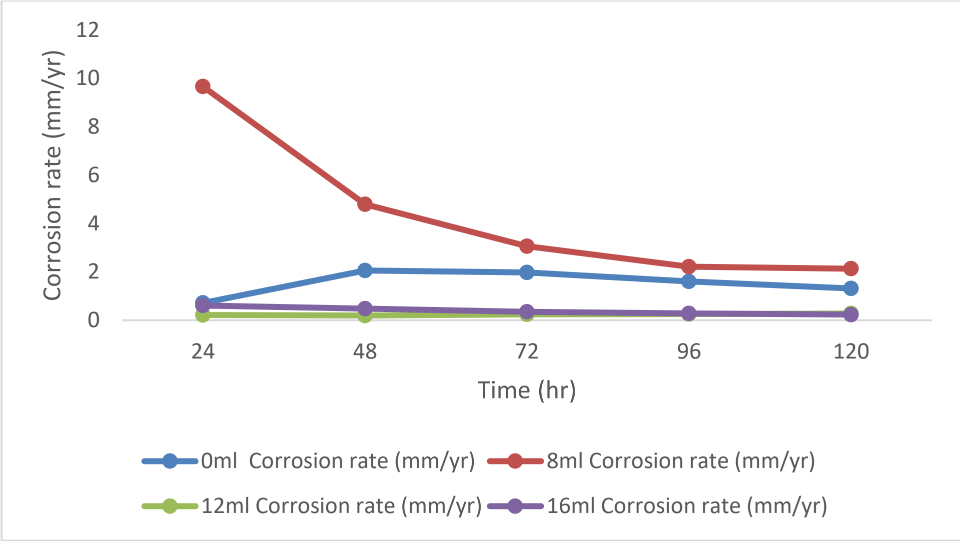

Fig. 4: Corrosion rate vs Time plot for mild steel

Table 3: Effect of vernonia amygdalina extract on the corrosion of galvanized steel coupon

Time (hour)	0ml Weight Loss (g)	8ml Weight Loss (g)	12ml Weight Loss (g)	16ml Weight Loss (g)	0ml Corrosion Rate (mm/yr)	8ml Corrosion Rate (mm/yr)	12ml Corrosion Rate (mm/yr)	16ml Corrosion Rate (mm/yr)
24	0.499	0.17	0.041	0.04	17.875	6.0897	1.4687	1.4329
48	0.649	0.15	0.056	0.075	11.624	2.6866	1.003	1.3433
72	0.754	0.13	0.071	0.091	9.003	1.5523	0.8478	1.0866
96	0.839	0.11	0.102	0.105	7.514	0.9851	0.9135	0.9403
120	0.846	0.1	0.114	0.111	6.061	0.7164	0.8167	0.7952

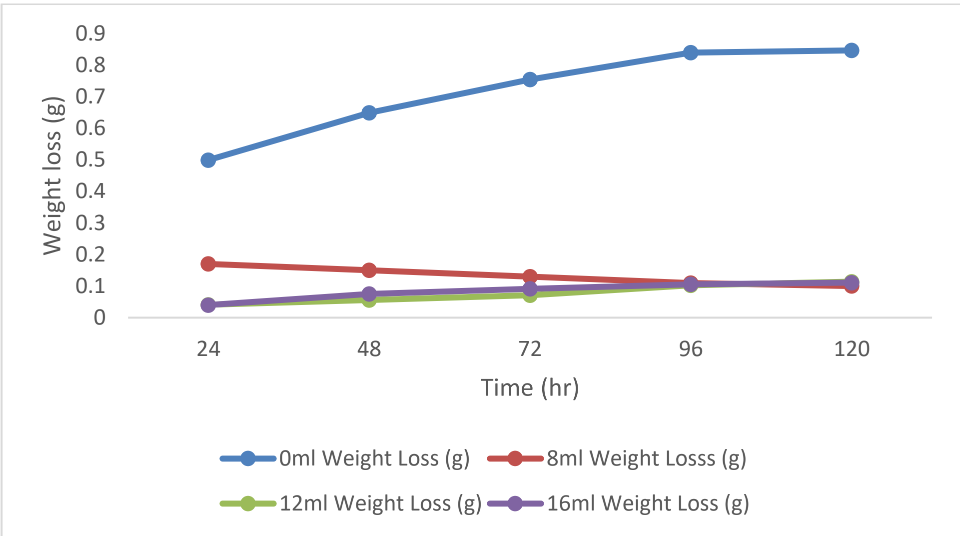

Fig. 5: Weight loss vs Time plot for galvanized steel

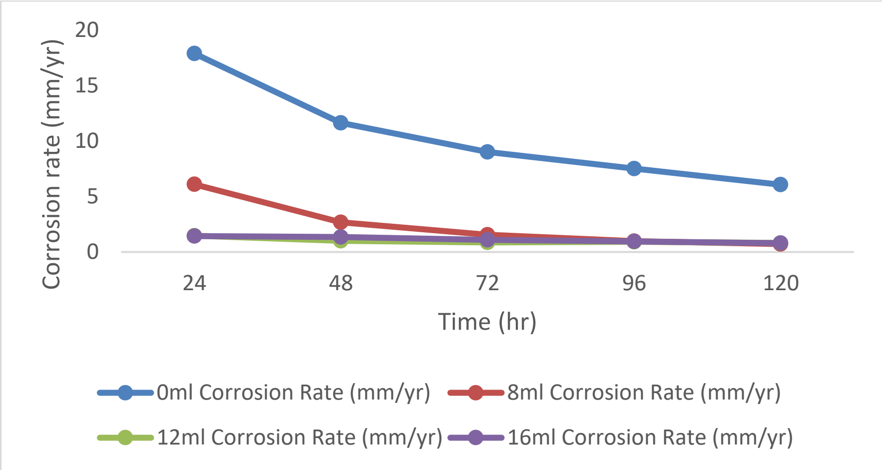

Fig. 6: Corrosion rate vs time plot for galvanized steel

4. Discussion

The VA inhibitor effectively reduced corrosion in aluminum, mild steel, and galvanized steel, with higher concentrations generally offering better protection for galvanized steel. The optimal performance of VA was observed at a concentration of 12 mL for both aluminum and mild steel coupons. Aluminum, being the most susceptible to corrosion, exhibited a significant reduction in corrosion rate with the application of a 12 mL dose of VA. Mild steel demonstrated the highest resistance, with its corrosion rate at a VA concentration of 12 mL. Similarly, galvanized steel experienced a notable decline in corrosion rate 16 mL of VA, effectively protecting both the zinc coating and the underlying steel. The observed dose-dependent effect highlights the potential for optimizing VA concentration and warrants further investigation into its inhibition mechanisms, including possible synergistic applications with other protective methods

5. Conclusion

This study shows that the VA inhibitor effectively reduces corrosion in several commonly used metals, with mild steel displaying the most substantial improvement. As the concentration of the inhibitor increased, its protective effects strengthened, suggesting room for further optimization. Aluminum exhibited the highest corrosion rates and required more inhibitor for protection, while galvanized steel showed moderate improvement, protecting both zinc and steel layers. These results indicate that the VA inhibitor interacts uniquely with different metals, underscoring the need for more research into its mechanisms. Overall, the study highlights VA inhibitor's potential as a versatile anti-corrosion solution for various industries.

References

Abdel-Gaber, A.M., Khamis, E.E. and Osman, M.M. (2006) Synergistic effect of clove oil and sodium dodecyl sulphate on the corrosion inhibition of carbon steel in acidic media. Corrosion Science, 48(10):2735-48.

Amutha, P., Sivakumar, M. and Nithya, A. (2015) 'Corrosion inhibition of mild steel in acidic media by ginger extract', International Journal of ChemTech Research, 7(1): 1–6.

Arockia-Selvi, V. and Rajendran, S. (2009) 'Corrosion inhibition of mild steel by aqueous extract of Ocimum basilicum L. in acidic media', Materials Chemistry and Physics, 115(2–3): 517–522.

El-Shafei, M.M., El-Sherif, Z.M. and El-Mazny, A.M. (2012) 'Corrosion inhibition of bronze artifacts using henna extract', Corrosion Science, 54(11): 835–844.

Fouda, A.S., El-Hariry, O.A., El-Shafei, M.M. and El-Sherbini, E.F. (2020) 'Green corrosion inhibitors for steel in acidic media: A comprehensive review', Materials and Corrosion, 71(10): 1000–1034.

International Energy Agency (IEA) (2019) World energy outlook 2019. Paris: IEA. Available at: https://www.iea.org/reports/world-energy-outlook -2019 (Accessed: 31 October 2024).