International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 12 Dec. 2025, pp: 125-130 www.ijaem.net ISSN: 2395-5252

Effect of Saline Water on Formulated Marine Paint from Organic Binder

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Date of Submission: 01-12-2025 Date of Acceptance: 10-12-2025

ABSTRACT
Marine water as a major means of transportation and economic growth serves as a critical component of modern society. The marine transport system is facing the problem of corrosion and fouling leading to high cost of maintenance and operation. In order to ascertain the effectiveness of marine paint produced from organic materials, the effect of marine water on these kinds of paint has to be studied. Therefore, this work seeks to studies the properties of saline water and their effect on the produced organic marine paint. Saline water samples were collected from three different locations in Akwa Ibom State, The Qua Iboe River, Okoroette River and Utaewa River. The tree different river samples were tased for their dissolved oxygen content, temperature, turbidity, total dissolved solid, alkalinity pH and Electrical conductivity. The results show the water samples dissolved oxygen content of 3.46, 2.98 and 3.27; temperature of 26.86^{o}C, 36.92^{o}C and 26.47^{o}C; Turbidity of 33.81 NTU, 31.26NTU, and 32.49NTU;Total dissolved oxygen 271.98 Ppm, 281.95Ppm and 310.74Ppm; pH of 6.92, 6.48 and 6.41; Electrical conductivity of 1100.26, 986.45 and 1453.86 lastly, Alkalinity of 90.70µs/cm, 132.51µs/cm and 172.9µs/cm for the three river samples respectively. The results confirm the corrosive nature of these marine water samples on the produced organic paint.

I. INTRODUCTION

One of the most obvious differences between sea water and freshwater is that seawater contains dissolvedsubstances that give it a distinctly salty taste (Tarbucket al., 2025). Thesedissolved substances are not simply sodium chloride(Table salt);they include various other salts, metals,and even dissolved gases. This obviously affect the characteristics of marine water, the kind of organisms found in them, their effect on materials like sea vessels and also its uses. Seawaterplays a veryimportant role in the human existence.Historically, saline water was most valued due to its use as a source of salt that can be used for both industrial and domestic uses(Sverdrupand Armbrust2008).Marine water alsoserves as habitats for various wide lives, ranging from microorganisms to big fishes like whales etc (Aryal et al., 2015).

Apart from its domestic application, marine water plays a major role in the transport sector, it serves as a major means of transportation and economic growth across the globe (Arachchigeet al., 2021). Transportation, being a critical component of modern society, enables the movement of people, goods, and services across various distances and environments. It supports economic growth, connects communities, and supports global trade. Itis sometimes described as container transportation(Oladimeji, et al., 2023). According to report, almost 80% of global trade accounts through sea transportation (Matekenya andNcwadi, 2022). On a global scale, sea transport is essential due to its ability to carry large quantities of cargo using high-capacity compartments. The containers can handle a large number of products with ease. It makes this strategy particularly profitable for global exchanges. It has become the most popular choice among organizations and people (Lee, et al.,2024). It is observed that sea transport is commonly used due to its rationality and lower natural impact compared to other modes of transportation.

Despite all the advantages associated with marine transportation, there are several challenges faced by the marine transport system, some of which are fouling of marine vessels which may lead to higher fuel consumption and corrosion of marine vessels which lead to increase in cost of maintenance(Ramansata 2022). In line with this, several ship builders have come up with several means of protection for sea vessels, some of which pose serious threat to the aquatic ecosystem, some authors have studied means of replacing some of these harmful and toxic chemicals with ecofriendly

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materials (David and Babalola 2025). In order to ascertain the effectiveness of this paint produced from organic materials, the effect of marine water on these kinds of paint has to be studied. Marine water is mainly characterized by the presence of dissolved substance (majorly salt) which gives it the unique salty taste, buoyancy and other characteristic properties (Tarbuck et al., 2025). Therefore, this work seeks to studies the properties of saline water and their effect on the produced organic marine paint

II. MATERIALS AND METHODS

Marine water is a complex, highly corrosive electrolyte solution containing dissolved salts (primarily sodium and chloride ions), atmospheric gases, organic matter, and a slightly alkaline. (Jingloaet al.,2023). To study the effect of saline water on the produced marine paint from organic binder, the characteristics of saline water was studied.

Electrical conductivity of the samples were determined using a Jenway 4020 conductivity meter; the electrode was immersed into the sample, allowing the meter to stabilize and results recorded. Toluene extraction method was used for measurement of total hydrocarbon content (Wemedo 2016)

To measure the total dissolved solid content of the water sample, the obtained water sampleswere filtered using Whatman filter paper, the filtrate was collected into a clean empty container and then dried in an oven at 180°C for 8hours, thereafter it was removed and cooled in a desiccator and reweighed. The concentration of the TDS was measured using the equation 1

$$TDS = \frac{W_{SR} - W_S}{V_S} \times 1000mg/g \times 1000ml/L$$

equation 1

Where W_{SR} - Weight of clean dried container (gm)
W_S - Weight of container and residue(gm)
V_S - Volume of Sample (ml)

To determine the alkalinity of the seawater, the method of Dhoke (2023) was used, the determination of alkalinity of the seawater sample was carried out experimentally by titrationmethod using a phenolphthalein and methyl orange indicator The temperature and pH of the water samples were determined in situ, to read the pH of the samples, the pH meter was dipped in the water sample and the readings were recorded appropriately, to get the temperature of the water, this was done by dipping the thermometer of the 110°C calibration range into the water, and the reading is taken after 5 minutes interval (APHA, 1998).

To study the effect of saline water on the formulated marine paint from organic binder, two different formulated paint samples were applied to flat metal panels, dried, and cured. The panels were then immersed in fresh and salt water for 1 to 21 days to observe any chemical or physical changes following the method of David and Babalola (2025)

III. RESULTS

The characterization of saline water was done using saline water samples from three different locations and the results are presented in Table 1, the result shows the Dissolved Oxygen, temperature, turbidity, total dissolved solids, pH, Electrical conductivity and alkalinity of samples obtained from Qua Iboe River, Okoroete River and Utawa River, these Rivers are salt water rivers bodies situated closed to the Atlantic Ocean (Ekpe et al., 1995, Ekanimet al., 2016).

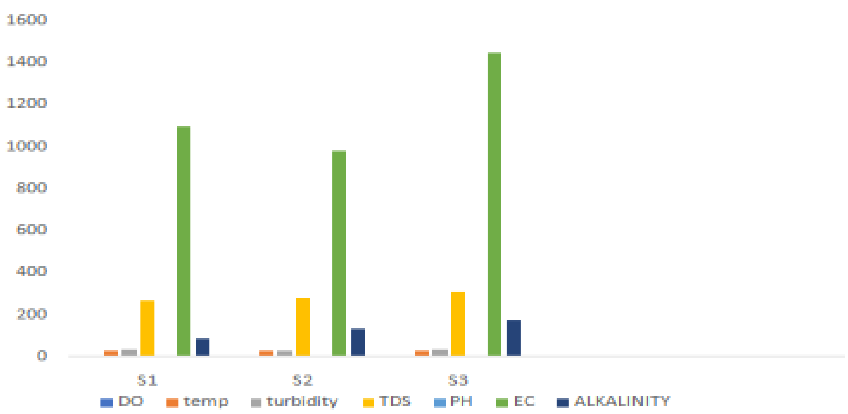

Figure 1: Bar chart showing chemical properties of saline water

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Figure 1 presents the properties of the three different water samples on a bar chart, it is observed from the bar that Utaewa River sample (S3) shows the highest properties of turbidity, total dissolved solid, electrical conductivity and the alkalinity while having the lowest pH and temperature.

Dissolved oxygen, oftentimes abbreviated as DO, is the measure of the amount of free oxygen (O_2) that is dissolved in the water (Jacket al., 2009).Dissolved oxygen is vital to aquatic life, as it is needed to keep organisms alive. Although the effect of dissolved oxygen in salt water has been reported to have significant effect on the aquatic lives, high dissolved oxygen in water has been report to increase corrosion rate on metal sheets (Su et al., 2019). In this study, the Dissolved oxygen level was between the range of 2.98 to 3.46 as shown in table 1 which is lower that the results obtained by (Jacket al., 2009) and WHO standard of 4.0mg/l to 5.omg/l(UNESCO/WHO, 1978), this isdue to different anthropogenic activities being carried out around these water bodies (Alexanderet al., 2020). The temperature range of 26.47 to 26.91 also aligned with the result obtained by Abowei (2010). high temperature of salt water can accelerate chemical reactions, increase kinetic energy of the molecules, making it more likely for corrosion reactions to occur, but the result obtained in this study is moderate hence the painted panel has will not corrode easily.

Turbidity is a measure of water clarity in streams, rivers, lakes, and the ocean. It describes the amount of light scattered or blocked by suspended particles in a water sample (Pisantiet al., 2022). High turbidity level in salt water due to suspended particle may contribute to coating performance in both standard and organic painted panels (Matos et al., 2024).Clear water has low turbidity and cloudy or murky water has a higher turbidity level. Turbidity is caused by particles of soil, organic matter, metals, or similar matter suspended in the water column (ADEC 2013).Although the turbidity of saline water does not have a direct effect on marine paints, it has a direct correlation with the salinity of the water. Research have shown that turbidity decreases with increase in salinity due to flocculation and coagulation. This implies that a clearer water may contain much salt and less suspended particles. This will increase the rate of corrosion in marine vessels as reported by Zhuet al.,(2020) and FEI(2014). Salinity also affects water clarity (Czubaet al., 2011). This is due to the effect of salt on the aggregation and settling velocity of suspended particles. In other words, salt ions collect suspended particles and bind them together, increasing their weights and thus their likelihood of settling to the bottom. Due to this mechanism, oceans and estuaries tend to have a higher clarity (and lower average turbidity) than lakes and rivers (Czubaet al., 2011). These marine environments also have a higher rate of sedimentation as solids are pulled out of the water column to the seafloor.

Table 1: Characterization of chemical properties of saline water

Parameter	Unit	S1	S2	S3
DO	------	3.46	2.98	3.27
Temperature	°C	26.86	26.91	26.47
Turbidity	NTU	33.81	31.26	32.49
TDS	Ppm	271.98	281.95	310.74
pH	-------	6.92	6.48	6.41
EC	µs/cm	1100.26	986.45	1453.86
Alkalinity	mg/L	90.70	132.51	172.9

S_1-Qua Iboe River,S_2-Okoroette River and S_3-Utaewa River

Total Dissolved Solid although stated by some authors as not having a direct influence on the corrosivity of water, but dependent on the concentration of some certain dissolved ions (mostly sulfates and chlorides)(Huet al., 2025). Marine water contains high percentage of these ions, making it highly corrosive medium for metals (Hou et al., 2018) TDSrepresents the total concentration of dissolved substances in water, it is made up of inorganic salts, as well as a small amountof organic matter. High TDS levels can increase the conductivity of water, making it more corrosive to metals (Meens 2025). The result shows that the total dissolved solid for the different water samples were within the range of 271.98 to 310.74, which is in agreement with the result of (Boerlage 2012) with

UtaewaRiver having the highest TDS, this implies that the corrosion rate of both paints will be highest in Utaewa River than Qua Iboe and Okoroette River.

The acidic or basic nature of a solution is expressed as the pH. The pH scale ranges from 0 to 14, with 7 being neutral. Water is said to be corrosive at pH values less than6.5, causing the release of toxic metals into the water from piping (USGS 2019).Acidic water (low pH) can accelerate corrosion by increasing the availability of hydrogen ions, which can react with metals(Tang et al., 2015). High pH levels can lead to the formation of a protective oxide layer on some metals thereby reducing corrosion. pH levels between 5.0 and 9.0 are generally considered acceptable for most metals, but extreme pH values can cause corrosion. From the result, near neutral pH of 6.92 may reduce acidic corrosion and support long term durability on both painted panels.

Conductivity is defined as the ability of a substance to conduct electric current. Electrical conductivity in water measures water's ionic content which gives water its conductivity properties (Meens 2025, CNMI DEQ, 2004). There is a direct relationship between conductivity and the minerals dissolved in water (total dissolved solids, (TDS).High electrical conductivity can indicate high levels of dissolved solids, which can contribute to the increase of decrease in corrosion rate in water (Adjovuet al., 2023, CNMI DEQ, 2004). The result shows that higher EC may suffer alkali-silica reaction that can weaken metal integrity over time therefore making both painted panel prone to corrosion over time. The electrical conductivity of the samples were within the range of 1100.26 to 1453.86 which is with the values reported by Meens (2025).

Alkalinity is a chemical measurement of a water's ability to neutralize acids. Alkalinity is also a measure of a water's buffering capacity or its ability to resist changes in pH upon the addition of acids or bases (CNMI DEQ 2004, Dhoke 2023). Alkalinity can help neutralize acids and reduce corrosion. Low alkalinity can make water more susceptible to pH fluctuations, potentially increasing corrosion. From the result, higher alkalinity level can be less aggressive and pH buffer to both painted panels. In general, the interplay between these factors can significantly impact the corrosion of metals. High temperatures, high salinity, and low pH can create a highly corrosive environment. Choosing materials resistant to corrosion in specific environments can help mitigate the effects of these factors. According to CNMI DEQ (2004), alkalinity of about 80 mg/L will provide adequate buffering capacity, therefore the water sample in this study showed alkalinity range of 90.70 to172.9 which show that the corrosiveness of the water is not so high.

IV. CONCLUSION

The tree different river samples were tased for their dissolved oxygen content, temperature, turbidity, total dissolved solid, alkalinity and pH and Electrical conductivity. The results show that the water samples dissolved oxygen content of 3.46, 2.98 and 3.27, temperature of 26.86^{o}C, 36.92^{o}C and 26.47^{o}C; Turbidity of 33.81 NTU, 31.26NTU, and 32.49NTU; Total dissolved oxygen 271.98 Ppm, 281.95Ppm and 310.74Ppm, pH of 6.92, 6.48 and 6.41, Electrical conductivity of 1100.26, 986.45 and 1453.86 lastly, Alkalinity of 90.70µs/cm, 132.51µs/cm and 172.9µs/cm for the three river samples respectively. The results confirm the corrosive nature of these marine water samples on the produced organic paint.Utaewa River sample (S3) shows the highest properties of turbidity, total dissolved solid, electrical conductivity and the alkalinity while showing the lowest pH and temperature this indicates that utaewa river is the most corrosive among the three Rivers.

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