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Bacterial Detection in Corrosive Media and Assessment of Corrosion Inhibition Efficiency of Novel Paints

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Abstract
Anti-corrosive pigments such as zinc chromate, frequently used in paint formulations to combat steel corrosion, are potentially toxic. In this study, the corrosion inhibition properties of eleven water-based paints formulated with novel corrosion inhibitors were compared with a reference conventional paint (2). The paints were applied on galvanized steel (GS) and mild steel (MS). Painted and unpainted [control (C)] steel samples were immersed in corrosive media (1M HCl, 3.5% NaCl, and tap water). Bacterial population and pH of the corrosive media, as well as corrosion rates of immersed samples, were determined over six months. Escherichia coli, Klebsiella sp., Providentia stuartii, Staphylococcus aureus, S. epidermidis, Pseudomonas aeruginosa, P. oleovorans, and Bacillus anthracis were detected in the corrosive media. Bacterial populations ranged from 3.0×10^4 to 1.00×10^6, 3.5×10^4 to 1.80×10^6, and 3.0×10^4 to 2.50×10^6 CFU/mL for acid, 3.5% NaCl, and water with painted MS, respectively. For painted GS, bacteria ranged from 3.0×10^4 to 9.0×10^4, 3.2×10^4 to 7.0×10^4, and 3.0×10^4 to 1.20×10^6 CFU/mL for acid, salt, and water, respectively. The pH decreased for all samples: 2.4 to 0, 6.5 to 1.0, and 7 to 1.6 for acid, salt, and water, respectively. Paints 1, 2, 5, 7, 11, and 12 showed the lowest MS corrosion rate (0.0002 mm/y) in salt, while paint 9 had the lowest GS corrosion rate (0.0002 mm/y) in salt. All samples corroded completely in acid after six months. Paint 9 (MS) achieved the highest inhibition efficiency of 66.66%. The novel paints performed comparably to conventional paints.

Keywords: Corrosion inhibition, bacterial detection, novel paints, mild steel, galvanized steel, inhibition efficiency

1.0 INTRODUCTION

Corrosion remains a significant challenge in various industries, leading to economic losses and safety concerns. Industrial machinery and equipment with steel components are susceptible to corrosion, thereby significantly increasing the running costs of steel and oil companies. The advent of climate change has further introduced a new layer of complexity to this challenge (Arachchige *et al.,* 2025). As the world faces unpredictable weather patterns and increased exposure to environmental weathering, the emphasis on protective coatings that can preserve surfaces becomes even more pronounced. With these evolving threats, safeguarding the longevity and durability of industrial equipment has never been more crucial (Firoozi *et al.,* 2024).

Previous studies have reported the general use of hydrochloric acid solutions in oil and gas operations for descaling, cleaning, and elimination of rust in metallurgical and materials sections (Korozní *et al.,* 2017). During these industrial operations, the surfaces of most metals are severely corroded to varying degrees (Olusegun *et al.,* 2010; Gassama *et al.,* 2015; Khadraoui *et al.,* 2016). To mitigate these effects and prolong the lifespan of metallic materials, corrosion scientists introduce inhibitors to the corrosive environment during these industrial processes. The use of corrosion inhibitors is the most convenient, simple, and practical method to protect metallic materials in corrosive environments.

In recent times, environmental regulations have gradually restricted the use of inorganic inhibitors, especially those containing chromate, phosphate, and other heavy metals (Rodríguez-Torres *et al.,* 2015). Chromate-based paints have been used in earlier times to protect metals against corrosion, but they were found to be carcinogenic and subsequently prohibited (Mahvash *et al.,* 2017). Paint life depends on several factors such as the metallic substrate, the selected paint system, and the paint-substrate interface (Del Amo *et al.,* 2004).

Therefore, several organic inhibitors (Bismarck brown dye, imidazoline derivatives, and *Capparis decidua*) have been reported in earlier studies (Sharma *et al.,* 2008; Putilova *et al.,* 1960; Jain *et al.,* 2006). They were found to contain numerous N, O, and S-containing alkaloids. These alkaloids become adsorbed onto the metal surface and subsequently hinder the release of H^+ ions and disintegration of metal ions. In this study, we formulated paints with different novel corrosion inhibitors and assessed their respective corrosion inhibition efficiencies.

2.0 MATERIALS AND METHOD

2.1 *Metal Elemental Composition and Preparation*

Galvanized steel and mild steel sheet metal samples were sourced from Owode-Onirin Market, Lagos, Nigeria. They were initially cut to rough dimensions (10.5 mm × 10.5 mm × 3 mm) using an Electric Powered Guillotine Machine (MAC Model) (Fig. 1a). Subsequently, the sheet metals were machined to finished dimensions (10 mm × 10 mm × 3 mm) using a Vertical Milling Machine (MAC Model) (Fig. 1b), with each specimen weighing 2.1 g. This machining was performed at the Department of Physics Workshop, University of Lagos.

Spark test compositional analysis was conducted at the Department of Metallurgical and Materials Engineering Laboratory, University of Lagos, using a Thermo Scientific Emission Spectrometer (Model: ARL Quantodesk Optical). The metal specimens were polished using a grinding machine to achieve a mirror-like surface, cleaned, and positioned in the spectrometer for spark testing sequentially. Each sample underwent spark testing three times with an acquisition time of 15 seconds per measurement point. The average weight percentage of different elements present in the mild steel and galvanized steel samples was then determined.

The specimens' edges were smoothed using a hand file and polished with fine-grade emery cloth. They were subsequently degreased in absolute ethanol, rinsed with double-distilled water, and dried with acetone to remove mill scales from the coupons. The prepared coupons were then used for corrosion studies.

Figure 1(a): Electric Powered Guillotine Machine

Figure 1(b): Vertical Milling Machine

2.2 *Experimental Set-Up*

Eleven paint samples (1, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12) were formulated with selected potential corrosion inhibitors (data not shown). Paint 2 (conventional paint) served as a positive control. Corrosive media included 1M HCl, 3.5% NaCl, and tap water. Holes were drilled into each metal coupon to accommodate copper wires for immersion into corrosive media and to allow for ease of removal. Copper wires of 2 cm length were used to hold each of the coupons. The wires were stripped at both ends. One end of the wire was attached to each metal using a soldering iron by plugging the soldering iron and allowing it to heat up before using it to melt the wire onto the metal, thereby creating a connection between both.

The epoxy and hardener were used for metallographic analysis, polishing, grinding, and to hold the sample in place during electrochemical testing. Epoxy and hardener were mixed properly in a 2:1 ratio (Epoxy:Hardener) to avoid air bubbles. The samples were subsequently mounted at room temperature to obtain a small, exposed surface area for painting, surface analysis, and electrochemical measurements. Each sample surface was ground with a grinding machine (silicon carbide grinding paper of 80, 150, 320, and 600 grades) to remove excess resin from the metal surface.

2.3 Paint Preparation and Application

Paints were formulated to contain 5.6% by volume in relation to total solid content and represented 30% (v/v) of the total pigment formula, as often recommended for phosphate pigments (Roselli *et al.,* 2017). To complete the pigment formula, titanium dioxide was incorporated. The acrylic dispersions, thickener (dissolved in 50% water), as well as additives such as antifoaming agents, neutralizing agents, antimicrobial agents, and co-dispersants were utilized, while neutral water constituted the solvent. Each paint sample was used to coat 3 galvanized steel samples (one for acid, one for salt, and one for water immersion) and 3 mild steel samples (one for acid, one for salt, and one for water immersion, respectively) according to their labeling. Three unpainted coupons each of the galvanized and mild steel samples were used as negative control samples.

2.4 Immersion of Steel Samples into Corrosive Media

The painted coupons were left to dry for 24 hours. All painted and unpainted (negative control) samples were then immersed in plastic containers labeled with appropriate codes based on the type of metal, the paint sample number coated on them, and the corrosive medium in which each was immersed. The negative control samples were labeled as "control" in place of a paint sample number. All samples were evaluated for weight loss and corrosion rate at 24 hours, 1 week, 1 month, 2 months, 3 months, 4 months, 5 months, and 6 months, respectively, and the mean values were obtained.

2.5 Bacterial Isolation

Nutrient agar (HiMedia Laboratories PVT LTD) was purchased from local vendors and used for microbial isolation at 24 hours, 1 week, 1 month, 2 months, 3 months, and 6 months intervals after immersion of test coupons. Each sample's corrosive medium was serially diluted, and 0.1 ml aliquots were plated. Aerobic incubation was performed at 37°C for 24 hours for bacterial isolation. The isolated bacteria were subsequently purified and identified using conventional biochemical identification tests as described by Cheesbrough (2004).

2.6 pH Measurement

A pocket-sized pH meter (HANNA Instruments) alongside buffer solution (pH 7.00 phosphate) (LOBA CHEMIE PVT. LTD) was used for taking pH readings of each sample's corrosive medium weekly for 6 months. The pH meter was dipped into the buffer solution for proper calibration before being dipped into the corrosive medium. The pH meter was left for approximately 1-2 minutes to stabilize and obtain an accurate reading. This procedure was carried out weekly in duplicates for all sample media for 6 months.

2.7 Corrosion Studies

2.7.1 Gravimetric Measurement

The pre-weighed galvanized and mild steel coupons of 2.1 g each were suspended with copper wire rods in 250 ml plastic containers containing 200 ml of the corrosive solutions at room temperature (27 ± 2°C). The coupons were retrieved at specified intervals from the corrosive media with the aid of the copper wires attached to each of them and allowed to air dry for 1-2 hours. They were then dipped in acetone and cleaned. The air-dried samples were subsequently weighed using a weighing balance at intervals of 24 hours, 1 week, 1 month, 2 months, 3 months, 4 months, 5 months, and 6 months, following standard procedures (James *et al.,* 2006). The difference in weight (ΔW) of the metal coupons before and after immersion in different corrosive solutions was obtained in duplicates, and the mean was taken as the weight loss. The obtained weight loss data were then used to calculate the corrosion rate, CR (mm/y), as follows:

$$CR = [87.6\omega / DAt]$$

where ω is the weight loss (g), D is density (g/cm^3), A is the total surface area of the coupon (cm^2), 87.6 is a constant for rate determination, and t is the time of immersion (h).

2.7.2 Percentage Inhibition Efficiency

Subsequently, the Inhibition Efficiency (IE) was determined from the mathematical relationship indicated below:

$$\%\ IE = [(\omega_1 - \omega_2) / \omega_1] \times 100$$

where ω_1 is the weight loss without paint and ω_2 is the weight loss with paint.

3.0 RESULTS AND DISCUSSION

3.1 Chemical Composition of the Mild and Galvanized Steel Specimens

The average weight percentage of different elements present in the mild steel and galvanized steel samples is displayed in **Table 1**. The analysis revealed that the mild steel sample contains 98.95% iron (Fe), 0.2621% carbon (C), 0.1122% silicon (Si), 0.3798% manganese (Mn), less than

0.009% sulfur (S), 0.0237% chromium (Cr), 0.0085% copper (Cu), 0.0166% nickel (Ni), 0.0350% aluminum (Al), 0.0025% titanium (Ti), 0.00093% vanadium (V), and 0.0074% cobalt (Co).

In contrast, the galvanized steel sample contains 98.53% iron (Fe), 0.3437% carbon (C), 0.0346% silicon (Si), 0.3093% manganese (Mn), 0.0621% sulfur (S), 0.0510% chromium (Cr), 0.027% copper (Cu), 0.0319% nickel (Ni), 0.0571% aluminum (Al), 0.0086% titanium (Ti), 0.0384% vanadium (V), and less than 0.001% cobalt (Co). Comparatively, the mild steel sample has a higher percentage of Fe, Si, Mn, and Co than the galvanized steel sample, while the galvanized steel sample has a higher percentage of C, S, Cr, Cu, Ni, Al, Ti, and V than the mild steel sample.

Table 1: Composition Analysis of Mild Steel and Galvanized Steel in weight % of Elements.

Materials	**Chemical Composition wt. %**											
	Fe	C	Si	Mn	S	Cr	Cu	Ni	Al	Ti	V	Co
Mild Steel	98.95	0.2621	0.1122	0.3798	<0.009	0.0237	0.0085	0.0166	0.0350	0.0025	0.0093	0.0074
Galvanized Steel	98.53	0.3437	0.0346	0.3093	0.0621	0.0510	0.027	0.0319	0.0571	0.0086	0.0384	<0.001

3.2 Bacterial Detection and Population Dynamics

Escherichia coli, *Klebsiella* sp., *Providentia stuartii*, *Staphylococcus aureus*, *S. epidermidis*, *Pseudomonas aeruginosa*, *P. oleovorans*, and *Bacillus anthracis* were observed in the corrosive media. **Figures 2-7** present the bacterial population growth over the six-month study period in acid, salt, and water containing mild and galvanized steel painted with different paint samples.

The results showed that bacterial population density ranged from 3.0×10^4 to 1.00×10^6, 3.5×10^4 to 1.80×10^6, and 3.0×10^4 to 2.50×10^6 CFU/mL for acid, 3.5% NaCl, and water media containing immersed painted mild steel, respectively. Bacterial populations ranged from 3.0×10^4 to 9.0×10^4, 3.2×10^4 to 7.0×10^4, and 3.0×10^4 to 1.20×10^6 CFU/mL for acid, 3.5% NaCl, and water media containing immersed painted galvanized steel, respectively. Generally, samples containing immersed painted mild steel supported higher bacterial growth (3.0×10^4 to 2.50×10^6 CFU/mL) in water from 24 hours to 6 months than in acid (3.0×10^4 to 1.00×10^6 CFU/mL) and salt (3.5×10^4 to 1.80×10^6 CFU/mL) (**Figures 2-7**). Previous research also reported the isolation of microorganisms from various corrosive media. Charlene and Johnson (2013) reported the isolation of a total of 20 bacteria from corroded mild steel immersed in 5 mM $NaNO_3$ and NH_4NO_3.

In the present study, the occurrence of *Pseudomonas aeruginosa* and *P. oleovorans* suggested the potential of these bacteria to grow and survive in corrosive media and stress-induced environments, as also reported by Mansouri *et al.,* (2015) and Muatasem *et al.,* (2025).

In addition, the corrosive media containing mild steel supported higher bacterial population densities than samples containing galvanized steel. It is noteworthy that corrosive media with unpainted steel (negative controls) exhibited greater bacterial growth than media containing painted coupons, suggesting the potential antibacterial properties of the tested paints on the steel samples.

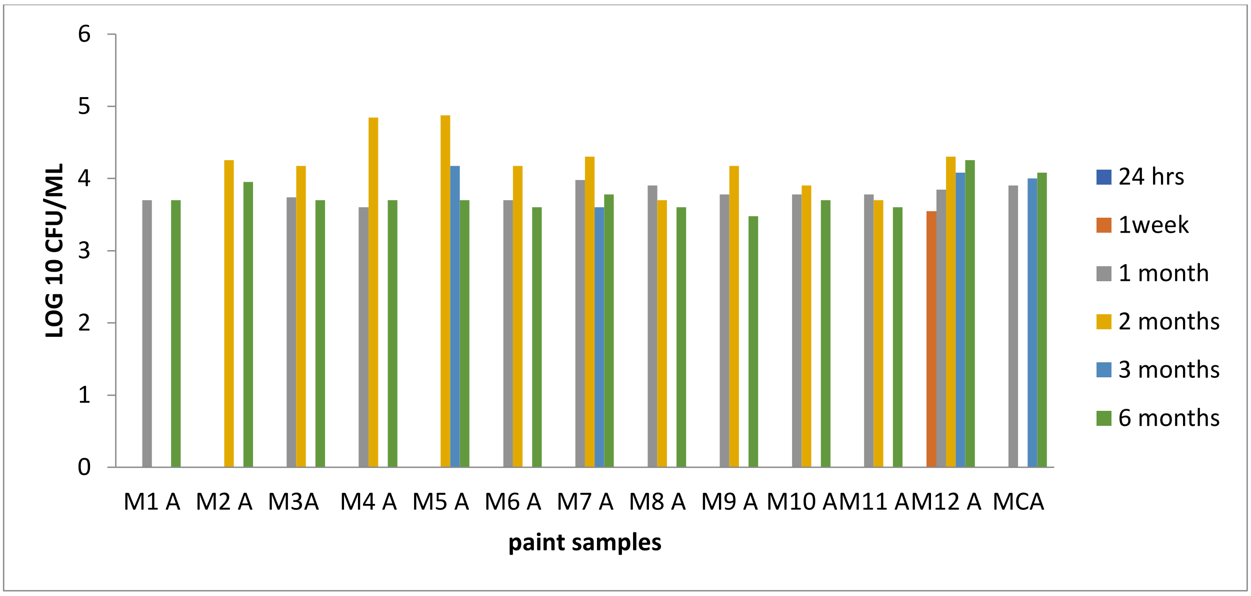

Figure 2: Bar chart of mean bacterial population in 1M HCL with immersed painted mild steel for six months. M, mild steel; 1-12, paint samples; A, acid; C, unpainted control sample; 2, conventional paint.

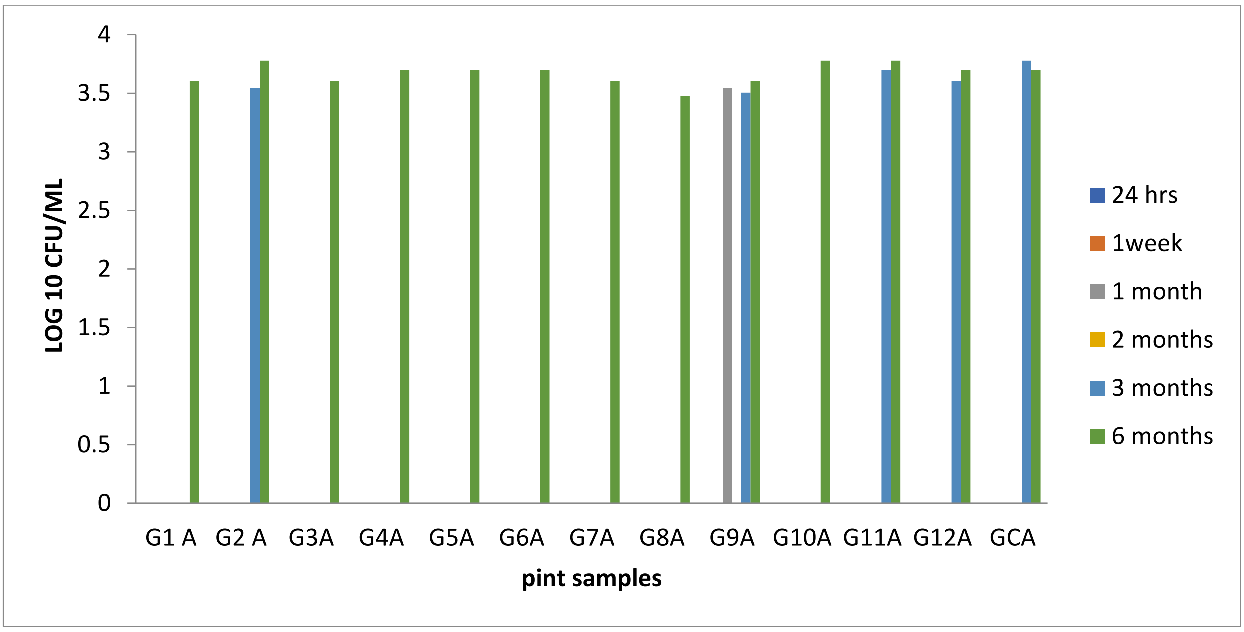

Figure 3: Bar chart of mean bacterial population in 1M HCL with immersed painted galvanized steel for six months. G, galvanized steel; 1-12, paint samples; A, acid; C, unpainted control sample; 2, conventional paint.

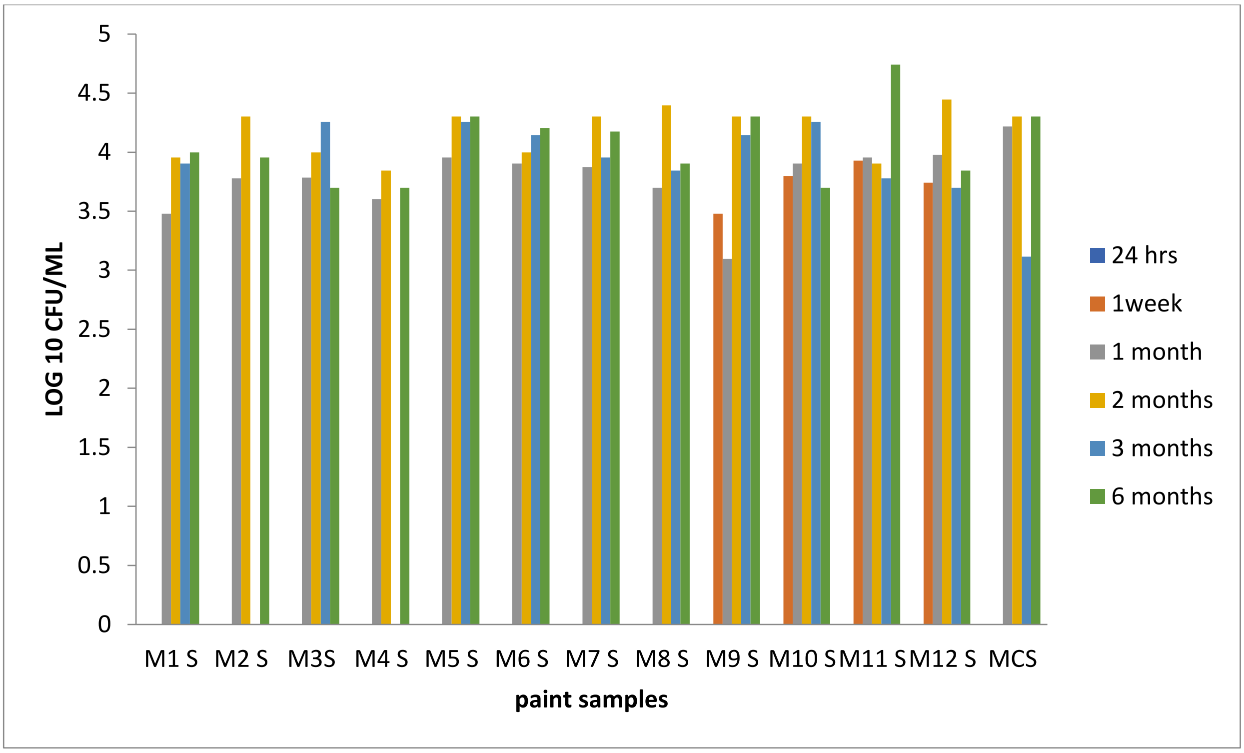

Figure 4: Bar chart of mean bacterial population in 3.5% NaCL with immersed painted mild steel for six months. M, mild steel; 1-12, paint samples; S, salt; C, unpainted control sample; 2, conventional paint.

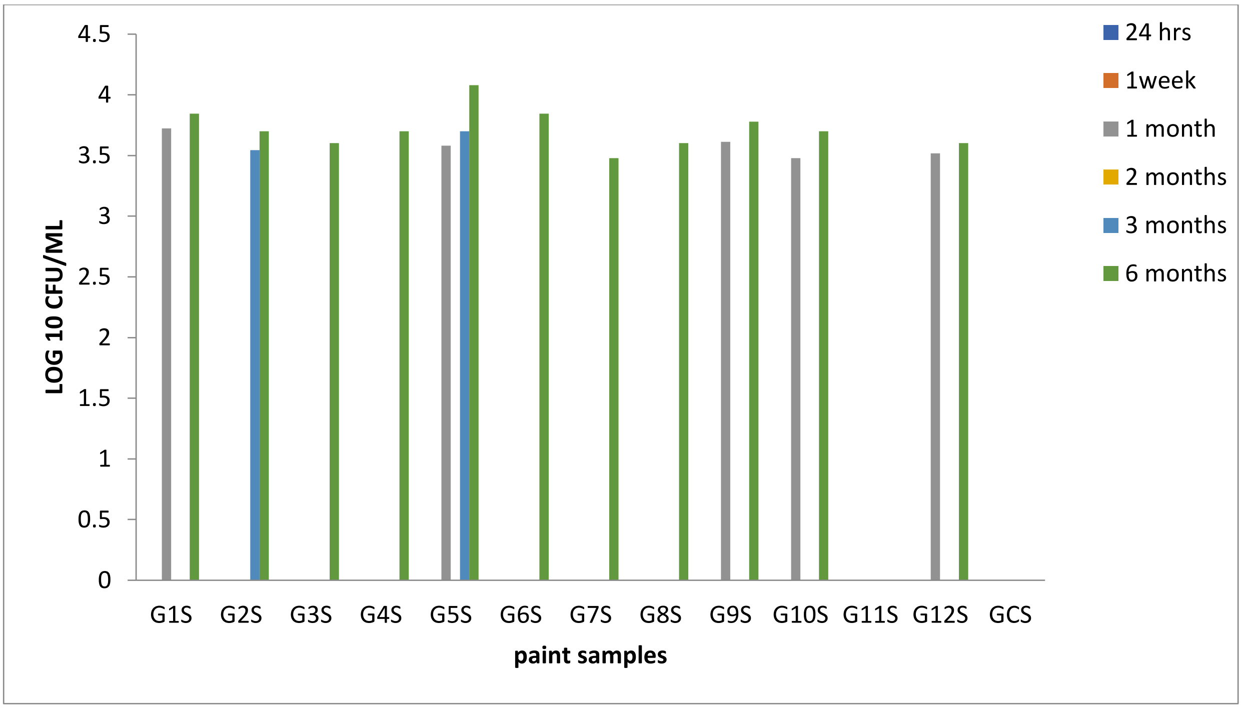

Figure 5: Bar chart of mean bacterial population in 3.5% NaCL immersed with painted galvanized steel for six months. G, galvanized steel; 1-12, paint samples; S, salt; C, unpainted control sample; 2, conventional paint.

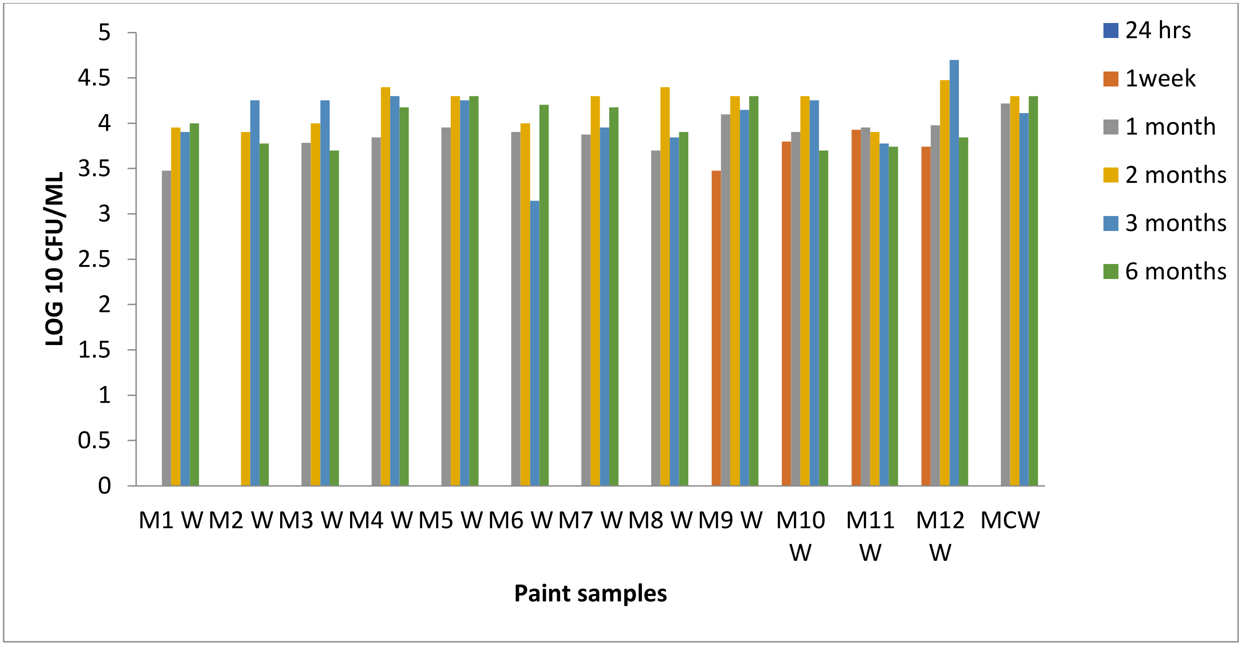

Figure 6: Bar chart of mean bacterial population density in tap water with immersed painted mild steel for six months. M, mild steel; 1-12, paint samples; W, water; C, unpainted control sample; 2, conventional paint.

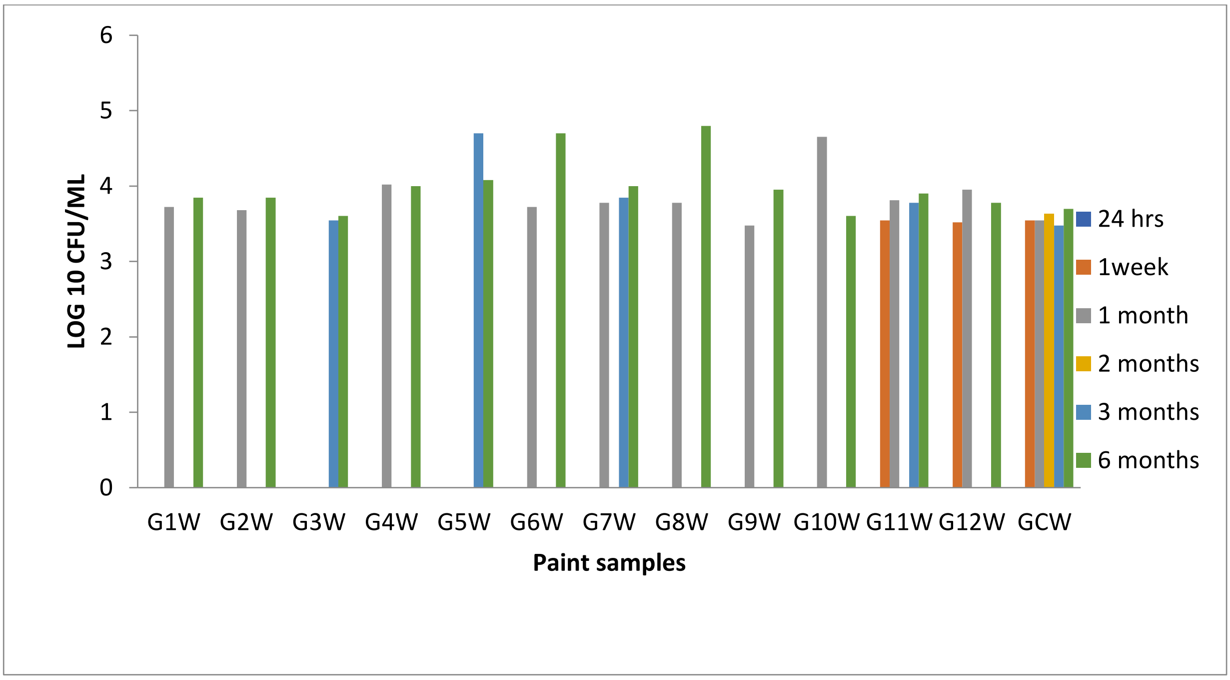

Figure 7: Bar chart of mean bacteria population in tap water with immersed painted galvanized steel for six months. G, galvanized steel; 1-12, paint samples; W, water; C, unpainted control sample; 2, conventional paint.

3.3 pH Changes in Corrosive Media

The pH values of the different corrosive media with immersed painted mild and galvanized steel coupons are displayed in **Figures 8-13**. The results show that the pH of all samples' corrosive media significantly decreased with time, thereby increasing their acidity.

For mild steel samples in acid, the pH ranged from the initial value of 2.48 to 0.5 within the first five months. For mild steel samples in salt, the initial pH recorded was 6.5, which decreased to 0.1 by the final week of the study period. For galvanized steel samples in acid, pH decreased from

2.48 to 0.1, with G10A having 0.6, G5A having 0.5, and G8A having 0.5 by the final week. G1S, G2S, and G10S had pH values of 2.2, while G7S had 2.6, which was the highest value in the final week of the study. Other samples had pH values of 1.0 in the final week, making 1.0 the lowest pH value for galvanized steel in salt medium.

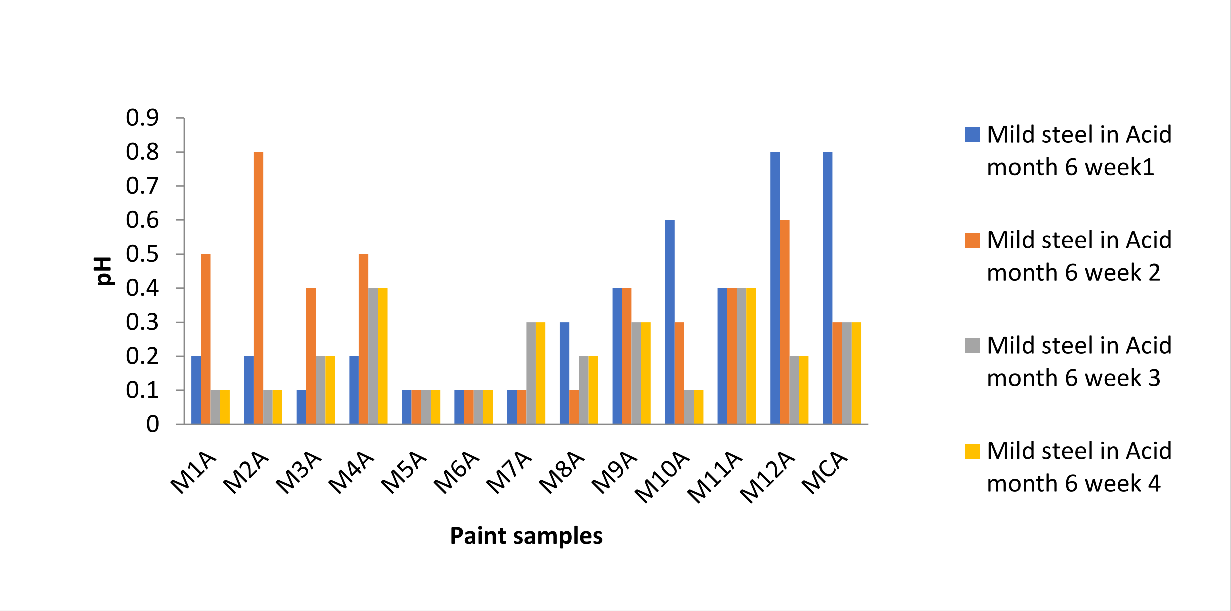

Figure 8: Bar chart showing the pH of 1M HCL after six-month immersion of mild steel. M, mild steel; 1-12, paint samples; A, acid; C, unpainted control sample; 2, conventional paint.

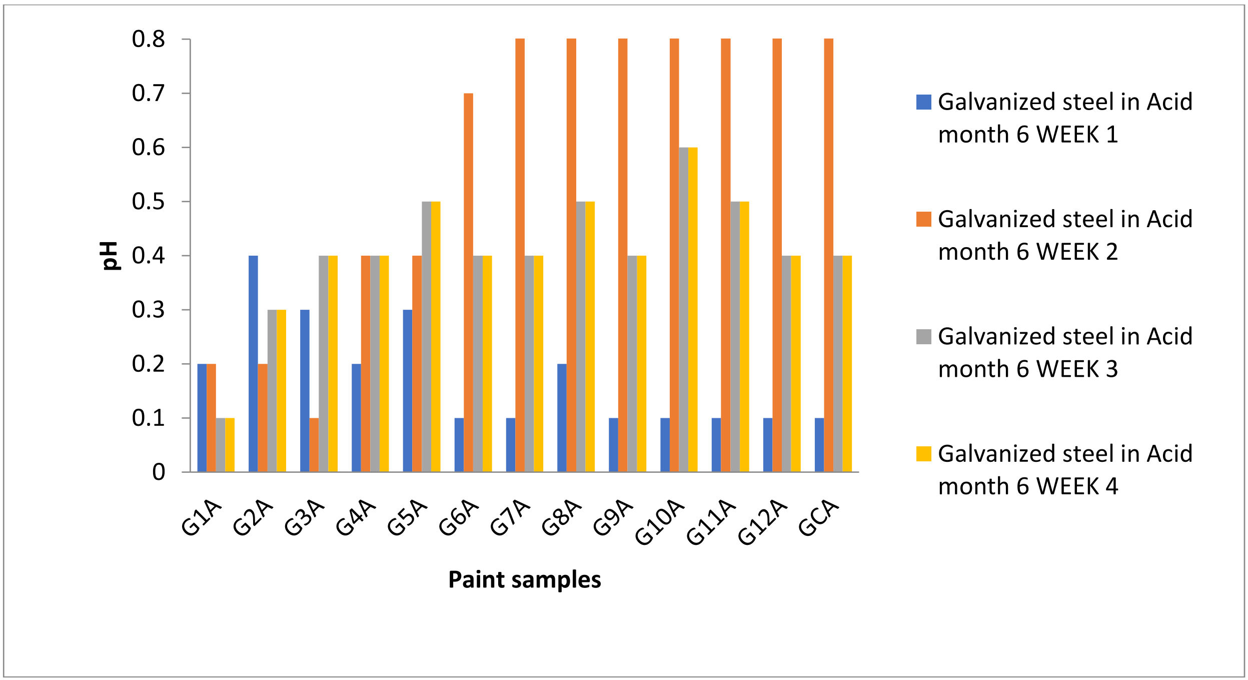

Figure 9: Bar chart showing the pH of 1M HCL after six-month immersion of galvanized steel. G, galvanized steel; 1-12, paint samples; A, acid; C, unpainted control sample; 2, conventional paint.

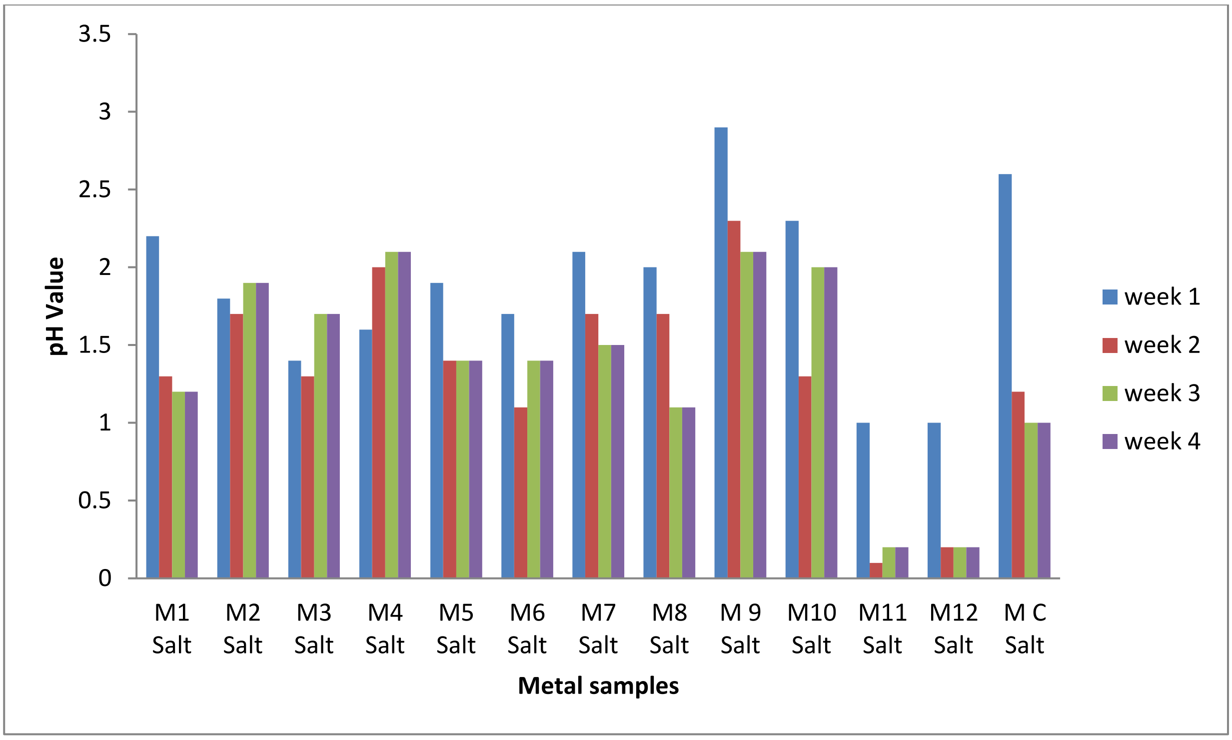

Figure 10: Bar chart showing the pH values of painted mild steel samples in salt for month 6.

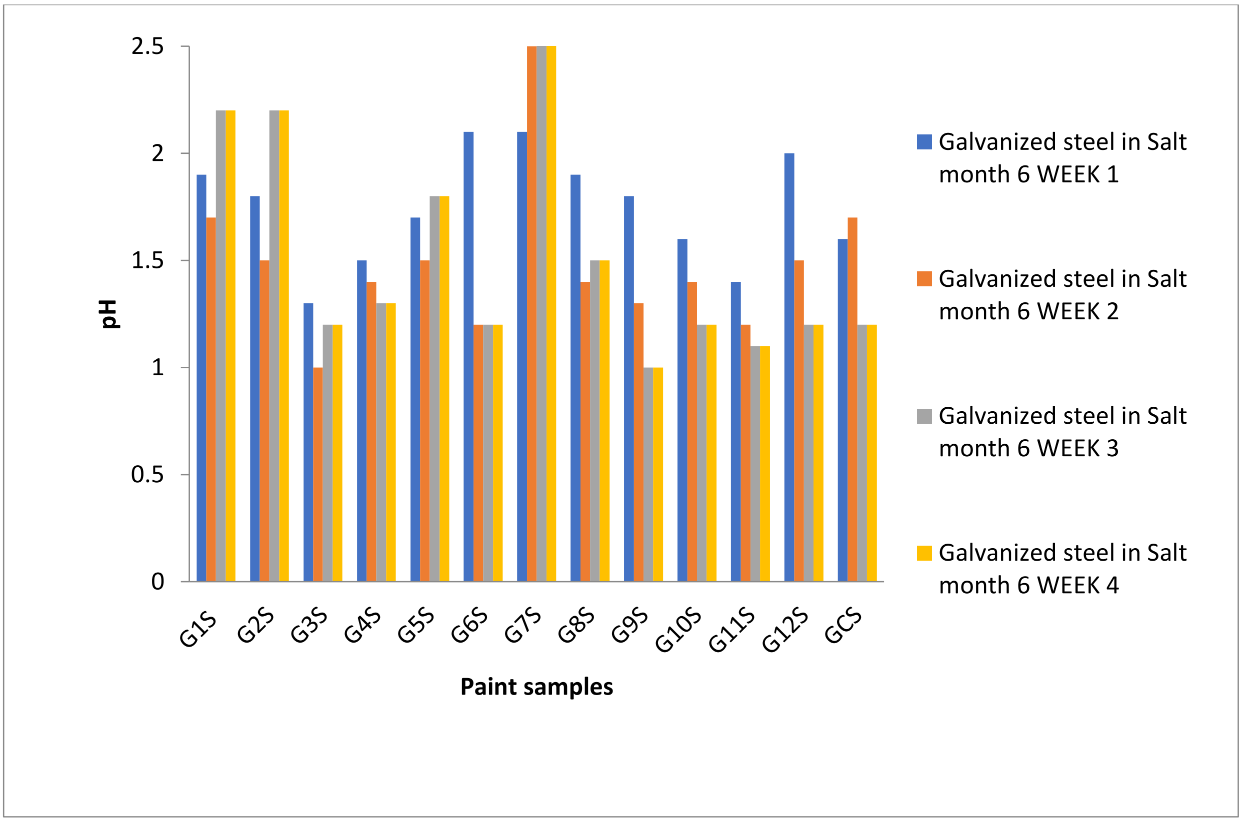

Figure 11: Bar chart showing the pH of 3.5% NaCL after six-month immersion of galvanized steel. G, galvanized steel; 1-12, paint samples; A, acid; C, unpainted control sample; 2, conventional paint.

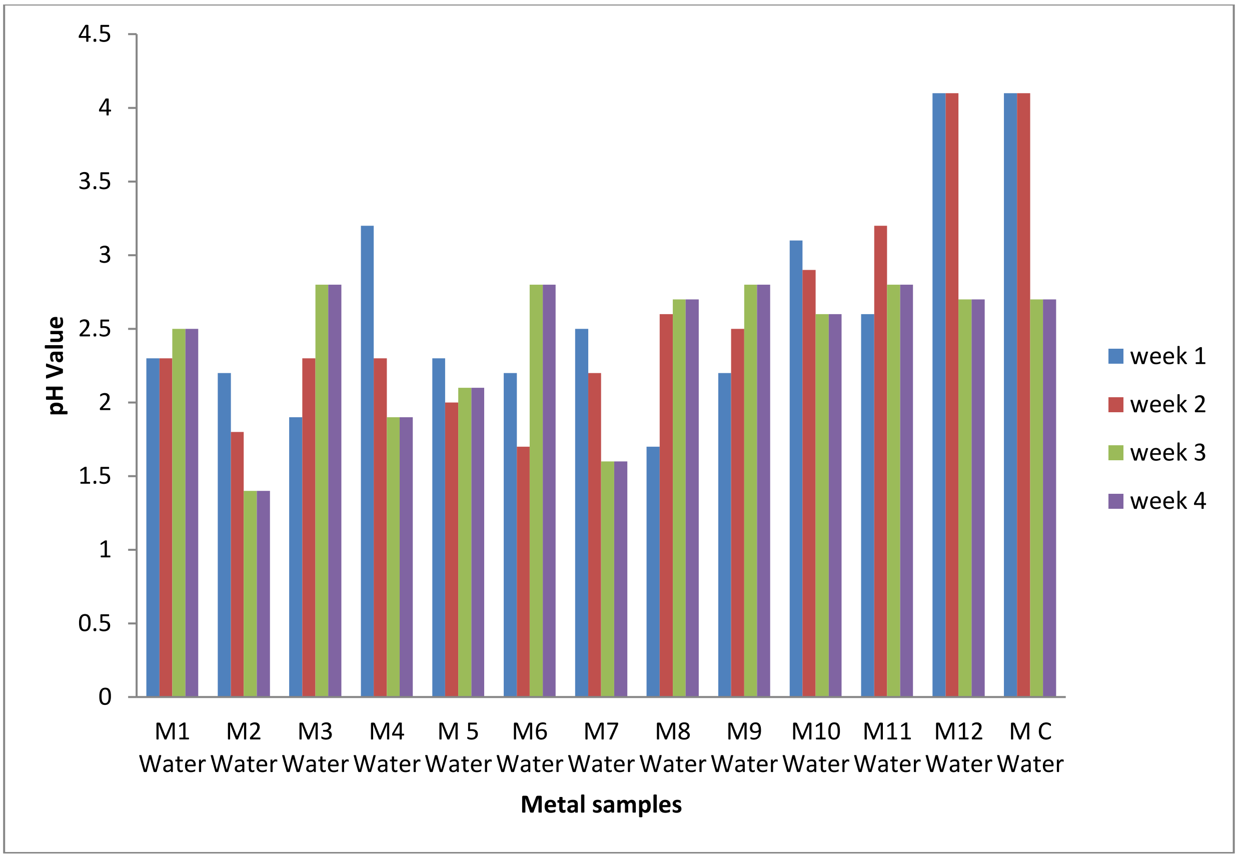

Figure 12: Bar chart showing the pH values of painted mild steel samples in water for month 6.

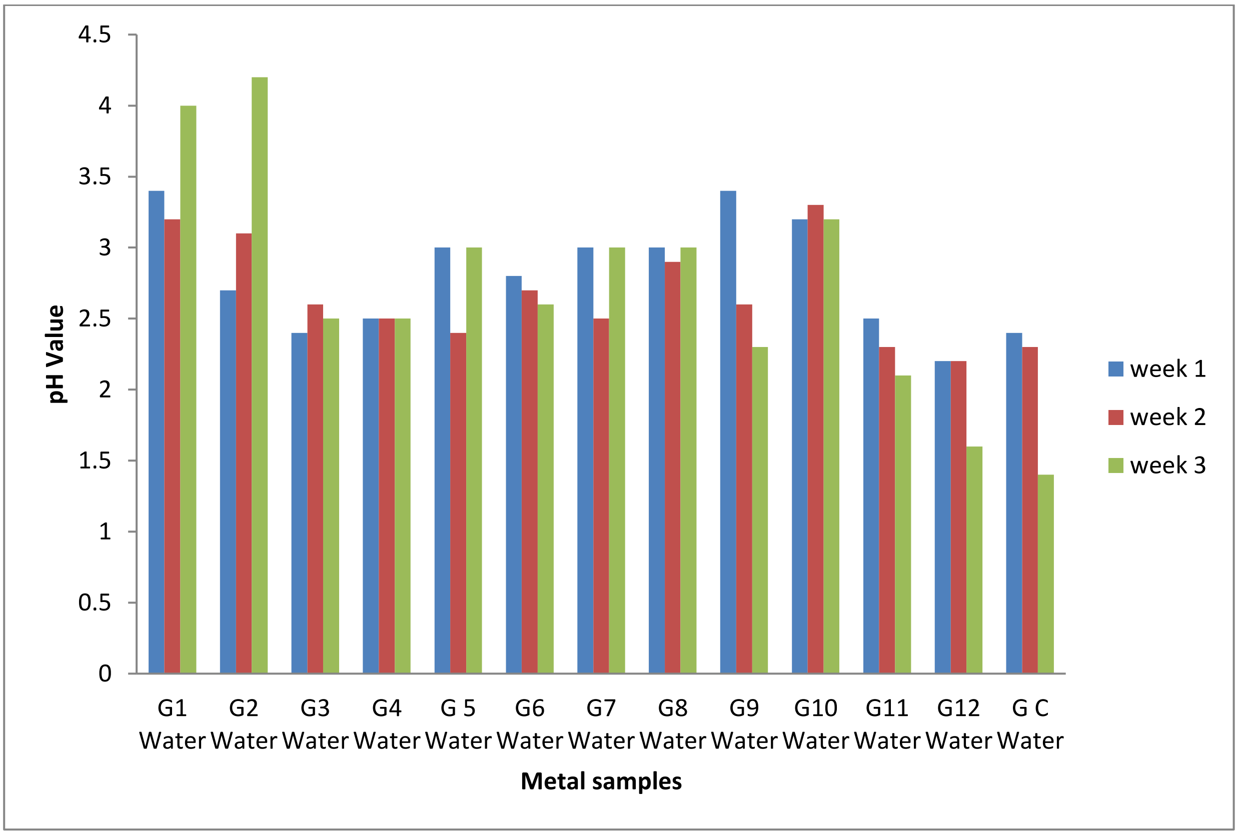

Figure 13: Bar chart showing the pH values of painted galvanized steel samples in water for month 6.

The pH for galvanized steel and mild steel samples in water started at approximately 7.0 and decreased to 1.4 in the final week. The pH value of 1.4 was recorded in M2W, while M3W, M6W, M9W, and M11W had the highest value of 2.8 for mild steel samples in water. G2W had 4.2, G1W had 4.0, and G7W and G8W had 3.0 in the final week. The present study showed a general decline in the pH of the corrosive media over six months, indicating increasing acidity that subsequently led to increased corrosion rates. This was more prevalent in acid media than in salt and water, as well as in samples with immersed mild steel compared to those with galvanized steel. The corrosion rate was observed to increase with time. Previous studies by Stephen (2014) also showed that the pH of a sodium hydroxide solution with immersed mild steel affected the corrosion rate of the steel. The study reported that solutions with the highest pH had the lowest corrosion rates, while those with the lowest pH had the highest corrosion rates. This agrees with the findings of Tanaporn *et al.,* (2013) that corrosion rates at lower pH are higher than at higher pH.

In this study, the pH of mild steel in acid decreased from 2.48 to 0.2 and finally to 0.1 by the second month. For mild steel in salt, pH decreased from 6.5 to 1.1 by the sixth month. Meanwhile, water samples with mild steel had pH values that decreased from 7 to 1.6 by the sixth month. These findings agree with the work of Stephen (2014). For acid media with galvanized steel, pH decreased from 2.48 to 0.1 by the fourth month. Salt media with galvanized steel showed a pH reduction from 6.5 to 1.2 by the sixth month, while water with galvanized steel had pH values that decreased from 7 to 2.5, supporting previous reports (Chohan *et al.,* 2024).

3.4 Corrosion Rate Analysis

For acid media, the corrosion rate of mild steel decreased from 0.0542 mm/yr at 24 hours to 0.000 mm/yr by the third month. For salt media, mild steel corrosion rate decreased from 0.0542 mm/yr to 0.0002 mm/yr by the sixth month. Meanwhile, for water media, the corrosion rate of mild steel decreased from 0.0517 mm/yr to 0.0002 mm/yr by the sixth month.

Galvanized steel in acid had a corrosion rate of 0.0517 mm/yr at 24 hours, which decreased to 0 mm/yr by month 3. Galvanized steel in salt had 0.0517 mm/yr at 24 hours, which decreased to 0.0002 mm/yr at the sixth month. Galvanized steel in water had a corrosion rate of 0.0517 mm/yr at 24 hours, which decreased to 0.0003 mm/yr at the sixth month.

The positive controls showed the following results: M2A decreased from 0.0517 mm/yr at 24 hours to 0.0001 mm/yr at month 4. M2S decreased from 0.0542 mm/yr at 24 hours to 0.0002 mm/yr at month 6, while M2W decreased from 0.0542 mm/yr at 24 hours to 0.0002 mm/yr at month 6. At the sixth month, the MS control (negative control) had 0 mm/yr for acid, 0.0002 mm/yr for salt, and 0.0003 mm/yr for water (**Figures 14-19**).

For galvanized steel in acid, the positive control G2A decreased from 0.0517 mm/yr at 24 hours to 0 mm/yr at month 4. For the negative controls at the sixth month, the GS control had 0 mm/yr for acid, 0.0002 mm/yr for salt, and 0.0003 mm/yr for water (Figures 17-19). Both mild steel and galvanized steel samples in 1M HCl corroded faster (within one to three months) than samples in other media. Consequently, no data were available beyond three months for samples immersed in acid. This agrees with the work of Chinwko (*et al.,* 2014) and Al-saade (2013), who reported that mild steel and galvanized steel corroded faster in acidic environments than other metals in corrosive environments. Similarly, Bani and Gloria (2023) reported corrosion of galvanized steel in acid and salt media.

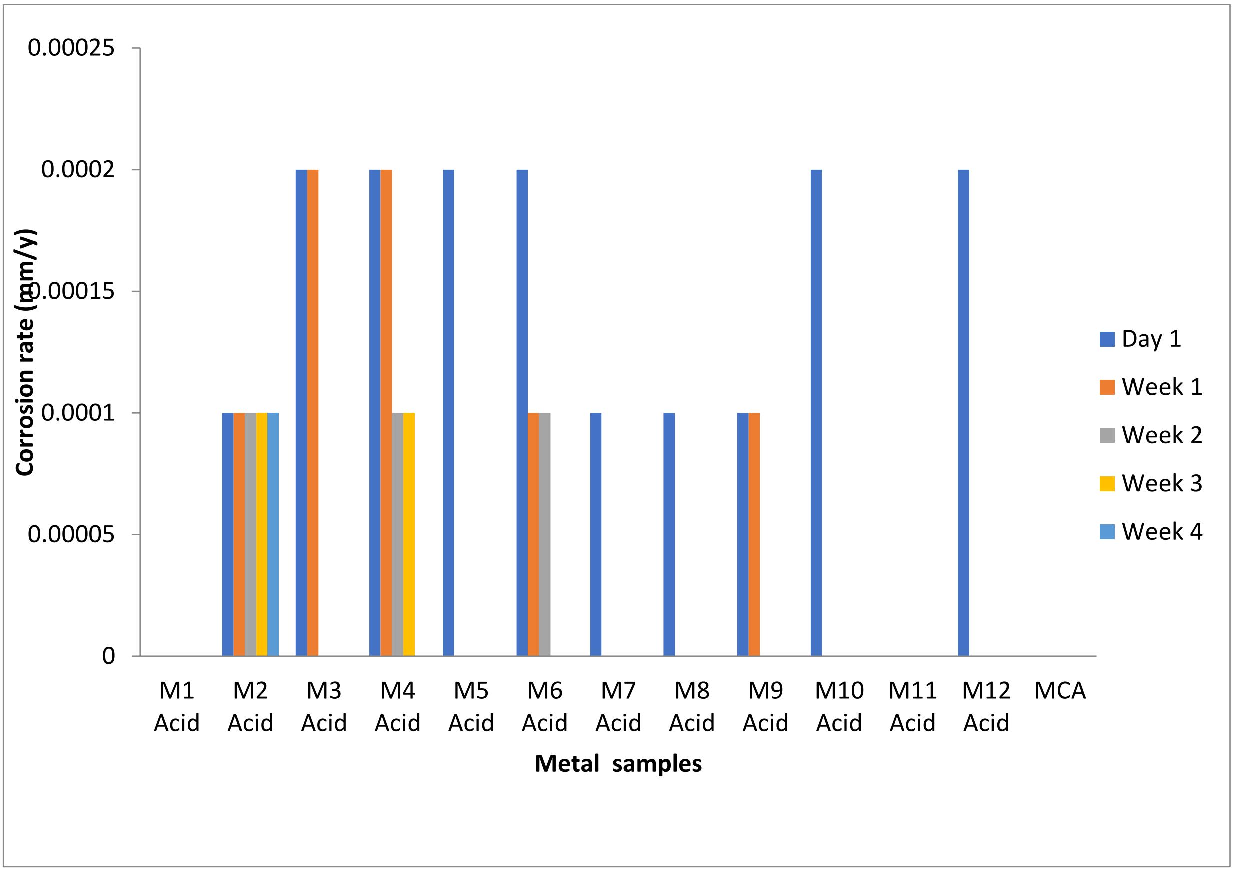

Figure 14: Bar chart showing the corrosion rate for mild steel immersed in 1M HCl within the fifth month.

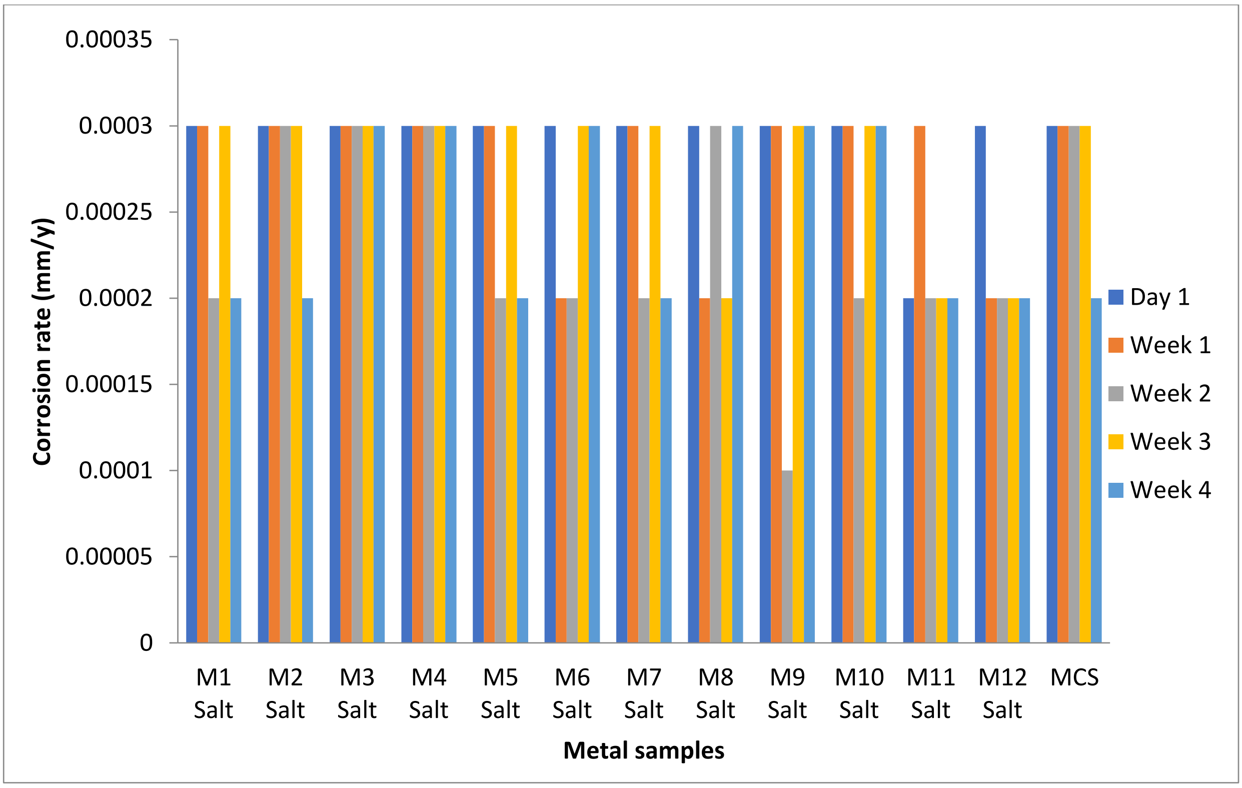

Figure 15: Bar chart showing the corrosion rate for mild steel immersed in 3.5% NaCl within the sixth month.

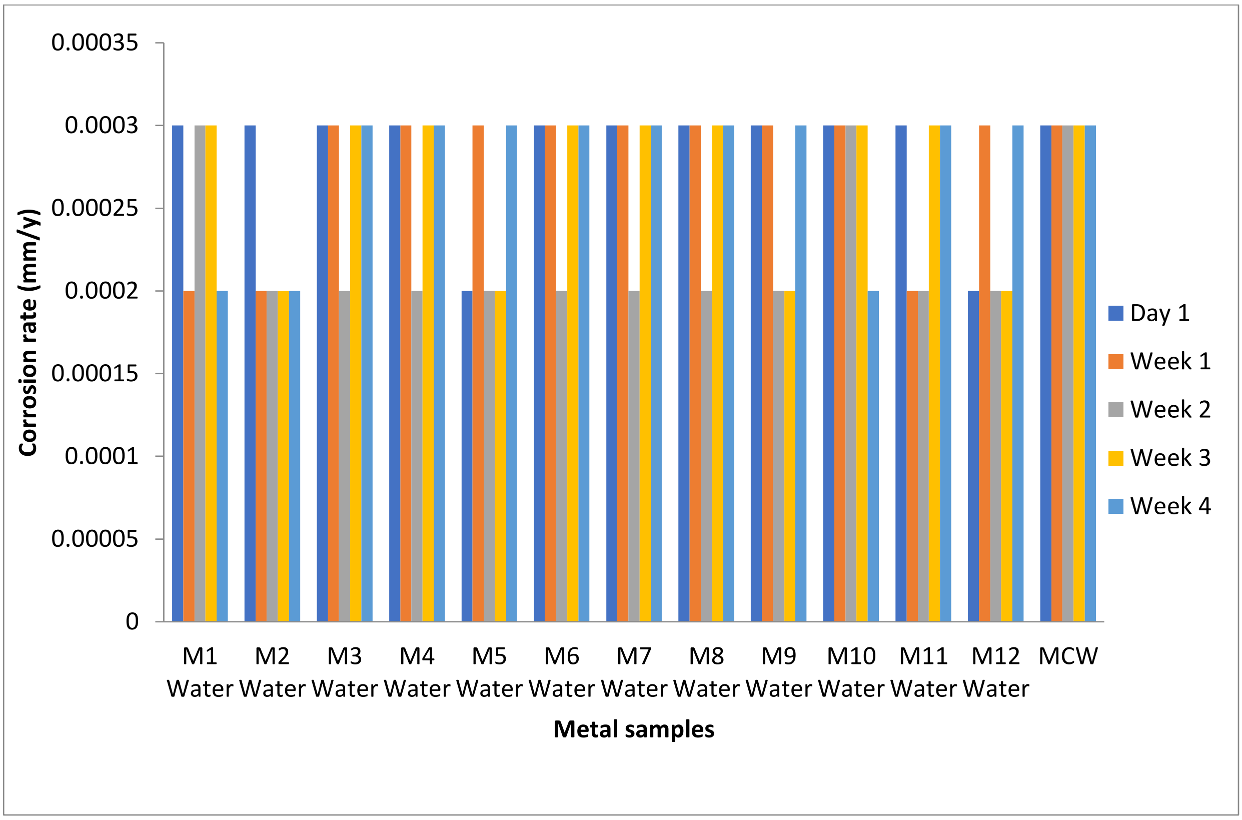

Figure 16: Bar chart showing the corrosion rate for mild steel immersed in Tap water within the sixth month.

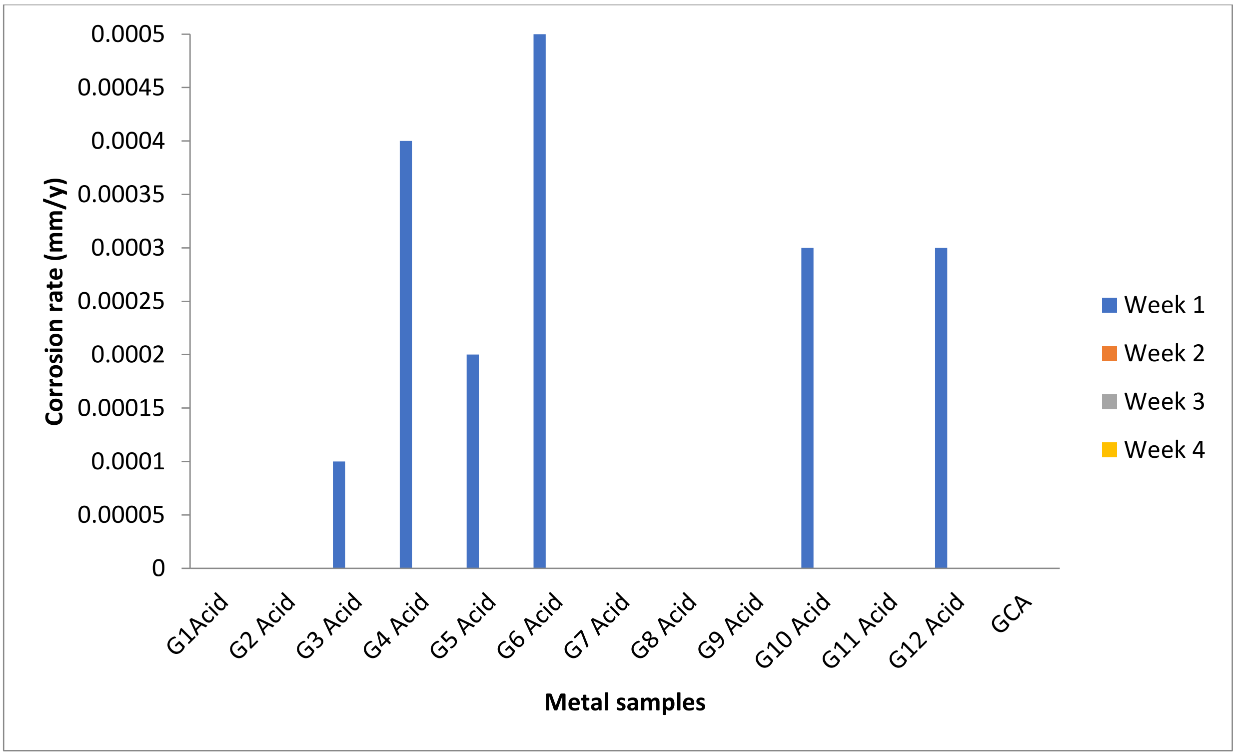

Figure 17: Bar chart showing the corrosion rate for galvanized steel immersed in 1M HCl within the second month.

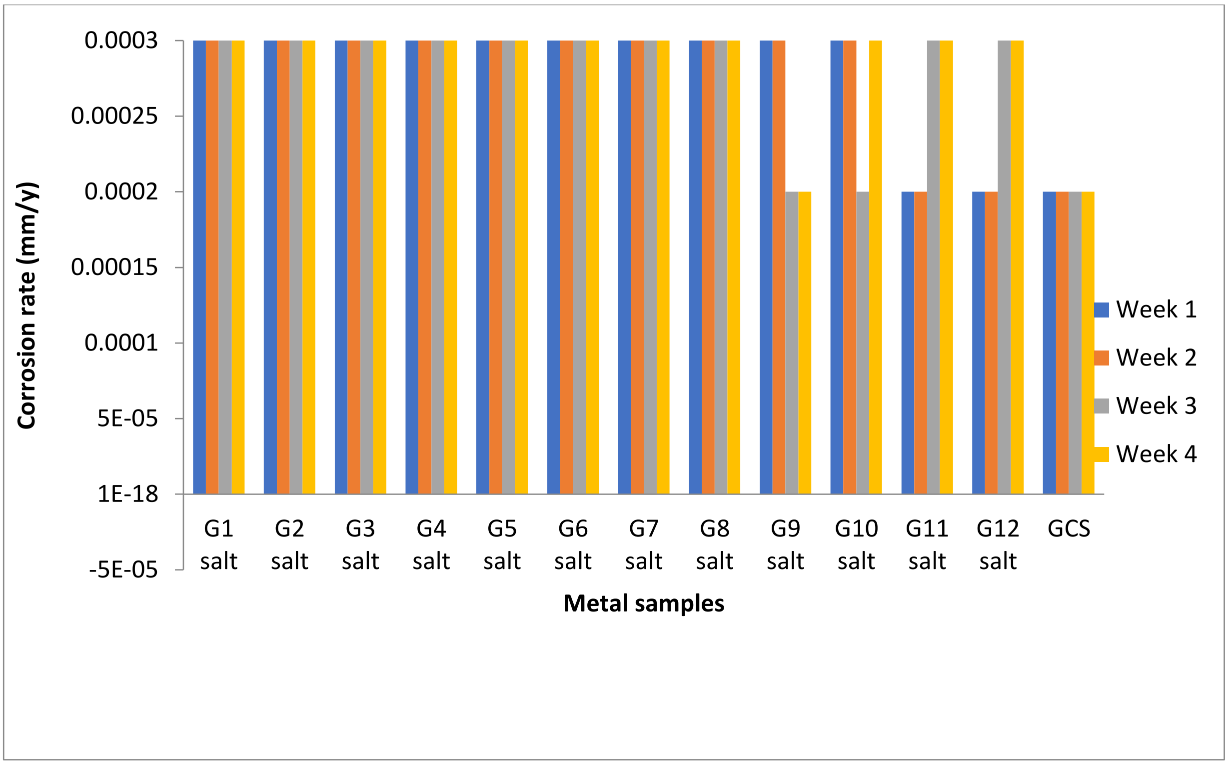

Figure 18: Bar chart showing the corrosion rate for galvanized steel immersed in 3.5% NaCl within the sixth month.

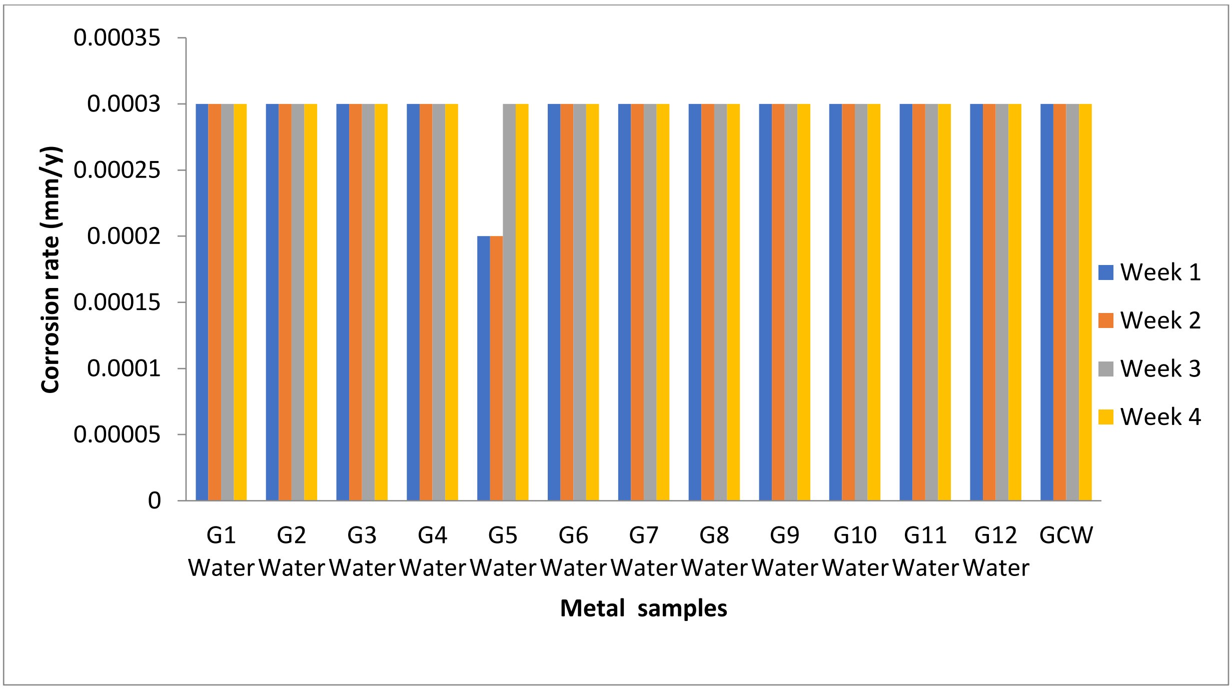

Figure 19: Bar chart showing the corrosion rate for galvanized steel immersed in Tap water within the sixth month.

3.5 Inhibition Efficiency Assessment

Paint sample 5 coated on mild steel and immersed in acid (M5A) had an inhibition efficiency (IE) of 6% after one month of immersion. Similarly, samples M7A, M5S, M7S, M1W, M2W, M3W, M9W, and M11W had 6% IE. However, samples M12W and M9A had 12% and 14% IE, respectively. The highest inhibition efficiency observed was in Paint 9 (MS), which had an inhibition efficiency of 66.66%. Other samples had 0-33.33% IE and some showed negative IE after six months of immersion in salt and water (**Figures 20-25**).

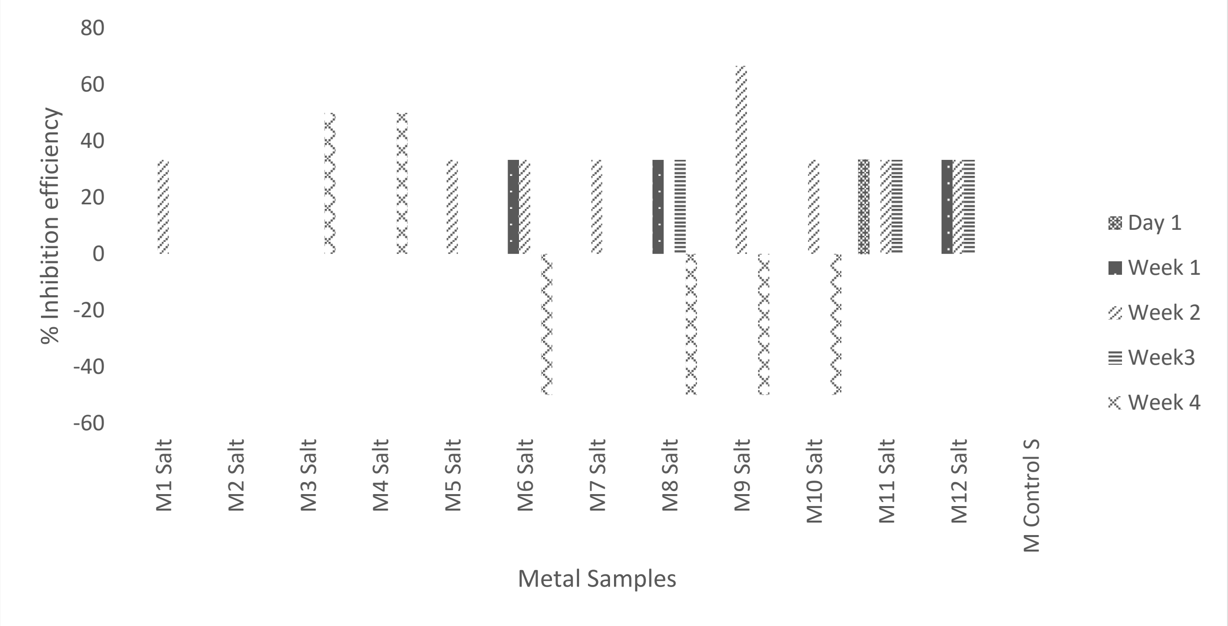

Figure 20: Bar chart showing % inhibition efficiency of mild steel in 3.5 % NaCl for month six.

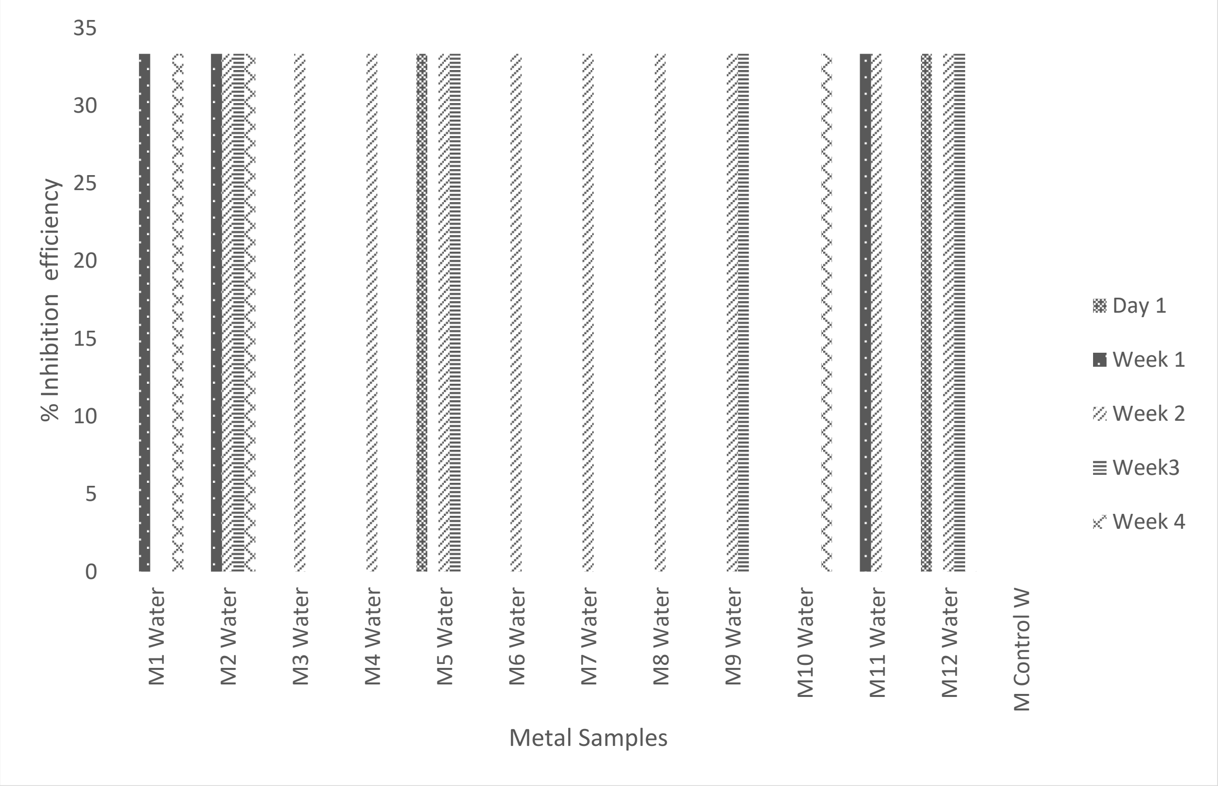

Figure 21: Bar chart showing % inhibition efficiency of mild steel in tap water for month six.

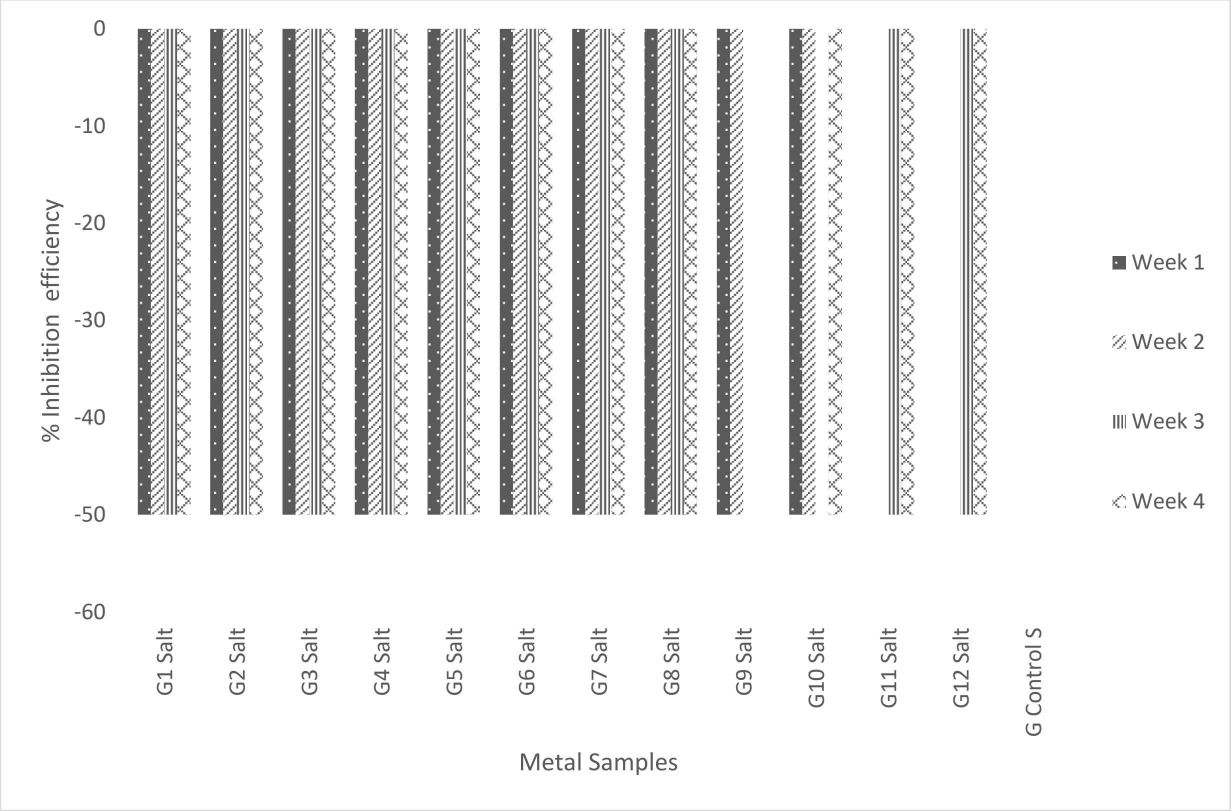

Figure 22: Bar chart showing % inhibition efficiency of galvanized steel in 3.5% NaCl for month six.

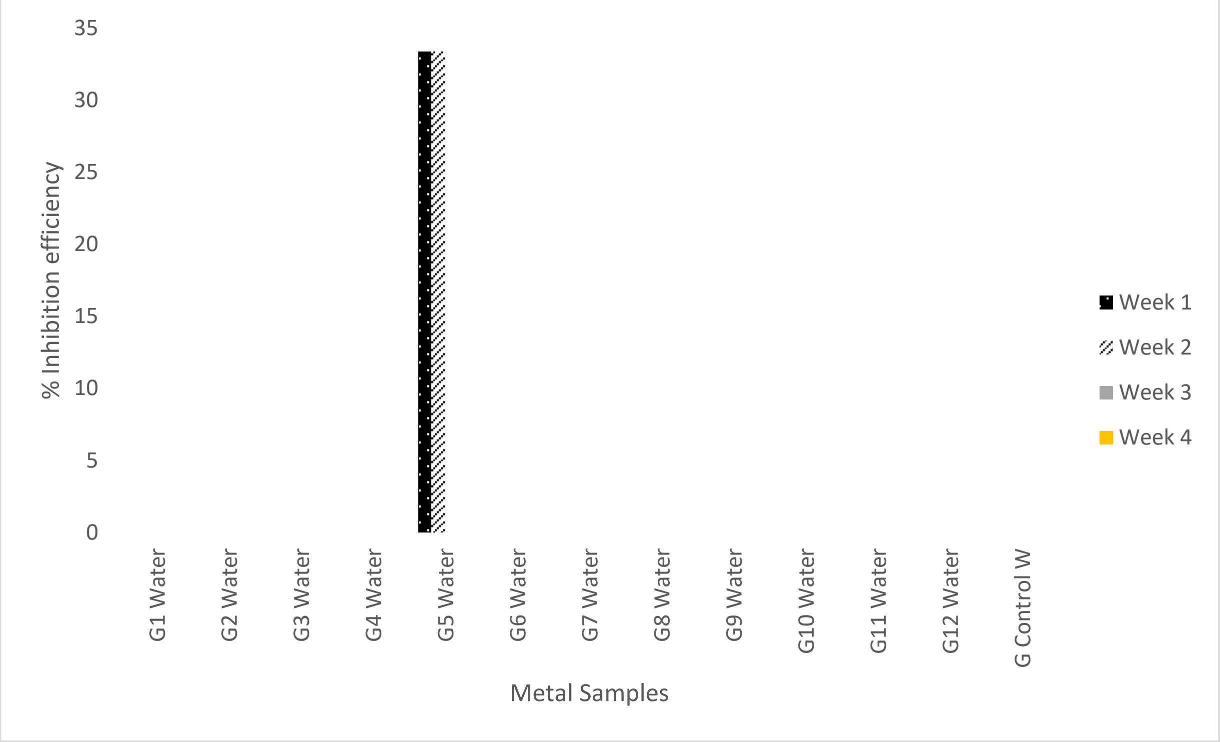

Figure 23: Bar chart showing % inhibition efficiency of galvanized steel in tap water for month six.

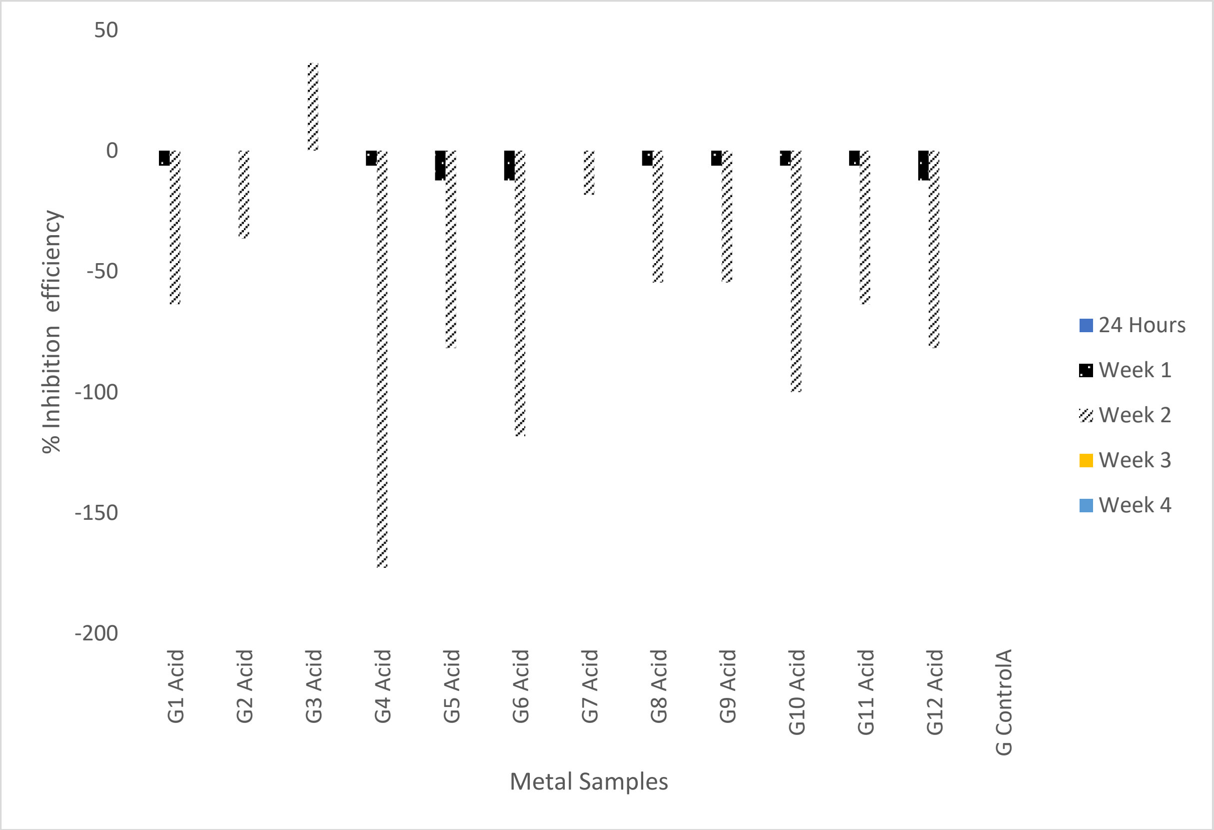

Figure 24: Bar chart showing % inhibition efficiency of galvanized steel in 1M HCl for month one.

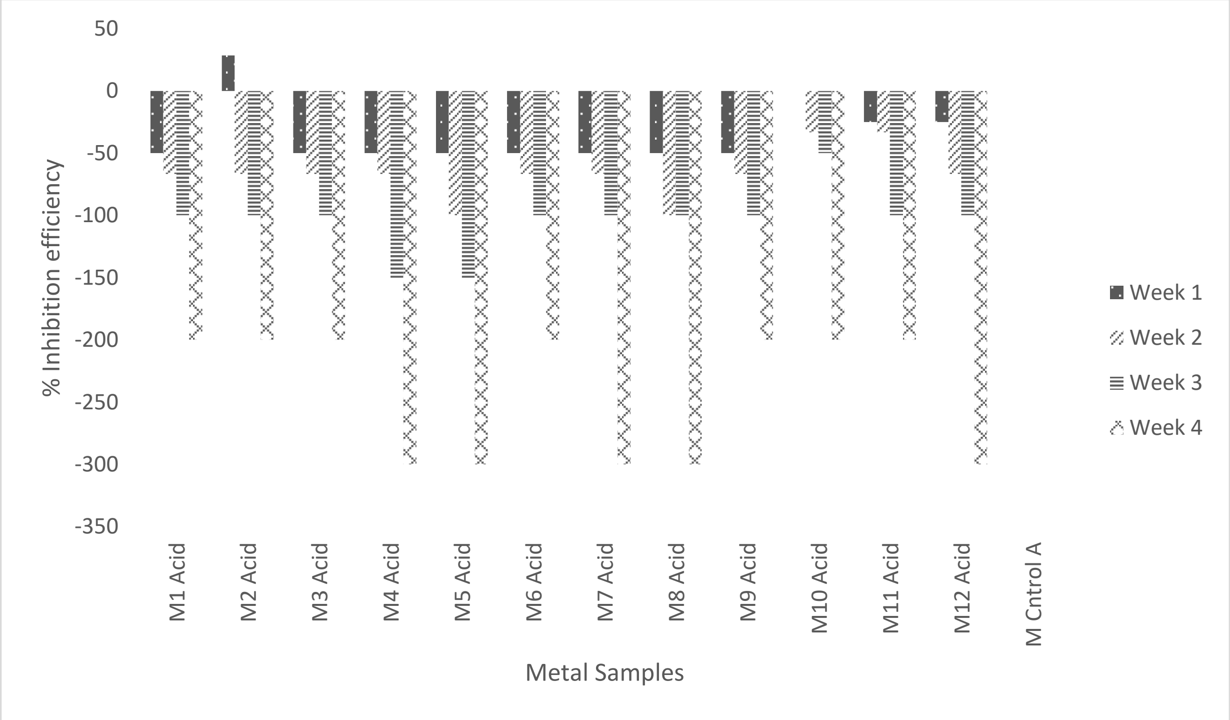

Figure 25: Bar chart showing % inhibition efficiency of mild steel in 1M HCl for month three.

The present study also showed that increased exposure time contributed to increased corrosion rates as inhibition efficiency decreased with exposure time. Chuan *et al.,* (2017) reported that increased inhibition efficiency of mild steel in acid occurred with increased inhibitor concentration. The increase in inhibition efficiency of mild steel in acid also increased with increasing inhibitor concentration in an experiment carried out by Yuli *et al.,* (2014). Aniyam *et al.,* (2020) also reported that inhibition efficiency increases with increased inhibitor concentration and decreased exposure time for galvanized steel in acid. In a similar study, Yanhong *et al.,* (2018) reported increased inhibition efficiency of galvanized steel in salt with corresponding increases in inhibitor concentration.

However, Micheal *et al.,* (2014) reported that the inhibition efficiency of mild steel in salt is greater than that of mild steel in acid, which was also observed in the current study. Samples M3S and M4S had 40% inhibition efficiency (IE) after 4 weeks of immersion in salt, while IE was negative for samples in acid. The study also reported increased inhibition efficiency with increased inhibitor concentration and decreased acid or salt concentration.

In the current study, paint samples of the same concentrations but varying formulations were used as inhibitors on mild and galvanized steel to understand the inhibition potential of the individual novel paint samples. Overall, the newly formulated paints with selected inhibitors compared favorably with conventional paint, suggesting the potential of the novel inhibitors to replace conventional anticorrosive paints.

4. CONCLUSION

The advent of advancing engineering tools and progress in materials and manufacturing has necessitated the development of robust anticorrosion materials, unlike in earlier times. The mechanism by which a coating protects a substrate is complex and results from different factors acting simultaneously. The novel corrosion inhibitors utilized in this study for mild steel and galvanized steel immersed in corrosive media proved effective in corrosion protection based on electrochemical, visual inspection, and standardized test results.

The paint system permeability, a characteristic directly related to polymeric film composition and its capacity to develop a high barrier against water, ionic, and oxygen diffusion after curing, showed varying levels of effectiveness in reducing corrosion. For mild steel in salt media, paints 1, 2, 5, 7, 11, and 12 exhibited the lowest corrosion rates, while for mild steel in water, paints 1, 2, and 10 had the lowest corrosion rates. For galvanized steel in salt media, paint 9 demonstrated the lowest corrosion rate, while in water, all paints showed similar anticorrosive effects.

The different anticorrosive paints, therefore, exhibited varying corrosion inhibition potentials, which compared favorably with conventional paint. Although the inhibiting agents have been patented and are therefore not disclosed, additional inhibitors can be explored to reduce environmental impact, with the ultimate goal of advancing progress in the field of corrosion science and engineering.

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AUTHORS’ CONTRIBUTIONS STATEMENT

OFO: Conceptualization, Investigation, Methodology, Research supervision, Writing original draft. IAR: Investigation, Data collection, Review & editing of initial write-up. AOT, BMA, ORS: Investigation, Methodology and Data collection. TEA, NA, ETA, YAA, POA, EOO, CEN, FAA, TT, OMO, CME, MAS, IRA, AAY: Investigation and Data collection. All authors read and approved the final manuscript.

DATA AVAILABILITY

Datasets generated or analysed during the current study will be made available on request.

STATEMENTS AND DECLARATIONS

ETHICAL

The current study did not include any human or animal subjects. Thus, this study is not subject to an ethics review committee and does not require any informed consent. Authors can revise/customise the sample statements according to their needs.

COMPETING INTERESTS

The authors declare that they have no known competing financial or non-financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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