International Journal of Advances in Scientific Research and Engineering (ijasre)

E-ISSN : 2454-8006

DOI: 10.31695/IJASRE.2023.9.5.2

Volume 9, Issue 5
May - 2023

# Effects of Extracts of Alchornea Cordifolia on Biocorrosion Control on Sewer Concrete

**William-Porbeni D[1], Ogbereyo, S[2] and Gumus, R.H [3]**

Research Scholar[1,2] and Professor[3]

Department of Chemical Engineering

Faculty of Engineering, Niger Delta University

Wilberforce Island, Bayelsa State, Nigeria

---

## ABSTRACT

*Concrete infrastructures that make up the sewer system exposed to sewer waste waters are often subjected to microbial corrosion. The biogenic sulfuric acid produced by the activity of sulfur-oxidizing bacteria A.thiooxidans attacks concrete in sewers leading to loss of concrete mass and deterioration. The aim of this study was to control concrete biodegradation using plant extracts of Alchornea Cordifolia. Concrete samples were corroded for 26 months in real sewer wastewater conditions. The influence of biogenic sulfuric acid on the biocorrosion of concrete samples was determined in terms of weight loss, pH, sulfate concentration variation, chemical composition changes, and formation of corrosion by-products. Recorded corrosion rates before coating were between 0.071996mpy – 1.168546mpy. Changes in sample morphology, ettringite and gypsum formed were observed by X-ray diffraction and SEM methods with corrosion progression.Phytochemicals analysis of extracts samples confirmed the presence of tannins, saponins, flavonoids, and terpenoids produced in plant tissues. GC-MS analysis of the ethanolic extracts identified 26 compounds. The most dominant being Eugenol. Biocorrosion control determined the effects of extracts on concrete corrosion in sewer waters. A marked decline in the rates of corrosion with each extract's coating was recorded for extracts coated concretes (0.002589mpy -0.003256mpy). An increase in inhibition efficiency with an increase in extract concentration was observed and was in the range of 50% A.Cordifolia extracts gave the highest inhibitor efficiency. X-ray diffractive analysis and scanning electron microscopy showed morphological variations in concrete before and after coating. Results of ANOVA showed inhibitor concentration as having the most significant effect on the extracts' corrosion inhibition.*

**Key Words*:*** Concrete, Corrosion, Inhibitor, SOB, Sulphate, Extracts.

---

## 1. INTRODUCTION

Bio-corrosion, also known as microbial induced corrosion (MIC), is deterioration of metals and materials facilitated by microorganisms. MIC has been the subject of substantial investigation due to the economic and environmental consequences of corrosion, with numerous models developed to describe the mechanisms regulating the bio-corrosion process. [1]
Microbial induced corrosion is commonly used to denote an increase in corrosion activity caused by bacteria. [2, 3]. Biogenic Sulfuric acid is the corrosive media in wastewater treatment systems and concrete sewers. [4, 5]. Corrosion begins in concrete sewer infrastructure after a succession of events. [6]. The biodeterioration process proceeds by first chemically lowering the alkaline pH of the moist concrete surfaces to a more neutral pH by hydrogen sulphide dissociation and by carbonation. This is followed by the colonization of the concrete surface by a variety of neutrophilic sulphide oxidizing bacteria and fungi. The reduced sulphur compounds are oxidized to sulphuric acid as a result of this process. As the pH of the concrete surface falls below 2, an increase in the population of acidophilic organisms occurs, with Acidithiobacillus thiooxidans (A. thiooxidans) becoming the dominant microbe [7]. The bacteria A. thiooxidans produces biogenic sulphuric acid, which interacts with the cementitious material to form ettringite or gypsum.

The term "green inhibitors" or "environmentally friendly inhibitors" refers to chemical substances that are biocompatible with nature, such as plant extracts utilized for corrosion inhibition in various test conditions and environments. Due to their biological origin, these inhibitors possess biocompatibility property. Green inhibitors are classified into two; organic green inhibitors and inorganic green inhibitors [8].

The presence of many complex phytochemical elements of plant extracts such as tannin, saponins, alkaloids, and polyphenols, among others, has been attributed to the extracts' corrosion inhibiting effects. These plant extracts that are utilized as inhibitors are safe and environment friendly.

The use of green inhibitors offers a versatile and cost effective means of preventing or controlling corrosion. Inhibitors are used to reduce or eliminate corrosion or degradation by introducing a retarding catalyst into a corrosive media.

Natural chemicals, such as plant and food extracts, are non-aggressive alternatives to conventional biocides for microbial induced corrosion reduction. Fungi and bacteria have been shown to be inhibited by a variety of plant oils and aqueous extracts. [9, 10, 11].

*Alchornea Cordifolia (A. Cordifolia)* Mull. Arg is a *Euphorbiaceae* shrub that can be found in tropical Africa. It grows to a height of around 4-5 meters in moist and swampy environments. It's a bushy, perennial shrub or small tree that grows erect and sometimes scrambles in forests, usually near water. The plant is said to be utilized as a tropical anti-inflammatory, antibacterial, and antifungal agent in African traditional medicine [12]. Phytochemical analysis of the extracts of *Alchornea Cordifolia* leaves has shown the presence of alkaloids, anthocyanin, anthraquinone, tannins, flavonoids, saponins and terpenoids. [13]. The aim of this study is the application of plant based extracts of *Alchornea Cordifolia* as green inhibitors for the mitigation of microbial corrosion on concrete sewers systems.

## 2. EXPERIMENTAL PROCEDURE

The experimental procedures for concrete sample preparation, micro-organism isolation and identification, concrete sampling, chemical analysis of sewer water, corrosion study and weight loss measurement have been described in previous publication. [14, 15]

### 2.1 Plant Selection and Extraction (Marceration)

Antimicrobial plant used in this study were recommended after consultations with the Department of Pharmacognosy and Herbal Medicine Niger Delta University. *Alchornea Cordifolia* was identified and authenticated by the Head of Department. Ariel parts of selected plant samples were air dried until brown and crispy. The dried samples were thereafter blended to powder form. Weighted samples of powdered material were measured into a glass jar and completely immersed in absolute ethanol (50%) solvent for 72 hours with occasional shaking. This was thereafter strained and the filtrate concentrated to dryness in a *vacuo* at 35$^o$C. This extraction process was repeated twice to get concentrated filtrates.

### 2.2 Phytochemical Analysis

The phytochemical screening of the ethanolic extracts were carried out using a conventional approach as described by Edeoga *et al.*, 2005 and Ojo *et al.*, 2012. [16, 17] The following parameters were tested qualitatively: tannins, saponins, alkaloids, flavonoids, terpenoids, and cardiac glycosides. GC-MS analysis of extracts samples were done to determine phytochemicals constituents in the plants extracts. The Agilent inventions 7890A and 5977B MSD were used to investigate the specimens, with the following GC-MS system experimental setting;

Dimensions: 30M, ID: 0.25mm, Film thickness: 0.25m, HP 5-MS capillary standard non-polar column. The mobile phase flow rate (carrier gas: He) was tuned to 1.0ml/min. The temperature setting (oven temperature) was 40oC rising to 250$^o$C at 5oC/min in the gas chromatography section, and the injection volume was 1l. The results were matched using the NIST mass spectral library search tool and samples saturated in methanol were exhaustively scanned at a span of 40-650 m/z.

### 2.3 Minimum Inhibitory Concentration of Extracts

Sensitivity tests with determination of minimum inhibitory concentration (MIC) of the plant extracts were done. The lowest quantity of ethanolic extracts of plants that inhibits observable microorganism growth is known as the minimum inhibitory concentration of extracts. The clinical and laboratory standards institute's standard testing protocols were used to conduct the tests [18]. For the antibacterial extracts, the MICs of the engaged substances were evaluated using the agar dilution approach published by Okore (2004) [19] and CLSI M100 (2021) [18]. For the microorganisms that exhibited reasonable sensitivity to the test crude extracts, the minimum inhibitory concentration was determined.

### 2.4 Modification of Epoxy Resin with Plant Extracts

Analytical grade epoxy resin and hardener were used in this study. The epoxy resin was modified with plant extracts using the procedure by Masiewisc *et al*, 2020. [20] Varying concentrations of plant extracts by weight of extract recovery (10%, 25%, and



DOI: 10.31695/IJASRE.2023.9.5.2

50%) were added into the epoxy resin and stirred with a mechanical stirrer for 10 minutes. Trailed by the addition of a stoichiometric amount of Hardener according to manufacturer's requirements.

### 2.5 Concrete Coating with Modified Epoxy

Corroded concretes samples were coated with modified epoxy resins to study the effects of plants extract on the coated concrete in sewer waste water. Corroded concrete coupons were removed from the sewer water air dried for 48hrs to reduce the moisture content. The dried concrete cubes were thereafter brushed with a hand brush to remove surface particles and corrosion by-products on the surface. The cleaned particles were then weighed. The weighted coupons were then coated with the plant extracts modified resin. The coated concrete surface were allowed to cure for 24hrs at room temperature before re-introduction in the sewer reactors.

### 2.6 Inhibition Studies using Plant Extracts

The coated and cured concrete samples were immersed totally in the sewer water for the corrosion control studies. For control a blank coated sample without any plant extract was also prepared and immersed in sewer water as control experiment (i.e. without the inhibitor). Additionally, for comparison a commercial biocide Glutaraldehyde (25%) was prepared and coated on corroded concrete and immersed in sewer. All experiments were conducted at room temperature.

To study the effects of the plant extracts on sulphate uptake, biogenic acid production and biocidal effects on growth of SOB bacteria in sewer water, at periodic intervals sewer water was withdrawn and analysed for sulphate concentration, pH and SOB bacteria concentration. This process was repeated continuously until the final result was obtained.

## 3.0 RESULTS AND DISCUSSION

Following the methodology outlined above, the detailed results are presented and discussed. Preliminary results of chemical analysis of sample sewer wastewater and isolation and identification of predominant sulphur oxidizing bacteria in the sample sewer waster has previously been published. [14, 15]

### 3.1 Composition of *Alchornea Cordifolia* Extracts

Preliminary Qualitative analysis of the ethanolic extracts showed the presence of tannins, saponins, flavonoids, terpenoids produced in plant tissues. GC-MS analysis of the ethanolic extracts identified 26 compounds. The most dominant being Eugenol and Estragole. Eugenol and Estragole extracted from plant sources have shown significant antibacterial activity against test strains of pseudomonas. [21]

### 3.2 Minimum Inhibitory Concentration of Extracts

The minimum inhibitory concentration of the extracts is defined as the lowest plant extracts concentration at which no microorganism growth was witnessed after a period of incubation when inspected visually. Outcome of the MIC confirmed the antimicrobial properties of the extracts samples. The range of the MICs were between 15-25 mg/ml. the results showed the plants extracts as having inhibition potential against SOB than fungi isolates. The results showed that the extracts inhibited SOB (-pseudomonas) organisms significantly. The susceptibility of SOB isolates to extracts fractions *A.Cordifolia* was thus confirmed. At maximum extracts concentrations for 20 mg/ml no fungal growth was observed for *A.Cordifolia* extracts. The results of the MIC indicates that bacteria were more sensitive to the extracts than the fungi.

Extracts of *Alchornea Cordifolia* has been reported as having excellent antimicrobial activity against SOB- *Pseudomonas aerigunosa* and *serratia marcensces.* Okeke *et al*, 1999, [22] reported the susceptibility of *A.Cordifolia* extracts against bacteria (positive & negative grams). The study suggested that the antimicrobial properties of the *A.Cordifolia* extracts may have been due to the intrinsic properties of the bacteria species as well as the high bioactivity of the *A.Cordifolia* leaf extracts against a broad spectrum of micro-organisms. It has been further suggested that the antimicrobial properties of plants extracts may be due to the synergy between the various phytochemicals constituents of the plant extracts.

### 3.3 Corrosion Study

Concrete weight loss after coating and immersion was determined as a parameter to judge the effectiveness of extracts in concrete deterioration control. Table 1 presents the results of corrosion rates calculation before coating and 5 weeks after coating and immersion in wastewater.



DOI: 10.31695/IJASRE.2023.9.5.2

**Table 1: Corrosion Rates of Concrete Before and After Coating**

| **Extracts** | **Corrosion rates without extracts coating (mpy)** | **Corrosion rates with extracts coating(mpy)** |
|---|---|---|
| AC 10% | 1.168546 | 0.002589 |
| AC 25% | 0.537199 | 0.003026 |
| AC 50% | 0.071996 | 0.003256 |
| BLANK | 0.024195 | 0.000437 |
| GLUTARALDEHYDE | 1.290385 | 0.003266 |

The results showed that the rate of corrosion was reliant on the concentration of inhibitor used but also on diffusion and extract solubility in water. The greater the volume of the inhibitor, the higher the corrosion rate of the concrete possibly due to increased diffusion with increase in immersion time. It was observed that the samples coated with *10% A.cordifolia* had the lowest corrosion rates after coating. Corrosion rates observed for Glutaraldehyde coated concrete was observed to closely approximate that observed for samples at higher extracts concentrations. Hence plant extracts are likely to have same active bactericidal properties and function as commercial biocides at high extracts concentration.

### 3.4 Inhibition Efficiency

The inhibitor efficiency of the extracts in corrosion control was estimated by the following equation:

$$E_f = \frac{W_0 - W_{inh}}{W_0} X\ 100\%$$

Where, $E_f$ is inhibitor efficiency (percentage), $W_{inh}$ is weight loss with inhibitor and W*o* is weight loss without inhibitor (Otaibi *et al*, 2012). After 5 weeks of immersion after coating the extracts inhibition efficiency was calculated. The values of the inhibition efficiency for the studied plants extracts are given in below.

For extracts coated concrete samples, an increase in inhibitor concentration accompanied an increase in extracts inhibition efficiency. 50% *A.Cordifolia* extracts gave the highest inhibitor efficiency. These results suggest that medicinal herbs could be an effective alternative to heavy metal salts and commercial biocides in inhibiting and controlling the rates of corrosion in concrete sewers. Extracts of plants origin are reported to be rich in phytochemicals with antibacterial properties against a wide variety of micro-organisms. [23, 24, 25] Nevertheless, the effectiveness of plant extracts could be affected by the diffusion and solubility of the extracts in corrosive media for uptake by bacteria and adsorption into concrete matrix.

**Table 2: Extracts Inhibition Efficiency**

| Extracts | Corrosion rates without extracts coating (mpy) | Corrosion rates with extracts coating(mpy) | Inhibitor efficiency (%) |
|---|---|---|---|
| AC 10% | 1.168546 | 0.002589 | 68.02 |
| AC 25% | 0.537199 | 0.003026 | 71.51 |
| AC 50% | 0.071996 | 0.003256 | 90.32 |
| BLANK | 0.024195 | 0.000437 | 48.47 |
| GLUTARALDEHYDE | 1.290385 | 0.003266 | 86.43 |



DOI: 10.31695/IJASRE.2023.9.5.2

At higher concentration it is suggested that the high efficiency could be as a result of higher dissolution of phytochemicals with time from the coating matrix into concrete and corrosive media. Additionally extracts coatings provides a barrier inhibiting the adsorption of toxic reactive constituents in the corrosive media into the coated concrete matrix. These results suggests that plant extracts with active biocidal phytochemical constituents can be applied in coating formulations to control the corrosive activity of biogenic sulfuric acids in sewer systems.

### 3.5 Effects of Extracts on Sewer pH

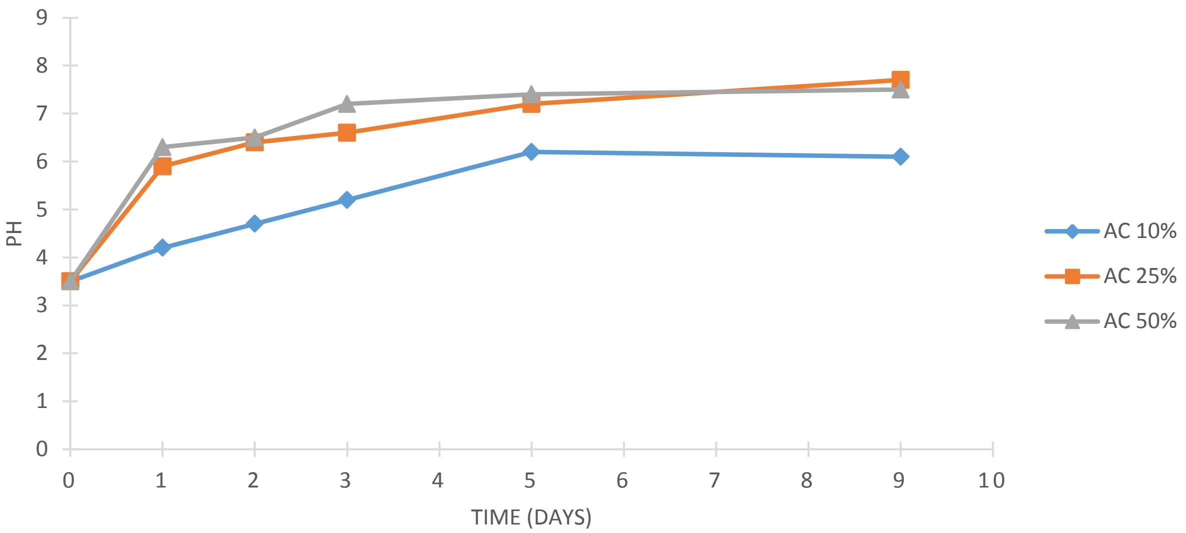


**Figure 1: pH Variation with *Alchornea Cordifolia***

Figure 1 shows changes in pH of the *Alchornea Cordifolia* extracts coated concrete sample. For all concentration of extracts a gradual increase in pH was observed. At higher extract concentration a more marked increase in pH was observed. Figure 1 gives a representation of the variation in sewer pH with the immersion of the epoxy modified coated concrete. The introduction of coated concrete into the sewer water saw a gradual and marked increase in the pH of the water. It can be theorized that this increase in pH towards the neutral/basic range is as a result of desorption and presence of phytochemicals and their metabolites into the sewer water thus gradually neutralizing the pH and reducing the acidity. The rise in pH of the sewers with the introduction of the various extracts modified epoxy coated concrete resulted in a decline in the production of biogenic sulfuric acid subsequently affecting the growth and metabolism of the sewer micro-organisms. By increasing the pH to 7 and above, the activities of alkalophilic fungi and bacteria is increased while that of acidophilic bacteria is reduced. There exists a strong relationship between the growth of sewer microbes and metabolism of substrate to pH of the corroding environment.

To control sewer concrete corrosion, it is important that the pH of the sewer environment is made unfavorable for the colonization of the acidophilic sulfur oxidizing bacteria thus reducing the production of the biogenic sulfuric acid and its corrosive activity. The addition of the extracts-coated concrete in the sewer wastewater saw a gradual upsurge in the pH of the bulk solution until alkalinity is obtained. Although not investigated it is believed that the pH variation to alkalinity will ultimately lead to microbial succession that further reduces the production and availability of biogenic sulfuric acid and reducing the corrosion rate. After a 9 days immersion period it was observed that the pH of the bulk solutions increased towards the alkaline pH with the exception of 10% *C.Odorata*.

Figure 2 shows the pH variation in sewer wastewater for Glutaraldehyde and blank coated concrete samples. Similarly, the commercial biocide Glutaraldehyde coated concrete also had similar effects on the pH as did the plants extracts.



DOI: 10.31695/IJASRE.2023.9.5.2

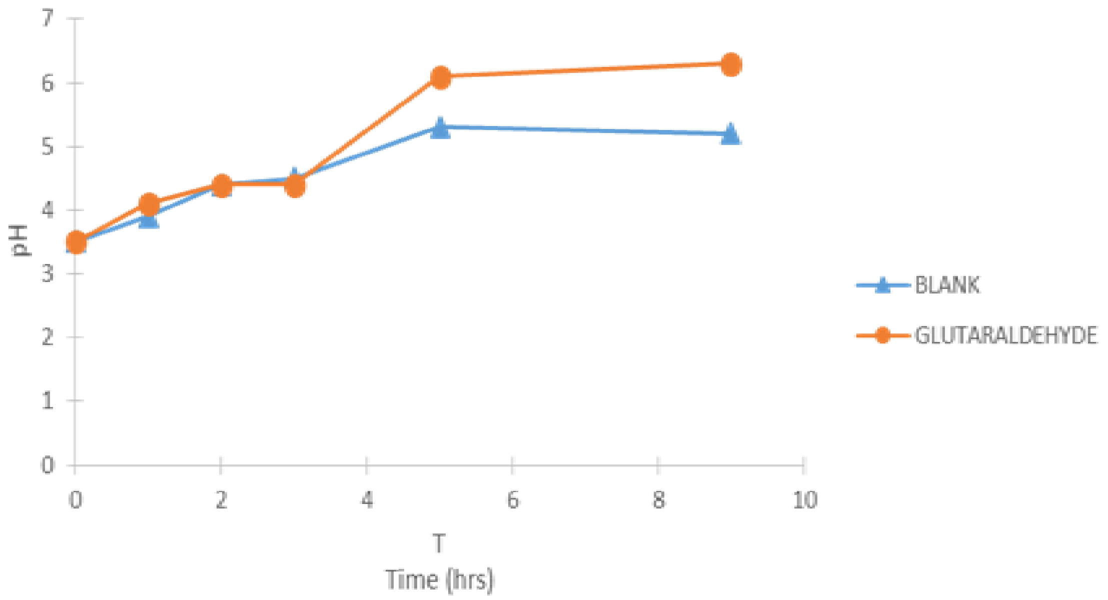


**Figure 2: pH variation in Blank and Glutaraldehyde coated concretes.**

For the blank coated sample a slower rise in pH was observed. This can be explained has been due to the uptake of dissolved Sulphate in solution by bacteria producing biogenic acid without the addition of a substrate and additional source of energy endogenous catabolism sets in leading to the death of SOB and an eventual gradual increase in pH. Compared to the plants extracts the increase in pH for the blank samples was relatively slower.

### 3.6 Effects of Plant Extract on Sulfate Concentration

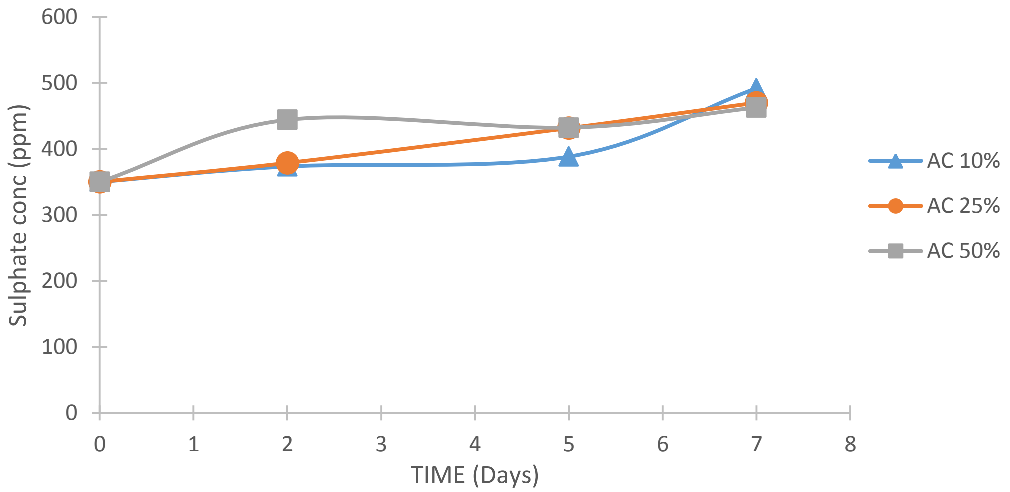


**Figure 3: Sulfate variation with time for *Alchornea Cordifolia* coated concrete**

Figure Figure 3 shows the variation in sulfate concentration with time for *Alchornea Cordifolia* extract coated concrete samples. For *Alchornea Cordifolia* coated concreted samples $SO_4$ increased from $35mg/l$ to $49.1mg/l$, $47mg/l$ and 46.2 $mg/l$ respectively for 10%, 25% and 50% coated extract samples. And continued to increase for the period studied.



DOI: 10.31695/IJASRE.2023.9.5.2

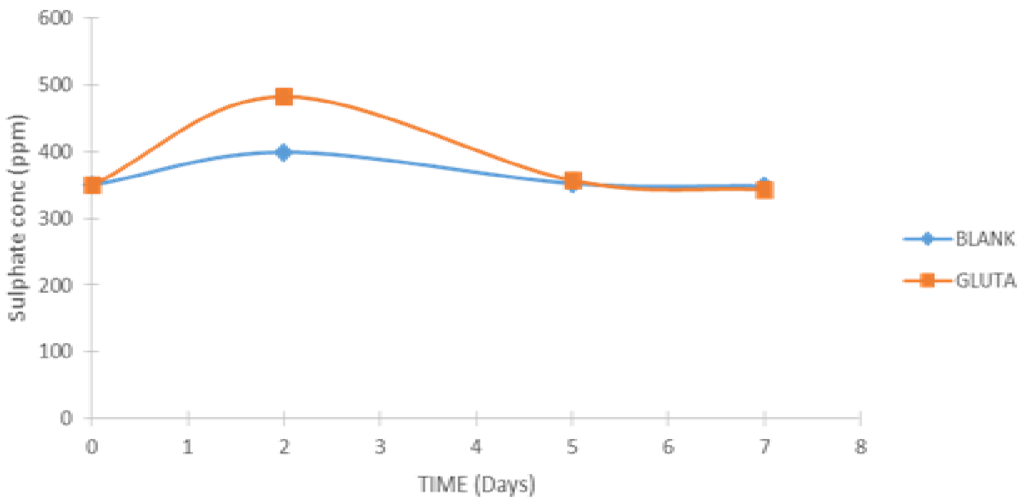


**Figure 4: Sulfate variation with time for Blank and Glutaraldehyde coated concrete**

Figure 4 shows the variation in sulfate concentration with time for Glutaraldehyde and blank coated concrete samples. Similarly, Glutaraldehyde coated sample saw an increase in sulfate concentration to 48.2mg/l from 35 mg/l. for Blank coated samples a slight decrease in sulfate concentration to 34.8mg/l was observed within 48hrs of coating immersion.

Diffusion susceptibility in addition to extracts concentration is vital in the availability of extracts for bacteria uptake for antimicrobial and bactericidal activities. At low extracts concentration higher dissolution and ultimately higher diffusion of extracts into solution is possible. Additionally, extracts solubility in water is critical for diffusion and uptake in solution. A pattern of initial increase in sulfate concentration followed by a decrease was observed. This initial increase in $SO_4$ is likely due to biotic oxidation of $H_2S$ dissolved in solution. This process in sewer wastewaters plays a key role in concrete corrosion. However, with increase in diffusion of extracts into solution the antimicrobial action of the extracts kicks in leading to a drop in sulfate concentration. However, with a drop in microbial count and ultimately sulfate concentration, as the biotic process slows down a process of abiotic oxidation of the sulfides in solution takes place. This leads to an increase in sulfate concentration, this process continues until all the sulfides in solution is converted to $SO_4$. This cycle of abiotic oxidation leads to an increase in pH.

### 3.7 Acidophilic Sulfur Oxidizing Bacteria

To effectively and efficiently control the progression of microbial induced concrete corrosion (MICC) in sewer systems, the succession, growth and sulfate uptake of SOB bacteria was monitored. The variation of concentration of SOB during corrosion in the laboratory scale sewer was monitored and is presented herein. Figure below gives a representation of the variation of bacteria count with each extract coated concrete.

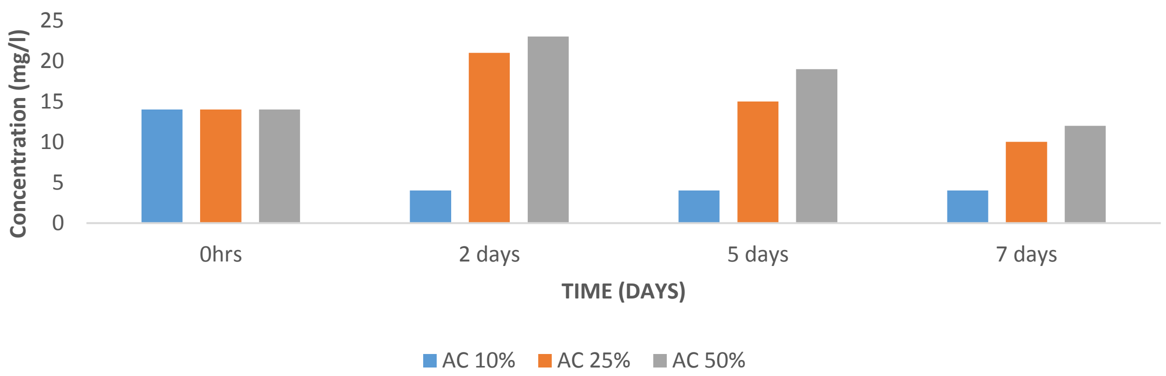


**Figure 5: SOB Variation with *Alchornea Cordifolia extract* modified epoxy coated concrete.**

Figure 5 shows the variation in SOB concentration with time for *Alchornea Cordifolia* extract coated concretes. For 10% extracts coated concrete, a decline in SOB concentration was observed within the first 48hrs. This decline continued for the period



DOI: 10.31695/IJASRE.2023.9.5.2

observed. For 25% and 50% extracts coated concretes an initial increase in SOB concentration was observed within the first 48hrs. This increase was followed by a gradual decline over the next five days.

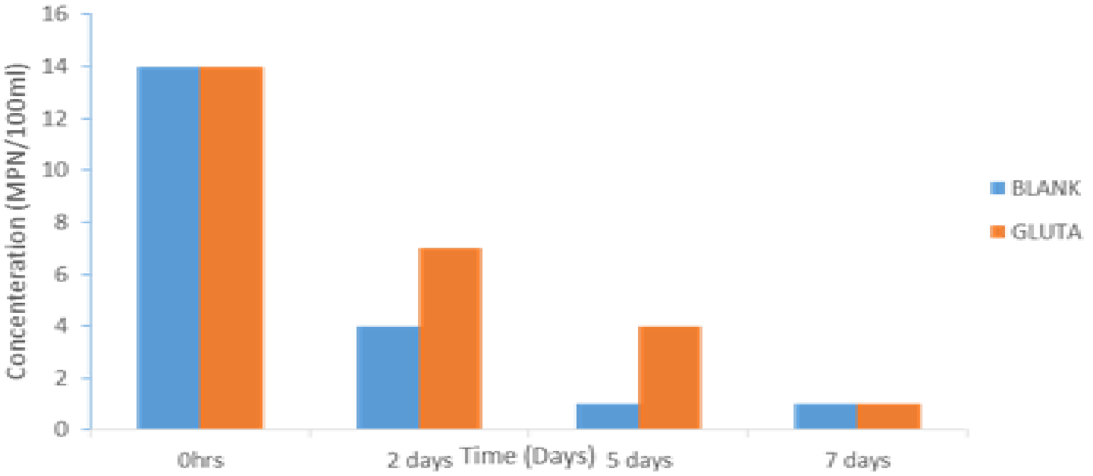


**Figure 6: variation in SOB for Glutaraldehyde and blank coated samples.**

Figure 6 unveils the deviation in concentration with time for Glutaraldehyde and blank coated concretes. A gradual decline in SOB concentration with time observed for the Glutaraldehyde and blank coated samples. However, it was observed that at higher extracts concentrations of 25% and 50% of *A.Cordifolia* saw a pattern of an initial increase in bacteria concentration within the first 48hrs of immersion of extracts coated samples in sewer waste water. This initial period of increase was followed by a gradual decrease in concentration of bacteria with time of immersion. This is likely due to improved diffusion and dissolution of extracts from the epoxy matrix into sewer water for uptake by sewer microbes. This observation closely agrees with the pattern of sulfate variation observed after coating. This initial increase is also likely due to the bacteria metabolism of dissolved sulfur and sulfur compounds in solution to $SO_4$. In real sewer systems a decline in SOB populations with a reduction in $SO_4$ and pH increase leads to a succession and progression of neutrophilic sulfur oxidizing bacteria (NSOM) in the sewer system. Although not investigated this bacterial succession is very unlikely as the plants extracts studied have been reported as possessing exceptional antimicrobial activity against both bacteria (gram negative and positive).

### 3.8 Microstructural Analysis

The morphology and content of corrosion outcomes with and without extracts were studied using XRD and SEM on uninhibited and inhibited coated samples. The use of SEM-XRD techniques provide an insight into the surface morphology with the formation of corrosion by-products on the surface of concrete and within the concrete matrix during the corrosion process with and without the extracts as corrosion inhibitors and antimicrobial elements. X-ray diffractive (XRD) analysis technique and SEM were used to determine the changes in concrete morphology and corrosion outcomes after coating. The results are presented below.



DOI: 10.31695/IJASRE.2023.9.5.2

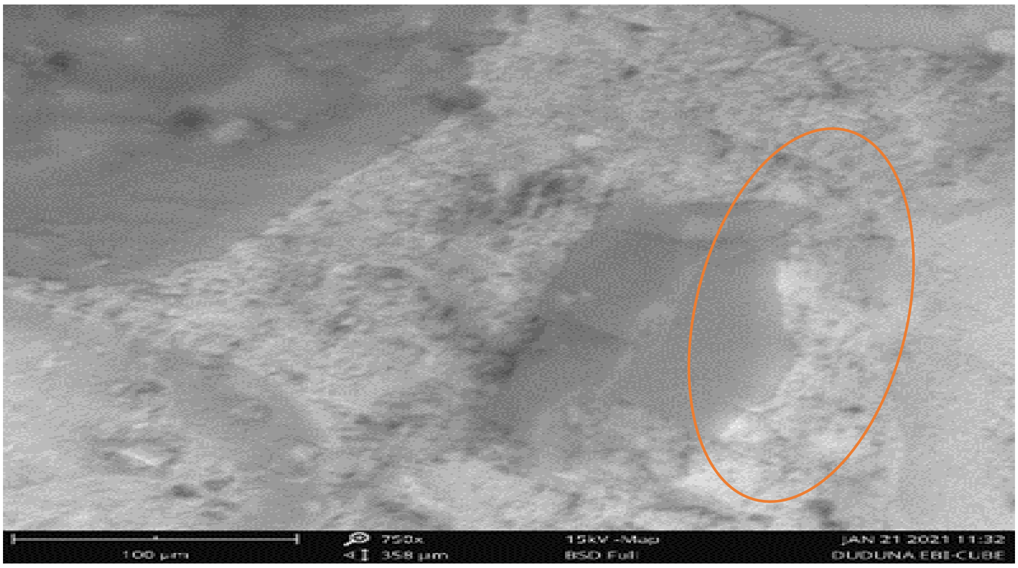


**Figure 7: SEM for uninhibited concrete.**

Figure 7 shows the concrete morphology of the corroded concrete before extracts coating. Corrosion progression within sewer led to the formation of gypsum a corrosion by-product of biogenic sulfuric acid corrosion within the concrete matrix.

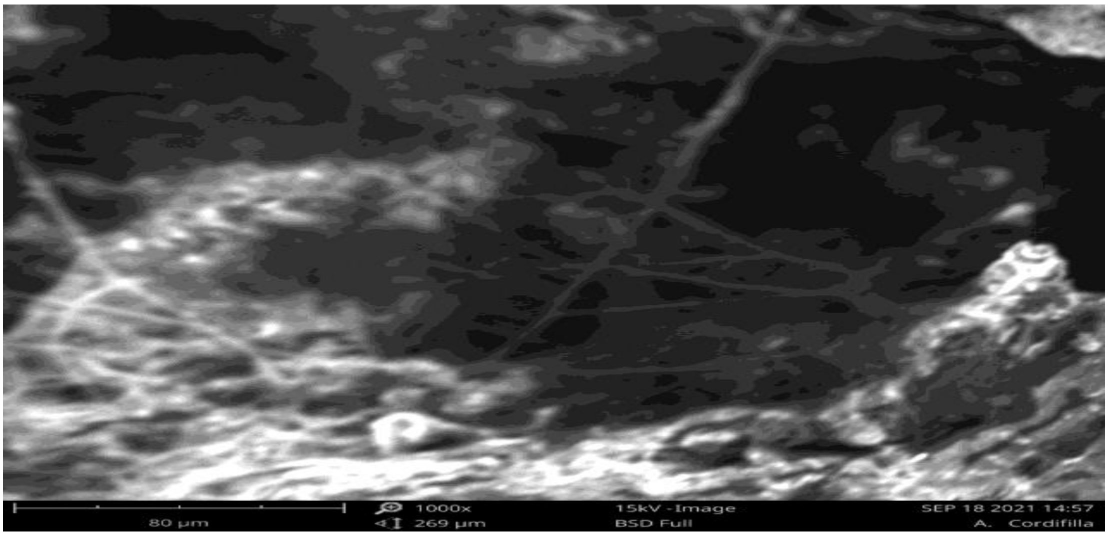


**Figure 8: SEM for *Alchornae Cordifolia* coated concrete**

Figure 8 shows the SEM images of *Alchornea Cordifolia* coated concrete samples. SEM images showed the formation of needle like crystalline and powder like compounds with *Alchornea Cordifolia* extract coatings. The XRD results revealed the presence of crystals of anorthite, anthophylite and montmorillonite chlorite. No corrosion byproducts were observed. Similar observations were made by Chen *et al*, (2021) [26] using an inorganic coating material to develop green concrete to study the resistance of coating materials to the penetration of chloride ions into concrete matrix. It was reported that the needle-like material formed comprised of C-S-H colloids and calcium silicate and was formed 20um below the coating layer. Similarly, El-Shami *et al*, 2020 [27] using *Molokha* and *Aubepine* extracts on reinforced concrete to prevent corrosion as a result of chloride ion ingress observed that the plant extracts formed a protective film. Inhibitor molecules formed a thin protective layer on specimen giving the surfaces protection against corrosion.

**3.9 Statistical Analysis**

In this study, parameters considered as a function of the corrosion rate are inhibitor concentration (In_c) and Sulphate concentration ($SO_4^-$). That is, CR = (In_c,$SO_4^-$). The significance of the variables and their interactions were determined using the analysis of variance (ANOVA) method. A linear regression equation and ANOVA were used to resolve the effects of process variables on the corrosion rate of the extract coated samples.



DOI: 10.31695/IJASRE.2023.9.5.2

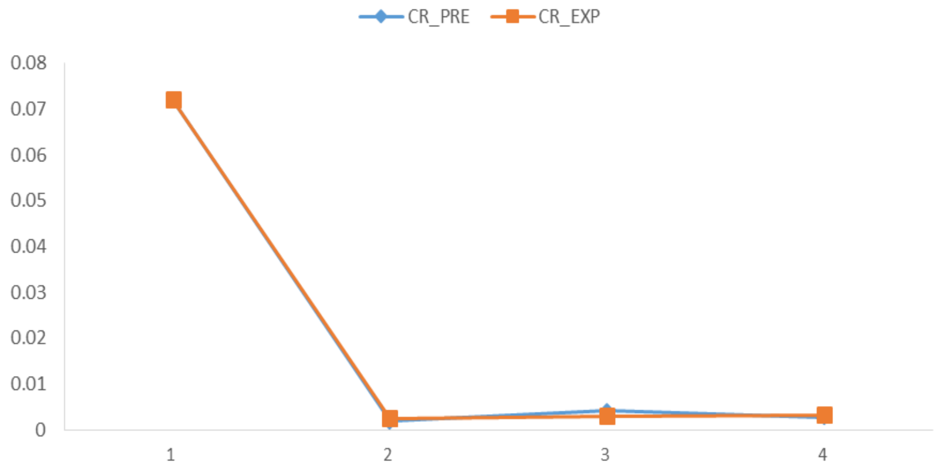


**Figure 9: Regression plot for *Alchornae Cordifolia* coated concrete**

Figure 9 presents' plots of predicted and actual experimental values of the corrosion inhibition studies for each extract coated concrete samples. As indicated in the Figures, the predicted corrosion rates of all coated samples were found to be close to those experimentally observed.

**Table 3: ANOVA for Corrosion Inhibition of Extracts**

| plants | Df | Sum of Square | Mean of Square | F | Significance F | $R^2$ |
|---|---|---|---|---|---|---|
| *Alchornea Cordifolia* | 2 | 0.003573 | 0.001787 | 906.0984 | 0.023484 | 0.9994 |

ANOVA computation is outlined in Tables 3, the analysis was evaluated for a confidence level of 95%, that is for significance level of $\alpha$ = 0.05. According to the findings, inhibitor concentration was the single important variable with the greatest statistical impact on the corrosion mitigation approach.

## 4.CONCLUSION

In this study, *Alchornea Cordifolia* leaf extract has been utilized to inhibit the concrete biocorrosion in sewer wastewater. The study investigated the effects of *Alchornea Cordifolia* extract on concrete properties. From the results obtained from the experimental procedures, the following conclusions were drawn from this study;

1. Extracts coated concrete had significant effects on sewer pH, Sulphate concentration and SOB populations within the sewer.

2. *Alchornea Cordifolia* extract inhibitor showed resistance to sewer corrosive environment comparative to the commercial biocide Glutaraldehyde. This could be due to its pore-blocking properties by the formation of microcrystalline compounds within the concrete matrix.

3. *Alchornea Cordifolia* coated concrete showed a significant reduction in the corrosion rate compared to blank sample. SEM images of *Alchornea Cordifolia* coated concrete revealed the formation of needle like crystalline and powder like compounds within the coated concrete matrix.

4. SEM and XRD observation showed no visible corrosion by-product with *Alchornea Cordifolia* coated concrete.

## REFERENCES

1. Beech, I.B. (2004) 'Corrosion of technical materials in the presence of biofilms – current understanding and state-of-the art methods of study. *Int. Biodeter. Biodegrad.* 53:177 – 183.
2. Dexter, S.C. (2003)" Microbiologically influenced corrosion, corrosion: fundamentals, testing and protection", Volume 13A, ASM Hand book, ASM. International, pp. 398-416.



DOI: 10.31695/IJASRE.2023.9.5.2

3. Videla, H.A and Herrera, L.K (2005)" Microbiologically influenced corrosion: looking to the future". Int. Microbiol. 8:169-180.
4. Idriss A.F., Negi S.C., Jofriet J.C., and Hayward G.L., (2001). Corrosion of steel reinforcement in mortar specimens exposed to hydrogen sulphide, part 1: impressed voltage and electrochemical potential tests. *J. Agr. Eng. Res.79:223-230.*
5. Vincke E., Verstichel S., Monteny J., and Verstraete W. (1999). A new test procedure for biogenic sulfuric acid corrosion of concrete. *Biodegrad 10: 421–28.*
6. Vollertsen, J., Nielsen, A.H., Jensen, H.S., Wium-Andersen, T., Hvitved-Jacobsen, T., (2008). Corrosion of concrete sewers the kinetics of hydrogen sulfide oxidation. *Sci.Total. Environ. 394 (1): 162-170.*
7. Okabe S., Odagiri M., Ito T., and Satoh H. (2007) Succession of sulphur-oxidizing bacteria in the microbial community on corroding concrete in sewer system. *Appl. Env. Microbiol. 73:971-980.*
8. Devarayan, K., Mayakrishnan, G., and Nagarajan, S. (2012). Green Inhibitors for Corrosion of Metals: A Review. *Chemical Science Review Letters, 1, 1-8.*
9. Bhola, S.M., Alabbas, F.M., Bhola, R., Spear, J.R., Mishra, B., Olson, D.L. and Kakpovbia, A.E. (2014) Neem extract as an inhibitor for biocorrosion influenced by sulfate reducing bacteria: a preliminary investigation. *Eng. Fail Anal 36:92–103.*
10. Korenblum, E., De Vasconcelos Goulart, F.R., de Almeida Rodrigues, I., Abreu, F., Lins, U., and Alves, P.B., (2013). Antimicrobial action and anticorrosion effect against sulfate reducing bacteria by lemongrass (Cymbopogon citratus) essential oil and its major component, the citral. *AMB Express. 3(1):44.*
11. Narenkumar, J., Parthipan, P., Nanthini, A.U.R., Benelli, G., Murugan, K. and Rajasekar, A. (2017) Ginger extract as green biocide to control microbial corrosion of mild steel. *Biotech. 7(2):133.*
12. Osadebe, O.P., Okoye, F.B.C., Uzor, P.F., Nnamani, N.R., Adiele, I.E. and Obiano, N.C. (2012) Phytochemical analysis, hepatoprotective and antioxidant activity of Alchornea cordifolia methanol leaf extract on carbon tetrachloride-induced hepatic damage in rats. *Asian Pac J Tropic Med. 5:289–93.*
13. Djimeli, M.N., Fodouop, S.P.C, Njateng, G.S.S., Fokunang, C., Tala, D.S., Kengni, F. and Gatsing, D. (2017). Antibacterial activities and toxicological study of the aqueous extract from leaves of Alchornea cordifolia (Euphorbiaceae). *BMC Complementary and Alternative Medicine 17:349-359.*
14. William-Porbeni, D. and Gumus R. H. (2021a) Study on Microbiologically Induced Corrosion of Concrete in Sewer Waste water. *Int. Journal of Advances in Scientific Research and Engineering. 7 (9).*
15. William-Porbeni, D. and Gumus R . H. (2021b) Identification and characterization of microorganism from a domestic sewer. *Jour. Multidisciplinary Engineering Science Studies. 7(8):4007-4013.*
16. Edeoga, H.O., Okwu, D.E. and Mbaebie, B.O. (2005) phytochemical constituents of some Nigerian medicinal plants. *African Journal of Biotechnology 4 (7):685-688.*
17. Ojo, O.O., Ajayi, S.S. and Owolabi, O.L. (2012) phytochemical screening, anti-nutrient composition, proximate analyses and the antimicrobial activities of the aqueous and organic extracts of bark of Rauvolfia Vomittorria and leaves of Peperomia pellucida. *Int. Res. Jour. of Biochemistry and Bioinformatics. 2(6): 127-134.*
18. CLSI. Performance Standards for Antimicrobial Susceptibility Testing. 31st ed. CLSI supplement M100. Clinical and Laboratory Standards Institute; 2021.
19. Okore V. A (2004) Standard laboratory technique in pharmaceutics and pharmaceutical. Microbiology (2nd Edition). Naphtali prints, Nigeria. 2004; 6–24.
20. Masiewicz, J. Roszowska – Jarosz, M., Kostrzewa, M., Jasik, A., and Paulina Krawczyk (2020). The modification of an epoxy resin by natural plant materials. *Environmental Protection and Natural Resources. Vol. 31 No 1(83): 14-20.*
21. Mohammadi Nejad, S., Özgüneş, H. And Nurşen Başaran, N. (2017). Pharmacological and Toxicological Properties of Eugenol. *Turk J Pharm Sci 2017:14 (2):201-206.*
22. Okeke, I.N., Ogundaini, A.O., Francis O. Ogungbamila, F.O. and Adebayo Lamikanra, A. (1999) Antimicrobial Spectrum of Alchornea cordifolia Leaf Extract. *Phytother. Res. 13, 67–69 (1999).*
23. Adeshina, G.O., Onaolapo, J.A., Ehinmidu, J.O. and Odama, L.E. (2010) Phytochemical and antimicrobial studies of the ethyl acetate extract of Alchornea cordifolia leaf found in Abuja. *Nigeria Journal of Medicinal Plants Research , 4(8): 649-658.*
24. Ayoola, G. A., Folawewo, A. D., Adesegun, S. A., Abioro, O. O., Adepoju-Bello, A. A. and Coker, H. A. B. (2008) Phytochemical and antioxidant screening of some plants of apocynaceae from South West Nigeria. *African Journal of Plant Science. 2(9): 124-128.*
25. Emencheta, S.C., Enweani, B.I., Oli, A.N., Ibezim, E.C. and Imanyikwa, I.E.O., (2020) Antimicrobial Evaluation of Plant Parts of Rauwolfia Vomitoria. *Journal of Complementary and Alternative Medical Research 12(1): 11-20*
26. Chen, S.C., Lin, W.T., Huang, R and Hsu, H.M. (2021) Performance of Green Concrete and Inorganic coating. Materials. *Materials 14:832.*




DOI: 10.31695/IJASRE.2023.9.5.2

27. El-Shami, A.A., Bonnet, A., Nazaire, S., Makhlouf, M.H., Khelidj, A. and Leklou, N. (2020) Novel green plants extract as corrosion inhibiting coating for steel embedded in concrete. *Pigment and Resin Technology. DOI: 10.1108/PRT-09-2019-0078.*



**DOI: 10.31695/IJASRE.2023.9.5.2**