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Effect of Indigenous Micros on Metal Corrosion in Different Water Environment

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Abstract

The research on the effect of indigenous micros on metal corrosion in different water environment in life sciences and other fields as well as their significance was investigated. Mild Steel is one of the construction materials used in the industries. It has a young modulus of 200GNm-2. This paper focuses on the experimental study for the effect of indigenous micros on metals in different water environment and also of the corrosion behavior and mechanism for mild steel in three different media namely:, rain water, Salt water, Fresh water. Indeed, this research illustrates the effect of micros in metal corrosion as media characterization contributes to the rapid increase in population. The research revealed that the rain water is more acidic followed by salt water and lastly the fresh water medium. Based on this observation the micros activities were high in the rain water medium revealing high degradation in the metal specimen sampled, followed by metal specimen in salt water medium and metal specimen in fresh water. This investigation was able to demonstrate the required measures needed in mild steel installation in these water environment. The rate effect by corrosion on metal is identified as a major component that influence degradation of systems service lifetime. The microorganisms were isolated, identified and characterized.

Keywords: Effect, indigenous micros, metal, corrosion, water, environment

INTRODUCTION

The role of microorganisms in metal corrosion is known since the first part of the 20th century; since then, hundreds of publications appeared that are dedicated to the significance of organisms on metal degradation in any given environment [1–4]. A major knowledge gap is, knowing “which kind of microbe is causing corrosion [5–7]. The significant than its mere presence, i.e., just knowing “the microbial inhabitants” as well as the attributes in terms of active performance in initiating metal corrosion [8–10]. The characterization of responsible for micro biologically influenced corrosion and some microorganisms that produce hydrogen sulfide as result redox reaction and also in the water or aqueous environment [11–14].

The laboratory immersion test remains the best method of screening and eliminating from further consideration of those constructive materials for engineering application as well as the behaviors of these metals when the environment is harmful. Indeed, the metal corrosion is a challenging factors to the service time of this installations in the industries where majority of the failures are attributed to the function of physicochemical parameters as well as the micros [15–20]. Today, theoretical approach is found useful in examining the characteristics of metal

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corrosion in any given environment, once the dependent coefficients and independent coefficients are established [21–24]. Mild steel as considered in this research experienced the influence of environment factor in terms of failure as related to corrosion [25–27]. It is imminent that the process of micro-organisms was confirmed through a microscope.

The aim of this study is to examine the effect of indigenous micros on metal corrosion in different water environment. The objectives of the study are to: Isolate and identify the possible microorganisms present in metal environment**,** examine the roles of the micro in metal corrosion**, e**valuate the corrosion rate of the metal, analyze the Physico-Chemical properties of the water and determine the weight upon the action of the micro on the metal.

The activities of microbiologically influenced corrosion evaluations have been investigated, both at the laboratory and field locations, more reliable. Using micro sensors to perform local chemical analysis within the study is one of the most exciting advances in instrumentation. A major knowledge gap is, knowing “which kind of microbe is causing corrosion?” and the significant than its mere presence may cause, i.e., just knowing “the microbial inhabitants” is not enough to understand the role of microbes.

The research significance priory can be listed as follows: Material structure and the effect of microbiologically influenced corrosion are being classified correctly from the experimental view point. Collection of various samples should be of top standard importance. The scope of work is focused on knowing the bio-chemical analysis of the different water samples, characterization of the micro-organisms, isolating and identification of the micro-organisms using the various tests that will be provided Figures 1-4.

MATERIALS AND METHODS

The Experiment: Determination of the Effect of Indigenous Micros on Metal Corrosion in different water environments.

Materials: The following materials were used, three 8.5 cm mild steel rods with diameter 1.2 cm shows in Figure 3 and weighing 76.53 g, weighing balance shows in Figure 4, three 30 CL experiment bottles**,** 20 CL of fresh water, rain water and salt water, Mac conkey agar, blood agar, chocolate agar and nutrient agar.

Methods

Similar sizes of mild steel will be exposed to different corrosive environment and re-immersing into the various environments. Based on the weight assessment, appropriate corrosion formulas will be employed to ascertain reliable analysis.

This method of analysis may be seen as reliable on the basis that the corrosion rate of a metal will vary in different environments because of the distinguishing corrosive properties of these environments. In this experiment for different environments: Rain Water, Salt Water and Fresh Water are chosen, mild steel will be exposed to the corrosive properties of these environments the results obtained will then be used for the effect of indigenous micros on metal corrosion in different water environment will be well explained.

Sample Collection

After determining the various sampling point, the different water samples was collected.

Procedure

i. The three mild steel rods were properly cleaned with wire brush and sand paper to remove bio-film which must have formed during exposure taking precaution not to create cervices on the metal shows in Figure 1 and Figure 2.
ii. These metals were then washed cleaned and allowed to properly dry and cool.
iii. The rods were weighed on weighing balance to take note of the initial weights.

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iv. The liquids where poured into the experiment bottles and three of the rods were immersed into these bottles.

In consideration of the limited time available for the experiment, the period did not give a wide margin for weight variation and so small weight losses were anticipated.


Figure 1. Wire brush.


Figure 2. Sand paper.


Figure 3. Mild steel.


Figure 4. Weighing balance.

Measurement of Weight Loss

The weight loss was measured by examining the initial and final weight within the period of sampling.

The model

Equation (1) was used in terms of monitoring corrosion rate of mild steel

$$CR = \frac{\Delta \times 13.56}{A \times \rho \times T} \quad (1)$$

Surface area of cylinder = $2\pi r l + 2\pi r^2$ (2)

Physico-Chemical Properties of the Various Water Samples and other Procedures Adopted for Sampling

The Water samples collected were analyzed for some Physico chemical properties.

Physico-Chemical Properties of Fresh Water

i. *Temperature:* the temperature of water is one of the important physical parameters which directly influence some chemical reaction in aquatic environment.
ii. *pH:* pH meter was used.
iii. *Turbidity:* Turbidity is a natural water bodies is a mainly caused by sand, silt clay, microorganisms and organic materials suspended.
iv. *Electrical Conductivity:* pure water is a poor conductor of electricity, conductivity of a substance or isolation is the measure of its capacity to conduct electric current.

v. *Dissolved Oxygen:* The dissolved oxygen is one of the most important factors in aquatic ecosystem. All living organisms are dependent of Oxygen in one form or the other to maintain their biological processes that produce energy for their growth.
vi. *Hardness:* hardness is measured as the capacity of water to react with soap. Hard water require much amount of soap to form lather than soft water, the hardness of water is predominately caused by divalent cations such as calcium, magnesium and alkaline earth metals such as iron, manganese etc.
vii. *Sodium:* The source of sodium in natural water is weathering of rocks and mining of minerals in the surrounding area, the principal one being rock salt- sodium chloride.

The Physico-Chemical Properties of Salt Water

i. *Density:* probably the most important dynamic of salt water is in density r. in general the observed differences in salt water density are due to the combined of variability of temperature salinity and Pressure. Though relative small (the range of salt water surface densities is from 1.024 to 1.030 gm/cm^3).
ii. *Pressure or Compressibility:* pressure is an important physico chemical properties of water because of it effect on density to decrease the volume of water parcel by squeezing the molecules closer together
iii. *Temperature:* temperature is arguably the most important physical oceanographic variables in ocean. Temperature is the major factor determining latent and sensible heat transfers between the ocean and the atmosphere. Temperature is also salinity control of the potential density and hence the stratification (layering) of sea water, in most regions, Temperature is more important. The total amount of dissolved non- organic and non- volatile material in salt water is it salinity.
iv. *Elements:* All of the chemical elements exist in salt water, but about 87% of the dissolved salts are sodium chloride.
v. *Ions:* The six most abundant ions of salt water are chloride (Cl^-), Sodium (Na^+), Sulfate.

Isolation Method

During the isolation method 10 ml of the various water samples was collected into sterile test tube and was centrifuged at 5000 rpm for ten minutes. The sediments was collected, inoculated unto mac conkey agar, blood agar, nutrient agar and chocolate agar so it was cultured at 37˚C for 72 hours then it was then checked for isolates. The isolates identified were then extreme collected and characterized biochemically shows in Figure 5.

Figure 5. Shows the various agars used for isolation.

Identification Method

This method will be used for identifying the type of micros been found in the different water samples.

Characterization of the Microorganism

In characterizing the Isolate the bio-chemical analysis was used with respect to various test was carried which include: Indole test, Lysine decarboxylase test, citrate test. H_2S test, Urea test, Lactose test, glucose test, glucose test, sucrose test, oxidase test and each of the various Water Sample yielded different result.

RESULTS AND DISCUSSION

Result: The data obtained from the sampling as well as the experimental data and theoretical calculated data are given below:

Data

- Specimen: mild steel
- Number of specimens: three (3)
- Specimen description: mild steel rods
  - Length: 8.5 cm [85 mm]
  - Diameter: 1.2 cm [12 mm]
  - Radius: 0.6 cm [6 mm]
  - Surface Area: [22.288 cm square]
  - Initial weight: 76.53 g
  - Density of mild steel: 7.85 g per cubic cm
  - Period of Experiment: five weeks
  - Intervals of weighing: weekly

The Slope of the graph is calculated using the straight line formula.

y = mx + c

$$m = \frac{\Delta y}{\Delta x}$$

Calculating for Rain water

$$mRw = \frac{\Delta W_L R_W}{\Delta t\ (weeks)}$$

$$= \frac{56.13 - 76.53}{1 - 0}$$

$mR_W = – 20.41$

$cR_W =$……

y = m x + c

56.13 = – 20.41 (1) + c

c = 56.13 – 20.41

c = 35.72

$yR_W = – 20.41x + 35.72$

c = 15.31

Calculating for salt water

y = mx + c

$$m = \frac{\Delta y}{\Delta x} = mSw = \frac{\Delta W_L S_W}{\Delta t\ (weeks)}$$

$$= \frac{76.51 - 76.52}{2 - 1} = -0.01$$

But when y = 76.52, x = – 0.1

y = mx + c

76.52 = – 0.01 (1) + c

c = 76.52 – 0.01

c = 76.51

$yS_W = -0.01x + 76.51$

$c = 76.5$

Calculating for Fresh water (Appendix)

$y = mx + c$

$$mFw = \frac{\Delta y}{\Delta x} = \frac{\Delta W_L F_W}{\Delta t\ (weeks)}$$

$$= \frac{76.39 - 73.33}{4 - 3}$$

$$mFw = \frac{2.03}{1} = 2.06$$

But $y = mx + c$

At $y = 75.39 - x = 3$, 75.39

$= 2.06\ (3) - c$

$c = 75.39 - 618$

$c = 69.21$

$y = 2.06x + 69.21$

$F_W\ c = 71.27$

Figure 6 illustrate the relationship between weight loss of mild steel and water media. The result obtained revealed decrease in weight loss of mild steel with increase in period of exposure (time). The order of magnitude in terms of weight loss is $W_LR_W > W_LS_W > W_LF_W$. The variation in the weight loss can be attributed to variation in period of exposure (time) as well as the characteristics of the water medium. Table 1 demonstrates the weight loss of the sample of mild steel on various water media and the trend in terms of behaviours is the same as shown in Figure 7.

Table 1. Weight loss of the sample of mild steel in various water media.

	Weight loss of samples (g)					
Environment	**Initial**	**1**	**2**	**3**	**4**	**5**
Rain water	76.53	56.13	44.4	42.64	42.53	37.37
Salt water	76.53	76.52	76.51	75.39	73.33	72.42
Fresh water	76.53	76.52	76.51	76.48	76.06	76.02

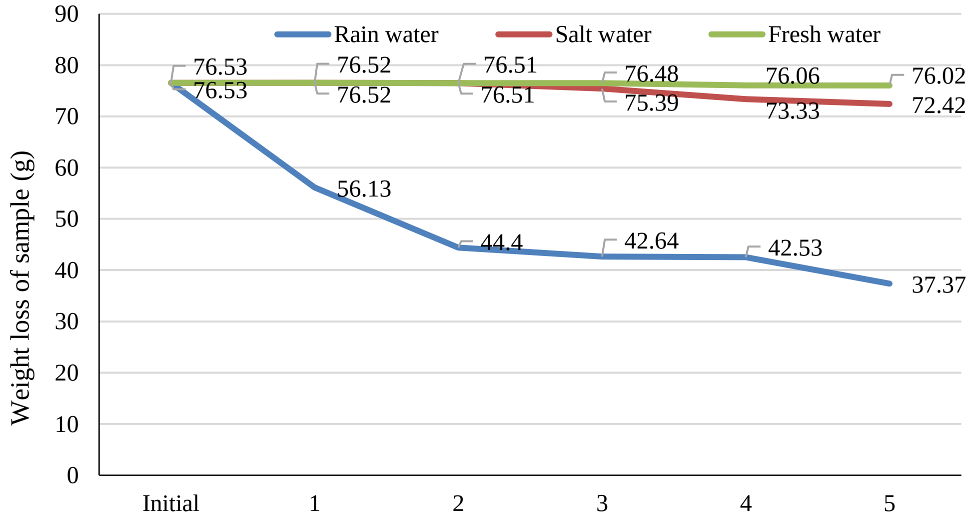

Figure 6. Graph of weight loss of mild steel versus time.

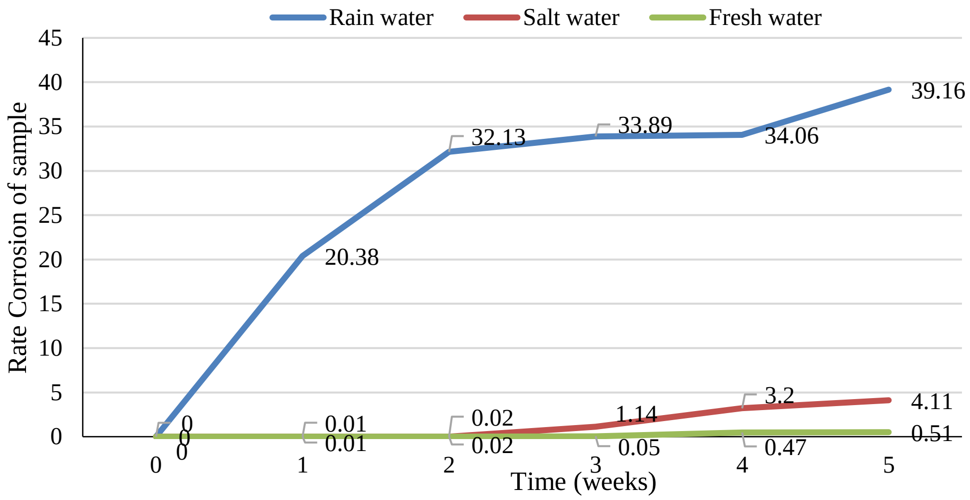

Figure 7. Graph of rate corrosion versus time.

Figure 7 illustrates the relationship between rate of corrosion of mild steel and water media. The result obtained revealed increase in the rate of corrosion of mild steel with increase in the period of exposure (time), the order of magnitude in terms of corrosion rate is as follows C_RR_W> C_RS_W> C_RF_W where CR is the corrosion rate of the different water media. The variables in the corrosion rate can be attributed to the variation in the period of exposure (time) as well as the characteristics of the water media. Table 2 demonstrates the corrosion rate of the sample of mild steel in various water media and the trend in terms of behavior is as shown in Figure 8.

Table 2. Rate of Corrosion of Samples (g).

Δ Rate Corrosion of sample (g)						
Environment	**Initial**	**1**	**2**	**3**	**4**	**5**
Rain water	0	20.38	32.13	33.89	34.06	39.16
Salt water	0	0.01	0.02	1.14	3.2	4.11
Fresh water	0	0.01	0.02	0.05	0.47	0.51

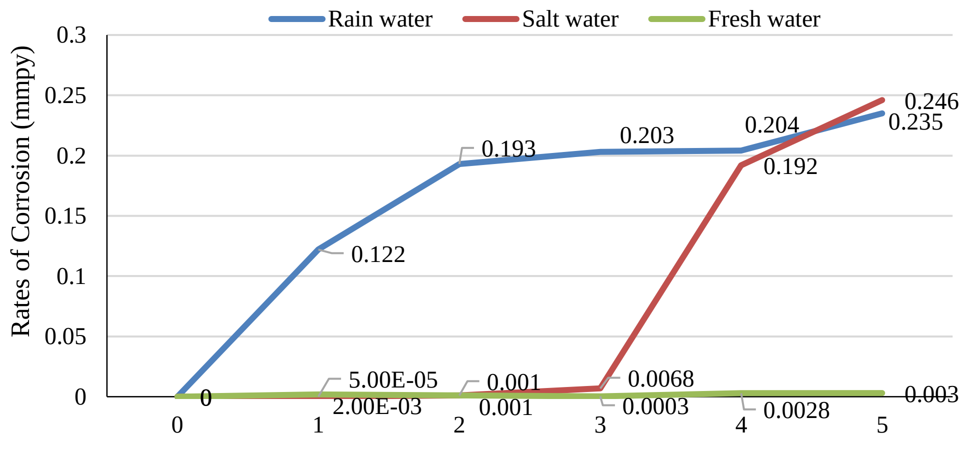

Figure 8. Graph of rate of corrosion of samples (mmpy) versus time.

Figure 8 illustrates the relationship between the rate of corrosion in (mmpy) of mild steel and water media. The result obtained revealed increase in the rate of corrosion (mmpy) of the mild steel with increase in the period of exposure (time).

The order of magnitude in terms of corrosion rate (mmpy) is as follows: C_RS_W> C_RR_W > C_RF_W (mmpy) where CR is the corrosion rate of the different water media and mmpy stands for millimeter per year. The variations of the corrosion rate (mmpy) can be attributed to the variation in the period of exposure (time) as well as the characteristics of the water media.

Table 3 demonstrates the corrosion rate (mmpy) of mild steel in various water media and the trend in terms of behavior shows low increase in corrosion rate (mmpy) of the salt where media within the expense of the first to the third weeks and high increase of corrosion (mmpy) within the expense of the fourth to the fifth week as shown in Figure 8 which is the graph profile of the rate of corrosion (mmpy) against time (weeks).

Table 3. Shows the rate of corrosion of samples.

Rates of corrosion of samples (mmpy)						
Environment	**Initial**	**1**	**2**	**3**	**4**	**5**
Rain water	0	0.122	0.193	0.203	0.204	0.235
Salt water	0	0.00005	0.001	0.0068	0.192	0.246
Fresh water	0	0.0002	0.001	0.0003	0.0028	0.003

Table 4 shows for the physico-chemical properties of the three different water samples after undergoing the water analysis and after which it was tabulated indicating all the parameters that was been detected during the analysis.

Table 4. Shows the physico-chemical properties of the water samples.

Physico-chemical properties			
	Rain water	**Salt water**	**Fresh water**
Appearance	Clear	Clear	Clear
Turbidity	Nil	Nil	Nil
Colour	Clear	Clear	Clear
Odour	Odourless	Odourless	Odourless
pH	6.0	5.5	6.0
Specific Gravity	1.015	1.020	1.010
Culture	E. coli	No growth	No growth

Table 5 indicates or shows the bio-chemical analysis of three different water samples using different tests.

Table 5. Shows the biochemical analysis of the water samples.

Bio-Chemical Analysis			
Test	**Rain water**	**Salt water**	**Fresh water**
Indole	+	NA	NA
Lysine decarboxylase	+	NA	NA
Citrate	–	NA	NA
H_2S	–	NA	NA
Urea	–	NA	NA
Beta galactose	+	NA	NA
Lactose	+	NA	NA
Maminitol	+	NA	NA
Sucrose	d*	NA	NA
Glucose	+	NA	NA
Oxidase yield	–	NA	NA

NA = Not applicable
d = Different strains give different result*

The result where accepted based on the following assumptions:

1. The rods were assumed to have the shape of a cylinder and so the surface area calculation was based on that cylinder.
2. The top and bottom of the rod where chamfered to assume the shape of a circle and the salt water, fresh water and rain water was subjected into this process. The presence of halide ions breakdown any passive films available and can sometimes prevent passive films from forming on the mild

steel rod the specimen in the rain water also experienced high corrosion rates towards the first week as presented in Table 1. The rain water had a pH of 6.0. From Table 2 it is shown that the first three weeks, the corrosion rate for salt water behavior was high since the available oxygen and the medium will form a corrosion cell and initiate the corrosion process until passive films were formed when the rate became constant.

Physical Changes Observed on the Coupons during the Experiment

The specimens changes colors as the concentration of the salt fresh and rain water increases. However, each of the medium influences the mild steel and cause corrosion as well as failure and reduction in the service time.

Identification Method

As stated earlier in our objectives, the microorganisms that was been identified in the rain water samples was found to be a bacteria living microorganism which is known as Ecoli and they was no other micros found in the salt and fresh water.

CONCLUSION

Characterization of the micro-organism found was actualized using the various tests.

The rate of corrosion is proportional to the period of exposure. And the order of corrosion effect is rain water > salt water > fresh water as revealed in this investigation. The micro–organism identified was known as Ecoli which happens to be a bacteria micro-organism. This investigation revealed the following:

i. The nature of the environment is a contributing factor to mild corrosion
ii. The nutrient obtained by the micros when degradating the mild steel can catalyze the corrosion of the system
iii. The theoretical application of the model is a good tools for evaluating corrosion rate of mild steel
iv. In stalling mild steel there is need to examine the composition of the environmental factors.

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Appendix

CR= Corrosion rate [mmpy]
Δw = Weight loss in grams
A = Surface Area in mm^2
ρ= Density
T = Time
Surface area of cylinder = $2\pi r l + 2 \pi r^2$
l = length
r = radius in millimeters

