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Effect Chemical and Physical Properties of Tigris River Water on Low Carbon Steel Corrosion in Wasit Governorate

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ABSTRACT

This study focused at how the resistance of carbon iron to electrochemical corrosion was effected by the chemical and physical characteristics of the Tigris River water at different locations of Wasit City. For each of these four locations, models were obtained. Al-Ahrar, Al-Kut, Al-Zubaidiyah, and Al-Numaniyah. Models were obtained for four of these locations Al-Zubaidiyah, Al-Numaniyah, Al-Ahrar, and Al-Kut and their chemical qualities were estimated and determined. The results of the cathodic and anodic behavior are represented by two curves. Two tangents have been drawn for these two curves, and their point of capture indicates the value of the current that causes corrosion and the corrosion voltage. According to the findings the most corrosion occurred in the Al-Kut area due to the combination of high percentage of chlorides than other locations and a highconcentration of dissolved oxygen, which causes rust when iron and oxygen come together.

Keywords: Low-carbon steel, corrosion rate, Tigris, conductivity, PH.

INTRODUCTION

Transportation pipes and the majority of land transportation components are made of steel. Steel is also employed in the production of parts for maritime transportation. Petroleum, construction projects, and bridges. Iraqi civilians' health and safety are at risk due to pollution in the Tigris River. Skin conditions and colon cancer are brought on by the chemicals and garbage from several government buildings and power stations that pollute the Tigris River's water. The Tigris River, which flows past the capital Baghdad and into the Wasit Governorate, is also filled with sewage water. Additionally, hospitals discharge chemicals and harmful liquids into the Tigris River. Furthermore, people who live in communities around the river dump their trash into it. The air is polluted and smells awful due to the extreme pollution and trash in the river. Numerous researchers have been interested in examining steel's corrosion resistance and looking for potential solutions due to the material's significance in engineering applications and its limited resistance to corrosion in most environments. When it comes to electrochemical corrosion, it might happen because of a galvanic reaction or an electric current that the metal is exposed to as a result of an external voltage. There are several kinds of corrosion based on its kinds include uniform corrosion, stress corrosion, hydrogen embrittlement corrosion, and intergranular corrosion, depending on the conditions of the medium corrosion with pitting and flaking. The movement of electrons from the cathodic to the anodic regions of an electric current is what produces corrosion. Iron atoms lose electrons and become ions when they come into touch with the water around a metal structure through soil

or water. The following is iron cation:[1-10]
$Fe = Fe^{+2} + 2e^-$
These electrons react with oxygen in water to generate a hydroxide ion.
$O_2 + 2H_2O + 4e^- = 4OH^-$
Iron hydroxide is formed when iron ions mix with hydroxide ions.
$Fe + O_2 + 2H_2O = 2Fe(OH)_2$

Rust, or oxidized iron hydrates, is created as the process proceeds.
$2Fe(OH)_2 + O_2 = 2H_2O + 2Fe_2O_3.H_2O_4$

Several factors can effects the rate of corrosion of metal in liquid media, including the following:
1. Temperature: Corrosion processes speed up with rising temperatures.
2. The existence of substances that alter the electrical potential difference and therefore either raise or decrease the metal's rate of corrosion; these substances are materials that either speed up or slow down the corrosion process.
3. The medium's movement speed clearly affects the rate of corrosion since it increases the medium's movement and causes erosion while reducing corrosion while the overall speed helps prevent electrons from collecting on the non-electrodes.
4. The metal's place in the electrochemical chain. The metal's standard reduction voltage determines this location. The greater the number, the fact that the metal's reduction potential is less than zero suggests that it canoxidize.
5. The pH of the solution, or the medium's degree of acidity. The combination of ions causes a rise in the medium's acidity level when the metal is subjected to corrosion once more, the positive hydrogen ions interact with the negative chlorine ions to generate an acid that aids in the disintegration of the rust coating the metal hasformed.
6. Elements that comprise the aquatic medium and their respective quantities, such as ions and O_2, are considered components of the medium additional oxidants like Fe^{+3} or Ag^{+} ions. This is seen as oxygen and can be decreased, causing the metal to corrode. Since oxygen is the most potent oxidizing agent in the corrosion process and most metals corrode when exposed to it, it is well known when oxygen is present, corrosion proceeds far more quickly than when it isn't. Certain contaminants can occasionally increase.[11-15]

EXPERIMENTAL WORK

1. Select of metal

Low-carbon steel 37St was chosen, and its chemical composition was determined using a spectrometer as below shown:

W% element	C	Si	Mn	Cr	Mo	Cu	Co	V	W	Al	Ni	P	S
Actual value %	0.18	0.008	0.60	0.01	0.003	0.038	0.003	0.0008	0.002	0.001	0.013	0.08	0.04
Standard value %	0.18-0.23	0.01	0.3-0.6	--	--	--	--	--	--	--	--	0.04	0.05

2. Producing Test Samples

In the present work metal that was utilized in accordance with the test standard71-31G,several number of corrosion test samples were made. The dimension of specimens prepared were (1.5 cm x 1.5 cm x 0.5 cm) with accordance to the ASTM.

3. Samples of river water

At four different locations at the Governorate of Wasit, Al-Zubaidiyah, Al-Numaniyah, Al-Ahrar, and Al-Kut were selected. Amounts of 2.5 liters of Tigris River water were collected at a distance of 5 meters from the river's edge in sterile containers. Some of the characteristics were estimated directly, chemical and assessing its purity, using an acid measuring device, and a specific kind of measuring device. The level of bacterial groups in the river was ascertained by measuring the kind and amount of dissolved oxygen using a device, electrical conductivity, and a direct detection approach.

Test for electrochemical corrosion

Aqueous medium preparation

The water sources of the Tigris River (above) were used to prepare the test media.

Corrosion test by Potentiostat

The corrosion test was carried out utilizing the triple electrochemical cell seen in Figure (1) and by potentiostat device with a speed rate of 3 Sec./mV.
Electrodes are made up of:[16-20]
1. The sample that will be evaluated is represented by the working electrode.
2. The electrode at which the platinum-based electrons emitted from the anode congregate in this cell is known as the accelerator electrode.
3. Standard calomel Electrode (SCE).
4- The electrolytic medium's solution, which consists of Tigris River water gathered from four separate locations.
5. An electrical current source.

Mechanism of the electrochemical cell

A voltage in an open circuit is set based on the kind of metal present and where it is located. An electric current flows through with a voltage increase to± 100 millivolts in the electrochemical series, the reading was determined to be -0.44 millivolts. The voltage-current relationship was then sketched, with the current being measured at intervals of 10 millivolts (this range was used to understand the overall behavior). To determine the amount of corrosion current that causes an effort to change by sloping the resultant line to cathodic and anodic behavior and locating the junction of the two lines. The Tafel equation used to determine the corrosion rate as demonstrated by the following:[21-25]

C.R(mpy) =0.13*Icorr*eq.wt/d

Where; **C.R** is corrosion rate in(mpy), **Icorr** is corrosion current density(μA.cm^2), **eq.wt** is equivalent weight of corroding species ,**d** is density of corroding species (g/cm^3)

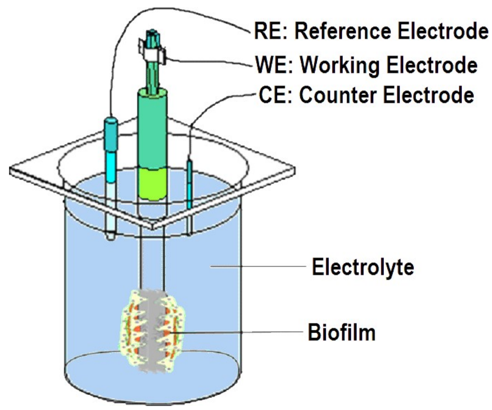

Figure 1 : Electrochemistry cell

RESULTS AND DISCUSSION

The areas are listed in Table 1 are Al-Zubaidiyah, Al-Numaniyah, Al-Ahrar and Al-Kut. The reason for the increase in conductivity is the presence of chlorides salts in these areas and the reason for the slight increase in acidity is due to a slight decrease in basicity in the water, and also that the total number of bacteria is decreasing for these areas and a decrease in bacteria is due to the presence of salts. Increasing both corrosion current and corrosion potential lead to an increase in rate of corrosion according to Table 2.[21-25]

Table 1: Represents the effect of conductivity, chlorine concentration, acid function, bacteria, and the amount of dissolved oxygen on sites in the Tigris River.

position	sample	conductivity	Chloride concentration milequiv./liter	Acidity PH	Total no. of Bacteria	Amount oxygen dissolved
Zubaidiya	A	870	3.75	7.2	96	63
Numaniyah	B	882	3.82	7.5	85	67
Ahrar	C	896	3.95	7.6	72	72
Kut	D	995	4.08	7.8	68	82

Table 2: Represents the effect of Corrosion current density , Corrosion potential and Corrosion rate on sites in the Tigris River.

position	sample	Corrosion current density (μA/cm^2)	Corrosion potential (mV)	Corrosion rate (mpy)
Zubaidiya	A	5.24	-473.8	2.471
Numaniyah	B	5.42	-474.2	3.325
Ahrar	C	6.12	-475.1	4.896
Kut	D	6.36	-476.4	5.245

Tables (1-2) and Figures (2-6) represents the relationship among the corrosion rate with conductivity, chloride concentration, acidity, the total number of bacteria, and the amount of dissolved oxygen. As the corrosion rates increase, the conductivity, chloride concentration, acidity and the amount of dissolved oxygen increase, and hence the total number of bacteria decrease.[21-25]

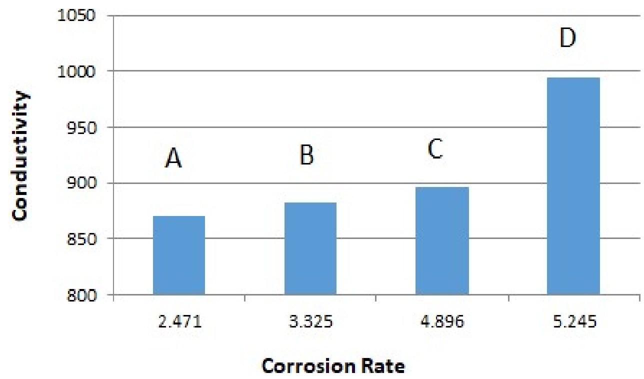

Figure 2: Relation between corrosion rate with conductivity

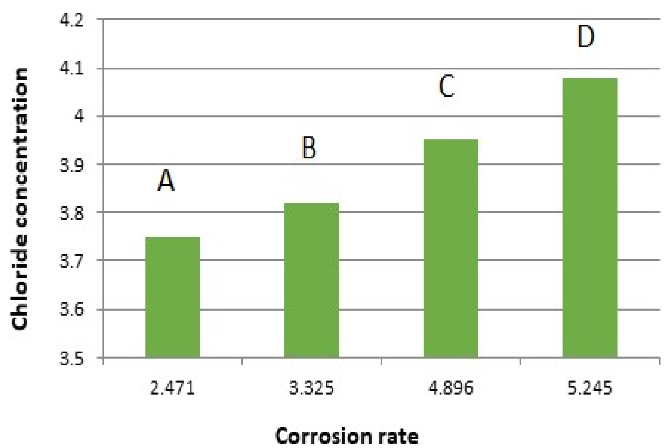

Figure 3: Relation between corrosion rate with chloride concentration

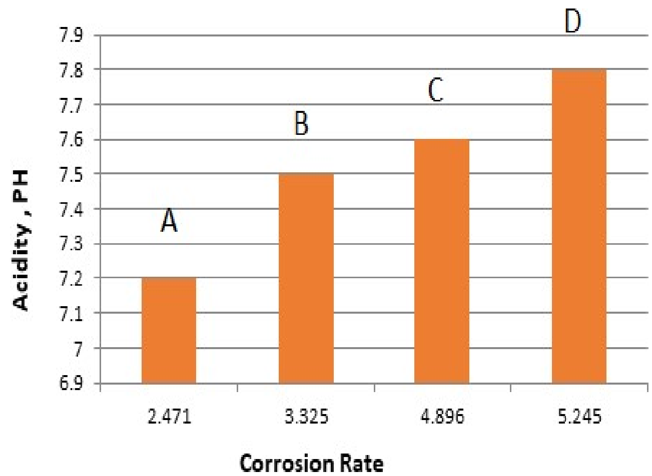

Figure 4: relation between corrosion rate with Acidity , PH

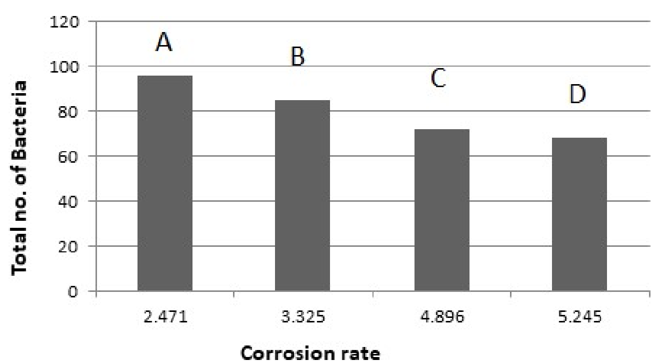

Figure 5: Relation between corrosion rate with total no. of Bacteria

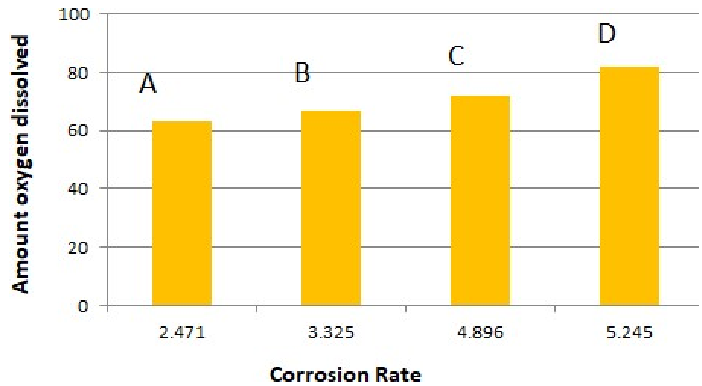

Figure 6: Relation between corrosion rate with Amount oxygen dissolved

Figures (7-10) represents the relationship between potential and current density. However it is clearly noted that there is a change in the anodic and cathodic curves for the areas of Al-Zubaidiyah, Al-Numaniyah, Al-Ahrar, and Al-Kut, and there is a noticeable increase in the corrosion potentials and currents and the corrosion rates increases, for the above areas respectively.[25-30]

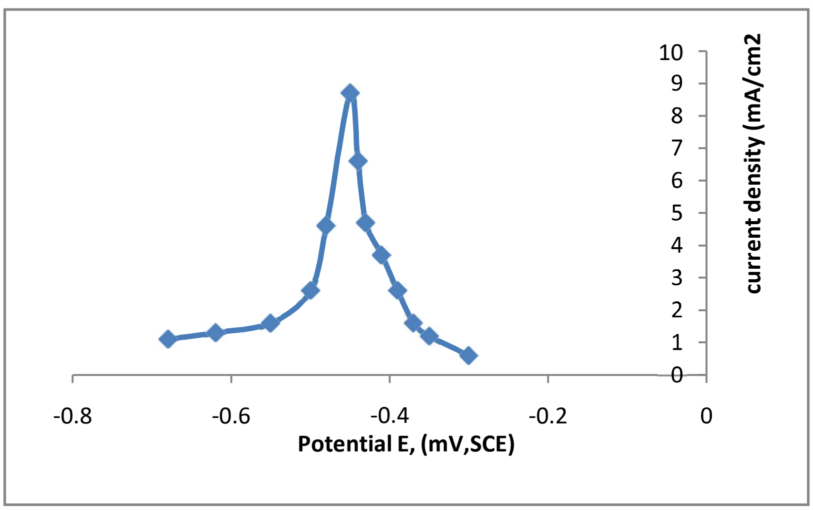

Figure 7: Potential vs. current density polarization in region A (Zubaidiya)

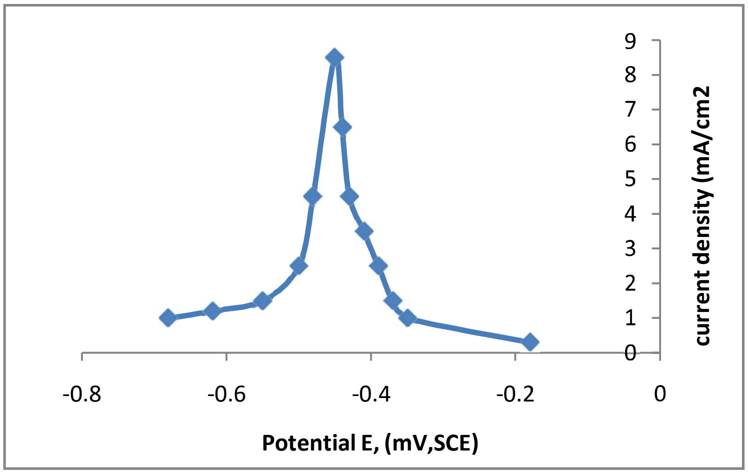

Figure 8: Potential vs. current density polarization in region B (Numaniyah)

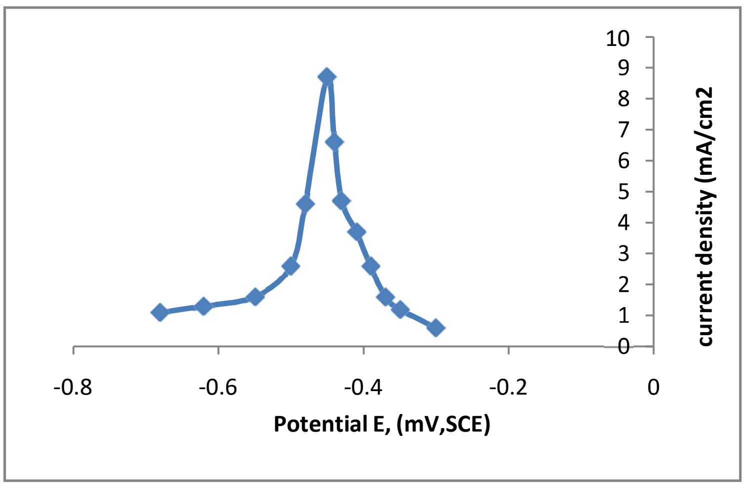

Figure 9: Potential vs. current density polarization in region C (Ahrar)

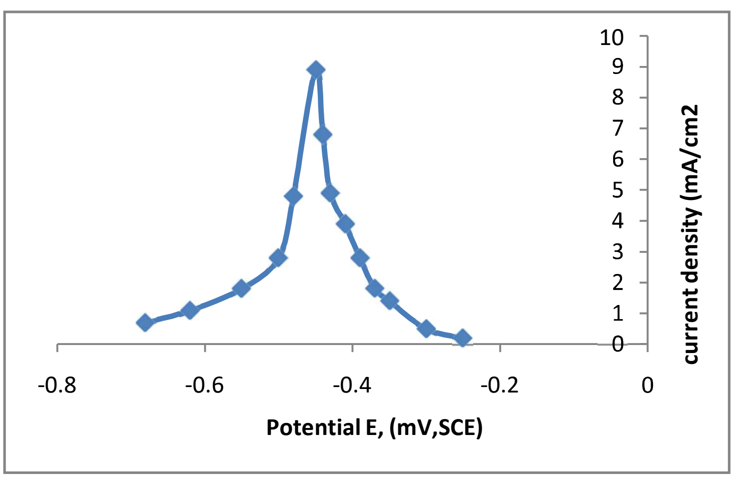

Figure 10: Potential vs. current density polarization in region D (Kut)

CONCLUSION

This study examined the chemical and physical characteristics of Tigris River water in several location of Wasit Governorate regions and showed how resistant carbon steel stand toward electrochemical corrosion. Samples have been gathered from four locations: Al-Zubaidiyah, Al-Numaniyah, Al-Ahrar, and Al-Kut. Their chemical properties were examined. When salts for chlorides were present in the aforementioned locations, it was found that the total number of bacteria reduced and the electrical conductivity, chloride concentration, acid function, and amount of dissolved oxygen increased, correspondingly. This causes the corrosion potential and current to rise, which in turn increases the corrosion rate.

REFERENCES

1. A. Toloei, S. Atashin and M. Pakshir, “Corrosion Rate of Carbon Steel Under Synergistic Effect of Seawater Parameters Including pH, Temperature, and Salinity in Turbulent Condition”, Corros. Rev, 31(3–6), p 135–144, 2013
2. Raheem A.H. Al-Uqaily, Subhi A. Al-Bayaty, “Study A Corrosion Inhibitor Of 1-Isoquinolinyl Phenyl Ketone For Mild Steel In Acidic Medium As Hcl Acid” , Journal of Physics: Conference Series,2019.
3. Al Dahaan, S., Al-Ansari, N., & Knutsson, S. “Influence of Groundwater Hypothetical Salts on Electrical Conductivity Total Dissolved Solids. Engineering, 8(11), 823-830, 2016.
4. Raheem A.H. Al-Uqaily , Subhi A. Al-Bayaty , Ehssan A. Abdulameer, “Inhibition by 4-Phenylpyridine N-oxide as Organic Substance for Corrosion for Carbon Steel in 1 M HCl Media”, Journal of Advanced Research in Dynamical and Control Systems,vol.11,special assue 11,1013-1018,2019.
5. D. de la Fuente, J. Alcantara, B. Chico, I. Diaz, J.A. Jimenez and M. Morcillo, “Characterization of Rust Surfaces Formed on Mild Steel Exposed to Marine Atmospheres Using XRD and SEM/Micro-Raman Techniques”, Corros. Sci., 110, p 253–264, 2016.
6. Raheem A.H. Al-Uqaily, Subhi A. Al-Bayaty, Sadik Hameed, “2-Amino-6 Chlorobenzothiaozole as Effective Corrosion Inhibitor for Copper in acidic media”, Journal of International Pharmaceutical Research, vol.46, 4,342-345, 2019.
7. G. Sundjono, L. Priyaotomo and S. Nuraini, Prifiharni, “Corrosion behaviour of mild steel in seawater from Northern Coast of Java and Southern Coast of Bali”, Indonesia, J. Eng. Technol. Sci., 49(6), p 770– 784, 2017.
8. Raheem A.H. Al-Uqaily ,Subhi A. Al-Bayaty, Anees A. Khadom and Mustafa M. Kadhim, “ Inhibitive performance of 4-Methoxyphenethylamine on low-carbon steel in 1 M hydrochloric acid: Kinetics, theoretical, and mathematical views”, Journal of Molecular Liquids, 350,118523,2022.
9. Boerlage, S. F. E. “Measuring salinity and TDS of seawater and brine for process and environmental monitoring—which one, when? Desalination and Water Treatment, 42(1–3), 222–230,2012.
10. Raheem A.H. Al-Uqaily , Fatema Abbas Khazal and Subhi A. Al-Bayaty, “Study inhibition by 2-mercaptobenzothiazole as inhibitor and effect for carbon steel corrosion in 1M HCl solution”, AIP Conference Proceedings ; 2386,2022.
11. R. Starosta, Influence of Seawater Salinity on Corrosion of Austenitic Steel, J. Kones Power. Trans., 26, p 3, 2019.
12. Raheem A.H. Al-Uqaily, Subhi A. Al-Bayaty, Sarah B.Jasim , “Kinetics study of the corrosive behavior of copper in 1 M HCl acid and its inhibition with 2-benzothiazolethiol”, solid state technology,vol.63,6,2020.
13. P.K. Katiyar, S. Misra and K. Mondal, Corrosion Behavior of Annealed Steels with Different Carbon Contents (0.002, 0.17, 0.43 and 0.7% C) in Freely Aerated 3.5% NaCl Solution, J. Mater. Eng. Perform., 28, p 4041–4052, 2019.
14. Raheem A. H. AL-Uqaily, “Inhibition by 4-Chloro-2-FluoroBenzylamine Hydrochloride for Corrosion for Mild Steel in HCl Media”, Research journal of science and IT management,vol.5, issue 2 , pp. 1-7,2015.
15. F. Smith, F. Brownlie, T. Hodgkiess, A. Toumpis, A. Pearson and A.M. Galloway, Effect of Salinity on the Corrosive Wear Behaviour of Engineering Steels in Aqueous Solutions, Wear, 462–463, p 203515, 2020.
16. S.A. Al-Fozan and A.U. Malik, Effect of Seawater Level on Corrosion Behavior of Different Alloys, Desalination, 228, p 61–67, 2008.
17. Eyu, G. D., Will, G., Dekkers, W., & MacLeod, J. “Effect of dissolved oxygen and immersion time on the corrosion behaviour of mild steel in bicarbonate/chloride solution”. Materials, 9(9), 748, 2016.
18. K. Zakowski, M. Narozny, M. Szocinski and K. Darowicki, Influence of Water Salinity on Corrosion Risk: The Case of the Southern Baltic Sea Coast, Environ. Monit. Assess, 186, p 4871–4879, 2014.
19. Raheem Aziz Hussein Al-Uqaily, “Corrosion behavior of Carbon steel in HCL media and Inhibition by 3-Hydroxy-2-Methylpyridine”, International Journal of Advance Scientific and Technical Research,vol.3, issue 5,pp.181-190, 2015.
20. C.Q. Ye, R.G. Hua, S.G. Dong, X.J. Zhang, R.Q. Hou, R.G. Du, C.J. Lin and J.S. Pan, EIS Analysis on Chloride-Induced Corrosion Behavior of Reinforcement Steel in Simulated Carbonated Concrete Pore Solutions, J. Electro. Chem., 688, p 275–281, 2013.

21. Raheem A.H. Al-Uqaily, Subhi A. Al-Bayaty, Sattar O. Maiws Al-Mayyahi , "Study of Kinetics and Inhibition efficiency by Isoquinoline-5-carboxaldehyde for Corrosion for carbon Steel in HCl acid", Journal of Southwest Jiaotong University, vol.55,3,2020.
22. Ismail,A. &Adan,N.H. " Effect of Oxygen Concentration on Corrosion Rate of Carbon Steel in Seawater", American Journal of Engineering Research, 3(1), 64-67, 2014.
23. Raheem A. H. Al-Uqaily, "Inhibition by 1-methyl isoquinoline for mild steel corrosion in 1 M HCl media", American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS), vol.14, issue 1,pp.55-63,2015.
24. Mousa May. "Corrosion behavior of mild steel immersed in different concentrations of NaCl solutions, Journal of Sebha University (Pure and Applied Sciences), 15(1), 1-12, 2016.
25. Ennas Abdul Hussein, Dunya Y. Fanfoon, Raheem A.H. Al-Uqaily, Ali M. Salman, Mustafa M. Kadhim, Abbas W. Salman, Zaid M. Abbas, "1-Isoquinolinyl phenyl ketone as a corrosion inhibitor: A theoretical study", Materials Today: Proceedings, vol.42, pp.2241-2246,2021.
26. Raheem A.H. Al-Uqaily, Subhi A. Al-Bayaty, Athra G. Sager, "Inhibition and adsorption by using thiazole-2-carboxylic acid as anti-corrosion for copper metal in HCl media", Journal of Southwest Jiaotong University,vol.55,2,2020.
27. Blqees Raheem Odhafa , Sadik Hameed , Hussein Ali Awad AL-Zamili , Raheem A. H. Al-Uqaily , Subhi A. H. Al-Bayaty , Verification of the physical, chemical and microbiological characteristics of the Tigris river using the water quality assessment index in Misan Province, Iraq , AIP Conf. Proc. 3051, 020003, 1-16, 2024.
28. Asam Hussein Ali, Aseel Farhan Abdullah, Mohammed Mahdi Mohammed, Raheem A. H. Al-Uqaily , Subhi A. H. Al-Bayaty, The use of an organic compound (ethyl-2-bromothiazole-4- carboxylate) as an inhibitor to reduce the corrosion of copper in acidic media, AIP Conf. Proc. 3051, 070008, 1-10, 2024.
29. Sura Hamid Kathim, Sarah Badri Jasim, Atheer Abdulsahib Ali, Raheem A. H. Al-Uqaily, Subhi A. H. Al-Bayaty, "Investigation of (4-ethylphenethylamine) as organic inhibitor for carbon steel corrosion in HCl acid under various conditions", AIP Conf. Proc. 3051, 070003,1-9, 2024.
30. Jawad Kadhim Abaies , Blqees Raheem Odhafa , Sura Hamid Kathim , Raheem A. H. Al-Uqaily , Subhi A.H. Al-Bayaty , Effect of inhibition on low carbon steel corrosion in acidic conditions by 2-(p-tolyl) ethylamine under different conditions" , AIP Conf. Proc. 3051, 070010 , 1-10, 2024.