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Evaluating the corrosion problems induced by the of chlorine in pipe water facilities in Alkufra - Libya

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Abstract

Corrosion processes consist of a series of electrochemical reaction occurring at the metal surface in contact with water and its constituents. Analyzes were conducted on water samples in various wells in the studied area. Electrical conductivity EC, pH, total soluble salts TDS, a negative charge ion (anion) sulphate, chloride. Through the results obtained from water analysis operations to study the rates of corrosion inside the pipes, it causes corrosion processes, temperature values ranged from 35 C^0 to 37 C^0 Electrical conductivity EC ranges between (206-1301) microseism/cm the pH values ranged between (7.25-7.39). TDS between (195- 736) ppm). The values the Larson Index ranged between (0.408 to 1.88). Through these values obtained from analyses, the electrical conductivity values were found to increase with the presence of chloride ions in the water, as well as the values of the corrosion coefficients resulting from the chloride ions, showing the presence of corrosion processes inside the pipes.

Keywords: Water; Corrosion; Electrical conductivity; Al kufra; Chloride

1 Introduction

Corrosion is one of the most common problems that cause damage to water pipes. A companies in the world is working on all inhibitors to reduce the increase in corrosion processes inside industrial pipes, which causes deterioration and failure of plumbing pipes. Corrosion has several harms. Corrosion is an electrochemical process that occurs as a result of several electrochemical reactions, which can be defined as the destruction of the metal surface by electrochemical or chemical agencies [1]. Corrosion occurs in water pipes, as well as the effect of other factors on increasing corrosion rates, because continuous corrosion works to transfer electrons between the metal surface and solutions containing ions, and electrochemical conduction occurs. It results from the overwhelming tendency of metals to chemically react in the aqueous environment. As it contains ions such as chlorite, sulfite, sodium and other underwater elements [2]. The effect of chloride concentration in water on the corrosion of iron in was found to increase the corrosion rate received most probability consideration chlorides increase the electrical conductivity of the water so that the flow of corrosion currents will be facilitated.

Ability to dissolve materials In ground water This depends on many factors such as temperature, pressure, pH, total TDS values, total salt content and positive and negative ions polarized water and has a high dielectric constant [3]. Different temperatures and the flow of element ions in groundwater, the percentage of deposits and gases dissolved in the water is revealed by corrosion in water pipes[4], the corrosion that occurs inside the pipes as a result of the movement of dissolved ions And the corrosion of dissolved gases in the water due to oxygenated oxygen or hydrogen

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ions formed from decomposition. The aqueous action of sulfates, salts and chlorides is electrochemical corrosion [4-5-6]. One of the most important factors that affect the corrosion of drinking water pipes is any change in the drinking water [7]. Rapid pitting occurs with increasing levels of chloride ions, which initiates a series of chemical reactions with chemical elements that collect on the surface of the metal when it comes into contact with water and its components. Local corrosion also occurs. In addition to general corrosion, in the obvious case of the presence of metal, oxide, or a higher scale of ions. Corrosion also depends on its chemical properties and physical properties [8, 9].

The chemical and electrochemical reactions that occur inside the pipes cause the deterioration of metal materials as a result of the corrosion phenomenon, because these materials are always trying to reach a lower energy state [10]. The concentration of anions in the electrolyte is important, as is the percentage of dissolved salts and in the presence of certain ions carried by water, the chloride ion is a negatively charged ion. Chloride is very sensitive to metals containing iron anions in the electrolyte. Corrosion rate It is affected by many factors such as water temperature, including electrical conductivity, oxygen concentration, and temperature, which is how prep plumbing products dissolve. Although corrosion and dissolution are fundamentally different, but the result is similar they are generally discussed as corrosion. Regarding the behavior of the electrolyte on corrosive metals [11].

One of primary reasons leading to failures of various industry facilities such as pipelines, concrete structures, bridges, resulting economic loss [12-13]. Physical, chemical and biological analysis of groundwater samples must be carried out and their suitability, the amount of sedimentation and the changes that cause corrosion of pipes in one of the sources of water with minerals must be determined [14].

Watersheds and aquifers depend on many factors: groundwater, infrastructure, and chemical structure. It causes corrosion and expansion in water disinfection facilities [15]. High levels of chloride and sulfate in water may lead to increased rates of corrosion processes in the water pipe network [16].

Chlorine is a strong oxidizing agent, and corrosion attack may occur in the gas phase due to many species containing chlorine. Iron is the most affected by the addition of free chlorine. When free chlorine is introduced to disinfect the drinking water system, it increases pipe corrosion rates, followed by copper, followed by lead, which may Whether or not it is exposed to increased corrosion. Commonly Chlorinated Chemicals and Their By-Products Hydrochloric Acid Cl2 may be formed in a reducing environment by thermal decomposition of hydrochloric acid but Cl2 may be present locally at higher temperatures and in the absence of moisture. These substances can adversely affect the performance of infrastructure and metal piping materials in particular. Selection, from corrosion. The first is the dominant Cl species in the bulk gas, moreover, [17]. Organic chlorine phenomenon: The rate of corrosion of very hot alloys increases in the gaseous state. The presence of Cl2 in the oxidized water environment. Research has studied and demonstrated the effect of Cl2 gas on corrosion when studying different alloy temperatures [18-25]. Chlorides are usually present in surface oxide crusts in most cases. Chloramines are more stable and corrosive. [26].

1.1 Study area

Conducting a group of physical and chemical analyzes on a group of groundwater wells distributed in several neighborhoods in the city. These wells are located in the Kufra basin, Jabal Ouinat and Tibesti.

2 Methods and materials

Groundwater samples were collected from 9 different wells distributed in various places, and measurements were determined according to the methods mentioned [27], using an electrical conductivity measuring device. Electrical conductivity (EC) was measured. The pH value was determined using a salinity measuring device. Bicarbonate was measured. By titration and measuring chloride ions by titration with a standard solution of silver nitrate in the presence of potassium chromate to calculate the chloride ion concentration. The total amount of dissolved salts (TDS) was measured.

3 Results and discussion

In Table (1) increase in the degrees temperature (35 C^0 to 37C^0), effect temperature in All industrial chemical reactions inside groundwater pipes corrode, multiply, and increase in speed with the rise in temperature inside the water pipes, as sodium chloride causes an increase in temperature to increase the constant solubility values, and increase the sedimentation rate, which leads to increased corrosion of the pipes and thus the corrosion rate. Which leads to an increase in surface corrosion activity and an increase in the rate of the number and movements of nutrient and negative

ions such as $SO4^{-2}$, CL^{-} and sulphate results from study grades (35.4 - 650) ppm, complete chloride between (42. - 266.25) ppm

From result in Table (2 of the Larson Index for corrosion samples. The indicator is the ratio of equivalents (ppm) of sulphate (SO4 2−) and chloride (Cl−). The Larson-Schöld index indicates local corrosion of pipelines that transport water. It is expressed as ppm of alkalinity in the model. T.ALK Results obtained from a corrosion indicator indicate chloride and sulfate concentrationsn. Larson-Skold Index, Larson ratio (LR) or Corrosivity Index (CI) = ($[Cl^{-}]$ + $[SO_4^{2-}]$) / ([T.ALK])

Table 1 Results of samples in the study area

NO.W	T	pH	EC	TDS	CO3--ppm	HCO3-ppm	CL- ppm	SO4 --ppm	Na+ ppm
W1	37	7.25	305	195	0	45.75	42.5	62.4	28.06
W2	35	7.32	657	420	0	38.43	113.6	58.08	49.91
W3	36.5	7.3	653	418	0	39.48	156.5	66.24	26.91
W4	35.6	7.33	630	403	0	58.60	110.5	650	85.21
W5	35.7	7.43	479	307	0	38.43	81.28	35.28	40.94
W6	37.02	7.06	428	274	0	45.75	56.80	106.08	53.18
W7	36.21	7.36	1150	736	0	61	266.25	80.16	163.96
W8	35	7.37	1301	641	0	106.25	21.53	285.6	196.79
W9	36	7.32	425	272	0	53.86	67.45	54.72	40.94

Table 2 Results of the Larson Index of samples

NO.W	Larson Index
W1	0.537
W2	0.408
W3	0.532
W4	1.88
W5	0.3796
W6	0.594
W7	0.470
W8	0.479
W9	0.449

Table 3 Range of Larson coefficient and water states

Larson Index	Water condition
0.1-0.2	Corrosion free
>0.2	More corrosion (Corrosive)

Through the results obtained from Table 2, the values of corrosion rates using the Larson coefficient ranged from (0.3796 -1.88) and the highest rate was in a well W4. Comparing it with the range of the Larson coefficient in Table 3 shows the high amount of corrosion in water pipes within the area.

The effect of temperature on iron corrosion is often overlooked. Many parameters that influence corrosion can vary with temperature: dissolved oxygen (DO) solubility, solution properties (e.g. viscosity and ion mobility), ferrous iron oxidation rate, thermodynamic properties of iron scale (leading to formation of different phases or compounds), and biological activity. Through the obtained results referred to in Table (1) with increase in the temperature increases the number and movement of positive and negative ions such as $SO4^{-2}$, CL^{-} and H_2S and CO_2 gases, which leads to an increased activity of the medium for corrosion.

Effect temperature in corrosion observing Fig. 1 The rate of corrosion increases when the specific temperature increases due to increased electrical conductivity,for water shows that at high the temperature is the higher the corrosion,oxygen solubility and oxygen diffusivity. Increasing the temperature of the bulk of the solution to the metal surface increases the transfer of oxygen to the metal surface. Changing and increasing the temperature gives an acceleration of the reaction rate for all oxygen species by increasing the ionic interactions with the increase in the soluble temperature of the iron [28].. The doubling of oxygen plays an important role in the corrosion rate, setting the trend of the corrosion rate with which leads to a higher corrosion rate. They are subject to oxygen solubility, oxygen diffusion, solution velocity,

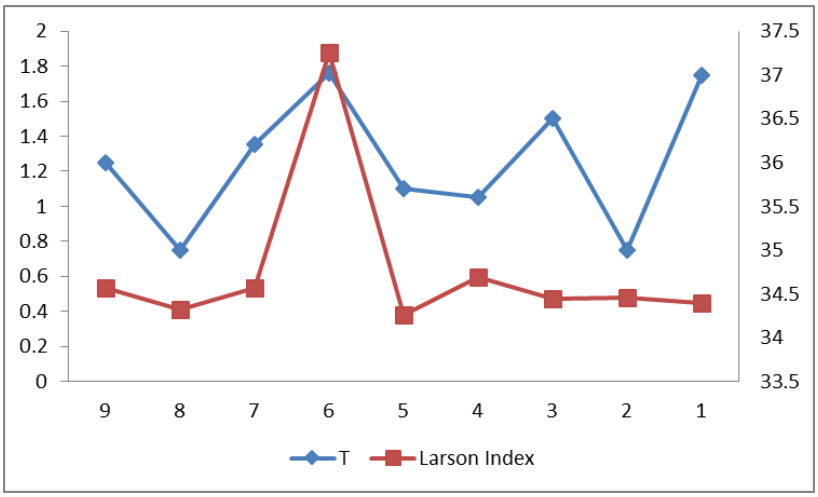

Figure 1 Study Temperature with Corrosion Rate

High dissolved solids and electrical conductivity total TDS values

When water contains a high percentage of minerals and active ions, it is considered to have high conductivity, as pure water that does not contain ions does not conduct electricity. Metals bind with ions and salts in water samples inside pipes, which increases the rates of corrosion and deposition of ions and salts in the pipes. Electrical conductivity is an appropriate and accurate measurement of the proportion of elements and ions, the rate of salinity or chlorination within the water, and an important indicator of the average taka, as well as dissolved oxygen, an important factor indicating the corrosion of metals immersed in water. Table 1. TDS values for wells that contain a high percentage of dissolved salts in the water are indicated as water that has the potential to cause corrosion or precipitation of polymeric salts. In this study the various elements dissolved in water was collected from water studies of the wells from which they were selected in the Kufra region shown in Table No. (1) to collect the impurities. In Al Kufra, it the total dissolved salts fond between. **TDS** between (195- 736) ppm).

Increasing salt content increases leads to increase the corrosion rate for the entire investigated range Lr and temperature by increasing the solution electrical conductivity figure(3,4).

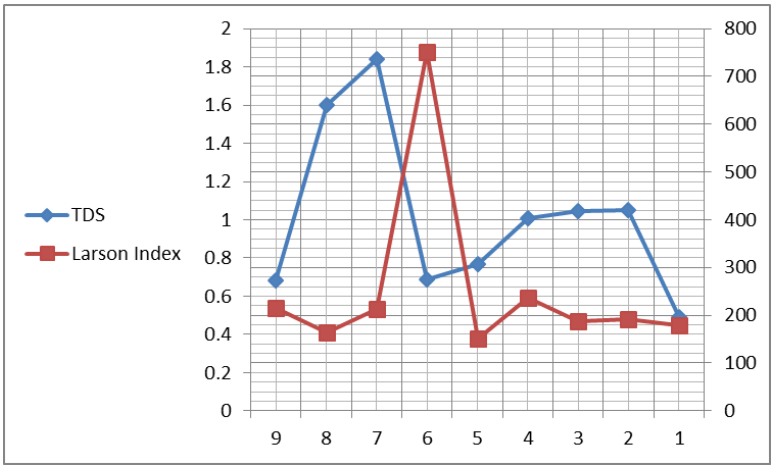

Figure 2 Effect of TDS on the Corrosion Rate

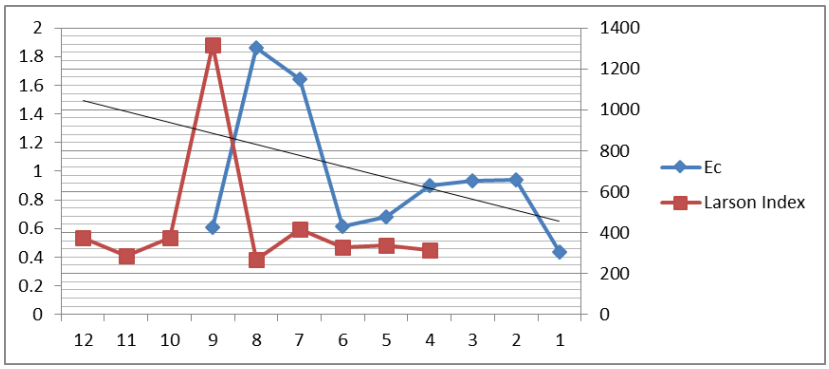

Figure 3 Effect of Ec on the Corrosion Rate

3.1 Corrosion rate by LPR technique

Corrosion rate by From the results it was observed that the corrosion current density increased with increase in free chloride LPR technique the corrosion current density values indicate the progress of corrosion [29]. The average corrosion current density value at The HCl and/or Cl_2 may react with the metal according to reaction (1) to form metal chlorides. Metals can also react directly with HCl according to reaction (2). Metal chlorides have high vapor pressures at the metal–scale interface, and continuous evaporation may take place (reaction (3).

$$M.(s) + Cl_2.(g) \rightarrow MCl_2.(s) \ldots\ldots\ldots\ldots (1)$$

$$M.(s) + 2HCl.(g) \rightarrow MCl_2.(g) + H_2(g) \ldots\ldots\ldots\ldots (2)$$

$$MCl_2(s) \rightarrow MCl_2(g) \ldots\ldots\ldots\ldots (3)$$

where M ;Fe

Oxides are chemical compounds with one or more oxygen atoms combined with another element scale surface. The oxygen concentration increases with increasing distance from the metal.These volatile metal chlorides may diffuse to the, leading to oxidation, of the metal chlorides to solid metal. The resulting oxides that precipitate from this gas-phase reaction form a very loose metal oxide layer, providing no protection against further attack. Thus, chlorine corrosion is often governed by a linear corrosion rate:

$$3MCl_2(g) + 2O_2.g \rightarrow M_3O_4(s) + 3Cl_2(g) \ldots\ldots\ldots\ldots (4)$$

$$2MCl_2(g) + 3/2O_2(g) \rightarrow M_2O_3(s) + 2Cl_2(g) \ldots\ldots\ldots\ldots (5)$$

This cycle provides a continuous transport of metals away from the metal surface toward higher oxygen partial pressures with little net consumption of chlorides. By reactions (4) and (5), chlorine is released and can diffuse to the bulk gas or back to the metal surface, and thus a cycle is formed. A graphical presentation of the corrosion mechanism is shown in Fig. 4. The net reaction is thus:

$$4M(s) + 3O_2(g) \rightarrow 2M_2O_3(s) \quad \ldots\ldots\ldots\ldots (6)$$

The rate is controlled by the outward diffusion of metal chlorides through the The high concentration of HCl and Cl_2 gas may resulting in higher concentrations of alkali Gas diffusion the scale is believed to be the rate controlling step in the corrosion process. [30].Small concentrations of alkali chlorides may increase the corrosion rate caused by of corrosion rate expressed [cl-] concentration Severe corrosion may occur when chlorine is present in the deposits which are in direct contact with the metal scale. The corrosion can be severe in air, which may cause intra-deposit sulfation of alkali chlorides releasing HCl(g) or Cl_2(g) close to the metal surface. Furthermore, alkali chlorides may react with the metal scale or with chromium carbide to form gaseous HCl or Cl_2 close to the metal. the deposit to form molten phases, the corrosion may be further enhanced.

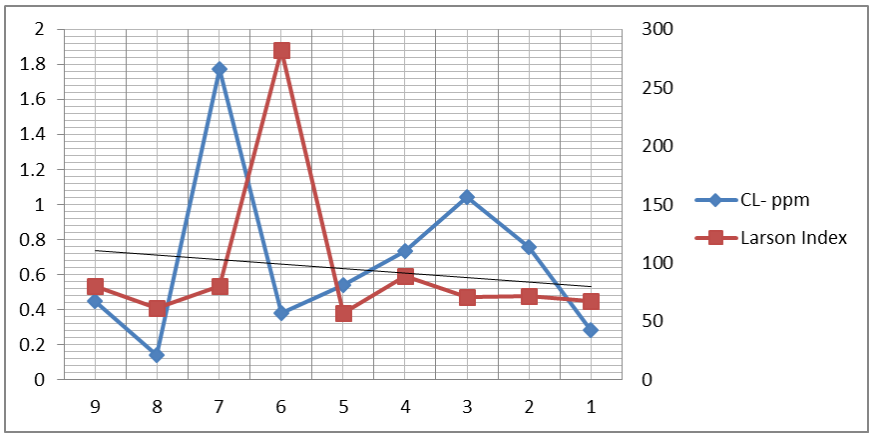

Figure 4 The of corrosion rate expressed [cl^-] concentration

The higher the salt content in water samples, the higher the corrosion rate. Chlorides increase corrosion rates and also increase the electrical conductivity of water, which facilitates the flow of corrosion currents. To increase the electrical conductivity of the solution and chlorides, most studies have shown interest regarding their effect on corrosion. It was found that the effect of sodium chloride concentration on the corrosion of iron in water-saturated air leads to an increase in the corrosion rate.

The effect of pH in figure. 5, the chloride ion concentration with the Larson Index of can significantly be different between water and effects of chloride ion concentration on corrosion processes from salt ions.

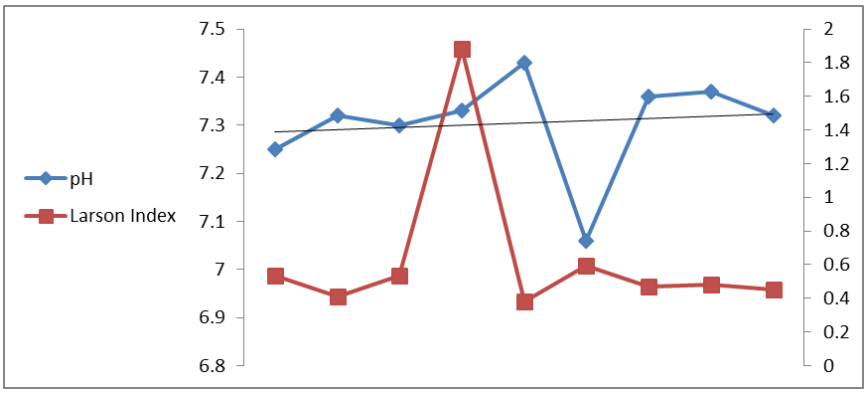

Figure 5 Effect of PH on the Corrosion Rate

4 Conclusion

Chloride ions is expected to increase the rate of corrosion presence of metallic facts,. This factor is important for assess the rate of corrosion. All subjects were conducted to give an indication of the presence of a corrosion condition, its degree and severity.Chlorine and chlorine dioxide are aggressive towards both metallic pipes, some chemical compounds confirmed that corrosion in the study areas corrosion ranges from the degree of corrosion to medium to severe corrosion. They will increase the corrosion rates of other metallic component favoring the formation of pitting corrosion. Chlorine and chlorine dioxide will also oxidize components with the result of premature material failures. The cause of corrosion is the presence of high concentrations of chloride ions, which would attack the metal surface from inside the pipes, thus forming deposits because chlorine is one of the active ions that form active electrochemical reactions in the aqueous medium. Through a study of the groundwater of the study area, it is corrosive and has a negative effect on the surfaces of internal pipes carrying water over time, causing economic and material losses. We recommend monitoring the concentrations in the water and that all state institutions work to improve the quality and monitor its corrosive properties. Groundwater in the region must be monitored.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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