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The Problem of Expansion in Erosion and Sedimentation Extensions of Drinking Water in Libya: A Case Study of Kufra City

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Authors' contributions

This work was carried out in collaboration among all authors. Author HAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author ASOS performed the statistical analysis. Authors ASOS and IB managed the analyses of the study. Author HAA managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Corrosion problems that occur in all fields in engineering activities cause high negative economic impacts, therefore research into operations of different wear mechanisms is a prerequisite for mitigating the effects of corrosion problems can reduce economic loss. Groundwater is vital and the sole resource in most of the studied region in the city of kufra. In this study, some physical and chemical analysis studies were conducted on the water samples in the study area, which included: pH, total soluble salts, sulfate, chloride, calcium and magnesium. The values of these concentrations in the studied water samples indicate that they constitute a chemically suitable environment for corrosion and precipitation reactions, additionally, the pH values for the studied water samples ranged between (6.02 - 8.2), EC ranges between (266 - 3054) microseism/cm, temperature values ranged from 34.8 C0 to 37.4 C0, TDS between (270 - 1936 ppm). It was found that the Aggressiveness coefficient ranged between (9.03 to 11.58) and this indicates that the water in this region is highly corrosive and the Ryzner coefficient ranges between

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(8.98 -11.49), which indicates the water condition is the cause of corrosion. The Langelier coefficient index shows that the negative values are the cause of the increase in wear rate values from -2.73 to -0.89.

Keywords: Water; corrosion; sedimentation; Kufra; ground.

1. INTRODUCTION

Corrosion phenomena means to the deterioration of metallic materials due to chemical and electrochemical reactions, because these materials are always trying to reach a state of lower energy potential [1] it has been considered as one of primary reasons leading to failures of various industry facilities such as pipelines, concretes structures, bridges, etc., resulting in huge economic loss [2,3]. Corrosion may occur under anaerobic conditions, and scientifically, all environmental conditions are considered corrosive .To some extent, corrosion is a very important factor in industrial processes, as it is the main cause of many troubles facing operations in production lines such as breakdowns and interruptions in production, etc [4]. From an economic standpoint, erosion destroys the urban infrastructure and from an environmental point of view, erosion causes siltation of lakes and canals. In addition to the environmental problems, there are also health issues, since areas excavated by erosion in urban regions tend to become the focus of pathogenic vectors due to the accumulation of waste and sewage [5]. Corrosion resistance is a basic property related to the ease with which materials react with a given environment This tendency causes metals to be classified according to rising that again leads to classification of decreasing activity and increasing potential. When it is observed that the existing material of construction is prone to corrosive attack, generally a decision is made to change the materials of construction and select an alternate material to suit the specific need. For specific recommendations concerning materials selection [6], the problems caused by water are plankton and chemical classes that lead to precipitation in the form of salts, crusts and chemical products. apart from this, depending on its quality and specifications, may be an aggressive environment for most of the materials, especially mineral ones, which makes it a major cause of the occurrence of corrosion and damage to various metals and alloys by chemical products dissolves in this medium and works to change its quality, physical appearance and quantity [7].. A general phenomenon in our lives, it is widespread everywhere and in all environments, whether in the atmosphere, corrosion of wells, filters and pumps is a serious phenomenon that plays a major role in the rate of corrosion of metals [8,9]. The corrosion of pipes and the melting of their products in the water networks is also a source of contamination of water with minerals, and this poses a great danger and calls for the urgent need to follow the physical, chemical and biological analysis of groundwater samples in order to determine the extent of their suitability and control of the resulting problems [10,11,12].

Groundwater is polarized water and has a high dielectric constant, that is, it has great ability to dissolve materials. This depends on many factors such as temperature, pressure, pH, total TDS values, total salt content and positive and negative ions [13]. The of salts, plankton and dissolved gases in water are described as corrosion or sedimentation, as well as a change in the temperature and movement of water [14]. Most of the corrosion that occur in tubes is electrochemical corrosion due to the oxygenated oxygen or hydrogen ion formed from the hydrolysis of the sulfate and salts [14,15,16]. The water may not be abrasive, but it is precipitated and has the ability to form solid crusts that cause clogging of the pump inlet holes and filter holes in the wells and result in a decrease in the production rates of the water of those wells [17,18]. High levels of chloride and sulfate in water can accelerate corrosiveness in the distribution networks [19]. On the other hand, calcium carbonate can precipitate its component, which is called cortical formation, which can add electrochemical corrosion reactions in the aqueous medium, especially with iron metals, as it gives balance with carbon dioxide and its cause of increased corrosion [20,21].

Chemical quality of groundwater depends on many factors, such as the composition of precipitation, the geological structure, the mineralogy of the watersheds and the aquifers. From hygienic and economic points of view, these factors play an important role in corrosion and scaling in water supply utilities [22].

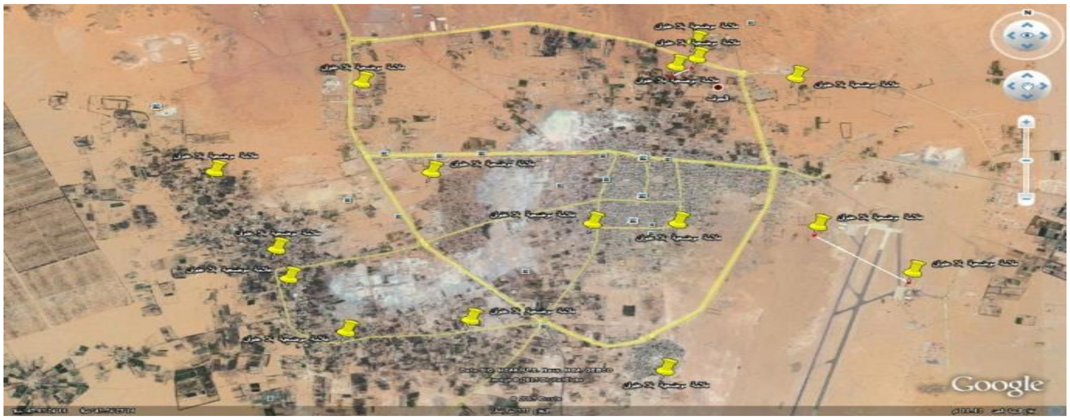

Fig. 1. Distribution of wells within the study area source Google earth

1.1 Study Area Location

The study was based on a group of groundwater wells in the city of Al Kufra. It is approximately in the middle of the northern corner of this basin. Chad and the Arab Republic of Egypt and covers an area of about 380,000 km^2 inside Libya and the basin is a flat desert covering most of the surface of the Nubian sandstone rock and its height ranges from sea level between 230-550 meters except for mountainous areas, where the height ranges between 1000 meters at the eastern edge of Geb For Etbista and to more than 1,800 meters at the summit of Mount Owaynat [23].

2. MATERIALS AND METHODS

Water samples were collected from 10 different wells distributed over each study area, where the depths of the studied wells ranged from 90 to 597 meters. The water samples were drawn from different depths and the samples were taken in a plastic bottle of one and a half liters. We washed them more than once with distilled water and during this study we are doing some physical and chemical analysis on these Wells samples. These wells are used by citizens for domestic purposes, drinking, irrigation and agriculture. The total amount of soluble salts (TDS) and the degree of electrical conductivity (EC) were measured. Immediately after collecting the samples using the Conductivity meter, (the pH value was measured using a pH device meter), bicarbonate was measured by titration using diluted standard sulfuric acid in the presence of an orange methyl guide, sulfate was measured using a Spectrophotometer, and chloride was measured by titration with a standard solution of silver nitrate in the presence of a potassium chromate as indicator and for the total basal measurement and chloride ion concentration. These measurements were determined according to the methods reported by [24].

3. RESULTS AND DISCUSSION

The results obtained were shown in Table (1) where the increase in the temperature of the groundwater is offset by the increase in the content of sodium chloride and calcium carbonate. The content of carbon dioxide and hydrogen sulfide and the solubility of calcium sulfate in water decreases. Thus, the increase in the studied water temperature increases the number and movement of positive and negative ions such as SO_4^{-2}, CL^- and H_2S and CO_2 gases, which leads to an increased activity of the medium for corrosion. The most important factors which can affect the corrosion rate include pH, temperature, hardness, alkalinity, residual chlorine, total dissolved solids (TDS), gases, dissolved salts, and microorganisms in water. Scaling is a process in which divalent cations such as calcium and magnesium react with other water-soluble substances and form a thin layer in the inner walls of water pipe lines [25,26].

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The role of temperature in corrosion is that all chemical reactions inside the pipes of groundwater are affected, stimulated, and their speed increases with a rise in temperature, which leads to an increase in the speed of corrosion of pipes. Also, the temperature affects the increase in the values of the solubility constant, the increase in the sedimentation speed, and thus the corrosion rate. The rate of corrosion triples or quadruples as water temperature rises from 60°F to 140°F. Above 140°F the rate of corrosion doubles for every

20°F increase, thereby results in increase in temperature of the groundwater from 34.8 C^0 to 37.4 C^0 and (94.64 F0 to 99.62 F) respectively.

Water with pH values above 7.5 also can be corrosive when alkalinity is low [27]. The pH plays an important role in determining the degree of corrosion and aggressiveness of the water, as the pH values for the studied water ranged between (6.02 - 8.2) pH. The presence of proteins constitutes half of the cathode reaction for the escalation of hydrogen gas and the increase in the rate of corrosion in the presence of a cathode reaction of half the oxygen reduction [11]. If this medium is in direct contact with the iron metal, these reactions will take place.

$$Fe(s) + 2H^{+} \rightarrow Fe^{++} + H_2 \quad (1)$$

$$Fe(s) + \tfrac{1}{2}O_2 + 2H+ \rightarrow Fe^{++} + H_2O \quad (2)$$

$$2H^{+} + 2e^{-} \rightarrow H_2 \quad (3)$$

The degree of specific conductivity is used to compare the conductivity degrees of different materials water with a relatively high specific degree of conductivity has the ability to cause iron and steel corrosion, while some other chemical properties may not result in that effect .The degree of electrical conductivity of well water in the area of Kufra , from which samples were taken, ranges between(266 – 3054) microseisms / cm. in degree of electrical conductivity highly at S7 ,S5and S10 increase of electrochemical reactions Corrosion.

Results in Table (1) carbonate, bicarbonate, and total alkalinity in water indicate that the carbonate concentration in all studied wells was non-existent, as a result of the reactions that occur between carbonates and hydrogen ions to produce bicarbonate or carbonic acid. As carbonates are rarely found in natural waters and in biological formations. Increasing the concentration of bicarbonate leads to the formation of deposits and crusts in water and water pipes, and it is one of the factors that lead to corrosion, as it works to attack steel and erode it. The values of bicarbonate were in the study area (42.8134ppm) at sit S8 and S7 highly concentration.

The values of the TDS wells that contain a high content of salts must be seen as water having the ability to cause corrosion or sedimentation of a salt layer inside the various equipment and devices regardless of other results are shown by the process of chemical analysis of water. In this research by collecting the concentration of ions of the various elements dissolved in water through the results of analyzes of well water from which samples were taken in the area of Kufra , it was found that the total dissolved salts ranged between (270 - 2936 ppm).The sulfate results of the study samples were (10- 483.36 ppm), so dissolved sodium, chloride, sulfate, and pH have a significant correlation with corrosion potential increasing chloride concentration in water increased galvanic corrosion and denitrification of plumbing materials, resulting in increased metal leaching and pipe wall thinning [24].

The values of calcium and magnesium are important in erosion and sedimentation processes, as their value ranged in water 6.63ppm at S4, 76 ppm at S7 for calcium and magnesium results of the study samples were 8ppm at S8, 56ppm at S7. And for calcium an important role in corrosion and sedimentation, as it is associated with carbonates and bicarbonates, as it is deposited inside the tubes in static media or Slow motion [20].

$$Ca\,(HCO_3)_2 \xrightarrow{\Delta} CaCO_3 + CO_2 + H_2O \quad (4)$$

$$CaO + CO_2 \rightarrow CaCO_3 \leftrightarrow Ca^{++} + CO_3^{--} \quad (5)$$

Tests can determine if water is likely to be corrosive: the Langelier Saturation Index (LSI) and the Ryzner Stability Index (RSI) From the results obtained in Table (2).

In order to use the LSI, a laboratory must measure pH, electrical conductivity, total dissolved solids, alkalinity, and total hardness. The LSI is typically negative or positive and only rarely zero. Negative values predict that the water is more likely to be corrosive. Potentially corrosive water typically has an LSI value –1 (mild) to –5 (severe). The Langelier Saturation Index is probably a good indication of corrosion or scaling potential of a well [27].

When the RSI is used, a value over 6.5 indicates that the water is probably corrosive; higher values are increasingly corrosive A parameter through which the aggressive index of the aqueous medium of well water is determined as it deals with the conditions of that water that have different exponent values. Hydrogen as well as basic and given by:

$$AL = pH + Log\,(ALK^{*}\,[Ca])$$

Table 1. Results of the physical and chemical properties of groundwater samples in the city of Kufra

NO. W	T C^0	PH	E_c eµ/cm	TDS ppm	CO3 ppm	HCO_3 ppm	SO_4 ppm	Cl ppm	Mg ppm	Na ppm	k ppm	Ca ppm
S1	36.5	6.35	266	270	0	97.8	31.8	14.9	19.8	20	12.8	16
S2	37.5	7	286	196	0	61	28.8	24.8	16.8	16.1	23.9	32
S3	36.4	6.77	590	377	0	61	95.53	110.05	21.6	83.95	9.36	52
S4	37.4	6.42	540	298	0	45.75	42.73	42.6	18	28.9	30	6.6
S5	34.8	6.02	1788	1144	0	47.8	214.56	308.8	34.02	219.88	15.99	24
S6	34.9	7.7	643	406	0	61	94.16	74.55	11.3	37.95	6.63	62
S7	37.3	7.42	3054	1936	0	122	483.36	122	56	39.99	46.05	76
S8	35.6	7.2	522	148	0	134	10	9	8	16	20	18
S9	35.9	6.84	1030	690	0	84.8	78.24	181.05	16.38	71.15	8.91	20
S10	36.6	6.9	1976	1183	0	97.3	392.92	223.65	52.92	179.86	17.94	66

Table 2. A parameters through which the aggressive index, ryzner index and langelier index

No.Well	Aggressiveness Index	Langelier Index	Ryzner Index
S1	9.544	-2.03	10.42
S2	10.06	-1.26	9.52
S3	10.27	-1.34	9.45
S4	9.55	-2.01	10.46
S5	9.03	-2.73	11.49
S6	10.90	-0.89	9.49
S7	10.38	-2.42	10.26
S8	11.58	-0.96	9.13
S9	9.82	-1.85	10.55
S10	10.61	-1.03	8.98
	≥10 more corrosion 11.9-10 modern corrosion <12 no corrosion	0< corrosion <0 Sedimentat corrosion =0 no corrosion	6< sediment at <6 Increase corrosion ≥10 More corrosion

where, AL aggressiveness factor, ALK total basal, Ca Calcium ion concentration[28] :

where the values of indicators for the state of the studied water terms of corrosion and sedimentation showed that the aggressiveness factor ranges between 9.71 in S4 and 11.72 in S10. This indicates that the water is deposited by salts to cause highly corrosive with the Langelier index [28]. Is an indicator of the degree of saturation, sedimentation, calcium carbonate, or corrosion, and the molting of calcium carbonate, so all the negative values ranged between -0.89 in S6 and (-2.73) in S5.

Through the study of water corrosion, it became clear that the Ryzner coefficient the Ryznar Index (RI) is an alternative method to the LSI for computing calcium carbonate scale formation. The RI is given by the following expression [29]:

$$RI = 2 \cdot pHsat - pH$$

This is directly related to the LSI by:

$$RI = pH - 2 \cdot LSI$$

This value is computed using the pH of the water sample and the saturation pH, pH sat, as determined for the calculation of the LSI [29]. The criteria for interpreting the value of RI are as follows ranges between (8.98 -11.49) is a clearer idea of the degree of water saturation and consequently, subject to precipitation or corrosion . Some studied (RSI) illustrated that numerous the samples could be classified into aggressive and very aggressive categories of corrosion [30]. These values are total above 6, and this, in fact, indicates that the water is corrosive. Medium corrosive environment. These results are consistent with and support the results obtained from Langelier [27]. Coefficient, due to the fact that both factors depend on the same variables in the calculations (pH, calcium, ALK, and T). Among the results obtained for estimating the aggressiveness factor, the values of the aggressiveness factor ranged between 9. 82 in S9 11.58 in S8.

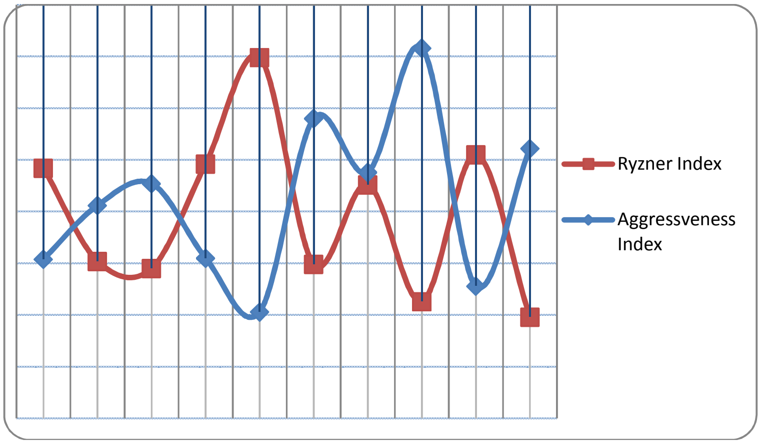

Fig. 2. Correlation between the aggressive index and Ryzner index

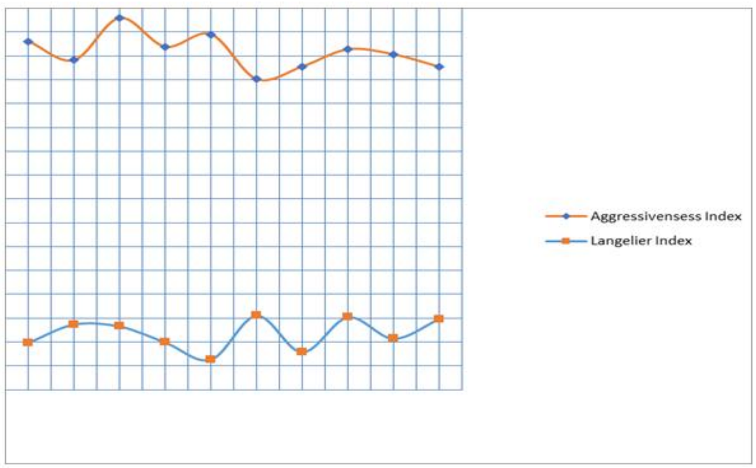

Fig. 3. Correlation between the aggressive index and Langeler index

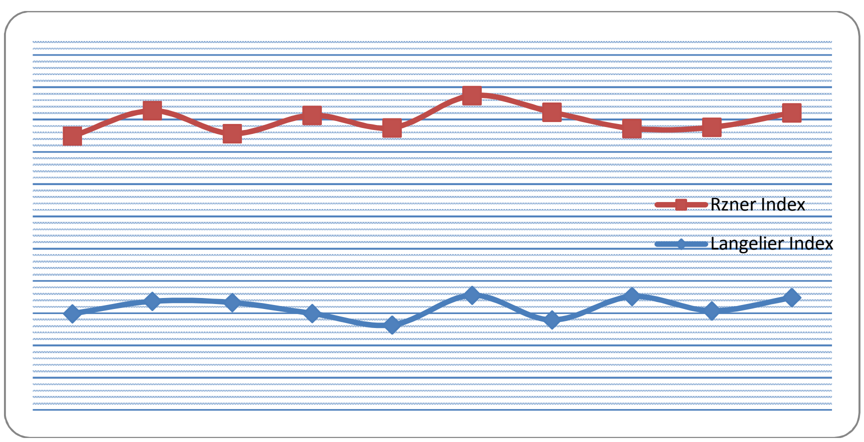

Fig. 4. Correlation between the Langeler index and Ryzner index

The degree of corrosion of the aqueous medium, and these figures refer to the corrosion of the mean of the medium (water), and these results are consistent with those obtained from the previous two coefficients and support them, especially since the maximum level of corrosion is in S6 and the lowest in S10. These values confirmed the corrosion of the aqueous medium and the absence of sedimentation on the water of the tubes. This compatibility is due to the fact that the aggressiveness coefficient depends on pH, calcium, T, ALK, and temperature. The Langelier saturation index, (RSI), were evaluated for assessing the corrosiveness and scaling potential of the groundwater. Corrosiveness and scaling indices stated that the majority of samples are classified into “Aggressive” and “Very Aggressive” category. Also, chloride and sulfate interfere [31].

4. CONCLUSIONS

All the treatments used and the tests that were studied in the assessment of the degree of corrosion and sedimentation, some chemical compounds confirmed that corrosion in the study areas ranges from the degree of medium corrosion to severe corrosion, these tests indicate a potential problem; further testing is needed to determine the causes and severity of the corrosion potential. Corrosion damages in pipes as well as in private homes. Changing pipes or machines involves high costs and downtime, if safety valves, sprinklers and other devices get immovable due to rust. The aggressiveness coefficient degree indicates that the water in this region is highly corrosive, and the Ryzner coefficient, which indicates that the water condition is the cause of corrosion the presence of high concentrations of chloride ion that will attack the steels, thereby creating dissolved products in the aqueous medium, it became clear through studying the physical and chemical properties of groundwater that it is corrosive and has a negative impact on mineral equipment and devices and therefore leads to a high rate of economic losses and groundwater in the area should be monitored, programs established for treatment and control of concentrations and values that improve quality control of its corrosive property these results indicate the saturation of the wells studied as well as the erosive and aggressive process of groundwater in the area. Some factors, such as high levels of chloride, total dissolved solids, and sulfate result in aggravating the corrosion process in some areas. Therefore, it is necessary to control the corrosion process. In order to control this difficult and expensive process, some methods, such as painting the pipes, using polyethylene pipes instead of metal pipes and asbestos-cement materials, covering plumbing, maintenance, implementation of cathodic protection for metal pipes, pH adjustment and inject inhibitors have been used in the distribution system. Selecting the best method to prevent the corrosion process depends on chemical properties of water. Using lime as a pH adjustment is the most common method for control of the corrosion.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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