Journal of University of Babylon, Engineering Sciences, Vol.(26), No.(2): 2018.

Investigation of the Corrosion and Scaling Potentials of Raw and Treated Water and Its Effect on Concrete Tanks at Al-Tayyaraa Water Treatment Plant

Layla Abdulkareem Mokif
Environmental Research and Studies Center, Babylon University
laylaabdulkareem86@yahoo.com
Zainab Hashim Abbas
Sustainable Management Department, College of Water Resources Engineering, AlQasim Green University
Zainab89@wrec.uoqasim.edu.iq
Noor Alaa Abdulhusain
Environmental Research and Studies Center, Babylon University
nooralaa21@yahoo.com

Abstract

This study is conducted to evaluate corrosion and scaling potentials of raw and treated water at Al-Tayyaraa water treatment plant during a period of twelve months, starting from January to December 2016. Three indices of corrosion and scaling in this study are considered including Ryznar Index (RI), Langelier Saturation Index (LSI), and Aggressive Index (AI). Water quality parameters pH, Alk, (Ca), temperature, calcium as $CaCO_3$, and (TDS) are measured. For raw water, the values of LSI and RI are (0.14-0.504) and (6.956 -7.62), respectively, whereas for treated water, the values of LSI and RI are (0.03-0.4) and (7.02-7.7), respectively. The values of AI are (11.77-12) for raw water and (11.67-11.948) for treated water. The calculated values of Langelier Saturation Index (LSI) reveal that the treated and raw water are balanced to some faint coating (light scale forming). The values of RI point that the raw and treated water are corrosive and values of aggressive index show that the water is moderate corrosion and no obvious effect on concrete tank at water treatment plants.

Keywords: Langelier saturation index, Ryznar index, Aggressive index, Corrosion.

الخلاصة

تم إجراء هذه الدراسة لتقييم الامكانيات التآكلية وتكوين التكلس للمياه الخام والمعالجة في محطة الطيارة لمعالجة المياه خلال فترة اثني عشر شهرا بدءا من يناير حتى ديسمبر 2016. تم النظر في ثلاثة مؤشرات للتآكل والقياس في هذه الدراسة بما في ذلك مؤشر ريزنار (Ryznar Index (RI)) ومؤشر لانجيلير للتشبع (Langelier Saturation Index (LSI)) والمؤشر العدواني (Aggressive Index (AI)). في هذا البحث تم قياس معاملات جودة المياه pH، Alk (Ca)، درجة الحرارة، الكالسيوم متمثلا بـ ($CaCO_3$)، و أخيرا المعامل TDS. واظهرت النتائج للمياه الخام ان قيم LSI وRI كانت على التوالي (0.14−0.504) و (0.03−0.4) في حين كانت نتائج نفس المؤشرين للمياه المعالجة هي (6.956 −7.62) و (7.02−7.7) على التوالي. وكانت نتائج المؤشر AI للمياه الخام والمياه المعالجة هي (11.77−12) و (11.67−11.948) على التوالي. وكشفت القيم المحسوبة للمؤشر LSI أن المياه المعالجة والماء الخام كانت متوازنة أو ممكن تكون طبقة رقيقة جدا من الترسبات. أشارت قيم المؤشر RI إلى أن المياه الخام والمعالجة كانت مسببة للتآكل وأظهرت قيم المؤشر العدواني (AI) أن الماء كان مسببا لتآكل معتدل وليس له تأثير واضح على الخزان الخرساني في محطات معالجة المياه.

الكلمات المفتاحية: مؤشر لانجلير للتشبع ، مؤشر ريزنار، المؤشر العدواني ، التآكل.

1. Introduction

The corrosion cause the most complex problems that negatively affect the drinking water utilities and very expensive in terms of maintenance and also have a negative impact on public health. Corrosion leads to increase the concentrations of certain metals in tap water like toxic metals, lead, cadmium, nickel, copper, iron, and zinc, which cause staining of fixtures or metallic taste or both. The accumulation of corrosion products inside the pipes can cause plugging and can lead to operational difficulties. Other aspects of the corrosion problem are the high costs of repair, replacement, and water loss. Water corrosivety or scaling tendency is affected by its physical and chemical properties. Various water quality parameters can effect on the existence of corrosion scales in iron and steel pipes used in water distribution utilities. These include pH, alkalinity, buffer intensity, and total dissolved solids (Arkoç, 2013). The major components forming scale in salt water environments are calcium carbonate, calcium sulfate, and magnesium hydroxide. Important factors effect on scale formation such as concentration of salts, flow velocity, water temperature and pH of air (Varaprasad and Viswanadh, 2012). Deposition of scale is a chemical precipitation process, where dissolved salts in the cooling water "out" surfaces in contact with the water due to their solubility limits are being exceeded. Previous studies revealed that factors influencing the scale are water hardness, temperature, and pH (Hamzah *et.al.,* 2008). Using corrosion indices is a simple numerical method to estimate the water quality in terms of corrosion. Indices based on calcium carbonate saturation are useful in connection with the corrosion of unlined iron pipe and cementations materials. Application of one index from water stability indices may not be able to predict water corrosivity, while some factors such as water quality and water installation materials should be regarded too (Gholikandi *et.al.,* 2011).

Survey of water stability indices have demonstrated that treated water of places in Al-Hilla city are characterized by moderate corrosion potential and the corrosivity of water shows decreases in the water following downstream (Al-Husseini, 2012).

The mean values of Ryznar Index (RI), Langelier Saturation Index (LSI), and aggressive index (AI) were slightly scale forming, non-scale forming, corrosive and non-corrosive, respectively. Also the mean of scale formation rate values in Shiraz drinking water pipes was 0.26 mm/y. Results indicated that main compositions in scale samples were calcium carbonate, calcium sulfate, magnesium carbonate, magnesium sulfate, hematite, magnetite, goethite, zinc oxide, gypsum, dolomite, and hydroxyapatite. Main elements in scale samples were magnesium, silicon, phosphorus, sulfur, zinc, copper and lead (Tavanpour *et.al.,* 2016). The studied of stability indices of drinking water in Dehloran indicates that the water is corrosive; therefore, the water quality in distribution network should be absorbed constantly and necessary measurements should be taken to control the corrosion (Dargahi *et.al.,* 2016).

Drinking water of Babol city has corrosion potential and thus, the water quality must be monitored depending on pH, Alk, and hardness along with the use of corrosion resisting materials and pipes in drinking water distribution systems (Amoueia *et.al.,* 2017).

The Langelier Saturation Index (LSI) values obtained at four sampling points from the intake to the consumer suggested that the water in the distribution line in Malawi was corrosive all the way to the consumers. This could cause risky effect on consumer health and may influence the lifespan of the water pipes themselves (Kabwazi *et.al.,* 2015).

2. Materials and methods:

2.1. Study area:

This study conducted in middle of Al-Hilla city at Al-Tayyaraa water treatment plant. The samples were collected during a period of twelve months, starting from January to December 2016.

2.2. Corrosion and Scale-forming Potential of Water Indices:

2.2.1. *Langelier Saturation Index (LSI)*

The Langelier saturation index (LSI) is probably the most indicator of water scale potential or water corrosivity. The LSI is define as (Arkoç, 2013):-

$LSI = pH - pHs$ …………………………………………… ……………….. (1)

Where,

$pH = measured\ pH$ and $pHs = pH\ at\ saturation\ in\ calcium\ carbonate$ and it is given by

$PHs = (9.3 + A + B) - (C + D)$ ....…..….... (2)

Where, A, B, and C are defined by

$A = (Log10\ [T\ DS] - 1)/10$ ……………………………………………………. (3)

$B = -13.12 \times Log10\ (C° + 273) + 34.55$ ……………… …..…….…………. (4)

$C = Log10\ [Calcium\ Hardness] - 0.4$ ………...……………….…………..…. (5)

$D = Log10\ [Alkalinity\ as\ CaCO\mathbf{3}]$ ………...……………………………..... (6)

Table (1) below shows the values of LSI:

Table (1): Scale and Corrosion potential tendencies of water with different Langelier Saturation Index values (LSI) (Tavanpour *et.al.*, 2016)

Index value(LSI)	Description	Index value (LSI)	Description
- 5	Severe Corrosion	0	Near Balanced
- 4	Severe Corrosion	0.5	Some Faint Coating
- 3	Moderate Corrosion	1	Mild Scale Coating
- 2	Moderate Corrosion	2	Mild to Moderate Coatings
-1	Mild Corrosion	3	Moderate Scale Forming
-0.5	None- Mild Corrosion	4	Severe Scale Forming

2.2.2. *Ryznar Index (RI)*

Same parameters in the Langelier saturation index are also used in the Ryznar index (Arkoç, 2013). Table (2) below shows the values of RI. The index RI is given by

$RI = 2pHs - pH$ ……………………………………………………….………… (7)

Table (2): Scale and Corrosion potential tendencies of water with different Ryznar Index (RI) values ((Al-Husseini, 2012)

Index value(R I)	Description
Less than 5.5	Heavy scale formation
5.5 to 6.2	Some scale will form
6.2 to 6.8	Non –scaling or corrosive
6.8 to 8.5	Corrosive water
More than 8.5	Very corrosive water

2.2.3. *Aggressive Index (AI)*

The aggressive index AI is given by

$AI = pH + Log\mathbf{10}[(Alk)\ (Ca)]$ ……………...…………………..……………. (8)

Where, Alk is Alkalinity as $CaCO\mathbf{3}\ in\ (mg/L)$ and Ca is Calcium concentration in (mg/L). Table (3) below shows the values of AI.

Table (3): Scale and Corrosion Tendencies of water with various Aggressive Index (AI) values (Tavanpour, et al., 2016)

Index value(AI)	Description
Less than 10	Highly corrosive
10 -12	Moderate corrosion
More than 12	Scaling

3. Results and discussion

Three indices of corrosion and scaling in this study are considered, which are namely Ryznar Index (RI), Langelier Saturation Index (LSI), and Aggressive Index (AI). To determine the potential of corrosion and scaling of raw and treated water in at Al-Tayyaraa water treatment plant, water quality parameters including pH, alkalinity, calcium (Ca), temperature, calcium as $CaCO_3$, and total dissolved solids (TDS) were measured. The determined values of LSI are (0.14-0.504) for raw water and (0.03-0.4) for treated water as shown in Figure (1). The calculated results reveal that the values of RI are in the range of (6.956 -7.62) for raw water and in the range of (7.02-7.7) for treated water as shown in Figure (2). Figure (3) shows the determined results for AI, which are in the ranges of (11.77-12) and (11.67-11.948) for raw and treated water, respectively. The alkalinity values of less than 30 mg/L, in the form of calcium carbonate, cause water corrosion. If the alkalinity values as calcium carbonate are maintained at levels higher than 65 mg/L, the extent of corrosion and release of iron decrease (Tavanpour et.al., 2016). In water having low pH and low alkalinity (i.e. highly aggressive waters), the conditions are not suitable for calcite precipitation and thus concrete is susceptible to corrosion/lime leaching. However, in waters with high carbonate concentrations and at a higher pH, calcium carbonate ($CaCO_3$) precipitates readily, both at the concrete-water interface and within the micropores that extend from the concrete interior to the interface. In general, this precipitated $CaCO_3$ has been assumed to protect the underlying concrete from degradation (Douglas *et.al.,* 1996). Excessive precipitation of calcite can lead to scaling problems, which might occur in passive water conditions (i.e. high alkalinity and high pH). The corrosion of concrete in water concrete plant is a function of the water chemistry and chemical equilibrium with the various hydration phases. The degree of calcium carbonation saturation and the carbonation speciation of water control the degradation of cement materials. This is generally called the carbonic aggressively (AWWARF and DVGW-TZ. 1996). When there is an increase in the Alkalinity value, there will be an increase in calcium carbonate deposition and thus reduces corrosion. High pH (alkaline water) may form a layer that would help to protect against corrosion (Al-Husseini, 2012). The main reasons of internal corrosion of steel bars in water treatment plants is conventional acid attacks, which are caused by lower levels of pH value that leads to sulphate attack, which is attributed to the direct discharge of industrial waste in sewer systems (Parande *et.al.,* 2005).

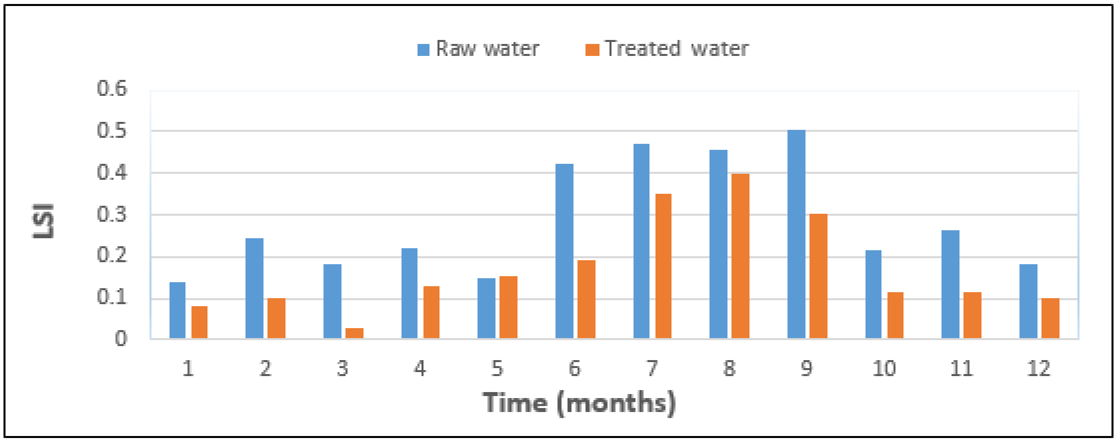

Figure (1): variation of (LSI) values with months.

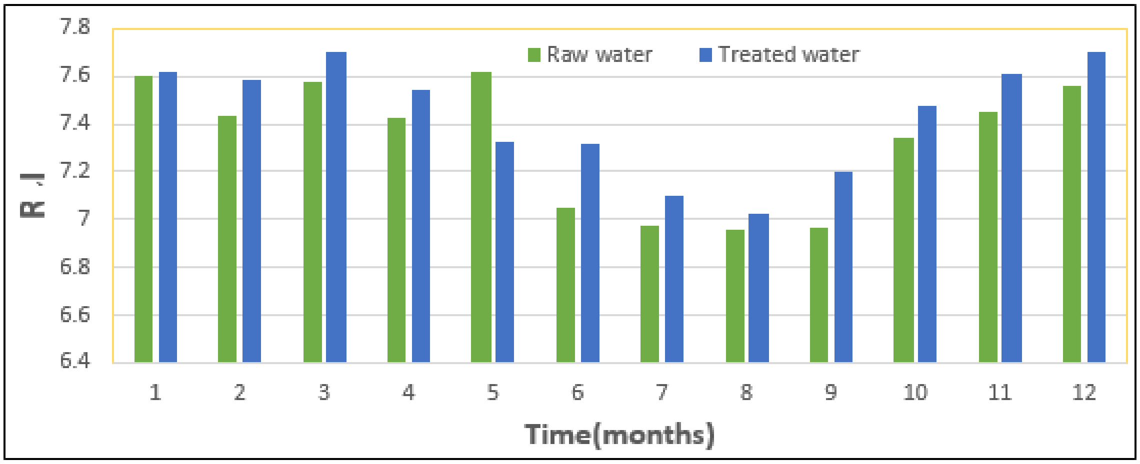

Figure (2): variation of (RI) values with months.

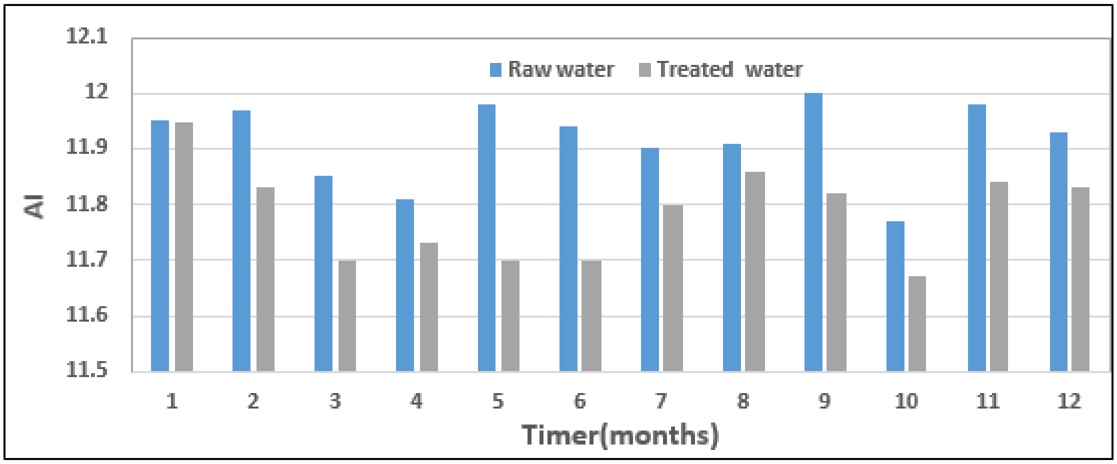

Figure (3): variation of (AI) values with months.

4. Conclusion

The calculated values of Langelier Saturation Index (LSI) indicated that the raw and treated water were balanced to some faint coating (light scale forming). The values of

RI pointed that the raw and treated were corrosive and the values of aggressive index showed that the water was of moderate corrosion.

References

Al-Husseini A.H. E. ,2012 , “Study of Potential Corrosion and Scaling for Treated Water of Two Water Treatment Plants in Al-Hilla City”, Journal of Babylon University/Engineering Sciences, Vol. 20, No. 4, PP. 1180-1190.

Amoueia A., Fallaha S. H., Asgharniaa H., Yaric A. R., and Mahmoudi M. , 2017 “Corrosion and Scaling Potential in Drinking Water Distribution of Babol, Northern Iran Based on the Scaling and Corrosion Indices**”,** Hygiene Sciences, Vol. 6, No. 1, PP. 1-7.

Arkoç O. ,2013, “Assessment of scaling properties of groundwater with elevated sulfate concentration: a case study from Ergene Basin, Turkey”, Arab J Geosci, Vol. 6, PP. 4377-4385.

AWWARF and DVGW-TZ. , 1996, “Internal Corrosion of Water Distribution Systems” AWWARF: Denver.

Dargahi A., Shokri R., Mohammadi M., Azizi A., Tabandeh L., Jamshidi A. and Beidaghi S. , 2016, “Investigating of the corrosion and deposition potentials of drinking water sources using corrosion index: a case study of Dehloran”, JCHPS Special Issue 7, PP. 73-79.

Douglas B.D., Merrill D.T., and Catlin J.O. , 1996 , “Water quality deterioration from corrosion of cement-mortar linings”, Journal of American Water Works Association, Vol. 88, No. 7, PP. 99-107.

Gholikandi G. B., Ahmadi M., Haddadi S., and Dehghanifard E. , 2011 , “Study of Andimeshk's Drinking Water Resources in Iran”, Asian Journal of Chemistry, Vol. 23, No. 8, PP. 3334-3338.

Hamzah Z., Abdul Ghani H., and Alias M. , 2008 , Water Quality Analysis and Its Relation to the Scaling and Corrosion Tendency in an Open Water Cooling System”, The Malaysian Journal of Analytical Sciences, Vol. 12, No. 2, PP. 380-383.

Kabwazi M., Mwenechanya J., BHZ M., and Mumba P.P. , 2015 , “Assessment of the corrosiveness of the water in the distribution line from intake to consumer outlets in Malawi”, Vol. 3, No. 3, PP. 075-079.

Parande K., Ramsam L., Ethirajan S., Rao C., and Palanisamy N. , 2005 , “Deterioration of reinforced concrete in sewer environments”, Municipal Engineer 159, Issue ME1.

Tavanpour N., Noshadi M., and Tavanpour N. , 2016 , “Scale Formation and Corrosion of Drinking Water Pipes: A Case Study of Drinking Water Distribution System of Shiraz City”, Modern Applied Science, Vol. 10, No. 3, PP.166-177.

Varaprasad B.J.S. and Viswanadh G.K. , 2012 ,“A study on scale formation in water distribution systems”, IJWREM, Vol. 3, No. 1, PP. 129-136.