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Evaluating the Potential of Corrosion and Sedimentation in Drinking Water Distribution System

[1]Yazdan Kheradmand, [2]Farzad Ghaderi Baft, [3]Abbas Moghanizadeh

[1,2,3]*Department of Civil Engineering, College of Engineering, Shirvan Branch, Islamic Azad University, Shirvan, Iran.*

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ABSTRACT

Corrosion is an important problem in the water industry which can affect the public health, water quality and the cost of production. Deposit formation also results in pipes clogging; therefore, the efficiency of hot water systems in homes is reduced and the energy consumption is increased. The objective of this study is to investigate the potential of corrosion and sedimentation in drinking water Distribution System. In the current study, the results obtained from the tests conducted on 22 samples from 4 stations in water Distribution System within a year were evaluated. Samples were tested in accordance with guidelines provided in the book entitled Standard Methods. The obtained results were evaluated and analyzed using descriptive statistics and statistical tests. In general, according to the results, Shirvan drinking water has a quality ranging from scale-forming to relatively moderate based on Ryznar Index, and based on Langelier Index, it has the scale-forming quality.

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INTRODUCTION

Corrosion is an important problem in the water industry which can affect the public health, water quality and the cost of production (Amiri, M., 2006). In other words, corrosion is a chemo-physical reaction caused by several chemical, electrical, physical, and biological factors (Birdie, G.S., 2000). Corrosion can pose high costs for water systems. Corrosion also causes problems for economic, aesthetic and health issues (Tebbutt, T.H.Y., 1998). This process can be a threat for human health and cause problems in long run (WHO, 1997). Corrosion is a phenomenon created due to the contact between materials and the environment. In engineering materials, based on the nature of the corrosion process, it is examined in two different categories including erosion corrosion and electrochemical corrosion. The first is caused by material destruction by physical factors such as suspended solids in water or sewage pipes. However, the second is caused by electrochemical reactions between the environment and the material contained in the water Distribution System (AWWA., 1999). Sedimentation means the creation of a hard layer on the surfaces in contact with water due to the saturation of dissolved solids in water (Adams V. Dean, 1990). Calcium deposit formed in water is the most common sediment needed to be controlled. In pipes and in waters where calcium carbonate is supersaturated and the hardness is high-level, sedimentation results in pipes clogging; therefore, the efficiency of hot water systems in homes is reduced and the energy consumption is increased (Steel, R.E.W., J. Terence, Mc Ghee, 1979). Currently, the economic issues associated with corrosion and sedimentation forms a significant percentage of per capita income in countries. In America, the cost imposed by corrosion and sedimentation is more than 4-5% of gross national income. The exact number is not available for Iran; however, the researches on treated-water losses indicate that more than 30% of supplied water is lost every year due to the erosion resulting from corrosion of pipes in water Distribution System (Peavy, H.S. and *et al.*,). Langelier Saturation Index (LSI) is a model derived from the theoretical concept of saturation and is an index for calcium carbonate saturation of the water. LSI expresses the concept of saturation using pH as a main variable. LSI can be considered as the changes the pH needed to have in order to make the water moderate (American Water Work Association, 1986). Ryznar Stability Index (RSI) represents the relationship between the experimental data with the thickness of the layer observed in water systems using the water chemistry and similar to LSI, it is based on the saturation and quantitatively represents the relationship between saturation and the formation of calcium carbonate layer. To calculate RSI and LSI, it is necessary to analyze parameters including alkalinity, hardness, total dissolved solids, pH, and water temperature (Yong, P., 1996). In fact, Langelier and Ryznar indices are the difference between the actual pH and the pH of

Corresponding Author: Yazdan Kheradmand, Department of Civil Engineering, College of Engineering, Shirvan Branch, Islamic Azad University, Shirvan, Iran.
E-mail: y_kh_1386@yahoo.com

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the water saturated by calcium carbonate and are used as a marker to represents the corrosion and sedimentation in water (Mullen, R.E.D.& A. Ritterj, 1974).

MATERIALS AND METHODS

The study period was 12 months and the sampling period was 6 months. The study is a cross-sectional study. The number of samples is 22 gathered in four stations during the months of September, October, November, December, January and February. The sampling points were selected based on the topography and the population density and the sampling area was the area in Shirvan city covered by water Distribution System. The water-supply network has a length of 161,800 meters and is made of asbestos and polyethylene, the water tank is also a reservoir with the capacity of 10,000 cubic meters (Mirzaei, Bahman, 2006).

In this study, the results of tests conducted to evaluate the parameters including alkalinity, hardness, total dissolved solids, pH and water temperature for 22 samples in 4 stations of Shirvan water Distribution System within one year were examined. Samples were tested in accordance with guidelines provided in the book entitled Standard Methods (standardization, 2005). The obtained results were evaluated and analyzed using descriptive statistics and statistical tests via SPSS program. The sample points were selected on the map considering that the objective of this study is to investigate the potential for corrosion and sedimentation of drinking water Distribution System.

Corrosion indices are calculated based on the following formulas:

A- Determining the Langelier Index (LSI): $LSI = PH-PH_S$

Interpretation of Langelier index is as follows:

1. LSI> 0, water is super-saturated and tends to sediment.
2. LSI = 0, water is saturated and moderate.
3. LSI <0, water is under saturated and tends to corrosion.

B - Determining the Ryznar Index index: ($RSI = 2pH_S-PH$)

Interpretation of Ryznar index is as follows:

1. RSI <4, water has a high-level sedimentation.
2. RSI = 5-6, water is relatively scale-forming and slightly corrosive.
3. RSI = 6-6.5, water is corrosive and is not scale-forming.
4. RSI = 6.5-7, water is corrosive.
5. RSI> 8, water is a strongly corrosive. (Ryder, R.A., 1980)

Results:

The results of tests on parameters including alkalinity, hardness, total dissolved solids, pH and water temperature for 22 samples in 4 stations of Shirvan water Distribution System in the months of September, October, November, December, January is provided in tables (1) and (2).

Table 1: represents the values of Ryznar index for Shirvan drinking water.

Water Quality	RSI	pH	pH_S	Logalk.	Logca.	Alk.	Ca.	B	T.D.S	A	Tem.	Num.
Sedimentation.	5.86	7.7	6.78	2.477	2.6	300	400	9.9	1180	1.96	27	1
Sedimentation.	5.86	7.6	6.64	2.6	2.6	362.5	400	9.9	1384	1.94	28	2
Sedimentation.	5.76	7.6	6.68	2.56	2.62	362.5	420	9.9	1444	1.96	27	3
Sedimentation.	5.9	7.7	6.8	2.49	2.55	312.5	350	9.9	1452	1.94	28	4
Moderate.	6.32	7.4	6.86	2.54	2.48	350	300	9.9	1296	1.98	26	5
Moderate.	6.02	7.5	6.76	2.55	2.55	355	350	9.9	1392	1.96	27	6
Sedimentation.	6	7.6	6.8	2.56	2.57	365	375	9.9	1240	2.04	22	7
Moderate.	6.1	7.7	6.9	2.52	2.55	330	350	9.9	1360	2.06	23	8
Sedimentation.	6	7.8	6.9	2.5	2.6	325	400	9.9	1292	2.12	21	9
Moderate.	6.42	7.5	6.96	2.54	2.52	345	330	9.9	1568	2.12	21	10
Moderate.	6.4	7.6	7	2.53	2.4	340	250	9.9	1280	2.08	24	11
Moderate.	6.3	7.6	6.95	2.53	2.48	340	300	9.9	1304	2.06	23	12
Moderate.	6.14	7.5	6.82	2.5	2.58	330	380	9.9	1344	2	25	13
Moderate.	6.14	7.6	6.87	2.55	2.6	355	410	9.9	1360	2.12	21	14
Moderate.	6.1	7.7	6.9	2.53	2.54	337.5	350	9.9	1408	2.08	24	15
Moderate.	6.3	7.7	7	2.5	2.53	325	340	9.9	1328	2.15	18	16
Moderate.	6.3	7.7	7	2.52	2.5	330	320	9.9	1280	2.17	19	17
Moderate.	6.5	7.5	7	2.52	2.5	330	320	9.9	1360	2.175	19	18
Moderate.	6.36	7.6	6.98	2.5	2.54	315	350	9.9	1816	2.12	21	19
Moderate.	6.9	7.5	7.2	2.45	2.48	280	300	9.9	1328	2.225	17	20
Moderate.	6.72	7.6	7.16	2.48	2.53	302.5	340	9.9	1280	2.275	15	21
Moderate.	6.8	7.4	7.1	2.51	2.48	327.5	300	9.9	1448	2.2	16	22

Table 2: represents the values of Langelier Index for Shirvan drinking water.

Water Quality	LSI	pH	pH_S	Logalk.	Logca.	Alk.	Ca.	B	T.D.S	A	Tem.	Num.
Sedimentation.	0.92	7.7	6.78	2.477	2.6	300	400	9.9	1180	1.96	27	1
Sedimentation.	0.96	7.6	6.64	2.6	2.6	362.5	400	9.9	1384	1.94	28	2
Sedimentation.	0.92	7.6	6.68	2.56	2.62	362.5	420	9.9	1444	1.96	27	3
Sedimentation.	0.9	7.7	6.8	2.49	2.55	312.5	350	9.9	1452	1.94	28	4
Sedimentation.	0.54	7.4	6.86	2.54	2.48	350	300	9.9	1296	1.98	26	5
Sedimentation.	0.74	7.5	6.76	2.55	2.55	355	350	9.9	1392	1.96	27	6
Sedimentation.	0.8	7.6	6.8	2.56	2.57	365	375	9.9	1240	2.04	22	7
Sedimentation.	0.8	7.7	6.9	2.52	2.55	330	350	9.9	1360	2.06	23	8
Sedimentation.	0.9	7.8	6.9	2.5	2.6	325	400	9.9	1292	2.12	21	9
Sedimentation.	0.54	7.5	6.96	2.54	2.52	345	330	9.9	1568	2.12	21	10
Sedimentation.	0.6	7.6	7	2.53	2.4	340	250	9.9	1280	2.08	24	11
Sedimentation.	0.65	7.6	6.95	2.53	2.48	340	300	9.9	1304	2.06	23	12
Sedimentation.	0.68	7.5	6.82	2.5	2.58	330	380	9.9	1344	2	25	13
Sedimentation.	0.73	7.6	6.87	2.55	2.6	355	410	9.9	1360	2.12	21	14
Sedimentation.	0.8	7.7	6.9	2.53	2.54	337.5	350	9.9	1408	2.08	24	15
Sedimentation.	0.7	7.7	7	2.5	2.53	325	340	9.9	1328	2.15	18	16
Sedimentation.	0.7	7.7	7	2.52	2.5	330	320	9.9	1280	2.17	19	17
Sedimentation.	0.5	7.5	7	2.52	2.5	330	320	9.9	1360	2.175	19	18
Sedimentation.	0.62	7.6	6.98	2.5	2.54	315	350	9.9	1816	2.12	21	19
Sedimentation.	0.3	7.5	7.2	2.45	2.48	280	300	9.9	1328	2.225	17	20
Sedimentation.	0.44	7.6	7.16	2.48	2.53	302.5	340	9.9	1280	2.275	15	21
Sedimentation.	0.3	7.4	7.1	2.51	2.48	327.5	300	9.9	1448	2.2	16	22

In a study conducted by Mokhtari *et al*. on water Distribution System in Ardebail, it was shown thet the water in the city is partly corrosive (Mokhtari *et al*., 2010). Based on another study by R. Piri *et al*. on Khorramabad water Distribution System, the water was evaluated as corrosive (Piri, R. *et al*., 2010).

According to a study on drinking water resources in conducted Hamadan by Zare *et al*., the groundwater resources of the city, in terms of sedimentation and corrosion, range from low to moderate (Zare *et al*., 2010). In another study on corrosion and sedimentation potentials in a dual water supply system conducted by Qaneian *et al*., the chemical quality of water in water supply systems and installations was evaluated as scale-forming (Qaneian *et al*., 2007). According to a study conducted by Ghanizadeh *et al*. entitled " the corrosion and sedimentation potential of drinking water in water supply systems in military centers corrosion", some centers had corrosive and some other scale-forming potentials (Ghanizadeh *et al*., 2009).

Discussion and Conclusion:

According to the findings of this study and other studies, although factors affecting the water quality may be in standard range, but in general and according to the used criteria and obtained results, it is possible for them to cause deposition or corrosion in water Distribution System. In general, according to the results, Shirvan drinking water has a quality ranging from scale-forming to relatively moderate based on Ryznar Index, and based on Langelier Index, it has the scale-forming quality.

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