ISSN: 0975-766X
CODEN: IJPTFI
Available Online through
Research Article
www.ijptonline.com

EVALUATION OF HEAVY METAL CONTAMINATION AND SCALING AND CORROSION POTENTIAL IN DRINKING WATER RESOURCES IN NURABAD CITY OF LORESTAN, IRAN

Leila Tabandeh[1], Ghodratollah Shams khorramabadi[2], Amir Karami[1], Zahra Atafar[1], Hooshmand Sharafi[1], Abdollah Dargahi[3*], Farhad Amirian[4]

[1]Department of Environmental Health Engineering, School of Public Health, Kermanshah University of Medical Sciences, Kermanshah, Iran.

[2]Department of Environmental Health Engineering, School of Public Health, Lorestan University of Medical Sciences, Khoramabad, Iran.

[3]Department of Environmental Health Engineering, School of Public Health, Hamadan University of Medical Sciences, Hamadan, Iran.

[4]Department of Patology, School of Medicine, Kermanshah University of Medical Sciences, Kermanshah, Iran.

Email: a.dargahi29@yahoo.com

Received on 13-05-2016 *Accepted on 12-06-2016*

Abstract

Corrosion can cause economic damages, decreased useful life and diseases in the consumers. Therefore, in the present study, the status of heavy metal pollution and potential of corrosion and scaling were investigated in water resources of Nurabad city of Lorestan. In this cross-sectional study, samples were collected from 7 wells of drinking water and 2 water storage tanks during 6 month (fromautumn to winter) in Nurabad. So that, four indexes including Langelier, Reisner, Aggressive and Pokoryus were determined. Moreover, heavy metals such as copper, lead, zinc, cadmium, iron and manganese were measured using an atomic absorption device. Results showed that Langelier, Reisner, Pokoryus and Aggressive indexes were in the range of +0.07 to +0.61, 7.44 to 8.06, 6.9 to 7.25 and 11.38 to 11.9, respectively. Moreover, the concentration of studied metals in water supplied water was lower than the national standards and World Health Organization standard. Also in the water supply system the concentration of some metals was more than standard level. Result obtained from studied indexes showed that the drinking water in Nurabad is corrosive and so that the water quality in water supply system should be monitored continuously. The best applicable practices for decreasing water corrosion in water supply system are including continuous control of pH, chlorination mechanism and the use of corrosion resistant pipelines and facilities.

Keywords: Corrosion, Scaling, Water Resources, Heavy Metals, Nurabad, Lorestan

Introduction

Corrosion is a physical and chemical reaction between material and its surrounding which is lead to the materials characteristic's change. The corrosion process is harmful and have difficulties for citizen's health and economic, social, technical and aesthetical aspect (1). Some of the problems of houses distribution network pipes corrosion could be the life reduction of pipes, the necessity of replacing worn-out and perforated tubes, increasing the amount of water lost and secondary contamination incidence in distribution network which imposed a lot of cost to the water installation cities annually (2). Every year more than a hundred million dollars of damage have occurred in societies due to the corrosion of water distribution systems in a way that the yearly cost of its prevention in U.S have estimated for more than eight billion dollars (3). Corrosion in addition to causing financial damages to the installations, could cause the heavy metals entrance such as lead, calcium, copper and chromium to the distribution network and threaten the consumers health (4,5). The researches have shown that lead and cadmium are two metals which have potential toxicity (2) in a way that U.S EPA categorized them in B2 group (probable) carcinogen for human group. Because this substance have accumulative property and keep the productive hemoglobin's enzyme activity and cause anemia and nervous disorders. Other side products of corrosion such as copper, zinc, iron and manganese are among the secondary standards of water and have a great importance from the aesthetic aspect (6). In a way that theses metals caused some spot on plates and metallic taste in water. Copper cause blue spot and metallic taste, iron caused brown and red spot, manganese caused black spot and zinc caused metallic taste in water (7). A lot of parameters are effective in corrosion spread but the high speed of water, pH, temperature, hardness, acidity, alkalinity, residual chloride, TDS, gases, soluble salts and microorganism in water and the contact level with water are among the most important effective factors of corrosion spread in water system. Beside the corrosion, the sedimentation process in pipes could cause damages of water installation. The harmful effect of sedimentation in pipes could be the reduction of water flow in pipes which caused the loss of energy in these pipes and as a result need more energy for water pumping. According to the hygienic and economic harms of heavy metals corrosion and sedimentation in water installation, continuous qualitative monitoring of water is necessary. Therefore, the aim of this study is to evaluate the heavy metal contamination situation and corrosion and sedimentation potential of drinking water resources in Nurabad city of Lorestan.

Material and Methods

This is a cross-sectional study. In this study seven drinking water resources (7 wells) in Nurabad city were analyzed and evaluated during six months (autumn and winter season) in terms of physical and chemical index. The geographical property of drinking water resources in Nurabad city was presented in table 1.

Table-1: Geographical characteristics of water resources of Noor-Abad city.

Resources	X	Y	Z
1	3777294	S022721039	1807
2	3777288	39S0227636	1810
3	3777288	39S0228107	1809
4	3777410	39S0228488	1830
5	3777491	39S0228902	1828
6	3777304	39S0229671	1817
7	3776865	39S0230324	1813
Reservoir 1	3775611	38S0774303	1838
Reservoir 2	3772648	38S0775334	1875

- **The studied region**

Nurabad city with the population of 64500 person is placed in the west-north of Lorestan province. This city's distance with the center of city is 85km. this city is placed in the geographical position of 47 degree and 27 minute to 48 degree to 18 minute of east Greenwich meridian longitude and 33 degree and 50 minute to 34 degree and 18 minute north latitude. In a way that showed the spread of 52 minute longitude and 28 minute in latitude. The city has a total area of 8km3 and annually average precipitation of 550-600 ml.

- **Sampling**

The sampling have done by stratified method. From seven wells which were the drinking water samples, three sample were taken from each resource and combined with each other and analyzed with three time repeating for the considered parameters. The covered region water was distributed by two water resources (1, 2 reservoirs) in a way that the number 1 and 2 resource covered 2.3 and 1.3 subscribers of the city respectively.

Therefore, the covered region according to the categorizing water distribution reservoirs divided into two classes. In each classes there are several points and these points considered as cluster heads (city blocks) and some clusters have selected

from these cluster heads randomly. In a way that in class one, there are three cluster head and from each cluster head, eight cluster have selected randomly by the certain intervals. In second class, three cluster head were selected and from each cluster head four cluster have selected randomly with certain intervals and overall in both classes 12 samples have taken. In fact, the final sample size, according to the population which covered by cluster head was 36 sample from municipal distribution network and 7 samples from wells (water supplies) with a combination situation. For sampling the 0.5 lit plastic container was used.

- **The parameters analysis**

After sampling and transferring them to the public health faculty's laboratory, the test have been done on samples in terms of considers parameters. The pH and temperature in sampling place have evaluated by pH meter and thermometer device. Calcium, alkalinity, chloride, sulfate, TDS, EC and DO have evaluated in laboratory by the standard method book and compared with the national and environmental standard (8, 9). The langelier saturation and Rayzner saturation, Puckoriusand aggressive index have calculated and divided to three categorizes of sedimentation, neutral and corrosive based on the obtained numbers and comparison with table2. The heavy metals parameter measured by atomic adsorption spectrometry. For validation of devices, the standard samples and a unknown sample have used for each element with three time repeating which was averagely between 90-95%.

Table-2: Classification of water based on the stability indices.

Stability index	Corrosive	Neutral	Scaling
Langelier(LSI)	LSI<0	LSI=0	LSI>0
(RSI) Ryznar	RSI>7	6<RSI<7	RSI<6
Aggressive (AI)	AI<10	10<AI<12	AI>12
Puckorius (PSI)	6<PSI<7	PSI=6	PSI<6

- **Corrosion *index* calculation**

For evaluating the corrosive index, the following formula have been used (1, 10, and 11).

- **Determining langelier saturation index method (LI):**

The calculation formula of this is as bellows:

$$LI = \mathrm{pH} - \mathrm{pHs}$$

When this index is negative, the water is probably corrosive. If this index is positive, the water have a desire for sedimentation the calcium carbonate and if the langelier index is zero the water is balance, the water is nor corrosion neither have a desire for creating a protective layer of calcium carbonate.

- **Determining Rayzner saturation index method (RI):**

For calculating this index the bellow formula have been used:

$$RI = 2\mathrm{pHs} - \mathrm{pH}$$

- **Determining the aggressive index method (AI):**

For determining this index the bellow formula have been used:

$$AI = [\mathrm{pH} + \mathrm{Log(A)(H)}]$$

- **A:** the total alkalinity based on the mg/L CaCO3
- **H:** the Ca hardness based on the mg/L $CaCO_3$

- **Determining the Puckorius**
- **index method (PI):**

For calculating this index the bellow equation have been used:

$$\mathrm{PI} = 2\mathrm{pHs} + \mathrm{pHeq}$$

- PI: Puckoriusindex
- pHs: the pH of water which saturated with CaCO3
- pHeq: the pH of balanced water which calculated by the bellow equation
- pHeq= 1.465+ Log(T.ALK)+4.54
- T.ALK: The total alkalinity based on mg/l

For analyzing the data the descriptive statistical index methods such as means, standard deviation, Kolmogorov Smirnov Test, one-sample T-test and one-sample Wilcoxon-test were used.

Results and Discussion

Table3, showed the related parameters with corrosion, sedimentation of drinking water resources in Nurabad city in autumn and winter based on the evaluation unit in the form of mean and standard deviation. The numerical means

parameter of temperature, alkalinity and DO based on the evaluation unit for drinking water resources in autumn and winter season were (19.65, 14.6), (224.895, 271.104), (3.73, 3.81) and the standard deviation were (2.76, 1.698), (7.647, 22.84), (0.818, 0.209) respectively. The results showed that the alkalinity parameters in autumn season have higher standard deviation than winter season. In a way that the maximum concentration in autumn was 310.140mg/lcaco3 and the minimum concentration was 230 mg/lcaco3. Based on the Kolmogorov Smirnov Test, the TDS, EC, sulfate, hardness, chloride and pH variables in autumn and winter in drinking water resources of Nurabad city have normal distribution. The obtained results showed that the mean of evaluated concentration in Nurabad city's drinking water resources except TDS in winter which was higher than the maximum acceptable limit of environmental standard was in the national standard range of environment. Also table3 presented the results of related parameters with corrosion and sedimentation in 24 station of covered points with number 1 reservoir in the form of mean and standard deviation based on the evaluated units. The numerical mean of temperature, alkalinity, DO parameters based on the evaluation unit for number 1 reservoir in autumn and winter season were (16.69, 17.66), (231.28, 165.52), (4.39, 3.078) respectively with the standard deviation of (23.78, 1.562), (1.8, 1.5) and (0.478, 0.584). Based on the , Kolmogorov Smirnov Test the sulfate, hardness in autumn and winter, chloride and EC in winter and pH in autumn have normal distribution. Based on the,Kolmogorov Smirnov Test the TDS variable in autumn and winter, chloride and EC in autumn and pH in winter don't have a normal distribution. The results based on the one-sample T-test and one sample Wilcoxon-test showed that all the parameters in autumn and winter, in covered points with number 1 reservoir were in the national standard range of environment (except TDS which wasn't in standard range of environment). But in autumn it was in the environmental standard range. The results of mean and standard deviation parameters for corrosion in covered points with number 2 reservoir have presented in table3. The numerical mean of temperature, DO, alkalinity parameters which were (16.34, 17.97), (4.82, 3.48), (208.933, 175.713) respectively have presented in table separately in autumn and winter based on the evaluation unit with the standard deviation of temperature, DO and alkalinity (1.334, 0.933), (0.611, 0.619), (15.62, 20.23). Based on the, Kolmogorov Smirnov Test, all the variables except pH have normal distribution in winter. Based on the, Kolmogorov Smirnov Test the pH variable don't have a normal distribution in winter.

The obtained results showed that the average of evaluated concentration from covered points with number 2 reservoir in Nurabad city was in the standard range for all cases except in winter which weren't in the standard range of environment.

According to the data analysis about the corrosion and sedimentation index in water resources based on the chi-square test, there was a significant difference between various level of langelier index in two autumn and winter season (P<0.05). Based on the chi-square test, there wasn't any significant difference between various level of Rayzner index in autumn and winter season (P>0.05). Based on the chi-square test there wasn't a significant difference between various level of Puckoriusindex in two autumn and winter season (P>0.05). In reservoir number 1 based on the chi-square test, there was a significant difference between various level of langelier index in two season of autumn and winter (P<0.05). Based on the chi-square test there was a significant difference between various level of Puckoriusindex in two season of autumn and winter (P<0.05). and in the covered point with number2 reservoir, based on the chi-square test there was a significant difference between various level of langelier index in two season of autumn and winter (P>0.05). Based on the chi-square test, there was a significant difference between various level of Puckoriusindex in two season of autumn and winter (P<0.05).

Table-3: The physical and chemical parameters results which were related to corrosion and sedimentation in water resources of Nurabad city.

Parameters	Mean ±SD							
	Water resource (7 wells)		The points covered by reservoir 1		The points covered by reservoir 2		Standards	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	National	Protectio
Temperature (° C)	14.6±1.6	19.6±2.7	17.6±16.7	16.69±1.8	17.9±0.93	16.3±1.3	-	-
Alkalinity (mg /l $CaCO_3$)	271.1±22.84	224.8±7.4	165.52±26.56	231.2±23.78	7.1±0.08	7.3±0.11	--	-
DO (mg/l)	3.81±0.21	3.73±0.81	3.07±0.47	4.39±0.58	353.02±13.9	962.4±121.8	-	--
TDS (mg/l)	344.2±22.4	940.95±56.6	530.87±37.8	1199.3±134.4	1725.3±100.1	1604.1±202.1	1500	500
ES (mg/l)	537.8±35.03	1568.2±92.5	584.7±63.12	1622.4±168.5	3.48±0.82	4.82±0.61	2000	-

Sulfate (mg/l)		46.6±10.3	48.4±10.8	56.19±17.47	49.4±13.37	171.5±12.34	179.3±17.32	600	250
Calcium hardness (mg /l $CaCO_3$)		160.6±41.6	182.09±28.3	177.9±30.06	180.16±14.42	175.7±20.2	208.9±15.62	250	200
Chloride (mg/l)		11.57±3.5	8.4±2.2	14.84±5.65	10.53±3.48	54.4±8.3	48.8±11.77	400	250
pH		6.83±0.022	7.28±0.09	7.14±0.15	7.31±0.177	7.1±0.08	7.34±0.12	6.5-9	6.5-8.5
Stability indices	LI	+0.61	+0.07	+0.37	+0.16	+0.38	+0.148	-	-
		Scaling	Scaling	Scaling	Scaling	Scaling	Scaling	-	-
	RI	8.06	7.44	7.88	7.65	7.86	7.84	-	-
		Corrosive	Corrosive	Corrosive	Corrosive	Corrosive	Corrosive	-	-
	PI	7.19	6.9	7.25	7.07	7.19	7.13	-	-
		Corrosive	Corrosive	Corrosive	Corrosive	Corrosive	Corrosive	-	-
	AI	11.38	11.90	11.59	11.86	11.59	11.90	-	-
		Corrosive	Corrosive	Corrosive	Corrosive	Corrosive	Corrosive	-	-
PHs		7.44	7.36	7.51	7.47	7.5	7.48	-	-

Table 4, showed the analysis results of heavy metals (copper, lead, zinc, cadmium, iron and manganese) standard deviation in two season of autumn and winter in water resources of Nurabad city.

Based on the Kolmogorov Smirnov Test the copper, lead, zinc, cadmium, iron and manganese of water resources in winter have normal distribution. According to the independent T-test variables, there was a significant difference between calcium, chloride, manganese of water resources in two season of autumn and winter ($P<0.05$) and there wasn't any significant difference between sulfate, zinc, cadmium and lead in two autumn and winter season ($P>0.05$). Based on the Kolmogorov Smirnov Test, copper, lead, (in autumn season) cadmium, and manganese (autumn and winter) have normal distribution and other variables don't have normal distribution. The obtained results showed that the average of the iron variable in autumn and winter were not in the national standard range of WHO ($P>0.05$) and other variables were in the national standard range of WHO ($P<0.05$). According to the obtained results from table4 about the heavy metals of covered points with number 1 reservoir, it could be said that based on the independent T-test there wasn't any significant

difference between calcium and manganese variables in autumn and winter (P>0.05). and based on the independent T-test there was a significant difference between TDS, EC, chloride, sulfate and copper in autumn and winter (P<0.05). And there wasn't any significant difference between iron, zinc, lead and pH variables in different covered points with number 1 reservoir (in autumn and winter) (P>0.05). The mean and standard deviation of heavy metals (copper, lead, zinc, cadmium, manganese and iron in different covered points with number 2 reservoir in Nurabad city have presented separately in table3. Based on the Kolmogorov Smirnov Test, the lead (autumn), zinc (autumn and winter), iron (winter) have normal distribution and based on Kolmogorov Smirnov Test other variables don't have normal distribution. The results showed that the average concentration of iron in winter season was not in the national standard range of WHO (P>0.05). Based on the independent T-test there wasn't any significant difference between copper, cadmium, sulfate, chloride in two autumn and winter season (P>0.05). and based on the independent T-test, there was a significant difference between the pH, TDS, EC, iron and manganese in autumn and winter also there wasn't any significant difference between zinc and lead in autumn and winter (P>0.05).

Table-4: The results of evaluated chemical parameters in water resources of Nurabad city.

Water sample	Season	Cu	Pb	Zn	Cd	Fe	Mn
Water resource (7 wells)	Autumn	0.0164±0.0091	0.00098±0.0005	0.031±0.0196	0.0001±0.00009	0.109±0.0389	0.0315±0.0045
	Winter	0.0276±0.0232	0.001±0.0007	0.036±0.0242	0.0001±0.00009	0.108±0.0379	0.0714±0.097
The points covered by reservoir 1	Autumn	0.119±0.079	0.521±0.412	0.006±0.003	0.0001±0.00009	0.280±0.0272	0.045±0.022
	Winter	0.155±0.311	0.501±0.307	0.006±0.0006	0.0002±0.000016	0.446±0.216	0.05±0.017
covered by .	Autumn	0.141±0.084	0.0064±0.005	0.641±0.562	0.0001±0.00003	0.091±0.007	0.0368±0.012

	Winter	0.107±0.014	0.0075±0.0051	0.879±0.284	0.0002±0.00001	0.9±0.792	0.074±0.006
Standards	National	2	0.05	3	0.005	0.3	0.4
	WHO	2	0.01	3	0.003	0.3	0.4

Table5, represent the analysis result of related parameters to corrosion and sedimentation in terms of Rayzner and langelier index in autumn and winter of water resources and covered points with number 1 and 2 reservoir in the form of percentage. According to the table5, in water resources the highest percentage of langelier index in autumn and winter were (66.6, 100%) in sedimentation range respectively. Also the results showed that in covered points with number 1 and 2 reservoir in autumn and winter the most langelier percentage were (81.94, 95.83%) and (86.11, 100%) in sedimentation range respectively. Table3, showed the Rayzner index percentage in water resources and covered points with number 1 and 2 reservoir separately in autumn and winter. The results showed that the most cases of Rayzner index in autumn and winter in water resources of covered points with number1 and 2 reservoir were (100, 85.71%), (100, 100%) and (100, 100%) in the corrosion range respectively.

Table-5: Situation percentage Langelier index and Ryznar index in water supplies and water resource and distribution network in the Noor-Abad city.

Sample Location	Number of Samples		Langelier Index						Ryznar Index			
			Scaling		Neutral		Corrosive		Corrosive		Extremely Corrosive	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
Water resource (7 wells)	21	21	100	86.11	0	0	0	33.33	85.71	100	14.28	0
The points covered by reservoir 1	72	72	95.83	81.94	1.38	1.38	2.77	16.66	100	100	0	0

The points covered by reservoir 2	36	36	100	86.11	0	0	0	13.8	100	100	-	-

Table6, showed the analysis results of related parameters to corrosion and sedimentation of Puckoriusand aggressive index in the form of percentage which in the above points, 100% Puckoriusindex in autumn and winter were in the corrosion range and for the aggressive index based on the table it could be said that the highest percentage in water resources of covered points with number 1 and 2 reservoir separately in autumn and winter were (100, 85.71), (81.94, 98.61%), (100, 100%) in the average range of corrosion.

Table-6: Situation percentage Aggressive index and Puckorius index in water resource and distribution network in the Noor-Abad city.

Sample Location	**Number of Samples**		Aggressive Index						Puckorius Index			
			High corrosive		Without corrosive		Medium corrosive		Corrosive		Scaling	
	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter	Autumn	Winter
Water resource (7 wells)	21	21	0	4.76	0	9.52	100	85.71	100	100	0	0
The water distribution network(1)	72	72	0	0	1.38	13.82	98.61	81.94	100	100	0	0
The water distribution network (2)	36	36	0	0	0	0	100	100	100	100	0	0

Based on the Rayzner and Pokurious, aggressive index all the evaluated drinking water resources and number 1 and 2 reservoir of Nurabad city were corrosion in a way that based on the Rayzner index all the evaluated drinking water resources and number 1 and 2 reservoirs of Nurabad city were sedimentation. A study which have done by Dehghani et al. (2007) in Fars province showed that the langelier and Rayzner index in drinking water of Shiraz were in the range of 0.42 and 6.7 respectively. The researchers reported that 95% of experimented samples during the study have the sedimentation potential based on the langelier index. And based on the Rayzner index 82% of samples have balanced situation and 12% have corrosion potential (12) which were consistent with this study. In a study which have done by Zazouli et al. (2011) for evaluating the corrosion and sedimentation of Yasujs drinking water resources, the analysis results showed that the langelier, Rayzner, aggressive and Puckoriusindex amount in winter were -0.66 to 0.25, 8.48, 11.58 and 8.13 respectively which showed that most of the waters don't have a desire for sedimentation and they were corrosion (13). Also the results of Aiman et al. (2007) study about evaluating the drinking water quality and its potential for sedimentation and corrosion in Tafila province by langelier and Rayzner index showed that the langelier amount were negative and were in the range of -0.39 to -1.5 and the amount of Rayzner were 7.8-9.8 which showed the corrosion situation of water and this fact is attributed to the heating and evaporating with releasing CO2 (14) which was consistent with the results of present study. The results of Rezaei Kalantary et al. about evaluating the quality and determining the sustainability of drinking water resources in Qom villages showed that the langelier, Rayzner, aggressive and Puckorius index were -1.62, 10.5, 12.03 and 9.92 respectively (15). A study which have done by Taghipour et al. (2012) about evaluating the corrosion and sedimentation of drinking water in Tabriz city, concluded that the langelier, Rayzner, aggressive, and Puckoriusindex level were -0.79, 8.16, 11.6 and 8 respectively (16). Also the results of Asgari et al. (2015) about evaluating the technical quality and corrosion and sedimentation index of drinking water network in Booshehr showed that the average langelier index for corrosion was 0.28, Rayzner 7.24, aggressive 22.02 and Puckorius was 7.81 (17). In this study, the drinking water of Nurabad city based on the Rayzner index was a little sedimentation and other indexes showed the waters corrosion property. The results of Teimouri et al. (2012) showed that the langelier and Rayzner corrosion index for the KianShahr water were -0.68 and 8.52 respectively and this water have the corrosion property with the minor to sever condition (18). In a study which have done by Mokhtari et al. (2010) about evaluating the corrosion and sedimentation condition of drinking water distribution network of Ardebil by langelier and Rayzner index,

it was revealed that the water of water system in Ardebil have a desire for corrosion and the water quality control should have done based on the parameters such as pH regulation, alkalinity, hardness with the use of resistant material against corrosion in drinking water network and the results of this study is somehow similar to the present study (19).according to the obtained results of water situation in Nurabad city, it have been revealed that, although most of the related parameters to corrosion and sedimentation are in the standard range, but the drinking water resources and distribution network was not balanced. The aggressive index is a scale for waters desired for destruction of waters pipes which made by Asbestos cement. This index is usable for water pipes which made by asbestos cement and the temperature of 4-27 °c. if the aggressive index amount is less than 10 the water is almost corrosion, between 10-12 is corrosion and more than 12 is sedimentation which according to this researches results most of the water resources in Dehloran are almost corrosion. In the study of Ebrahimi et al. (2012) about evaluating the corrosion and sedimentation potential of drinking water resources in Koohdasht city by corrosion index, the results showed that water have corrosion property and control measures should have taken in the field of pH balance and water stabilization (20). Studying the results of Teimouri et al. (2012) research about evaluating the corrosion and sedimentation potential of KianShahr water by Rayzner and langelier index showed that the water have corrosion property (18). Based on the results of the present study the numerical mean of pH parameter in water resources of covered points with number 1 and 2 reservoir in autumn and winter were (6.83, 7.28), (7.31, 7.14), (7.34, 7.1) respectively which was in the range of national and environmental standard range. In general the water of Nurabad city was in the range of neutral to somehow corrosion. The soluble solids of water were in the ionic form and caused the increased of EC in water. The more waters soluble solids, or in other words the greater the amount of dissolved solids, water corrosion potential is increased and this corrosion potential become faster by increased of the EC and ionization (21). Based on the results of this study the numerical mean of TDS in the water resources, the covered points with number 1 and 2 reservoir in autumn and winter were (940.95, 344.23), (1199.34, 530.87), (962.43, 353.109) mg/lit respectively. The results showed that TDS of drinking water resources in autumn was in the national and environmental acceptable standard range. But in winter it wasn't in the environmental standard range and it was in the national standard range. Also the covered points with number 1 reservoir in winter wasn't in the national and environmental standard range. While, in the covered points with number 2 reservoir in winter it was in the national and environmental standard range. One of the reason for increased of TDS in winter could be the high level of ground water and increased of precipitation

during the sampling in comparison with autumn. The waters which contain chloride and sulfate ions prevent the protective CaCO3 layer formation in walls pipes by the hardness ions, therefore, they named corrosion ions and if their concentration in water was increase , the corrosion of water become more due to the CaCO3 protective layer forming (22). The sulfate concentration in water resources and covered points with number 1 and 2 reservoirs in autumn and winter were (48.47, 46.61), (49.41, 56.19), 48.78, 54.40) mg/l. based on the analysis results, sulfate parameter in water resources and covered points with number 1 and 2 reservoir in autumn and winter were in the national and environmental standard range. The results showed that the lead concentration in municipal water distribution network was increased in comparison with water resources in autumn and winter. One of the reason of lead concentrations increased in distribution network could be the existence of PVC pipes which contain lead and the lead ions could be exchanged with the Ca ions of drinking water. Lead pipes are not the only source of lead, because in the solder of copper pipes, the leads usually used. As a results it could have some effect on water qualities which exposed to this pipes. According to the facts that in water distribution network of this city, the PVC pipes were used, The statistical data analysis showed that in water resources and distribution network in autumn and winter the lead concentration was in the desirable range of national and WHO standards. In 2007 Johana evaluated the heavy metal concentration in water of 364 private wells in Batinay of Oman and its results showed the excessive increased of lead and chrome standards in 80% of these wells. The reason of contamination was the industrial activity of region and destruction of some regions reef because of climatic corrosion (23). The results showed that cadmium concentration in distribution network have increased in comparison with water resources in autumn and winter. Also according to the results, the cadmium concentration in water resources and covered points with number1 and 2 reservoir based on mg/l in autumn and winter were in the national and WHO standard range. Cadmium have found naturally in a few level in drinking water but higher amount of acceptable limit showed the environmental contamination such as waste water entrance or using chemical fertilizers in agriculture and entering them to the drinking water resources (24). According to the evaluation in this research the chemical and environmental contamination of water resources in this city have not observed but it may be one of the reasons for the increased of cadmium concentration in distribution network in comparison with water resources, and could be because of the existence of primary material in galvanized pipes and brass valves. The results showed that the numerical mean of copper concentration in drinking water distribution network in two autumn and winter season have increased. According to the

fact that in our country the application of copper pipes in distribution network and houses plumping is not common unlike the U.S, therefore, the only resources of copper in the studied cities was the brass valves and pipes (24, 25). And its existence in this study's samples could be because of the waters corrosion property and this metals leakage through corrosion of brass valves. In 2006 Aker et al. evaluate the heavy metals (copper, cadmium, lead) in the surface water of Mytilus sp. Region. The results showed that the concentration of these heavy metals in surface water in various time were different and the cadmium concentration was in the lower range. But the copper concentration in primary sampling was higher (26). The zinc metal in human body have found with high concentration in prostate, bone, muscle and liver. The half-life of residual zinc in human's body is one year. Zinc is an essential element for all the living organism. Some of the adverse effect of it are poisoning, fever, nausea, vomiting and diarrhea due to the consumption of acidic drinks or foods which prepared and stored in galvanized containers (3). The results showed that the zinc concentration in water resources in autumn and winter in comparison with distribution network was lower but due to their corrosion property and also maybe because of the existence of zinc in coated galvanized pipes and also brass valves and tube in internal network of houses, the zinc leakage to the water. Also the results showed that the zinc concentration in water resources and covered points with number 1 and 2 reservoirs in autumn and winter was in desirable national and WHO standard range. The hygienic risk of manganese in drinking water is rare and its adverse effect are almost related to aesthetic, taste, odor, turbidity and color.

The numerical means of manganese in autumn and winter due to the existence of DO in water resources were (0.071, 0.031) and the covered points with number 1 reservoir (0.05, 0.045) and with number 2 reservoir was (0.074, 0.036) mg/lit. In water distribution network the manganese transferred into water through the leakage of primary material of houses plumps (1, 3). The results showed that the manganese concentration in winter have increased in comparison with autumn and in distribution network have increased too which may be because of the primary materials leakage of houses plumping into water.

Conclusion

In general the results confirmed the corrosion and sedimentation potential of drinking water in Nurabad city. The results of corrosion and sedimentation index of water resources and distribution network in autumn and winter season showed that in langelier and Rayzner index, the corrosion percentage of water in winter have increased in comparison with water

resources which its reason could be the increase of TDS and EC in winter in comparison with autumn and also the low pH (in neutral range). But the important fact is that relying only on the analysis results of waters chemical quality and the consistency of some qualitative parameters or most of them with national and international (WHO, EPA) standards have not represented the real situation of water quality. The Results of this study showed that most of the parameters which related to corrosion and sedimentation have not amajor problem. But overall, according to the used index in water resources and distribution network, it caused the heavy metals leakage to water distribution network, due to the water corrosion, pipes, valves and tubes which used in water system and the possibility for creating problems in drinking water of Nurabad city have increased.

The best way for the studied water system is reducing the water corrosion, continuous control of pH, chlorination mechanism and using the valves and tubes and installations which are resistant to corrosion. Also due to the public health and high concentration of heavy meals in distribution network, it has suggested that the continuous and regulate monitoring have done on the drinking waters heavy metals concentration by the responsible organizations.

References

1. AllafpourHaghighi S, Mansourin N, Mirzaei N, AziziNahid, Hosseinei Z, Sharafi H, Sharafi K. Survey of corrosion and silting potential in drinking water of urban distribution system during one year period a case study. International Journal of Pharmacy & Technology. 2015 ; 7(3): 9701-9708.
2. Sharafi K, Karami A, Pirsaheb M, Moradi M. Physicochemical Quality of Drinking Water of Kermanshah Province. Zahedan Journal of Research in Medical Sciences. 2013;15(12):44.
3. Pirsaheb M, Khosravi T, Sharafi K, Babajani L, Rezaei M. Measurement of Heavy Metals Concentration in Drinking Water from Source to Consumption Site in Kermanshah—Iran. World Applied Sciences Journal. 2013;21(3):416-23.
4. Shahmansoori MR, PourmoghadasHossien, Shams Ghodrat. Survey of Micro Pollutant of Pipes Corrosion in the Water Distribution System. Journal of Research in Medical Sciences. 2003; 8(3):35-40.[Text in Persian]
5. Edwards M. Controlling Corrosion In Drinking Water Distribution System; A Grand Challenge For The 21St Century. Water Science & Technology. 2002; 49(2): 58-68.
6. Karbassi AR, NabiBidhendiGh R. Corrosion In Water Distribution System and Drinking Water Quality. Journal of Environmental Studies. 2000; 17: 24-33.

7. Schock M R. Internal Corrosion and Deposition Control. In Association AWW (Ed) Water Quality and Treatment: A Handbook of Community Water Supplies. Philadelphia; Mcgraw-Hill, 1999: 1–17.
8. Standard Methods for the Examination of Water and Wastewater. 21st Ed. American Public Health Association (APHA). WashingtonDC; 2005.
9. Torkian A. The hand book of the water and sewage tests,first Edition, Asfahan, Reseach `s assistance publication of Asfahan university of medical science, winter. 2000; 65-98. (In Persian).
10. United States Environmental Protection Agency(U.S.EPA). corrosion Manual for Internal Corrosion of Water distribution System.2nd. USA1984; p:11-81.
11. Rossum JR, Merrill DT. An Evaluation of the Calcium Carbonate Saturation Index. AWWA. 1983; 198
12. Dehghani M, Fayaz T, Tabatabaee H. Assessment of scale formation and corrosion of drinking water supplies in Shiraz. 11th National Conference on Environmental Health. Zahedan. 2006. (In Persian).
13. Zazouli1MA, BarafrashtehPour M, SedaghatF, Mahdavi Y. Assessment of scale formation and corrosion of drinking water supplies in Yasuj (Iran) in 2012. J MazandUniv Med Sci 2013; 23(Suppl-2): 29-35 (Persian).
14. Aiman E, Al-Rawajfeha, Ehab M, Al- Shamaileh. Assessment of tap water resources quality and its potential of scale formation and corrosivity in Tafila Province, South Jordan. Desalination 2007;206(1-3):322-332.
15. RezaeiKalantary R, Azari A, Ahmadi E, AhmadiJebelli M. Quality evaluation and stability index determination of Qom rural drinking water resources. Journal of Health in Field. 2013; 1(3): 9-16. (In Persian)
16. Taghipour H, Shakerkhatibi M, Pourakbar M, Belvasi M. Corrosion and Scaling Potential in Drinking Water Distribution System of Tabriz, Northwestern Iran. Health PromotPerspect. 2012;2(1):103-111 (In persian)
17. Asgari G, Ramavandi B, Tarlaniazar M, Fadaienobandegani A, Berizie Z. Survey of chemical quality and corrosion and scaling potential of drinking water distribution network of Bushehr city. ISMJ 2015; 18(2): 353-361. (In Persian).
18. Teimouri F, Sadeghi M, Drees F, Hashemi H, Shakeri K, Rezaei S. Survey of Corrosion or Scaling Potential of Resources, Storage and Distribution of Wate Supply System in Kian by using Langlier and Rizne Indexes. Journal Research Health. 2012; 8(1): 78-84. (In Persian).

19. Mokhtari S, Aliqadri M, Hazrati S, Sadeghi H, GHarari N, Ghorbani L. Evaluation of corrosion and sedimentation of drinking water in Ardebil city. Res Sci J Ardabil Univ Med Sci. 2010;1(1):14-23.
20. Ebrahimi A, Kamarehie B, Asgari G, Mohammadi AS, Roshanaei G. Drinking Water Corrosivity and Sediment in the Distribution Network of Kuhdasht, Iran. Resae Health Syst 2012; 8(3): 479-86. (In Persian).
21. Edwards M. EFFects of selected Anions on copper corrosion Rates. j. AWWA , vol 86, No.12, December 1994.
22. Johana B. Measurement of arsenic and manganese in underground water sources in bangladesh Cambodia. Water Research, 2007;36: 1211-1218
23. Vairavamoorthy K, Yan J, Galgale HM, et al. IRA-WDS: A GIS-based risk analysis tool for water distribution systems. Environ Model Softw 2007; 22: 951-965.
24. Aker F. Calculate the amount of heavy metals copper and cadmium and lead in surface water area Mytilus sp. Wat. Sci. Tech, 2006;75: 98-105.

Corresponding Author:
Abdollah Dargahi[*],
Email: *a.dargahi29@yahoo.com*