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SURVEY OF CORROSION AND SILTING POTENTIAL IN DRINKING WATER OF URBAN DISTRIBUTION SYSTEM DURING ONE YEAR PERIOD A CASE STUDY

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Abstract

One of the main problems in urban and rural water distribution systems is corrosion and silting which occurs during physicochemical reactions in transmission and distribution tubes and decreases the water quality and reduces facility`s lifetime. The aim of this research is determination of corrosion and silting potential of the drinking water of Kermanshah city in distribution system during one year period (2014). This is a cross-sectional study that carried out by Langelier and Ryznar stability indexes to determinate corrosion and silting potential of water in the distribution system of Kermanshah city. For measuring above indexes in water of distribution system of Kermanshah, seven different regions of this city are chosen randomly. The samples were taken in these 7 regions during 3 months. Total dissolved solids, calcium hardness, total alkalinity, water temperature, pH, pHs, Langelier and Ryznar stability indexes were measured. Simple sampling according to standard method instruction was used. The results demonstrate that mean and standard deviation is -0.28 and -0.09 for Langelier index, 7.57 and 0.57 for Ryznar index, respectively. Survey of these indexes indicate that drinking water of Kermanshah city is corrosion so water quality of distribution system needs to monitored and necessary actions for controlling the corrosion have to perform.

Keywords: Corrosion Potential, Silting, Drinking Water, Urban Distribution System, Langelier Indexes, Ryznar Indexes.

Introduction: One of the considerable factors in water quality is corrosion or silting of water. According to ISO 8044 standard, corrosion is a physicochemical reaction between metal and environment which causes changing in

properties of metal, leading to damage on metal`s duty, environment or their technical system (1). When corrosion water passes through the distribution system`s tubes and plumbing houses, corrosion's by-products such as lead, cadmium, copper, iron, zinc and manganese are entered into the water. Increasing in the concentration of these metals make health, aesthetic and economic problems including reduce the lifetime of tubes, pumps and it`s appurtenances and increase of lost water in distribution systems (2). Corrosion of distribution system`s main iron tubes, causes deposition of iron which is called Tubercool. Tubercool protects the microorganisms against residual chlorine, then water pressure and velocity in main tube release these microorganism into the water leading to emission various diseases. Corrosion of water also causes color, taste and odor. Dissolving the iron of main iron tube by corrosion water produce red water. Soluble iron is a nutrient for a group of microorganisms, are called iron bacteria, which are the reason of water`s odor and taste. Corrosion of copper tubes lead to producing water with metal taste and makes blue green stains in WCs, bathtubs and washing machines. Unstable water has so much cost for water distribution system and consumers. Corrosion water significantly reduces the lifetime and increases the operation cost of pipe fitting and unshielded asbestos-cement or metal tubes in water distribution system of city and houses (3, 4). Generally corrosion is a destroyer and costly phenomenon which wastes a vast part of capital country every year (5). Corrosive drinking water makes internal corrosion and corrosive soil and humidity make external corrosion (6-8). In one hand, tube`s internal corrosion decreases the lifetime of facilities, In the other hand through the producing Red water leads to decrease drinking water quality (9). An important factor which always considering is entering lead into water through corrosion, because lead is a toxic and cumulatively element, it is also prevent the activity of hemoglobin's producer enzymes(10). It`s symptoms like anemia and neurological disorders are proven. It also delays physical and mental development in newborns and children (11). Among the other entered pollutant into the water through tube`s corrosion, we can mention to arsenic which causes neurological disorder, anorexia, skin and lung cancer, selenium that creates liver and kidney diseases and causes digestive disorders, and finally continuous use of copper causes liver damage (8, 12, 13). Silting blocks the tubes, decreases water velocity in system and external flow rate, impacts on valves efficiency and water quality, contrast influence on corrosion, microorganisms` growth and permanent and sectional tension (1, 14). Sediments may cause decrease of heat transfer or local increase of heat transfer in heat converters and destroy some parts of system. According to the above mentioned this study Surveys of corrosion and silting potential in drinking water of urban distribution system in a metropolis (Kermanshah) during one year (2014) period to provide necessary corrective solutions for solving possible problems in drinking water of the city.

Materials and Methods

Kermanshah`s drinking water is daily provided by 110 wells, 2 springs and some aqueduct. This is a cross-sectional study that carried out by Langelier and Ryznar stability indexes to determinate corrosion and silting potential of water in Kermanshah city`s distribution system. For measuring above indexes in water of Kermanshah`s distribution system, seven different regions of this city are chosen randomly. The samples were taken in these 7 regions during 3 months. Total dissolved solids, calcium hardness, total alkalinity, water temperature, pH, pHs, Langelier and Ryznar stability indexes were measured and Simple sampling according to standard method instruction were used (15).

Temperature and pH by HACH portable device in sampling location and other parameters according to standard method in laboratory were tested (16). For measuring Langelie and Ryznar stability indexes following equation were used. Water`s real pH (pH) and water saturated with calcium carbonate (pHs) were obtained from this equation (Equation 1).

$$pHs = \left[(9.3 + A + B) - (C + D)\right] \qquad (1)$$

In Equation 1:

A is Total dissolved solids (mg/l)

B is Temperature ($_0$C)

C is Calcium hardness (mg/l-$CaCO_3$)

And D is alkalinity (mg/l-$CaCO_3$) (11)

After that Langelier and Ryznarstability indexes was obtained by Equation 2 and 3 respectively:

$$LI = pH - pHs \qquad (2)$$

$$RI = 2pHs - pH \qquad (3)$$

pH: water`s real pH

pHs: saturated water with calcium carbonate

LI: Langelier index

RI: Ryznar index (17)

Results are evaluated according to national and international standards, then water condition in terms of corrosion and silting was identified.

Results

In term of determination corrosion and silting condition in Kermanshah city`s water, totally 70 sample in 7 regions (10 sample in each region) and 8 qualitative parameters for each sample was measured. The data are showed in table 1. Results are analyzed by Excel 2003 and Water stability Analyzer software; results are showed in table 2, Figure 1 and Figure 2.

Table-1: minimum, maximum, mean and standard deviation of measured parameter in Kermanshah city`s drinking water.

Measured parameter	Unit	Maximum	Minimum	Mean	Standard deviation	Iran standard		EPA Standard (MCL)
						Desirable value	Allowable value	
Temperature	$_0$C	28	20	23.42	3.4	-	-	-
pH	-	7.4	7	7.16	0.13	7-8.5	6.5-9	6.5-8.5
Total dissolved solids	mg/l	393	212.39	314.62	61.98	500	1500	500
calcium hardness	mg/l $_{CaCO3}$	188	104	158.85	28.72	-	-	-
total alkalinity, water	mg/l $_{CaCO3}$	228	136	181.14	25.97	-	-	-
pHs	-	7.7	6.93	7.36	-	-	-	-
Langelier stability index(LI)	-	-0.19	-0.49	-0.28	0.1	-	-	-
Ryznar stability index(RI)	-	8.18	6.66	7.57	0.57	-	-	-

Table-2: Corrosion and silting condition of drinking water in seven studied regions of Kermanshah city.

Region Name	Langelier index	Condition	Ryznar index	Condition
Maskan	-0.49	Corrosive	8.18	Corrosive
Elahie	-0.3	Corrosive	8	Corrosive
Taghbostan Blvd.	-0.27	Corrosive	6.66	Corrosive
Shariati	-0.21	Corrosive	7.52	Corrosive
Kasra	-0.24	Corrosive	7.48	Corrosive
Bahar	-0.19	Corrosive	7.58	Corrosive
Dolatabad	-0.3	Corrosive	7.6	Corrosive
Maximum	-0.19	Corrosive	8.18	Corrosive
Minimum	-0.49	Corrosive	6.66	Corrosive
Mean	-0.28	Corrosive	7.57	Corrosive

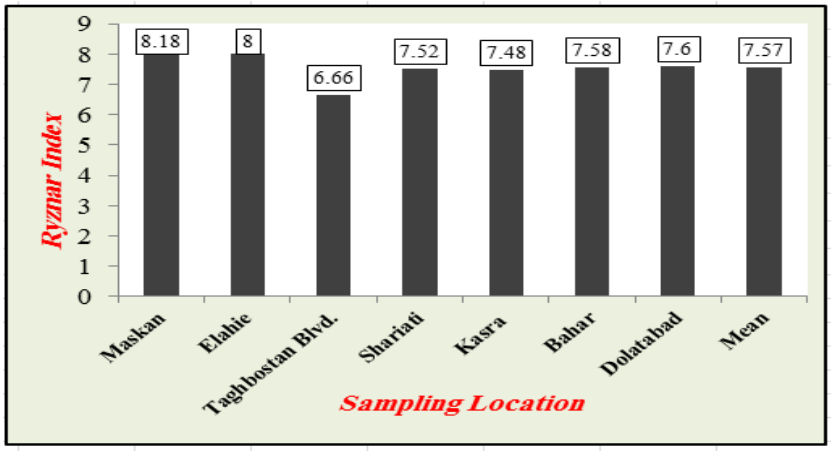

Figure-1: Ryznar index for water distribution system of studied regions.

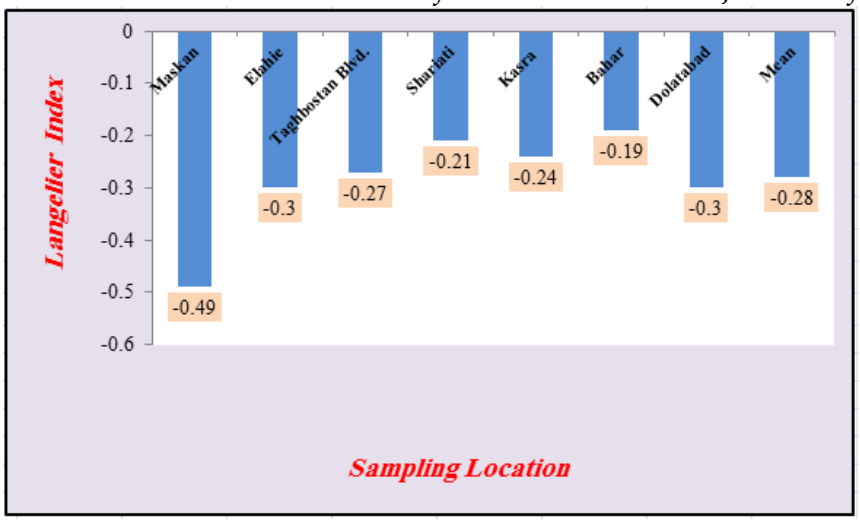

Figure-2: Langelier index for water distribution system of studied regions.

Discussion

Water corrosion and silting is one the important issues which needs more accuracy in water distribution systems monitoring, because neglecting the water chemical quality in term of chemical balance and appearance either of these phenomena make a lot of health and economic damages. According to table 1 mean and range of pH in Kermanshah city`s water are 7.16 and 7-7.4, respectively which it means the water is stable and it`s pH matches with Iran standard and Environment Protection (EPA) that could help to control the water corrosion and silting. Results of Langelier and Ryznar indexes, which have more application than other indexes, show that all the 7 regions of Kermanshah have corrosive water and none of them have silting property according to these indexes. The corrosion property of regions are not similar though, some of them are more corrosive (e.g.; Maskan) and some are less (e.g; Bahar). Results of Ryznar index show that all the 7 regions of Kermanshah have corrosive water. Minimum and maximum quantities of this index are 6.66 for Taghbostan and 8.818 for Maskan, respectively. It is exactly match with Langelier index. Both indexes introduce Maskan as the region where has the maximum corrosive water (diagram 1 and 2). Ghezavati M, et.al in the survey of chemical quality and corrosion potential of internal and produced drinking water in Abas port`s refinery, concluded that three samples (the port`s water, refinery produced and mixture of port`s water and freshwater) in this port are corrosive. They also suggested some prevention measures such as continuous monitoring, use of corrosion`s control materials and appropriate support for tubes (18). Hosaeini et.al in a case study to survey of corrosion and silting indexes of drinking water in west regions of Iran, analyzed corrosion and silting condition in different temperatures (15,20,25 $_0$C) and concluded that Ryznar or saturation index (7.52, 7.7, 7.96) is out of the balance range (6-7) and it demonstrate the corrosion of water. Langelier index (-0.18, -0.07, -0.04) was in a acceptable range (±0.5) and it shows that the water is balance and its ultimate pH doesn`t need modification (19). Aghapor A and mohamadi Boini A in a survey of corrosion and silting in effluent of Orumie number 1 refinery

in 2008, concluded that the water according to Langenier index is silting and according to Ryznar and Pocorius indexes is corrosive. Considering to water volecity (more than 0.6 m/s) and pH (more than 8), They recognized that Rizner and Pocorius indexes are more acceptable and emphasized the corrosive of water (20). An article in Fars (2007) which was written by Dehghani et.al has shown that RSI and LSI indexes in Shiraz city`s drinking water is 0.42 and 6.7, respectively. Researchers has reported that 95% of tested samples during the study had silting potential according to LSI index, and according to RSI index 82% of samples had balance condition and 12% of them was silting. Because of the relation between land cover and chemical quality of water, the lime lands around the water resources increase silting and hardness of water. This condition in some points of country is expectable and causes relative difference with the results of this study (21).

Conclusion

According to Langelier and Ryznar indexes data, water of Kermanshah city is corrosive and this corrosion could increase dissolving of heavy metals such as lead, cadmium, zinc and copper into the water and could be a threat for citizen`s health. In terms of both Langelier and Ryznar indexes that exactly emphasize the corrosion of water, to protect the presence system and prevent healthy and economic damages of corrosion issues, the water of distribution system should studied continuously through these indexes. Also some protective actions to prevent corrosion have to perform.

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