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Survey of Corrosion and Scaling Potential Produced Water from Ilam Water Treatment Plant

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Abstract: Corrosion causes metals delivering (conduit materials) into the conveyed liquid. If the corrosion be very rapid, it will cause pipes cavitation. Then, the intrusion of contaminants into the pipes result in negative suction and if the water has been scaling tendency, a scale layer will introduce, then induce internal scaling and reduce convey potential in pipes. The aim of this research was determining the corrosion potential of produced water in Ilam Water Treatment Plant during 2007 to 2008. For this reason the measures of temperature and pH determined by pH meter model E520 manufactured of Switzerland at site and determining of Total Dissolved Solids, calcium hardness, calcium, total alkalinity and bicarbonate concentration had done in laboratory according to standard method manual. Values of pHs, Langlier Saturation Index, Ryznar Stability Index, Aggressiveness Index, Puckorius Scaling Index and Larson Ratio, calculated twice at month during 12 months between 2007to2008. The calculated results showed that the mean and Standard Deviation values of Langlier Saturation Index, Ryznar Stability Index, Aggressiveness Index, Puckorius Scaling Index and Larson Ratio are equal to 0.29 and 0.5, 7.45 and 0.17, 12.44 and 0.16, 7.99 and 0.14 and 0.77 and 0.1, respectively. By survey of corrosion indexes, it founded that produced water from Ilam water treatment plant has average corrosion potential. By comparing of the quality parameters produced water from Ilam Water Treatment Plant with available standards, it's founded that the average concentration for Ca^{++}, $SO4^{--}$, Cl^{-}, TDS, hardness and pH is in the range of Iran and EPA water quality standards.

Key words: Corrosion potential · Scaling · Corrosion index · Ilam city · Dinking water

INTRODUCTION

Ilam city is center of Ilam province. It is located at a height 1319 m above the mean sea level. It is located in the west of Iran at altitude of 31°58′ to 34°15′ and longitude of 45°24′ to 48°10′ east. According to demographic information of Iran demography organization 1n 2007 the Ilam city has 199516 population. The water requirement of this city is produced by three sources: Chamegardelan dam (about 60%); GolGOl River and Ghooch Ali well (about 40%). According to investigation the water requirement of this city to 2025 would equal to 914 l/s. sometimes at peak consumption (special warm seasons), in many part of the city (special altitude zones) occur cutoff the water flow. Therefore many of people for remove this problem, use of special can or container with 2-4 m^3 capacity. This condition creates negative suction in distribution network so induce health problems relative with it. Although nearby all the city is covered by distribution network because increase of population, migration (according to demographic information of Iran demography organization in 2007 announced about 40800 person within 1997-2007) and decrease of source water, this city would affront water crisis special at warm season. Although the quantity of produced water mentioned at above, because inadequate condition of distribution network design, the rate of unaccountable water is equal to about 20-25% [1].

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In Langlier Saturation Index (LSI) to specify the pHs, must be determined the effect of calcium, total alkalinity, TDS and temperature. In LSI equation the measure of pHs subtracting of actual pH. Based on this equation, water with positive LSI tended to be scaling and with negative LSI the water calcium carbonate tended to be soluble [2, 3]. In Ryznar Stability Index (RSI) the measure of pHs determined by actual pH, Concentration of calcium, bicarbonate, TDS and temperature. In this equation the number less than 5 creation scaling, within 5-7 little scaling or corrosion and more than 7 tended to corrosion [3]. Aggressiveness Index (AI) is used for Asbestosis cement pipelines (with temperature within 4-27°C). This index based on effects of pH, calcium concentration and alkalinity. The water with AI measures less than 10 are heavy corrosive, within 10-12 are approximately corrosive and more than 12 are scaling [4]. The Pockurius Scaling Index (PSI) is based on buffer capacity. And it is explanatory of the maximum quantity of scale that may to bring in water. Then in this index the use of equilibrium pH (pH_{eq}) is more than actual pH. This index is practical scaling index. The number resulting from this index is similar to RSI, so a value less than 5 shows that the water intended to be scaling and a number greater than 7 show that the water tended to be scaling if exist any scaling [5]. The Larson Ratio (LnR) is a practical index too. It used for potential impacts on iron pipe corrosion result in chloride (Cl^-) and sulphate (SO_4^-). For calculation the corrosion potential by this equation; the concentration of carbonate and bicarbonate is necessary. Waters with LnR less than 0.2 are considered no potential for corrosion; LnR 0.2 to 1 are considered medley corrosive; and more than 1 considered highly corrosive [6].

Corrosion cause delivering the metals (pipeline materials) to the conveyed flow. When the corrosion is rapid, it may cause of pipes cavitation. Then during the negative suction, will raise the intrusion potential of contamination to the pipelines. Also in this condition unaccountant water will increase. When the water tended to be scaling, during the time create thin layers in the internal parts of pipes then increase internal diameter, at result the conveyed flow will diminish. Moreover physical and chemical parameters, microbial biofilms can create corrosion too (microbial corrosion). Depend on corrosion and scaling agents, suitable methods can be used for eliminating these problems. For notability corrosion and scaling and great costs for eliminating these problems, libratory and field tests exist for calculating the corrosion and scaling potential [7].

MATERIALS AND METHODS

The aim of this study is determining the corrosion and scaling potential of produced water from Ilam water treatment plant during 2007-2008 based on Langlier Saturation Index (LSI), Ryznar Stability Index (RSI), Aggressiveness Index (AI), Pockurius Scaling Index (PSI) and Larson Ratio (LnR). For this reason the measures of temperature and pH determined by pH meter model E520 manufactured of Switzerland at site and determining of Total Dissolved Solids (TDS), calcium hardness, calcium, total alkalinity and bicarbonate concentration had done in laboratory according to standard method manual. Values of pHs, LSI, RSI, AI, PSI and LnR, calculated twice at month during 12 months between 2007 to 2008.

For determining the LSI and RSI, first must be determine the measures of pH and pHs. The value of pH and pHs are obtained by equation 1:

$$pHs= \{(9.3+A+B)-(C+D)\} \quad (1)$$

A= TDS (mg/l), B= Temperature °C, C= Calcium Hardness (mg/l CaCo3), D= Alkalinity (mg/l CaCo3) [2].

After calculating of pH and pHs, the value of LSI and RSI obtain by using of equations 2 and 3, respectively.

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

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

pH: actual pH of water, pHs: pH of water at Carbonate Calcium saturation condition, LSI: Langlier saturation Index [7] , RSI: Ryznar Stability Index [3].

For calculating the Aggressiveness Index using of equation 4:

$$AI= \{pH + \log [(A) (H)]\} \quad (4)$$

AI= Aggressiveness Index, A: Total alkalinity (mg/l $CaCO_3$), H: Calcium hardness (mg/l $CaCO_3$) [4].

Values of Pockurius Scaling Index are obtained by equation 5 and 6:

$$PSI=2pHs-pHeq \quad (5)$$

pH_{eq}= pH of water at equilibrium condition

$$pH_{eq}= 1.465+ \log (T.ALK) + 4.54 \quad (6)$$

T.ALK= Total alkalinity,
PSI: Pockurius Scaling Index [5].

Values of Larson Ratio are computed by using of equation 7:

$$LnR = \frac{[Cl^-] + 2.[SO_4^{2-}]}{[HCO_3^-]} \quad (7)$$

$[Cl^-]$ = Concentration of chloride ions in [mg/l],
$[SO_4^{2-}]$ = Concentration of sulfate ions in [mg/l],
$[HCO_3^-]$ = Concentration of the bicarbonate ions in [mg/l],
LnR = Larson Ratio [6].

The collected data were analyzed by use of the SPSS16.0 and Microsoft Excel software packages for determining the corrosion and scaling indexes.

RESULT AND DISCUSSION

For determining the water corrosion and scaling potential of Ilam Water Treatment Plant, we have measured water quality parameters include; temperature, pH, total alkanity, total hardness, calcium, sulfate and chloride concentration and total dissolve solid. The maximum, minimum, mean and standard deviation values of these parameters have been shown in Table 1.

Then was calculated the corrosion and scaling indexes (Langlier Saturation Index (LSI), Ryznar Stability Index (RSI), Aggressiveness Index (AI), Pockurius Scaling Index (PSI), Larson Ratio (LnR)) per month during the 2007 to 2008 by use of above equations.

After calculation of data the mean and standard deviation of Langlier Saturation Index (LSI) was equal to 0.29 and 0.15, respectively (Fig. 1). Results also show that the mean and standard deviation for Ryznar Stability Index (RSI) was equal 7.54 and 0.17, respectively (Fig. 2). Obtained results showed that the mean and standard deviation for Aggressiveness Index (AI), Pockurius Scaling Index (PSI), Larson Ratio (LnR) was equal to 12.44 and 0.16 (Fig. 3), 7.99 and 0.14 (Fig. 4), 0.77 and 0.1 (Fig. 5), respectively. Table 2 show the produced water condition of Ilam water treatment plant from view point corrosion and scaling indexes.

Corrosion and scaling may cause of pipe blocking. At result may reduce the flow and create some other problems in the pipelines. It can also damage the pipeline. If it occurs, water leakage increases and so water loss will be high [7]. By calculation of corrosion indexes and based on Langlier Saturation Index (LSI) and Ryznar Stability Index (RSI) which are being used more than other

Table 1: The values of max, min, mean and S.D of measured parameters in produced water from Ilam Water Treatment Plant

	Parameter	Max	Min	Mean	Standard deviation	EPA standard(MCL)	Iran standard
Measured parameters	Temperature (°C)	18	12	13.95	2.17	-	-
	pH	8.45	7.58	8.12	.14	6.5-8.5	6.5-8.5
	Calcium concentration (mg/l)	67.2	52.8	60.43	3.56	-	75-200
	Sulfate concentration (mg/l)	103.8	60.5	82.91	0.14	250	200-400
	Chloride concentration (mg/l)	17.8	7.81	12.01	2.49	250	200-600
	TDS (mg/l)	332	281	2.95	1.08	500	500-1500
	Bicarbonate concentration (mg/l)	176.9	149.4	163	7.49	-	-
	Calcium hardness (mg/l $CaCo_3$)	168	132	151.1	8.91	-	-
	Total Alcanity (mg/l $CaCo_3$)	147.5	125	136.4	6.48	-	-

Table 2: The condition of produced water from Ilam Water Treatment Plant in view of scaling and corrosion indexes

Month	Langlier Saturation Index (LSI)	Ryznar Stability Index (RSI)	Aggressiveness Index	Pockurius Scaling Index (PSI)	Larson Ratio(LnR)
Mar	Balance	Relative corrosion	Balance	Relative corrosion	Moderate corrosion potential
Apr	Balance	Relative corrosion	Balance	Relative corrosion	Moderate corrosion potential
May	Balance	Relative corrosion	Balance	Relative corrosion	Moderate corrosion potential
Jun	Balance	Relative corrosion	Balance	Relative corrosion	Moderate corrosion potential
Jul	Balance	Balance	Balance	Balance	Moderate corrosion potential
Aug	Balance	Balance	Balance	Balance	Moderate corrosion potential
Sep	Balance	Light corrosion	Balance	Light corrosion	Moderate corrosion potential
Oct	Balance	Light corrosion	Balance	Light corrosion	Moderate corrosion potential
Nov	Balance	Light corrosion	Balance	Light corrosion	Moderate corrosion potential
Dec	Balance	Light corrosion	Balance	Light corrosion	Moderate corrosion potential
Jan	Relative scaling	Balance	Balance	Balance	Moderate corrosion potential
Feb	Relative scaling	Balance	Balance	Balance	Moderate corrosion potential

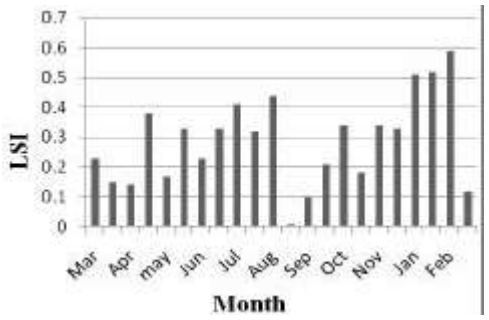

Fig. 1: Values of Langlier Saturation Indexes vs. months of year

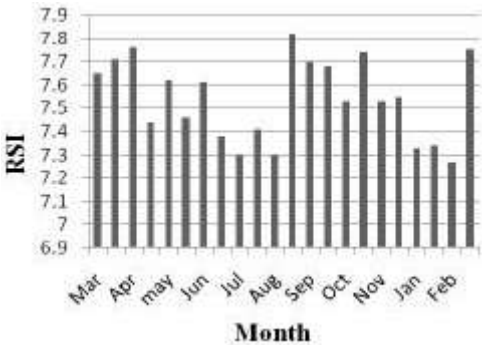

Fig. 2: Values of Ryznar Stability Indexes vs. months of year

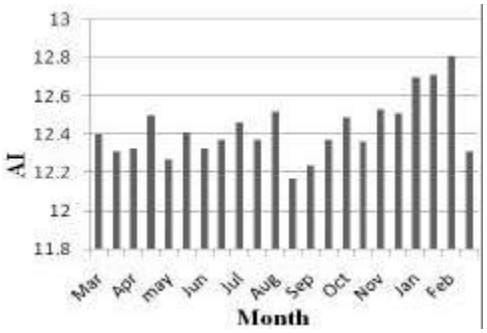

Fig. 3: Values of Aggressiveness Indexes vs. months of year

corrosion indexes, founded that the produced water from Ilam Water Treatment Plant was in balance or tended to be corrosive (Table 2). According to the Aggressiveness Index (AI) which was used more for cement-asbestosis pipes, the produced water from Ilam Water Treatment Plant was in balance or tended to be scaling. Pockurius Scaling Index (PSI) which was used for the waters which having pH more than 8 is better and more reliable than other indexes[5]. Since pH of the produced water from Ilam Water Treatment Plant is more than 8 so using it is better

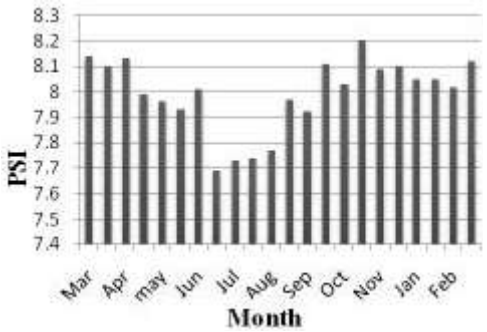

Fig. 4: Values of Puckorius scaling Indexes vs. months of year

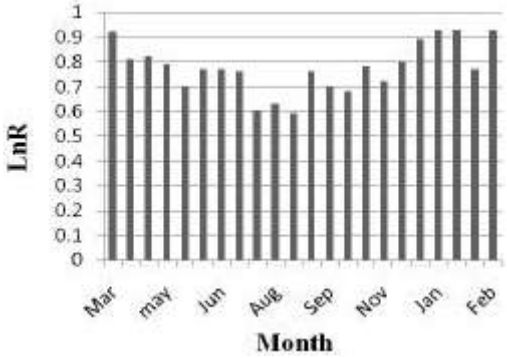

Fig. 5: Values of Larson Ratios vs. months of year

than other indexes. The results of Pockurius Scaling Index (PSI) showed that the produced water from Ilam Water Treatment Plant was in balance or tended to be corrosive.

Larson Ratio is a new index which is used in many parts of the world for determining the water corrosion potential. This index is based on measures of chloride and sulphate concentrations. It used for determining the corrosion potential of metallic pipes. The results of Langlier Saturation Index (LSI) showed that the produced water from Ilam Water Treatment Plant had a moderate corrosion potential. Corrosion of water distribution systems provide a condition to entering the harmful pollutants such as cadmium, copper, lead and some other into the water which have harmful health effects [8]. Water scaling causes gastrointestinal disorders. Water scaling can also reduce the internal diameter of the water pipes. So the pipe will not transfer the expected capacity of water. Therefore it is necessary to repair or to replace the water distribution facilities which need high economic costs [9].

According to studies of Savari *et al.,* during to 2004-2006 on Ahvaz city drinking water, he founded that this water tended to be corrosive and may be because the intrusion of pollutants to distribution network [12].

Lowental *et al.,* (2004) in South Africa remarked that scaling and corrosion are conventional problems in groundwater convey pipelines and distribution networks that the mechanism of them is related to either quality and material of pipeline [13]. Also Nikpoor *et al.,* (2006) in study on distribution network corrosion indexes of Behshahr water, founded that the Langlier Saturation Index of distribution network water of this city lean to be equilibrium and making a thin layer of carbonate calcium and Ryznar Stability Index shown that this water tended to be light corrosive [14]. Also poorzamani *et al.,* (2006) investigated upon corrosion potential of Oshtrojan industrial area groundwater and measured temperature, pH, calcium hardness, alkalinity and TDS at 5 locations and 125. In comparison of results expressed that; first the groundwater lean to corrosion but during the route decrease the corrosiveness properties and almost reached to scaling condition. Results were shown that the industrial activities affected on the quality water of this region [15].

CONCLUSION

By comparing the water quality parameters to the current standards founded that the mean value of water temperature was in the range 12- 18°C which is in standard rang. The mean value of pH for produced water from Ilam Water Treatment Plant was 8.12. This is in the Iran and EPA (6.5-8.5) drinking water guidelines [10, 11]. The mean value of calcium during the sampling was 60.34 mg/l. Therefore is lower than Iran drinking water guidelines (250 mg/l) [10, 11]. The mean concentrations of sulphate and chloride were 82.9mg/l and 12.01 mg/l, respectively. Thus it is lower than drinking water guidelines [10]. The mean value of Total Dissolved Solids was 295 mg/l which is less than Iran and EPA drinking water guidelines [10, 11]. Although there has no any standard for hardness in view of health, but there has standards for hardness in view of engineering and economic aspects (a maximum permissible level is 500 as mg/l $CaCO_3$). By comparison of hardness standards it was seen that produced water from Ilam Water Treatment Plant was in standards range.

By survey of corrosion indexes it was founded that the most of these indexes in produced water from Ilam Water Treatment Plant have moderate corrosion potential.

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