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Quality Evaluation of Drinking Water in Softening Plant at Libyan Iron and Steel Company

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Abstract— **The evaluation of quality for drinking water produced in softening plant of Libyan Iron and Steel Company in Misurata were studied at four sites in distribution network form January to June 2013. Some physicochemical parameters were measured such as, Temperature, EC, pH, TH, Ca-H, Cl^{-1}, SO_4^{-2},TA ,HCO_3^{-1} and Fe. These parameters used in indices calculation in this study.**

Fives indices such as Langlier Saturated Index (LSI), Ryzer Stability Index (RSI), Puckorius Scaling Index (PSI), Larson-Skold Index (LI) and Aggressive Index (AI) are used to know the state of equilibrium in water inside the network. LSI ,RSI ,PSI ,LI and AI, calculations assigned that water was not able to form precipitate, which might be a cause of corrosion inside the pipes.

***Index Terms*—: Water stability Indies, Drinking water, Corrosion scaling**.

I. INTRODUCTION

Scaling and corrosion potential are one of the most important indices in water quality evaluation [1]. Occurrence of corrosion may create disorder in economy of water and wastewater industry. In addition, corrosion produces by-products in water leading to health problems and reduction of water pipe life time [2],[3]. According to World Health Organization guideline, corrosion control is an important aspects of providing safe drinking water [4]. Corrosivity of water related to its pH, alkalinity, hardness, temperature, dissolved O_2 ,CO_2 ,TDS and other physicochemical and biological factors[5].

Kemmer etc [6] reported that corrosion have an effects in drinking water especially a change in color. Dee and Sarnato [7] showed that corrosion process inside metal pipes elevated with pH decrease, increase in flow rate, increase in temperature and increase in % suspended materials such as sand and soil. In addition the change in odor and color of water assigned the presence of corrosion. The study by Sarin [8] proved that, increasing in pH of water effected the liberation of Fe in water and ultimately cause the lowering the solubility of $Fe(OH)_2$ and $CaCO_3$ in water. Yau Zang [9] study proved that, the free Cl_2 control the red-water and microbial activity in water pipes. Also, he reported that the study of bacterial activity was important in corrosion study and considered a great challenge in water different fields. The study was done by Shams. etc. [10] assigned that water might have natural equilibrium or tendency for formation precipitates or aggressive leading corrosion. The water nature could be identified by LSI and RSI calculations. Hoseninzadeh.etc [11] showed that the application of indices calculation for corrosion was necessary at performing the analysis of physicochemical parameters of water for evaluation of water quality. This protected the puplic health and economic sites.

The object of this study was to evaluate the quality of drinking water in softening plant of Libyan Iron and Steel Company and using calculation of indices as a monitor for evaluation of extent of corrosion and scaling .In addition ,this could be gave an explanation of changing the color in drinking water.

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II. MATERIALS AND TECHNIQUES

Water samples collection was carried out according to APHA standard [1]. In this study 24 samples of drinking water were taken from four different sites in water distribution network, one in each site for 6 months from January to June.

Some physicochemical parameters such as temperature, electrical conductivity(EC), pH, total dissolved solid(TDS), total hardness(TH), calcium-hardness(Ca-H), total alkalinity(TA), bicarbonate(HCO_3^-), chloride(Cl^-) , sulfate(SO_4^-) and Fe were determined according to procedures in APHA standard[1]. Temperature measured by thermometer (1-100 C^o), EC by Jenway model 4310, pH by Jenway model 3320, TDS by Jenway model 4070, while $SO_4^-$and Fe measured by colorimeter DR 890. The HCO_3^- only calculated by following equation:

HCO_3^- = TA-5.0 x $10^{(PH-10)}$ / 1 + 0.95 x $10^{(pH-10)}$. The corrosion study and scaling potential of drinking water were calculated by LSI, RSI, PSI, LI and AI. The indices equations, results and their indications are illustrated in Table I. Also, pH_s can be calculated by obtaining the values of A, B, C and D from table I.

Tables and Figures

Table.I: Summary of water stability indices in present study[12].

Index	Equation	Index value	Water condition
LSI	LSI= pH_s – pH	LSI<0	Under saturated with respect to $CaCO_3$.
		LSI=0	Considered to be neutral.

		LSI>0	Supersaturated tend to precipitate $CaCO_3$.
RSI	RSI=2pH$_s$ – pH	RSI<6	Supersaturated tend to precipitate CaCO3.
		6< RSI <7	Saturated, CaCO3 is in equilibrium.
		RSI >7	Under saturated tends to dissolve CaCO3.
PSI	PSI=2pH$_s$ - #pH$_{eq}$	PSI< 6	Scaling is unlikely to occur.
		PSI> 7	Likely to dissolve scale
LI	LI= $(Cl^-+SO_4^=)/(HCO_3^-+CO_3^=)$	LI< 0.8	Cl^-,$SO_4^=$ are likely to interfere with formation of protecting film.
		0.8< LI< 1.2	Corrosion rates may be higher than expected
		LI >1.2	High rates of localized corrosion may be expected.
+AI	Log[(Ca-H)(TA)]+pH	AI >12	Non-aggressive.
		AI=10-11.9	Moderately -aggressive.
		AI <10	Very aggressive.

*pH$_s$=[(9.3+A+B)-(C-D)], pH$_s$=pH at saturation in calcite, A=[log$_{10}$(TDS)-1]/10 B=-13.2xlog$_{10}$(C°+273)+34.55, C=log$_{10}$(Ca-H)-0.4 , D=log$_{10}$(TA) , Ca-H=Calcium hardness TA=Total alkalinity ,#pH$_{eq}$=1.465+log$_{10}$(TA)+4.54, +Asbestosis cement pipe lines only.

Table.II The results of measured parameters and indices calculations.

Item / Parameter	Max.	Min.	*Mean	*Standard Deviation
Temp. °C	31.3	22.0	26.9	4.80
pH	8.4	7.8	8.1	0.10
TDS mg/l	199	154	182	7.09
Ca-H mg/l	74.7	28.3	59.0	6.56
TA mg/l	55.6	20.8	35.9	8.78
HCO_3^- mg/l	55.1	18.3	35.0	8.74
Cl^- mg/l	59.3	35.1	44.9	4.90
LSI	0.05	-0.97	-0.49	0.23
RSI	9.7	8.3	9.1	0.40
PSI	7.1	6.5	6.9	0.17
LI	0.8	1.7	1.4	0.25
AI	11.8	10.9	11.4	0.173

*Mean values of six months for four studied sites. Note- No sulfate detection was observed.

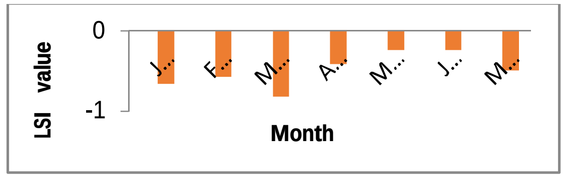

Fig.1: The values of LSI from January to June and the mean

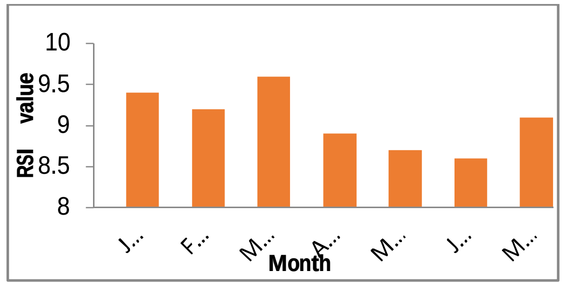

Fig. 2: The values of RSI from January to June and the mean.

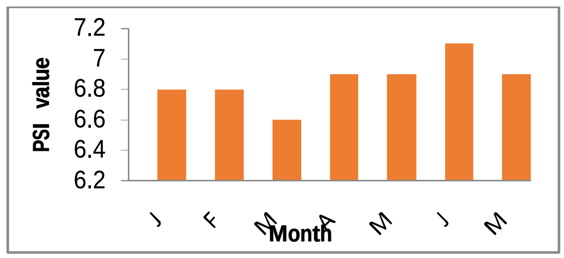

Fig. 3: The values of PSI from January to June and the mean .

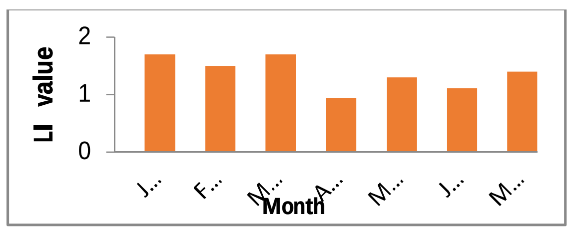

Fig. 4: The values of LI from January to June and the mean.

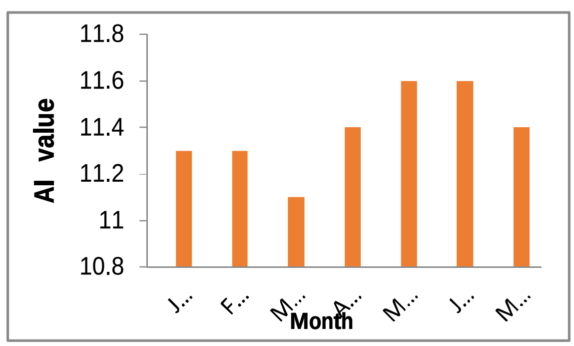

Fig. 5: The values of AI from January to June and the mean.

III. Results and Discussion

The results of measurements for some physicochemical parameters based on monthly average for four sites in Libyan Iron and Steel Company and the calculations of indices based on Table.I are shown in Table.II. The physicochemical parameters under investigation were in the range of WHO standards and Libyan standards except Fe in some water samples. The high value of 1.16 ppm was found at Maintenance Building, which exceeded the permissible level of 0.3 ppm according to WHO. The increase in Fe values in some water samples gave indication for presence of corrosion in the distribution network pipes .In this case a color change to bright brown was observed.

Calculations of each index based on monthly averages of parameters values have been provided in figures 1 to 5. Based on LSI and AI indices results, water tend to scale formation while based on RI and PSI indices results water tend to corrosive.

The results shown in Table.II , appeared that LSI for water samples were between -0.97to 0.05 and all values are negative except 0.05 at a point of water exit from water storage. The average value of LSI was -0.49(Fig.1) indicated that water did not form precipitate and ultimately, there is no possibility for formation of $CaCO_3$ layer on the internal wall of pipe. As a result, corrosion happened, causing an increase in Fe concentration in water and with a time, precipitation as a silt on a form of dust layers inside pipes leading to change in color of drinking water.

The RSI results form Table.II shown that the values were between 8.3-9.7, 8.3 value recorded at the exit of water storage, while the higher value was 9.7 recorded at Mechanical Maintenance Building. The average value was 9.1(Fig.2). The results showed that values for most water samples above 8.5 indicated that the water in network did not form precipitate and there is no chance to form protecting layer of $CaCO_3$ on the internal wall. Also in this case ,the water was corrosive and ultimately causing corrosion with rust formation leading to change in color of drinking water, which is the big problem facing the network (Table.II) .

The results of PSI appeared that the values ranged between 6.5 to 7.1,while the average value for all samples was 6.9 (Fig.3). This gave indication that all samples of drinking water have no tendency to form precipitate and finally the water may become corrosive in the network.

LI calculation showed that the values between 0.8-1.7 and the average value was 1.4(Fig.4). This assigned that drinking water in softening plant of all sites might cause corrosion.

AI was used only for Asbestos Cement Pipes. The AI results (Table-II) showed that the values were between 10.9-11.8 and the average value was 11.4 (Fig.5). These values pointed out that the water was moderately aggressive and corrosive. From the results of AI, drinking water might be corrosive inside the asbestos cement pipes and after a period of time, this released asbestos capillaries in water resulting a risk to human health [13].

IV. CONCLUSION

The results showed that values of all measured physicochemical parameters were in the range of national and international standards. Based on LSI and AI indices results, water tends to scale forming while based on RI and PSI indices results water tend to be corrosive. Finally, monitoring of chemical quality, scaling and corrosion potential of water should be considered in quality control programs.

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