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Study for Determination of Industrial Water Corrosivity in Kashan Fajre Sepahan Galvanizing Mills During 2005-2006 Iran

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Abstract: This research was carried out in Kashan Fajre Sepahan Galvanizing mills (KFSGM) for evaluation of water corrosivity during 2005-2006. A total of 18 samples were taken from various points of the water supply system for testing the specific parameters and calculation Langelier Index (LI), Ryznar Index (RI) and Pukorious Index (PI). This research showed that in raw water (sand filter effluent) LI were positive as well as RI and PI were lower than 7 which means that mentioned water is not corrosive. Also LI in treated water by reverse osmosis process was negative and RI and PI were higher than 7, so, this water has corrosive properties. Finally, calculated indexes indicate that according to LI, conditioned water is not corrosive but based on RI and P. this water tend to corrosivity which this findings is compatible with literature review statement. So it is recommended that, for water conditioning addition of preservative chemicals to be continued but at the same time another alternatives such as pH adjustment, air stripping and deoxygenating, control of carbonate concentration and split flow treatment should be studied.

Key words: Corrosion, Langelier index, Ryznar index, Pulkorious index

INTRODUCTION

Corrosion is destruction of a matter such as metals in responses to reaction with environment. This environment can be a liquid media such as water flowing in pipes and solid media such as soil in contact with buried pipes. Corrosion can be occurs due to various processes including physical, chemical, biological and electrochemical reactions (Saatchi, 1993; Pishnamazi, 2005; Oram, 2007).

In the world, every year several billion dollars loses via corrosion in industrial activities. In our country (Iran) especially in the past two decade which was in economic and scientific development stage, these problems exist as an economical challenge (Saatchi, 1993). For the best operation of a boiler or cooling tower, the water quality control is detrimental factor. In the past, our researches have been focused upon leakage and economical damages of corrosion but generally health and aesthetic aspects of water quality weren't considered (Log *et al*., 2004). At the present, since metal pipes for water transmission is commonly used in the world, so water industry have to consider effects of corrosion upon water quality and conversely (Dietrich, 2004).

Unfortunately, in our country limited studies was carried out in the field of corrosion. Findings of a study in Zarrinshahr city (Iran) water distribution system show that high concentrations of lead, cadmium and zinc in drinking water relates to corrosion of internal walls in galvanized pipes (Shahmansori and Pormoghadas, 2004).

Kashan Fajre Sepahan Galvanizing Mills (KFSGM) has been set in operation since 1999. Its products are a lot of galvanized sheets (105 tons year^{-1}). Water consumption in these mills is 600 L tone^{-1} of products. At the beginning, one of the main problems facing with was corrosion, especially in cooling towers. Thus one of the attempts was feeding of two preservative chemicals (DM and 8410 as trade name) to cooling water. It is to notify that since now a comprehensive research was not carried out on corrosion control in mentioned mills, so this research was conducted in KFSGM.

MATERIALS AND METHODS

This research is an experimental study which carried out during 2005-2006 upon samples collected from the various points of KFSGM water supply system. The water supply system includes deep well, raw water storage tank, sand filter, ion exchange and Reverse Osmosis (RO) process. Some of treated water after conditioning feeds to three cooling towers. Flow diagram

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of water supply system in KFSGM is showed in Fig. 1. A total of 18 samples were taken for testing, including 6 samples from raw water after sand filter (filter effluent), 6 samples from the effluent of reveres osmosis (treated water) and 6 samples from conditioned water in cooling towers (conditioned water). Analysis of samples has been carried out by methods described in standard methods for examination of water and wastewater book (ADHA, AWWA and WPCF, 1995). Upon each sample 11 parameters including total hardness, calcium hardness, conductivity, total alkalinity, sulfate, chloride, pH, temperature, Total Dissolved Solids (TDS), CO_2 and Dissolved Oxygen (DO) has been analyzed. Finally three Indexes, Langelier Index (LI), Ryznar Index (RI) and Pulkorious Index (PI) calculated for evaluation the rate of water corrosivity.

The formulas for calculation of LI, RI and PI are as below (Pishnamazi, 2005; Hammer, 1986; Salvato, 2003):

$$LI = pH - pH_s$$

Where:

pH_s = 9.3+ A+B-(C+D)

A = TDS factor based on mg L^{-1} of TDS

B = Temperature factor based on °F

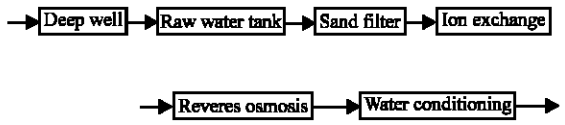

Fig. 1: Flow diagram of water supply system in KFSGM

C = Calcium hardness factor based on mg L^{-1} as $CaCO_3$

D = Alkalinity factor based on mg L^{-1} as $CaCO_3$

$$RI = 2\,pH_s - pH$$
$$PI = 2\,pH_s - pH_{eq}$$

Where:

pH_{eq} = 1.465log(T.A)+4.54

TA = Total alkalinity mg L^{-1} as $CaCO_3$

RESULTS

Table 1 shows, the average concentration of TDS, temperature, calcium hardness and total alkalinity of filtered water were 3329.20 mg L^{-1}, 70.70 °F, 702.00 mg L^{-1} and 122.33 mg L^{-1} as, respectively. In addition average of DO and CO_2 were 8.90 and 11.75 mg L^{-1} as respectively. Also as it is revealed in this table, for reveres osmosis effluent average concentration of TDS, DO, CO_2, chloride and sulfate were 93.77, 5.02, 4, 33.02 and 11.51 mg L^{-1}, respectively, For conditioned water range of electrical conductivity was 1817.00 to 8690.00 μmhos cm^{-1}. Also the average of TDS, DO, CO_2 and Cl^- concentrations were 3023.00, 7.80, 0 and 563.23 mg L^{-1}.

Table 2 shows the summary of values for pH and three indexes to evaluation of water corrosivity in KFSGM. Regarding the table it is revealed that in raw water LI, RI and PI were +0.36 to +0.93, 6.11 to 6.79 and 6.17 to 6.95 as, respectively. In addition, only LI in treated water were negative but in other cases were positive.

Table 1: Analysis of water quality in KFSGM

Parameters samples		Total hardness (mg L^{-1} as $CaCO_3$)	Calcium Hardness (mg L^{-1} as $CaCO_3$)	Conductivity (μmhos cm^{-1})	Total Alkalinity (mg L^{-1} as $CaCO_3$)	Sulfate (mg L^{-1})	Chloride (mg L^{-1})	Temp. (°F)	TDS (mg L^{-1})	DO (mg L^{-1})	CO_2 (mgL^{-1})
Raw water	Ave.	1231.25	702.00	4756.00	122.33	623.82	1314.15	70.70	3329.20	8.90	11.75
(Filter effluent)	SD	194.60	155.19	638.55	30.99	141.45	123.11	3.37	446.98	0.22	0.42
Treated water	Ave.	55.67	17.83	133.96	13.58	11.51	33.02	69.80	93.77	5.02	4.00
(RO effluent)	SD	62.92	9.87	54.15	12.82	7.96	12.15	3.94	37.90	0.42	0.63
Conditioned water	Ave.	361.00	53.58	4342.38	308.67	351.72	563.23	67.40	3023.00	7.80	0.00
	SD	92.94	17.92	2386.09	74.12	201.63	245.08	3.35	1666.76	0.43	0.00

Table 2: Values of various indexes for water corrosion control in KFSGM

Index	Raw water				Treated water				Conditioned water			
samples	pH	LI	RI	PI	pH	LI	RI	PI	pH	LI	RI	PI
1	7.61	+0.45	6.71	6.95	6.50	-3.55	13.60	14.98	8.34	0.68	7.18	7.26
2	7.51	+0.36	6.79	6.55	6.19	-3.45	13.09	13.50	9.50	1.94	5.62	6.78
3	7.60	+0.51	6.58	6.76	6.70	-2.87	12.44	13.36	9.00	1.32	6.36	7.09
4	8.00	+0.93	6.14	6.39	6.74	-2.67	12.08	12.12	8.58	0.24	8.10	8.84
5	7.65	+0.48	6.69	6.29	6.78	-2.60	11.98	12.06	9.00	0.95	7.10	7.97
6	7.71	+0.80	6.11	6.17	6.00	-4.24	14.48	14.92	9.00	1.18	6.64	7.99

DISCUSSION

Analysis of filtered water (raw water) in KFSGM shows that LI is positive as well as RI and PI were lower than 7 which means that mentioned water is not corrosive. A positive Langelier index is indicative primarily of calcium carbonate (scale) deposition; a negative index number is indicative of increasing water corrosivity with -2.0 considered high. Slightly positive is the goal. A Ryznar index number of less than about 6.0 is indicative primarily of the start of calcium carbonate (scale) deposition; an index number greater than 6.0 to 7.0 is indicative of increasing water corrosivity (Pishnamazi, 2005; Salvato, 2003). Study in Birjand plain showed that groundwater in these regions were not corrosive and LI was positive. This is compatible with our study results in KFSGM (Asghari Moghadam and Zia, 2005). Since CO_2 concentration is not considered in calculation of LI, so presence of CO_2 in filtered water (about 12 mg L^{-1}) can cause corrosion of galvanized piping. Measured CO_2 in filtered water can probably due to low distance between KFSGM and previous Kashan solid waste sanitary landfill site. Leachate in sanitary landfill contain high CO_2 gases, carbon dioxide is heavier than air so move down through soil layers and finally reach to ground water (Salvato, 2003). This problem can results to, internal pitting and tuberculation of iron and galvanized pipes and steel water tank walls as in the past in KFSGM (Dietrich, 2004).

Based on analysis of treated water (RO effluent) LI has been negative in all samples (Table 2), also RI and PI were higher than 6, that means treated water is corrosive and in long time can do damages to metal piping and galvanized tanks and facilities. Reverse osmosis process is high efficient for TDS removal. In this case RO process reduced TDS from 3329.2 mg L^{-1} in raw water to 93.7 mg L^{-1} in treated water, thus removal efficiency calculated 97%. Although TDS reduction help to corrosion control, but decrease of calcium concentration (soft water) and alkalinity can be result in corrosiveness properties in mentioned water. Also decreased pH, presence of DO and CO_2 in treated water can increase the rate of corrosion effectively (Pishnamazi, 2005; Oram, 2007; Dietrich, 2004; Chalkeshamiri, 2002; Mc Laughhan and Stuetz, 2004).

Calculated Indexes in our study indicate that according to the LI, conditioned water is not corrosive but based on RI and PI (Table 2) this water tend to corrosivity. Based on literature review there are contradictory results related to LI, RI and PI. In some cases LI shows that water is corrosive but RI and PI do not confirm this trend. In the most cases results that obtained by PI is true for water samples with pH higher than eight (Pishnamazi, 2005; Pakshir *et al*., 2004).

Study in Scolord city, has been showed that optimum iron protection against corrosion achieved when $CaCO_3$ were in super saturation condition. Also reduction of CO_2 and addition of calcium silicate as preservative agent to water will usually result in reduced corrosion to a considerable level (Hem, 2001). So for corrosion control in KFSGM facilities, it is recommended that addition of preservative chemicals for water conditioning, to be continued but at the same time another alternatives such as pH adjustment, air stripping and deoxygenating, control of carbonate concentration and split flow treatment should be studied (Edwards, 2004; AWWA, 1990).

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