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Scaling Potential and Corrosion Assessment through Langelier Saturation Index and Ryznar Stability Index of Under Ground Water in Udaipur, Rajasthan

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Abstract: The quality of water entering into water distribution network often provides requirements for corrosion and scaling in areas lacking adequate treatment methods, which can cause serious problems. The most commonly used corrosion indices are Langelier saturation index (LSI), Ryznar stability index (RSI). This study aimed to evaluate the corrosion and scaling potential of water resources in Udaipur, Rajasthan. Therefore, the corrosion and scaling potential of groundwater resources were investigated according to LSI, RSI. Scaling and corrosion are from common indicators of water quality and can cause economic and health damages.

According to the results, total hardness and TDS had high mean values, but the values of pH, temperature, and alkalinity were rather admissible. As well, most of the water resources of studied area had low to moderate corrosivity according to LSI and RSI. On the basis of LSI, around 50% result showing that water was slightly scale forming and corrosive and remaining 50% showing that water was scale forming but non-corrosive as mentioned in table 3. Ryznar Stability Index (RSI) showing that 4.5% samples were heavy corrosion, 9.0% samples were light scale, 50% samples were light scale or corrosion, and 36% samples were corrosion significant

Keywords: Scaling, Corrosion, LSI, RSI, Groundwater

I. INTRODUCTION

Groundwater resources are the main water sources in different countries and provide about 60% of drinking water and 30% of agriculture water supplies in these areas[1]. The quality of groundwater resources can significantly influence the scaling and corrosion in water facilities[2, 3]. By considering the importance of these resources and taking into account this fact that Iran has been classified as an arid and semi-arid country, it seems essential to examine the chemical quality of water[4].

Scaling and corrosion are from the most common indicators of water quality assessment. Corrosion is defined as the physical and chemical interaction between the metal and its environment which usually has an electrochemical nature resulted in the change in metal properties[5, 6]. This phenomenon not only can import some by-products such as lead, arsenic, etc. to the drinking water, which may lead to serious health problems, but also reduces the lifetime of pipes and fittings, whereas scaling can aid corrosion resistance in the water distribution system by creating a barrier between the conductive water and surface of the pipe.

Moreover, scaling is a multi-phased process in which ions (such as calcium and magnesium) react with existing substances in water to form a film deposited on the inner surface of the tubes. The most commonly produced sedimentary layer is the calcium carbonate, which can stain pipes, block nozzles, and coat the internal wall of the pipes. Deposits can greatly affect the efficiency of boilers and heat exchangers, which substantially increase energy consumption and maintenance costs[7].

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The Langelier Saturation Index is the difference between the actual pH of the solution and pH_s calculated.

$$LSI = pH_{actual} - pH_s$$

The Langelier Saturation Index (LSI), a measure of a solution's ability to dissolve or deposit calcium carbonate, is often used as an indicator of the corrosivity of water. The index is not related directly to corrosion, but is related to the deposition of a calcium carbonate film or scale; this covering can insulate pipes, boilers, and other components of a system from contact with water. When no protective scale is formed, water is considered to be aggressive, and corrosion can occur. Highly corrosive water can cause system failures or result in health problems because of dissolved lead and other heavy metals. An excess of scale can also damage water systems, necessitating repair or replacement. In developing the LI, Langelier derived an equation for the pH at which water is saturated with calcium carbonate (pHs).

This equation is based on the equilibrium expressions for calcium carbonate solubility and bicarbonate dissociation. To approximate actual conditions more closely, pHs calculations were modified to include the effects of temperature and ionic strength. The Langelier Index is defined as the difference between actual pH (measured) and calculated pHs. The magnitude and sign of the LI value show water's tendency to form or dissolve scale, and thus to inhibit or encourage corrosion. Although information obtained from the LI is not quantitative, it can be useful in estimating water treatment requirements for low pressure boilers, cooling towers, and water treatment[8, 9]

The indications for the LSI and the improved LSI by Carrier are based on the following values[10, 11]:

LSI	**Indication**
LSI<0	Water is undersaturated with respect to calcium carbonate. Undersaturated water has a tendency to remove existing calcium carbonate protective coatings in pipelines and equipment.
LSI=0	Water is considered to be neutral. Neither scale-forming nor scale removing.
LSI>0	Water is supersaturated with respect to calcium carbonate ($CaCO_3$) and scale forming may occur.

Table 1: Tendency of Water on the basis of Langelier Saturation Index

S. No.	Langelier Saturation Index	Tendency of Water
1	LSI < -2	Intolerable corrosion
2	-2 < LSI < -0.5	Serious corrosion
3	-0.5 <LSI < 0	Slightly corrosive but non-scale forming
4	LSI = 0	Balanced but pitting
5	0 < LSI < 0.5	Slightly scale forming and corrosive
6	0.5 < LSI < 2	Scale forming but non-corrosive

One of the major factors in the quality of drinking water is corrosion and scaling[10, 12]. The aim of the present study was to evaluate corrosion and scaling potential of drinking water supply network in Udaipur, Rajasthan[13, 14].

II. MATERIALS AND METHODS

22 samples of drinking water in distribution network were collected randomly in summer and autumn seasons and transferred into laboratory. Some parameters including temperature, TDS, pH, total alkalinity and hardness and calcium hardness were measured based on the standard methods. The corrosion and scaling potential of water have been evaluated by Langelier, Ryznar. The collected data were analysed using descriptive statistics[15, 16].

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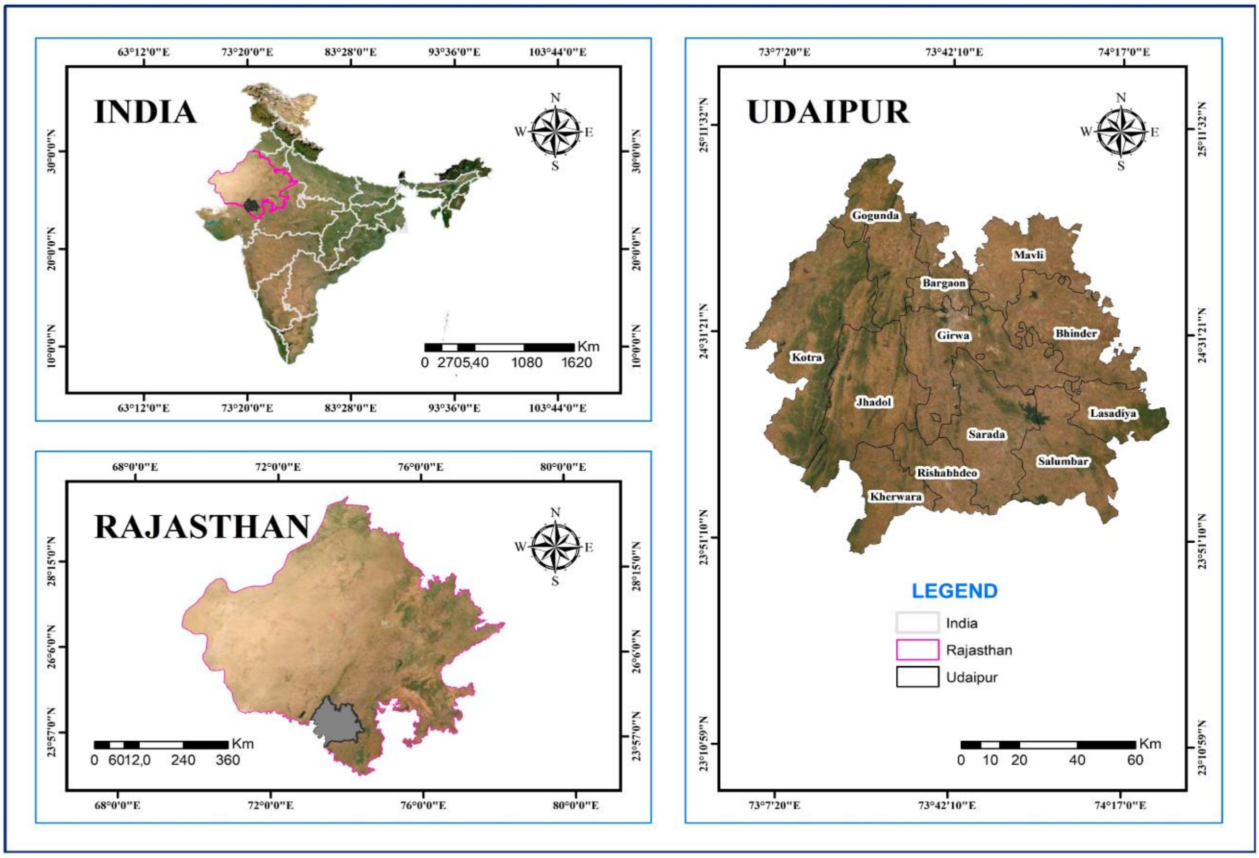

Figure 1: Study Area - Udaipur

S. No.	Blocks in Udaipur	pH	TDS	Ca^+	HCO_3^-	Water Temperature	LSI	pHs	RSI
1	Bhindar	8.09	501	28	342	25	0.43	7.7	7.31
2	Bhindar	8.28	1027	116	561	27	1.4	6.9	5.52
3	Mavli	7.75	3068	156	268	25	0.44	7.3	6.85
4	Phalasiya	7.94	533	48	171	28	0.26	7.7	7.46
5	Salumber	7.87	793	64	293	27	0.48	7.4	6.93
6	Gogunda	7.87	670	60	329	28	0.55	7.3	6.73
7	Rishabhdev	8.07	982	48	488	25	0.60	7.5	6.93
8	Bhindar	7.55	1040	52	427	27	0.20	7.4	7.25
9	Sayra	8.29	1034	76	549	23	1.1	7.2	6.11
10	Bhindar	9.05	923	12	427	25	1.0	8.0	6.95
11	Jhalara	7.73	462	68	305	26	0.43	7.3	6.87
12	Phalasiya	7.73	533	60	183	25	0.12	7.6	7.47
13	Mavli	7.97	332	48	207	27	0.41	7.6	7.23
14	Kherwara	8	670	40	317	28	0.49	7.5	7
15	Gogunda	7.84	975	80	329	25	0.53	7.3	6.76
16	Sayra	8.23	930	120	500	28	1.3	6.9	5.57
17	Salumber	7.89	1859	84	598	27	0.80	7.1	6.31
18	Semari	8.34	1216	24	378	25	0.53	7.8	7.26

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19	Girwa	8.07	787	40	403	23	0.54	7.5	6.93
20	Phalasiya	7.9	514	64	268	26	0.51	7.4	6.9
21	Bargaon	8	384	60	207	25	0.48	7.5	7
22	Girwa	8.05	585	32	342	24	0.41	7.6	7.15

Table 2: Water quality characteristics associated with LSI and RSI of the study area

III. RESULTS AND DISCUSSION

On the basis of LSI, around 50% result showing that water was slightly scale forming and corrosive and remaining 50% showing that water was scale forming but non-corrosive as mentioned in table 3. Ryznar Stability Index (RSI) showing that 4.5% samples were heavy corrosion, 9.0% samples were light scale, 50% samples were light scale or corrosion, and 36% samples were corrosion significant as mentioned in table 4.

Table 3: Tendency of Water on the basis of LSI

Blocks in Udaipur	LSI	Tendency of Water
Bhindar	0.43	Slightly scale forming and corrosive
Mavli	0.44	
Phalasiya	0.26	
Salumber	0.48	
Bhindar	0.2	
Jhalara	0.43	
Phalasiya	0.12	
Mavli	0.41	
Kherwara	0.49	
Bargaon	0.48	
Girwa	0.41	
Bhindar	1.4	Scale forming but non-corrosive
Gogunda	0.55	
Rishabhdev	0.6	
Sayra	1.1	
Bhindar	1	
Gogunda	0.53	
Sayra	1.3	
Salumber	0.8	
Semari	0.53	
Girwa	0.54	
Phalasiya	0.51	

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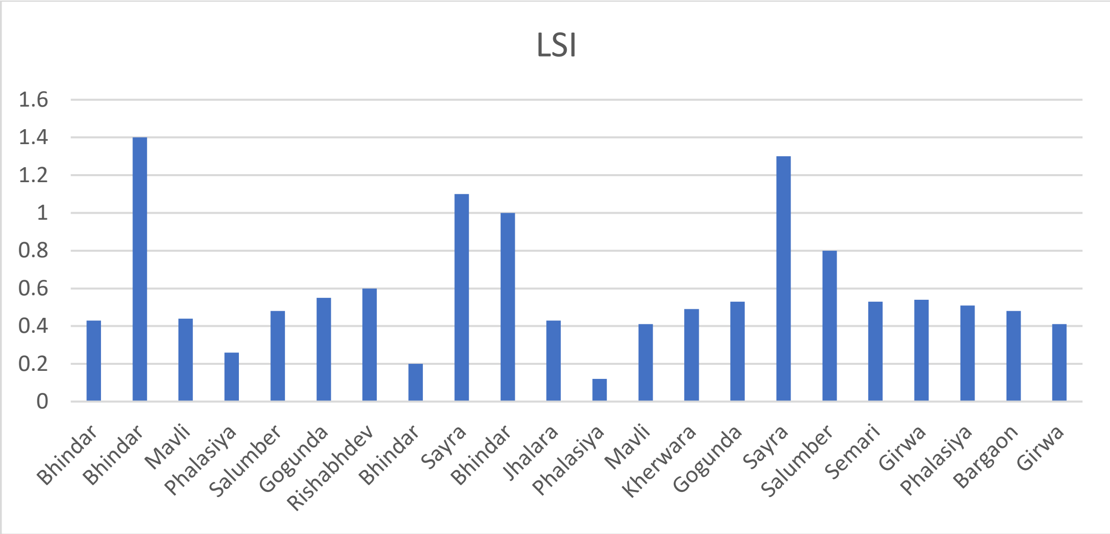

Figure 2: LSI values of different locations in the study area

Table 4: Tendency of Water on the basis of RSI

Blocks in Udaipur	RSI	Tendency of Water	RSI
Bhindar	7.31	Heavy Corrosion	7.5-9.0
Bhindar	5.52	Light Scale	5.0-6.0
Sayra	5.57		
Mavli	6.85	Little Scale or Corrosion	6.0-7.0
Salumber	6.93		
Gogunda	6.73		
Rishabhdev	6.93		
Sayra	6.11		
Bhindar	6.95		
Jhalara	6.87		
Gogunda	6.76		
Salumber	6.31		
Girwa	6.93		
Phalasiya	6.9		
Phalasiya	7.46	Corrosion significant	7.0-7.5
Bhindar	7.25		
Phalasiya	7.47		
Mavli	7.23		
Kherwara	7		
Semari	7.26		
Bargaon	7		
Girwa	7.15		

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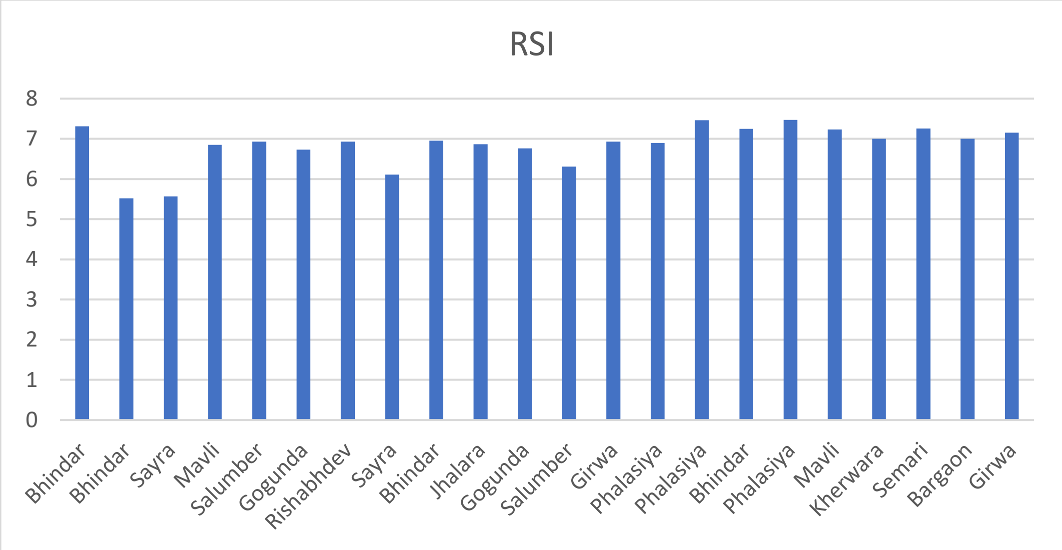

Figure 3: RSI values of different locations in the study area

IV. CONCLUSION

This study aimed to evaluate the corrosion and scaling potential of water resources in Udaipur, Rajasthan. Therefore, the corrosion and scaling potential of groundwater resources were investigated according to LSI, RSI. Scaling and corrosion are from common indicators of water quality and can cause economic and health damages. Corrosion is one of the most important problems in the drinking water industry[17, 18]. It can affect public health, public acceptance of a water supply, and the cost of providing safe water. Maintaining the integrity of drinking water distribution system materials and distribution system water quality are important objectives of drinking water suppliers[19]. Deterioration of materials resulting from corrosion can necessitate huge yearly expenditures of resources for repairs, replacement, and system maintenance. Corrosion tends to increase the concentrations of many metals in tap water[20].

The most common ways of achieving corrosion control are to properly select system materials and adequate system design, modify water quality, use inhibitors, provide cathodic protection, and use corrosion-resistant linings, coatings, and paints. Many important decisions are likely to be made on the basis of the sampling and chemical analyses performed by a utility or contract laboratory. Therefore, care must be taken during the sampling and analysis to obtain the best data.

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