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Research Article

Determination of Scaling and corrosion tendencies of water through the use of Langelier and Ryznar Indices

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Abstract: The present study aims to evaluate the Langeliersaturation index and Ryznar stability index for the groundwaters of K.R.Puram area in Bangalore, India. Thirty groundwater samples were drawn from the area and subjected to physico-chemical analysis and the analysis results were used to evaluate the two indices. Based on Langelier index, 26.67% of the samples were found to be scale forming, 13.33% slightly scale forming, 6.67% were slightly corrosive, 13.33% indicated serious corrosion and 40% intolerable corrosion, while based on Ryznar stability index, 13.33 % of the samples were found to little scale or corrosive,13.33 % indicated significant corrosion ,6.67 % heavy corrosion and a whopping 66.67% of the samples showed intolerable corrosion.It is very clear that the results of LSI are reasonably comparable with the RSI values and the samples show the same property more or less with respect to the two indices.

Keywords: Corrosion, Langelier saturation index,Ryznar stability index**,** scaling.

INTRODUCTION

While most people in urban cities of the developing countries have access to piped water, several others still rely on groundwater for domestic use [1]. Industrial effluents, if not treated and properly controlled can pollute ground water [2]. Therefore, the groundwaters generally have poor quality water in the affected areas. Depending upon its specific chemistry, water can promote scaling, corrosion or both. Scaling is one of the most critical water quality issues in India. Scale can be formed from a variety of dissolved chemical species but two reliable indicators are hardness and alkalinity. Calcium carbonate is the most common form of scale deposition attributable to ground water used in residential geothermal heat pump (GHP) systems. Two indices commonly used in the water treatment industry to evaluate the nature of a water source are the Langelier Saturation Index (LSI or Saturation index) and the Ryznar Stability Index (RSI or Stability index). In both cases these indices are based upon a calculated pH of saturation for calcium carbonate (pHs). The pHs value is then used in conjunction with the water's actual pH to calculate the value of the index as follows:

LSI = pH - pHs
RSI = 2pHs - pH

Calcium carbonate saturation index (Langelier index) is commonly used to evaluate the scale forming and scale dissolving tendencies of water [3, 4]. Assessment of these tendencies is useful in corrosion control programme and in preventing calcium carbonate scaling in piping systems and equipments such as industrial heat exchanger or domestic water heater [5].

In the recent past, works on similar lines have been carried out [6-7]. Evaluation of the saturation index is as indicated in Table 1. The Ryznar stability index (Table 2) produces a slightly different value numerically but is interpreted in a similar fashion.

Langelier Saturation Index

The Langelier Saturation index (LSI) is an equilibrium model derived from the theoretical concept of saturation and provides an indicator of the degree of saturation of water with respect to calcium carbonate. It can be shown that the Langelier saturation index approximates the base 10 logarithm of the calcite saturation level. The Langelier saturation level approaches the concept of saturation using pH as a main variable. Thus, the LSI can be interpreted as the pH change required to bring water to equilibrium.

Water with a Langelier saturation index of 1.0 is one pH unit above saturation. Reducing the pH by 1 unit will bring the water into equilibrium. This occurs because the portion of total alkalinity present as CO_3^{2-} decreases as the pH decreases, according to the equilibria describing the dissociation of carbonic acid:

The equation developed by Langelier expresses the effects of pH, calcium, total alkalinity, dissolved solids and temperature as they relate to the solubility of calcium carbonate for waters in the 6.5 - 9.5 pH range [8]. The equation is written as: pHs = (pK2 - pKs) + pCa + pAlk.

The left side of the equation represents the pH at which water with given calcium content and alkalinity is in equilibrium with calcium carbonate. The terms K2 and Ks symbolize the second dissociation constant and the solubility product constant for calcium carbonate, respectively. These terms are functions of temperature and total mineral content. Their values for any given condition can be computed from the known thermodynamic constants. Both the calcium and the alkalinity terms are the negativelogarithms of their respective concentrations. The calcium content is molar, while the alkalinity is an equivalent concentration. That is, it is the titratable equivalence of alkaline base per litre.

The algebraic difference between the actual pH of a sample of water and its computed pHs is called the Calcium Carbonate Saturation Index. Hence, Saturation Index equals pH minus pHs.

Langelier Index (LSI) = pH - pHs

Calculation of the value for pHs can be done using the nomograph [8, 9] or through the use of the following equation

pHs = (9.3 + A + B) - (C + D) [10] Where: A = [log (TDS) -1)/10], TDS in ppm

B = [-13.12 log (T + 273)) + 34.55], Temperature, T in ^{o}C,
C = [log (calcium hardness) - 0.4], Ca hardness in ppm (as $CaCO_3$)
D = log (alkalinity), alkalinity in ppm as (CaCO3)

It is apparent that the temperature at which the calculation is made has considerable impact upon the results. This index is a qualitative indication of the tendency of calcium carbonate to deposit or dissolve. If the index is positive, calcium carbonate tends to deposit. If it is negative, calcium carbonate tends to dissolve. If it is zero, the water is at equilibrium. The LSI was not intended as an indicator of corrosivity towards mild steel or other metals of construction. The LSI describes only the corrosivity of water towards an existing calcium carbonate scale or other calcium carbonate bearing structure. The LSI does describe the tendency of water to dissolve (corrode) calcite scale. It has also been used to control the corrosion of asbestos-concrete-board (ACB) fill which uses calcium carbonate as part of the binder. But the interpretation of corrosivity towards metals is not explicit in the LSI.

Ryznar Stability index The Ryznar Stability index (RSI) is an empirical method for predicting scaling tendencies of water based on a study of operating results with water of various saturation indices. Stability index = 2pHs - pH = pHs - Langelier's Saturation pH

This index is often used in combination with the Langelier index to improve the accuracy in predicting the scaling or corrosion tendencies of water.

Table 1: Interpretation of the Langelier Saturation Index

Langelier saturation index	Tendency of water
LSI <- 2	Intolerable corrosion
-2.0 <LSI < -0.5	Serious corrosion
-0.5 <LSI < 0	Slightly corrosive but non-scale forming
LSI = 0	Balanced but pitting
0 < LSI < 0.5	Slightly scale forming and corrosive
0.5 < LSI < 2	Scale forming but non corrosive

Table 2: Interpretation of Ryznar Stability Index

Ryznar Stability Index	Tendency of water
RSI 4.0 – 5.0	Heavy scale
RSI 5.0 – 6.0	Light scale
RSI 6.0 – 7.0	Little scale or corrosion
RSI 7.0 – 7.5	Corrosion significant
RSI 7.5 – 9.0	Heavy corrosion
RSI >9.0	Intolerable corrosion

Details of the study area

The K.R.Puram industrial area, is located at a distance of about 20kms from the city and covered in part of the Survey of India toposheet No. 57 G/12.This is one of the oldest industrial areas in Karnataka State, spread over an area of 44 sqkm with over 800 industries of all sizes and types and a population of 2.8 lakhs. Drinking water shortage is said to be the bane of K.R.Puram area. While Cauvery water supply pipelines from the Bangalore Water Supply and Sewerage Board (BWSSB) are still being laid, many a deadline for completing the same have elapsed. As a result, the 286 borewells and 50 hand pumps meet the larger part of the City Municipal Corporation (CMC)'s water supply needs. A certain part of the needs is met through bulk purchase from the BWSSB. As for sanitation, soak/percolation pits are still the order of the day resulting in groundwater contamination from the community as well as effluent disposal from the industries.

MATERIALS AND METHODS

Thirty water samples were collected from the groundwaters (borewells, open wells and hand pumps) in and around the area, in two litre PVC containers, sealed and were analyzed for 20 major physico-chemical parameters in the lab. Figure 1 shows the location map of study area with the sampling stations. The chemical characteristics including metals were determined as per the Standard methods for examination of water and wastewater of American Public Health Association [11].

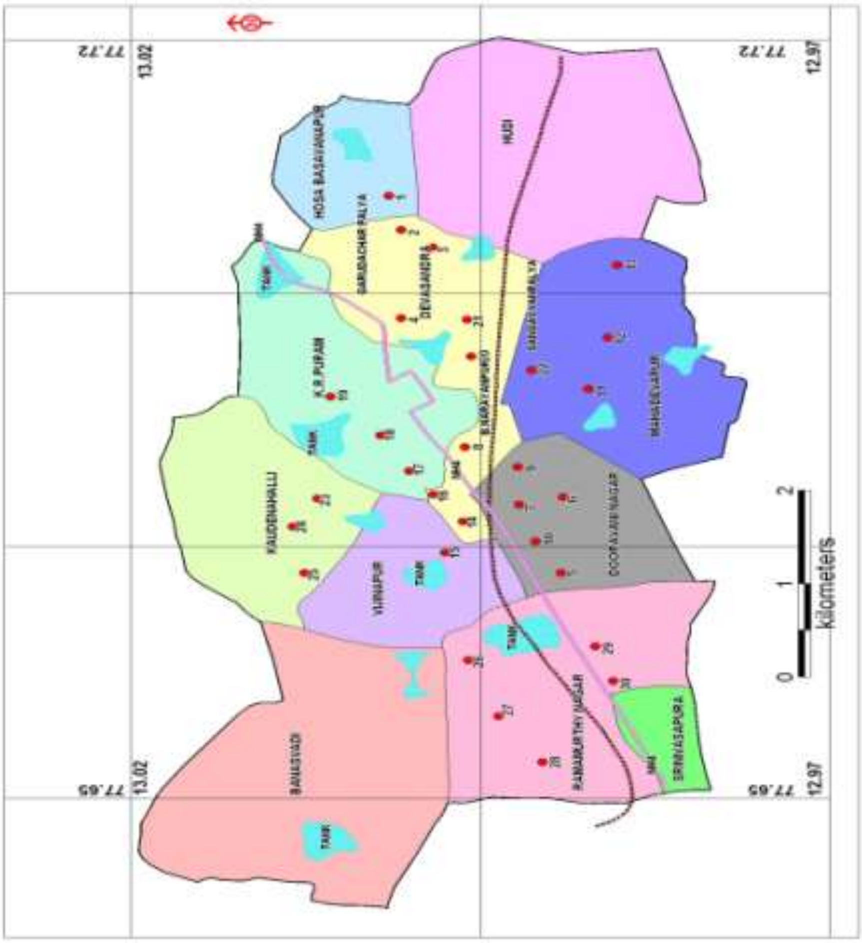

Figure 1: GIS map of K.R.Puram area showing the sampling locations

RESULTS AND DISCUSSION

The groundwater samples were analysed for 20 physico-chemical parameters. However table 3 presents the analysis data for only those parameters which are required for calculating the two indices. From the analysis, based on Langelier index, it is seen that 26.67 % of the samples are found to be scale forming, 13.33% slightly scale forming, 40 % showing intolerable corrosion, 13.33% showing serious corrosion and 6.67% slightly corrosive, while based on Ryznar stability index, none of the samples are found to be heavy scaling in nature, 13.33% little scale or slightly corrosive, 13.33% indicating significant corrosion and 6.67% heavy corrosion. An alarming 66.67% of the samples are found to be of intolerable corrosion. According to LSI,most of the samples exhibiting scale forming tendency have a pH on the alkaline side (pH >7) .It is very clear that the results of LSI reasonably comparable with the RSI values and the samples show the same property more or less with respect to the two indices. From the view point of corrosion, it is seen that the groundwaters exhibiting corrosive / significant corrosive property are the ones which are on the acidic side (pH <7). Based on LSI, nearly 73.33 % of the samples are corrosive, while the RSI values indicate that nearly 87% of the samples exhibit significant to heavy corrosion. The correlation of pH and LSI presented in fig 2, indicate clearly that alkaline waters are scale forming and acidic waters corrosive in nature. Waters with high corrosive property cannot be transported in metallic pipes and non-corrosive PVC pipes may have to be used. Thus, both the scaling as well as corrosive nature of groundwater render them unfit for regular domestic use, unless otherwise properly treated, and it thus becomes highly imperative for the civic authorities to pay due attention to this and reduce the adverse effects that may be caused.

Table 3 : Results of physic-chemical analysis of samples along with their saturation indices

Sample number	pH	Calcium hardness, mg/L as CaCO3	TDS, mg/L	Alkalinity, mg/L	Temperature, 0^C	LSI	RSI
1	8.21	125	500	208	25	0.45	7.31
2	7.20	226	650	140	25	-3.10	13.40
3	8.05	394	1085	287	25	0.88	6.29
4	7.95	225	765	141	25	-3.07	14.09
5	8.23	548	1510	266	25	0.92	6.39
6	6.95	145	765	327	25	-25.8	58.55
7	8.25	183	725	146	25	0.57	7.11
8	7.35	207	1095	294	25	-0.53	8.41
9	8.05	639	2150	431	25	0.96	6.13
10	7.45	117	510	211	25	-4.38	16.21
11	6.50	1060	2545	246	25	-4.01	14.52
12	6.56	195	760	247	25	-29.44	65.44
13	7.95	510	1070	139	25	-0.84	9.63
14	6.26	328	1695	320	25	13.51	33.28
15	7.52	382	1840	440	25	0.19	7.14
16	7.67	405	1295	278	25	-0.18	8.03
17	7.22	440	1490	390	25	0.35	6.52
18	8.43	163	515	248	25	0.54	7.35
19	7.53	227	1780	280	25	-1.44	10.41
20	7.56	127	440	191	25	-4.38	16.32
21	7.69	620	2340	237	25	0.15	7.39
22	8.23	95	365	154	25	-0.05	8.33
23	8.05	137	535	82	25	0.08	7.89
24	6.52	699	1930	193	25	-7.98	22.48
25	7.31	333	1095	200	25	-1.21	9.73
26	6.89	258	1010	186	25	-25.33	57.55
27	6.11	393	1220	330	25	-8.75	23.61
28	7.91	180	620	229	25	-2.11	12.13
29	6.93	100	340	172	25	-82.88	172.69
30	7.23	187	690	139	25	-3.26	13.75

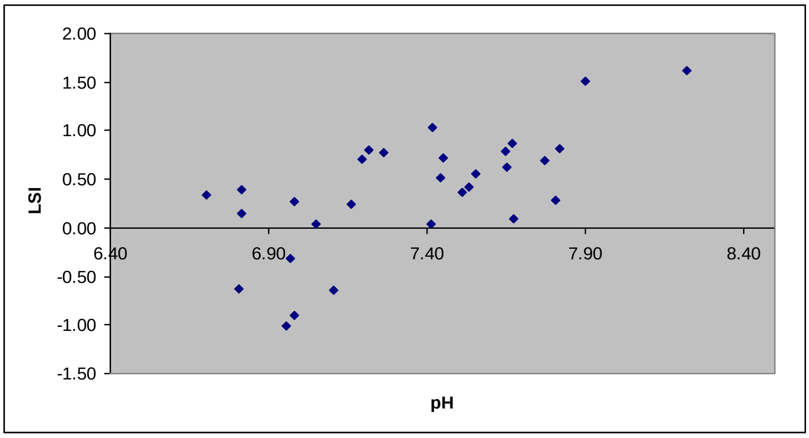

Figure 2: Correlation of p^H and Langelier saturation index for the groundwaters of K.R.Puram area

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