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A Software Generated Chart for Balancing Water Indices with Respect to Langelier Saturation Index: A Study in and Around the Tea Gardens of Lakhimpur District, Assam, India

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ABSTRACT

Scale and Corrosion are still the major water problems all over the globe. Langelier Saturation Index (LSI) is generally used as an indicator of corrosivity and is an equilibrium model derived from the theoretical concept of saturation which provides an indicator of the degree of saturation of water with respect to calcium carbonate. Ryznar slightly modified LSI and found empirically that the actual pH was twice as important as pHs in flowing systems. Another stability index is the Practical Scale Index or Puckorius Scaling Index (PSI) attempts to quantify the relationship between saturation state and scale formation by incorporating an estimate of buffering capacity of the water into the index. The present research was carried out to study these water indices in the five selected tea gardens of Lakhimpur District, Assam and also to study the impact of these indices on the water quality and public health. Computerized computations based on the experimental facts is performed to construct a table for calculating LSI, RSI and PSI for ready reference of common people. It was recommended that sample A4, A8 & B1, B2, B5, B7, B9, and B10 have mild corrosion and require treatment. The other three samples A2, A6 and A10 also need treatment for mild scale coatings. The study observes that the water used for bathing, drinking and other recreational purposes need attention. A software generated original chart for balancing water is also developed with recommendations.

Key words: *Corrosion, Stability Index, Saturation, pH, Hardness, Alkalinity, TDS etc.*

Introduction

Scale and Corrosion are still the major water problems all over the globe. The cost of corrosion can be expensive. Corrosion can impact health, aesthetic quality of drinking water, waste money, and damage household piping and fixtures. The Langelier Saturation Indexal (LSI), Ryznar Stability Index (RSI), and Practical or Puckorius Scale Index (PSI) were created so that the several factors which influence scaling or corrosion could be reported in a single number. This number can be determined from charts, tables, and graphs, but slide rules and computer programs are also extensively utilized.

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We have suggested here a method for arriving at the PSI, RSI and LSI. It is to be noted that water which is "strong dissolving" for scale is also "corrosive" to other metals.

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 (Langelier, W.F, 1936). It can be shown that the LSI 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. The LSI can be interpreted as the pH change required bringing water to equilibrium according to the equilibriums describing the dissociation of carbonic acid:

$H_2CO_3 = H^+ + HCO_3^-$

$HCO_3^- = CO_3^{2-} + H^+$

Interpretation of LSI (**Carrier, 1965**)

LSI	Indication
2.0	Scale forming but non corrosive
0.5	Slightly Scale forming and corrosive
0.02	Balanced but pitting corrosion possible
-0.5	Slightly corrosive but non scale forming
-2.0	Serious corrosion

It simply indicates the driving force for scale formation and growth in terms of pH as a master variable. In order to calculate the LSI, it is necessary to know the alkalinity (mg/l as $CaCO_3$), the calcium hardness (mg/l Ca^{2+} as $CaCO_3$), the total dissolved solids (mg/L TDS), the actual pH, and the temperature of the water (°C). LSI is defined as:

$LSI = pH - pH_s$;

Where, pH is the measured water pH, pH_s is the pH at saturation in calcite or calcium carbonate and is defined as:

$pH_s = (9.3 + A + B) - (C + D)$ (Edstrom, 1998),

Where, $A = (Log_{10}\,[TDS] - 1) / 10$, $B = -13.12 \times Log_{10}\,(°C + 273) + 34.55$, $C = Log_{10}\,[Ca^{2+} \text{ as } CaCO_3] - 0.4$ and $D = Log_{10}\,[\text{alkalinity as } CaCO_3]$.

Ryznar slightly modified LSI and discovered empirically that the actual pH was twice as important as pHs in flowing systems (Ryznar, 1944, Liptak, 1974). This led to his stability index, $RSI = 2pH - pH_s$. The Ryznar Stability Index provides a closer correspondence between calculated predictions and results obtained in the field, and consequently has replaced the Langelier in many applications. When used in conjunction with the Langelier Index, its effect is to severely limit the pH of the saturated water. T. E. Larson expressed the opinion, based on experience, that water should have a slightly positive Langelier Index, and that ideally the pH should not exceed 8.6 (Larson, 1951).

Another stability index the Puckorius Scaling Index (PSI) attempts to quantify the relationship between saturation state and scale formation by incorporating an estimate of buffering capacity of the water into the index (Puckorius, 1983). Puckorius uses an equilibrium pH rather than the actual system pH to account for the buffering effects and mathematically $PSI = 2\,(pH_s) - pH_{eq,}$ Where: pH_s is the pH at saturation in calcite or calcium carbonate and $pH_{eq} = 1.465 \times log_{10}\,[Alkalinity] + 4.54$.

This paper mainly focuses on the evaluation of recreational water quality in and around the tea gardens of Lakhimpur district, Assam with respect to LSI along with necessary recommendations. An attempt has also been made to construct a theoretical water balancing chart.

Study Area

There are nine tea gardens in the district of Lakhimpur, Assam. Lottery method was adopted to select the names of five tea gardens as samples of research, namely Harmutty, Silonibari, Johing, Dirju and Koilamari. These gardens are situated near the banks of river Dikrong and Subansiri respectively (Figure 1).

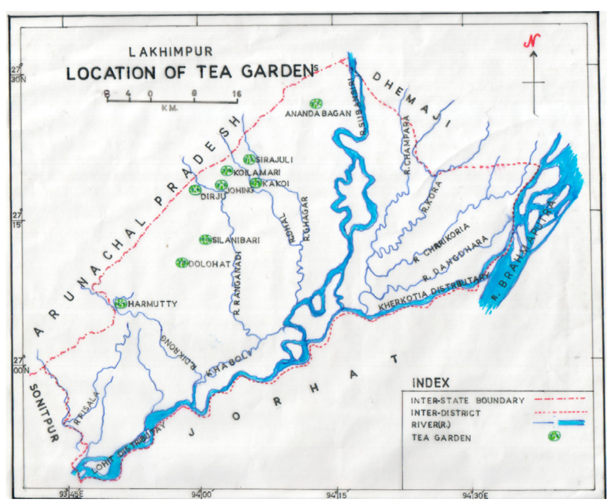

Fig.1

Methodology

Separate water samples are selected by random selection and compiled together in plastic bottles to set a representative sample. Temperature, pH and conductivity were determined quickly after sampling. Samples were protected from direct sun light during transportation. Analytical techniques as described in "Standard Methods for the Examination of Water and Wastewater" (Clesceri *et al.*, 1992) were adopted for analysis of Total Dissolved Solid (TDS), pH, Alkalinity and Hardness. Twenty samples were analysed by taking two representative samples from each sampling site during winter season (December, 2022). Then water indices were calculated by using standard procedures. Computerized computations based on the experimental facts were performed to construct a table for calculating LSI, RSI and PSI for ready reference. Water balancing chart was also prepared with computer programming.

Results

Table 1.

Sample No.	Source	Location
A1, A3, A5, A7, A9	Supply Water	Inside Tea Garden
A2, A4, A6, A8, A10	Tube Well	Inside Tea Garden
B1- B10	Ring Well	Outside Tea Garden

Discussion and Summary of Findings

The ideal range for the Langelier or Saturation Index (LSI or SI) is -0.5 to +0.5. Test values more negative than -0.5 are considered corrosive and steps should be taken to adjust the pH, total alkalinity or calcium hardness, in order to avoid the effects of corrosion. Test values higher than +0.5 are indicative of scale-forming tendencies and steps should be taken to adjust the pH, total alkalinity or calcium hardness, in order to avoid scale formation and cloudiness. It was observed that samples A4, A8 & B1, B2, B5, B7, B9, and B10 have corrosion and require treatment. The other three samples A2, A6 & A10 also needed treatment for mild scale coatings. It is apparent that the temperature at which the calculation is made has considerable impact upon the results. The water chemistry of the investigated samples is non - scaling to corrosive at the temperature at which it would be delivered from the source. If exposed to higher temperature, it would deposit scale. It is also clear that low and high Langelier Indexes can be raised or lowered, to within -0.5 to +0.5, only by adjusting the pH, the total alkalinity and the calcium hardness for the samples whose LSI limits were found outside the safe limit. While it is always possible to lower the pH, it is not as simple with the total alkalinity or calcium hardness. Lowering the total alkalinity usually lowers the pH as well. Lowering the calcium hardness is not always possible, given the fact that some water sources are filled with hard water. In those situations, where the calcium level is high, attention should be paid to lowering the pH and/or total alkalinity as a means of improving the Langelier Index. A high Langelier Index can lead to scale formation, cloudy water, filtration problems, heater problems, loss of chlorine efficiency and bather discomfort. A low Langelier Index can result in corrosion, bather irritation and discomfort.

Two tables (Table 4, Table 5) have been constructed by using computer programming for easy calculation of LSI, RSI and PSI directly from their experimental results. It has the advantage that one can easily adjust their system variables *viz.* pH, temperature, TDS, alkalinity and hardness of samples to the safe limit without carrying out laborious mathematical calculations. This table also provides the behaviour pattern of various system variables with one another along with the necessary adjustment required in their values to balance water with respect to LSI advisable limit. The table gives the value of pHs as:

Table 2.

Sample No	Temp. (°C)	TDS mg/l	pH	Alkalinity mg/l	Hardness mg/l	LSI
A1	21	395	6.6	400	294	-0.35
A2	20	180	8.0	316	30	+0.97
A3	20	450	7.4	178	156	-0.20
A4	21	535	6.8	110	105	-1.17
A5	20	340	7.6	160	110	-0.19
A6	19	300	7.9	336	296	+0.84
A7	21	550	6.8	330	268	-0.29
A8	22	380	6.5	92	316	-1.04
A9	22	260	7.9	160	180	+0.37

pHs = X –Y; Where X = 9.3 + A + B and Y= C + D

The difference between two system variable is taken as 50 as for this difference the value for X and Y is correct upto two decimal place. However, the exact value can be obtained by adding the required number as is given at the side and bottom of each table.

Effects of water testing parameters on different animal models

pH : Rodent models studies have shown that alterations in drinking water pH had an adverse affect both on host glucose regulation and the composition of the gut microbiota as represented by Shannon's index. Analyses of within period effects showed a significant enhancement in the relative abundance of 9 OTUs that falls under order Clostridiales, family Ruminococcaceae, genus Bacteroides, and species Prevotella copri, signifying a potential effect of qualitative or quantitative changes in habitual drinking habits. When comparing the alkaline to the neutral intervention, an increase in the concentration of plasma glucose at 30 minutes and the incremental area under the curve of plasma glucose from 0 30 and 0 120 minutes, respectively, was observed. In contrast to what has been reported in rodents, in young male adults, it was observed that a change in drinking water pH had no impact on glucose regulation or the composition of the gut microbiota (Tue *et al.,* 2018).

In another study, exercise-induced dehydration on people were allowed to consume electrolyzed, high-pH water. Results revealed that subjects had reduced high-shear viscosity by an average of 6.30% compared to 3.36% amid standard purified water (p = 0.03). Other measured biomarkers (bioimpedance, plasma osmolality and body mass change) revealed no considerable difference between the two types of water for rehydration. Conversely, a mixed model analysis validated the effect of high-pH water on high-shear viscosity when compared to standard purified water (p = 0.0213). The above study revealed a significant divergence in whole blood viscosity when assessed with a high-pH, electrolyte water as against an acceptable standard purified water during the recovery phase in subsequent strenuous exercise-induced dehydration (Weidman *et al.,* 2016).

However a systematic review of the literature revealed that there is no evidence that correlates an association between alkaline water and a acid diet load that may increase the risk of cancer and no studies revealed that alkaline diet can be used as preventive treatment for cancer (Fenton and Huang, 2016).

Alkalinity: Studies on one hundred postmenopausal women when they are predisposed to osteoporosis (T-score ≤ –2.5) and a control (n = 50 each) group. The intervention group received calcium D (daily), alkaline drinking water (1.5 L daily with pH 8.6, and Osteofos tablet (70 mg weekly), whereas the control group received only calcium D and Osteofos tablet for 3 months. Results after intervention have shown that the mean T-scores of the spine and femur bones significantly increased in both the intervention groups (P < 0.05) and the control suggesting that drinking alkaline water elevates spine T-scores in postmenopausal women with osteoporosis.

In another study, hydrogen-rich water (HRW) and electrolyzed-alkaline water (EAW) were fed to mice to evaluate the effect onhigh-fat-induced non-alcoholic fatty acid disease. Compared to Rich Water and L-HRW, H-HRW resulted in a lower in-

Table 3.

Sample No	Temp. (^{0}C)	TDS mg/l	pH	Alkalinity mg/l	Hardness mg/l	LSI
B1	22	352	7.2	100	60	-1.02
B2	23	133	6.9	115	55	-1.24
B3	22	442	7.4	113	203	-0.25
B4	21	362	7.3	105	192	-0.42
B5	20	150	7.3	125	110	-0.56
B6	23	133	7.2	142	280	-0.14
B7	23	368	6.7	90	300	-0.85
B8	23	337	7.0	91	340	-0.49
B9	23	321	6.7	180	70	-1.18
B10	22	348	6.9	175	165	-0.64

Table 4. Calculation of X

	TDS (mg/L)																					
Temperature (^{0}C)	10	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000	
0	11.89	11.96	11.99	12.01	12.02	12.03	12.04	12.04	12.05	12.05	12.06	12.06	12.07	12.07	12.07	12.08	12.08	12.08	12.08	12.09	12.09	
5	11.78	11.85	11.88	11.90	11.91	11.92	11.93	11.94	11.94	11.95	11.95	11.96	11.96	11.97	11.97	11.97	11.97	11.98	11.98	11.98	11.98	-0.0207
10	11.68	11.75	11.78	11.80	11.81	11.82	11.83	11.84	11.84	11.85	11.85	11.86	11.86	11.86	11.87	11.87	11.87	11.88	11.88	11.88	11.88	-0.0203
15	11.58	11.65	11.68	11.70	11.71	11.72	11.73	11.74	11.74	11.75	11.75	11.76	11.76	11.76	11.77	11.77	11.77	11.78	11.78	11.78	11.78	-0.0200
20	11.48	11.55	11.58	11.60	11.61	11.62	11.63	11.64	11.64	11.65	11.65	11.66	11.66	11.67	11.67	11.67	11.68	11.68	11.68	11.68	11.68	-0.0196
25	11.39	11.46	11.49	11.51	11.52	11.53	11.54	11.54	11.55	11.55	11.56	11.56	11.57	11.57	11.57	11.58	11.58	11.58	11.58	11.59	11.59	-0.0193
30	11.29	11.36	11.39	11.41	11.42	11.43	11.44	11.45	11.45	11.46	11.46	11.47	11.47	11.47	11.48	11.48	11.48	11.49	11.49	11.49	11.49	-0.0190
35	11.20	11.27	11.30	11.32	11.33	11.34	11.35	11.35	11.36	11.37	11.37	11.37	11.38	11.38	11.38	11.39	11.39	11.39	11.40	11.40	11.40	-0.0187
40	11.11	11.18	11.21	11.23	11.24	11.25	11.26	11.26	11.27	11.27	11.28	11.28	11.29	11.29	11.29	11.30	11.30	11.30	11.30	11.31	11.31	-0.0184
45	11.02	11.09	11.12	11.14	11.15	11.16	11.17	11.17	11.18	11.18	11.19	11.19	11.20	11.20	11.20	11.21	11.21	11.21	11.21	11.22	11.22	-0.0181
50	10.93	11.00	11.03	11.05	11.06	11.07	11.08	11.08	11.09	11.09	11.10	11.10	11.11	11.11	11.11	11.12	11.12	11.12	11.12	11.13	11.13	-0.0178
55	10.84	10.91	10.94	10.96	10.97	10.98	10.99	11.00	11.00	11.01	11.01	11.02	11.02	11.02	11.03	11.03	11.03	11.03	11.04	11.04	11.04	-0.0175
60	10.76	10.83	10.86	10.87	10.89	10.90	10.90	10.91	10.92	10.92	10.93	10.93	10.93	10.94	10.94	10.94	10.95	10.95	10.95	10.95	10.96	-0.0172
	0.0175	0.0060	0.0035	0.0025	0.0019	0.0016	0.0013	0.0012	0.0010	0.0009	0.0008	0.0008	0.0007	0.0006	0.0006	0.0006	0.0005	0.0005	0.0005	0.0004		

Table 5. Calculation of Y

Alkalinity (mg/L)	Hardness (mg/L)																					
10	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900	950	1000		
10	1.60	2.30	2.60	2.78	2.90	3.00	3.08	3.14	3.20	3.25	3.30	3.34	3.38	3.41	3.45	3.48	3.50	3.53	3.55	3.58	3.60	
50	2.30	3.00	3.30	3.48	3.60	3.70	3.78	3.84	3.90	3.95	4.00	4.04	4.08	4.11	4.14	4.17	4.20	4.23	4.25	4.28	4.30	0.1747
100	2.60	3.30	3.60	3.78	3.90	4.00	4.08	4.14	4.20	4.25	4.30	4.34	4.38	4.41	4.45	4.48	4.50	4.53	4.55	4.58	4.60	0.0602
150	2.78	3.48	3.78	3.95	4.08	4.17	4.25	4.32	4.38	4.43	4.48	4.52	4.55	4.59	4.62	4.65	4.68	4.71	4.73	4.75	4.78	0.0352
200	2.90	3.60	3.90	4.08	4.20	4.30	4.38	4.45	4.50	4.55	4.60	4.64	4.68	4.71	4.75	4.78	4.80	4.83	4.86	4.88	4.90	0.0250
250	3.00	3.70	4.00	4.17	4.30	4.40	4.48	4.54	4.60	4.65	4.70	4.74	4.78	4.81	4.84	4.87	4.90	4.93	4.95	4.98	5.00	0.0194
300	3.08	3.78	4.08	4.25	4.38	4.48	4.55	4.62	4.68	4.73	4.78	4.82	4.86	4.89	4.92	4.95	4.98	5.01	5.03	5.05	5.08	0.0158
350	3.14	3.84	4.14	4.32	4.45	4.54	4.62	4.69	4.75	4.80	4.84	4.88	4.92	4.96	4.99	5.02	5.05	5.07	5.10	5.12	5.14	0.0134
400	3.20	3.90	4.20	4.38	4.50	4.60	4.68	4.75	4.80	4.86	4.90	4.94	4.98	5.01	5.05	5.08	5.11	5.13	5.16	5.18	5.20	0.0116
450	3.25	3.95	4.25	4.43	4.55	4.65	4.73	4.80	4.86	4.91	4.95	4.99	5.03	5.07	5.10	5.13	5.16	5.18	5.21	5.23	5.25	0.0102
500	3.30	4.00	4.30	4.48	4.60	4.70	4.78	4.84	4.90	4.95	5.00	5.04	5.08	5.11	5.14	5.17	5.20	5.23	5.25	5.28	5.30	0.0092
550	3.34	4.04	4.34	4.52	4.64	4.74	4.82	4.88	4.94	4.99	5.04	5.08	5.12	5.15	5.19	5.22	5.24	5.27	5.29	5.32	5.34	0.0083
600	3.38	4.08	4.38	4.55	4.68	4.78	4.86	4.92	4.98	5.03	5.08	5.12	5.16	5.19	5.22	5.25	5.28	5.31	5.33	5.36	5.38	0.0076
650	3.41	4.11	4.41	4.59	4.71	4.81	4.89	4.96	5.01	5.07	5.11	5.15	5.19	5.23	5.26	5.29	5.32	5.34	5.37	5.39	5.41	0.0070
700	3.45	4.14	4.45	4.62	4.75	4.84	4.92	4.99	5.05	5.10	5.14	5.19	5.22	5.26	5.29	5.32	5.35	5.37	5.40	5.42	5.45	0.0064
750	3.48	4.17	4.48	4.65	4.78	4.87	4.95	5.02	5.08	5.13	5.17	5.22	5.25	5.29	5.32	5.35	5.38	5.40	5.43	5.45	5.48	0.0060
800	3.50	4.20	4.50	4.68	4.80	4.90	4.98	5.05	5.11	5.16	5.20	5.24	5.28	5.32	5.35	5.38	5.41	5.43	5.46	5.48	5.50	0.0056
850	3.53	4.23	4.53	4.71	4.83	4.93	5.01	5.07	5.13	5.18	5.23	5.27	5.31	5.34	5.37	5.40	5.43	5.46	5.48	5.51	5.53	0.0053
900	3.55	4.25	4.55	4.73	4.86	4.95	5.03	5.10	5.16	5.21	5.25	5.29	5.33	5.37	5.40	5.43	5.46	5.48	5.51	5.53	5.55	0.0050
950	3.58	4.28	4.58	4.75	4.88	4.98	5.05	5.12	5.18	5.23	5.28	5.32	5.36	5.39	5.42	5.45	5.48	5.51	5.53	5.56	5.58	0.0047
1000	3.60	4.30	4.60	4.78	4.90	5.00	5.08	5.14	5.20	5.25	5.30	5.34	5.38	5.41	5.45	5.48	5.50	5.53	5.55	5.58	5.60	0.0045
		0.1747	0.0602	0.0352	0.0250	0.0194	0.0158	0.0134	0.0116	0.0102	0.0092	0.0083	0.0076	0.0070	0.0064	0.0060	0.0056	0.0053	0.0050	0.0047	0.0045	

crease in fat mass (46% vs 61%), a decrease in hepatic lipid accumulation ($P < 0.01$) and an increase in lean body mass (42% vs 28%) (Jackson *et al.*, 2018).

Logozzi *et al.* (2020) while working on the effect of the daily intake of alkaline water on the molecular hallmark of aging (Telomeres length and telomerase activity) and the anti-oxidant response. After 10months, the levels of ROS, SOD-1, GSH in the blood, the bone marrow and the ovaries, revealed a reduced level of ROS and increased SOD-1, GSH. Moreover the telomeres length and telomerase activity in alkaline supplemented mice also increased supporting the fact that watering by using alkaline water supplementation greatly improves aging at the molecular level.

Hardness: Simob *et al.* (2017) enrolled 80 participants, including both healthy individuals and patients with Alzheimer's disease (AD), with and without filaggrin (FLG) mutations. Each participant's skin underwent cleansing with sodium lauryl sulfate (SLS) in water with varying degrees of hardness and chlorine concentration. After cleansing, the skin was rinsed and covered with chambers to assess the impact of surfactant residues. Areas washed with hard water showed a significant increase in sodium lauryl sulfate (SLS) deposits. These deposits led to a rise in transepidermal water loss and induced irritation, particularly in AD patients carrying FLG mutations (Cork *et al*., 2009).

The hardness of drinking water is crucial, impacting both aesthetic preferences and operational considerations. While some epidemiological studies suggest a potential protective effect of magnesium or hardness on cardiovascular mortality, ongoing debates question the establishment of causality. Further research is underway to clarify these relationships. Nevertheless, drinking water remains a viable source of dietary calcium and magnesium. This aspect could be particularly significant for individuals on the borderline of adequate calcium and magnesium intake (Sengupta, 2013).

Recommendations

1. A positive index indicates a scale forming condition. Experience has shown that under these conditions corrosion would still take place. The high TDS level in case of bathing water can be reduced by dilution with fresh water. This introduces a large quantity of fresh soft water. This, of course, reduces the calcium hardness level. To raise the calcium hardness level we can add calcium chloride. This of course adds to the TDS level, requiring the introduction of more fresh water again for lowering the calcium level.
2. A negative index indicates not only the signs of corrosion but also grouts loss from the well or pool tank. Alkalinity can be reduced by the addition of sodium bicarbonate which has a very little effect on pH. The calcium hardness can also be raised by the addition of calcium chloride or, preferably a change of sanitizer to calcium hypochlorite.
3. It is strongly recommended that a householder or new homeowner have the corrosivity of the water tested at least once every few years. Corrosive or Aggressive water could result in aesthetic problems, increased levels of toxic metals, and deterioration of household plumbing and fixtures.
4. The maximum pH at which favourable bathing conditions can be maintained is around 7.6 (www.europa.eu.int). We have prepared a chart (Table VI) by developing a formula for balancing water. The chart is constructed by taking the TDS as 500 mg/L (WHO, 2004, Trivedy, R.K, 1990 & Train, R.E., 1979). Now, by determining either hardness or alkalinity of water it is possible to balance the water with respect to either alkalinity or hardness at a temperature range of (10-45) ^{0}C and pH in between 7-8.

Suppose calculated water hardness = X mg/L

Then according to our findings alkalinity of the sample under investigation must have to lie within the limit [Y/X, 10*Y/X], for it to be inside the safe LSI limit i.e. (-0.5 to +0.5), where Y is the value that is provided in the Table VI for the preferred temperature and pH value. Similarly, by knowing Alkalinity, we can calculate the Hardness range by adopting the same procedure.

5. Corrosion control is a complex science, requiring considerable knowledge of corrosion chemistry and of the system being evaluated. Corrosive water can be managed by installing pretreatment systems, installation of non-conductive unions, reducing hot water temperature, and replacing copper piping with PVC. The pretreatment process treats the corrosivity of the water by changing the Saturation Index through an increase or decrease in the pH, hardness, and/or alkalinity. The resultant Saturation Index is typically more positive and preferably the LSI is in between -0.5

Table 6. Balancing Chart

Temperature (⁰C)	pH															
	6.5	6.6	6.7	6.8	6.9	7	7.1	7.2	7.3	7.4	7.5	7.6	7.7	7.8	7.9	8
15	178924	142124	112893	89674	71231	56581	44944	35700	28358	22525	17892	14212	11289	8967	7123	5658
16	170969	135806	107874	85688	68064	54065	42946	34113	27097	21524	17097	13581	10787	8569	6806	5407
17	163394	129788	103095	81891	65048	51670	41043	32601	25896	20570	16339	12979	10309	8189	6505	5167
18	156178	124057	98542	78275	62176	49388	39230	31162	24753	19662	15618	12406	9854	7827	6218	4939
19	149305	118597	94205	74830	59439	47214	37504	29790	23663	18796	14931	11860	9421	7483	5944	4721
20	142756	113395	90073	71548	56832	45143	35859	28484	22625	17972	14276	11340	9007	7155	5683	4514
21	136515	108438	86135	68420	54348	43170	34291	27238	21636	17186	13652	10844	8614	6842	5435	4317
22	130567	103713	82382	65438	51980	41289	32797	26052	20693	16437	13057	10371	8238	6544	5198	4129
23	124896	99209	78804	62597	49722	39496	31373	24920	19795	15724	12490	9921	7880	6260	4972	3950
24	119490	94915	75393	59887	47570	37786	30015	23842	18938	15043	11949	9491	7539	5989	4757	3779
25	114335	90820	72141	57303	45518	36156	28720	22813	18121	14394	11434	9082	7214	5730	4552	3616
26	109419	86914	69039	54839	43560	34601	27485	21832	17342	13775	10942	8691	6904	5484	4356	3460
27	104729	83189	66080	52489	41693	33118	26307	20896	16598	13185	10473	8319	6608	5249	4169	3312
28	100255	79635	63256	50246	39912	31703	25183	20003	15889	12621	10025	7964	6326	5025	3991	3170
29	95986	76244	60563	48107	38213	30353	24111	19152	15213	12084	9599	7624	6056	4811	3821	3035
30	91912	73008	57992	46065	36591	29065	23087	18339	14567	11571	9191	7301	5799	4607	3659	2907
31	88023	69919	55539	44116	35043	27835	22110	17563	13951	11081	8802	6992	5554	4412	3504	2784
32	84311	66971	53197	42256	33565	26661	21178	16822	13362	10614	8431	6697	5320	4226	3356	2666
33	80767	64155	50960	40479	32154	25541	20288	16115	12801	10168	8077	6416	5096	4048	3215	2554
34	77382	61467	48825	38783	30806	24470	19438	15440	12264	9742	7738	6147	4883	3878	3081	2447
35	74150	58900	46786	37163	29520	23448	18626	14795	11752	9335	7415	5890	4679	3716	2952	2345
36	71063	56447	44838	35616	28291	22472	17850	14179	11263	8946	7106	5645	4484	3562	2829	2247
37	68113	54104	42977	34138	27116	21539	17109	13590	10795	8575	6811	5410	4298	3414	2712	2154
38	65295	51866	41199	32725	25995	20648	16401	13028	10349	8220	6530	5187	4120	3273	2599	2065
39	62602	49727	39499	31375	24922	19797	15725	12491	9922	7881	6260	4973	3950	3138	2492	1980
40	60028	47682	37875	30085	23898	18983	15078	11977	9514	7557	6003	4768	3788	3009	2390	1898

to +0.5.

6. In addition to changing the LSI, one approach includes establishing a thin film of calcium or magnesium carbonate on the inside of the piping which acts as a physiochemical barrier. The pre-treatment systems typically used in application for householders or small private water supplies include either a neutralizing tank filter or caustic liquid treatment feed system. One of the more effective methods of controlling corrosion and leaching of toxic metals into the water is preventive, such as using dielectric couplings, installing PVC piping, and stainless steel equipment

Conflict of Interest- None

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