Assessment of Groundwater Quality of Outer Skirts of Kota City with Reference to its Potential of Scale Formation and Corrosivity

NITIN GUPTA, S.M.NAFEES, M.K.JAIN and S. KALPANA

Environmental Chemistry Laboratory
P.G. Department of Chemistry, Govt. College, Kota, Rajasthan, India
guptanitin2002@yahoo.com

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Abstract: Kota City is a prominent industrial and educational town of Rajasthan state, India. Mega industrial projects of cement, fertilizers, power plant, oil seed processing units are located nearby the city. The groundwater of study area is used in domestic as well as in industrial activities. It is worthwhile to know the water quality status and its effect on entity, which is exposed in practical use. A comprehensive assessment of water quality parameters in groundwater samples drawn from 24 different locations, 6 sites from each direction at outer skirts of Kota City of Rajasthan, India, in four seasons of years 2006 to 2008 was carried out. To find out the suitability and stability of water, various indices available to assess the scale formation and corrosivity was used. The Langelier saturation index (LSI) and Ryznar saturation index (RSI) were calculated and discussed with respect to saturation level.

Keywords: Water quality, Groundwater, Langelier saturation index, Ryznar saturation index

Introduction

Groundwater sources range over a broad spectrum of chemical quality, which reflects the history of water and the region of origin. The effect of water on the industrial equipment, piping system, utensils and other objects, appears in four forms: fouling, deposition, aggression and corrosion. Fouling is a complex phenomenon resulting from the accumulation of undesirable deposition on surface. Deposition is the phenomenon in which salts gets deposit on surface. Aggression is the dissolution of cement material comprising the conduits and retaining structures. Corrosion is the end result of electro chemical reaction between water and the metal components. Factors causing corrosion include acidity,
hardness, high chloride concentration, dissolved oxygen and scale formation depends upon temperature, pH and concentrations of $\text{HCO}_3^-$, $\text{CO}_3^{2-}$, $\text{Ca}^{2+}$ and $\text{Mg}^{2+}$. The occurrence of scale formation and corrosion in natural and processed waters can cause serious operational and cost problems in industries and drinking water supply systems\(^4\). It has been roughly assessed that in India direct loss due to corrosion is amounting Rs. 200 crore/annum. To evaluate the scale formation and corrosivity potential of water, so many indices are there but Langelier saturation index (LSI) and Ryzner saturation index (RSI) are the most famous $\text{CaCO}_3$ saturation indices, in which LSI determines whether water has tendency to precipitate or dissolve $\text{CaCO}_3$ and RSI estimates the quantity of the precipitated or dissolved amount of $\text{CaCO}_3$. It is believed that supersaturated waters are scale forming whereas undersaturated waters are corrosive.

Kota City is a prominent industrial and educational town of Rajasthan state. Mega industrial projects of big industrial houses as DCM, CFCL, KSTPS, KS Oil etc. established their projects comprising the production facilities of cement, fertilizers, power plant, edible oil etc. nearby the city. Perennial River Chambal is the main water source for industries and agricultural activities but in lean season when canals are not flowing industries supposed to use groundwater in industrial activities. In the present study, the quality, potential of scale formation and corrosivity of twenty four groundwater samples collected from four different directions including six sites from each direction at outer skirts of Kota City of Rajasthan, India, in four seasons of years 2006 to 2008 were studied and the results were fully interpreted with respect to saturation level.

**Experimental**

Details about study area, sampling locations, sampling techniques and standard methods applied for analysis are as discussed below:

**Study area**

Kota City is centrally located in Hadoti Region. Over the years of industrial development Kota’s name became synonymous with industrial town of Rajasthan as large industrial houses like KSTPS, DCM, instrumentation Ltd., Chambal fertilizers LTd., etc. have their units located at Kota.

Kota has good number of prominent industrial units, good network of railway lines, perennial sources of water and electricity. The Chambal River provides the irrigation, water supply and electricity to the whole Hadoti Region. It is well connected with all major cities of India by broad gauge railway system. National highway 12 Jaipur to Jabalpur and 76 Shivpuri to Pindwara pass through the city.

The district Kota lies between $24^\circ 25'$ and $25^\circ 51'$ North latitudes and $75^\circ 31'$ and $77^\circ 26'$ East longitudes with total area of 5203.94 Sq Kms. “Kota City” is located at extreme South of it at $25^\circ 11'$ North latitude and $75^\circ 51'$ East longitude occupying total area of 238.59 Sq Kms with average height 253.30 meters from sea level. The only perennial river “Chambal” originating from the hills of Western Madhya Pradesh passes through the district. According to 2001 census total population of district was 1568525 and according a survey estimated population for 2008 was 1836021. Kota District has Bundi on its West, Sawai Madhopur in the North, Chittorgarh in South West and Jhalawar in the South East and Baran in the East.

The climate of Kota varies from semi-arid to arid. The climate of Kota division is characteristic of South Eastern Rajasthan with a long and intensely hot summer, low rainfall and a short mild winter. The temperature normally varies from 7 °C in January to
48 °C in May. The average annual precipitation in the area is approx 700 mm. The lithological units that constitute the Kota division are mainly those of upper Vindhyan system. The upper Bhandar sandstone covers wide areas on the North and parts of Southern sector are mantled by deccan trap flows. The Eastern parts of the central belt is occupied by the Suket Shales, while on the West there are rock out crops of Kaimur sandstone. Alluvium covers part of the area on the Northeastern parts.

**Sampling locations and techniques**

To find out potential of scale formation and corrosivity in groundwater of outer skirts of industrial and educational Kota City water samples were collected from 24 different selected sites in years 2006, 2007 and 2008 in all the four major seasons i.e. winter, spring, pre-monsoon and post-monsoon. The selection of sampling sites is done to give coverage to the largest area of outer skirts of Kota City in all the four directions, covering estimated points of high probability of groundwater pollution. Kota district map is shown on Figure 1 and sampling locations are shown in Figure 2. Six villages of prime importance from each direction were selected for study. The bore wells / hand pumps located in residential, commercial, agricultural and industrial area were selected for sampling. Before collecting groundwater samples the pipeline of bore wells / hand pumps were flushed for a sufficient period of time, so that actual sample can be collected which represents the actual quality of groundwater\(^5\). The samples were collected as composite samples, at every site samples collected from four different points and then mixed together. Sample collected in pre-cleaned good quality narrow mouth screw-capped polypropylene bottles of two-liter capacity and rinsed thrice with the water to be collected and then filled completely to avoid encroachment of any air bubble. Sample bottles screw-caped tightly and brought to the laboratory. The samples were preserved in refrigerator at 4 °C. Samples were protected from any outside contamination.

![Figure 1. Calculated values of Langelier saturation index (LSI)](image-url)
Analytical methods

The analysis of groundwater samples was done using procedures of standard methods (APHA, 1995)\(^6\) and all analysis were carried out in triplicate. Water used in reagent / standard preparation is of Milli-Q and chemicals were of AnalR grade. The pH of sample was measured at site with the help of portable meter. Total alkalinity was estimated in laboratory by titration with standard hydrochloric acid. Total hardness and calcium hardness was measured by titration with standard EDTA and total dissolved solids was estimated by evaporation method. For calculation of indices temperature of water was taken 25 °C for all the samples so that impact of physicochemical parameters on potential of scale formation and corrosivity can be figure out.

Calculation of indices

Langelier saturation index (LSI)

It simply indicates the driving force for scale formation and growth in terms of pH as a master variable. It is purely an equilibrium index and deals only with the thermodynamic driving force for calcium carbonate scale formation and growth. It provides no indication of how much scale or calcium carbonate will actually precipitate to bring water to equilibrium\(^7\).

If LSI is negative: No potential to scale, water will dissolve CaCO\(_3\).
If LSI is positive: Scale can form and CaCO\(_3\) precipitation may occur.
If LSI is close to Zero: Borderline scale potential.

In order to calculate the LSI, it is necessary to know the total alkalinity (mg/L as CaCO\(_3\)), the calcium hardness (mg/L as CaCO\(_3\)), the total dissolved solids (mg/L TDS), the actual pH and the temperature of the water (°C).

LSI is defined as:

\[
LSI = \text{pH} - \text{pHs}
\]  

(1)
pH is the measured water pH.
pHs is the pH at saturation in calcite or calcium carbonate and is defined as:

$$}\text{pH}_s = (9.3 + A + B) - (C + D)\text{ (2)}$$

Where

$$A = (\log_{10}[\text{TDS}] - 1)/10\text{ (3)}$$

$$B = -13.12 \times \log_{10}(°\text{C} + 273) + 34.55\text{ (4)}$$

$$C = \log_{10}[[\text{CaH as CaCO}_3] - 0.4\text{ (5)}$$

$$D = \log_{10}[[\text{total alkalinity as CaCO}_3].\text{ (6)}$$

From analyzed data calculated LSI using equations (1) to (6).

The use of the equation developed by Langelier made it possible to predict the tendency of natural or conditioned water to deposit calcium carbonate or to dissolve calcium carbonate. This is useful in predicting the scaling or corrosive tendencies of the water. If the water dissolves calcium carbonate, the water is corrosive and has a negative value, if the water deposits calcium carbonate; it has a scaling tendency and a positive value.

**Ryznar saturation index (RSI)**
The Ryznar saturation index is an empirical method for predicting scaling tendencies of water based on a study of operating results with water of various saturation indices. The Ryznar saturation index is defined as:

$$\text{RSI} = 2\ \text{pH}_s - \text{pH} = \text{pH}_s - \text{Langelier's saturation pH}\text{. (7)}$$

This index is often used in combination with the Langelier index to improve the accuracy in predicting the scaling or corrosion tendencies of water. Calculated Ryznar saturation index values can be construed as; RSI values in between 4.0 - 5.0, than water have heavy scaling tendency; between 5.0 - 6.0, light scaling; 6.0 - 7.0, little scale or corrosion; 7.0 - 7.5, corrosion significance; 7.5 - 9.0 heavy corrosion and higher than 9.0, water have tendency to make corrosion which is intolerable.

**Results and Discussion**
The sampling locations and their respective code along with numbering on Figure 2 is given in Table 1. Observations and results obtained from the physicochemical analysis of groundwater samples collected from 24 different selected sites in years 2006, 2007 and 2008 in all the four major seasons, i.e. winter, spring, pre-monsoon and post-monsoon from outer skirts of industrial and educational Kota City are summarized in Table 2; calculated values of LSI and RSI are shown in Table 3; interpretation of LSI and RSI with respect to scale formation and corrosivity potential is given in Table 4 & 5 respectively. The observations summarized in Table 2 and calculated indices given in Table 3 are interpreted in a manner given below.

**Langelier saturation index (LSI)**
Calculated values of Langelier saturation index (LSI) varied from 0.80 to 2.37 with an overall average of 1.52 for all the samples analyzed in four major seasons in year 2006; from 1.31 to 2.42 with an overall average of 1.95 for all the samples analyzed in four major seasons in year 2007; from 1.02 to 2.40 with an overall average of 1.75 for all the samples analyzed in four major seasons in years 2008 and the average values of three successive years varied from 1.19 to 2.40 with an overall average of 1.72. Use of groundwater without any treatment may result in such manner; in 2006 only one sample have slight scale formation tendency, four samples have moderate scale formation tendency and remaining nineteen samples have mild scale formation tendency.
Table 1. Sampling locations and codings of groundwater samples collected at outer skirts of Kota City

| S.No. | Location | Code  |
|-------|----------|-------|
| 1     | Gangaycha | GWS/N/1 |
| 2     | Notana   | GWS/N/2 |
| 3     | Rangpur  | GWS/N/3 |
| 4     | Bhim Mandi | GWS/N/4 |
| 5     | Gamach   | GWS/N/5 |
| 6     | Tirath   | GWS/N/6 |
| 7     | Raipur   | GWS/E/1 |
| 8     | Borkhandi | GWS/E/2 |
| 9     | Dhakar Kheri | GWS/E/3 |
| 10    | Tather   | GWS/E/4 |
| 11    | Manpura  | GWS/E/5 |
| 12    | Kaithoon | GWS/E/6 |
| 13    | Ranpur   | GWS/S/1 |
| 14    | Jagpura  | GWS/S/2 |
| 15    | Alaniya  | GWS/S/3 |
| 16    | Shankarpura | GWS/S/4 |
| 17    | Dad Devi | GWS/S/5 |
| 18    | Naya-Gaon | GWS/S/6 |
| 19    | Nanta    | GWS/W/1 |
| 20    | Ganeshpal | GWS/W/2 |
| 21    | Badgaon  | GWS/W/3 |
| 22    | Kunhadi  | GWS/W/4 |
| 23    | Balita   | GWS/W/5 |
| 24    | Sinta    | GWS/W/6 |

Table 2. Water quality, physicochemical study of groundwater samples (Given values are average of the respective year)

| S.No. | Sample Code | pH | TDS | TA | CaH | pH | TDS | TA | CaH | pH | TDS | TA | CaH |
|-------|-------------|----|-----|----|-----|----|-----|----|-----|----|-----|----|-----|
| 1     | GWS/N/1     | 7.60 | 674 | 314 | 159 | 8.03 | 468 | 240 | 87  | 7.85 | 479 | 225 | 100 | 7.83 |
| 2     | GWS/N/2     | 7.78 | 1285 | 456 | 147 | 8.25 | 967 | 335 | 112 | 8.05 | 855 | 322 | 120 | 8.03 |
| 3     | GWS/N/3     | 7.63 | 964 | 549 | 156 | 8.20 | 866 | 403 | 116 | 7.80 | 1078 | 491 | 84  | 7.88 |
| 4     | GWS/N/4     | 7.90 | 674 | 307 | 132 | 7.95 | 223 | 140 | 63  | 7.95 | 444 | 193 | 86  | 7.93 |
| 5     | GWS/N/5     | 8.13 | 687 | 304 | 26  | 8.03 | 691 | 303 | 49  | 8.13 | 891 | 462 | 36  | 8.09 |
| 6     | GWS/N/6     | 7.95 | 294 | 164 | 75  | 7.98 | 300 | 156 | 71  | 7.95 | 344 | 166 | 82  | 7.96 |
| 7     | GWS/E/1     | 7.83 | 610 | 252 | 84  | 8.23 | 529 | 238 | 119 | 8.05 | 539 | 242 | 101 | 8.03 |
| 8     | GWS/E/2     | 7.88 | 854 | 438 | 115 | 7.90 | 828 | 439 | 118 | 7.75 | 1017 | 539 | 195 | 7.84 |
| 9     | GWS/E/3     | 7.88 | 740 | 336 | 104 | 8.05 | 556 | 320 | 74  | 7.98 | 493 | 257 | 86  | 7.97 |
| 10    | GWS/E/4     | 7.78 | 736 | 286 | 136 | 8.40 | 723 | 257 | 82  | 8.30 | 713 | 287 | 86  | 8.16 |
| 11    | GWS/E/5     | 7.95 | 833 | 331 | 120 | 7.98 | 732 | 308 | 115 | 8.13 | 978 | 395 | 124 | 8.02 |
| 12    | GWS/E/6     | 7.93 | 603 | 330 | 152 | 7.98 | 619 | 216 | 74  | 7.88 | 496 | 233 | 84  | 7.93 |
| 13    | GWS/S/1     | 7.45 | 473 | 251 | 153 | 7.90 | 359 | 153 | 67  | 7.70 | 443 | 168 | 93  | 7.68 |
| 14    | GWS/S/2     | 7.73 | 586 | 223 | 130 | 8.03 | 295 | 132 | 76  | 7.43 | 477 | 192 | 169 | 7.73 |
| 15    | GWS/S/3     | 8.10 | 529 | 230 | 125 | 7.93 | 400 | 165 | 61  | 7.78 | 400 | 172 | 63  | 7.93 |
| 16    | GWS/S/4     | 8.00 | 764 | 375 | 228 | 8.05 | 354 | 161 | 56  | 7.95 | 411 | 176 | 64  | 8.00 |
| 17    | GWS/S/5     | 7.63 | 509 | 227 | 146 | 7.83 | 564 | 209 | 168 | 7.70 | 540 | 218 | 139 | 7.72 |
| 18    | GWS/S/6     | 7.73 | 526 | 227 | 144 | 7.95 | 392 | 198 | 123 | 7.80 | 397 | 242 | 99  | 7.83 |
| 19    | GWS/W/1     | 8.28 | 524 | 189 | 116 | 8.00 | 307 | 138 | 88  | 8.00 | 320 | 142 | 89  | 8.09 |
| 20    | GWS/W/2     | 8.85 | 551 | 221 | 116 | 8.08 | 528 | 232 | 56  | 8.03 | 504 | 229 | 56  | 7.98 |
| 21    | GWS/W/3     | 7.70 | 454 | 230 | 88  | 7.90 | 397 | 166 | 73  | 7.90 | 372 | 160 | 71  | 7.83 |
| 22    | GWS/W/4     | 7.95 | 509 | 340 | 82  | 8.25 | 624 | 281 | 42  | 8.08 | 523 | 266 | 43  | 8.09 |
| 23    | GWS/W/5     | 7.98 | 300 | 147 | 40  | 8.10 | 335 | 151 | 46  | 8.10 | 360 | 166 | 44  | 8.06 |
| 24    | GWS/W/6     | 7.90 | 627 | 304 | 39  | 7.98 | 551 | 324 | 56  | 7.70 | 666 | 386 | 57  | 7.86 |

TDS: Total Dissolved Solids, TA: Total Alkalinity, CaH: Calcium Hardness, TDS, TA and CaH are in mg/L
### Table 3. Calculated Indices of groundwater samples collected from outer skirts of Kota City (Indices are calculated from average values of the respective year)

| S.No. | Sample code | Name of sampling location | Year 2006 | Year 2007 | Year 2008 | Overall average |
|-------|-------------|---------------------------|-----------|-----------|-----------|----------------|
|       |             |                           | LSI       | RSI       | LSI       | RSI           |
| 1     | GWS/N/1     | Gangaycha                 | 1.03      | 5.53      | 1.85      | 4.32          | 1.49           | 4.85          |
| 2     | GWS/N/2     | Notana                    | 1.05      | 5.68      | 1.79      | 4.67          | 1.58           | 4.89          |
| 3     | GWS/N/3     | Rangpur                   | 0.80      | 6.02      | 1.65      | 4.90          | 1.30           | 5.21          |
| 4     | GWS/N/4     | Bhim Mandi                | 1.42      | 5.05      | 2.18      | 3.59          | 1.88           | 4.20          |
| 5     | GWS/N/5     | Gamach                    | 2.36      | 3.40      | 1.99      | 4.05          | 2.03           | 4.07          |
| 6     | GWS/N/6     | Tirath                    | 2.03      | 3.90      | 2.10      | 3.78          | 1.98           | 4.00          |
| 7     | GWS/E/1     | Raipura                   | 1.63      | 4.56      | 1.91      | 4.40          | 1.80           | 4.45          |
| 8     | GWS/E/2     | Borkhandi                 | 1.29      | 5.29      | 1.31      | 5.29          | 1.02           | 5.17          |
| 9     | GWS/E/3     | Dhakar Kheri              | 1.46      | 4.96      | 1.81      | 4.43          | 1.78           | 4.42          |
| 10    | GWS/E/4     | Tather                    | 1.31      | 5.15      | 2.20      | 3.99          | 2.04           | 4.23          |
| 11    | GWS/E/5     | Manpura                   | 1.47      | 5.01      | 1.55      | 4.87          | 1.55           | 5.03          |
| 12    | GWS/E/6     | Kaithoon                  | 1.36      | 5.21      | 1.91      | 4.16          | 1.73           | 4.42          |
| 13    | GWS/S/1     | Raipur                    | 1.01      | 5.43      | 2.04      | 3.81          | 1.66           | 4.39          |
| 14    | GWS/S/2     | Jaspura                   | 1.40      | 4.93      | 2.19      | 3.65          | 1.06           | 5.31          |
| 15    | GWS/S/3     | Alaniya                   | 1.78      | 4.53      | 2.07      | 3.78          | 1.89           | 3.99          |
| 16    | GWS/S/4     | Shankarpura               | 1.19      | 5.61      | 2.26      | 3.54          | 2.05           | 3.85          |
| 17    | GWS/S/5     | Dad Devi                  | 1.25      | 5.13      | 1.42      | 4.99          | 1.36           | 4.98          |
| 18    | GWS/S/6     | Naya-Gaon                 | 1.35      | 5.02      | 1.72      | 4.52          | 1.57           | 4.65          |
| 19    | GWS/W/1     | Nanta                     | 2.08      | 4.12      | 2.08      | 3.84          | 2.06           | 3.88          |
| 20    | GWS/W/2     | Ganeshpal                 | 1.58      | 4.69      | 2.10      | 3.87          | 2.06           | 3.90          |
| 21    | GWS/W/3     | Badgaon                   | 1.54      | 4.62      | 1.97      | 3.97          | 2.00           | 3.90          |
| 22    | GWS/W/4     | Kunhadi                   | 1.65      | 4.66      | 2.31      | 3.63          | 2.16           | 3.76          |
| 23    | GWS/W/5     | Balita                    | 2.37      | 3.23      | 2.42      | 3.26          | 2.40           | 3.30          |
| 24    | GWS/W/6     | Sinta                     | 1.96      | 3.98      | 1.86      | 4.26          | 1.49           | 4.72          |

### Table 4. Interpretation of langelier saturation index (LSI) test results

| S.No. | Index | Appearance                  | Water condition Quality Issues |
|-------|-------|------------------------------|--------------------------------|
| 1     | -4.00 | Very Severe Corrosion        | Conditioning required          |
| 2     | -3.00 | Severe Corrosion             | Conditioning usually recommended |
| 3     | -2.00 | Moderate Corrosion           | Some conditioning is recommended |
| 4     | -1.00 | Mild Corrosion               | Need some conditioning         |
| 5     | -0.50 | Slight Corrosion             | Should not / may need some conditioning |
| 6     | 0.00  | Balanced                     | Conditioning usually not recommended |
| 7     | 0.50  | Faint Scale Coating          | Conditioning usually not recommended |
| 8     | 1.00  | Slight Scale / Encrustation  | Some visual appearance concerns |
| 9     | 2.00  | Mild Scale / Encrustation    | Should consider some conditioning |
| 10    | 3.00  | Moderate Scale / Encrustation| Should use some conditioning   |
| 11    | 4.00  | Severe Scale / Encrustation  | Conditioning usually required  |
Table 5. Interpretation of Ryzner saturation index (RSI) test results

| S.No. | Saturation Index | Appearance / Description | Water condition comments |
|-------|------------------|--------------------------|-------------------------|
| 1     | 4.0 - 5.0 (Below 4.0) | Heavy Scaling | Non-Aggressive, Non-Corrosive |
| 2     | 5.0 - 6.0          | Moderate Scaling        | Non-Aggressive, Non-Corrosive |
| 3     | 6.0 - 7.0          | Little Scaling          | Slight Corrosion, Balanced Saturation |
| 4     | 7.0 - 7.5          | Non-Scaling, Corrosive  | Aggressive, Under Saturation |
| 5     | 7.5 - 9.0          | Heavy Corrosive         | Very Aggressive, Moderate Corrosive |
| 6     | 9.0 and Above      | Severe Corrosion        | Extremely Aggressive, Highly Corrosive |

In year 2007 groundwater quality change little bit and the analyzed samples exhibited the property as eleven samples have moderate scale formation tendency and remaining thirteen samples have mild scale formation tendency. In year 2008 eight samples have moderate scale formation tendency and remaining sixteen samples have mild scale formation tendency. The average of calculated LSI values for analyzed groundwater samples in successive three years interpreted in the way that five values were greater than 2.0 showing the moderate scale formation tendency and remaining nineteen values were in between 1.0 to 2.0 showing mild scale formation tendency.

Ryzner saturation index (RSI)

Calculated values of Ryzner index (RSI) varied from 3.23 to 6.02 with an overall average of 4.82 for all the samples analyzed in four major seasons in year 2006; from 3.26 to 5.29 with an overall average of 4.15 for all the samples analyzed in four major seasons in year 2007; from 3.30 to 5.72 with an overall average of 4.41 for all the samples analyzed in four major seasons in years 2008 and the average values of three successive years varied from 3.27 to 5.46 with an overall average of 4.50. Use of groundwater without any treatment may result in such manner; in 2006 only one sample have little scale formation tendency, eleven samples have moderate scale formation tendency and remaining twelve samples have heavy scale formation tendency. In 2007 only one sample have moderate scale formation tendency and remaining twenty three samples have heavy scale formation tendency. In 2008 four samples have moderate scale formation tendency and remaining twenty samples have heavy scale formation tendency. The average of calculated RSI values for analyzed groundwater samples in successive three years interpreted in the way that four values were less than 5.0 showing the heavy scale formation tendency and remaining four values were in between 5.0 to 6.0 showing moderate scale formation tendency.

Conclusion

From the present study of groundwater, it can be concluded that the groundwater of outer skirts of Kota city are having scaling tendency in comparison to corrosion tendency, hence the water required some conditioning before use. The use of groundwater without treatment may results in precipitation of calcium carbonate as it is visually seen in bottom of utensils used by residents of the area. Rapid urbanization and indiscriminate disposal of solid waste and domestic effluents causes depletion in quality of nearby surface water bodies and alter the physicochemical properties of water. Percolation of such polluted water in groundwater table results in changing the behavior of water towards its scale formation and corrosivity. Hence to prevent the pristine quality of groundwater at outer skirts of Kota city, pollution control measures should be taken immediately.
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