*International Journal of Basic and Applied Chemical Sciences ISSN: 2277-2073 (Online)*
*An Online International Journal Available at http://www.cibtech.org/jcs.htm*
*2011 Vol. 1 (1) October-December, pp.79-88/ Malviya et al.*
***Research Article***

# DETERMINATION OF WATER QUALITY INDEX TO ASSESS WATER QUALITY FOR DRINKING AND AGRICULTURAL PURPOSES

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## ABSTRACT
Water quality monitoring was carried out for two and a half years from fifteen groundwater sources in Kalmeshwar region of Nagpur District. The study area was of 200 sq km. The objective was to study different parameters viz. physicochemical, mineral, demand, nutrient, bacteriological and metals to check the pollution levels in the region using Water Quality Index (WQI). The WQI for most of the samples ranges between 25 – 50 indicating its bad quality while for other samples it was between 50 – 70, showing bad to medium water quality. The study revealed that all the groundwater sources of Kalmeshwar region in Nagpur District are contaminated, water is unfit for human consumption and requires assessment some degree of purification before it is used for domestic or agricultural purposes.

***Key Words:*** *Water quality, Water Quality Index, Salinity, Sodium Adsorption Ratio*

## INTRODUCTION
The quality of water is of utmost importance compared to quantity in any water supply planning, and especially for potable purpose purity is the prime requirement. The chemical, physical and bacterial characteristic of groundwater determines its usefulness for municipal, commercial, industrial, agricultural and domestic water usage (Tatawat *et. al.*, 2007). Due to lack of proper operation and maintenance, the water supply systems are unable to run at their full capacity (Biswas *et. al.*, 2007). As fresh water will be a scarce in the future water quality monitoring program is necessary for the protection of fresh water resources (Pesce and Wunderlin, 2000).
In recent years, because of continuous growth in population, rapid industrialization coupled with the accompanying technologies involving waste disposals, the rate of discharge of the pollutants into the environment is far exceeding the treatment capacities. The study carried out in the Kalmeshwar industrial and town area is a case study in this direction.
Kalmeshwar is located about 20 km north-west of Nagpur, a fast developing city in Central India. The Maharashtra Industrial Development Corporation (MIDC) developed an industrial area in Kalmeshwar. The industrial area supports many industries involved in the manufacturing of iron sheets, basic alloys, chemicals, coal products, general engineering equipments and pharmaceuticals (Sharma *et. al.*, 2002; Malviya et al., 2010). The study area was of 200 sq km, covered by 1 m thick fertile black clayey soil. Geologically, the area is underlain by deccan trap lava of 50 – 60 m thickness and 4 –7 m weathered mantle. The water level varies 3 – 10 m below ground level during pre-monsoon and 1.5 – 8.5 m during post-monsoon period. The average hydraulic gradient is 1.5 m/km with ground level flow towards north-east direction (Subbarao, *et. al.*, 1998; Malviya *et al.*, 2010).
The groundwater pollution problem in the area first came into light in the year 1993. The local resident in the town area complained about the quality deterioration in the drinking and irrigation water wells due to the disposal of wastes and effluent in the unlined drain passing through the Kalmeshwar town area. The present groundwater pollution study explains how the groundwater has been polluted since then due to percolation of effluent receiving poor treatment (Sharma *et. al.*, 2002; Malviya *et al.*, 2010).
The Water Quality Index (WQI) has been considered as one criterion for drinking water classification based on the use of standard parameters for water characterization (Samantray *et al.*, 2009). The WQI

classification proposed by Department of Environment, Malaysia (DOE, 2001) has been used to assess the quality of major water supply sources indicating the level of pollution (Sari and Wan Omar, 2008). The National Sanitation Foundation (NSF) WQI was developed to provide a standardized method for comparing the water quality of various water sources based upon nine water quality parameters i.e. temperature, pH, dissolved oxygen, turbidity, faecal coliform, biochemical oxygen demand, total phosphates, nitrates and total solids. The water quality ranges have been defined as excellent, good, medium, bad and very bad.

**MATERIALS AND METHODS**

One hundred and fifty samples were collected over a period of two and half years from fifteen groundwater structures. The sampling sites were selected within 8 km radius around an iron industry, the source of pollution in the district as shown in Figure 1. Analysis was carried out for the assessment of 35 parameters including minerals, demands, nutrients, bacteriological and metal analyses. Various physical parameters like pH, temperature, dissolved oxygen, turbidity and electrical conductivity were monitored on site. Sampling, analysis and preservation of water samples were carried out as per Standard Methods for the Examination of Water and Wastewater (Standard Methods, 2005).

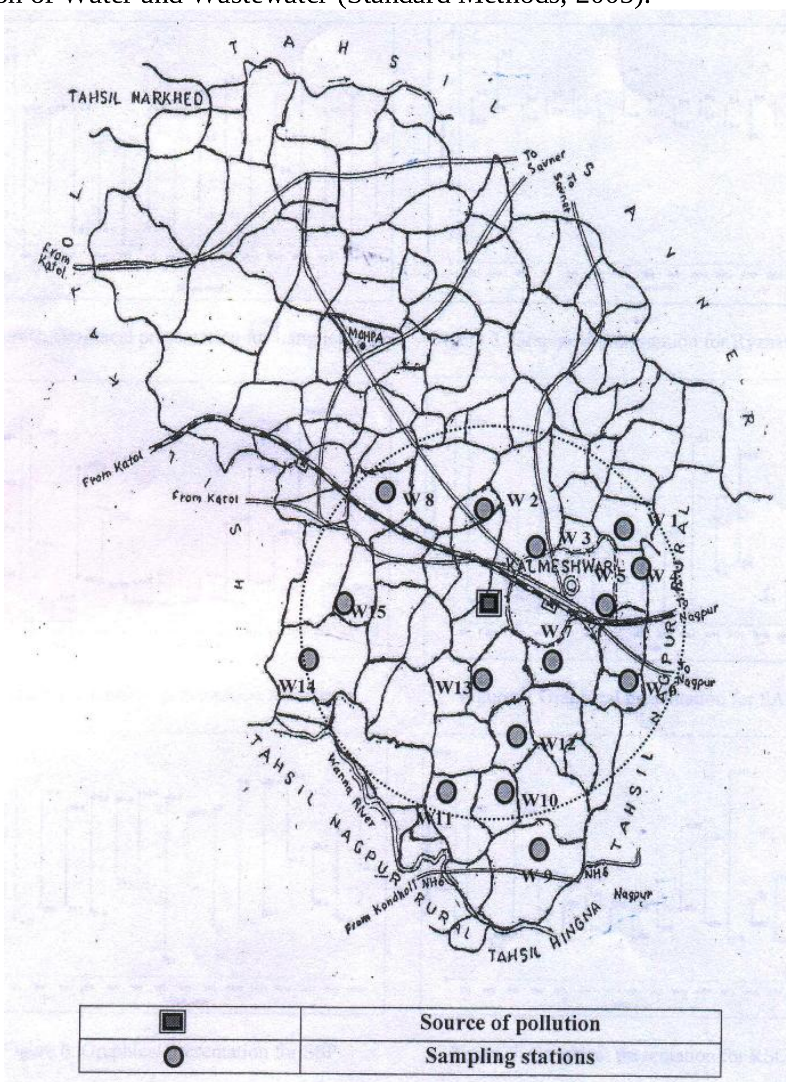


Figure 1: Location map for water sampling stations

***Calcium Carbonate Saturation Indices***

Calcium Carbonate Saturation Indices are given by Langlier Index and Ryznar Index. The two indices are based on four parameters viz. total solids, temperature, calcium hardness and methyl orange alkalinity. The two indices are calculated as follows

Langlier Index = pH - pHs and Ryznar Index = 2 pHs - pH

Where pHs = (9.3 + A + B) – (C + D).

And the alphabets A, B, C and D represents factor for total solids, temperature, calcium hardness and methyl orange alkalinity respectively.

The water is considered to be chemically balanced if Langlier index is zero. However if it is positive then the water shows scale forming tendency while negative value shows corrosive nature of water.

Ryznar index values classification is as follows

| **Range** | **Significance** |
|---|---|
| 4 – 5 | Heavy scales |
| 5 – 6 | Slight scales |
| 6 – 7 | Equilibrium |
| 7 – 7.5 | Slightly corrosive |
| 7.5 – 8.5 | Highly corrosive |

***Water Quality Index (WQI)***

WQI is a numeric expression used to transfer large quantity of water characterization data into a single number, which represents the water quality level (Samantray et al., 2009; Sindhu & Sharma, 2007; Saanchez et. al., 2006; Bordalo et. al., 2006). WQI is a 100 point scale that summarizes results from a total of nine different measurements viz. temperature, pH, dissolved oxygen, turbidity, faecal coliforms, biochemical oxygen demand, total phosphate, nitrates and total solids. Water quality factors with their corresponding weights are given in the following Table 1.

**Table 1:** Water Quality Index Calculators

| Sr. No. | Factor | Weight |
|---|---|---|
| 1. | Dissolved oxygen | 0.17 |
| 2. | Fecal coli forms | 0.16 |
| 3. | pH | 0.11 |
| 4. | BOD | 0.11 |
| 5. | Temperature change | 0.10 |
| 6. | Total phosphate | 0.10 |
| 7. | Nitrates | 0.10 |
| 8. | Turbidity | 0.08 |
| 9. | Total solids | 0.07 |

The 100 point index has been divided into several ranges corresponding to the general descriptive terms shown below.

| **Range** | **Quality** |
|---|---|
| 90 – 100 | Excellent |
| 70 – 90 | Good |
| 50 – 70 | Medium |
| 25 – 50 | Bad |
| 0 – 25 | Very bad |

For calculating WQI proposed by NSF an algorithm has to be followed

Step 1 : Calculate the water quality parameter value

Step 2 : Calculate quality value (Q-value) from the value function graph using a calculator (http://www.water-research.net/wterqualityindex/index.htm) for each parameter.

Step 3 : Multiply Q value by weight factor to get parameter sub-index.

Step 4 : Compute the WQI from the sum of sub-indices of parameters by the sum of weight factors for the parameters.

***Salinity***

The most influential water quality guideline on crop productivity is the salinity hazard as measured by electrical conductivity (EC). Saline water is categorized as water with an EC greater than 3000 μS/cm. If salty water is used for irrigation, the capacity of soil with respect to transmitting of water and air reaches undesirable limits, as a result amount of moisture decreases and plants cannot take necessary nutrition from the soil (Tatawat et. al., 2007).

***Sodium Absorption Ratio (SAR)***

SAR is an important parameter for determination of suitability of irrigation water. This index quantifies the proportion of sodium ($Na^+$) to calcium ($Ca^{++}$) and magnesium ($Mg^{++}$) ions in a sample. Sodium hazard of irrigation water can be well understood by knowing SAR (Tatawat et. al., 2007). Irrigation water with SAR values less than 6 are classified as 'fit', between 6 and 10 are classified as 'marginally fit' and SAR values greater than 10 are classified as 'unfit' for any crop (Siddique et. al., 2002**;** Todd D. K). Lower the ionic strength of sodium, greater the sodium hazard; and conversely, if calcium and magnesium are predominant, the hazard is low. Consequently the SAR values of each water sample were calculated by Richard equation (Diagnosis and Improvement of Saline and Alkali Soils, Handbook) given below:

$$SAR = (Na^+) / \sqrt{[(Ca^{2+}) + (Mg^{2+})] / 2}$$

Where all concentrations are in milliequivalents per litre (meq/l) defined as

$$meq / l = ([C] \times |Charge|) / MW$$

[C] - concentration in mg/l

|Charge| - oxidation state

MW - atomic or molecular weight

There is a significant relationship between SAR values of irrigation water and the extent of sodium absorption by the soil. If the water used for irrigation is high in sodium and low in calcium, the cation – exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of clay particles (Tatawat et. al., 2007).

***Soluble Sodium Percentage (SSP)***

SSP determines the ratio of sodium in total cations including sodium, potassium, calcium and magnesium in meq/l. The SSP is calculated by Todd equation (Todd D. K) given below:

$$Na\,\% = (Na \times 100) / (Na + K + Ca + Mg)$$

The SSP values are divided into three categories as 'good' (20 – 40 Na %), 'permissible' (40 – 60 Na %) and 'doubtful' (60 – 80 Na %) according to Wilcox (Tatawat et. al., 2007).

***Residual Sodium Carbonate (RSC)***

RSC reflects the sodium hazard; the irrigation water containing excess of $CO_3^{2-}$ and $HCO_3^-$ will precipitate out calcium and increase the sodium level. It leads to saturation of clay complex and consequently decreases the infiltration rate. The RSC values < 1.25 meq/l or < 66 mg/l are classified as 'fit' values ranging between 1.25 – 2.5 meq/l or 66 – 133 mg/l as 'marginally fit' and RSC values > 2.5 meq/l or > 133 mg/l as 'unfit' for crops (Siddique et. al., 2002). RSC is computed by using values of water sodium ($CO_3^{2-}$ and $HCO_3^-$) and cations ($Ca^{2+}$ and $Mg^{2+}$) (Acharya, et. al., 2008). RSC value is given by Richards equation as (Diagnosis and Improvement of Saline and Alkali Soils, Handbook)

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

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**RESULTS AND DISCUSSION**

The range of analyses for 22 physico-chemical parameters for 15 samples are given in Table 2 - 4. The results obtained were cross checked by the use of an automated workbook of water analyses (Bassin, 2007). The respective values for all the 22 parameters were compared with the standard limit recommended by Indian Standards for drinking water (Indian Standards IS 10500 : 1993).

**Table 2:** Range of analyses result for water samples W- 1 to W-5

| Parameters | Desirable Limit | Permissible Limit | W 1 | W 2 | W 3 | W 4 | W 5 |
|---|---|---|---|---|---|---|---|
| pH | 6.5 - 8.5 | NR | 6.5 - 7.3 | 7.0 - 7.6 | 6.6 - 7.4 | 6.8 - 7.3 | 6.8 - 7.4 |
| DO | - | - | 0 - 0.6 | 1.1 - 4.0 | 1.8 - 3.8 | 1.2 - 5.2 | 0.2 - 4.2 |
| Conductivity | - | - | 8390 - 20500 | 1160 - 2520 | 4500 - 17050 | 3900 - 11230 | 2070 - 4350 |
| TDS | 500 | 2000 | 5538 - 13530 | 761 - 1662 | 3150 - 11253 | 2573 - 7409 | 1365 - 2869 |
| COD | < 20 | NR | 94 - 360 | 8 - 32 | 172 -327 | 112 - 274 | 32 - 94 |
| BOD | < 5 | NR | 13 - 46 | <5 - 8 | 24 - 39 | 16 - 33 | <5 - 12 |
| Alkalinity | 200 | 600 | 164 - 380 | 150 - 258 | 195 - 292 | 165 - 236 | 166 - 338 |
| Hardness | 300 | 600 | 2180 - 6200 | 360 - 650 | 1450 - 5500 | 1670 - 3380 | 840 - 1500 |
| $Ca^{++}$ | 75 | 200 | 496 - 1740 | 79 - 176 | 332 - 1160 | 332 - 744 | 188 - 299 |
| $Mg^{++}$ | 30 | 100 | 225 - 519 | 7 - 60 | 149 - 630 | 187 - 406 | 84 - 206 |
| $Na^{+}$ | - | - | 375 - 2986 | 64 -393 | 376 - 2361 | 205 - 1645 | 163 - 567 |
| $K^{+}$ | - | - | 8 - 61 | 1 - 8 | 8 - 48 | 4 - 33 | 3 - 16 |
| Chloride | 250 | 1000 | 560 - 4655 | 56 - 500 | 540 - 3554 | 290 - 2548 | 190 - 776 |
| Sulphate | 200 | 400 | 23 - 242 | 35 - 159 | 39 - 206 | 31 - 87 | 49 - 154 |
| Iron | 0.3 | 1 | 0.81 - 3.80 | 0.45 - 2.2 | 0.42 - 2.70 | 0.26 - 2.70 | 0.27 - 3.10 |
| Coliforms | 0 | NR | > 1100 | 7 - 21 | > 1100 | 7 - 23 | 14 - 43 |
| LI | 0 | - | - 0.1 - 0.9 | - 0.1 - 0.9 | 0.1 – 0.9 | 0.1 – 0.7 | 0.0 – 0.7 |
| RI | 6 - 7 | - | 5.5 – 6.6 | 6.0 – 8.2 | 5.6 – 6.4 | 5.9 – 6.6 | 5.9 – 7.0 |

*All parameters are in mg/l except for pH, Conductivity, Coliforms, LI and RI.*
*Units for conductivity is µS/cm and coliform is MPN/100 ml.*
*NR – No Relaxation.*

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**Table 3:** Range of analysis result for water samples W- 6 to W-10

| **Parameters** | **Desirable Limit** | **Permissible Limit** | **W 6** | **W 7** | **W 8** | **W 9** | **W 10** |
|---|---|---|---|---|---|---|---|
| pH | 6.5 - 8.5 | NR | 6.9 - 7.3 | 6.8 - 7.5 | 6.8 - 7.3 | 6.8 – 7.4 | 6.9 – 7.4 |
| DO | - | - | 0 - 3.6 | 3.1 - 4.2 | 2.6 - 4.7 | 1.4 – 4.0 | 1.8 – 3.2 |
| Conductivity | - | - | 1865 - 5170 | 750 - 2330 | 2470 - 5060 | 2060 - 11230 | 4375 - 16690 |
| TDS | 500 | 2000 | 1232 - 3413 | 491 - 1634 | 1731 - 3336 | 1360 – 7409 | 2973 - 11682 |
| COD | < 20 | NR | 98 - 214 | <8 - 32 | 48 - 146 | 86 – 276 | 188 – 364 |
| BOD | < 5 | NR | 14 - 31 | <5 - 5 | 7 - 26 | 12 – 35 | 24 – 48 |
| Alkalinity | 200 | 600 | 250 - 384 | 210 - 332 | 150 - 252 | 176 – 360 | 150 – 264 |
| Hardness | 300 | 600 | 892 - 1780 | 300 - 1690 | 880 - 2600 | 1180 – 3380 | 2310 – 5650 |
| $Ca^{++}$ | 75 | 200 | 204 - 391 | 77 - 304 | 219 - 416 | 312 – 955 | 554 – 1444 |
| $Mg^{++}$ | 30 | 100 | 86 - 250 | 27 - 223 | 38 - 250 | 98 – 283 | 187 – 490 |
| $Na^{+}$ | - | - | 163 - 725 | 19 - 184 | 210 - 653 | 85 – 1267 | 208 – 2982 |
| $K^{+}$ | - | - | 3 - 15 | 1 - 6 | 4 - 13 | 2 – 24 | 19 – 50 |
| Chloride | 250 | 1000 | 140 - 913 | 15 - 50 | 260 - 864 | 90 – 1502 | 320 – 4588 |
| Sulphate | 200 | 400 | 31 - 374 | 19 - 74 | 75 - 219 | 51 – 145 | 40 – 104 |
| Iron | 0.3 | 1 | 0.12 - 2.30 | 0.44 - 2.70 | 0.19 - 4.30 | 0.67 – 1.9 | 1.7 – 4.4 |
| Coliforms | 0 | NR | 15 - 93 | 9 - 23 | 20 - 240 | 11 – 93 | > 1100 |
| LI | 0 | - | 0.1 – 0.9 | 0.0 – 0.7 | 0.2 - 0.7 | 0.2 – 1.1 | 0.2 - 0.7 |
| RI | 6 - 7 | - | 5.5 – 6.7 | 5.8 – 7.6 | 5.9 – 6.6 | 5.4 – 6.3 | 5.8 – 6.5 |

*All parameters are in mg/l except for pH, Conductivity, Coliforms, LI and RI.*
*Units for conductivity is µS/cm and coliform is MPN/100 ml.*
*NR – No Relaxation.*

***Groundwater Quality for Drinking Purpose***

The pH value ranges between 6.5 and 7.6. The lowest value is observed in W-1 and the highest in W-2, W-12 and W-14 (Table 2 - 4). It is observed that all the water samples lie in the range of 6.5 – 8.5 prescribed by Indian Standards for Drinking Water.

Electrical conductivity (EC) is a useful tool to evaluate the purity of water. Maximum EC is recorded in W-12 (22950 µmhos/cm) and the minimum EC at W-7 (750 µmhos/cm). The EC for nearly all samples was above 2000 µmhos/cm even in rainy season except for W-2 and W-7. For samples W-1, W-3, W-4, W-10, W-11 and W-12 the minimum EC is above 4000 µmhos /cm.

The TDS of the water samples analyzed ranged from 491 mg/l to 16297 mg/l. TDS value of 491 mg/l is shown by sample W-7, whereas W-2 showed a value of 761 mg/l. Rest of the samples exceed permissibility of 2000 mg/l for drinking water as per Indian Standards. W-1 and W-12 shows the TDS values above 5000 mg/l as their minimum value and maximum TDS value as 13530 mg/l and 16297 mg/l.

**Table 4:** Range of analysis result for water samples W- 11 to W-15

| Parameters | Desireble Limit | Permisible Limit | W 11 | W 12 | W 13 | W 14 | W 15 |
|---|---|---|---|---|---|---|---|
| pH | 6.5 - 8.5 | NR | 6.6 – 7.4 | 6.6 – 7.6 | 6.8 – 7.2 | 6.8 – 7.6 | 6.9 – 7.4 |
| DO | - | - | 1.6 – 4.0 | 0.0 – 1.2 | 2.2 - 3.4 | 1.9 – 3.6 | 1.8 – 3.8 |
| Conductivity | - | - | 3650 - 9725 | 6435 - 22950 | 1910 - 4140 | 1550 - 3860 | 1865 - 4150 |
| TDS | 500 | 2000 | 2445 - 6710 | 4377 - 16297 | 1307 - 2878 | 1068 - 2626 | 1267 – 2800 |
| COD | < 20 | NR | 128 – 214 | 218 – 340 | 44 – 128 | 76 – 194 | 72 – 112 |
| BOD | < 5 | NR | 28 – 45 | 39 – 71 | 12 – 30 | 18 – 36 | 14 – 27 |
| Alkalinity | 200 | 600 | 180 – 362 | 100 – 328 | 274 – 440 | 150 – 400 | 220 – 356 |
| Hardness | 300 | 600 | 1210 – 5480 | 1400 – 7920 | 785 – 2240 | 620 – 1540 | 760 – 1210 |
| $Ca^{++}$ | 75 | 200 | 314 - 1520 | 368 – 2088 | 170 – 564 | 158 – 680 | 206 – 364 |
| $Mg^{++}$ | 30 | 100 | 89 – 403 | 115 – 706 | 79 – 199 | 54 – 344 | 48 – 102 |
| $Na^{+}$ | - | - | 494 – 1334 | 977 – 3457 | 206 – 296 | 154 – 518 | 177 – 683 |
| $K^{+}$ | - | - | 11 – 24 | 13 – 33 | 7 – 19 | 7 – 22 | 7 – 26 |
| Chloride | 250 | 1000 | 640 – 2050 | 1590 – 5318 | 213 – 418 | 160 – 751 | 180 – 1051 |
| Sulphate | 200 | 400 | 44 – 371 | 31 – 90 | 76 – 192 | 23 – 124 | 18 – 324 |
| Iron | 0.3 | 1 | 0.88 – 1.67 | 0.7 – 2.96 | 0.64 – 1.32 | 0.41 – 2.80 | 0.83 – 2.73 |
| Coliforms | 0 | NR | 43 – 240 | > 1100 | 9 – 93 | 7 – 23 | 15 – 93 |
| LI | 0 | - | 0.5 – 1.0 | 0.1 – 1.3 | 0.2 – 0.9 | 0.0 – 1.0 | 0.2 – 0.7 |
| RI | 6 - 7 | - | 5.4 – 6.4 | 5.0 – 6.5 | 5.4 – 6.6 | 5.5 – 6.9 | 5.7 – 6.5 |

*All parameters are in mg/l except for pH, Conductivity, Coliforms, LI and RI.*
*Units for conductivity is µS/cm and coliform is MPN/100 ml.*
*NR – No Relaxation.*

The Chemical Oxygen Demand (COD) values obtained for the water samples are quite high ranging between 32 – 360 mg/l. The low COD values are shown by samples W-2 and W-7 where it ranges between 8 – 32 mg/l. The COD shown by W-1, W-3, W-4, W-6, W-9, W10, W-11 and W-12 is always above 100 mg/l.

Biochemical Oxygen Demand (BOD) values are high for nearly all the samples ranging 12 – 71 mg/l except for W-2, W-5 and W-7 where the values of BOD are in the range <5 – 12 mg/l. High level of BOD indicates the presence of some organic matter which requires oxidation.

The values obtained for alkalinity in the water samples varied from 150 - 440 mg/l except for W-12 where the minimum value of alkalinity is 100 mg/l. Nearly in all the seasons and in all the samples the values of alkalinity have crossed the desirable limit of 200 mg/l except for few but the values are far below the permissible limit of 600 mg/l as prescribed by Indian Standards for drinking water

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In almost all the water samples the hardness is found to be due to calcium and magnesium. All the metallic cations besides the alkali metals also cause hardness. Total Hardness was found to vary from 760 to 7920 mg/l except for W-2 where maximum value of total hardness is 650 mg/l. All the samples exceed the permissible value of 600 mg/l and the values are very high. The hardness is due the calcium and magnesium salts. Calcium ($Ca^{+2}$) and Magnesium ($Mg^{+2}$) ions contribute the greatest portion of the hardness occurring in natural waters. $Ca^{+2}$ concentration is observed to vary from 77 to 2088 mg/l and that of $Mg^{+2}$ concentration from 7 to 706 mg/l. in most of the cases these values are above permissible limits prescribed by Indian Standards for Drinking Water ($Ca^{++}$ = 200 and $Mg^{++}$ = 100 mg/l) except for W-7. Sodium ($Na^{+}$) and Potassium ($K^{+}$) have been found to be present in large amounts which can impart a salty taste with chloride ions. $Na^{+}$ and $K^{+}$ ion concentrations are seen to vary from 19 to 3457 mg/l and 1 to 50 mg/l respectively.

It was observed that around 50 % of the water samples have chlorides higher than the permissible limit of 1000 mg/l. The highest concentration of chloride ions was recorded in W-12 (5318 mg/l) and the lowest at W-7 (15 mg/l). High chloride content in groundwater can be attributed to lack of under ground drainage system and bad maintenance of environment around the sources. Chloride salts in excess of 100 mg/1 give salty taste to water, which when combined with calcium and magnesium, may increase the corrosive activity of water. It is recommended that chloride content should not exceed 250 mg/1. Sulphate concentration varied from 19 to 374 mg/l and these values are within permissible limits prescribed by Indian Standards for Drinking Water (400 mg/l).

It is found that nearly all the water samples show the iron concentration above the permissible limit given by Indian Standards for Drinking Water (1.0 mg/l). The iron concentration observed ranges from 0.12 to 4.4 mg/l. The minimum value is obtained for sample W-6 while maximum value is found for sample W-10. Water samples W-1, W-3, W-10 and W-12 shows the values for coliforms as > 1100 MPN/100 ml, while all other samples show coliform values less than 240 MPN/100 ml. As all the samples show coliform values water has to be disinfected before use. The samples W-2, W-4 and W-14 can be used directly for domestic purposes.

Langlier index indicates that nearly all the water samples show scale forming characteristics which is supported by the values of Ryznar index ranging between 5 – 7.

The WQI indicates the “Bad” quality of water for water samples W-1, W-10, W-11 and W-12, “Medium” quality for water samples W-2, W-4, W-7 and W-14 while rest of the water samples show “Bad to Medium” water quality.

***Groundwater Quality for Irrigation Purposes***

The concentration and composition of dissolved constituents in water determine its quality for irrigation use. Several chemical constituents of water affects its suitability for irrigation from which the total concentration of the soluble salts and the relative proportion of sodium to calcium and magnesium. Moreover suitability of water for irrigation depend on the effect of some mineral constituents in the water on both the soil and the plant (Wilcox, 1948 & 1955). Sampling stations W-2, W-7, W-13, W-14 and W-15 are considered suitable for irrigation uses while other sampling stations were found to be unfit even for irrigation in the light of salinity. Graphical presentation of salinity for all the water samples is shown in Figure 2(a).

The SAR values varied from 0.3 to 21.9. The data reveals that about 60 % of the water samples under study have low values (<10.0) shown in Figure 2(b). The soluble sodium percentage (SSP) values of the water samples ranged from 5.7 % to 75.3 %. The lowest value of 5.7 % was observed in W-7 whereas the highest value of 75.3 % was recorded in a water sample from W-1. Further the data revealed that about 65 percent of the water samples have high values (>60) of SSP as shown in Figure 2(c). The RSC values varied from 333 to 1853 which is very high from the usable level. The graphical representation for RSC values are shown in Figure 2(d).

The groundwater in Kalmeshwar town area seems to be highly polluted and its potability is severely

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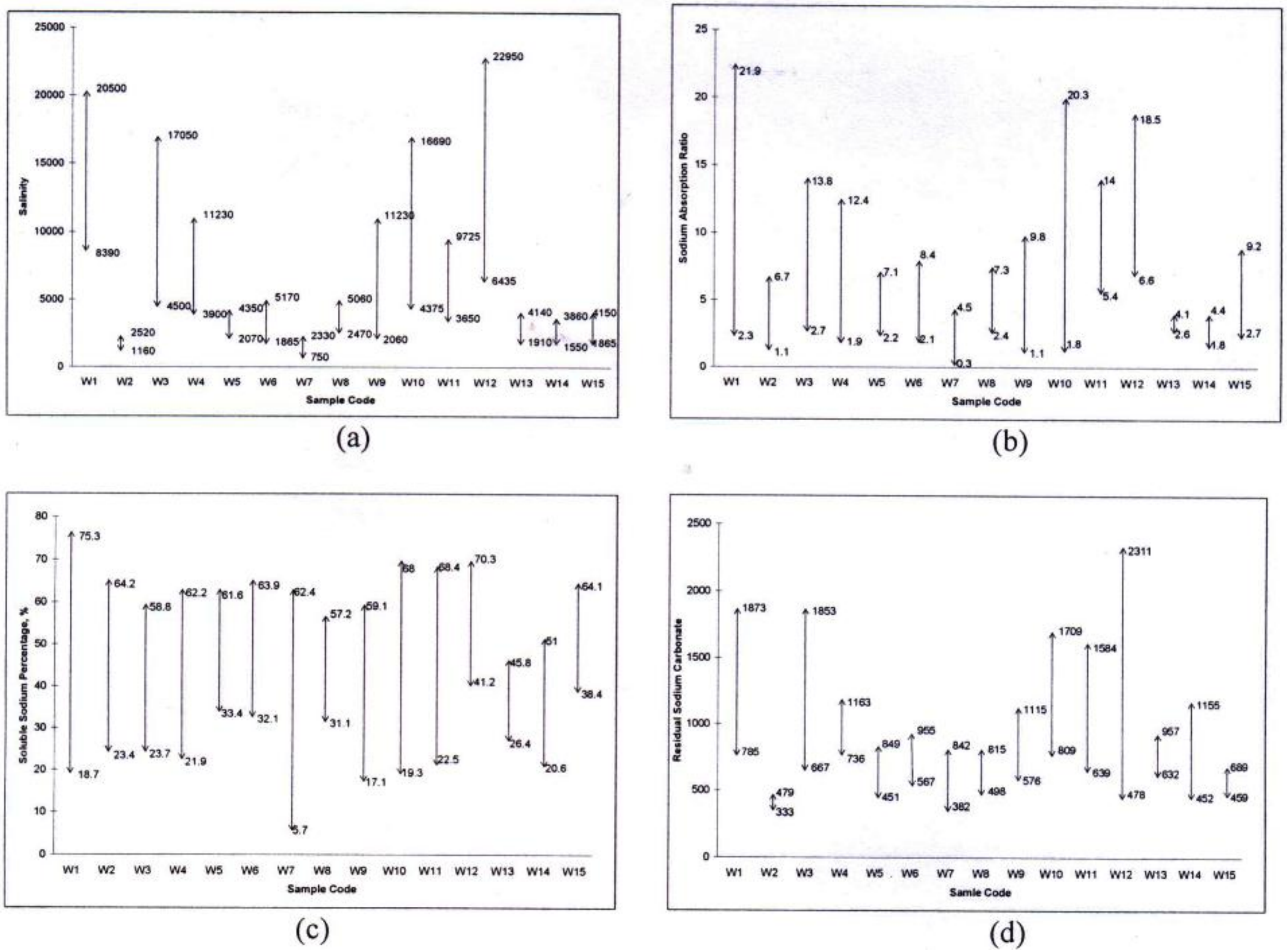


**Figure 2:** Graphical representations for (a) salinity, (b) sodium absorption ratio, (c) soluble sodium percentage and (d) residual sodium carbonate

affected as the TDS (2000 mg/l), total carbonates (600 mg/l), chlorides (1000 mg/l), calcium (200 mg/l), magnesium (100 mg/l) and iron (1.0 mg/l) have crossed the maximum permissible limits of ISO for drinking water (Indian Standards IS 10500 : 1993). The WQI for most of the samples ranges between 25 – 50 indicating its bad quality while other samples range between 50 – 70 showing bad to medium water quality. The groundwater in Kalmeshwar area is also not suitable for irrigation purpose as the water has high salinity, high SSP and very high values of RSC.

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