CHAPTER - VI
ANALYSIS OF SPECIFIC CHEMICAL PARAMETERS: CATIONS
CHAPTER - VI

ANALYSIS OF SPECIFIC CHEMICAL PARAMETERS – CATIONS

The cations studied are Calcium, Magnesium, Sodium and Potassium.

6.1 Experimental Procedure

6.1.1 Calcium – Volumetric Method

Principle

Many indicators such as ammonium purpurate, calconform a complex only with Ca\(^{2+}\) even in the presence of Mg\(^{2+}\) at higher pH. This complex is broken down by EDTA as it has higher affinity towards Ca\(^{2+}\) giving the solution a new colour. However, as EDTA also complexes with Mg\(^{2+}\) easily, the latter is removed by precipitation as hydroxide at higher pH.

Procedure

50 cm\(^3\) of the water sample was taken in a conical flask. (If the sample was found to have higher alkalinity, smaller volumes diluted to 50 cm\(^3\) were used).

About 2.0 cm\(^3\) of IN NaOH solution was added to the sample along with 100-200 mg of Murexide indicator (0.2g of ammonium purpurate with 100 g of A.R sodium chloride and ground finely). The solution developed a pink colour.

This solution was titrated against 0.01M EDTA solution until the pink colour changed to purple. For better judgment of end point, the purple colour of the solution was compared with the end point of the distilled water blank titration.
Calculation

\[ \text{Ca}^{2+}, \text{mg/L} = \frac{x \times 400.8}{\text{cm}^3 \text{ of sample}} \]

where \( x \) = Volume of EDTA used.

### 6.1.2 Magnesium – Volumetric Method

\( \text{Ca}^{2+} \) and \( \text{Mg}^{2+} \) ions form complexes with both EDTA and eriochrome black–T at pH10, with EDTA having more affinity than the latter. Therefore, the wine red coloured complex of \( \text{Ca}^{2+} / \text{Mg}^{2+} \) with eriochrome black-T is broken down when EDTA is added and a new complex of blue colour is formed. The value of \( \text{Mg}^{2+} \) is obtained by subtracting the value of \( \text{Ca}^{2+} \) from the total value of \( \text{Ca}^{2+} \) and \( \text{Mg}^{2+} \).

**Procedure**

The water sample added with eriochrome black–T is titrated with EDTA solution and the volume is noted when the wine red solution turns blue. This gives \( \text{Ca}^{2+} \) concentration (already obtained under \( \text{Ca}^{2+} \) estimation)

For the same volume of sample, the total \( \text{Ca}^{2+} \) and \( \text{Mg}^{2+} \) concentration is determined using standard EDTA solution using the procedure for determination of hardness of water.

**Calculation**

\[ \text{Mg}^{2+}, \text{mg/L} = \frac{(y-x) \times 400.8}{\text{Volume of sample} \times 1.645} \]

Where \( Y \) = EDTA used in hardness determination

\( X \) = EDTA used in Calcium determination for the same volume of the sample.

b) \( \text{Mg}^{2+} \text{ mg/2} = \text{total hardness (as mg/L CaCO}_3\text{)} – \text{Calcium hardness (as mg/L CaCO}_3\text{)} \times 0.244. \)

Calcium hardness (as mg/L CaCO\textsubscript{3}) = \( \text{Ca}^{2+} \text{ mg/L} \times 2.497 \)
6.1.3 Sodium – Flame Photometric Method

**Principle**

When a sample with sodium is sprayed into a flame, a characteristic light (yellow) is produced. The intensity if this light is proportional to the concentration of sodium in the sample and can be read at 589 nm by using suitable filter devices. The intensity of light produced by a sample can be computed from a standard curve which is linear at low concentrations of sodium. However at higher concentrations, the linearity levels off.

Potassium (in excess of 5 times in ratio to sodium and calcium (10 times more) and magnesium (100 times) if present interfere with the determination of sodium

The samples were stored in polythene bottles while determining sodium to prevent leaching of sodium from the glass.

**Procedure**

For non-polluted water samples, the samples were filtered through filter paper to remove suspended matter. If highly polluted, water samples were pre-treated before determination of total sodium following the standard procedure for pre-treatment.

Sodium stock solution (1000 mg Na/L), intermediate sodium solution (100mg Na/L) and standard sodium solution (10mg Na/L) were prepared.

The flame photometer was calibrated with calibration curves in the range of 0 to 1.0, 0 to 10.0 and 0-100 mg/L sodium by using the various standard solutions of sodium.

The concentration of sodium in the water sample was determined using anyone of the calibrated curves depending on the initial concentration of sodium in the sample. (for accurate results smaller ranges were
preferred. Samples were diluted so as to bring the sodium concentration in the range of determination)

Calculation

\[ \text{Na, mg /L} = (\text{mg / L Na in diluted aliquot}) \times \text{dilution factor} \]

6.1.4 Potassium – Flame Photometric Method

Principle

Potassium can also be determined accurately by flame photometer just like sodium. The characteristic radiation for potassium is studied using a 768 nm wavelength filter.

Procedure

Stock potassium solution (1000 mg K/L), intermediate potassium solution (100 mg K/L) and standard potassium solution (10 mg K/L) were prepared and standard curves were obtained using these solutions in the range of 0 to 1, 0 to 10 and 0 to 100 mg K/L of potassium at 768 nm wavelength.

The potassium in the sample was determined using the same filter from the standard curves.

Calculation

\[ \text{K, mg /L} = (\text{mg / L of K in diluted aliquot}) \times \text{dilution factor} \]

6.2 Results and Discussion

6.2.1 Calcium

Calcium is naturally present in water. It is dissolved from rocks and soils attributing hardness to water. Presence of calcium in water leads to scale formation. The main sources of calcium in ground water are silicate minerals, igneous and metamorphic rocks, limestone and sedimentary rocks. According to WHO, the permissible limit of calcium in water is 75 – 200 mg/L.
Khursid (1998) suggests that the presence of calcium to a small extent is beneficial to prevent corrosion of water pipes. Actually, hard water is found to benefit human cardiovascular system (MERI, 2001) and presents no problems to human health.

In the present study the calcium was present within the permissible limits in most of the months of all the places. The monthly variations are given in Fig 6.1 (Ahmadabad, Arasur, Ghaemabad, Khampich and Khonsar) and Fig 6.2 (Malga, Qudejan, Rahmatabad and Wist). The seasonal averages are given in Table 6.1 and in graphical form in Fig 6.3.

In Ahmadabad, calcium varied from 59 (±10.0) mg/L in October 2011 to 270 (±18.5) mg/L in February 2012 during the twelve month period. The monthly average of calcium was 97.58 (±60.28) mg/L. The winter average was the highest at 173.33 (±88.68) mg/L with rainy season average at 81.67 (±33.29) mg/L and the summer average at 69.67 (±10.2) mg/L.

At Arasur, the average of calcium concentration of the twelve months was 93.0 (±43.1) mg/L. The highest value recorded was 200 (±12.05) mg/L in December 2011. The lowest value was 55.0 (±8.4) mg/L in March 2012. Seasonally, the winter average was highest at 119.33 (±70.72) mg/L followed by summer season average at 73.3 (±6.44) mg/L. The rainy season average was 61.7 (±9.07) mg/L.

The monthly values in Ghaemabad ranged from 72.0 (±4.8) mg/L in February 2012 to 250 (±12.4) mg/L in July 2012. The seasonal averages were 139.67 (±65.16) mg/L in winter, 154 (±14.73) mg/L in rainy and 1728.67 (±62.93) mg/L in summer seasons.

At Khampich, the maximum calcium content was observed in June 2012 (183.0±5.6 mg/L) and the least value was in July 2012 (109.9±3.5 mg/L). The monthly average was 137.83(±25.63) mg/L. Seasonal averages were 125.67 (±8.02) mg/L in winter, 130.33 (±27.47) mg/L and 148.0 (±37.16) mg/L in rainy and summer seasons respectively.
The calcium content was undetectable in most months in Khonsar. The highest value recorded was 40.0 (±2.05) mg/L in January 2012 and the lowest was 10.0 (±1.8) mg/L in April 2012. The season average was highest in the winter season at 13.3 (±23.09) mg/L.

In Malga, the monthly average was 65.42 (±40.2) mg/L. The month of December 2011 had the highest concentration at 140.0 (±10.2) mg/L while the lowest concentration was 20.0 mg/L in January 2012 and September 2012. The monthly average was 65.42 (±40.2) mg/L. The winter average was 73.33 (±61.10) mg/L, rainy season average was 58.0 (±20.66) mg/L and the summer season average was 50.33 (±32.80) mg/L.

The monthly average of the twelve month period in Qudejan was 31.08 (±46.01) mg/L. In Qudejan too, some of the months showed zero presence of calcium. The highest value recorded was 100.00 (±8.5) mg/L in November 2011 and least was 86.0 (±1.45) mg/L. Seasonally, rainy season average was 31.7 (±54.85) mg/L followed by winter average of 30.67 (±53.11) mg/L and then by summer average of 28.67 (±49.65) mg/L.

Rahmatabad showed a monthly calcium variation from 102.0 (±2.75) mg/L in August 2012 to 227.0 (±18.4) mg/L in January 2012. The average of the twelve months was 155.33 (±31.77) mg/L. The winter average was highest at 167.0 (±52.3) mg/L followed by summer average of 127.0 (±21.7) mg/L.

The monthly average at Wist was 93.42 (±30.19) mg/L. The highest value of calcium concentration in Wist was 150.0 (±7.3) mg/L in May 2012. The least value was 50.0 (±2.46) mg/L. The rainy season average was the highest at 123.33 (±25.17) mg/L followed by summer season average at 101.33 (±28.02) mg/L and then by winter by winter season at 63.33 (±11.55) mg/L.

Calcium found naturally in water is also found to some extent in sewage and industrial wastes. The type of rocks determine the amount of calcium in natural water.
In the present study, the calcium content was well within the permissible limit of 200 mg/L in most months of the nine places. However, in some of the months, the concentration of calcium exceeded the permissible limit like in Ahmadabad, the maximum value was 270 mg/L in October 2011. In Ghaemabad, it was 250 mg/L in July 2012. The higher calcium content in some places in some of the months can be attributed to the mixing of urban run-off and industrial waste-water.

**Fig 6.1: Monthly variation of Calcium between period 2011-12 in Ahmadabad, Arasur, Ghaemabad, Khampich, Khonsar**

**Fig 6.2 Monthly variation of Calcium between period 2011-12 in Malga, Qudejan, Rahmatbad, Wist**
Table 6.1: Average Seasonal Variation of Calcium (mg/L)

<table>
<thead>
<tr>
<th>Season</th>
<th>Place</th>
<th>Ahmadabad</th>
<th>Arasur</th>
<th>Ghaemabad</th>
<th>Khampich</th>
<th>Khonsar</th>
<th>Malga</th>
<th>Qudejan</th>
<th>Rahmatbad</th>
<th>Wist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>av</td>
<td>173.33</td>
<td>119.33</td>
<td>139.67</td>
<td>125.67</td>
<td>13.33</td>
<td>73.33</td>
<td>30.67</td>
<td>167.00</td>
<td>63.33</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>83.86</td>
<td>70.72</td>
<td>65.16</td>
<td>8.02</td>
<td>23.09</td>
<td>61.10</td>
<td>53.12</td>
<td>52.31</td>
<td>11.55</td>
</tr>
<tr>
<td>Rainy</td>
<td>av</td>
<td>81.67</td>
<td>61.67</td>
<td>154.00</td>
<td>130.33</td>
<td>3.33</td>
<td>58.00</td>
<td>31.67</td>
<td>161.33</td>
<td>123.33</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>33.29</td>
<td>9.07</td>
<td>14.73</td>
<td>27.47</td>
<td>5.77</td>
<td>20.66</td>
<td>54.85</td>
<td>20.53</td>
<td>25.17</td>
</tr>
<tr>
<td>Summer</td>
<td>av</td>
<td>69.67</td>
<td>73.33</td>
<td>178.67</td>
<td>148.00</td>
<td>0.00</td>
<td>50.33</td>
<td>28.67</td>
<td>127.00</td>
<td>101.33</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>10.02</td>
<td>16.44</td>
<td>62.93</td>
<td>37.16</td>
<td>0.00</td>
<td>32.81</td>
<td>49.65</td>
<td>21.70</td>
<td>28.02</td>
</tr>
</tbody>
</table>

Fig 6.3: Average seasonal variation of Calcium
6.2.2 Magnesium

Magnesium also contributes towards hardness of water. It is sourced from minerals like dolomite, magnetite etc. The permissible limit of magnesium in water is about 100mg / L. Magnesium Sulphate has a laxative effect on persons not accustomed to it. (Khursid 1998).

The month wise magnesium concentration is represented graphically in Fig 6.4 and 6.5. The season wise magnesium values are presented in Table 6.2 and graphically in Fig 6.6.

At Ahmadabad the monthly variation average of the twelve month period was 8.77 (±2.75) mg/L. The highest magnesium content was in February 2012 at 12.81 (±2.45) mg/L. The values raged from a low of 5.78 (±1.02) mg/L in September 2012 to 12.81 mg/L. Season wise the winter season displayed the highest concentration 10.46 (±2.51) mg/L while summer season and rainy season had values of 6.14 (±0.68) mg/L and 8.52 (±2.03) mg/L respectively.

At Arasur, the maximum value of magnesium was 12.78 (±0.98) mg/L in March 2012. Averaging over 8.69 (±2.27) mg/L, the lowest monthly value recorded was 4.35 (±0.81) mg/L. The winter season had an average of 9.12 (±0.79) mg/L while rainy season showed an increase to 11.18 (±1.8) mg/L and the summer season had the lowest value of 5.79 (±1.39) mg/L.

Ghaemabad recorded the monthly magnesium average of 7.77 (±2.56) mg/L. It had the least concentration at 3.5 (±0.54) mg/L in the month of September 2012 and the most concentration at 12.1(±0.92) mg/L in the month of December 2011. Seasonally, the winter average was 10.49 (±1.57) mg/L followed by rainy season with 7.53 (±1.19) mg/L and then by summer season with 5.5 (±0.82) mg/L.
The values at Khampich varied from a minimum of 1.56 (±0.32) mg/L in the month of November 2011 to a high of 8.0 (±0.46) mg/L in August 2012. The monthly average was 4.06 (±2.41) mg/L. The seasonal averages were 2.72 (±1.51) mg/L, 2.73 (±1.04) mg/L and 6.84 (±1.31) mg/L during winter, rainy and summer seasons respectively.

Khonsar displayed a monthly average of 7.75 (±3.998) mg/L. The month of February 2012 showed a high value of 14.9 (±2.1) mg/L compared to other months. The lowest value recorded was 3.0 (±0.51) mg/L in May 2012. The winter average of magnesium concentration was 9.0 (±5.1) mg/L.

In Malga, the seasonal magnesium concentration average was highest in the rainy season at 10.53 (±2.32) mg/L followed by winter season (6.83 (±3.28) mg/L) and then by summer season (5.9±0.38 mg/L). The monthly average at Malga was 8.19 (±2.99) mg/L. The highest value of 13.5 (±1.48) mg/L in November 2011 and the lowest value was 4.6 (±0.25) mg/L.

Qudejan had a monthly average of 9.26 (±5.37) mg/L whereas seasonal winter average was 8.8 (±6.00) mg/L, rainy average was 6.4 (±4.16) mg/L and summer average was 7.17 (±0.65) mg/L. The month of October 2011 recorded 18.8 (±2.31) mg/L concentration of magnesium while 2.7 (±0.05) mg/L was determined in April 2012.

In Rahmatabad the magnesium concentration varied from 4.5 (±1.06) mg/L to 11.0 (±1.45) mg/L over the twelve month period with an average of 6.31 (±2.16) mg/L. The summer values averaged at 5.19 (±0.55) mg/L while that of rainy season was 6.12 (±2.17) mg/L and that of winter season was 8.23 (±2.42) mg/L.

In Wist, the monthly average was 6.90 (±4.33) mg/L. The concentration values varied from 1.11 (±0.05) mg/L in September 2012 to 13.2 (±1.21) mg/L in May 2012.
Magnesium is also found in minerals such as dolomite, magnetite and also sea waters. Magnesium forms the other important constituent of hardness of water along with calcium. Generally, the magnesium content was well within the permissible limits in the present study (WHO). The variation of magnesium content monthly and seasonally could be due to variation in the amount of urban run-off and industrial effluents reaching the river water.

Fig 6.4: Monthly variation of Magnesium in between period 2011-12 Ahmabad, Arasur, Ghaemabad, Khampich, Khonsar

Fig 6.5: Monthly variation of Magnesium between period 2011-12 in Malga, Qudejan, Rahmatbad, Wist
Table 6.2: Average Seasonal Variation of Magnesium (mg/L)

<table>
<thead>
<tr>
<th>Season</th>
<th>Place</th>
<th>Ahmadabad</th>
<th>Arasur</th>
<th>Ghaemabad</th>
<th>Khampich</th>
<th>Khonsar</th>
<th>Malga</th>
<th>Qudejan</th>
<th>Rahmatbad</th>
<th>Wist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>av</td>
<td>10.46</td>
<td>9.12</td>
<td>10.49</td>
<td>2.72</td>
<td>9.00</td>
<td>6.83</td>
<td>8.80</td>
<td>8.23</td>
<td>4.29</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>2.51</td>
<td>0.79</td>
<td>1.57</td>
<td>1.51</td>
<td>5.11</td>
<td>3.28</td>
<td>6.00</td>
<td>2.42</td>
<td>2.92</td>
</tr>
<tr>
<td>Rainy</td>
<td>av</td>
<td>8.52</td>
<td>11.18</td>
<td>7.53</td>
<td>2.37</td>
<td>6.30</td>
<td>10.53</td>
<td>6.40</td>
<td>6.12</td>
<td>10.37</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>2.03</td>
<td>1.80</td>
<td>1.19</td>
<td>1.04</td>
<td>4.88</td>
<td>2.32</td>
<td>4.16</td>
<td>2.17</td>
<td>4.15</td>
</tr>
<tr>
<td>Summer</td>
<td>av</td>
<td>6.14</td>
<td>5.79</td>
<td>5.50</td>
<td>6.84</td>
<td>5.90</td>
<td>5.98</td>
<td>7.17</td>
<td>5.19</td>
<td>5.73</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>0.68</td>
<td>1.39</td>
<td>0.82</td>
<td>1.31</td>
<td>2.48</td>
<td>0.38</td>
<td>0.65</td>
<td>0.55</td>
<td>4.11</td>
</tr>
</tbody>
</table>

Fig 6.6: Average seasonal variation of Magnesium
6.2.3 Sodium

Sodium is a major component of potable water with an average presence of greater than 100mg/L (Khopkar, 1993). High concentration of sodium leads to difficulty in boiler operations. It also affects health. The permissible limit of sodium in water is 200 mg/L.

The monthly variation of sodium is represented in Fig 6.7 and Fig 6.8. The average seasonal variations are given in Table 6.3 and graphically in Fig 6.9.

The sodium concentration in Ahmadabad varied from 12.9 (±2.08) mg/L in April 2012 to a maximum of 54.14 (±2.78) mg/L in January 2012. The average of the 12 month period was 36.11 (±14.26) mg/L. The winter average value was 42.53 (±16.12) mg/L while 19.11 (±5.58) mg/L and 34.94(±8.22) mg/L were those of rainy and summer seasons respectively.

In Arasur, the monthly sodium average was 34.43 (±14.95) mg/L. The monthly values varied from a minimum of 11.35 (±1.42) mg/L in May 2012 to a highest value of 58.9 (±0.96) mg/L in the month of December 2011. Seasonally, the winter average was 48.5 (±9.11) mg/L while that of rainy season was 19.78 (±10.90) mg/L and summer season was 24.63 (±7.06) mg/L.

Ghaemabad recorded a monthly average value of 35.31 (±12.77) mg/L. The least value was 19.05 (±0.78) mg/L in August 2012 and maximum value was 51.6 (±1.45) mg/L in September 2012. The seasonal sodium concentration averages were 18.94 (±2.50) mg/L in rainy season, 33.73 (±8.17) mg/L in summer and 39.60 (±9.59) mg/L in winter season.

Khampich had a monthly average of 34.22 (±15.75) mg/L. The highest sodium concentration recorded was 61.2 (±1.85) mg/L in October 2011. The least value was 6.5 (±1.04) mg/L. The winter season average was 39.53 (±4.01) mg/L, summer average was 24.53 (±15.69) mg/L. The rainy season average was 20.57 (±7.26) mg/L.
The city of Khonsar had a monthly average sodium concentration of 36.75 (±16.65) mg/L. The monthly values varied between 12.0 (±1.42) mg/L in April 2012 to 62.0 (±2.31) mg/L in November 2011. In the seasonal averages, winter season had the highest value of 38.67 (±22.50) mg/L while rainy season had the least value at 25.67 (±15.82) mg/L. The summer season averaged at 31.0 (±6.56) mg/L.

Malga had perceptibly higher values with monthly variations ranging from a low of 30.5 (±2.14) mg/L in May 2012 to a high of 57.5 (±1.19) mg/L in December 2011. The seasonal averages were 46.57 (±9.62) mg/L in winter, 33.83 (±8.6) mg/L in rainy season and 38.93 (±1.75) mg/L. The monthly average was 40.8 (±7.97) mg/L.

Qudejan values ranged from 20.9 (±1.10) mg/L in March 2012 to 67.0 (±1.45) mg/L in December 2011. The average of the 12 month variation was 39.79 (±13.29) mg/L. The season averages were 48.9 (±21.05) mg/L, in winter, 31.4 (±11.76) mg/L in rainy season and 34.2 (±6.91) mg/L in summer season.

The monthly average of sodium concentration in Rahmatabad was observed to be 39.18 (±11.93) mg/L. The variations over the 12 month period was from 16.5 (±1.14) mg/L in May 2012 to a high of 58.8 (±2.02) mg/L. The average of winter season values was 48.26 (±4.51) mg/L, 24.66 (±10.22) mg/L and 36.57 (±7.40) mg/L.

In Wist the maximum monthly value recorded for sodium was 60.5 (±2.81) mg/L and the least value was 11.84 (±0.86) mg/L. The monthly average value was 37.70 (±16.18) mg/L. The seasonal averages were in the order rainy season 25.08 (±16.10) mg/L, summer season 34.30 (±7.40) mg/L and winter season (42.996) mg/L.

Surprisingly the sodium concentration showed almost similar to very close monthly average values at all the nine places studied.
Sodium can be introduced into water by base exchange reactions when certain clay minerals and zeolites are present. In the present study, the sodium content was well within the permissible limits. The variation in sodium content between months and seasons of the places undertaken to study can be attributed to these base exchange reactions with chemicals getting added from industrial waste water and other run-offs into the river water at the locations studied.

Fig 6.7: Monthly variation of Sodium between period 2011-12 in Ahmadabad, Arasur, Ghaemabad, Khampich, Khonsar

Fig 6.8: Monthly variation of Sodium between period 2011-12 in Malga, Qudejan, Rahmatbad, Wist
Table 6.3 Average Seasonal Variation of Sodium (mg/L)

<table>
<thead>
<tr>
<th></th>
<th>Ahmadabad</th>
<th>Arasur</th>
<th>Ghaemabad</th>
<th>Khampich</th>
<th>Khonsar</th>
<th>Malga</th>
<th>Qudejan</th>
<th>Rahmatbad</th>
<th>Wist</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>WINTER</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>av</td>
<td>42.53</td>
<td>48.50</td>
<td>39.60</td>
<td>39.53</td>
<td>38.67</td>
<td>46.57</td>
<td>48.90</td>
<td>48.26</td>
<td>43.00</td>
</tr>
<tr>
<td><strong>Rainy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>av</td>
<td>20.71</td>
<td>32.10</td>
<td>21.40</td>
<td>19.50</td>
<td>22.00</td>
<td>43.60</td>
<td>20.90</td>
<td>36.12</td>
<td>20.40</td>
</tr>
<tr>
<td>sd</td>
<td>12.90</td>
<td>15.90</td>
<td>19.00</td>
<td>13.90</td>
<td>12.00</td>
<td>27.40</td>
<td>29.20</td>
<td>21.35</td>
<td>11.84</td>
</tr>
<tr>
<td><strong>Summer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>av</td>
<td>34.94</td>
<td>24.63</td>
<td>33.73</td>
<td>24.53</td>
<td>31.00</td>
<td>38.93</td>
<td>34.20</td>
<td>36.57</td>
<td>34.30</td>
</tr>
<tr>
<td>sd</td>
<td>8.22</td>
<td>7.06</td>
<td>8.17</td>
<td>15.69</td>
<td>6.56</td>
<td>1.75</td>
<td>6.91</td>
<td>3.20</td>
<td>7.40</td>
</tr>
</tbody>
</table>

Fig 6.9: Average seasonal variation of Sodium
6.2.4 Potassium

Potassium is not present in high concentrations in water generally. It is lesser in concentration than sodium.

The monthly variation of potassium is depicted in Fig 6.10 and Fig 6.11. The average seasonal values are given in Table 6.4 and shown graphically in Fig 6.12.

The potassium values of Ahmadabad ranged from 13.32 (±2.42) mg/L in May 2012 to 36.7 (±1.84) mg/L in October 2011. The monthly average was 21.24 (±4.42) mg/L. The winter average was 25.04 (±4.42) mg/L while that of rainy season was 14.79 (±1.54) mg/L and summer season was 16.45 (±1.85) mg/L.

In Arasur, the seasonal averages of potassium were close to each other with winter season having an average of 15.79 (±3.75) mg/L, rainy season with 13.55 (±5.07) mg/L and summer season with 19.92 (±2.23) mg/L. The monthly average being 17.62 (±4.52) mg/L, the monthly values ranged from 7.54 (±0.82) mg/L in March 2012 to 23.4 (±1.92) mg/L in November 2011.

Ghaemabad recorded a monthly average of 17.12 (±4.96) mg/L. The variations of potassium concentration over the 12 month period ranged from 7.9 (±0.48) mg/L in April 2012 to 25.8 (±1.32) mg/L in November 2011. The winter average value was 19.2 (±3.44) mg/L, rainy season average was 11.13 (±2.87) mg/L and the summer average was 17.27 (±2.84) mg/L.

At Khampich, the monthly average was 18.17 (±2.87) mg/L. The highest potassium concentration recorded was 21.6 (±1.30) mg/L in June 2012. The lowest concentration was 12.87 (±2.20) mg/L in March 2012. Seasonally, 19.53 (±3.27) mg/L was winter average, 15.89 (±2.84) mg/L was rainy season average and 20.17 (±2.15) mg/L was summer season average.
The Khonsar city had a monthly average of 16.02 (±5.44) mg/L with monthly variation starting from 7.3 (±0.82) mg/L in April 2012 to 26.0 (±2.18) mg/L in January 2012. The summer potassium average was the highest at 17.21 (±1.72) mg/L followed by winter average with 16.57 (±9.07) mg/L and then by rainy season with 10.9 (±3.38) mg/L.

Malga showed a 12 monthly variation of potassium concentration ranging from 12.68 (±1.44) mg/L in March 2012 to a maximum of 34.4 (±2.4) mg/L. The average of all these values were 19.54 (±5.76) mg/L. Seasonal averages were 5.98 (±0.38) mg/L in winter, 14.25 (±2.04) mg/L on rainy season and 18.09 (±1.26) mg/L in summer season.

Qudejan showed winter average value of 22.13 (±3.59) mg/L, rainy season average of 11.37 (±5.35) mg/L and a summer average value of 18.53 (±1.96) mg/L. The monthly average of 12 months study was 17.71 (±5.01) mg/L. The highest concentration was recorded in December 2011 at 25.0 (±1.44) mg/L and the least recorded was 6.1 (±0.95) mg/L in April 2012.

During the monthly variation in the water samples of Rahmatabad, the least potassium value of 9.5 (±1.1) mg/L was recorded in April 2012 while the highest value was 25.3 (±0.98) mg/L in January 2012. Seasonally, winter average was the highest at 18.43 (±7.64) mg/L followed by summer season with 17.07 (±3.55) mg/L and then by rainy average at 12.7 (±2.82) mg/L.

In Wist, the winter average value was 18.84 (±9.65) mg/L, rainy average was 10.91 (±3.37) mg/L and summer average was 15.09 (±3.27) mg/L. The monthly average was 16.50 (±6.12) mg/L. The minimum value was 7.04 (±0.28) mg/L in April 2012 and the maximum value was 24.6 (±1.53) mg/L in December 2011.

The concentration level of potassium in water is generally low because of the resistance of potassium minerals towards weathering and also because of its fixation in clay mineral due to weathering.
In the present study, potassium content was found to be in low concentrations and well within permissible limits. The maximum value observed was at Malga at 34.4 mg/L

Fig 6.10: Monthly variation of Potassium between period 2011-12 in Ahmadabad, Arasur, Ghaemabad, Khampich, Khonsar

Fig 6.11: Monthly variation of Potassium between period 2011-12 in Malga, Qudejan, Rahmatbad, Wist
Table 6.4 Average Seasonal Variation of Potassium (mg/L)

<table>
<thead>
<tr>
<th></th>
<th>Ahmadabad</th>
<th>Arasur</th>
<th>Ghaemabad</th>
<th>Khampich</th>
<th>Khonsar</th>
<th>Malga</th>
<th>Qudejan</th>
<th>Rahmatbad</th>
<th>Wist</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>av</td>
<td>25.04</td>
<td>15.79</td>
<td>19.20</td>
<td>19.53</td>
<td>16.57</td>
<td>20.97</td>
<td>22.13</td>
<td>18.43</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>4.42</td>
<td>3.75</td>
<td>3.44</td>
<td>3.27</td>
<td>9.07</td>
<td>3.27</td>
<td>3.59</td>
<td>7.64</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>1.54</td>
<td>5.07</td>
<td>2.87</td>
<td>2.84</td>
<td>3.38</td>
<td>2.04</td>
<td>5.35</td>
<td>2.82</td>
</tr>
<tr>
<td>Summer</td>
<td>av</td>
<td>16.45</td>
<td>19.92</td>
<td>17.27</td>
<td>20.17</td>
<td>17.21</td>
<td>18.09</td>
<td>18.53</td>
<td>17.07</td>
</tr>
<tr>
<td></td>
<td>sd</td>
<td>1.85</td>
<td>2.23</td>
<td>2.84</td>
<td>2.15</td>
<td>1.72</td>
<td>1.26</td>
<td>1.96</td>
<td>3.55</td>
</tr>
</tbody>
</table>

Fig 6.12: Average seasonal variation of Potassium