Study of Change in Water Quality at Different Distances from Sea in Mahi Estuarian Area

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Abstract. Main perennial rivers of Gujarat, Tapi, Narmada, Mahi and Sabarmati are meeting Arabian Sea in Gulf of Khabhath. The out flow of Mahi River into the sea is decreased due to construction of dams like Bajaj Sagar, Kadana, Panam and Wanakbori weir. So, Tidal effect of sea and sea water intrusion is being increased on landward side. Moreover, due to erratic nature of rainfall and improper management of the existing water resources in the region, the ground water withdrawal rate has increased. Since the existing ground water resources have not been replenished as per demand, Mahi estuarian area is facing a problem of sea water intrusion. Day by day quality of ground water and soil going on deteriorating. An attempt is made to study the pre and post-monsoon ground water quality by collecting and analyzing the water samples of open well, bore well etc. Considering radial distances from Kavi Town (sea) i.e. to study the effect of salinity ingress. It is observed that as the distance from Kavi village increases, the T.D.S, Cl and, TH, values decreases. The high pre-monsoon values get normalized after the post monsoon because of rain water recharge and dilution, except some locations due to many reasons.

Keywords: Sea water intrusion, Salinity, Ground water, Ground water quality, Estuary.
Introduction
The Mahi River is one of the major west’s flowing perennial rivers and flowing through Central Gujarat into the Gulf of Cambay near Kavi village. The Mahi river originates from Mahud Tank on the northern slopes of the western flank of Vindhya mountain range at about 22° 35’ N and 74° 15’ E near the village Sardarpur in district Dadarpur of Madhya Pradesh. First it flows in Jhabua Dhar districts and Ratlam district before entering Rajasthan and then Gujarat. Total length of the Mahi River is 583 Km. Out of which 167 km in Madhya Pradesh, 174 km in Rajasthan and 242 km in Gujarat. In Gujarat it passes through Panchmahal, Anand and Vadodara District.

This estuarian area is lying under three district viz. Vadodara district (Vadodara, Padra and Savli Talukas) on left bank, some portion of Bharuch district (Jambusar Taluka) on left bank at meeting point of river and sea and Anand district (Ananad, Anklav, Borsad, Petlad and Khambhat or Cambay Talukas) on right bank of Mahi river.

The study was conducted to study the pre and post monsoon effects on the ground water quality by collecting the water samples of open well, borewel, etc. considering radial distances from Kavi Town (the meeting point of the Mahi river and Sea) i.e., to study the effect of salinity ingress.

Details of Study Area
Mahi River meets gulf of Kambhat near Kavi Town. This estuarial area lies between 22° 05’ 06" to 22° 33’ 36" North Latitude and 72° 27’ 18" to 73° 13’ 57" East longitude. The total approximate area by planimeter is about 2298.23 sq. km. (Fig.1) the area between Wanakbori to Gulf of Cambay is gently sloping to almost flat near the Gulf and is a fully developed and fertile alluvial tract. The type of soil is deep black coastal alluvium in Bharuch district and medium black in Vadodara and Anand districts. The geology is recent to sub-recent alluvium. The climate is semi-arid (moist) to dry, sub-humid. Average temperature during winter and monsoon is 30°C and during summer is 43°C. Rainfall range of annual rainfall is 750-1100 mm for Anand, Vadodara and Bharuch districts.

Fig. 1. Map Showing Mahi Estuarian Area
Methodology
To get the comprehensive picture of change of water quality in Mahi estuarian area in pre and post-monsoon season. The representative water samples were collected from surrounding bore well/open well and tube wells parallel to the Mahi River on both sides within 10 km distance from river in one lit. Plastic container in May-June for the pre-monsoon and in November for post-monsoon period of year 2003. We collected about 36 samples. The water samples then were analyzed for different important chemical parameters like PH, EC, T.D.S., Cl, CO3, HCO3, TH, Na, Ca, Mg, K, S04 to evaluate water quality in Environmental Engineering Laboratory, Civil Engg. Department, Faculty of Technology and Engineering, the M S University of Baroda, Vadodara.

Analysis and Results
Results obtained in the laboratory are recorded as statement of different chemical analysis of Mahi estuarian area (distance from Kavi) (Table1) These laboratory results are also represented graphically to see at a glance the change of ground water quality in Mahi estuarian area in pre-monsoon and post-monsoon season.

T.D.S. (Total dissolved solids) v/s distance from Kavi (graphs 1.1,1.2,1.3)
Cl (Chlorides)v/s distance from Kavi (graphs 1.4,1.5,1.6)
TH (Total hardness)v/s distance from Kavi (1.7,1.8,1.9)
Table 1. Statement OF Different Chemical Analysis of Mahi Estuarian Area (DIST. form KAVI)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>EC (mmho/cm)</th>
<th>TDS (mg/l)</th>
<th>SiO₂ (mg/l)</th>
<th>PO₄ (mg/l)</th>
<th>Fe₂O₃ (mg/l)</th>
<th>CaCO₃ (g/l)</th>
<th>MgO (g/l)</th>
<th>MnO (mg/l)</th>
<th>K₂O (mg/l)</th>
<th>Na₂O (mg/l)</th>
<th>Cl (mg/l)</th>
<th>SO₄ (mg/l)</th>
<th>Cr (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.8</td>
<td>23.5</td>
<td>2.3</td>
<td>0.1</td>
<td>0.2</td>
<td>0.3</td>
<td>0.1</td>
<td>0.01</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
<td>0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>2</td>
<td>11.2</td>
<td>20.6</td>
<td>1.8</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.02</td>
<td>0.06</td>
<td>0.07</td>
<td>0.1</td>
<td>0.11</td>
<td>0.05</td>
</tr>
<tr>
<td>3</td>
<td>12.5</td>
<td>25.8</td>
<td>2.5</td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.2</td>
<td>0.03</td>
<td>0.07</td>
<td>0.08</td>
<td>0.11</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>4</td>
<td>9.2</td>
<td>18.9</td>
<td>1.6</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.01</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
<td>0.12</td>
<td>0.04</td>
</tr>
<tr>
<td>5</td>
<td>14.7</td>
<td>30.2</td>
<td>3.0</td>
<td>0.4</td>
<td>0.2</td>
<td>0.3</td>
<td>0.1</td>
<td>0.02</td>
<td>0.06</td>
<td>0.07</td>
<td>0.11</td>
<td>0.12</td>
<td>0.06</td>
</tr>
<tr>
<td>6</td>
<td>11.8</td>
<td>21.5</td>
<td>2.2</td>
<td>0.2</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.01</td>
<td>0.05</td>
<td>0.06</td>
<td>0.09</td>
<td>0.12</td>
<td>0.04</td>
</tr>
</tbody>
</table>

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Graph 1.1. Total Dissolved Solids v/s Distance from Kavi

Graph 1.2. Total Dissolved Solids v/s Distance from Kavi (Pre-Monsoon TDS > 6000ppm)

Graph 1.2. Total Dissolved Solids v/s Distance from Kavi (Pre-Monsoon TDS > 6000ppm)
Graph 1.3. Total Dissolved Solids v/s Distance from Kavi (Pre-Monsoon TDS<6000ppm)

Graph 1.4. Chlorides v/s Distance from Kavi
Graph 1.5. Chlorides v/s Distance from Kavi (Pre-Monsoon CI>3000ppm)

Graph 1.6. Chlorides v/s Distance from Kavi (Pre-Monsoon CI < 3000 ppm)
Graph 1.7. Total Hardness v/s Distance from Kavi

Graph 1.8. Total Hardness v/s Distance from Kavi (Pre-Monsoon TH>1000ppm)
Conclusions
Based on results obtained from chemical analysis of water samples following conclusions are drawn.

I. Considering Distances from Kavi Town

For T.D.S.:

<table>
<thead>
<tr>
<th>Village</th>
<th>Distance from Kavi km.</th>
<th>T.D.S. in p.p.m. Pre-monsoon</th>
<th>T.D.S. in p.p.m. Post-monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sarod</td>
<td>15</td>
<td>8472</td>
<td>4436</td>
</tr>
<tr>
<td>Kareli</td>
<td>24.8</td>
<td>13036</td>
<td>2074</td>
</tr>
<tr>
<td>Dabka</td>
<td>32.9</td>
<td>8076</td>
<td>6442</td>
</tr>
<tr>
<td>Kotana</td>
<td>44.75</td>
<td>35414</td>
<td>1978</td>
</tr>
<tr>
<td>Angadh</td>
<td>45.25</td>
<td>20612</td>
<td>10312</td>
</tr>
</tbody>
</table>

1. From table and graphs for pre-monsoon and Post-monsoon results of T.D. S., it is observed that as the distance from Kavi Town increases, the T.D.S. values decreases of ground water samples. The high pre-monsoon values of the T.D.S. get normalized after the Post-monsoon period because of the rain water recharge and dilution with the high T.D.S. water.

2. Very high values of T. D. S. for pre-monsoon of ground water samples of distances of 44.75 and 45.25 km. Of Kotana and Angadh observed are 35414 p.p.m. and 20612 p.p.m. This may be because of their locations very nearer to river and the effect of Tidal water. Minimization of flow is observed in river due to construction of dams, weirs and many French wells are constructed in river for withdrawal of water by Industries and Vadodara Municipal Corporation. Also this is highly intensified agricultural area. Many tube wells are located in this area and due to high withdrawal of ground water a vacuum in the aquifer may be created and resulted into sea water intrusion. Upcoming of ground water during pumping may be the main cause of high T.D.S. values. The post-monsoon values of T.D.S. decreased more at the Kotana as compared to Angadh. This may be due to less depth of tube well at Kotana compared to Angadh. Another possible
reason may be because of local geological formations.

3. It was also seen that the pre-monsoon T.D.S. values of groundwater samples of Sarod, Kareli and Dabka at 15, 24.8 and 32.9 km. Distances from Kavi are 8472 p.p.m., 13036 p.p.m. and 8076 p.p.m. The high T.D.S. values of Sarod and Kareli ground water samples may be due to their location near Kavi and they are in Jambusar Taluka, which is nearer to the bay of Khambhat. All the tube wells in Jambusar taluka are affected by sea water intrusion. Kareli is at more distance from Kavi as compared to Sarod but the high T.D.S. is observed at Kareli. The probable reason may be due to over withdrawal of ground water or may be due to local geological formation. At Dabka, value of T.D.S. decreased compared to Sarod as Dabka is 17.90 km. away on u/s from Sarod. The post-monsoon T.D.S. values decreased more at Kareli as compared to Sarod. This may be due to the effect of rainfall recharge dilution and their location from Kavi. The decrease in T.D.S. value at Dabka is less compared to Sarod and Kareli. This may be due to local.

II. For Cl:

<table>
<thead>
<tr>
<th>Village</th>
<th>Distance from Kavi km.</th>
<th>Cl in p.p.m. Pre-monsoon</th>
<th>Cl in p.p.m. Post-monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tithor</td>
<td>25.05</td>
<td>7747.59</td>
<td>2374.26</td>
</tr>
<tr>
<td>Dabka</td>
<td>32.9</td>
<td>7197.76</td>
<td>2924.09</td>
</tr>
<tr>
<td>Kotana</td>
<td>44.75</td>
<td>15995.07</td>
<td>909.72</td>
</tr>
<tr>
<td>Angadh</td>
<td>45.25</td>
<td>14995.3</td>
<td>6697.92</td>
</tr>
</tbody>
</table>

1. From table and graphs for pre-monsoon and post-monsoon results of Cl, it is observed that as the distance from Kavi town increases the Cl values decreases of ground water. The high pre-monsoon values of the Cl get decreased after the post-monsoon period because of the rainwater recharge.

2. High values of Cl for pre-monsoon of ground water samples of Kotana and Angadh are observed. The higher Cl value observed at Kotana compared to Angadh similar to T.D.S. values. The post-monsoon values of Cl decreased more at Kotana as compared to Angadh. This may be for same reasons as mentioned in I (2).

III For TH:

<table>
<thead>
<tr>
<th>Village</th>
<th>Distance from Kavi km.</th>
<th>TH in p.p.m. Pre-monsoon</th>
<th>TH in p.p.m. Post-monsoon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kotana</td>
<td>44.75</td>
<td>3380.37</td>
<td>415</td>
</tr>
<tr>
<td>Angadh</td>
<td>45.25</td>
<td>5851.93</td>
<td>3100</td>
</tr>
</tbody>
</table>

1. From table and graphs for pre-monsoon and post-monsoon results of TH, it is observed that.

2. As the distance from Kavi town increases the TH values varying of ground water samples and so no clear relation can
be predicted. The high pre-monsoon values of the TH decreased after the post-monsoon. The high pre-monsoon values of the TH decreased after the post-monsoon period because of the rain water recharge.

3. High values of TH for pre-monsoon of ground water samples of Kotana and Angadh are observed. The high value of pre-monsoon TH at Kotana compared to Angadh is observed. The post-monsoon TH values decreased much more at Kotana as compared to Angadh. This is similar to variation of T.D.S. and Cl at above stations. This may be for same reasons as mentioned in I (2).

IV The values of pre-monsoon and post-monsoon T.D.S. of ground water samples of villages located on right bank of river are observed less compared to the villages on left bank of river. This may be due to irrigation by MRBC from Wanakbori weir on right bank of Mahi River.

**Recommendations**

- The government of Gujarat should construct more tidal regulator-cum-recharge structures to prevent surface salinity ingress as well as to recharge the surrounding land.
- Structures like check dams should be constructed to recharge ground water reservoirs.
- Withdrawal of the ground water used for irrigation should be restricted in the affected area for these framers should be initiated to use drip and sprinklers irrigation methods, so that saving of water.

**Acknowledgement**

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**References**


