EFFECT OF SUGAR INDUSTRY LIQUID WASTE ON GROUND WATER AND RIVER WATER IN GADARWARA

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Abstract: River water and Groundwater, the main source of irrigation, drinking or domestic purposes, is affected due to discharge of industrial effluents. The sugar industry contain remnants of chemical used for processing like caustic soda, sodium chloride, lime, sulphur and softening agents etc. and have potential to cause groundwater quality deterioration. In order to assess the water quality index, water samples of various sources were collected from around the sugar mills placed at Gadarwara, Narsinghpur. Altogether four groundwater samples three river water sample were processed to detailed analysis of various parameters following the standard guideline of APHA, WHO study under investigation alarming pH ranges (6.8-8.6), 400-1350 mg/l of Ca2++ Mg2+, and (234.3-468.4) ppm chloride concentrations were obtained might be certainly problematic for drinking purpose. Amongst the Physical & Chemical parameters water quality index (W.Q.I.) concentration found beyond the permissible limit (both the sugar mills, Shakti, Narmada) for irrigation and domestic purpose. Based on categorization of irrigation classes under the study indicated that the sources fall under either medium or high salinity hazards required special attention for irrigation and domestic purpose.

Keywords: Physical and chemical water quality, Water quality index (W.Q.I.), Shakkar River, Gadarwara, Madhya Pradesh, India, W.H.O.

1. Introduction

River is a natural source of water for house use, agriculture use, as well as industrial use. Generally, river water is fresh and safe for use. Water is a very good solvent and it can dissolve so many substances either they are organic or inorganic in nature. Quality of water is decided on the basis of its dissolved and suspended substances which are either useful or harmful for the growth of living organisms. Our work was aimed to know the water quality index of Shakkar River on Gadarwara, Narsinghpur district of Madhya Pradesh, India. The main factors responsible for increasing water pollution are exponential growth of population, urbanization, industrialization and agricultural revolution. Groundwater quality is affected due to discharge of poor quality water from various industries and urban wastewater to the natural water courses. The sugar industry contain remnants of chemical used for processing like caustic soda, sodium chloride, lime, sulphur and softening agents etc. which degrade the quality of ground water. During the last few decades, disposal of sewage-sludge without proper treatment from urban areas and effluents from industries have caused the deterioration in the quality of groundwater. The need has arisen to review and recognise environmental problems associated with sugar mills. The effluents discharged from the sugar factories, distilleries etc. introduced in to the groundwater might be causing undesirable qualities. Therefore, the present study has been carried out to assess the various quality parameters of ground water sample of different water bodies situated in the vicinity of sugar mills.

2. Methods and Materials-2.1 Study Area

The Shakkar River is a tributary of the Narmada River in the state of Madhya Pradesh in central India. It meets Narmada near Gadarwara. The Shakkar River passes through 23.0°N 8.41°E and nearby towns are Pipariya, Bareli, Sohagpur, Gadarwara.

2.2 Selection of sampling site map
2.3 Sampling stations

<table>
<thead>
<tr>
<th>Code Name</th>
<th>Site Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Effluent from Shakti sugar mill Gadarwara</td>
</tr>
<tr>
<td>B</td>
<td>U/S Before mixing Shakkar river</td>
</tr>
<tr>
<td>C</td>
<td>D/S After mixing Shakkar river</td>
</tr>
<tr>
<td>D</td>
<td>Ground water taken from shallow well, Kodiya</td>
</tr>
<tr>
<td>E</td>
<td>Ground water taken from deep well, Kodiya</td>
</tr>
<tr>
<td>F</td>
<td>Effluent from Narmada sugar mill Gadarwara</td>
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<tr>
<td>G</td>
<td>Ground water taken from shallow well, Salichouka</td>
</tr>
<tr>
<td>H</td>
<td>Ground water taken from deep well, Salichouka</td>
</tr>
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</table>

2.4 Sampling and field work

Samples were collected as per the guidelines of APHA. Each sample was taken in clean plastic bottle and kept in iceberg on the field. Turbidity, Colour, Odour, Temperature, Total Suspended Solid, Oil & Greases, Alkalinity, Total Hardness, Calcium, pH, Total Solids, COD, DO, BOD, Chlorides, Fluorides, Sulphates, Phosphates were tested in a laboratory while BOD bottles were filled at site and reagents for DO fixation were mixed at the time of sample collection. The Physical and chemical water quality analysis of samples was performed using standard analytical methods. All samples were transported to the Madhya Pradesh Pollution Control Board Jabalpur.

2.5 Methods

The physical & chemical water quality analysis of water samples was carried out using standard analytical methods as per the guidelines of APHA. Following table shows the water quality index and their methods used during testing.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Parameter</th>
<th>Method of determination</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature</td>
<td>Dipping of thermometer</td>
</tr>
<tr>
<td>2</td>
<td>Colour</td>
<td>Colour matching technique</td>
</tr>
<tr>
<td>3</td>
<td>Turbidity</td>
<td>Nephelometer method</td>
</tr>
<tr>
<td>4</td>
<td>Odour</td>
<td>Dilution method</td>
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<tr>
<td>5</td>
<td>Electrical Conductivity</td>
<td>Conductivity meter method</td>
</tr>
<tr>
<td>6</td>
<td>Suspended Solids</td>
<td>Filtration method</td>
</tr>
<tr>
<td>7</td>
<td>Oil and Grease</td>
<td>5520 B. Partition-Gravimetric Method</td>
</tr>
<tr>
<td>8</td>
<td>Alkalinity</td>
<td>2320 B. Titration Method</td>
</tr>
<tr>
<td>9</td>
<td>Total Hardness</td>
<td>2340 C. EDTA Titrimetric Method</td>
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<td>10</td>
<td>Calcium</td>
<td>EDTA titration</td>
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<td>11</td>
<td>pH</td>
<td>pH meter</td>
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<tr>
<td>12</td>
<td>Total Solids</td>
<td>Evaporation Method</td>
</tr>
<tr>
<td>13</td>
<td>COD</td>
<td>5220 B. Open reflux method</td>
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<td>14</td>
<td>BOD</td>
<td>By DO Consumption Calculation</td>
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<td>15</td>
<td>DO</td>
<td>4500-0 C. Azide Modification method</td>
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<td>16</td>
<td>Fluorides</td>
<td>4500-F D. Spadns Method</td>
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<td>17</td>
<td>Sulphates</td>
<td>4500-SO₄²⁻ E. Turbidimetric Method</td>
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<td>18</td>
<td>Phosphate</td>
<td>4500-P D. Stannous Chloride Method</td>
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<td>19</td>
<td>Chlorides</td>
<td>4500-Cl B. Argentometric Method</td>
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<tr>
<td>20</td>
<td>Nitrate</td>
<td>4500-NO₃⁻ B. Ultraviolet Spectrophotometric Screening Method</td>
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</tbody>
</table>
3. Results and Discussion

Water Quality Index

1. W.Q.I. at station A

Table 3 Calculation of Water Quality Index at station A

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Value (Vn)</th>
<th>Unit</th>
<th>Standard Permissible Limit (Si)</th>
<th>Relative Weight W=I/Si</th>
<th>Quality Rating Q=100(Vn-Vi)/(Si-Vi)</th>
<th>Weighted Value WxQi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>34.5</td>
<td>ºC</td>
<td>4</td>
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<td>215.625</td>
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<td>TCU</td>
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<tr>
<td>Turbidity</td>
<td>91</td>
<td>NTU</td>
<td>10</td>
<td>0.1</td>
<td>910</td>
<td>91</td>
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<td>Odour</td>
<td>Unpleasant</td>
<td>TON</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Conductivity</td>
<td>548.26</td>
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<td>0.0033</td>
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<td>Suspended Solids</td>
<td>250</td>
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<td>100</td>
<td>0.01</td>
<td>250</td>
<td>2.5</td>
</tr>
<tr>
<td>Oil and Greases</td>
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<td>mg/l</td>
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<td>0.1</td>
<td>40</td>
<td>4</td>
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<td>Alkalinity</td>
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<td>unit</td>
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<td>3.00</td>
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<td>500</td>
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<td>mg/l</td>
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<td>-</td>
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</table>

∑Wn = 4.3266 ∑Wn x Qn = 3344.33

WQI = ∑Wn x Qn / ∑Wn

WQI = 3344.33 / 4.3266 = 865.42

2. W.Q.I. at station B

Table 4 Calculation of Water Quality Index at station B

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Value (Vn)</th>
<th>Unit</th>
<th>Standard Permissible Limit (Si)</th>
<th>Relative Weight W=I/Si</th>
<th>Quality Rating Q=100(Vn-Vi)/(Si-Vi)</th>
<th>Weighted Value WxQi</th>
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<tbody>
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<td>-</td>
<td>-</td>
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<td>-</td>
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<td>Turbidity</td>
<td>6.0</td>
<td>NTU</td>
<td>10</td>
<td>0.1</td>
<td>60.00</td>
<td>6.00</td>
</tr>
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<td>Odour</td>
<td>2.0</td>
<td>TON</td>
<td>-</td>
<td>-</td>
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<td>-</td>
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<tr>
<td>Conductivity</td>
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<td>0.0033</td>
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<td>0.01</td>
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<td>0.0033</td>
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<td>mg/l</td>
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<td>7.4</td>
<td>unit</td>
<td>8.5</td>
<td>0.117</td>
<td>26.6615</td>
<td>3.11</td>
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<td>Parameter</td>
<td>Test Value (V&lt;sub&gt;n&lt;/sub&gt;)</td>
<td>Unit</td>
<td>Standard Permissible Limit (S&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>Relative Weight W=1/S&lt;sub&gt;i&lt;/sub&gt;</td>
<td>Quality Rating Q&lt;sub&gt;i&lt;/sub&gt; =100(V&lt;sub&gt;n&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)/(S&lt;sub&gt;i&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)</td>
<td>Weighted Value W&lt;sub&gt;i&lt;/sub&gt;Q&lt;sub&gt;i&lt;/sub&gt;</td>
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<td>0.25</td>
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<td>0.004</td>
<td>17.93</td>
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<td>0.022</td>
<td>15.11</td>
<td>0.33</td>
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</table>

\[ \sum W_n = 4.3266 \sum W_n \times Q_n = 916.36 \]

\[ W_{QI} = \frac{\sum W_n \times Q_n}{\sum W_n} \]

\[ W_{QI} = 916.36 \times 4.3266 = 211.80 \]

W.Q.I. at station C

Table 5 Calculation of Water Quality Index at station C

\[ \sum W_n = 4.3266 \sum W_n \times Q_n = 2012.143 \]

\[ W_{QI} = \frac{\sum W_n \times Q_n}{\sum W_n} \]

\[ W_{QI} = 2012.143 \times 4.3266 = 465.06 \]
W.Q.I. at station D

Table 6 Calculation of Water Quality Index at station D

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Value (V&lt;sub&gt;n&lt;/sub&gt;)</th>
<th>Unit</th>
<th>Standard Permissible Limit (S&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Relative Weight W&lt;sub&gt;i&lt;/sub&gt; = 1/S&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Quality Rating Q&lt;sub&gt;i&lt;/sub&gt; = 100(V&lt;sub&gt;n&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)/(S&lt;sub&gt;i&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Weighted Value W&lt;sub&gt;i&lt;/sub&gt; x Q&lt;sub&gt;i&lt;/sub&gt;</th>
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<td>Temperature</td>
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<td>-</td>
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<td>16.94</td>
<td>0.372</td>
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\[ \sum W_n = 4.3266 \sum W_i \times Q_i = 766.72 \]

\[ WQI = \frac{\sum W_i \times Q_i}{\sum W_n} = 177.20 \]

W.Q.I. at station E

Table 7 Calculation of Water Quality Index at station E

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Value (V&lt;sub&gt;n&lt;/sub&gt;)</th>
<th>Unit</th>
<th>Standard Permissible Limit (S&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Relative Weight W&lt;sub&gt;i&lt;/sub&gt; = 1/S&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Quality Rating Q&lt;sub&gt;i&lt;/sub&gt; = 100(V&lt;sub&gt;n&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)/(S&lt;sub&gt;i&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Weighted Value W&lt;sub&gt;i&lt;/sub&gt; x Q&lt;sub&gt;i&lt;/sub&gt;</th>
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<td>-</td>
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Table 8 Calculation of Water Quality Index at station F

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<th>Standard Permissible Limit (S&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Relative Weight W&lt;sub&gt;i&lt;/sub&gt;=1/S&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Quality Rating Q&lt;sub&gt;i&lt;/sub&gt;=100(V&lt;sub&gt;n&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)/(S&lt;sub&gt;i&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)</th>
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\[ \sum W_n = 4.3266 \sum W_n \times Q_n = 683.56 \]

\[ WQI = \sum W_n \times Q_n + \sum W_n \]

\[ WQI = 683.56 + 4.3266 = 157.98 \]

I W.Q.I. at station F

Table 9 Calculation of Water Quality Index at station G

<table>
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<tr>
<th>Parameter</th>
<th>Test Value (V&lt;sub&gt;n&lt;/sub&gt;)</th>
<th>Unit</th>
<th>Standard Permissible Limit (S&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Relative Weight W&lt;sub&gt;i&lt;/sub&gt;=1/S&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Quality Rating Q&lt;sub&gt;i&lt;/sub&gt;=100(V&lt;sub&gt;n&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)/(S&lt;sub&gt;i&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Weighted Value W&lt;sub&gt;i&lt;/sub&gt;xQ&lt;sub&gt;i&lt;/sub&gt;</th>
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\[ \sum W_n = 4.3266 \sum W_n \times Q_n = 3626.48 \]

\[ WQI = \sum W_n \times Q_n + \sum W_n \]

\[ WQI = 3626.48 + 4.3266 = 838.183 \]

I W.Q.I. at station G
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test Value (V&lt;sub&gt;n&lt;/sub&gt;)</th>
<th>Unit</th>
<th>Standard Permissible Limit (S&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Relative Weight W&lt;sub&gt;i&lt;/sub&gt; = V&lt;sub&gt;n&lt;/sub&gt;/S&lt;sub&gt;i&lt;/sub&gt;</th>
<th>Quality Rating Q&lt;sub&gt;i&lt;/sub&gt; = 100(V&lt;sub&gt;n&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)/(S&lt;sub&gt;i&lt;/sub&gt;-V&lt;sub&gt;i&lt;/sub&gt;)</th>
<th>Weighted Value W&lt;sub&gt;i&lt;/sub&gt;Q&lt;sub&gt;i&lt;/sub&gt;</th>
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\[ \sum W_n = 4.3266 \sum W_n \times Q_n = 873.68 \]

\[ WQI = \sum W_n \times Q_n + \sum W_n \]

\[ WQI = 873.68 + 4.3266 = 201.933 \]

**W.Q.I. at station H**

**Table 10 Calculation of Water Quality Index at station H**

\[ \sum W_n = 4.3266 \sum W_n \times Q_n = 711.16 \]

\[ WQI = \sum W_n \times Q_n + \sum W_n \]

\[ WQI = 711.16 + 4.3266 = 164.37 \]
Conclusion

Water quality index of the river was found satisfactory before inclusion of waste water from sugar industry but after mixing of the waste water the quality of water decreases the course of river and it were not suitable for drinking and irrigation purpose. Most of the water quality index have higher values than the standard values given by Bureau Indian Standard as well as World Health Organization guidelines. Some positive steps should be taken by local authority to improve the water quality of river. Local public should be aware about the water pollution and adopt preventive measures for controlling the river and ground water pollution.

References