Physico-chemical and microbiological quality evaluation of groundwater for human domestic consumption in adjoining area of Omti Nallah, Jabalpur (M. P.), India

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ABSTRACT

Groundwater is one of the most useful water sources. Contamination of such water sources is a big problem creating health hazards. The sewage water from Omti nallah plays a vital role in contaminating the groundwater quality in Jabalpur city, M.P., India. Hence the present study was undertaken to characterize nature (parameters) of groundwater in Jabalpur city, by taking water samples from six different stations locating near to the Omti nallah area. Evaluation of physico-chemical and microbiological parameters of water samples was carried out during March – April 2011. To assess the quality of groundwater, each parameter was compared with the standard desirable limit of that parameter in drinking water as prescribed by BIS 10500-91. The comparison of different parameters spatially showed an increasing pattern of alkalinity, total dissolved solids, total hardness, calcium, fluoride and fecal coliform concentrations and decreasing concentration of dissolved oxygen in the groundwater. It is necessary to apply strong preventions immediately to save groundwater from deterioration in the area around Omti nallah in Jabalpur city.

Keywords: Groundwater, pollution, Omti nallah, sewage water, health hazard, Jabalpur city.

1. Introduction

People around the world have used groundwater as a source of drinking water, and even today more than half the world’s population depends on groundwater for survival (UNESCO, 1992). The value of groundwater lies not only in its wide spread occurrence and availability but also in its consistent good quality, which makes it an ideal supply of drinking water (UNESCO, 2000). Intensive use of natural resources and the large production of wastes in modern society often pose a threat to groundwater quality and have already resulted in many incidents of groundwater contaminations. Industrial waste, agricultural and domestic wastes, land use practices, geological formation which is subjected to reaction with percolating rainwater, reaches the aquifer system and contaminates the groundwater. Consequently number of cases of waterborne diseases has been seen which is the cause of health hazards. Therefore, a continuous periodical monitoring of groundwater quality is necessary so that appropriate steps may be taken for groundwater resource management practices.

In Jabalpur city, urbanization has major impact on groundwater environment. Household sewage and garbage discharge in open drainage or nallah is a common practice in all over the city. The sewage discharge from residential and commercial units into Omti nallah greatly distress the groundwater quality of the surrounding areas. Hence the areas around the Omti
nallah were selected to study the effect of sanitary conditions on groundwater quality. The social relevance of the problem has encouraged us in carrying out this work.

2. Materials and method

2.1 Study area

Jabalpur district is a district of Madhya Pradesh state in Central India. Geographically, the city is located at 23°10' North latitude and 79°57' East longitude. Jabalpur city is spread in about 5,211 sq. km with population of 2,460,714. Omti nallah is one of the main drain for water drainage from the city flows through the heart of Jabalpur city, discharges into Pariayat river which ultimately merges with Hiran river a tributary of river Narmada. Thus the entire defilement from the household and agricultural wash-off from the Jabalpur city goes to river Narmada. The natural slope of the nallah is approximately 1:20 and is suitable for lining with suitable falls. The calculated discharge at chainage 12,510 meters is 328.74 cumecs with a velocity of 3.18 m/sec. The catchments area of this nallah is approximately 44.75 sq. km. 60% of the town population habitation area is having slopes and drains towards Omti nallah. Along the drain, settlements have arisen with people depending on drain water for agricultural practices and on groundwater resources for their household water supply.

2.2 Collection of water samples

The groundwater samples were collected from the hand pump of various locations in plastic canes of one liter capacity as per standard procedure (APHA, 1989). Water samples from six sampling locations around the Omti nallah were selected at random as given in table -1, during March – April 2011.
Table 1: Showing sampling locations

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Sampling Locations</th>
<th>Types of Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Barau Mohalla</td>
<td>(A) Residential area</td>
</tr>
<tr>
<td>2</td>
<td>Ghamapur</td>
<td>(B) Residential area</td>
</tr>
<tr>
<td>3</td>
<td>Madan Mahal</td>
<td>(C) Residential area</td>
</tr>
<tr>
<td>4</td>
<td>Garha</td>
<td>(D) Residential area</td>
</tr>
<tr>
<td>5</td>
<td>Bilkhirwa</td>
<td>(E) Agricultural area</td>
</tr>
<tr>
<td>6</td>
<td>Raiyakheda</td>
<td>(F) Agricultural area</td>
</tr>
</tbody>
</table>

2.3 Analysis of water samples

Analysis was carried out for various physico-chemical and microbiological water quality parameters such as pH, electrical conductivity, total dissolved solids, turbidity, dissolved oxygen, total alkalinity, total hardness, calcium, magnesium, chloride, sulphate, phosphate, nitrate, fluoride, iron and fecal coliforms as per standard methods(APHA (1989), Trivedy et al., 1986). The quality of groundwater has been assessed by comparing each parameter with the standard desirable limit of that parameter in drinking water as prescribed by ISI 10500-91.

3. Results and discussion

The results of the physicochemical and microbiological parameters for water samples are presented in Table 2.

pH

pH is a term used universally to express the intensity of the acid or alkaline condition of a solution. The pH value of water samples varied between 7.6 to 8.6. It is observed that almost all the water samples have pH value within the permissible limit prescribed by Bureau of Indian Standard except at sampling location E.

Electrical Conductivity (EC)

Electrical conductivity is a measure of water capacity to convey electric current. It signifies the amount of total dissolved salts (UNESCO, 2000). EC values were in the range of 750 µmhos/cm to 1460 µmhos/cm. High EC values were observed for two sampling locations viz, sampling station C (1420 µmhos/cm) and sampling station D (1460 µmhos/cm) indicating the presence of high amount of dissolved inorganic substances in ionized form.

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is the amount of dissolved substances in water. The TDS of the water samples ranged from 394 mg/l to 830 mg/l. The values of TDS of 50% water samples were within the permissible limit prescribed by ISI 10500-91. TDS concentration beyond 500 mg/l, decreases palatability and may cause gastrointestinal irritation and constipation effects (Maiti, 2001).

Turbidity
In most waters, turbidity is due to colloidal and extremely fine dispersions. The turbidity of water samples ranged between 1.5 to 3.5 NTU. The turbidity values of all the water samples of selected places were under permissible limit prescribed by BIS.

**Dissolved Oxygen (DO)**

Dissolved oxygen is important parameter in water quality assessment; it reflects the physical and biological processes prevailing in the water. The DO values indicate the degree of pollution in water bodies (Balamurugan et al., 2012). In present study the DO values of different water samples ranged between 3.1 to 4.7 mg/l. All the samples showed low DO values, indicating the contamination by organic matter, which might be occurred due to the seepage of Omti nallah.

### Table 2: Showing results of the physico-chemical analysis of groundwater

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Sampling Points</th>
<th>ISI 10500-91 Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>TA</td>
<td>540</td>
<td>620</td>
</tr>
<tr>
<td>EC</td>
<td>1310</td>
<td>876</td>
</tr>
<tr>
<td>Turb</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>TDS</td>
<td>762</td>
<td>465</td>
</tr>
<tr>
<td>Cl</td>
<td>50.4</td>
<td>98.1</td>
</tr>
<tr>
<td>TH</td>
<td>229</td>
<td>376</td>
</tr>
<tr>
<td>Ca</td>
<td>62.9</td>
<td>129.5</td>
</tr>
<tr>
<td>Mg</td>
<td>17.4</td>
<td>12.7</td>
</tr>
<tr>
<td>DO</td>
<td>4.3</td>
<td>4.1</td>
</tr>
<tr>
<td>SO4</td>
<td>69</td>
<td>156</td>
</tr>
<tr>
<td>PO4</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td>NO3</td>
<td>20</td>
<td>16.8</td>
</tr>
<tr>
<td>F</td>
<td>1.69</td>
<td>1.54</td>
</tr>
<tr>
<td>Fe</td>
<td>0.075</td>
<td>0.081</td>
</tr>
<tr>
<td>FC</td>
<td>0</td>
<td>84</td>
</tr>
</tbody>
</table>

(All parameters are in mg/l except pH, EC, Turbidity and FC. EC in µmhos / cm, Turbidity in NTU and FC in CFU/100 ml)

**Total Alkalinity (TA)**

Alkalinity of water is its capacity to neutralize a strong acid and it is normally due to the presence of bicarbonate, carbonate and hydroxide compound of calcium, sodium and potassium (Pandey et al., 2012). The values of alkalinity of water samples varied from 350 to 620 mg/l. Total alkalinity values for the investigated samples were found to be greater than the value prescribed by BIS. The high alkalinity in groundwater samples might be due to the seepage of more alkaline sewage from Omti nallah. Seepage of domestic waste water present in nallah is source of organic matter. Decomposition of organic matter by microbes leads to formation of CO$_2$ in water, which increases the concentration of carbonate and bicarbonate, increasing the level of alkalinity in groundwater (Vyas et al. 2008).

**Total Hardness (THI)**
Hardness of water mainly depends upon the amount of calcium or magnesium salts or both (Rao, 2011). The hardness values of water samples ranged from 229 to 560 mg/l. The higher amount of total hardness in these sampling stations may be due to the groundwater receiving Ca and Mg rich minerals leached from the rocks or seepage of domestic sewage (Bhatnagar, 1999).

**Calcium and Magnesium (Ca, Mg)**

Calcium and magnesium are directly related to hardness (Devi et al., 2012). Calcium values of water samples were found in the range of 62.9 to 163.9 mg/l. The values of calcium of 67% samples were beyond the permissible limit. The higher values of Ca in these areas might be due to the availability of limestone or leaching of calcium from weathered granite. Magnesium content in the investigated water samples was ranged from 17.4 to 36.7 mg/l, which were found within the prescribed limit of BIS, except in sampling stations D and E. At high concentrations, magnesium salts have a laxative effect particularly when present as magnesium sulphate (Karunakaran et al. 2009).

**Chloride (Cl)**

The chloride concentration serves as an indicator of pollution by sewage (Balamuruganet al., 2012). People accustomed to higher chloride in water are subjected to laxative effects (UNESCO, 2000). In the present analysis, chloride concentration in the water samples was found in the range of 50.4 to 212.6 mg/l. All the values are below than the permissible limit of BIS.

**Nitrate (NO\textsubscript{3})**

The nitrate content in the groundwater of study area varied in the range of 16.8 to 50 mg/l. The data revealed that 33% of the water samples under study have higher values of nitrate than that of prescribed limit of BIS. In excessive amounts, nitrate may cause methemoglobinemia in infants, a disease characterized by blood changes (Manivaskam, 2005).

**Sulphate (SO\textsubscript{4})**

Sulphate in groundwater is obtained principally from gypsum and anhydrite (Sacks, 1996). Discharge of industrial wastes and domestic sewage tends to increase its concentration. The values of sulphate in the water samples varied from 45 to 156 mg/l. All the samples were far below than the permissible limit of 200 mg/l.

**Phosphate (PO\textsubscript{4})**

Phosphate occurs in groundwater as a result of domestic sewage, detergents, agricultural effluent with fertilizers and industrial waste water (Patil et al. 2011). The phosphate content in the groundwater samples of study was found in the range of 0.04 to 0.46 mg/l. There is no prescribed limit of phosphate in BIS.

**Fluoride (F)**
Small concentration of fluoride in drinking water has beneficial effect on human health for preventing dental carries. Higher concentration of fluoride than that of 1.5 mg/l carry an increasing risk of dental fluorosis and much higher concentration lead to skeletal fluorosis (Vyas et al. 2008). Fluoride content of groundwater samples of the study area ranges from 0.99 to 2.24 mg/l. It was observed that 83% of water samples have higher values of fluoride. The present study area contains Granite rock having two minerals namely apatite \((\text{Ca}_5(\text{PO}_4)_3(\text{F, OH, Cl})\) and tourmaline \((\text{Na}, \text{Mg, Fe}^{2+}, \text{Mn}, \text{Li} \text{Al}_3 \text{Al}_6(\text{BO}_3)_3[\text{Si}_6\text{O}_{18}] (\text{OH, F, }\text{Fe}^{3+})\) which contain fluorite, so it is certain that the leaching of fluoride through these minerals and entering into the groundwater of the study area.

**Iron (Fe)**

Iron is considered as essential micronutrient. Long term consumption of drinking water with high concentration of iron may leads to liver diseases (Gyamfi et al. 2012). The iron concentration was recorded in water samples in between 0.063 to 0.19 mg/l, which is under the prescribed limit of BIS.

**Fecal Coliform (FC)**

Coliform bacteria are considered as “indicator organisms”, their presence in water may indicate contamination of water by fecal waste, that may contain other bacteria, viruses parasites or disease causing organisms. The results of analysis indicated that the values of fecal coliform ranged between 0 CFU/100 ml to 84 CFU/100 ml. BIS standards suggest that fecal coliform must not present in drinking water. It was observed that the fecal coliform present in 50% of water samples. High incidence of fecal coliform in these areas was indicative of increasing pollution of the groundwater by organic means. Leaching of urban wastewater along with human or animal fecal matter from Omthi nallah into groundwater can be potential source of groundwater contamination.

4. Conclusion

In this study it was found that some physico-chemical and microbiological parameters determined from groundwater were above the limits set by BIS. The comparison of different parameters spatially showed an increasing pattern of Alkalinity, TDS, TH, Ca, F and fecal coliform concentrations and decreasing concentration of DO in the groundwater near Omthi nallah area in Jabalpur city. The people living in these areas are therefore at higher potential risk of contracting water-borne and/or sanitation related diseases. The existence of indicator organism demonstrates that there may be pathogenic bacteria present so that it is necessary to disinfect the groundwater before human use. In conclusion, it is necessary to apply strong preventions immediately to save groundwater from deterioration in the area around Omthi nallah in Jabalpur city.

5. References


