Irrigation groundwater quality based on hydrochemical analysis of Nandgaon block, Nashik district in Maharashtra

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Abstract

To identify the sources and quality of groundwater, the water samples were collected from 52 dug wells irrigation water in an area of 1089.82km2 and were analyses for pH, Conductivity, total dissolved solids, Calcium, Magnesium, Sodium, potassium, total hardness, Alkalinity (CO32-, HCO3-), sulphate, chloride, nitrate and fluoride to understand the (irrigation water quality index ) IWQI. The secondary parameters of irrigation groundwater quality indices such as Sodium adsorption ratio (SAR), Residual sodium carbonate (RSC), Kelley’s ratio (KR), Sodium soluble percent (SSP), Permeability index (PI),Magnesium adsorption ratio (MAR),and CRI (Corrosively ratio index) were calculated from the primary parameter for irrigation water quality index (IWQI). The IWQI was classified into excellent to unfit condition of groundwater quality based on their Water Quality Index (WQI). The IWQI (88%-12%) indicate that slightly unsustainable to good quality of ground water. But due to this quality deterioration of shallow aquifer, an immediate attestation requires for sustainable development.

Keywords: Groundwater Quality; Irrigation Water Quality Indices; Nandgaon Block.

1. Introduction

India is a vast country with a highly diversified hydrogeologic set-up. The ground water behavior in the Indian sub-continent is highly complicated due to the occurrence of diversified geological formations with considerable lithological and chrononological variations, complex tectonic framework, climatologically dissimilarities and various hydrochemical conditions. Quality of water is assuming great importance with the rising pressure on agriculture and rise in standard of living (Wijnen, 2012; Wani et al, 2014; Aher et al, 2015). Groundwater is a vital natural resource for the reliable and economic provision of potable water supply in both the urban and rural environment. It thus plays a fundamental role in human well-being, as well as that of some aquatic and terrestrial ecosystems. In the background of preserving this most important natural asset, water utility management is the key area that managers need to focus upon. Fresh and clean water is of fundamental importance to the survival, protection and development of human needs, as well as for the conservation of the environment. The movement of groundwater is controlled by physical and geochemical properties of (i) contaminant (ii) the groundwater and (iii) the geological system through which the contaminated groundwater is flowing. Presence of some substances beyond certain limits may make it unsuitable for irrigation, domestic or industrial uses (Purushotham et al, 2011). Groundwater quality is as important as the quantity. Poor quality of water adversely affects the plant growth and human health (US Salinity Laboratory Staff 1954). Adverse conditions increase investment in irrigation and health, and decrease agricultural production, which, in turn, reduces agrarian economy and retards improvement in the living conditions of rural people. A number of studies on groundwater quality with respect to drinking and irrigation purposes have been carried out in the different parts of the country (Datta, and Tyagi, 1996; Kaply, et. al,1998; Pawar, et. al., 1998; Subba Rao, et al. 1991; Tatakut & Chandel, 2008; Deshpande and Aher, 2009; Vijay, et.al. 2010; Anbazhagan & Balamurgan, 2014; Rao & Rao,2015).

In recent times, there has been a tremendous increase in demand for fresh water due to population growth and intense agricultural activities. The hydrogeologic factors controlling recharge and hydrogeochemical reactions are so important for the chemical constituents to reach the groundwater uses (Raju, 2007). Quality of water is an important consideration in any appraisal of salinity or alkali conditions in an irrigated area. All irrigation water contains some salts, but the concentration and nature of salts vary. The quality of irrigation water depends primarily on the total amount of salt present and the proportion of Na+ to other cations and certain other parameters (Shashi Kant, et al, 2015). Rajankar et al. (2009) calculated WQI for different groundwater sources, viz., dug wells, bore wells, and tube wells at Khaperkheda Region, Maharashtra. The problems of water quality are more acute in areas that are densely populated thickly industrialized and have shallow water set (Gowd, 2005). Keeping view above facts, present study is undertaken to assess the shallow groundwater quality of Nandgaon block in Nashik district, Maharashtra for irrigation purposes through different ground water quality indices and generate WQI.

2. Physiography and climate of the study area

The study area forms part of Western Ghat and Deccan Plateau covering an area of 1089.82km2. Physiographically comprises varied topography. The main system of hills is Sahayadri and its...
Water quality secondary parameters name SAR, RSC, SSP; KR MAR, CR and PI were analyzed for IWQI. The statistical analysis of various quality parameters IWQI was classified into excellent to unfit condition of groundwater quality based on their Water Quality Index (WQI). Based on their severity of WQI it can be further classified into good to poor state of groundwater quality for sustainable development.

4. Irrigation water quality indices (IWQI)

The various irrigation water quality indices were derived from the primary parameter of drinking water quality. Groundwater utilized for irrigation is an essential aspect in productivity of crop, its yield and quality of irrigated crops. The quality of irrigation groundwater depends mostly on the occurrence of dissolved salts and their concentrations. Sodium adsorption ratio (SAR) and residual sodium carbonate (RSC) are also influencing the water quality for irrigation purposes (Ayers and Westcot, 1985). The various irrigation water quality indices were derived from the primary parameter of drinking water quality (Table 2).

4.1. Electrical conductivity

It was a measurement of all soluble salts in samples, the most significant water quality standard on crop productivity which was the water salinity hazard. The primary effect of high EC water on crop productivity was the failure of the plant to compete with ions in the soil solution for water. The higher the EC, the lesser the water available to plants, even though the soil may show wet, because plants can only transpire “pure” water; usable plant water in the soil solution decreases significantly as EC increases. The amount of water transpired through a crop was directly related to yield; therefore, irrigation water with high EC reduces yield potential. In the study area, the classification for EC is given (Handa, 1969, Reddy, 2013) in Table 3. It indicated that overall the water quality was medium to high EC category except one sample showing very high EC.

3. Methods of investigation

Fifty two groundwater samples from different villages of the study area were collected during pre-monsoon season and analyzed for major parameters (Table1). In the present study, samples were collected in pre cleaned polyethylene containers of one litre capacity. The samples were collected from those wells only which are extensively used for drinking and irrigational purposes. Field samples were analyzed immediately (APHA, 1992) for hydrogen ion concentration (pH) and electrical conductivity (EC), using pH and EC meters. Total dissolved solids (TDS) were computed by using the formula 0.64 + EC. Total hardness (TH) as CaCO3 and calcium (Ca) were analyzed titrimetrically, using standard EDTA. Magnesium (Mg) was calculated by taking the differential value between TH and Ca concentrations. Total alkalinity (TA) as CaCO3, bicarbonate (HCO3) were estimated by titrating with HCl. Chloride (Cl) was determined titrimetrically by standard AgNO3 titration, sodium (Na) and potassium (K) were determined by using flame photometer. Sulfate measured by BaCl2 method using spectrophotometer. Nitrate was estimated by using an ion selective electrode. The results of analysis are tabulated in Table 1.
4.5. Permeability index (PI)

Doneen (1964) to be had water appropriateness classification for irrigation reason base on the permeability index (PI). Permeability index is calculated by using the formula; (PI=Na+/HCO3/Ca+Mg+Na×100). Where, all the values are in meq-l. The PI value of the groundwater ranges from 32.10 to 95.18 with an average values 63.18. The PI values >75 indicate excellent quality of water for irrigation. If the PI values fall in between 25 and 75, they indicate good quality of water for irrigation. However, if the PI values are <25, they reflect unsuitable nature of water for irrigation. On the basis of US salinity diagram and Doneen’s chart the groundwater in the study area is in general suitable for irrigation purposes (Table 2).

4.6. Kelly’s ratio (KR)

The Kellys Ratio (Kelly, 1963) values of the study area ranged between 0.09 to 2.66 (Table, 2). These indicate that Most of the KR for the groundwater samples (83%) however fall within the permissible limit of 1.0 and are considered suitable for irrigation purposes.
4.7. Corrosively ratio index (CRI)

The magnitude of the corrosiveness of water can be assessed by using a perimeter known as corrosivity ratio Index (CRI), the water having the corrosivity ratio less than one is safe and non-corrosive. Corrosivity ratio greater than two is suggestive of corrosiveness. The corrosively ratio index (CRI) values ranged from 0.03 to 0.25 meq L⁻¹ (Table 2), indicating groundwater is safe and suitable and less corrosive and hence can be used for domestic or industrial purposes.

4.8. Magnesium adsorption ratio (MAR)

Magnesium content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. Generally, calcium and magnesium maintain a state of equilibrium in most waters. More magnesium in water will adversely affect crop yields as the soils become more saline (Joshi et al., 2009; Obiefuna, & Sheriff, 2011). The values of the magnesium adsorption ratio of groundwater in present study vary from 18.79 to 89.43 (Table 2). The acceptable limit of MAR is 50. High MAR affects the soil unfavorably and harmful effect on soils appears when MAR exceeds 50. The waters are therefore, considered suitable (73%) and unsuitable (27%).

An attempt has been made to develop a model on Irrigation Water Quality Index (IWQI). The various irrigation water quality indices such as SAR, SSP, RSC, PI, and KR were considered to assess the ground water quality for irrigation. The indices value summed, then classified into excellent to unfit groundwater quality (Table 4). The output has shown only 88% of water slightly unsustainable for irrigation, whereas some parts of the area (12%) good quality good found in water sample.

<table>
<thead>
<tr>
<th>Water value range (mg/L)</th>
<th>Water quality</th>
<th>No. of Samples (IWQI)</th>
<th>% Sustainable state</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;50</td>
<td>Excellent</td>
<td>0</td>
<td>Sustainable</td>
</tr>
<tr>
<td>51-100</td>
<td>Good</td>
<td>6</td>
<td>Sustainable</td>
</tr>
<tr>
<td>101-200</td>
<td>Poor</td>
<td>46</td>
<td>Slightly Unsustainable</td>
</tr>
<tr>
<td>201-300</td>
<td>Very poor</td>
<td>0</td>
<td>Unsustainable</td>
</tr>
<tr>
<td>&gt;301</td>
<td>Very bad</td>
<td>0</td>
<td>Highly Sustainable</td>
</tr>
</tbody>
</table>

5. Conclusion

The present study may help to improve groundwater resource assessment management, achieves social, economic and environmental benefits to support governance and policy. The results have shown that the ground water of study area has been in good in IWQI and maximum samples (88%) fall under slightly unsustainable for irrigation. This study can offer the requisite information for the authority to pursue the sustainable approaches on groundwater management and contamination prevention. As the poor quality of irrigation groundwater of restricted for choice of the crops and only defiant crops can grow up successfully. Therefore, it is sturdily desired to improved irrigation practices and develops resistant varieties of crop that can grow without any yield slaughter.

Acknowledgement

The authors thankful to Director, Groundwater Survey and Development Agency, Pune to providing necessary facility for conducting this research work and granting permission to publish the paper.

References


