Research Article

# Hydrogeochemical Assessment of Groundwater Quality in Parts of Phulambri Block, Aurangabad, INDIA

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**Abstract** Detailed hydrogeochemical analysis of twentytwo samples of groundwater collected from parts of Phulambri block of Aurangabad district, has been carried out in an effort to assess the quality of groundwater in the area. These samples were analysed for pH, EC, TDS, TH, Ca, Mg, Na, K, Total Alkalinity, Cl NO3 and SO4. The suitability of the water from the groundwater sources for drinking purposes was evaluated by comparing the values of different water quality parameters with Bureau of Indian Standards and World Health Organization guideline values. The result of the analysis shows that the Water chemistry of Phulambri block is deteriorated at some places. The Suitability of groundwater for irrigation was determined by analyzing sodium adsorption ratio (SAR), Kelly's ratio (KR), Sodium percentage (Na%), Magnesium Ratio (MR) and study reveals that most of the samples of the study area falls below the permissible limit indicating groundwater is suitable for irrigation purpose. The geochemical characteristics of the groundwater's are impeded by natural geology and anthropogenic activities, and a proper groundwater management strategy is necessary to protect sustainably this valuable resource.

**Keywords:** Groundwater quality, Phulambri block, Irrigation purpose, Maharashtra, India.

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## INTRODUCTION

Groundwater is a vital natural resource, which is most important ingredient in multifarious facets of human civilization. It is an essential constituent of all animal and vegetable matters and inseparable commodity of animal and plant lives. 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 (Purushtotham et.al, 2011). Groundwater hydrogeochemistry is mainly affected by the geological formations that the water passes through during its course and by anthropogenic activities (Kelepertsis 2000; Siegel 2002; Stamatis *et al.* 2001; Sullivan *et al.* 2005; Konstantinos Skordas *et al,*2012, Aher and Deshpande, 2014 ). 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; Pawar N.J. et. al 1998; Subba Rao *et al*. 1991; Tatawat and Chandel 2008; Deshpande and Aher 2011; Vijay Ritesh and et.al. 2011), Twenty two groundwater samples are selected for the present study.

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**Physiography and Climate of the study area**

The study area forms part of Deccan Plateau. Physiographically comprises varied topography. The main system of hills is Sahayadri and its offshoots. The climate is characterized by a hot summer and a general dryness throughout the year except during the south west monsoon season, which is from June to September while October and November constitute the postmonsoon season. The winter season commences towards the end of November when temperatures begin to fall rapidly. December is the coldest month with the mean maximum temperature of 28.9° C, while the mean minimum temperature is 10.3°C. From the beginning of March, the daily temperature increases continuously. May is the hottest month with the mean maximum temperature of 39.8°C and the mean minimum temperature of 24.6° C. With the onset of the south-west monsoon by about the second week of June, the temperature falls appreciably.

**Geology and Hydrogeology**

The entire study area is underlain by the basaltic lava flows of upper Cretaceous to lower Eocene age. These flows are normally horizontally disposed over a wide stretch and give rise to table land type of topography also known a plateau. These flows occur in layered sequences and represented by massive unit at the bottom and vesicular unit at the top of the flow. The shallow alluvial formation of recent age also occurs as narrow stretch along the banks of Girja Rivers flowing in the area. The ground water in Deccan Trap Basalt occurs mostly in the upper weathered and fractured parts down to 15-20 m depth. At places potential zones are encountered at deeper levels in the form of fractures and inter-flow zones. The soils are the weathering products of Basalt and have various shades from gray to black, red and pink color (CGWB 2010).

## METHODS OF INVESTIGATION

Twentytwo groundwater samples from different villages of the study area were collected and analysed 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 $0.64 \times EC$. Total hardness (TH) as $CaCO_3$ 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 $CaCO_3$, bicarbonate ($HCO_3$) were estimated by titrating with HCl. Chloride (Cl) was determined titrimetrically by standard $AgNO_3$ titration.

## RESULT AND DISCUSSION

**Groundwater quality for domestic purpose**

The suitability of ground water for domestic purpose was determined keeping in view the effects of various chemical constituents in water on the biological system of human being. Understanding the quality of groundwater is important as its quality because it is the main factor determining its suitability for domestic, drinking, agricultural and industrial purposes. Physico-chemical characterization of the groundwater samples is given in Table 1 and table 2 shows the quality of groundwater of Phulambri block of Aurangabad.

**pH**

The relative concentration of hydrogen ion in water indicates its acidic or alkaline nature. The pH values in the ground water samples of study area was within the range of 7 to 8, the pH values of all samples are well within the limits prescribed by BIS (1991) and WHO (1996) indicates suitable for domestic and irrigation purposes.

**Electrical conductivity (EC)**

Electrical Conductivity measures the degree of salinity in water, which greatly affects the taste and thus has a significant impact on the user's acceptance of water (Langeneggar, 1990). The conductivity values in the ground water samples of study area vary from 219 to 1821 μS/cm (Table1)

**Total dissolved solids (TDS)**

In natural waters, dissolved solids consists mainly of inorganic salts such as carbonates, bicarbonates, Chlorides, sulphates, phosphates, and nitrates of calcium, magnesium, sodium, potassium, iron, etc., and a small amount of organic matter and dissolved gases. In the present study, the values of total dissolved solids (TDS) in the ground water vary from 190 to 1184 mg/L with mean of 541 m/L (Table 1). About 55% of the samples were found within the desirable limit of 500 mg/L while about 45% of the samples were found above the desirable limit but well within the maximum permissible limit of 2,000 mg/l (Table 2).

**Table 2:** Quality of groundwater of Phulambri Block, Aurangabad District

| Parameter | <DL% | >DL<MPL% | >MPL% |
|---|---|---|---|
| TDS | 55 | 45 | - |
| Ca | 77 | 23 | - |
| Mg | 41 | 59 | - |
| Total Hardness | 59 | 32 | - |
| Cl | 100 | - | - |
| SO4 | 100 | - | - |
| NO3 | 64 | - | 36 |

**Calcium (Ca)**

The presence of calcium in drinking water is natural geological source, industrial waste, mining by products and agricultural wastes. The desirable limits for calcium for drinking water are 75 (BIS 1991). In ground water of the study area, the value of calcium ranges from 17 to 148 mg/L (Table 1). About 77% of the samples of the study area fall within the desirable limit of 75 mg/L for calcium the remaining 23% of the samples exceed the desirable limit but are well within the permissible limits 200 mg/L prescribed for drinking water (Table 2).

**Magnesium (Mg)**

The principal sources of magnesium in the natural waters are various kinds of rocks, sewage and industrial wastes. Magnesium concentration in the groundwater samples of study area ranges from 14 to 62 mg/L, with mean value of 33 mg/L (Table 1). The desirable limits limit for this parameter in drinking 30 mg/l and 100 mg/l is maximum permissible limit). About 41% of the samples of the study area fall within the desirable limit of 30 mg/L for calcium the remaining 59% of the samples exceed the desirable limit but are well within the permissible limits 100 mg/L prescribed for drinking water (Table 2).

**Total Hardness (TH)**

Hardness may be considered a physical and chemical parameter of water. It represents the total concentration of Calcium and magnesium ions, reported as calcium carbonates. The total hardness values in the study area ranges from 119 to 643 mg/L (Table 1). A limit of 300 mg/L has been recommended for potable water. As evident from the results, about 59% of the samples fall within the desirable limit of 300 mg/L. The remaining 32% of the samples exceeds the desirable limit of 300 mg/l but is well within the maximum permissible limit of 600 mg/l (BIS 1991) (table 2).

**Chlorides (Cl)**

Chlorides are compounds of chlorine. They remain soluble in water, unaffected by biological processes, therefore, reducible by dilution. The chloride content in ground water of the study area varies from 33 to 211 mg/L (Table 1). All samples are with the permissible limit (BIS 1991; WHO 1996) (Table 2).

**Alkalinity**

Alkalinity is the measure of the capacity of the water to neutralize a strong acid. From the potability viewpoint, alkalinity is not a significant parameter. The Alkalinity in the water is generally imparted by the salts of carbonates, silicates, etc. together with the hydroxyl ions in Free State (Trivedi and Goyal, 1986).The bicarbonate alkalinity of the study area varies from 94 to 490 mg/L, indicating that all samples are within the limit.

**Sodium and Potassium (Na and K)**

Sodium (Na) and Potassium (K) are present in a number of minerals. The increasing pollution of groundwater has resulted in a substantial increase in the sodium content of drinking water. Sodium (Na) values of the study area ranges from 17 to 114 mg/L (Table 1). Potassium is an essential element for humans, plants and animals, and derived in food chain mainly from vegetation and soil. The main sources of potassium in ground water include rain water, weathering of potash silicate minerals, use of potash fertilizers and use of surface water for irrigation. The European Economic Community (EEC 1980) has prescribed the guideline level of potassium at 10 mg/L in drinking water. As per EEC criteria, Except one all the samples of the study area fall within the guideline level of 10 mg/L (Table 1).

**Sulphate ($SO_4$)**

The sulphate content in ground water generally occurs as soluble salts of calcium, magnesium, and sodium. Sulphate ($SO_4$) content in groundwater is made possible through oxidation, precipitation, solution and concentration, as the water traverses through rocks. The sources of sulphate in rocks are sulphur minerals, sulphides of heavy metals which are of common occurrence in the igneous and metamorphic rocks. The concentration of sulphate in the study area varies from 12 to 110 mg/L. No sample of the study area exceeds the maximum permissible limit prescribed for sulfate (BIS 1991).

**Nitrate ($NO_3$)**

The nitrate ($NO_3^-$) in the study area varies from 10 mg/L to 66 mg/L with an average of 32mg/L. (Table1) and 64% of the samples are within the permissible limit of 45 mg/L and 36% of the samples exceeded the permissible limit prescribed by BIS (1991) and WHO (1996). The concentration of $NO_3^-$ is due to the influences of poor sanitary conditions, decaying organic matter, sewage and fertilizer from agricultural runoff (Subba Rao *et al*, 2011; Karnath 1987). Nitrogen in groundwater is mainly derived from organic industrial effluents, fertilizer or nitrogen fixing bacteria, leaching of animal dung, sewage and septic tanks through soil and water matrix to groundwater (Richard, 1954). Higher concentration of $NO_3^-$ can cause blue baby syndrome called methemoglobinemia, gastric cancer, goiter, birth malformation and hypertension (Bouwer 1978).

**Groundwater quality for Irrigation purpose**

The water used for irrigation is an important factor in productivity of crop, its yield and quality of irrigated crops. The continuous use of poor quality water without drainage and soil management may lead to saline and sodic soil, particularly in clayey soils.The quality of irrigation water depends primarily on the presence of dissolved salts and their concentrations.

**Sodium Absorption Ratio (SAR)**

Sodium Absorption Ratio (SAR) is an expression pertaining to cation make up of water and soil solution and is used for characterizing the sodium hazard of irrigation water. SAR value is used to calculate the degree to which irrigation water tends to enter into cation exchange section in the soil. The main problem with high sodium concentration is its effect on soil permeability. Sodium also contributes directly to the total salinity of the water and may be toxic to sensitive crops such as fruit trees. The higher value of SAR indicates soil structure damage. The sodium adsorption ratio values for each water sample were calculated by using following equation (Richard, 1954)

SAR = [Na] / {([Ca] + [Mg]) / 2}1/2

Where all ionic concentrations are expressed in milliequivalents per liter. Sodium adsorption ratios for groundwater samples of the study area in pre and post-monsoon season are less than 10 indicate excellent quality for irrigation and 21 samples fall in excellent (S1) category and one sample fall in good category (Table 3).

**Kelly's Ratio (KR)**

Sodium measured against Ca and Mg is used to calculate Kelley's ratio. (Kelley 1940, Paliwal 1967). The formula used in the estimation of Kelley's ratio is expressed as (KR) = (Na/Ca+Mg). A Kelley's Ratio (KR) of more than one indicates an excess level of sodium in waters. Hence, waters with a Kelley's Ratio less than one are suitable for irrigation, while those with a ratio more than one are unsuitable for irrigation. Kelley's Ratio (KR) of the groundwater samples of the study area varies from 0.33 to 0.73 indicating that groundwater is suitable for irrigation.

**Table 3:** Classification of groundwater on the basis of SAR, KR, % Na and MR

| Parameter | Range | Water Class | Samples |
|---|---|---|---|
| SAR | < 10 | Excellent (S1) | |
| | 10–18 | Good (S2) | 21 |
| | 18–26 | Doubtful (S3) | 1 |
| | > 26 | Unsuitable (S4) | |
| KR | <1 | Suitable | All |
| | >1 | Unsuitable | |
| % Na | < 60 | Safe water | All |
| | > 60 | Unsafe | |
| MR | <50 | Suitable | 21 |
| | >50 | Unsuitable | 1 |

**Percent Sodium (%Na)**

The % Na is widely used for evaluating the suitability of water quality for irrigation (Wilcox,1955). It is defined by the expression: % Na= Na+K/(Ca+Mg+Na+K)x100. High % Na in irrigation water causes exchange of sodium in water, and exchange of calcium and magnesium contents in soil having poor internal drainage. The % Na in the study area ranges from 26.47 to 42.80 meq/L. The % Na < 60 represents safe water while it is unsafe if > 60 (Eaton,1950). As per this criterion the water from study area is safe for irrigation purpose.

**Magnesium Ratio (MR)**

Magnesium ratio (MR) is calculated as MR= (Mgx100)/(Ca+Mg). The MR values <50 are suitable for the irrigation and MR values >50 are unsuitable. Excess amount of magnesium can affect the quality of soil and reduces the yield of crops. Except one all samples are suitable for irrigation.

## CONCLUSIONS

Hydro chemical parameters of the study area are compared with BIS (1991) and WHO (1996) shows that groundwater of the study area is deteriorated at some places due to Nitrate and proper groundwater management strategies are necessary to protect sustainably this valuable resource. The Suitability of groundwater for irrigation with sodium adsorption ratio (SAR), Kelly's ratio (KR), percent Sodium (%Na), Magnesium Ratio (MR) indicate most of the samples is suitable for irrigation purpose. Overall the geochemical characteristics of the groundwater are impeded by natural geology and anthropogenic activities.

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**Table 1:** Physico-chemical compostion* and irrigation specification values of groundwater of study area

| Sr.No | PH | E.C. | TDS | Total Hardness | Ca | Mg | Na. | K. | Total Alalinity | Cl | SO4 | NO3 | SAR | KR | MR | Na % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| 1 | 7.5 | 524 | 339 | 244 | 33 | 42 | 25 | 2 | 206 | 42 | 30 | 11 | 3.29 | 0.33 | 56.00 | 26.47 |
| 2 | 7.4 | 1181 | 768 | 447 | 99 | 45 | 91 | 12 | 402 | 155 | 36 | 59 | 4.08 | 0.63 | 31.12 | 41.73 |
| 3 | 7.5 | 1081 | 703 | 383 | 60 | 52 | 73 | 2 | 326 | 139 | 31 | 38 | 10.71 | 0.65 | 46.46 | 39.94 |
| 4 | 8.1 | 291 | 190 | 119 | 17 | 14 | 17 | 2 | 94 | 33 | 17 | 10 | 9.71 | 0.52 | 45.73 | 37.23 |
| 5 | 7.4 | 541 | 352 | 203 | 32 | 26 | 29 | 1 | 170 | 59 | 20 | 18 | 4.17 | 0.51 | 45.29 | 34.70 |
| 6 | 7.7 | 451 | 294 | 179 | 28 | 22 | 28 | 2 | 142 | 53 | 24 | 15 | 5.47 | 0.56 | 43.95 | 37.34 |
| 7 | 7.5 | 1021 | 664 | 363 | 67 | 44 | 77 | 2 | 286 | 145 | 36 | 48 | 5.60 | 0.69 | 39.52 | 41.45 |
| 8 | 7 | 1821 | 1184 | 643 | 148 | 62 | 114 | 2 | 490 | 205 | 110 | 66 | 10.31 | 0.54 | 29.51 | 35.57 |
| 9 | 7.1 | 1241 | 807 | 367 | 76 | 39 | 70 | 2 | 250 | 141 | 59 | 58 | 11.14 | 0.61 | 33.68 | 38.46 |
| 10 | 7 | 431 | 281 | 163 | 28 | 18 | 21 | 1 | 138 | 39 | 18 | 18 | 9.20 | 0.46 | 39.30 | 32.67 |
| 11 | 7.21 | 361 | 235 | 139 | 24 | 15 | 25 | 2 | 110 | 47 | 14 | 17 | 4.40 | 0.64 | 39.59 | 40.51 |
| 12 | 7.3 | 811 | 528 | 207 | 48 | 17 | 44 | 5 | 170 | 81 | 20 | 29 | 5.66 | 0.67 | 26.78 | 42.68 |
| 13 | 7.5 | 621 | 404 | 231 | 38 | 29 | 27 | 2 | 202 | 59 | 13 | 22 | 7.63 | 0.41 | 43.35 | 30.62 |
| 14 | 7 | 1081 | 703 | 319 | 67 | 33 | 58 | 2 | 250 | 109 | 34 | 50 | 4.73 | 0.58 | 33.04 | 37.36 |
| 15 | 7.6 | 551 | 359 | 211 | 48 | 18 | 23 | 1 | 170 | 43 | 12 | 16 | 8.20 | 0.35 | 27.86 | 26.75 |
| 16 | 8.1 | 411 | 268 | 227 | 44 | 24 | 26 | 1 | 158 | 49 | 28 | 19 | 4.00 | 0.38 | 35.29 | 28.46 |
| 17 | 7.46 | 1741 | 1132 | 495 | 91 | 61 | 111 | 3 | 330 | 211 | 104 | 62 | 4.47 | 0.73 | 40.24 | 42.80 |
| 18 | 8 | 291 | 190 | 119 | 17 | 14 | 17 | 2 | 94 | 33 | 17 | 10 | 12.73 | 0.52 | 45.73 | 37.23 |
| 19 | 7.4 | 541 | 352 | 203 | 32 | 26 | 29 | 1 | 170 | 59 | 20 | 18 | 4.17 | 0.51 | 45.29 | 34.70 |
| 20 | 7.7 | 451 | 294 | 179 | 28 | 22 | 28 | 2 | 142 | 53 | 24 | 15 | 5.47 | 0.56 | 43.95 | 37.34 |
| 21 | 7.4 | 1021 | 664 | 363 | 67 | 44 | 77 | 2 | 286 | 145 | 36 | 48 | 5.60 | 0.69 | 39.52 | 41.45 |
| 22 | 7.3 | 1821 | 1184 | 643 | 148 | 62 | 114 | 2 | 490 | 205 | 110 | 66 | 10.31 | 0.54 | 29.51 | 35.57 |
| **Min** | **7** | **291** | **190** | **119** | **17** | **14** | **17** | **1** | **94** | **33** | **12** | **10** | **3.29** | **0.33** | **26.78** | **26.47** |
| **Max** | **8** | **1821** | **1184** | **643** | **148** | **62** | **114** | **12** | **490** | **211** | **110** | **66** | **12.73** | **0.73** | **56.00** | **42.80** |
| **Avg** | **7** | **831** | **541** | **293** | **56** | **33** | **51** | **2** | **231** | **96** | **37** | **32** | **6.87** | **0.55** | **39.12** | **36.41** |

All value in mg/L, except pH and EC in µs/cm at 25°C

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