GROUNDWATER QUALITY AND ITS SUITABILITY FOR AGRICULTURE PURPOSE IN KARHA RIVER BASIN AREA BARAMATI, INDIA

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Abstract

Study of groundwater quality in Karha River basin area has an importance because of geological reasons. This area is under arid to semi-arid region. An investigation was carried out by collecting seventeen groundwater samples for two seasons Pre-monsoon and Post – monsoon (February 2017 to December 2017) to study hydrochemistry and groundwater quality for determining its suitability for agriculture purposes. After analysis of groundwater samples from study area, the pH of water was found neutral to alkaline in nature with pH ranging from 6.5 to 8.6. Higher electrical conductivity was noted at Nepatwalan Village. Higher nitrate was observed during post- monsoon in the village Songaon due to action of leaching process. The recorded nitrate was 52 ppm. Residual sodium carbonate value indicated that 5 samples were not suitable for irrigation purpose in both seasons. In POM and PRM season about 41% samples showed hard water and 35% samples were very hard water quality. 29% samples recorded high salinity of groundwater which were found to be unsuitable for agriculture purpose. Climate and geographical conditions in the study area were mainly responsible for the quality of groundwater. Negative impact of groundwater was observed on the quality and growth of crops in the study area.

Keywords
Groundwater, Electrical Conductivity, SAR, Sodium Percentage, RSC

1. Introduction

Water is a valuable resource on which all life depends. Water is a basic necessity of life, not only for people but for every type of plant and animal as well (WHO). Water shortage have becomes an increasingly serious problem in India, especially in the arid and semi-arid regions of the country due to vagaries of monsoon and scarcity of surface water. Over the few decades, competition for economic development, associated with growth in population and urbanization, has brought in significant changes in land use, resulting in more demand of water for agriculture, domestic and industrial activities. In India, groundwater constitutes about 53% of the total irrigation potential of the country (FAO, 2003) and about 50% of the total irrigated area is dependent on groundwater irrigation (Central water commission, 2006). Sixty percent of irrigated food production is from groundwater wells (Shah et al., 2000). Groundwater quality is a major concern in many parts of the country.

Groundwater quality, in turn, depends on a number of factors, such as general geology, degree of chemical weathering of the various rock types, quality of recharge water and input from sources other than water- rock interaction (Domenico, 1972); (Schuh et al., 1997); (Todd et al., 1980). Such factor and their interaction results in a complex groundwater quality (Hussein, 2004). Various publications have concentrated on groundwater quality monitoring and evaluation for domestic and industrial activities (Jalali, 2005; Pritchard et al., 2008) reported high salinity and nitrate in groundwater from Wuwei basin, northwest China.

Nitrate is one of the common contaminate identified due to agricultural activities. In humans, a condition called methemoglobinemia, also known as blue baby syndrome, results due to ingestion of high nitrate in inorganic form. Nitrate (>300 mg/l) poisoning may result in the death of livestock consuming water (Canter, 1997). Nitrate contamination is strongly related to land use pattern (Rajmohan et al., (2009). Total dissolved solids (TDS) values are also considered as an important parameter in determining the usage of water and groundwater with high TDS values are not suitable. The objective of the present paper was to assess groundwater quality and its suitability for agriculture purpose in the Karha River basin area.

2. MATERIAL AND METHODS

2.1 Study Area

The study area lies between 18º3´ to 18°12´, north latitudes and 74°13´to 74°30´ east longitudes. It is located at an altitude of 538 meters above means sea level. The River originates from Saswad in Pune District. Ground water samples from different seventeen wells of Karha River basin area were selected randomly and by considering the topography of the study area (APHA, 1995) (Figure 1).

Figure 1: Location map of the study area

2.2 Sample Collection

Water samples from the selected sites were collected for two different seasons pre-monsoon (PRM) and post-monsoon (POM) in triplicates. During the period February 2017 to December 2017. Each sample was collected in a good quality polyethylene bottle of one-liter capacity.

2.3 Physico-chemical Analysis

Samples were analyzed in the laboratory for determination of major ions chemistry by employing standard methods of (APHA, 1995). Calcium (Ca^{2+}) and magnesium (Mg^{2+}) were determined titrimetrically using standard EDTA. Chloride by standard $AgNO_3$ titration, bicarbonate (HCO_3^-) by titration with HCl, Sodium (Na^+) and Potasium (K^+) by flame photometry. EC, pH and TDS were measured in situ. Sulphate (SO_4^{2-}) was determined by a spectrophotometer. The physicochemical composition of the groundwater samples were analyzed and the average results of each samples were given in the form of maximum, minimum and average parameters given in table 1.

Table 1: Statistics of groundwater chemistry in PRM & POM seasons

Parameters	PRM				POM			
	Min	Max	Avg	SD	Min	Max	Avg	SD
Ca^{2+}	10	291	82	101	10	260	77.6	93
Mg^{2+}	1.2	421	100	127	2.3	270	86	100
Na^{+}	23	454	152	144	21	469	158	148
K^{+}	0.7	7.8	2.6	2.4	0.6	7.6	2.9	2.5
HCO_3^-	159	769	396	158	148	730	389	156
Cl^-	71	2450	687	913	69	2400	662	880
SO_4^-	121	2300	490	552	102	2788	742	912
NO_3^-	16	48	33	10	22	52	35	10
F^-	0.3	0.7	0.5	0.1	0.3	0.6	0.5	0.1
TDS	314	6592	1915	2107	326	6131	1771	1841
EC	490	10300	2992	3293	510	9580	2767	2876
pH	6.75	8.5	7.6	0.5	6.5	8.6	7.6	0.5
RSC	0.4	11	4	3.9	0.3	10.2	3.7	3.4
SAR	0.8	36.6	4.7	8.6	0.8	34.5	5.3	8.8
SSP	8	96	40	25	11	96	42	25

Note:

1. All values are in mg/l except pH and EC
2. Min- Minimum, Max- Maximum, Avg- Average, SD- Standard Deviation

3. RESULTS AND DISCUSSION

3.1 pH

Physico-chemical parameters of ground water samples from different locations of Karha River basin area in PRM and POM seasons were given in Tables 1. The pH ranges from 6.75 to 8.5 and 6.5 to 8.6 with an average 7.6 and 7.6 during seasons PRM and POM respectively, which indicated the alkaline nature of groundwater. During POM, Na^+ was found to be higher (469 mg/l) indicating sources from weathering of feldspar (Hem, 1985). Calcium was found to be higher (291 mg/l) during PRM due to dissolution of $CaCO_3$ during recharge (Datta et al., 1996).

3.2 Electrical conductivity

EC is the most important parameter to indicate salinity hazard and suitability of water for irrigation purpose. The EC of water sample varied from 490 to 10300 µS/cm and 510 to 9580 µS/cm during PRM and POM respectively. Higher EC was noted during PRM when compared with POM. The spatio- temporal variation of EC is shown in Figure 2. Very high (>3000) EC concentration was prominent along up stream, central and downstream directions of the study area.

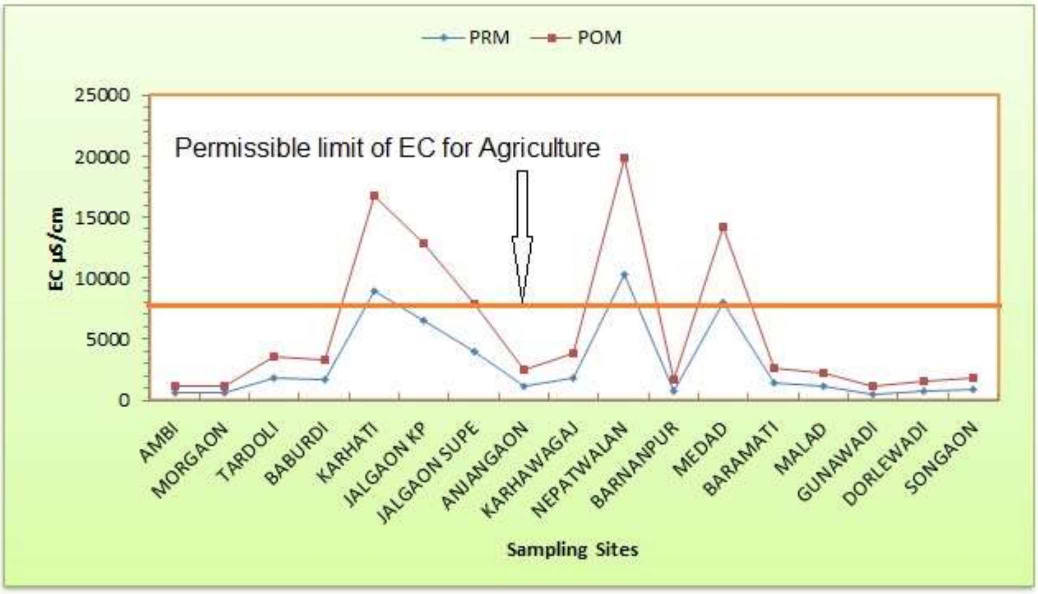

Figure 2: Spatio-temporal variation in EC

3.3 Chloride

The Cl^- ion concentration ranged from 71 to 2450 and 69 to 2400 mg/l with an average of 687 and 662 mg/l during PRM and POM seasons. The permissible limit of Cl^- in groundwater was 600 mg/l (WHO, 2008). 29% of the samples fall above the allowable limit. Higher concentration was noted during PRM (24500 mg/l) as compared with POM. Chloride is higher during PRM (2450 mg/l) due to leaching of upper layer of soil in dry climates (Srinivasamoorthy et al 2008), higher SO_4^{2-} was noted during POM season (2788 mg/l).

3.4 Sodium

Sodium toxicity were recorded as a result of high sodium in water as Na% and SAR. The maximum permissible limit of Na is 200 mg/l. the Na^+ ion ranges between 23 to 454 mg/l and 21 to 469 mg/l during PRM and POM seasons respectively. Majority of water samples 24% during both the seasons was above the guideline limit of WHO. The sources of the sodium into the groundwater were due to the weathering of feldspar and due to over exploitation of groundwater (Hem, 1985).

3.5 Nitrate

Nitrogen is essential for plant growth, when applied in excess affect the crop by over stimulation of growth, delayed maturity and poor quality of crop yield. Sensitive crop may be affected by nitrogen concentration above 45 mg/l. most other crops were unaffected until nitrogen exceeds 45 mg/l (Sundaray et al., 2009). Consumption of nitrogen above permissible limit creates severe problem of blue baby disease or Methemoglbinemia in children and gastric carcinomas.

The nitrogen in groundwater samples ranges from 16 to 48 mg/l and 22 to 52 mg/l during PRM and POM seasons respectively. Higher nitrate was noted in the study area where intensive irrigation practices are dominant. Higher nitrate was noted in POM (52 mg/l) indicating the application of nitrate fertilizers (Madison et al., 1984).

3.6 Total hardness (TH)

Water hardness has no known adverse effects; however, some evidence indicates its role in heart disease (WHO 2008). The TH is calculated by using the formula

$$TH = (\text{ppm of Ca} \times 2.496) + (\text{ppm of Mg} \times 4.118)$$

Hard water is unsuitable for domestic use and it is a measure of the Ca^{2+} and Mg^{2+} content expressed in equivalent of calcium carbonate. During PRM, total hardness (TH) ranged between 30 to 2028 mg/l with an average of 616, representing (82%) of the groundwater samples exceeded the permissible limit. During POM, TH ranged between 35 to 1736 mg/l with an average of 548 mg/l represented (76%) of the samples exceeded the permissible limit. It is inferred that, both the seasons records higher TH as permanent hardness. It is shown in figure 3.

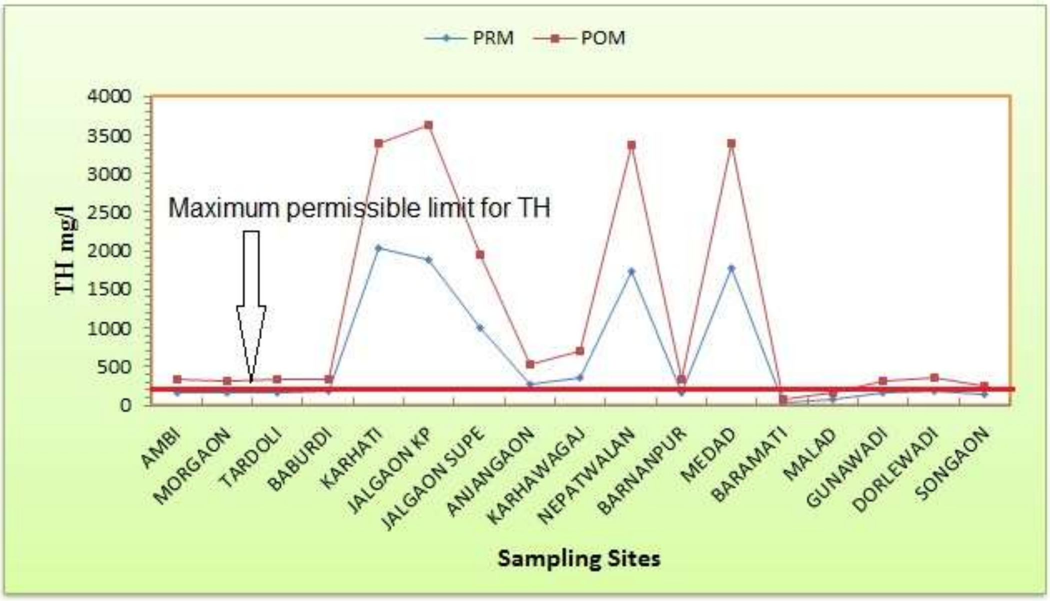

Figure 3: Spatio-temporal variation in Total Hardness

Table 2: Classification of groundwater quality based on suitability of water for irrigation purposes

Parameters	Range	Class	No of Samples		Percentage	
			PRM	POM	PRM	POM
EC	<250	Excellent	0	0	0	
	250-750	Good	4	3	24	18
	750-2000	Permissible	8	9	47	53
	2000-3000	Doughtful	0	0	0	0
	>3000	Unsuitable	5	5	29	29
SSP	200	Maximum allowable limit	17	17	100	100
	>200	Above allowable limit	0	0	0	0
NO_3	<200	Most desirable limit	17	17	100	100
	200- 600	Maximum allowable limit	0	0	0	0
	>600	Above the maximum allowable limit	0	0	0	0
MR	<50	Suitable	7	7	41	41
	>50	Unsuitable	10	10	59	59
TH	<75	soft	1	1	6	6
	75-150	Moderately	2	3	12	18
	150-300	Hard	9	7	53	41
	>300	Very hard	5	6	29	35
RSC	<1.25	Safe	4	3	24	18

	1.25-2.5	Marginally suitable	2	2	12	12
	>2.5	Not suitable	3	5	18	29
SAR	<20	Excellent	15	12	88	71
	20-40	Good	1	2	6	12
	40-60	Permissible	0	0	0	0
	60-80	Doughtful	0	0	0	0
	>80	Unsuitable	0	0	0	0

3.7 Residual Sodium Carbonate (RSC)

RSC is calculated to determine the hazardous effect of carbonate and bicarbonate on the quality of water used for agricultural activities (Janardhana Raju, 2007). From the observed values 29% of the samples are not suitable for irrigation purposes in both seasons. Hence, continued usage of high RSC waters will affect the yields of crop.

3.8 Soluble Sodium Percentage (SSP)

The classification of samples is given in Table 2. It is observed that maximum samples were suitable for irrigation during PRM and POM seasons.

3.9 Sodium Adsorption Ratio (SAR)

Total salt concentration and probable sodium hazard of the irrigation water were the two major constituents for determining SAR. Salinity hazard was based on EC measurements. If water used for irrigation is high in Na^+ and low in Ca^{2+}, the ion-exchange complex may become saturated with Na^+ which destroys the soil structure, due to the dispersion of clay particles (Todd, 1980) and reduces the plant growth. Excess salinity reduces the osmotic activity of plants (Subramani et al., 2005). The SAR was computed, using the formula

$$SAR = \frac{\mathrm{Na}+}{\sqrt{\frac{(\mathrm{Ca}+2 + \mathrm{Mg}+2)}{2}}}$$

Concentration of ions were expressed in meq/l. There was a close relationship between SAR values in irrigation water and the extent to which Na^+ was absorbed (Subba Rao, 2006). The computed SAR values ranged from 0.08 to 36.6 and 0.8 to 34.5 in PRM and POM respectively.

4. Conclusion

The groundwater quality in Karha River basin area has been evaluated for their chemical composition and suitability for agricultural uses. Higher EC values were confined along up stream, central and downstream area indicating the dominance of natural and agricultural activities. Higher sodium values were observed during both the season in groundwater samples collected from downstream parts of the study area.

Higher NO_3^- was observed during POM in areas where intensive irrigation practices area dominant. Higher TH was noted in central part of the study area like karhati. Sodium percentage and SAR was found in permissible level in both the season. Overall hydro geochemical analytical study revealed 29% RSC in the samples and showed unsuitable for irrigation purposes. 82% water samples were under hard to very hard categories and not suitable for agricultural purposes.

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