

RESEARCH ARTICLE

Water Quality of Kalugachalapuram–Kovilpatti Watershed of Tamil Nadu

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Abstract

Kalugachalapuram watershed is located at 9° 16' of North latitude and 77° 92' of East longitude with an altitude of 90 m above MSL in Ettayapuram taluk of Tuticorin district of Tamil Nadu. The study area was black soil region covering around 250 ha. Climatically the area experiences hot summer and rainy winter with mean annual rainfall of 650 to 750 mm and mean annual temperature of 30-32°C. The summer temperature ranges between 35 and 38°C and the winter temperature ranges between 20 and 23°C. Ground water of these areas was studied for determination of quality. Four villages viz., Kumarapuram, Kalugachalapuram, Chandragiri and Chidambarapuram were identified for this study. Open and bore wells were used as sources to analyze the quality of water. The pH of the watershed samples ranged from 7.84 to 8.37. The electrical conductivity ranged from 0.45 to 8.38 dSm⁻¹. Higher RSC values were recorded in some bore wells which may create alkalinity hazards in the soil and subsequent possibility of creating hard pan and root injury for the growing crops. All the well water showed the SAR values ranging from 1.48 to 7.25, but the SAR values have not reached the injury level both in the crop and in soil. High soluble sodium percentage values were obtained with well water having higher EC. Among the cations, sodium was dominant to maximum level of 25.09 me L⁻¹. Among the anions, sulphates dominated to the level of 113.4 me L⁻¹.

Keywords: Water quality, soluble sodium percentage, sodium adsorption ratio, residual sodium carbonate.

Introduction

Ground water is one of the most valuable natural resource which supports human health, agriculture, industry, economic development and ecological diversity (Jha *et al.*, 2007). Per capita availability of water has radically reduced from over 5000 m³ in the 50's to a meagre 1650 m³ in 2007 and is conjectured to be well less than the internationally prescribed level (1700 m³) to 1140 m³ by 2050. Failure of monsoon and erratic rainfall coupled with climatic change led to poor surface flow of water and storage in reservoirs leading to over exploitation of ground water in terms of both quantity and quality. Unfortunately, the excessive use and continued mismanagement of this vital resource led to ever-increasing water demand and increasing pollution of groundwater resources and degraded ecosystem worldwide (Tsakiris, 2004). Emerging industrialization without proper effluent recycling unit severely affects the ground water quality. Problems with water quality are often as severe as the problems of water availability. In many cases, ground water resources have been rendered unsuitable for human consumption as well as irrigation and industrial needs due to their poor quality. Natural contamination of ground water sources by dissolved salts is a major constraint mainly in arid and semi arid regions (Sudhakar and Mamatha, 2004). Hence, it is essential to maintain proper balance between the quantity as well as quality to prevent from rapid decline of groundwater table that affect not only

sustainable production but also environment degradation. In view of the above, the present study was undertaken to assess the nature, composition and quality of these ground water for irrigation.

Materials and methods

Experimental design: The study area lies between the latitude 9° 16' of North and longitude 77° 92' of East with an altitude of 90 m MSL in Tuticorin district of TN covering an area of 250 ha. Climatically the area experiences hot summer and rainy winter with mean annual rainfall of 650 to 750 mm and mean annual temperature of 30-32°C. Monsoon is the main source for ground water of this region. The summer and winter temperature ranges between 35 and 38°C and 20 and 23°C respectively. Around the watershed, 32 water samples of open and bore wells were collected from four villages (3 from open wells and 5 from bore wells in each village). The depth of open and bore wells ranged from 40 to 65 and 120 to 200 ft respectively. The samples collected for two years in between January and March of 2003 and 2004. The water samples were collected in capped PVC bottles, fortified with toluene to prevent any biological contamination. The water samples were analyzed for pH, EC, Ca, Mg, Na, K, HCO₃, CO₃ and SO₄ as per standard procedures outlined by Richards (1954). Ca and Mg were determined by versenate method, while K and Na analyzed by flame photometry.

Table 1. Guidelines for interpretations of quality for irrigation.

Parameters	Suitable	Moderately suitable	Not suitable
pH	6.5-8.4	0-5	>9.5
EC (dSm ⁻¹)	2.5	2.5-7.5	>7.5
Sodium adsorption ratio (SAR)	10	10-18	>18
Residual sodium carbonate (RSC)	<1.25	1.25-2.5	>2.5
Soluble sodium percentage (SSP)	<60	60-75	>75
HCO ₃ (me L ⁻¹)	<1.5	1.5-8.5	>8.5
Cl (me L ⁻¹)	<4.0	4.0-10.0	>10.0
B (me L ⁻¹)	<0.75	0.75-2.0	>2.0
NO ₃ -N (me L ⁻¹)	<5.0	5.0-30	>30.0
F (me L ⁻¹)	<1.0	1.0-15.0	>15.0

Source: FAO (1994).

The anions like CO₃ and HCO₃ analyzed by titration with standard acids. Water samples were characterized on the basis of EC, SAR, RSC, SSP and PS values as suggested by Gupta *et al.* (1994). The quality of water was classified based on the criteria developed by USSL (1954). For interpretation of results of water samples, the FAO guidelines were used (Table 1). The SAR, RSC, SSP and PS were calculated as under:

Sodium Adsorption Ratio (SAR):

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+} + Mg^{2+}}{2}}}$$

Residual Sodium Carbonate (RSC):

$$RSC = (CO_3^{2-} + HCO_3^-) - (Ca^{2+} + Mg^{2+})$$

Soluble Sodium Percentage (SSP):

$$SSP = \frac{Na^+}{\text{sum of all cations}} \times 100$$

Potential salinity:

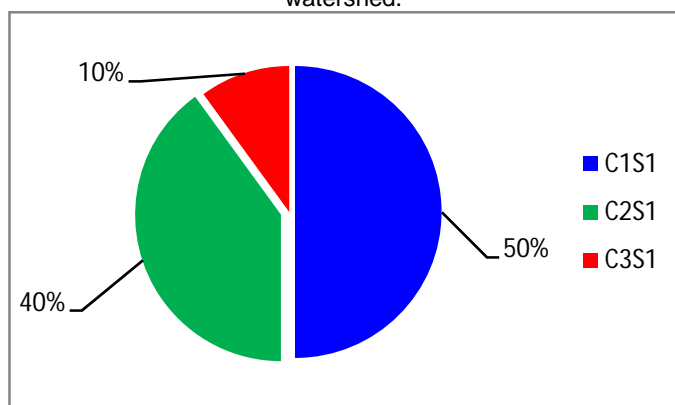
$$\text{Potential salinity} = Cl^- + \frac{1}{2} SO_4^{2-}$$

Na²⁺, Ca²⁺, Mg²⁺, CO₃²⁻ and HCO₃⁻ are in me L⁻¹.

Results and discussion

The two years pooled data on characteristics and quality of ground water collected from the four villages under this watershed are presented in Table 2. The pH of ground water samples collected from the four villages extended from 7.84 to 8.37 while salinity (EC) ranged from very low of 0.45 dSm⁻¹ to as high as 8.38 dSm⁻¹. The lowest and highest pH were observed from the open and bore well of Chandragiri village. In case of EC, the lowest value (0.4 dSm⁻¹) noted from Kalugachalapuram village, while it was high (8.38 dSm⁻¹) in Chandragiri village. The transportation of soluble salts from one place to other place by water might have facilitated the development of higher salinity. Mandal and Sharma (2010) reported similar findings. The dominant cation in water was sodium, which ranged from 2.55 to 25.50 me L⁻¹.

Fig. 1. Water quality criteria of Kalugachalapuram-Kovilpatti watershed.



C₁S₁–Low saline low sodic water; C₂S₁–Medium saline low sodic water; C₃S₁–High saline low sodic water

In the four villages, the dominant anion was sulphate, which varied from 1.50 to 113.40 me L⁻¹. Highest sodium observed in water of Kalugachalapuram and highest sulphate noticed from Chandragiri village. Sodium adsorption ratio (SAR) and soluble sodium percentage (SSP) of waters varied from 1.48 to 8.79 and 31.90 to 68.60% respectively. The higher values of SAR and SSP were due to the dominant sodium content in the water. Similar observations were made earlier by Chandrasekaran *et al.* (2005). The residual sodium carbonate (RSC) of this water varied from -33.12 to 4.56 me L⁻¹ suggesting that many of the water samples were within the permissible limit of <2.5 me L⁻¹. The highest RSC of 4.56 me L⁻¹ was observed from water samples of Kalugachalapuram village. The values less than 0 or negative values indicated that quality was good. The potential salinity (PS) of all water samples were within the permissible limit. Out of 32 samples tested, 50% water samples were found under the category “good” and 40% of water samples recorded under “marginally saline” and remaining 10% under category “saline” as suggested by Gupta *et al.* (1994). According to USSL (United States Salinity Laboratory staff classification, 1954), 50% of water samples are grouped under the category C₁S₁ (i.e.) low saline low sodium, 40% medium saline low sodium (C₂S₁), and 10% were grouped under high saline low sodium water (C₃S₁) (Fig. 1). Haroon *et al.* (2007) reported similar findings.

Table 2. Characteristics of water samples of Kalugachalapuram–Kovilpatti watershed (2 years pooled data).

Well No	pH	EC dSm ⁻¹	Cations (me L ⁻¹)				Anions (me L ⁻¹)				RSC (me L ⁻¹)	SAR	SSP (%)	PS (me L ⁻¹)	Category
			Ca ²⁺	Mg ²⁺	Na ⁺	K ⁺	CO ₃ ²⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ²⁻					
Kumarapuram															
1. BW	8.03	2.48	2.88	5.28	14.06	0.08	1.20	6.40	2.80	17.25	-0.56	6.96	63.00	10.20	C ₁ S ₁
2. BW	7.91	1.34	3.33	8.21	11.60	0.08	1.80	7.20	3.56	20.27	-2.54	4.83	49.96	13.69	C ₁ S ₁
3. OW	7.96	0.88	1.18	4.52	8.25	0.06	2.30	6.60	2.86	32.60	3.76	4.97	58.88	19.16	C ₁ S ₁
4. OW	7.85	1.30	2.15	8.24	10.15	0.04	1.18	4.76	2.03	28.75	-4.45	3.65	49.31	16.40	C ₁ S ₁
5. BW	8.14	0.72	1.68	6.20	10.70	0.04	0.88	5.60	2.20	17.45	-1.40	5.40	67.46	10.92	C ₁ S ₁
6. OW	8.02	0.47	1.52	2.56	2.11	0.03	1.20	4.40	1.60	1.81	1.52	1.48	33.90	2.50	C ₁ S ₁
7. BW	8.18	0.91	1.88	5.85	4.44	0.04	1.18	4.76	2.03	42.24	-1.79	2.26	36.36	23.15	C ₁ S ₁
8. BW	8.31	1.08	2.33	4.25	6.80	0.03	2.50	6.60	8.30	68.45	2.52	3.76	55.23	42.52	C ₁ S ₁
Kalugachalapuram															
9. BW	8.15	0.45	1.28	1.60	2.55	0.02	1.20	4.40	1.20	1.50	2.72	2.12	46.70	1.95	C ₁ S ₁
10. OW	8.26	1.20	1.92	1.92	8.49	0.04	1.20	7.20	1.20	8.38	4.56	6.09	68.60	5.39	C ₁ S ₁
11. OW	8.07	2.60	2.64	5.64	13.74	0.05	3.20	7.20	1.60	20.65	2.12	6.77	59.50	11.92	C ₂ S ₁
12. BW	8.02	5.41	1.62	3.55	2.45	0.06	3.30	5.80	1.40	24.6	3.93	1.52	31.90	13.70	C ₂ S ₁
13. BW	8.12	1.62	1.38	2.50	5.50	0.05	1.97	3.32	13.80	53.38	1.41	3.96	58.32	40.49	C ₁ S ₁
14. BW	8.22	6.80	3.72	2.34	7.86	0.02	1.34	8.20	12.30	49.50	3.48	4.52	56.38	37.05	C ₂ S ₁
15. OW	8.05	3.76	2.05	4.55	11.60	0.06	3.12	6.70	6.80	94.50	3.22	6.41	65.09	54.05	C ₂ S ₁
16. BW	7.92	3.03	2.15	4.58	7.20	0.07	1.80	7.45	15.24	62.80	2.52	3.93	51.42	46.64	C ₂ S ₁
Chandragiri															
17. BW	8.26	1.03	1.36	2.72	6.50	0.02	1.20	6.40	1.60	6.18	3.52	4.54	61.30	4.69	C ₁ S ₁
18. BW	8.37	2.58	2.56	7.28	13.23	0.04	2.00	7.20	6.40	16.40	-0.64	6.01	57.20	14.6	C ₂ S ₁
19. OW	7.84	8.38	13.04	25.68	23.88	0.13	0.40	5.20	10.00	82.50	-33.12	5.42	38.08	51.25	C ₃ S ₁
20. BW	8.16	8.06	8.64	15.36	25.09	0.15	0.80	8.40	10.80	113.40	-14.80	7.25	50.90	67.50	C ₃ S ₁
21. OW	8.06	2.15	2.06	5.74	15.78	0.05	2.30	8.40	3.50	84.40	2.90	7.96	66.77	45.70	C ₁ S ₁
22. OW	8.18	2.68	2.32	7.62	17.55	0.04	2.80	8.80	5.40	108.60	1.66	7.87	63.75	59.70	C ₂ S ₁
23. BW	8.24	1.08	1.38	2.53	5.60	0.04	1.30	4.70	2.60	78.18	2.09	4.00	58.64	41.69	C ₁ S ₁
24. BW	8.32	2.52	2.78	6.82	11.64	0.03	3.60	7.70	5.40	81.40	1.60	3.11	54.72	46.10	C ₂ S ₁
Chidambarapuram															
25. BW	8.24	5.62	11.34	20.68	19.60	0.06	1.80	4.30	22.30	68.63	-25.92	4.90	37.93	56.61	C ₂ S ₁
26. BW	8.12	3.10	10.52	18.70	16.78	0.12	1.60	6.66	13.35	27.82	-19.10	4.39	36.38	27.26	C ₂ S ₁
27. BW	8.08	0.82	7.30	10.68	12.23	0.58	1.52	4.40	1.88	16.80	-12.06	5.32	39.73	10.28	C ₁ S ₁
28. OW	7.85	1.22	3.28	6.27	18.32	0.12	2.37	7.77	8.23	32.45	0.59	8.40	65.45	24.45	C ₁ S ₁
29. OW	7.80	3.33	5.05	10.30	24.20	0.22	3.40	8.30	5.60	94.70	-3.65	8.74	60.85	52.95	C ₂ S ₁
30. BW	8.16	3.55	5.64	11.20	25.50	0.31	2.80	8.60	7.58	102.40	-5.44	8.79	59.79	59.05	C ₂ S ₁
31. BW	8.22	2.72	3.13	5.30	10.70	0.28	2.70	6.80	8.50	55.80	1.07	5.22	55.12	36.40	C ₂ S ₁
32. OW	8.07	3.47	2.37	3.84	12.11	0.31	2.20	5.30	7.60	77.40	1.29	6.88	65.00	46.30	C ₂ S ₁

OW- Open well; BW-Bore well; C₁S₁—Low saline low sodic water; C₂S₁—Medium saline low sodic water; C₃S₁—High saline low sodic water.

The water falling under category “good” can be used for any crops whereas which was “marginally saline” can be used for some saline tolerant crops. The water rated as “high saline” are unfit for irrigation and the indiscriminate use will cause secondary salinization and sodification to the extent that growth of crop may be severely affected. Among the water samples of four villages, all the water samples of Kumarapuram village were classified under the category of low saline low sodium (C₁S₁). The next category of medium saline low sodium (C₂S₁) was found in Chidambarapuram and Kalugachalapuram villages. The category of high saline low sodium water (C₃S₁) was found in Chandragiri village only.

Conclusion

From the present findings, it can be concluded that SAR, RSC, SSP and PS are within the permissible limit and these water is suitable for most of the crops. High saline water may not be used for crops especially horticultural crops. The water of high saline can be used only on soils with good permeability and salt tolerant crops can be grown, special leaching also to be provided to remove excess salts.

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