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Environmental monitoring: Assessment of irrigation water quality of agricultural research farms, Killikulam

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Abstract
The ground water quality of Agricultural Research Farms, Killikulam was assessed to test its suitability for irrigation. Eleven ground water samples were collected from different blocks of Agricultural College and Research Institute, Killikulam and analysed for various water quality characteristics. The suitability of ground water for irrigation purpose was evaluated based on conductivity, salinity, Sodium Adsorption Ration (SAR), Residual Sodium Carbonate (RSC). The study, as per the standards prescribed by CGWB and CPCB, revealed that 90% of test samples from Agricultural Research Farms, Killikulam is suitable for irrigation.

Keywords: Irrigation water quality, agricultural research farms, conductivity, SAR and RSC

Introduction
Groundwater is a vital life supporting resource that is essential for agricultural, industrial and human needs. It fulfils the water requirement of 80 % of rural needs and 50 % of the urban water needs in India [6]. Among the sectors that demand water, irrigated agriculture occupies 70% of consumptive water use [3]. Irrigation with poor quality water brings undesirable elements to the soil in excessive quantities affecting its fertility and health. Poor irrigation water quality has a negative effect on crop productivity, crop product quality and public health of consumers and farmers who come in direct contact with the irrigation water [9].

Deterioration of ground water quality in intense agricultural systems has become a widespread occurrence making it unfit for irrigation. This problem is more severe in intense farming systems which receive varied and multiple levels of inputs. Poor groundwater quality in agricultural fields is a consequence of the escalating use of fertilizers and its widespread contamination of ground water in rural areas [4]. Wastewater irrigation in agricultural lands also adds to groundwater quality deterioration as reported by [14] in Leon, Mexico. The quality of ground water is primarily governed by the concentration and composition of dissolved salts determine the quality for irrigation purpose. The major cations are Na^+, Ca^{2+}, Mg^{2+} and K^+, while anions include Cl^-, SO_4^2, HCO_3^-, CO_3^{2-} and NO_3^-. These specific ions may be toxic to various plant physiological processes or may cause nutritional disorders in plants. In the agricultural research farms of Killikulam, Thoothukudi district, a major source of irrigation is ground water, which has been used for decades for research with multitude input doses. Hence, this study was done to assess the irrigation water quality of Killikulam farm and its suitability as irrigation water.

Material and Methods
The study was conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu. The farm is geographically situated at 8^o 46'N latitude, 77^o 42' E longitude and at an altitude of 40 m above MSL. Groundwater samples were collected from aquifers, both tube wells and open wells, from all field blocks in clean, sterile polyethylene bottles of 500 ml capacity during winter at monthly intervals. All chemicals and reagents used in the study were of analytical reagent grade (Merck/BDH). De-ionized water was used throughout the study. Calcium and Magnesium content were determined by EDTA titration using Eriochrome black T as indicator. Sodium and potassium content were determined by using a flame photometer. Carbonate and bicarbonate content were measured by acid-base titration. CE 470 conductivity meter was used to measure the Electrical Conductivity.

Results and Discussion

Table 1: Irrigation water quality in Killikulam agricultural farms

S. No	Sample location	pH	EC (dSm^{-1})	TDS (mg L^{-1})	SAR	RSC (meL^{-1})
1	Ezhuthanioothu (open well)	7.53	0.51	352	0.67	-3.49
2	B 4 block (open well)	7.62	0.78	512	0.80	-2.37
3	B 5 block (open well)	7.46	0.79	512	1.14	-2.66
4	E block (open well)	7.62	0.76	499	0.99	-5.18
5	E1 block (bore well)	7.46	0.72	480	0.95	-2.63
6	D E2 (open well)	8.11	0.68	452	1.14	-4.35
7	D E8 (open well)	7.37	0.91	602	1.33	-2.82
8	D 47 (bore well)	8.52	0.87	589	1.36	-3.60
9	D 53 (bore well)	7.43	0.85	557	1.56	-3.33
10	Marthurkeezhakal canal	7.39	0.4	289	0.40	-2.02
11	Canal motor pump	8.39	0.88	598	1.22	3.02

pH of the test samples

High pH of irrigation water is a function of high carbonate and bicarbonate concentration. If the pH of water is less than 9, there should be essentially no carbonate reported. The pH of the water samples tested varied from 7.37 to 8.52 in various places from where the water samples have been collected. Highest value in pH was observed in D 47 sample, while lowest pH value of 7.37 was recorded from D E8 sample. Since none of the water samples showed pH higher than 9, However, the pH values were well within the CGWB standards.

Similar results were reported by [11] that pH of water samples shows variation from 6.84 to 7.27.

Conductivity and dissolved solids in samples

Electrical conductivity (EC) and total dissolved solids (TDS) represent the salt load of the water. High concentration of EC and TDS and electrical conductivity in irrigation water affect the soil structure, permeability and aeration, which indirectly affect the plant growth. Besides, it affects the salt intake of the plant. These effects are visible in plants by stunted growth, low yield, discoloration and even leaf burns at margin or top. The conductivity of the samples ranged from 0.4 to 0.91 dSm^{-1} indicating that none of the sample was bad for irrigation. The dissolved salts content varied from 289 mgL^{-1} to 602 mgL^{-1}, the IS acceptable limit being <3000 mgL^{-1}. The FAO guideline states that water having <3000 mgL^{-1} conductivity induce salinity to have potential irrigation problems. In this study, all the samples tested were suitable for irrigation.

Residual Sodium Carbonate (RSC)

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

Ground water containing high concentration of carbonate and bicarbonate ions tends to precipitate calcium and magnesium as carbonate. As a result, the relative proportion of sodium increases and gets fixed in the soil thereby decreasing the soil permeability.

Excessive RSC in irrigation water causes the soil structure to deteriorate, as it restricts the water and air movement through soil. If the value is between 1.25 meL^{-1} and 2.5 meL^{-1}, the water is of marginal quality, while values less than 1.25 meL^{-1} indicate that the water is safe for irrigation [15]. In the present study, the RSC values (Table 1) clearly indicate that the groundwater of Killikulam, except canal motor pump is not having any residual sodium carbonate hazard. The RSC of canal motor pump is 3.02 meL^{-1}. If RSC exceeds 2.5 meL^{-1}, the water is generally unsuitable for irrigation.

Sodium Adsorption Ratio (SAR)

A high salt concentration in water leads to formation of a saline soil and high sodium leads to development of an alkali soil. The sodium or alkali hazard in the use of water for irrigation is determined by the absolute and relative concentration of cations and is expressed in terms of Sodium Adsorption Ratio (SAR). If the proportion of sodium is high, the alkali hazard is high; and conversely, if calcium and magnesium predominate, the hazard is less. There is a significant relationship between SAR values of irrigation water and the extent to which sodium is absorbed by the soil. If water used for irrigation is high in sodium and low in calcium, the cation-exchange complex may become saturated with sodium. This can destroy the soil structure owing to dispersion of the clay particles. A simple method of evaluating the danger of high-sodium water is the sodium adsorption ratio, SAR [12]:

$$SAR = \frac{Na^+}{\left\{\frac{Ca^{2+}+Mg^{2+}}{2}\right\}^{1/2}}$$

Calculation of SAR for given water provides a useful index of the sodium hazard of that water for soils and crops. A low SAR (2 to 10) indicates little danger from sodium; medium hazards are between 7 and 18, high hazards between 11 and 26, and very high hazards above that. The values of SAR in the groundwater of Killlikulam, varies from 0.4 to 1.56. As evident from the SAR values, the groundwater of the study area falls under the IS 11624 (1986) category of low - medium sodium hazard (Fig.1), which reveals that groundwater of the study area is not having high sodium hazard. The sodium percentage in the study area was found to vary from 9.69 to 27.0. All the samples of the study area fall within the recommended value of 60% and are suitable for irrigation purpose.

Table 2: Guidelines for evaluation of irrigation water quality

Water class	EC, µS/cm	SAR	RSC (meq/l)
Excellent	< 250	< 10	< 1.25
Good	250-750	10-18	1.25-2.0
Medium	750-2250	18-26	2.0-2.5
Bad	2250-4000	> 26	2.5-3.0
Very bad	> 4000	> 26	> 3.0

Source: CGWB and CPCB (2000) [2]

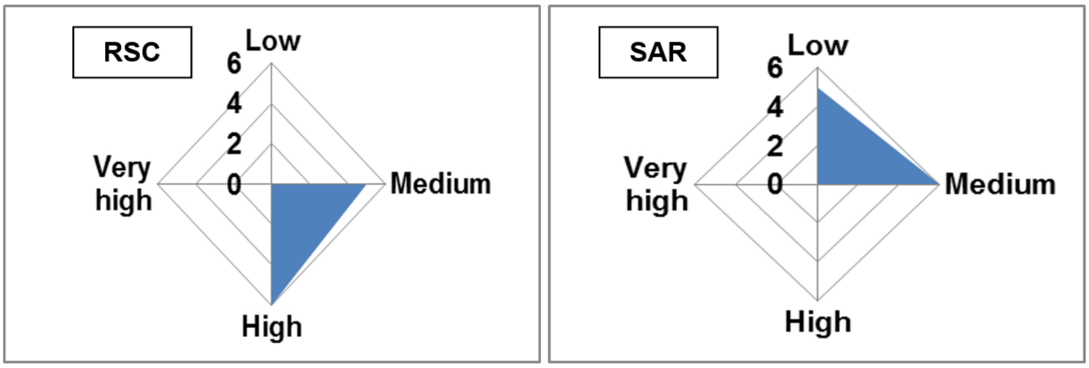

Fig 1: Rating of samples based on RSC and SAR values

Evaluation of irrigation water quality

The analysis of the samples indicated that about 90 % of the samples are safe for irrigation purposes and plants with moderate salt tolerance can be grown in most cases without special practices for salinity control. However, about 10% of the samples examined cannot be used on soils with restricted drainage. Even with adequate drainage, special management for salinity control may be required and plants with good tolerance should be selected.

The results obtained in this study collaborated with the observations of [1] in Tirunelveli and [10] in Trichy, wherein they reported overall status of groundwater as good except few samples. However [11], observed deterioration in water quality in farmers fields over a period of 12 years in Bangalore. More than 23% samples received for testing were found to be unsafe for irrigation with respect to EC during 2011 and 2012. Since differences in water quality varies from place to place, water table, intensity of agriculture, sea water intrusion, periodical assessment of local water resources is necessary to practice sound agriculture and safeguard soil health.

Summary and Conclusion

The study reveals that the acquifer waters of Killikulam agricultural farms are suitable for irrigation. Ninety per cent of the samples were safer for irrigation and were found suitable for most cultivated crops as per the CGWB and CPCB 2000 guidelines.

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