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Assessment of Irrigation Water Quality at Cheddipalayam area of Batticaloa District, Sri Lanka

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Abstract

The present study was aimed to analyze the groundwater quality for the irrigation purpose at Cheddipalayam in Batticaloa District. Groundwater samples were collected at three different distances such as 100m, 200m and 300m from seashore. Water quality parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), Ca^{2+}, Mg^{2+}, Na^{+}, sodium adsorption ratio(SAR) and Ca^{2+}/Mg^{2+} ratio were analyzed. The study revealed that pH, Ca^{2+}, Mg^{2+}, Na^{+}, SAR and Ca^{2+}/Mg^{2+} ratio values were found within permissible limit for irrigation while EC and TDS were in high range. The pH ranged from 7.23 -8.41 while EC and TDS ranged from 1.18 – 1.60dS/m and 732 – 1065mg/l respectively. Concentration of Ca^{2+}, Mg^{2+} and Na^{+} varied from 6.17 - 8.12meq/l, 1.76 – 2.53meq/l and 2.30-3.21meq/l respectively. The pH decreased slightly with distance from seashore while EC, TDS and Na^{+} increased slightly with distance. Even though EC and TDS exceed the desirable limits, this groundwater can be used for irrigation purpose with the suitable management practices against salinity.

Keywords: Groundwater, water quality, salinity, electrical conductivity, total dissolved solids.

Introduction

Agriculture sector plays an important role in Sri Lanka's economy and provides significant contribution to the total GDP of the country. Majority of people (about 70%) living in rural areas are farmers and involved in both non-irrigated (rainfed) and irrigated agriculture. Non-irrigated agriculture depends entirely on rainfall stored in the soil profile. It is possible only in regions where rainfall ensures the availability of soil moisture during the critical growth periods of crops and therefore potential to improve non-irrigated yields is restricted where rainfall is subject to large seasonal and inter-annual variations. On the other hand, irrigation makes agriculture possible in areas previously unsuitable for crop cultivation in Sri Lanka. In irrigated agriculture, water taken up by crops is partly or totally provided through human intervention. Water, in this system, is withdrawn from a water sources such as lakes, rivers, aquifers etc. However, quality of water, formerly a minor concern in Sri Lanka, is becoming as an important issue in crop production. Irrigation with poor quality water adversely affects plant growth and yields[1] and thus affects livelihood of the rural community in Sri Lanka.

In the east coast of Sri Lanka, coastal sand aquifer and alluvial aquifer are the very precious resources of groundwater which have been used for domestic and irrigation purposes. The coastal sand aquifers are re-charged annually during rainy seasons. Hence, the volume of the fresh water in these aquifers expands during the rainy seasons and contracts during the dry seasons. Further, the deeper and larger alluvial aquifers occur along the lower reaches of the major rivers that cut across the various coastal plains surrounding the low country region of Sri Lanka[2]. Farmers in this region extract groundwater by using shallow dug wells, agro-wells and tube wells in order to irrigate the crops. However, there is high chance for groundwater deterioration due to natural and anthropogenic activities. Higher amount of TDS and other parameters like salt, hardness, Na and variation in pH level are causing problem to the irrigation water[3]. Therefore, it is essential to assess the quality of groundwater used for irrigation purpose. So far no systematic study was carried out to assess the groundwater quality in this area. The present work therefore aimed to assess the quality parameters of the groundwater at Cheddipalayam in Batticaloa district.

Material and Methods

Study Area: This study has been carried out at Cheddipalayam which is the most prominent farming village in Batticoloa district. It is situated between the latitude 7^0 58'N and longitude 81^0 78'E. The major soil type in this area is sandy regosol. There are several shallow dug wells, agro-wells and tube wells in this area which have been used to extract groundwater for irrigation purposes.

Site Selection and Sampling: The sampling points were selected within the boundary of 800 m from North to South and 300 m from East to West. A total of 15 groundwater samples were collected from 15 farmers' fields as shown in figure-1. The water samples were collected in well cleaned one litre autoclaved bottles. The bottles prior to take water samples were rinsed 2 to 3 times with sample water.

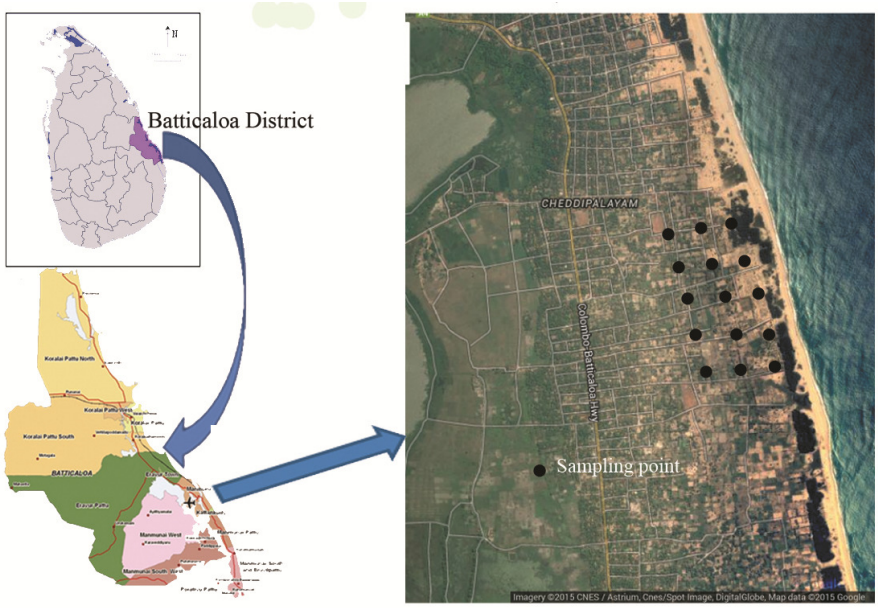

Figure-1
Location of sampling sites at Cheddipalayam area of Batticaloa

Analytical methods: Water quality parameters such as pH, EC and TDS were measured on the spot by using digital pH meter (pH /EC/ TDS Meter model HI 98130). The Calcium estimated by the Versanate titration using 10 percent NaOH and Calcon as an indicator. Total Ca and Mg concentrations were determined by using NH_4Cl and NH_4OH as a buffer and Eric Chrome Black T (EBT) as an indicators. From which the Magnesium concentration was found by deducting from the total concentration of Ca and Mg. Na was estimated by the flame photo meter, using standard solution of NaCl. The derived parameters such as Sodium Adsorption Ratio (SAR) and Calcium Magnesium ratio (Ca/Mg) were also determined using the following equations for the easy understanding of the quality of well water samples.

Sodium Adsorption Ratio, $$SAR = \frac{[Na^+]}{\sqrt{\frac{[Ca^{2+}]+[Mg^{2+}]}{2}}}$$

Where: all the cations are expressed in meq/l, Calcium Magnesium ratio = Ca^{2+}/Mg^{2+}

Results and Discussion

pH: pH is a measure of the intensity of acidity or alkalinity conditions of a solution[4]. According to this study, pH of water varied from 7.23 to 8.41 showing slightly alkaline to alkaline nature (table-1). The pH between 6.0 and 7.0 is most preferred range for irrigation purposes. Though, normal pH range for irrigation water is between 6.5 and 8.4[5]. It was also observed that pH of water samples had gradually decreased with distance away from seashore (figure-2). Presence of carbonates and bicarbonates in the groundwater samples might have attributed for alkalinity of water[6]. As alkaline water increases the soil pH, the availability of certain micronutrients, particularly iron (Fe) and manganese (Mn) will be reduced. It was found that Fe, Zn and Mn contents of both shoot and root of dwarf French beans increased with increased with decreasing pH[7].

Table-1
Physico-chemical parameters of irrigation water at Cheddipalayam in Batticalao district

Parameters	Min.	Max.	Mean	Distance from seashore (m)		
				100	200	300
pH	7.23	8.41	8.12	8.25	8.13	7.97
EC (dS/m)	1.18	1.60	1.49	1.46	1.50	1.52
TDS (mg/l)	732	1065	941	933	942	949
Na^+ (meq/l)	2.30	3.21	2.85	2.70	2.88	2.97
Ca^{2+} (meq/l)	6.17	8.12	6.74	6.65	6.50	7.06
Mg^{2+} (meq/l)	1.76	2.53	2.15	2.20	2.18	2.07
SAR	1.07	1.57	1.35	1.36	1.31	1.39
Ca/Mg ratio	3.21	3.51	3.14	3.04	3.00	3.46

Electrical Conductivity: Electrical conductivity (EC) indicates the total dissolved solids in water[8] and it is the most important parameter to determine salinity hazards and suitability of water for irrigation. In this study, it was observed that EC ranged from 1.18 dS/m to 1.60 dS/m (table-1). Further, mean value of EC at the distances of 100m, 200m and 300m away from the seashore were 1.46 dS/m, 1.50d S/m and 1.52 dS/m respectively (figure-2). The values exceeded the desirable limit of < 0.7 dS/m [5]. High levels of salinity affect germination percentage of soybean[9]. It was also found that the salinity affects growth, biomass partitioning and Na^+ and K^+ concentrations of poplar clones[10]. The high conductivity of well water samples in the study area may be due to over extraction of groundwater for agricultural purposes which might have facilitated water flow from sea to land area. Further, geological conditions (i.e closer to the coastal area), evaporation of water from the open wells and groundwater table also influence on the levels of EC in the present study.

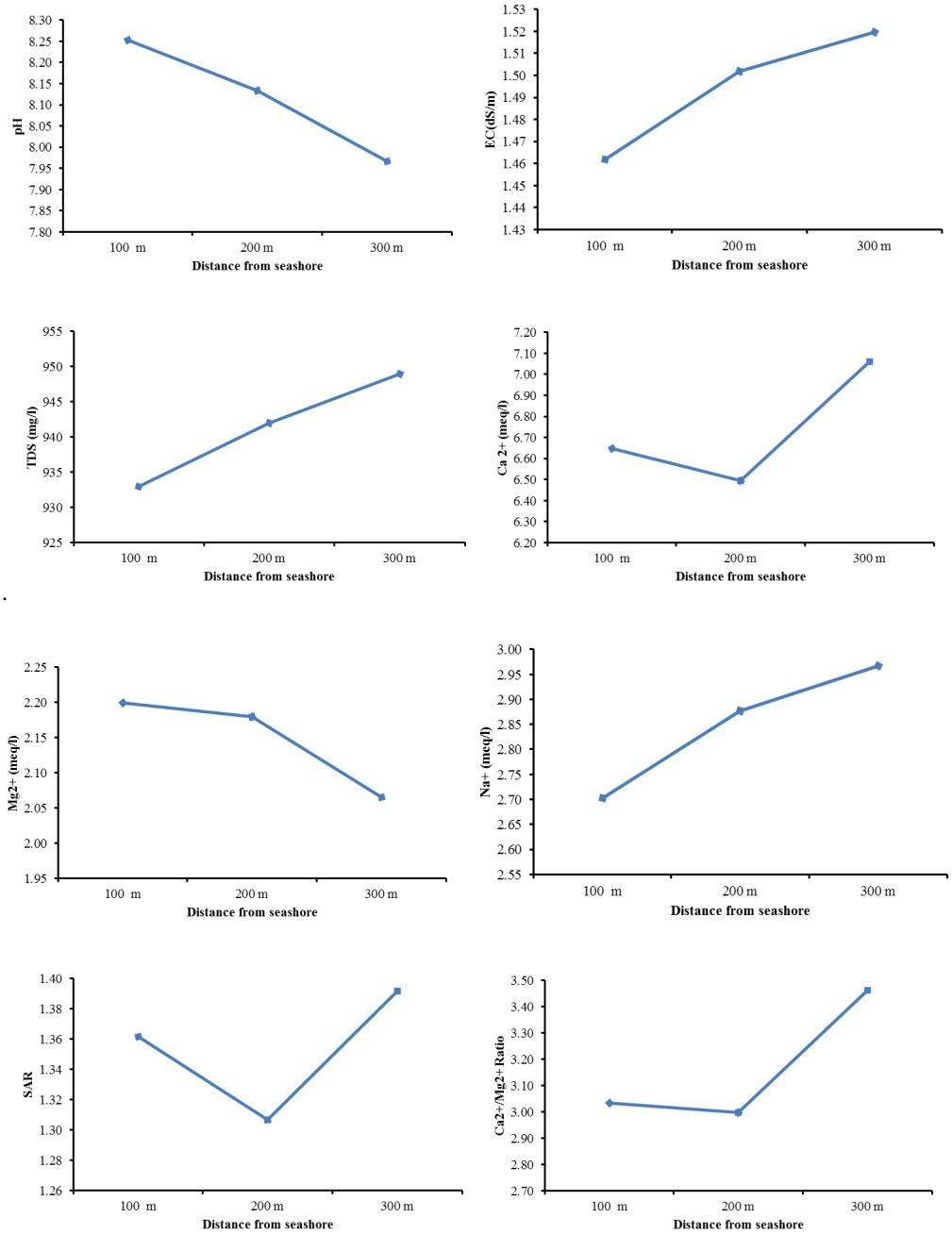

Figure-2
Physico-chemical parameters of irrigation water at different distance from seashore

Total Dissolved Solids (TDS): Total dissolved solids comprised of inorganic salts and some small amounts of dissolved organic matter and it has direct relation with EC[9]. From this study, it was found that TDS of well water ranged from 732 mg/l to 1065 mg/l with average value of 941 mg/l, which is higher than the desirable limit of 450 mg/l[5]. The levels of TDS were 933 mg/l, 942 mg/l and 949 mg/l at the distance of 100m, 200m and 300m away from seashore respectively (figure-2). Irrigation with high TDS water increases the EC value of the soil solution level[11].

Sodium (Na^+): Na is an important cation which in excess deteriorates the soil structure and reduces crop yield[12]. Sodium concentration varied from 2.3-3.21meq/l with the mean value of 2.85meq/l. The concentrations were also varied with distance from seashore (figure-2). According to this study, it was found that the Na^+ were 2.70 meq/l, 2.88 meq/l and 2.97 meq/l at the distances of 100m 200m and 300m away from the seashore respectively (figure-2). The concentrations of Na^+ were within the desirable maximum limit of 3meq/l [5]. However, the Na level was exceeded slightly in some locations. Geological conditions of the soil in addition to sodium salts might have attributed for higher concentration of Na^+ in these points. High level of Na^+ in water reduces the growth of bean and reduces the photosynthesis because of NaCl stress[13].

Calcium (Ca^{2+}): Supply of Ca^{2+} with irrigation water probably has a positive effect on protection of the cell wall and the plasmatic membrane and regulates the selectivity of ionic uptake[14]. Presence of calcium is directly related to hardness. In the present study, concentration of Ca^{2+} found to be 6.17 meq/l–8.12meq/l. The levels also varied with distance, shown 6.65meq/l, 6.50meq/l and 7.06meq/l at the distances of 100m 200m and 300m away from the seashore respectively (figure-2). The values fall within the maximum useable limit of 20meq/l[5]. It was confirmed that, high concentration of Ca^{2+} in plant medium under saline conditions increases the number of fruits per plant and total fruit yield[15]. However, it is also evident that the supply of Ca^{2+} in the irrigation water reduces uptake and transport of Na+ to the shoot and leaf[16]. The presence of Ca^{2+} in water may be due to the geological conditions and application of lime to soil in the study site.

Magnesium (Mg^{2+}): Magnesium content of water is considered as one of the most important qualitative criteria in determining the quality of water for irrigation. According to this study, concentration of Mg^{2+} ranged from 1.76meq/l to 2.53meq/l with an average of 2.15meq/l. It was also showed that the levels of Mg^{2+} varied slightly with distance from seashore (figure-2). However, it falls within the maximum useable limit of 5meq/l[5]. In general, concentration of Mg^{2+} usually lesser than concentration of Ca^{2+} due to the fact that the dissolution of magnesium rich minerals is slow process[4].

Sodium Adsorption Ratio (SAR): The SAR measures sodicity in terms of the relative concentration of sodium to the sum of calcium and magnesium ions in water and used to assess the suitability of irrigation water. The degree to which irrigation water tends to enter into cation-exchange reactions in soil can be indicated by the sodium adsorption ratio. The SAR value of the irrigation water at the present study site ranged from 1.07–1.57. Further, the levels showed slight variations with distance from the seashore (figure-2). Water with SAR ranging from 0 to 3meq/l is considered good and with greater than 9meq/l is considered unsuitable for irrigation purpose[17]. Therefore, as far as the SAR value is concerned water in the present study has less sodium toxicity.

Ca^{2+}/ Mg^{2+} ratio: In the present study, Ca/Mg ratio was found as in between 3.21 – 3.51, and the ratios at different distances from seashore showed similar trends (figure-2). The concentration of Ca^{2+} was higher than Mg^{2+} in all sampling points. Hence, there is no Mg^{2+} hazard in irrigation water. In general, irrigation water having comparatively more Mg than Ca proved deleterious not only for cops but also impaired the soil conditions[18]. The high level of Ca^{2+} might be due to the parent material inherently of calcic origin or the effect of salt water intrusion into the irrigation water source.

Conclusion

This study shows that the groundwater quality parameters such as pH, cations, SAR and Ca^{2+}/Mg^{2+} ratio are within permissible limits. However, EC and TDS slightly exceed the desirable limits for irrigation purpose. The quality parameters do not vary much with distance from the seashore. Calcium is the dominating cation followed by sodium and magnesium and thus there is no magnesium hazard. Further, there is a possibility of increasing EC, TDS and sodicity hazard in the study area if over exploitation of the ground water for the irrigation. In overall, this water can be used for irrigation purpose with the suitable management practices especially to control the salinity and sodicity hazard.

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