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THE SODIUM ABSORPTION RATIO IN NEYVELI AQUIFER

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Abstract: *A highly potential confined aquifer occurs in the South arcot district of Tamil Nadu (South India) covering large area of Cuddalore, Chidamparam and Virudhachalam Taluks, and is referred as Neyveli aquifer. The estimated recharge rate is in the order of 90M m^3 per year to 159M m^3 per year with a safe average of 120M m^3 per year. The pumped water has been used for thermal power station, fertilizer industry, agriculture purpose, township water supply and Chennai Metro Water Supply. The quantitative exploitation is steadily increasing year by year, quality aspects becoming increasingly important, since the aquifer is extending deep in to the Bay Bengal. Therefore the study aims to understand the Sodium absorption ratio of Neyveli aquifer. The study area is divided into three zones namely zone-1covers all around Neyveli, zone-2 covers between Neyveli and near Chidambram, and zone-3 between Neyveli and Cuddalore about thirty water samples have been collected during January 2004 over the entire study area and analyzed for Na, Ca, Mg and Sodium absorption ratio have been calculated. The value of Sodium absorption ratio is less than ten throughout the study area except in few location and follows the trends of increase in order from Zone-2>Zone-3>zone-1have been observed.*

Keywords: *Sodium absorption ratio, Percentage Sodium, Aquifer, Principal cations, Electrical conductivity*

INTRODUCTION

Ground water is precious and the most widely distributed resources of the earth and unlike any other mineral resources, it gets its annual replenishment from the meteoric precipitation. Intrusion of saline waters into aquifers in coastal regions occurs naturally and can be induced by exploitation of coastal aquifers as water sources. The intruded saline water can endanger, often practically irreversibly, the future exploitation of these water resources and so detection and monitoring of saline intrusion is essential to resource management. Early studies concentrated on major ion chemistry both as an ideal tracer' (e.g., Cl) of saline water intrusion and in distinguishing active intrusion from freshwater flushing and understanding the relation-ships between saline water bodies and surrounding freshwater in coastal sandstone aquifers (Cederstrom, 1946; Back, 1966; Howard and Lloyd, 1983; Mercado, 1985). The overexploitation of coastal aquifers for agricultural and drinking purposes, along with structural and climatic circumstances, increases possibility of seawater intrusion. The coastal zone of Neyveli aquifer was taken for discussions. This study tries to attempt analysis of some physico-chemical parameters of ground water in study area to asses Irrigation water quality. Irrigation water quality development. Salts are present in variable concentrations in all waters, concentrations influence refers to the kind and amount of salts present in the water and their effects on crop

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growth and osmotic pressure of the soil solution: the higher the concentration, the greater the osmotic pressure. Osmotic pressure in turn affects the ability of plants to absorb water through their roots. Plants can absorb water readily when osmotic pressure is low, but absorption becomes more difficult as the pressure increases. Even if the soil is thoroughly wet, plant roots have difficulty absorbing water when the osmotic pressure is high. When the pressure is unusually high, it may even be impossible for plants to absorb sufficient water for normal plant growth. Under these conditions, plants may actually wilt when the roots are in water. Salts break down into ions when they go into solution. The various anions and cations produced when the salts are dissolved in water exert considerably different effects on plants (Ramakumar, 2009). The ground water potential of Tmail Nadu gives the resources available for future use and the demand gives as an estimate about saline water intrusion due to over exploitation.

Ground Water resources of Tamil Nadu

The utilisable groundwater recharge is 22,423 MCM the current level of utilisation expressed as net ground water draft of 13.558 MCM is about 60 percent of the available recharge, while 8875 MCM (40 percent) is the balance available for use. Over the last five years, the percentage of safe blocks has declined from 35.6 per cent to 25.2 percent while the semi-critical blocks have gone up by a similar percentage. The water level data reveals that the depth of the wells ranges from an average of 0.93 meters in Pudukottai district to 43.43 meters in Erode. According to the Central Groundwater Board, there has been a general decline in groundwater level in 2003 due to the complete desaturation of shallow aquifers. There has been a considerable failure of irrigation wells in Coimbatore district (Tamil Nadu Development report, 2005). Over-exploitation has already occurred in more than a third of the 35.8 percent while 2 percent have turned saline in Tamil Nadu. The quantity of the water resources will meet the demand for irrigation and the quality of water decides fitment of irrigation water and the crop selection.

Ground Water Pollution in Tamil Nadu

The greater utilisation of water for industrial and domestic use and also due to the increased use of agricultural chemicals, ground water quality is deteriorating rapidly in the State. Diminished water quality also means that the quantum of fresh water available for particular uses is reduced, or that the water can be used only after treatment. Problems of water quality can be due to natural causes like geological formations or due to sea water intrusion.

1. In the black cotton soil areas of the State, dissolved salts are high.
2. In the coastal areas such as backwaters, estuaries etc. salinity levels are high. Effluents from the leather industry have contaminated the groundwater in the Palar basin.
3. Effluents from the textile industry have affected the groundwater in the Noyyal basin.
4. Seawater intrusion has taken place in some coastal areas due to over extraction of groundwater.
5. Excess application of fertilisers and pesticides has affected groundwater quality in certain pockets; high levels of nitrates are observed in the Western districts.

STUDY AREA

A highly potential confined aquifer occurs in the Cuddalore district of Tamil Nadu (South India) covering Cuddalore, Chidambaram and Virddhachalam Taluks, and is known as Neyveli Aquifer and referred as coastal aquifer shown in Fig-1. It has been estimated that the recharge rate is in the order of 90 - 150 Mm^3/Yr with a safe average of 120 Mm^3/Yr. The recharge is due to river flow percolation and rainfall with a recharge area of 350-360 km^2. The average rainfall in the area is about 1100mm, and the recharge is about 15 to 20 % of rainfall. The aquifer as it lies adjacent to the sea and there are indication that it lies underneath the sea between Cuddalore and Alapakkam. The aquifer outcrops in a NE-SW direction, the length along the normal being about 30 km and the average width at right angles to normal being 12 km. The river Manimuktar near Vriddhachalam is also flowing through the recharge basin and contributes to the recharge of the aquifer, river Gadilam in north also embraces the aquifer area. The aquifer, which is exposed in the recharge area gradually, dips in E-SE direction. The top of this aquifer occurs at about 73.1 m bgl in the first mine area and about 91.46 m bgl (below ground level) in the second mine area, and steeply in S-E direction in the sethiatope.

Geology of the study area

The aquifer swl as more or less steady about at 30 m above msl except for a small slope towards the sea, the hydraulic gradient being due to frictional loss during movement of ground water. So in places where the ground surfaces was lower than +30 m. The lignite deposit occurring at Neyveli on the top of the first aquifer separated by a thin layer of clay 1.5 to 3 m in thickness. While in open mine depth below which was dangerous to proceed

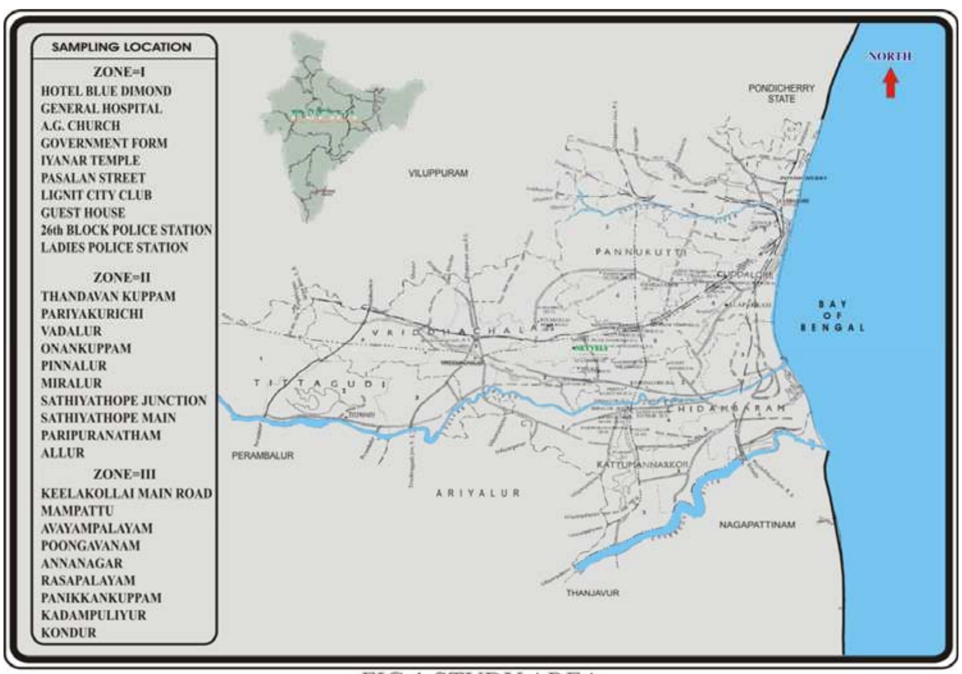


FIG:1 STUDY AREA

Hydro geological Characteristics of the study area

The average hydraulic characteristics of the aquifer were the storage coefficient S= $2.5X10^{-4}$, hydraulic conductivity K=40m/day, for thickness b= 30m, transmissibility coefficient T=Kb=1200 m^2/day. According to the water table depth the study area was divided into three zones. The water table depth is around 150 to 200 feet and the area mainly concerned with the industrial development and commercial area in Neyveli falling under the Zone-1. The water table depth was around 20 to 50 feet and the area between Neyveli to Chidambaram including Vadalur area mainly concerned with agricultural development falling under Zone-2. The water table depth was around 450 to 500 feet and the area between Neyveli and Cuddalore including Pannurutti falling under Zone-3 (Raghunath, 1990).

MATERIALS AND METHODS

The water samples were collected from open and boreholes in the study area. One liter of water samples were collected polythene bottles from various wells during the month of January 2004 covering summer season. Totally thirty samples were collected from three zones covering ten locations from each zone, for analysis various physio-chemical parameters, pH were measured portable pH meter, EC were measured Electrode. Cation, Calcium, Magnesium was analyzed volumetric method. Sodium, potassium were analyzed by Flame photometer meter, with respect to anions Chloride, Bicarbonate was carried out by volumetric method. Analyzing method followed (ALPHA, 1998).

RESULTS AND DISCUSSION

Irrigation water quality refers to the kind and amount of salts present in the water and their effects on crop growth and development. Salts are present in variable concentrations in all waters, and the salt concentrations influence osmotic pressure of the soil solution. The higher the concentration, the greater the osmotic pressure. Osmotic pressure in turn affects the ability of plants to absorb water through their roots. Plants can absorb water readily when osmotic pressure is low, but absorption becomes more difficult as the pressure increases. Even if the soil is thoroughly wet, plant roots have difficulty absorbing water when the osmotic pressure is high. When the pressure is unusually high, it may even be impossible for plants to absorb sufficient water for normal plant growth. Under these conditions, plants may actually wilt when the roots are in water. Salts break down into ions when they go into solution. The various anions and cations produced when the salts are dissolved in water exert considerably different effects on plants.

Principal Cations and Electrical Conductivity

The table 1 summaries the Principal Cations and Electrical Conductivity for Neyveli aquifer Calcium (Ca) is an essential plant nutrient. It occurs as limestone (calcium carbonate) and gypsum (calcium sulfate). Calcium carbonate considered slightly soluble, while calcium sulfate is moderately soluble. Waters from areas where gypsum is prominent are almost always high in calcium sulfate. Water contains high concentration of calcium or magnesium were considered hard and are not desirable for domestic water supplies, but hard water is considered good for irrigation. Calcium helps keep soils in good physical condition, which favors good water penetration and easy tilling. The concentration of calcium varying from 80-280 mgl^{-1} was observed over the entire study area and principal cations and electrical conductivity. Magnesium (Mg) is another essential plant nutrient found in abundance and the concentration of Magnesium varying from 16-120 mgl^{-1} was observed over the entire study area. Chemical reactions of magnesium in the water are similar to those of calcium. Magnesium normally occurs at about half the concentration of calcium, however, in the Portales area some irrigation waters have a magnesium concentration equal to or higher than calcium.

Table 1 Principal Cations and Electrical Conductivity

	Zone-1			Zone-2			Zone-3		
Zone	Min	Max	Average	Min	Max	Average	Min	Max	Average
Calcium (Ca)	80	280	208	90	238	132	94	239	135
Magnesium (Mg)	20	120	76	29	87	55	16	120	37
Sodium (Na)	13	83	67	73	121	77	15	126	65
Potassium (K)	1.9	13	5	2	14	7	1.9	10	5
Electrical conductivity mhos	0.42	0.89	0.52	2.03	11.26	4.4	0.32	4.87	1.7

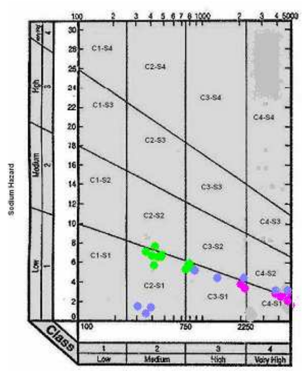
Sodium (Na), another cation, occurs in almost all irrigation waters in the state, generally not considered an essential plant nutrient, it is the most injurious of the cations found in irrigation waters. Unlike calcium and magnesium waters, those high in sodium are considered “soft” and are generally undesirable for irrigation. Unfavorable conditions are likely to develop when the concentration of sodium exceeds that of calcium plus magnesium. When clay particles adsorb the sodium, they tend to disperse and create “slick spots.” Sodium-affected soils take water slowly and form dry, hard clods that melt when wetted and tend to seal the soil surface, leaving a slick appearance. Sodium not only affects the soil structure, but also may have a toxic effect on plants. Sodium-affected soils can be improved by exchanging the adsorbed sodium with calcium and leaching out the sodium salt. Materials used to improve sodium soils include gypsum, sulfuric acid, and sulfur. The concentration of sodium varying from 13-122 mgl^{-1} was observed over the entire study area**.** Potassium (K) is an essential plant nutrient commonly found in soils ranging from 2-10 mgl^{-1}. Potassium was a minor element in irrigation waters, consequently, potassium determination was no longer a routine part of irrigation water analysis. The total concentration of salts in irrigation water is measured by the electrical current conducted by the ions in solution. This measurement is expressed as electrical conductivity or EC x 10^6. EC is an estimate of the quantity of salts in solution and is normally expressed in parts per million (ppm). The higher the salt concentration, the higher the EC.

Irrigation water quality (USSL Classification)

Irrigation water is classified based upon the Sodium Adsorption Ratio (SAR) and Electrical Conductivity (EC), USSL (United States Salinity Laboratory, 1954) classification, Sodium Absorption Ratio (SAR): Richards (1954) sodium adsorption ratio was calculated by the following equation

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

(All values in meq/l). Fig 2 shows the sodium absorption ratio against the electrical conductivity for Zone-1 plotted in green colour, Zone-2 in pink colour and Zone-3in blue colour. *Zone-1 i*n the study area most of the groundwater samples fall in the field of C2S1 and C2S2 indicating Medium-salinity water (C2) can be used if a moderate amount of leaching occurs, Low-sodium water (S1) can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium and Medium-sodium water (S2) may cause an alkalinity problem in fine-textured soils under low leaching conditions. It can be used on coarse textured soils with good permeability. Zone-2 High-salinity water (C3) cannot be used on soils with restricted drainage. Very high-salinity water (C4) is not suitable for irrigation under ordinary conditions, but it may be used occasionally under very special circumstances and Low- sodium water (S1) can be used for irrigation on almost all soils with little danger of developing harmful levels of sodium. Zone-3 fall under C2S1, C3S1 and C4S1 Medium-salinity water (C2) can be used if a moderate amount of leaching occurs. High-salinity water (C3) cannot be used on soils with restricted drainage. Very high-salinity water (C4) is not suitable for irrigation under ordinary conditions, but it may be used occasionally under very special circumstances. While comparing the values of Vedarniyam ground water studied in the year 2007 (Ramkumar, 2010) as C4S4 and C4S3 comparably good quality of groundwater was observed in Neyveli aquifer.



Percentage Sodium

Irrigation water having a higher sodium percentage will, after some time, give rise to a soil having a large percentage of replaceable sodium in the colloid. Such a soil is given known as black alkali. The percentage of sodium is determined from the following equation

$$\text{Percentage Sodium} = \frac{100Na}{(Ca+Mg+Na+K)}$$

If the percentage of Sodium is more, the aggregation of soil grains breakdown, and the soil become less permeable. Even on sandy soils with good drainage, water 85% sodium or higher are likely to make soils impermeable after prolonged use. With constant irrigation high sodium water, the soil become plastic and stickey when wet and forms clods and crust on drying. The table 2 shows the percentage sodium in various zones of Neyvelli aquifer.

Table 2 Percentage sodium

	Zone-1			Zone-2			Zone-3		
Zone	Min	Max	Average	Min	Max	Average	Min	Max	Average
Percentage sodium	8.6	29.80	18.0	27.02	30.8	29.0	9.44	32.88	23.3

The average value of percentage sodium is less than 20 represents the water quality was excellent for irrigation, whereas in zone 2 and zone 3 were lying between 20 to 40 represents water quality was good for irrigation.

CONCLUSION

Excess abstraction of water for domestic and industrial supply and agricultural uses without proper planning and priorities will adversely affect the surface water. The ground water table is being depleted year after year due to the failure of monsoon, inadequate recharge of the aquifers and excessive pumping of water from the wells over and above the annual recharge into the aquifers. In coastal aquifers the excessive pumping also causes saline water intrusion towards fresh water aquifer, and mixing of saline water with fresh water. This process of saline water intrusion is irreversible and causes the degradation of the quality of ground water with high concentration of TDS and mineral like chlorides and renders the ground water unsuitable for the purposes for which they were serving. The sodium absorption ratio was good in zone -1, Zone -3 and moderately good in the zone-2 and the average value of percentage was less than 20 in zone-1 and very nearer to 20 in Zone -2 and Zone-3 reveals good quality of ground water in Neyveli aquifer.

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