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STUDY OF SEA WATER INTRUSION OF PUDUCHERRY COASTAL AQUIFER BY CHEMICAL PARAMETER RATIO METHOD

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ABSTRACT

The groundwater from the coastal aquifers are subjected to over extraction, result in reduction of groundwater resource and lowering of water level. In general, the depletion of groundwater level enhances the landward migration of saltwater wedge. Puducherry is one such region which is presently vulnerable to sea water intrusion. Since the study area forms a part of the coastal aquifer system behaves as a fragile ecosystem. An attempt has been made in the present study to analyze the water quality parameters and to find the sea water intrusion regions in Puducherry. The water quality parameter comprises of physical, chemical and biological characteristics. Water samples were collected and analyzed for chemical characteristics such as Electrical Conductivity, Total Dissolved Solids, pH, Chloride, Calcium and Magnesium. It is found that Periyakalapet and Chinna kalapet region are affected by sea water intrusion in deep and shallow aquifers. But deep aquifer of Ganapathy Chettikulam is affected by sea water and shallow aquifer in the areas of Ganapathy Chettikulam and Veeram pattinam is vulnerable to sea water intrusion. The spatial extent of intrusion is observed more during summer season due to over pumping of groundwater.

KEYWORDS: Groundwater pumping, Groundwater recharge, Puducherry coastal aquifer, Sea water intrusion, Water quality.

INTRODUCTION

Saltwater intrusion is a major problem in coastal regions all over the world, as it threatens the health and possible lives of many people who live in the coastal areas. It increases the salinity of groundwater and water may become unsuitable for human use. Salinization of groundwater is considered a special category of pollution that threatens groundwater resources, because mixing a small quantity of saltwater in the groundwater makes freshwater unsuitable and can result in abandonment of freshwater supply. Due to the high population growth rate in coastal regions inhabited by about two-thirds of the world population, water demands have increased, leading to excessive abstraction from the aquifers and hence the migration of saltwater toward the aquifers (Ragunath, 2006). In coastal areas the aquifers are in hydraulic contact with the sea, and under normal conditions freshwater flows into the sea. However, over-pumping may result in inversion of the groundwater flow from the sea towards the interior, causing saltwater intrusion. Furthermore, the rise in sea levels accelerates seawater intrusion into the aquifers, thus further reducing the fresh groundwater resources. With the combined impact of sea level rise and over-pumping, the problem becomes very serious and requires control measures to protect available water resources from sea water intrusion.

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Sea water intrusion is the movement of saline water into fresh water aquifers. Most often it is caused by ground-water pumping from coastal wells or from construction of navigation channels or oil field canals. Pumping of fresh water from an aquifer reduces the water pressure and intensifies the effect, drawing salt water into new areas. When freshwater levels drop, saltwater intrusion can proceed inland, reaching the pumped well. To prevent this, more and more countries adopt extensive monitoring schemes and numerical models to assess temporal and spatial extent sea water intrusion in conjunction with groundwater recharge and discharge schemes. Adekunle et al (2008), Brian et al (2005), Adrian Werner et al (2011) and Oddmund et al (1994) has reported the effects and vulnerability index of seawater intrusion which mainly helps to know the status of intrusion in the aquifer. Many scientists have been working on simulation of sea water intrusion across the globe including India (Huyakorn *et al*, 1997; Putti & Paniconi,1995; Das & Datta, 2000; Sarva Mangala, 2011). The studies carried to focus the effects of sea water intrusion in the Puducherry region by analyzing the water quality parameters. Sathish et al (2011), Ramkumar et al (2010) has reported the analyzing of water quality parameters. Sivaraman et al (2010) and Shanmuga et al (2010) have reported the effect of contamination in specific zones of Puducherry region.

In order to develop any simulation and also optimization model that necessarily seeks to optimally exploit a coastal aquifer, it is necessary to investigate the coastal aquifer responses to the plausible stress scenarios. Theoretically, there can be an infinite number of plausible scenarios of aquifer stresses. However, a few typical stress scenarios (Das and Datta, 2001) might prove to be sufficient to (i) analyze the nature of aquifer responses, (ii) demonstrate the adequacy and viability of incorporating a mathematical model for simulation of the seawater intrusion phenomenon in coastal aquifers within a management model, and (iii) motivate the future formulation of optimization models. This paper presents the responses of coastal aquifers to some typical scenarios of aquifer stresses.

Hence for the conservation of fresh water resources, proper management and modernized technique should introduce to control sea water intrusion. However sea water intrusion cannot be prevented fully, but it can be controlled by using new techniques such as recharging the aquifer through rain water harvesting from roof top, artificial recharge by wells, pits, shafts, etc. Subsurface barrier are another controlling measures to reduce the sea water intrusion.

STUDY AREA

Puducherry is a coastal region which spreads over 840 km^2 including the Puducherry Union Territory with an area of 297.5 km^2, bounded between latitudes 11˚45'N and 12˚05' N and longitudes 79˚31' E and 79˚5' E (Figure 1). The region is impounded with Bay of Bengal on the East, Ponnaiyar River in the South and Kaluvezhi swamp in the North. Also it comprises, part of Cuddalore and Villupuram districts of Tamil Nadu State. This region in general, is a flat plain with an average elevation of about 15 m above mean sea level (MSL).The climate of Puducherry region is humid and tropical. The mean monthly temperature ranges as 22°C to 33°C. The average annual rainfall at Puducherry was 1254 mm. The region receives rainfall both from the south-west (June-September) and north-east monsoon (October-December). The region is drained by two rivers, Gingee in the north and Ponnaiar in south. The extent of coastal area in Puducherry is 70 km^2.

The study area is subjected to sea water intrusion due to extraction of fresh water from the coastal aquifer. The water quality samples collected from the nine wells are located in the Figure 1.

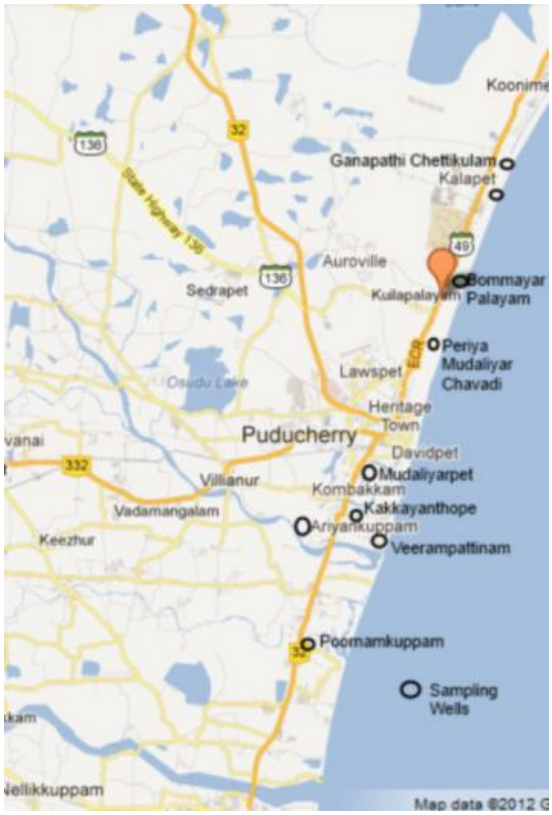

Figure 1. Study area and location of wells.

METHODOLOGY

An approach is taken to demarcate the present status of the sea water intrusion in the study area through water quality sampling. The detailed methodology adopted for the study is presented in Figure 2. The American standard of water quality is followed to carry out water quality sampling. The main reasons for analyzing the water quality are to 1) know the quality of Water, 2) compare it with the standards, 3) locate the area of contamination and 4) predict the reasons for contamination.

In most of the vulnerable areas of sea water intrusion at a distance of 1 km from the coastal area was selected for the purpose of water quality sampling. The samples were collected from both deep aquifer and shallow aquifer. The chemical properties of the samples were analyzed within a time span of two days after collecting the sample. The chemical properties of the samples were analyzed for a period of four months (January to April, 2012). The tested results are compared with permissible limits of the intrusion. This could help to demarcate the status of sea water intrusion and to implement the controlling techniques.

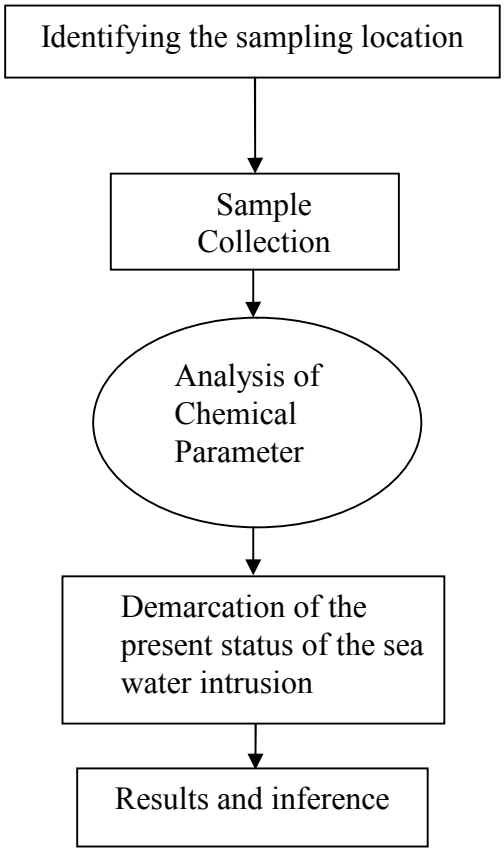

Fig. 2 Flow Chart of Methodology

RESULTS AND DISCUSSION

The important problem in the study area is sea water intrusion. It leads to less in groundwater quality. In this study, the groundwater samples are collected for four months and analyzed for water quality parameters such as Electrical Conductivity, Total Dissolved Solids, pH, Chloride, Calcium and Magnesium.

INDICATORS OF PERMISSIBLE LIMIT FOR SEA WATER INTRUSION

Different permissible limit for intrusion, which is evaluated in order to find out the intruded areas, is presented in Table 1. Brian *et al*. (2005) has reported the salinity mapping by using different chemical parameter ratios. The method is the most simplest and effective in assessing status of sea water intrusion.

Sl. No.	Parameter	Permissible limit for Intrusion of Seawater	
1	Chloride/Bicarbonate ratio	≤ 1.5	Unit less quantities
2	Chloride/ (Bicarbonate+Sulphate) ratio	≤ 1	
3	Magnesium/Calcium ratio	≤ 1	
4	Sodium/Chloride ratio	≤ 0.9	
5	Sodium/Total Hardness ratio	≤ 1.9	
6	Sulphate/Bicarbonate ratio	≤ 1.0	
7	Electrical Conductivity	≤ 1500	µmhos/cm
8	Total Dissolved solids	≤ 2000	mg/l
9	Chloride	≤ 1000	mg/l

Table 1. Permissible Limit for Sea Water Intrusion (Brian et al. 2005)

DEEP WATER: Mg / Ca RATIO

In the study area the deep water boring which is more than 100 ft depth is taken as deep aquifers.

S.l no	Habitation	Jan	Feb	Mar	April
1	Mudaliyarpet	0.106	0.117	0.115	0.126
2	Poorankuppam	0.467	0.449	0.442	0.500
3	Veerampatinam	0.566	0.604	0.640	0.673
4	Pudukuppam	0.729	0.937	0.800	1.000
5	Kakaiyanthope	0.545	0.395	0.361	0.416
6	Chinna mudaliyar chavadi	1.769	1.200	1.400	1.351
7	Ariyankuppam	1.017	1.000	1.033	1.016
8	Ganapathy chettipalayam	2.500	2.210	2.250	2.095
9	Periyakalapet	2.343	2.108	2.285	2.285

Table 2. Mg / Ca ration of deep water

Table 2 shows that Chinna Mudaliyar Chavidi, Ganapathy Chettipalayam and Periyakalapet are the regions affected by more sea water intrusion. Ariyankuppam seems to be closer to the intrusion.

SHALLOW WATER: Mg / Ca RATIO

In the study area, a depth of 40 feet is considered as shallow water aquifer. Samples collected and analyzed for the parameters (Table 4) mentioned above for wells having a depth of 40 feet.

S.l no	Habitation	Jan	Feb	Mar	April
1	Mudaliyarpet	0.354	0.329	0.414	0.400
2	Poorankuppam	0.701	0.719	0.700	0.775
3	Veerampatinam	1.031	0.937	1.066	1.166
4	Pudukuppam	0.571	0.590	0.663	0.641
5	Kakaiyanthope	0.439	0.469	0.581	0.583
6	Chinna mudaliyar chavadi	0.740	0.666	0.880	0.892
7	Ariyankuppam	0.341	0.365	0.400	0.435
8	Ganapathy chettipalayam	1.155	1.066	1.250	1.238
9	Periyakalapet	2.343	2.500	2.184	2.125
10	Pillaichavadi	0.436	0.472	0.583	0.580
11	Periya mudaliyar chavadi	1.027	1.055	0.952	0.933
12	Bommaiyar palayam	0.700	0.420	0.822	0.791
13	Chinna kalapet	1.722	1.555	2.000	1.600

Table 3. Mg / Ca ratio of shallow water

Table 3 shows that Chinna Kalapet and Periya Kalapet are more severe to the Sea water intrusion. Ganapathy Chettikulam and Veeram pattinam shows minor occurrence of seawater intrusion which can be reduced using suitable recharge techniques.

CONCLUSIONS

From the result obtained in this study, two region of Puducherry named Periyakalapet and Chinnakalapet exceeded the permissible limit and several other regions are within the permissible limit. While considering Mg / Ca ratio, Periyakalapet and Chinna kalapet exceeded the permissible limit and found salt water intrusion and in Ganapathi chettikulam considered as deep aquifer which is fully affected by seawater intrusion while shallow water table aquifers showed a tolerable sea water intrusion. In order to reduce sea water intrusion, suitable recharge method and reduce over withdrawal of ground water is recommended.

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