CONTAMINATION OF GROUNDWATER IN SRIKAKULAM COASTAL BELT DUE TO SALT WATER INTRUSION

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Abstract

Many urban centers of the country are located on the coastal tract apart from thousands of villages and industrial settlements. Water resources in coastal areas assume a special significance since any developmental activity will largely depend upon availability of fresh water to meet domestic, industrial and agricultural requirements.This increases the dependency upon groundwater for meeting the freshwater demand. As the region is close to the coast, the variations in the levels of water table due to excess withdrawals from wells and bore wells will cause the intrusion of seawater into the groundwater. In the present paper deals with the study of saltwater intrusion in the coastal tract of Srikakulam district, on an areal basis. From the results obtained the variation in the effect of contamination with respect to distance from shore is studied and a comparison of the contamination in open wells and bore wells is also carried out.

Key words: coastal tract, Conductivity, Contours, GIS, Coastal aquifers

1.Introduction

Water is naturally available in space and time but not necessarily in accordance with man's numerous needs. Technological activities have made it available even more conveniently and abundantly. Water supply for drinking, agriculture, municipal and industrial purpose is some of the familiar technological activities. In view of rapid population growth and proposed economic developments there is an increasing problem of resource depletion and environment pollution. Water is related to the economic development in complex manner. Therefore long-term policy planning is now increasingly being emphasized in India and as a part of the same assessment, exploration and planned utilization of ground water becomes necessary in urban and semi-urban areas where the population growth is rapid. GIS is playing role a significant role in making it possible to undertake studies on sustainable water resources development planning. Of the many essential elements for the existence of human being and the animals are universally require air, water food, shelter etc… Water's importance is rated as the highest. Water is considered absolutely essential to sustain life. Since the protoplasm of many living cells contain about 80% water and any substantial reduction in this level is disastrous. Most of the biochemical reactions which occur in metabolism and growth of living cells involve the medium of water. It is estimated that two-thirds of human body is constituted of water. Waters required for satisfactory performance of physiological organisms, as a circulatory fluid, as a carrier of nourishing food and for the removal of products of wastes. Ground water is water that is found underground in the cracks and spaces in soil, sand and rock. Groundwater is stored in and moves slowly through layers of soil, sand and rocks called Aquifers typically consists of gravel, sand, sandstone, or fractured, like limestone. These materials are permeable because they have large connected spaces that allow water to flow through. These speed at which ground water flow depends on the size of the spaces in the soil or rock and how well these spaces or connected. The area where water fills the aquifer is called the saturated zone. The top of this zone is called the water table. The water table maybe located only a foot below the grounds surface or it can sit hundreds of feet down. The ground water can be found everywhere. The water table may be deep or shallow and may rise or fall depending on many factors. Heavy rains or melting snow they cause the water table to raise or heavy pumping of ground water supplies may cause the water table to fall.

2. Saltwater Intrusion in Coastal Aquifers

Saltwater intrusion occurs naturally in almost all coastal aquifers. The definition of an aquifer is "an underground layer of water-bearing permeable rock or matter, like sand, gravel, clay or silt". Here, the groundwater can be extracted using a well. Along a coast there are many natural ways like precipitation, sea-spray accumulation, tides, and storm surges for salt water to be carried into and mix with a fresh water system. India has been blessed with a vast stretch of coastline. Many urban centers of the country are located on the coastal tract apart from thousands of villages and industrial settlements. Water resources in coastal areas assume a special significance since any developmental activity will largely depend upon availability of fresh water to meet domestic, industrial and agricultural requirements. However, fresh water resources in these coastal aquifers are likely to experience disastrous and irreversible impacts in the coming times due to overexploitation of groundwater resources and sea level rise. Human demand is doing greater damage to our freshwater levels than natural occurrences. Also, when salt water enters fresh water, most of the native plant life is destroyed. This is due to the concentration of the salt. This also causes erosion, which causes a reduction in our wetlands. Groundwater withdrawals in excess of safe yields and reduced recharges to groundwater due to rapidly changing land use pattern along the coasts have increased the incidences of seawater intrusions into the coastal aquifers. Classification of irrigation water based on salt concentration is given in table .1

Table:1 Classification of irrigation water

S.No	Type of water	Suitability for irrigation
1	**Low salinity water (C1)** Conductivity between 100 to 250 micro-mhos/cm at 25 0c	Suitable for all types of crops and all kinds of soils. Permissible under normal irrigation practices except in soil of extremely low permeability.
2	**Medium salinity water (C2)** Conductivity between 250 to 750 micro-mhos/cm at 25 oc.	Can be used, if a moderate amount of Leaching occurs. Normal salt tolerant plants can be grown without much salinity control.
3	**High salinity water (C3)** Conductivity between 750 to 2250 micro-mhos/cm at 25 0c.	Unsuitable for soil with restricted drainage. Only high-salt tolerant plants can be grown.
4	**Very high salinity (C4)** Conductivity more than 2250 micro-mhos/cm at 25 0c.	Unsuitable for irrigation

3. Study Area

The soil in the areas adjacent to the river Vamsadhara is alluvial clay. In some areas like Ampolu, Srikurmam, K.Saiga there are pockets of light soil, predominantly sandy loam. The soil in the rest of the area is medium to heavy soil. "Heavy" soils with high clay content havea bulk density of about 1 gram per cubic centimeter; "light" soils with less clay and more sand and silt size particles have a bulk density of about half that (0.5 g/cc).

In the study area there are around 1500-2000 wells, including both bore wells and open wells. On average each well is utilised to meet the needs of an area of 1.5-2.0 acres. Some of the wells are owned by private people while the rest are dug and maintained by the local panchayati and government. A cluster of open wells and bore wells can be found by in the villages whereas in the agriculture fields bore wells are widely used and spaced over large distances. Agriculture is the main source of livelihood in the area. Apart from that, Fishing has always been a major source of income to the people of the Coastal track.

There are two seasons of cropping pattern in the study area namely kharif and rabi seasons. Kharif crops are sown by the beginning of the south west monsoon and are harvested in autumn. Rabi crops are sown in autumn and are harvested in spring. The important season for cultivation in the region is kharif season with the major crops being Paddy, bajra and Sugarcane. The sowing time for Paddy is june/july and harvested in October/November. The sowing time for bajra is June/august and harvested in September /October. The sowing time for sugarcane is February/march to December/march. The rabi season is utilised for cultivation of other secondary seasonal vegetables like groundnuts, mesta and brinjal. The climate of the study area is a basically a tropical type of climate where the monsoon season comes at the end of summer. However, the wide variations in temperatures of day and night are negated due to coastal proximity.

4.Methodology

Some of the wells which are highly effected by salt water intrusion are already discarded for domestic as well as agricultural proposes. Such kind of wells and other such contaminated wells in each area were identified by using the help of the local people. An approximate of 2-3 wells were chosen in each region (village) of the study area. A majority of the affected wells were found out to be bore wells as they penetrated to greater depths than open wells. This was one of the reasons for people preferring more number of open wells for domestic purposes. All the wells which are

chosen for the study purpose are identified and labeled with appropriate numbers. At each of the identified wells, the latitude and longitude of the location is found out by using a GPS instrument. The model of the instrument used for which purpose is, eTrex vista hcx model made by GARMIN manufacturers, which gives the accurate values of longitude and latitude of that particular well where the sample is collected.

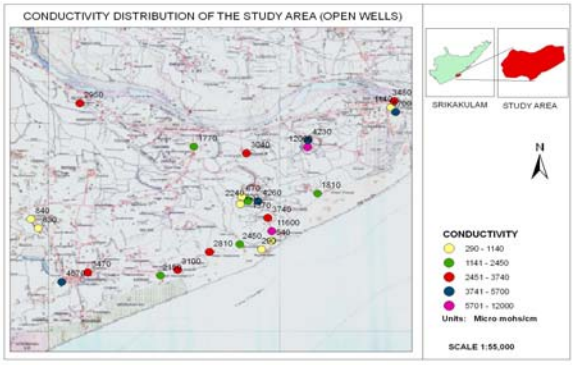
After identification and demarcation of each study well the next step was to determine the amount of contamination due to salt water intrusion in each of the wells. This can be determined by simply finding out the conductivity of the water sample collected from the wells. There are two ways in which we can determine the conductivity. The first way is a field-test in which a Conductivity Probe is taken to the field and having the sample from the well is checked on the spot itself. The other method is the laboratory test in which the samples are brought to the laboratory and checked for conductivity using Electrical Conductivity Meter available. For this study the laboratory method was followed. Samples of 100ml were brought from the field to the laboratory in 100ml plastic bottles.

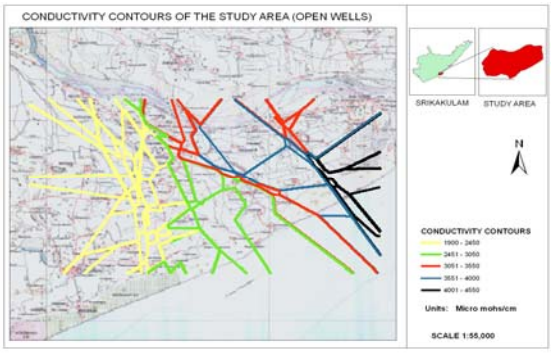
The collected samples are brought to the laboratory. The conductivity of the samples is determined by using Syntronics Conductivity Meter-304. The range of the instrumentis20µmhos – 200mmhos (µ-micro, m-milli). Each sample is cross checked two times for accuracy for values at 25ºC. The values obtained are tabulated.

5. Results and Discussions

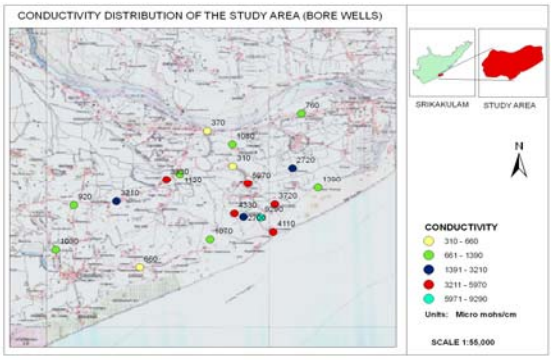
After collecting all the samples and finding out their conductivity values,. the maps are prepared separately for open wells and bore wells and maps showing the conductivity distribution and conductivity contours of the study are prepared and shown in below map1, map2, map3 and map4 . Based on these values subsequent graphs are obtained and observed.

Map 1: Conductivity Distribution of the study area (Open Wells)

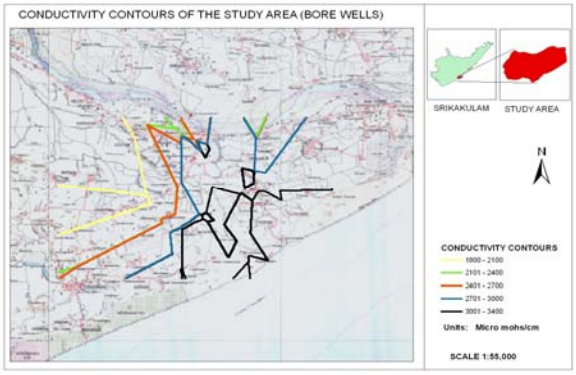




Map 2: Conductivity contours of the study area (Open Wells)



Map 3: Conductivity distribution of the study area (Bore Wells)

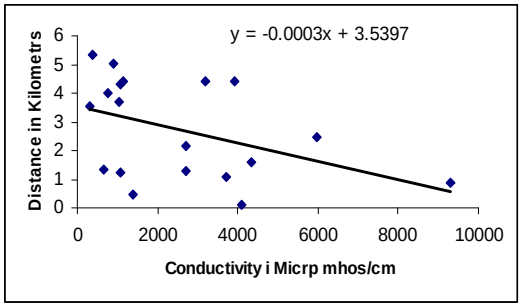


Map 4: Conductivity contours of the Study area (Bore wlls)

Conductivity with respect to Distance from the Coastal line (open wells)

The graph between conductivity Vs Distance is not uniformly varied (Fig: 1) but the average electric conductivity values in the study area are more nearer to the coastal belt. It indicates that the coastal belt is one of the reason for the increased values of the conductivity nearer to the coastal belt.

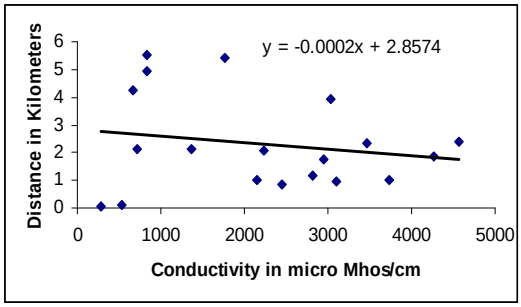
Fig.1 Conductivity vs Distance for open wells



Conductivity with respect to Distance from the Coastal line (Bore wells)

The graph between Conductivity Vs Distance (Fig: 2); the trend is same as the above open wells. But the slope towards the shore is more as compared with the open wells. It indicates that the salinity intrusion is more in case of bore wells as compared with the Open wells.

Fig: 2 Conductivity Vs Distance for bore walls



The salinity values are classified into four classes, namely, low salinity, medium salinity, highSalinity and very high salinity. The ranges and number of wells per class are given in table.2.Based on these values, the Severity Index can be calculated by dividing the number of wellsin each class with the total number of wells are given in table.3.

Table:2 Salinity ranges and number of wells per class

Class of salinity	Severity Index	Number of open wells	Number of bore wells
Low salinity	0	0	0
Medium salinity	13.33	3	3
High salinity	33.33	8	7
Very high salinity	53.33	15	9

Table:3. Severity Index

Sl.No	Type of water	Number of open wells.	Number of bore wells.
1	**Low salinity water (**Conductivity between 100 to 250 micro-mhos/cm)	0	0
2	**Medium salinity water (**Conductivity between 100 to 250 micro-mhos/cm)	3	3
3	**High salinity water (**Conductivity between 100 to 250 micro-mhos/cm)	8	7
4	**Very high salinity (**Conductivity between 100 to 250 micro-mhos/cm)	15	9

As we can observe from the severity index, we can find that more than half of the wells in the study area affected by very high salinity. This shows than salt water intrusion has already occurred to a great extent in the region and appropriate steps need to be taken for checking this problem.

Conclusion

In the present study area the salinity levels observed are in the range of 290-12000 micro Mhos/cm.In order to represent the degree of severity of salinity an index is proposed which is the ratio of number of wells crossing particular salinity level to the total number of wells. Among 45 wells 53.33% of wells are very high salinity, 33.33% of wells are high salinity, and 13.33% of wells are medium salinity. Based on those results, groundwater from all these wells is unfit for drinking and irrigation purpose. The study is carried out separately for open wells and bore wells. It is identified that bore wells are more affected by salinity than open wells in the study area. The possible reason for this is that the salinity concentration increases with depth of well. Based upon the geographical coordinates of the wells, mapping of the study area is carried out to represent the results of conductivity test. From the generated maps it is found that the concentration of

salinity with respect to distance from the shoreline is not varying uniformly and hence it can be attributed to variation in the geological strata and pumping pattern.

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