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Site investigations for the identification of a groundwater source for Sullurupeta, Andrha Pradesh, India

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Abstract: Sullurupeta is one of the major townships in Nellore district, Andhra Pradesh, having a population of 50,000. Following sea water intrusion, most of the aquifers around the township have became highly saline and are not fit for domestic or drinking water supply. Hence, there is an urgent need to identify an alternative groundwater source to meet the township requirements. A portion of Kalangi River was chosen for carrying out an investigation for the selection of a suitable site. It is essential that systematic investigations are carried out for such site selection because of heterogeneity of the geology which governs the occurrence, movement, quantity and quality of groundwater.

To identify the most suitable location, geological, hydrogeological, geophysical, and hydrogeochemical investigations are necessary. In the present study, such investigations have been applied and an area suitable for the development of large diameter wells identified.

The investigations revealed the geology of the area as alluvial formations over granitic gneiss with water restricted to a sandy aquifer, which lies at a depth ranging from 5.8 m to l5.5 m. This was also confirmed by geophysical data which indicated the occurrence of hard rock at an average depth of 11.2 m. Tested well yields ranged from 15.14 to 18.92 1itres per second. The water samples collected from the existing wells were analysed for various parameters and were found to be acceptable for drinking and domestic purposes.

Résumé: Sullurupeta est l'une des banlieues noires principales dans la zone de Nellore, Andhra Pradesh, ayant une population de 50.000. Après intrusion d'eau de mer, la plupart des couches aquifères autour de la banlieue noire ont sont devenues fortement salines et ne sont pas adaptées pour l'offre d'eau domestique ou potable. Par conséquent, il y a un besoin pressant d'identifier une source alternative d'eaux souterraines pour répondre aux exigences de banlieue noire. Une partie de fleuve de Kalangi a été choisie pour effectuer une recherche pour le choix d'un emplacement approprié. Il est essentiel que des investigations systématiques soient effectuées pour un tel choix d'emplacement en raison de l'hétérogénéité de la géologie qui régit l'occurrence, le mouvement, la quantité et la qualité des eaux souterraines.

Pour identifier l'endroit le plus approprié, les investigations géologiques, hydrogéologiques, géophysiques, et hydrogéochimiques sont nécessaires. Dans la présente étude, de telles investigations ont été appliquées et un secteur approprié au développement des puits de grand diamètre identifiés.

Les investigations ont indiqué la géologie du secteur en tant que gneiss granitique d'excédent alluvial de formations avec de l'eau limité à une couche aquifère arénacée qui se trouve à une profondeur s'étendant de 5.8 m à l5.5 m. Ceci a été également confirmé par les données géophysiques qui ont indiqué l'occurrence de la roche dure à une profondeur moyenne de 11.2 m. Bien examinés les rendements se sont étendus de 15.14 à 18.92 litres par seconde. Les échantillons d'eau rassemblés des puits existants ont été analysés de divers paramètres et sont avérés acceptables pour le boire et les buts domestiques.

Keywords: alluvium, drilling, pump test, hydrochemistry, geophysics, water table

INTRODUCTION

Sullurupeta is a major township in the Nellore district of Andhra Pradesh, with a population of some 50,000. Saline intrusion has rendered most of the surrounding aquifers unfit for domestic supply. The upstream area of Tanayali anicut (both banks of Kalangi river) of approximately 2 km^2 has been investigated in order to identify potential groundwater resources to augment the drinking water supply for Sullurupeta. In order to understand and identify the potential groundwater zones, geological, hydrogeological, geophysical, test drilling, pump testing and the hydrochemical investigations were carried out. The details of the site investigations conducted are discussed below.

LOCATION OF THE AREA

The area that lies between latitude N 13° 46' 10" and 13° 47' 00" and longitude E 79° 56' 36" and 79° 57' 36" was selected for the detailed investigation. The area is located in Survey of India toposheet No. 57 0/13 at a scale of 1:50,000 and is shown in Figure 1.

GEOLOGICAL INVESTIGATIONS

Detailed geological studies were conducted to understand the nature of rock units and their capabilities in terms of groundwater potential. The area is mostly covered by recent alluvial deposits consisting of small boulders, pebbles, sand and clay. Far away from the river course, a few lateritic outcrops are observed at the surface level. The bed rock is granitic gneiss.

HYDROGEOLOGICAL INVESTIGATIONS

In order to understand the occurrence, movement, quantity and quality of groundwater, detailed well inventory data were collected from 40 wells on both the banks of the river. The wells are all of similar construction, namely shallow dug wells of 1.2m diameter extended by tube wells. The total depths range from 5.8m to 15.5m and depth to water ranges from 1.5m to 9.1m. A typical well log is shown in Table 1.

Table 1. Typical well logs of the study area

Formation	Thickness (m)
Top soil	0.5-2.8
Hard clay	0.0-7.6
Sandy clay	0.0-4.4
Fine sand	0.0-5.1
Coarse sand	3.8-10.3

From the well inventory data, the summer season water table was not observed to fall below the base of the coarse sand.

GEOPHYSICAL INVESTIGATIONS

In order to understand the nature of subsurface lithology, geophysical investigations were carried out. Due to their ease and speed of use and reliability, many scientists have used electrical resistivity methods for groundwater identification (Patra & Nath 1997, Patra *et al.* 1978, Nath, Patra & Sahid 2000). Twenty five electrical resistivity soundings were conducted over the entire area on both banks of the Kalangi River using an electrode separation of 12m. The average depth of most of the wells is approximately 12 m, hence an electrode separation of 12m was chosen and interpreted by the standard method (Mooney & Wetzel 1956, Orellanna & Mooney 1966, Zokhdy 1989). The apparent resistivity values for an electrode separation of 12m were plotted (Figure 1) and a low resistivity zone of 20 Ohm-m identified on the right bank of the Kalangi River.

TEST DRILLING

Based on the hydrogeological and geophysical investigations, four locations were selected for test drilling. The lithological logs for at these test bores are given in Table 2. From the test drilling, it is evident that right bank is suitable for the development of groundwater down to a depth of about 11m.

PUMP TEST

Generally, pump tests are conducted to determine the aquifer parameters in an area in order to ascertain the potential of an aquifer (Patra *et al.* 1993, Singhal 1998). Pump tests were conducted at three of the existing wells for 4hrs and the measured discharge was recorded as being constant throughout the period of pumping. The farmers in that area pump the wells according to the availability of electricity, the maximum time limit for the availability of electricity ranging from 7- 9hrs. Pumping tests were conducted for four hours because no reduction in the discharge was observed. The depth to water table could not be measured because the water table was not visible in any well due to shallow dug-cum-tube-well nature of their construction. It was observed from the discharge data that no reduction in discharge occurred at any stage of pumping which indicates that the wells may have been in a steady state condition. Discharges ranged from 15.14 to 18.92 litres per second (lps).

HYDROCHEMISTRY

In order to understand the quality of water in the area of investigation, five water samples were collected and analysed for various parameters using standard methods (Rainwater & Thatcher 1960, U.S. Public Health Service 1962, Hem 1970, Amer. Public Health Assoc., Amer. Water Works Assoc. & Water Pollution Control Fed. 1975) and the results are given in Table 3.

From the above data, it is observed that sample no.3 shows high values of chloride, hardness and total dissolved solids. This may be due to its location in a fishpond, which could be responsible for the higher values.

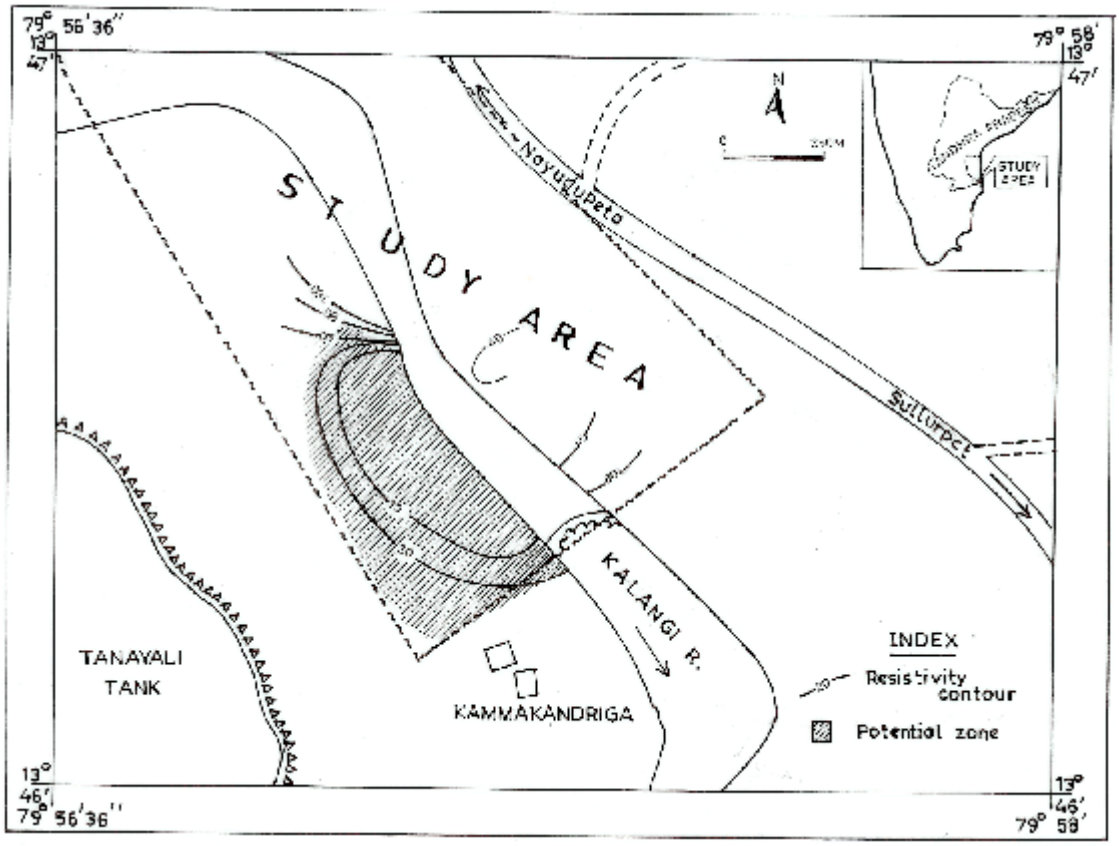

Figure 1. Map showing the location of study area, resistivity contours and potential zone

Table 2. Well logs of test bores

LITHOLOGY	TEST BORE-1	TEST BORE-2	TEST BORE-3	TEST BORE-4
	(Thickness in m)			
Top soil	0-1.5	0-1.0	0-0.5	-
Hard clay	1.5-4.2	1.0-2.0	0.5-3.2	-
Sandy clay	4.2- 5.7	2.0-3.1	3.2- 5.0	-
Fine sand	5.7-6.9	3.1-7.0	5.0 -7.2	0-6.6
Coarse sand	6.9-10.8	7.0-11.2	7.2-10.8	-
Hard rock	>10.8	> 11.2	>10.8	>6.6
Locations	13° 46' 24.3"	13° 46' 27.4"	13° 46'29.7"	13°46' 23.4"
	79° 57' 12.0"	79° 57' 09.3"	79° 57' 08.2"	79°57'21.8"
	(Right bank)	(Right bank)	(Right bank)	(Left bank)

Table 3. Analysis of water sample

Sample no.	1	2	3	4	5
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
Constituents					
Sodium(Na)	203	283	310	240	137
Potassium(K)	13	14	13	131	13
Calcium (Ca)	31	33	71	37	39
Magnesium(Mg)	20	53	44	20	16
Carbonate(CO_3)	12	12	20	39	24
Bicarbonate(HCO_3)	484	288	232	420	352
Chloride (CI)	151	480	603	209	105
Hardness as $CaCO_3$	160	300	360	176	164
Total Dissolved Solids	711	1045	1186	810	511
pH	8.40	8.40	8.45	8.55	8.50

CONCLUSIONS AND RECOMMENDATIONS

Based on the above investigations, the following are the interpreted results in order to identify areas having the potential for development.

From the geological investigations, it is evident that the groundwater potential in this region is restricted to recent alluvial deposits such as sand, pebbles and boulders.

The well inventory data revealed that the thickness of coarse sand ranges from 3.8 to 10.3m which is the only formation holding significant quantities of water. The depth to sand may not go beyond 15.5m. Hence, groundwater depth ranges from 4.5m to 15.5m which is a significant resource that can be tapped.

The electrical resistivity investigations were interpreted in order to identify the potential groundwater zones. As shown in Figure 1, the low resistivity zone of 20 Ohm-m was identified as having potential for groundwater development.

The test drilling data confirmed that the thickness of sand ranges from 6.9 m to 11.2m which is the only formation holding significant quantities of groundwater.

The pump test conducted on three wells indicated that discharges from 15.14 to 18.92 lps are possible.

The water analyses indicated that the water is potable. The range of total dissolved solids is from 511 to 1186 which is within the range of allowable limits.

From these results, it is evident that the area with potential for groundwater development is restricted to an area of c0.32km^2 on the right bank of Kalangi river, which is also upstream of Tanayali anicut (Figure 1). On the left bank, the occurrence of coarse sand is not found, hence, it is not suitable for the development of any type of well. On the right bank alone, one or two large diameter wells of 6m may be taken up to a depth ranging from 11.2m to 15.5m in order to augment water supply to Sullurupeta.

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