GPS-derived displacements (Table 1), while broadly conforming to the implications of reverse fault slips obtained from seismic data[2–4,12] (~15 m beneath Car Nicobar decreasing to half as much further north), are approximately parallel to the relative plate velocity between the Indian and Burma plates. However, while the surface displacement vectors at Car Nicobar and at Chatham Island are normal to the subduction boundary along this segment coinciding with the almost pure thrust mechanism of the main Sumatra and its extended rupture, those at Havelock and Diglipur are oblique requiring additional dextral strike-slip components, which could have been contributed by strike-slip ruptures or possibly aseismic strike-slip movements on the rupture plane.

While we are unable to quantify the separate contributions of co-seismic and post-seismic slip to our observed displacement vectors, we note that the positions were changing during the post-seismic measurements by 5 to 10 mm in several days. In summary, GPS measurements give a motion of the order of metres of Andaman Islands towards Bangalore in the southwest direction and also precise quantification of co-seismic displacements necessary to constrain the subsurface processes associated with the earthquake.


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ACKNOWLEDGEMENTS. We thank Dr C. P. Rajendran and Mr Anil Earnest, CESS, Trivandrum for their extensive involvement in setting up the five GPS control points (partly in association with C-MMACS, Bangalore) in the September 2003 GPS campaign, which has been funded by DST, New Delhi and CESS, Trivandrum. We acknowledge the pilot fast track grant received from DST for GPS measurements soon after the earthquake. We acknowledge the continuous support and encouragement from Dr Gangan Prathap, Director, C-MMACS for GPS projects. We thank Dr Tiwari and Dr Joshi, Baroda University for help with GPS receivers and M. S. M. Vijayan for technical assistance. We also thank the reviewers for excellent comments which helped immensely in improving the manuscript.

Received 28 March 2005; revised accepted 4 June 2005

# Changes in groundwater regime at Neill Island (South Andaman) due to earthquake and tsunami of 26 December 2004

**V. S. Singh*, M. V. Nandakumar, M. R. K. Sarma and V. P. Dimri**

National Geophysical Research Institute, Hyderabad 500 007, India

**The earthquake and tsunami of 26 December 2004 have caused vast devastation to human life and property. It has been severe in the Andaman and Nicobar Islands, particularly the Nicobar Islands. The earthquake has caused subsidence of land at some places and up-liftment at other places in many islands. Groundwater, which is only source of drinking water at some of the tiny islands, has been affected due to tsunami. Neill Island is one such island in South Andaman. Results of hydrogeological investigation before and after the earthquake and tsunami of 26 December 2004 are presented here.**

THE recent earthquake and tsunami of 26 December 2004 have caused severe destruction to human life and livelihood in the Andaman and Nicobar Islands. These islands have been receiving a series of aftershocks after the events. Thousands of people have died and several have gone missing. The earthquake and tsunami had major effects in parts of Car-Nicobar Islands. Many parts of the Middle and North Andaman have also suffered. Several places have submerged and many have been up-lifted. Houses have been completely washed away and many RCC structures have collapsed. Mud volcano has been activated in South Andaman (Bartang). In order to assess the effect of the earthquake and tsunami on Neill Island, particularly on the groundwater regime, a detailed investigation has been carried out.

The Neill Island lies in the South Andaman, about 32 km east of Port Blair and is part of Ritchie's Archipelago. It lies in the southern-most part of the Archipelago (Figure 1)

*For correspondence. (e-mail: vssingh77@hotmail.com)

between Havelock Island in the north and Sir Hugh Rose Island in the south. The aerial extent of the island is about 12 $km^2$ and is inhabited by about 2600 people. Major source of drinking water is groundwater tapped through shallow open wells. A 3D view of the island is shown in Figure 2. The eastern part is occupied by hills and forest. Most of the habitants occupy the low-lying areas in the foothills and in the central and western parts, and carry out farming utilizing groundwater.

Although Neill Island lies in the vicinity of Andaman, the earthquake of 26 December 2004 followed by tsunami have affected the groundwater regime to a limited extent. Details of hydrogeological investigations carried out prior to the 26 December event and post-26 December event are described.

Details of geological features of the island are described by Srinivasan and Azmi[1]. The western part of the island is occupied by limestone, whereas in the east massive mudstone forms high hills. The two major formations described are: (i) 'Sawai Bay Formation' occupying most of the island, particularly the eastern part and characterized by mudstone, and (ii) the litho unit, 'Neill West Coast Formation' consisting of limestone and mudstone and occupying the western part of the island. The Sawai Bay Formation of early Pliocene age is characterized by soft, light grey, massive calcareous mudstone. The top of the mudstone is overlain with shallow limestone and coral rags. All along the western coast, Neill limestone is exposed. It is weathered and at places pot-holes can be seen.

The island receives copious rainfall (about 3200 mm/yr) during the months between May and November, and most of it goes to the sea as surface and subsurface run-off. The water column in the wells becomes less than a metre in the pre-monsoon period.

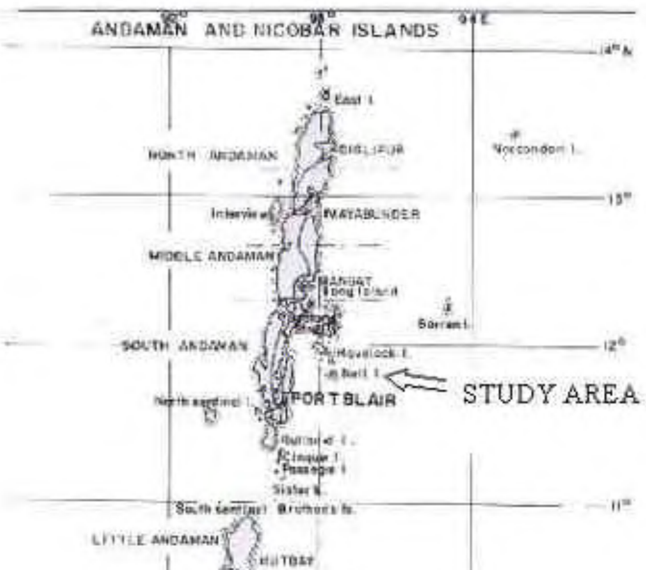


**Figure 1.** Location map of Niell Island.

Groundwater on the island occurs in the shallow coral sand and limestone, which are underlaid by mudstone. The thickness of the aquifer estimated from geophysical and hydrogeological investigations on the island varies from 0.5 to 7 m. The depth to basement of the aquifer with respect to mean sea-level is shown in Figure 3. It can be seen that in most part of the island, the base of the aquifer is relatively at a higher elevation than the mean sea-level, except in the central part near the jetty where it is below mean sea-level. It is this part of the island which is prone to sea-water intrusion.

The pre-monsoon and post-monsoon depth to groundwater level is shown in Figure 4 *a* and *b* respectively. It can be seen that in most part of the island, the groundwater is at a higher level than the mean sea-level and hence sea-water intrusion may not take place. The electrical conductivity (EC) value measured during post- and pre-monsoon season is depicted in Figure 5 *a* and *b* respectively, which indicates that there is limited effect of sea-water intrusion on the groundwater regime. The water column measured in the wells during post- and pre-monsoon is shown in Figure 6 *a* and *b* respectively. It can be seen that during pre-monsoon period, most of the wells have little water column left in them.

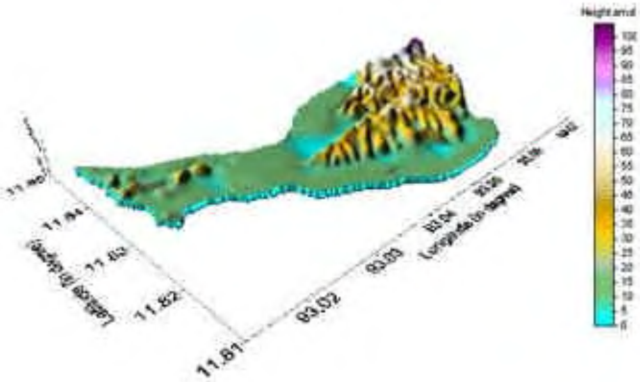

**Figure 2.** 3D view of Niell Island.

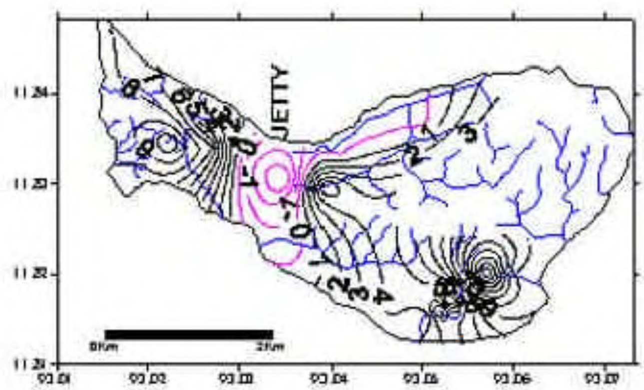


**Figure 3.** Base of aquifer above mean sea-level.

a b

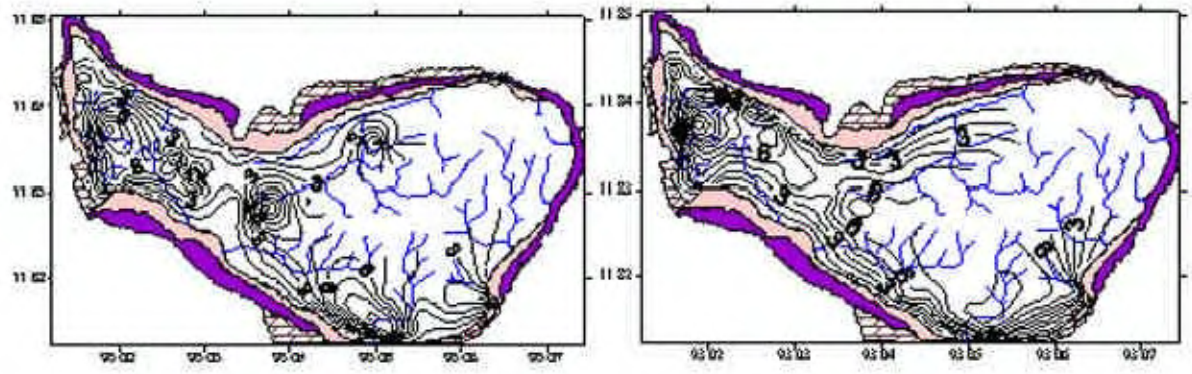

**Figure 4.** Pre-monsoon (***a***) and post-monsoon (***b***) water level (m amsl).

a b

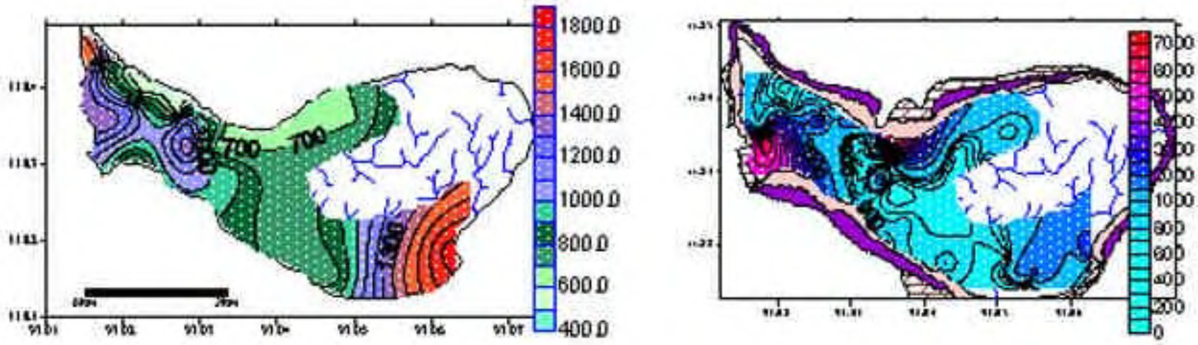


**Figure 5.** Post-monsoon (***a***) and pre-monsoon (***b***) electrical conductivity (μmho/cm) of groundwater.

a b

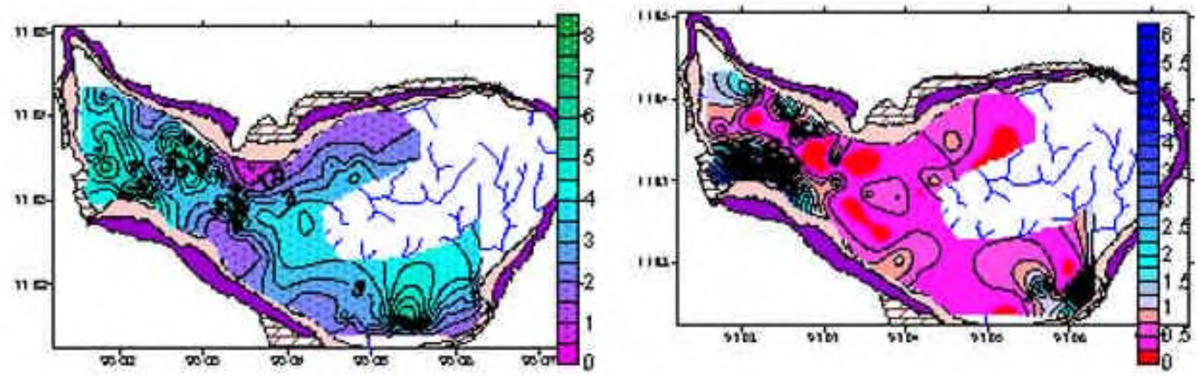


**Figure 6.** Water column during (***a***) post-monsoon and (***b***) pre-monsoon.

a b

**Figure 7.** ***a***, Cracks in road, well and field. ***b***, Subsided coral sand.

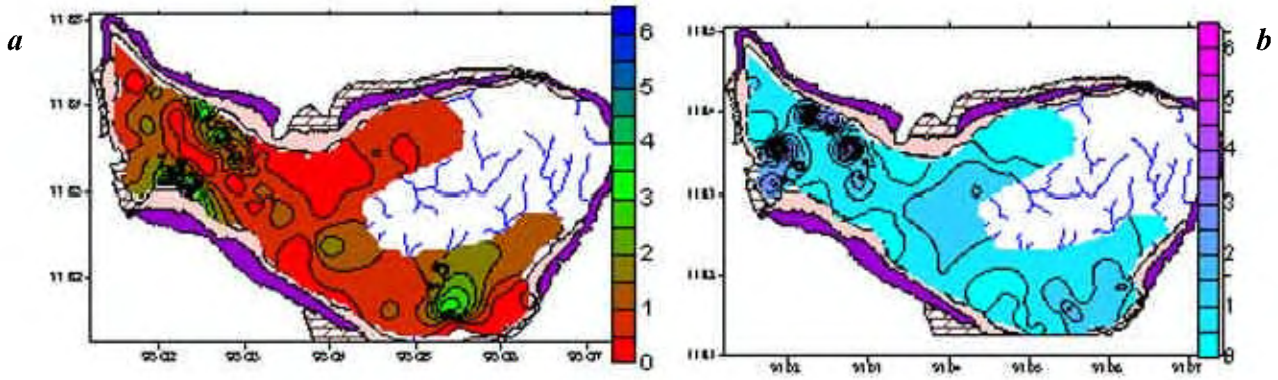


**Figure 8.** ***a***, Water column during January 2005. ***b***, Change in water column from November 2004 to January 2005.

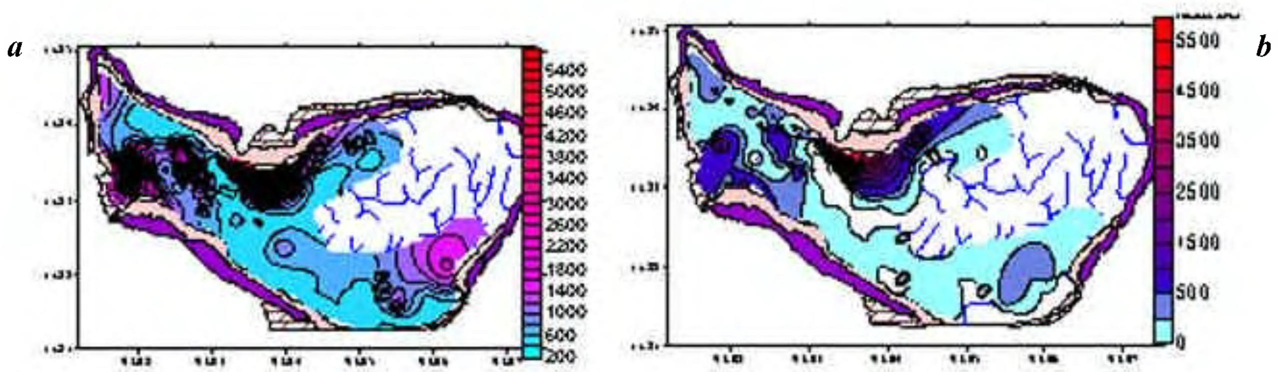


**Figure 9.** ***a***, EC during January 2005; ***b***, Change in EC of groundwater.

After the earthquake of 26 December and the tsunami event, hydrogeological investigations on the island have been carried out during the month of January, to assess the effect of these events on the groundwater regime.

It has been found that a couple of cracks have developed in the ground in the southwestern part of the island. These cracks are in the limestone formation cutting across the well structures, fields as well as the metalled road (Figure 7 *a*). Due to these cracks, the overlying coral sand at places has collapsed into these cracks (Figure 7 *b*).

The water level measured in about 105 wells spread all over the island has not shown any significant rise or fall; a few wells have become dry in the western corner where cracks have developed. Figure 8 *a* shows the water column in the wells. The water level is as expected during pre-monsoon period. Some of the wells in this region have been found to become dry due to these openings. The observed change in water level from the month of November 2004 to January 2005 is depicted in Figure 8 *b*. It can be seen that maximum change has occurred in the south western part of the island.

EC, a measurement of groundwater salinity, has been monitored on the entire island and is found to vary from 600 to 5600 μmho/cm (Figure 9 *a*). EC of groundwater observed during the month of January was similar to that during pre-monsoon (April). The tsunami has affected these low-lying areas and the quality of groundwater is similar to that during pre-monsoon (April). The change in groundwater EC from the month of November 2004 is shown in Figure 9 *b*. The change in groundwater quality is prominent in the north-central part near the jetty and in the southwestern part, which is low-lying and open to sea. The area around the jetty is at the sea-level, hence the groundwater quality is severely affected.

The earthquake of 26 December 2004 has caused cracks in the aquifer lying in the southwestern part of the island, which comprises of limestone. The groundwater in this part has gone deeper due to fractures developed in the limestone formation. The depths of the wells are above mean sea-level. It has also affected the quality of groundwater.

The groundwater quality in the low-lying areas around the jetty (at the centre of the northern beach) has also been severely affected due to tsunami. Most parts of the island which are protected either by high hills of mudstone or have relatively high elevation of ground have not been affected by the tsunami.

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Received 28 February 2005; accepted 12 April 2005