THE INDIAN OCEAN TSUNAMI AND ITS IMPACT ON ANDAMAN ISLANDS: A DETAILED POST-TSUNAMI FIELD STUDY

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Abstract

This paper is a report on the field observation undertaken through the DST project immediately after the occurrence of December 26, 2004 earthquake of magnitude >M 9.0 that occurred off the west coast of Sumatra Island of Indonesia with its epicenter located on the shallow depths in the Indian Ocean. The tsunamigenic earthquake that occurred on 26th December 2004 in the Indian Ocean caused severe damage and claimed many victims in some coastal villages through out the Islands. The main purpose of the survey was to assess morphological changes caused by the wave attacks and to evaluate the impact of the event on buildings, bridges and infrastructure. Attention was predominantly focused on the entire group of Andaman Islands such as Diglipur (North Andaman), Mayabunder, Baratang and Rangat (Middle Andaman) and Port Blair, Havelock and Hut Bay areas (South Andamans and Little Andamans), were examined for the most affected places in the islands. The most severe damage was observed at Hut Bay, in Little Andaman, where the buildings and coastal walls and the jetties were almost levelled by the violent waves. Most places were hit by these waves with documented wave height often exceeding 2-5 m according to the evidence by the local people and by filed investigations. The coastal landforms are changed and stagnation of the tsunami water is seen in the low lying areas of South Andaman. On the west coast of the Andaman, the coastline witnessed the raised reef flats to above the present day high tide mark, similar uplift of shallow fringing reefs. It was observed that a few kilometres of shallow water reef are now dead in the Diglipur area of North Andaman. In Sippighat creek (South Andaman) area, it was observed that the Mangrove was completely submerged with seawater and completely turned brownish, indicating that it had been dead. As a sequel, the maximum damage has been taken place to the structures very close to the low laying areas of the coast and severe impact has been noticed on the mangrove forest of Baratang and south Andaman localities. It is further noticed that few mud volcanoes of Baratang area became activate and started ejecting heavier mud.

Keywords: Tsunami, impacts, corals, mangroves, creeks, beaches, Andaman

Introduction

The deadliest Indian Ocean tsunami originated due to the occurrence of the Sumatra earthquake (magnitude >M 9.0, on Richter scale) of December 26, 2004 at 0:58:51 UT or 6:28:51 IST. The epicenter of the Sumatra earthquake (3°.2510N & 95°.7990E) was located about 255 km SSE of Banda Aceh, Sumatra, Indonesia at a depth of 10 km. (USGS, 2005). This resulted in upliftment of seafloor, which resulted in Tsunami, killing thousands of people across different countries. The Andaman and Nicobar islands located on the subduction zone of Burma Plate is

classified as Seismic zone 5 indicating high level of risk due to earthquake. Tsunami waves hit the Andaman and Nicobar group of islands within few minutes. The impact caused the uplift of North Andaman Island near Diglipur was reported as 0.5-0.8 m. and uplift of the western shore of Middle Andaman Island at 12.5°N near Flat Island (Malik, 2005) appears to be approximately 1 m. Collecting data in the field is a task involving a broad spectrum of different direct as well as subsidiary activities, the most notable being (a) interviewing witnesses, (b) taking images (pictures) to create a documentary basis, and (c) carrying out measurements of relevant quantities. The relevance of performing surveying trips has recently gained growing recognition in the scientific community, to such a point that it is now taken as a must, and all major tsunamis occurring since 1992 have been followed by post-event field campaigns (e.g. Baptista et al. (1993) for the 1992 Nicaragua tsunami; Yeh et al. (1993) and Tsuji et al. (1995) for the 1992 Flores Island (Indonesia) tsunami; Yeh *et al.* (1995) for 1994 Shikotan (Russia) and Imamura et al. (1995) for the and 1994 Mindoro Island (Philippines) tsunamis. The datas for knowing about the details of wave height and velocity were remaining unknown, as there was no measurement devices placed at these locations. Ramanamurthy et al. (2005) has reported that the Acoustic Tide Gauge (ATG) of the National Institute of Ocean Technology (NIOT), located inside the Port Blair bay (Chattam Island), which was set only for normal tidal variations, has record the sea water level up to 3.5 m on the day of tsunami. This is about 1.5 m more than normal tide level as shown in figure1. There was a sharp rise in sea water level was recorded between 7.01 and 7.25 am and again at 7.45 am on 26th December 2004. The micropaleontological investigation pertaining to the provenance of tsunami sediments of Andaman islands has been carried out by Hussain et al. (2006). They have stated that the tsunamigenic sediments have been brought from the inner to outer shelf areas and not from the deeper territory. Salvador f. Farreras (2000) has classified the main effects of the interaction of tsunami syndrome with the coast are such as (i) Sinking or rising sea-level and (ii) Earth landslides and/or submarine slumps (iii) Uplifting or subsidence of the ground, (iv) Inundation and currents, (v) Soil deformation or liquefaction, (vi) Sediment erosion, transport and deposition, (vii) Vegetation gets uprooting, destruction and immersion, (viii) Salt water penetration into the inland soil, (ix) Shoreline alteration. This study is also to evaluate the effects of the event on buildings, bridges and infrastructure. The effect of the tsunami on structures and infrastructure produced surprising behaviour with several new lessons to learn.

Study Area

Andaman groups of islands are situated in the Bay of Bengal, mid way between peninsular India and Myanmar, spreading like a broken necklace in the North-south direction. These islands are located between 6º 45” and 13º 41” North latitudes, and 92º 12” and 93º 57” East longitude, the entire group of Andaman Islands has been taken for this study and the locations are collected by the handheld GPS. There are in all 349 islands. There are 325 islands in Andaman group while Nicobar group has 24 islands. Total geographic area of Andaman Islands is 8249 sq.km. Out of which Andaman group of islands cover 6408 sq.km. Out of total 349 islands only 38 islands are inhabited by human beings – 24 in Andaman group and 12 in Nicobar group of islands. The extreme length of the Andaman group is 219 m with an extreme width of 32 m. The main part of it consists of a band of five chief islands, so closely adjoining and overlapping each other known collectively as *“the great Andaman”.* There are five islands in order from north to south: North Andaman (51 m. long); Middle Andaman (59 m.); South Andaman (49 m.); Baratang, running parallel to the east of the South Andaman for 17 m from the Middle Andaman; arid Rutland Island (n m.). (Figure2). The rocks are highly folded due to

frequent tectonic movements in past. The geological formations represent a period of sedimentation from Cretaceous to sub-recent period. The surface deposits of gravel beds and raised soil covers are of recent origin i.e., less than 10,000 years. The present configuration of these islands took shape only about 26 million years ago.

Materials and Methods

An extensive post- tsunami fieldwork was carried out from 8th May to 7th June 2005 through the DST tsunami project in order to map the penetration of tsunami water and sediment, by the field observation and interviews of eyewitnesses. The location sites are recorded by using handheld GPS and are given in the table1.These locations observed in the Andaman islands are volcanic in origin and emerged part of a mountain chain. The coastline has coral reefs, sandy beaches, lagoons, mangroves, creeks, bays, cliffs, and forestland. Geologically, these islands belong to a geosynclinal basin. The inundation distance of the seawater has been decoded by its signature in the coastal settings and from the local people's information.

Results and Discussion

The magnitude of the earthquake was particularly large and the tsunami was quite violent; it severely affected the southeastern part of the Little Andaman, in particular the Hut Bay village that was most heavily damaged, as well as the South Andaman and the North Andaman districts. The authors surveyed more than 150 km of coastline by ferry and by vehicle to the most damaged districts of Diglipur in the north and to Port Blair in the south and Hut Bay in the southern part of the Islands, and also inspected the parts of coral which are well exposed due to the upliftment occurred due to tsunami effect in the northern tip of the Islands. The tsunami caused the devastation of some villages, and claimed more than thousands of victims. Buildings were destroyed and a large number of fishing boats were damaged, sunk or carried offshore by the waves. Most of victims were from the South Andaman and most of the life losses form the Hut Bay, Little Andaman the beds were almost razed to the ground. During the survey in Hut Bay the tides are high up to approximately 1-4 m in height, the coastline is generally embedded with corals. Due to the presence of Ross Islands the Port Blair, capital of South Andaman is well safe.
In the middle Andaman an active Mud volcano is well observed near the Baratang Islands. The stagnant of Tsunami water in the agricultural land and low-lying parts are seen especially in South Andaman, Havelock Island and some parts of Wandoor (figure 3). This gives a clear picture that Tsunami water has been retained for a long time and there may possible change in soil salinity. Land subsidence are also seen in south Andaman the tsunami water intruded into the low lying areas and which stands for a long time in the residential sites due to this the concrete buildings gets corrode and subsidence of buildings took place in Mayabander in the Middle Andaman (Figure 4a,b). The typical damages and damage levels of tsunami on wooden structures are less when compared to concrete buildings. Tsunami waves which entered through the Kalighat River caused damages to Panighat Bridge where the entire blocks have been shifted for a meter in North Andaman. On the other hand some of the beaches get damage due to tsunami and deposits lot of debris and gravels get accumulated on the beach, fine black sand has been accumulated on the coast, some of the uprooted tress is also seen on the beaches (Figure 5d). A mud volcano has been active after the quake in Baratang Island (Figure 6c).

Conclusion

The authors surveyed more than 150 km of coastline of entire Andaman group of Islands by ferry and by vehicle and lot of observation are made. In Sipighat creek area, it was observed that the Mangrove was completely submerged with seawater and completely turned brownish, indicating death of mangroves. The impact of the earthquake in North Andaman is opposite to that in South Andaman. Due to earthquake, the landmass in South Andaman has got elevated. The east coast of South and Middle Andaman sank by 2.5–3 m, with subsidence increasing southward. On the west coast of the Andamans the island coastline rose by up to 2 m, upliftment took place in North Andaman. The geographical position of Ross Island played an important role and prevented Port Blair town from tsunami waves and only limited infrastructure damages were found. Impressive erosion took place on the beach where many long trunked trees that had been completely uprooted were left deposited by the water's return flow and rocky beaches were observed due to its backflow. Among the Andaman groups of Islands, mainly Hut Bay in Little Andaman was severely affected and about 7 m waves have been observed during the filed survey. Tourism spots like Corbyns cove, Jollyboy Islands, Chriyatapu, Wandoor, Havelock Island, Mayabander were found to be not much of tourists after the tsunami. The Indian Ocean tsunami was quite strong, although the magnitude of the tsunamigenic earthquake was big enough to justify such a large destruction all along the coastal areas and so many victims. In the Little Andaman the most aggravating factor was the buildings typology were most of the destroyed houses were built on a thin basic layer of concrete that was the only remaining seen after the disaster. From the detailed field observations, it is inferred that the South Andaman is more prone to Tsunami impact and accordingly lot of mangroves are dead when compared to North Andaman. In Sippighat creek (South Andaman) area, it was observed that the Mangrove forest was completely submerged with seawater and completely turned brownish, indicating floral death. Finally, it is recommended that the proper guidelines must be adopted in the Post-Tsunami period, which hopefully helps to save lives and property and impact of the phenomenon. A detailed study is needed to validate numerical model simulations for hazard assessment, and to carry out planning for adequately reducing the impact of future recurrent events of this nature.

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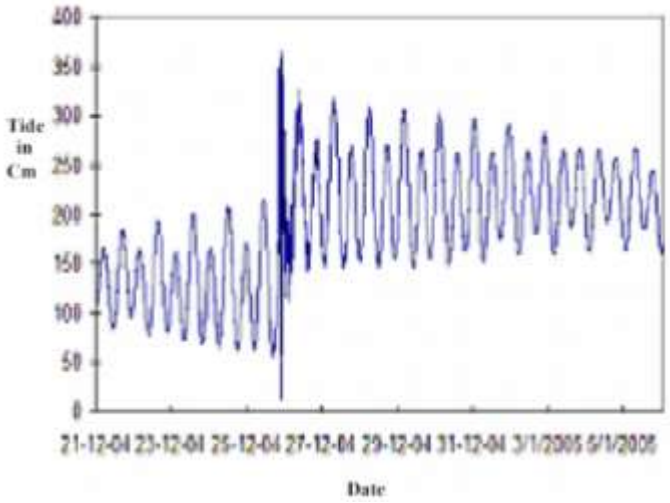

Figure 1 The seawater level recorded by tidal gauge at Chatam islands, Andaman

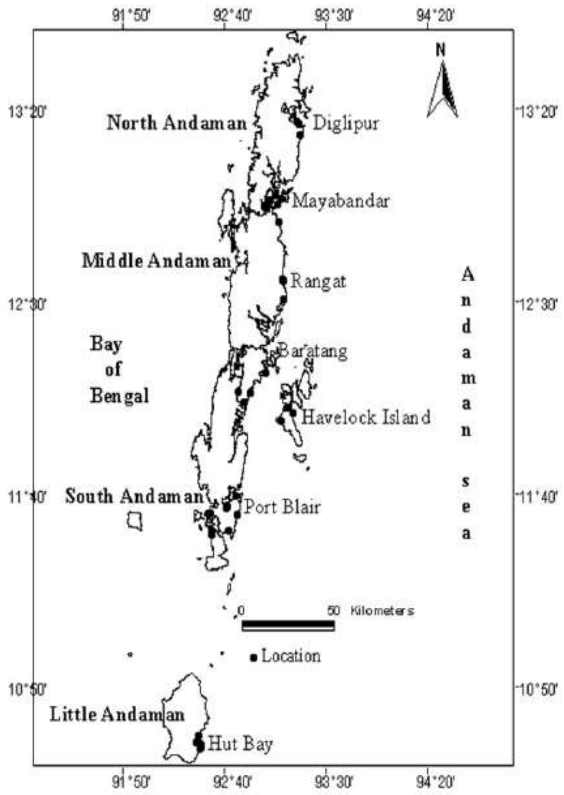

Figure 2 Study area map with locations of impacts

Figure.3. (a, b, c) Shows the stagnation of Tsunami water in the agricultural land and low lying areas in Port Blair in the South Andaman (d) Tsunami water which damage the buildings in the Hut bay, Little Andaman (e) Stagnation of Tsunami water in Radha Nagar Beach, Havelock Island (f) Tsunami devastation in the landward and stagnant of tsunami water in part of Wandoor.

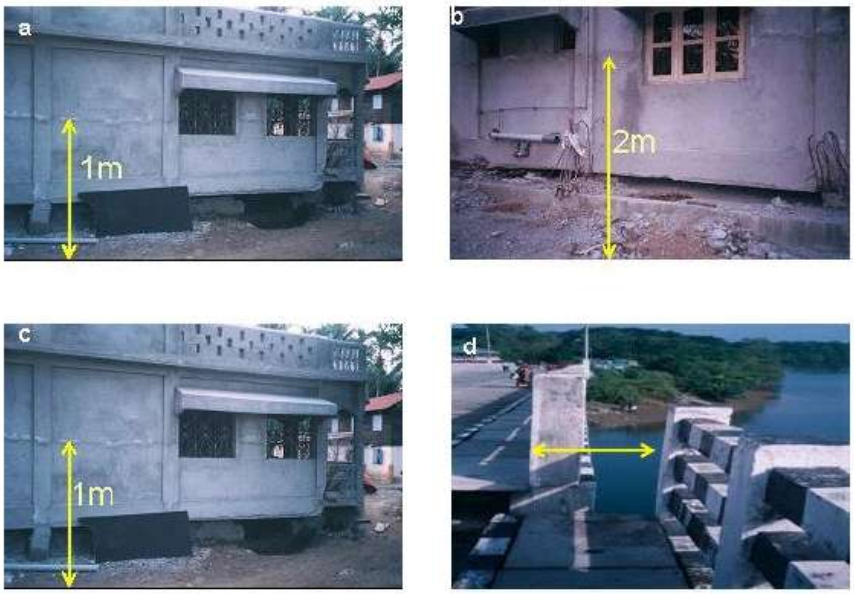

Figure.4. (a, b) Building collapse caused in the land subsidence due to earthquake before tsunami at Ramapuram, Mayabander, close to the coast and the level of Tsunami water intrusion (c) The typical damages and damage levels of tsunami on wooden structures (d) Damages caused to Panighat Bridge in North Andaman by Tsunami (connecting bridge to Diglipur) .

Figure.5. (a) Height of Tsunami Waves is shown by the local peoples which is approximately 7 m (b) Debris has been deposited by the tsunami waves (c) Gravels get accumulated on the beach (d) imprints shown by minute organisms (meiobenthos) (e) Extensive corals have been deposited on the beach (f) Uprooted trees in a rocky beach.

Figure.6. (a) Shows the impact of cracks on the ground in Middle Andaman (b) Devastation of mangroves in the sea front part of Baratang (c, d) An active mud volcano in Baratang Island after quake. (e) The uproots are seen in the Hut Bay, Little Andaman (f) rehabilitation in Chouldhari.