



Water Quality Assessment in the Tsunami-Affected Areas of Banda Aceh

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Abstract

Water quality assessment in the tsunami-affected areas conducted in Meuraxa and Kutaradja sub-districts in the area of Banda Aceh City. Water samples were collected in October 2006 from dug wells of tsunami-affected areas. These were characterized for various physical and chemical parameters. Water quality in the selected areas has shown that the surface water was contaminated due to the tsunami. Total Dissolved Solid, Total Suspended Solid, Acidity, and salinity were high in the affected areas indicating saline water intrusion into surface water tables. Dug wells in the highly affected locations showed higher values of heavy metal ions like Mn, Pb, Cu, Fe, Zn, and Cu compared to the reference points. No ion Hg was found in all samples.

Keywords: Banda Aceh, heavy metals, tsunami, water quality

1. Introduction

Earthquake and tsunami of 26 December 2004 have caused severe destruction to human life and livelihood. The earthquake followed by tsunami has affected the water quality and groundwater regime to a limited extent. In order to assess the effect of the earthquake and tsunami, particularly on the water quality and groundwater regime, detailed water quality assessment in the tsunami-affected areas have been carried out by many researchers (Palanivelu *et al.*, 2006; Villholth *et al.*, 2005; Chaudhary *et al.*, 2006). Singh *et al.* (2005) reported that groundwater, which is only source of drinking water at some of the tiny islands in South Andaman, has been affected due to tsunami. Reddy *et al.* (2005) also reported a drastic change in the coastal water quality of Thannirbhavi and Chitrapur region even while comparing with the observation made on 7 December 2004 three weeks before the tsunami. During that time, the coastal water temperature ranged from 27.60°C to 28.00°C, pH from 7.82 to 8.11, dissolved oxygen from 4.12 to 5.12 ml/l, salinity from 31.76 to 32.98 ppt, phosphate-phosphorus from 1.07 to 4.32 µg/l, nitrite-nitrogen from 0.76 to 1.23 µg/l, nitrate-nitrogen from 3.50 to 7.28 µg/l and silicate from 8.17 to 20.27 µg/l. The dug wells in tsunami affected Andhra coast contained higher values of heavy metals like Mn, Zn, Cu, Ni and Cd, etc. indicating intrusion of saline water into the surface water (Swamy *et al.*, 2006).

Banda Aceh City is one of tsunami affected area in Aceh province. This area has 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 Banda Aceh City. Many parts of the Banda Aceh City have also suffered. Several places have submerged and many have been up-lifted.

Houses have been completely washed away and many building structures have collapsed. In order to assess the effect of the earthquake and tsunami on Banda Aceh City, particularly on the water quality, a detailed investigation has been carried out. This study deals with the change in surface water quality in the tsunami-affected area in two sub-districts, Meuraxa and Kutaradja.

2. Methodology

Among the affected areas, Meuraxa and Kutaradja sub-districts suffered to the maximum extent in the City of Banda Aceh, as there was total loss of vegetation, fisheries as well as solar salt works and thousands of people deaths. Loss of property was high in these two sub-districts. In this study, nine locations of dug wells in the Meuraxa and Kutaradja sub-districts were identified for assessing water quality. The location map of study area is shown in Figure 1 and

Table 1 shows the locations of water sampling points after 3 years tsunami in the Banda Aceh City areas. Samples were collected from dug wells in duplicate during October 2006. Potable water as reference sample is distributed through mobile water tanks to these areas after treating the Kr. Aceh river water. The river water and un-affected area were considered as also reference sample and the difference in water quality with respect to reference samples gave an indication regarding the change in water quality due to the tsunami. Water quality analysis conducted by standard procedure as well as heavy metals concentration analyzed by using Atomic Absorption Spectroscopy, AA-630 (Eaton and Epps, 1995). Every metals to be specified using gas, air pressure, Hollow Cathode, and specific current lamps.

3. Results and Discussion

To quantify the extent of environmental damage, physical, chemical and biological parameters of water at these places were considered. To assess the physical and chemical parameters, pH, salinity, Total Dissolved Solid (TDS), Total Suspended

Solid (TSS), and parameters like Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), etc. of the water samples were determined. The location area and water quality is tabulated in Table 1. pH was neutral or slightly base at all locations. The village of Deah Baro, Asoenanggroe Blang Oi, and Peulanggahan showed neutral (pH of 7.0) and Kp. Jawa, Merduati, Lampaseh Aceh, and Ulee Lheue showed maximum pH of 8.0. pH of Kr. Aceh river water was 7.62. Its high basicity may be due to contamination by soap and detergent used during cleaning and bathing along the course of the river. pH of portable water was around 7.72 due to higher pH of input water used in treatment plants. The findings are shown in Table 2.

The salinity of water samples showed higher values compared to that of the reference areas. Peulanggahan showed minimum salinity of 0.2^{0}_{00} while Lampaseh Aceh showed maximum salinity of 1.52^{0}_{00} . Salinity of Kr. Aceh river water was 0.1. This is indicative of the presence of dissociable compounds and the extent of pollution. Higher values indicate contamination due to sea water.

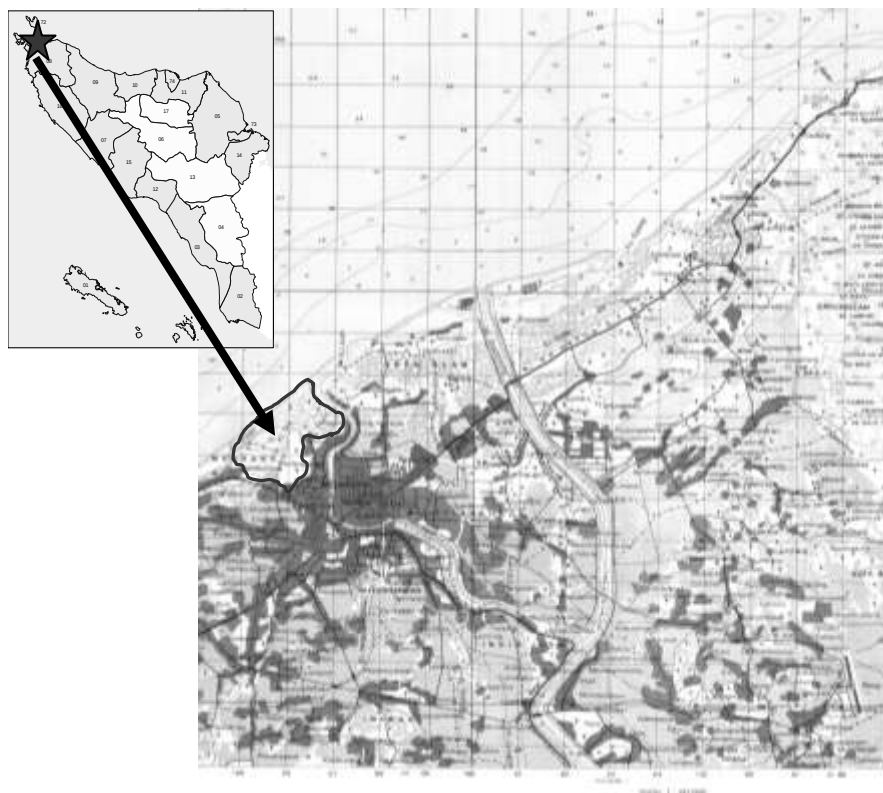


Figure 1. The location map of study area.

Table 1. Locations of water sampling points after tsunami in the Banda Aceh city.

Location/Village	Symbol	Coordinate	Distance from sea (km)
Peulanggahan	1	E 95° 19' 34,5"; N 5° 33' 57,9"	1.5
Kp. Jawa	2	E 95° 19' 18,0"; N 5° 33' 53,4"	0.7
Merduati	3	E 95° 18' 54,0"; N 5° 33' 15,6"	1.7
Lampaseh Aceh	4	E 95° 18' 41,2"; N 5° 33' 14,7"	2.0
Deah Baro	5	E 95° 18' 04,6"; N 5° 33' 24,9"	0.5
Deah Glumpang	6	E 95° 17' 41,6"; N 5° 33' 12,7"	0.5
Ulhee Lheu	7	E 95° 17' 19,6"; N 5° 33' 1,50"	0.1
Asoenanggroe	8	E 95° 17' 27,4"; N 5° 32' 22,3"	0.7
Blang Oi	9	E 95° 18' 11,9"; N 5° 32' 46,6"	1.0
Portable Water	10	Mobile Water Tank	
Kr. Aceh River Water	11	E 95° 20' 467" ; N 05 °32' 526"	5.0
Un-affected area	12	E 95° 20' 334" ; N 05° 32' 255"	7.0

Table 2. Physical, chemical, and biological parameters study in the tsunami affected areas.

Parameters	Units	Location of water sampling points											
		1	2	3	4	5	6	7	8	9	10	11	12
Temperature	°C	32.7	32.7	33.3	33.4	31.9	30.1	29.9	29.9	29.9	28.6	26.7	26.8
Acidity (pH)	-	7.0	8.0	8.0	8.0	7.0	7.5	8.0	7.0	7.0	7.72	7.62	7.39
Salinity	‰	0.20	2.20	1.06	1.52	0.70	1.20	0.90	0.90	0.80		0.1	
TDS	mg/L	1,106	2,405	9,343	5,150	672	1,132	943	913	976	130	190	294
TSS	mg/L	16.0	73.7	354.8	254.6	28.1	53.1	36.0	36.6	7.8		256	
BOD	mg/L	1.01	2.91	3.01	2.12	0.97	1.61	5.13	1.33	0.52		6.8	
COD	mg/L	0.33	12.33	153.67	18.00	29.67	0.33	32.67	23.67	2.33		24	
DO	mg/L	10.67	1.47	1.42	1.92	2.02	2.20	2.12	2.02	2.02		5.9	
Fe	mg/L	0.013	0.018	0.016	0.013	0.013	0.013	0.015	0.013	0.013	0.041	0.164	0.003
Mn	mg/L	0.201	23.500	11.733	3.242	0.013	0.069	0.124	0.032	0.216	0.001	0.002	0.017
Pb	mg/L	0.119	0.067	0.103	0.099	0.055	0.075	0.083	0.059	0.083	0.005	0.001	0.001
Cu	mg/L	0.065	0.057	0.070	0.021	0.046	0.057	0.030	0.022	0.003		0.002	0.014
Cd	mg/L	0.033	0.043	0.044	0.044	0.070	0.046	0.051	0.055	0.075	0.004	0.001	0.002
Zn	mg/L	0.238	0.158	0.575	0.083	0.083	0.025	0.266	0.200	0.003	0.007	0.002	0.018
Hg	mg/L	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr	tr
Coliform	cell/100 mL	11,000	11,000	>11,000	11,000	430	4,600	<30	750	>11,000			
E. coli	cell/100 mL	640	2,400	>11,000	36	<30	230	<30	<30	<30			

tr = trace

Higher in salinity in all locations may be due to the saline water intrusion into the surface water table. Salinity showed an upward trend with distance from sea. These findings are also shown in Table 2. Similarly, the TSS of water showed higher values compared to those of the reference samples in the range of 254.6 – 7.8 mg/L.

The maximum value of 254.6 mg/L was recorded at Lampaseh Aceh, while the lowest value of 7.8 mg/L was observed at Blang Oi. All samples showed high TDS in the range of 672 – 9,343 mg/L), where in the maximum level of Total Dissolved Solid (9,343 mg/L) was observed at Merduati and Deah Baro sample showed minimum level at 672 mg/L.

This clearly indicates intrusion of saline water into the drinking-water sources. TDS in affected areas was 72 times higher than that at the reference points. Based on the TDS concentration category, research results showed that Ulee Lheue, Merduati, Lampaseh Aceh are in the area of Saline Zone (TDS > 3000 mg/L), Kp. Jawa lies in the Buffer Zone (TDS 2500 – 3000 mg/L), and Peulanggahan, Deah Baro, Deah Glumpang, Asoenanggroe, and Blang Oi lie in the safe zone (TDS < 1500 mg/L).

Dissolved oxygen (DO), biochemical oxygen demand (BOD), total microbial and coliform counts were determined in the samples collected. DO varied from 1.42 to 10.67 mg/L compared to the Kr. Aceh river water value of 5.9 mg/L. BOD varied from 1.01 to 5.13 mg/L in the affected samples,

compared to 6.8 mg/L in the references. Similarly, the COD of water in the affected area varied from 0.33 to 153.67 mg/L.

Total bacterial and coliform counts in the affected areas showed much higher values compared to the reference points. Assessment of water quality in the selected areas has shown that the surface water was contaminated due to the tsunami. It may be contained appreciably high amounts of sulphate, nitrate and ammonium ions (Swamy *et al.*, 2006). TDS, TSS, Acidity, and salinity were also high in the affected areas indicating saline water intrusion into surface water tables.

Table 2 shows heavy metal concentration in the affected tsunami area and reference points. Mn concentration was high in Kp. Jawa (23.500 mg/L), Merduati (11.733 mg/L), and Lampaseh (3.242 mg/L). Mn was found in a very small amount (0.0011 mg/L) in the reference samples.

In all samples showed higher values of other metals like Pb, Cu, Fe, Zn, and Cu compared to the reference area. Hg was not detected in all samples. This result is in line with the former researchers. Swamy *et al.* (2005) and Palanivelu *et al.* (2006) also reported that higher heavy metals found in the tsunami affected area in Andhra coast and coastal areas of Chennai, respectively.

4. Conclusion

Assessment of water quality in the selected areas has shown that the surface water was contaminated due to the tsunami. TDS, TSS, Acidity, and salinity were high in the affected areas indicating saline water intrusion into surface water tables. Dug wells in the highly affected locations showed higher values of heavy metals like Mn, Pb, Cu, Fe, Zn, and Cu compared to the reference points. No Hg was found in all samples.

Acknowledgements

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