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Assessment of water quality in tsunami affected Andhra coast

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Water samples were collected in April 2005 (initial days of summer) and May 2005 (peak summer) from dug wells and bore wells of tsunami-affected coastal Andhra Pradesh. These were characterized for various physical and chemical parameters. The affected areas were ranked after considering certain attributes, based on which three locations (C.V. Lanka, P.V. Lanka and Vemuladevi) were found to be more affected. These three locations showed higher values of conductivity, hardness, alkalinity, etc. besides sulphate and chloride as compared to the reference samples selected in the study. Dug wells contained higher values of heavy metals like Mn, Zn, Cu, Ni and Cd, etc. indicating intrusion of saline water into the surface water.

Keywords: Andhra coast, tsunami, water quality.

VISAKHAPATANAM, and East and West Godavari districts of Andhra Pradesh (AP) were hit badly by the tsunami that followed the 9 *M* earthquake (26 December 2004), off the coast of the Indonesian island of Sumatra. Due to inundation of sea water, the salinity of surface water at these areas increased considerably, thereby decreasing the supply of sweet water for agriculture and human consumption. This study deals with the change in surface water quality in the tsunami-affected area.

Seven locations in the East and West Godavari districts in the Narasapur segment, AP were identified for assessing water quality. Samples were collected twice in duplicate, once during 9–20 April 2005 and again during 26–27 May 2005, from locations given in Table 1. Potable water is distributed through pipelines to these areas after treating the Godavari canal water. The canal water was considered as 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.

Among the affected areas, C.V. Lanka suffered to the maximum extent in the Andhra coast, as there was total loss of vegetation, fishing as well as solar salt works and it also resulted in four deaths. Loss of property in Vemuladevi and P.V. Lanka was considerable with only one casualty in Vemuladevi. Loss of property was high in Antarvedi, Perupalem and K.P. Palem, but less compared to the other three places mentioned above. Table 1 shows

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Table 1. Location of water sampling points after tsunami in the Andhra coast

Location	Symbol	Population	Deaths	Tide height (m)	Distance from sea (km)	Ranking
C.V. Lanka	CV	672	4	2.5	1	I
Vemuladevi	VE	2717	1	2.5	2	II
P.V. Lanka	PV	3637	–	3	0.5	III
Antravedi-I	AI	–	–	2.3	0.5	IV
Antravedi-II	AII	–	–	2.3	0.5	V
Perupalem	PE	1117	–	3	0.5	VI
K.P. Palem	KP	347	–	3	2	VII

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

	pH		Conductivity		Turbidity (NTU)		Dissolved oxygen		Biochemical oxygen demand		Total counts (cfu/ml)		Coliform (cfu/ml)	
Location	April 2005	May 2005	April 2005	May 2005	April 2005	May 2005	April 2005	May 2005	April 2005	May 2005	April 2005	May 2005	April 2005	May 2005
C.V. Lanka	1.52	42.3	2.2	22.4	1.52	42.3	4.85	3.45	18.6	20.2	100	80	100	80
Vemuladevi	0.96	0.45	19.5	16.7	0.96	0.45	6.07	5.55	11.4	13.5	1000	700	1000	600
P.V. Lanka	1.02	0.14	13.7	9.26	1.02	0.14	7.97	7.2	2.8	3.2	10000	8000	6500	5500
Antravedi-I	1.24	0.24	5.54	7.74	1.24	0.24	7.97	7.1	2.5	3	7000	6500	200	100
Antravedi-II	1.13	0.7	3.17	4.58	1.13	0.7	8.84	8.57	2.3	2.5	3000	2000	540	400
Perupalem	1.08	3.2	3.12	5.56	1.08	3.2	5.89	4.9	16.5	18.2	1600	960	600	400
K.P. Palem	2.23	2.3	1.66	2.05	2.23	2.3	4.69	3.8	22.2	25.4	5000	3000	300	100
Canal water (CA)	1.04	1.53	0.73	0.13	1.04	1.53	6.07	5.2	8.5	10.2	1000	900	200	100
Potable water (PO)	1.37	0.5	0.24	0.12	1.37	0.5	8.15	8	2.54	2.65	<30	<30	<20	<20

the ranking of various places along with their attributes. 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, turbidity, conductivity and parameters like chlorinity, total hardness, etc. of the water samples were determined. PH was neutral or slightly alkaline at all places and did not change appreciably between the two sets of samples taken in April and May 2005. For both sets, C.V. Lanka showed minimum pH of 7.3. K.P. Palem and Antarvedi showed maximum pH of 8.0 and 7.8 respectively. pH of Godavari canal water was >9.0 on both the occasions. The canal water is distributed after purification in water-treatment plants, while it is used directly for irrigation, washing and bathing. Its high basicity may be due to contamination by soap and detergent used during cleaning and bathing along the course of the canal. pH of potable water was around 8 due to higher pH of input water used in treatment plants. The findings are shown in Table 2.

The conductivity of water samples showed high values compared to that of the references. There was hardly any difference in conductivity of the samples collected after a time lag of about a month between the two sampling periods. This is indicative of the presence of dissociable compounds and the extent of pollution. Similarly, the turbidity of water showed higher values compared to those of the reference samples. Maximum turbidity (42 NTU) was observed at C.V. Lanka, but all the other samples showed turbidity <2 NTU.

All samples showed high chlorinity during both times. The maximum value of 8750 mg/l was recorded during April 2005 at C.V. Lanka, while in May 2005 the highest value was 5000 mg/l at Vemuladevi. The lowest value of 400 mg/l was observed at K.P. Palem. Chlorinity in all the affected areas increased from the first to second lot of samples, except in C.V. Lanka and reference samples showed values <200 mg/l. Chlorinity was highest at CV Lanka and decreased according to the order of tidal impact on the shoreline. Higher values indicate contamination due to sea water. Increase in chlorinity with time may be due to a drop of water level during summer. The findings are shown in Figure 1.

Alkalinity in the affected areas also showed higher values compared to those of the reference samples. P.V. Lanka showed highest alkalinity of 1600 mg/l both the times compared to that of the reference (~200 mg/l). It is seen that the most affected places like C.V. Lanka, P.V. Lanka and Vemuladevi showed high alkalinity compared to other locations. This may be due to the saline water intrusion into the surface water table. Alkalinity showed an upward trend with time. These findings are also shown in Figure 1.

Hardness of water was observed to be highest (4.1 g/l) at C.V. Lanka and lowest (0. 23 g/l) in K.P. Palem, which increased with time compared to that at the reference

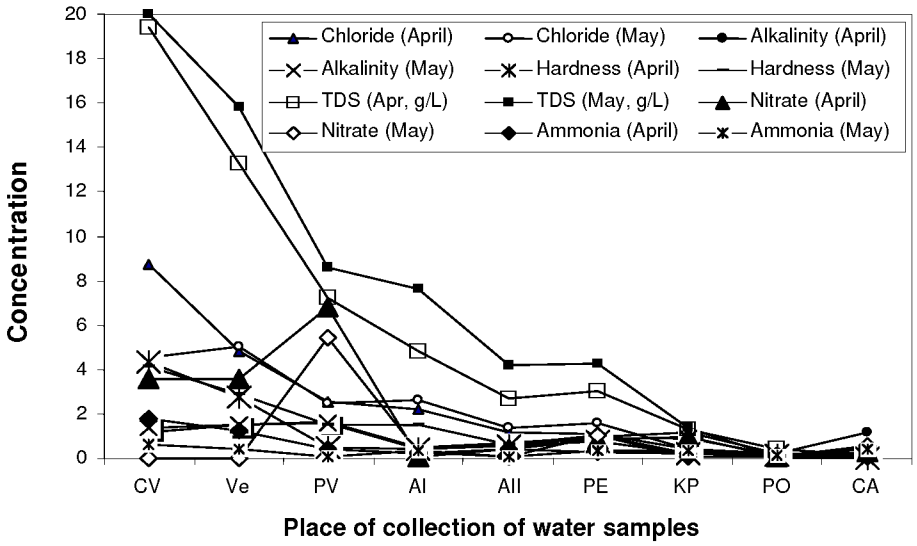

Figure 1. Chemical parameters and constituents of water samples collected at different points in the tsunami affected area. (All values are in g/l except for ammonia and nitrate which are in mg/l.)

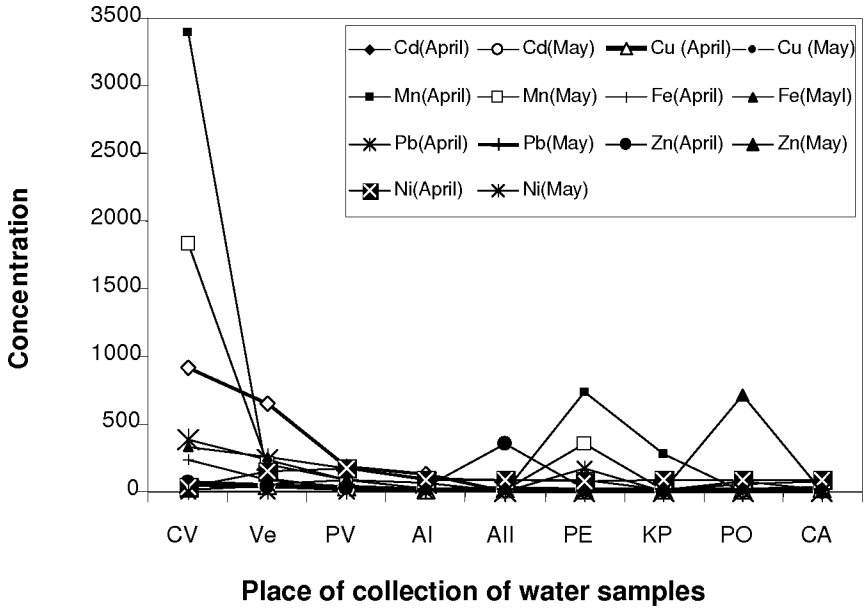

Figure 2. Heavy metal concentration in water samples at different locations in the tsunami affected area.

points <0.1 g/l, as shown in Figure 1. The trend is similar to alkalinity and chlorinity, i.e. higher values in the tsunami-affected areas. This clearly indicates intrusion of saline water into the drinking-water sources. Total dissolved solid (TDS) in affected areas was 100 times higher than that at the reference points. C.V. Lanka showed maximum value (~20 g/l), while minimum was recorded at K.P. Palem (~1.5 g/l). Similar high value was recorded in case of nitrate concentrations. Concentration of ammonia in samples from the affected and reference points showed similar values (Figure 1).

Figure 2 shows heavy metal concentration in the affected and reference points. Mn concentration was high in C.V. Lanka and Perupalam on both occasions. Mn was absent in the reference samples. C.V. Lanka samples also showed higher values of other metals like Pb, Zn and Cu. In a few samples, Ni was detected. The reference points had neither Pb nor Zn, whereas they contained traces of Fe. The first lot of samples had Ni, whereas it was absent in the second set except at Perupalam.

Dissolved oxygen (DO), biochemical oxygen demand (BOD), total microbial and coliform counts were deter-

mined in the samples collected (see Table 2). DO varied from 4 to 8 mg/l on both occasions compared to the canal water value of 8 mg/l. BOD varied from 2 to 20 mg/l in the affected samples, compared to 2–6 mg/l in the references. Total bacterial and coliform counts in the affected areas showed much higher values compared to the reference points, but decreased as the summer progressed.

Assessment of water quality in the selected areas has shown that the surface water was contaminated due to the tsunami. It contained appreciably high amounts of sulphate, nitrate and ammonium ions. TDS, alkalinity and total hardness were also high in the affected areas indicating saline water intrusion into surface water tables. Some of the highly affected locations showed higher values of heavy metals like Mn, Zn, Cu and Cd compared to the reference points.

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