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Has *Tsunami* Affected the Quality of Seawater and Backwaters? - Case Studies in and around Chennai, Tamil Nadu

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The coastal districts on the eastern coast of India, particularly Nagapattinam, Cuddalore and Chennai were worst affected due to *tsunami* during December 2004. Many hatchery facilities in these regions were severely affected with damages to pump houses, fencing, etc. especially in Kovalam, Marakanam and Pondicherry belt. In anticipation that *tsunami* tidal waves might have brought some changes in the elemental composition of seawater, samples were collected from different places in and around Chennai (Kanchipuram District - Muttukadu sea and backwater, Mamallapuram, Mudaliarpet boat house; Thiruvallur District - Pulicat backwater and seawater; Cuddalore District – Thalanguda; Villipuram District – Marakkanam; Pondicherry - Kurshikuppam) along the east coast immediately after *tsunami* and were analysed for chemical parameters, major ionic composition and heavy metal concentration. The cationic values in these water samples were slightly lower than the values of normal seawater. Marakkanam in Tamil Nadu and Kurshikuppam in Pondicherry recorded higher concentrations of arsenic. The values of some metals were above the Criteria Continuous Concentration (CCC) values as per EPA. While comparing the values of heavy metals at seashore of Muttukadu during September 2002, February 2003 and after *tsunami* during December 2004 and January 2005, no significant variation was noticed.

(Key words: Tsunami, *Seawater, Backwater, Heavy metals)*

The *tsunami* caused extensive damage in southern regions of India and Andaman & Nicobar Islands affecting a total of 2,260 km of coastline. The waves were reported to be as high as 3-10 m in southern India and penetrated in the range of 300 m to 3 km inland. The coastal districts on the eastern coast of India, particularly Nagapattinam, Cuddalore and Chennai were worst affected. The fisheries sector in Tamil Nadu, Andhra Pradesh and Andaman & Nicobar Islands has suffered major damages in terms of lives, boats, gear and the infrastructure such as harbours and fish landing centers. According to NACA/FAO/SEAFDEC/BOBP-IGO report (Anon., 2004) many hatchery facilities in Kovalam, Marakanam and Pondicherry belt were severely affected with damages to pump houses, fencing, etc. Aquafarms to an extent of 5753 ha were damaged in Tamil Nadu. Shrimp farms at Cuddalore, Chidambaram, Sirkali, Tharangampadi, Vedaranyam, Nagapattinam and Velankanni were severely affected with collapsed *bunds* and damage to the equipment including motors and pumps.

The increasing impairment of coastal water quality resulting from the discharge of domestic, agricultural and industrial wastes in coastal waters has affected the aquaculture profitability in certain areas (Federico Paez-Osuna *et al.*, 1998). The four estuaries in Northern Oregon, USA have buried peat and sand lenses, evidence of seismic disturbances and post-seismic *tsunamis*. At least six great earthquakes were documented in the last 3,000 years, originating in the Cascadia subduction zone (Darienzo *et al.*, 1994).

The *tsunami* flood can be expected to initiate a series of damage events, including fire and toxic/hazardous release (Preuss and Hebenstreit, 1990). The zone of vulnerability and secondary hazards should be identified for a complete risk management plan. Because the San Francisco Bay region is in a seismically active area, the ponds were inundated as a result of seismically induced seiche or *tsunami*, causing a large discharge of contaminants into the Napa River. The resulting discharge would most likely result in substantial impairment of water quality in the form of a large and rapid increase in the concentrations of salinity, suspended sediment and other contaminants. Hazard evaluation and predictive toxicology play a useful and important role for protection of aquatic environment from pollutants such as heavy metals and pesticides (Draggen, 1978 and Hamelink, 1980). The negative changes in the environment and biodiversity of source water bodies if any due to *tsunami* may affect the shrimp farming. In this direction, monitoring the quality of seawater and backwaters is receiving adequate attention in India.

MATERIALS AND METHODS

In anticipation that *tsunami* tidal waves might have brought some changes in the elemental composition of seawater which may lead to alteration in biodiversity of flora and fauna, composite water samples were collected during 4 – 9 January 2005 from about 5 - 10 m off the shoreline and at 0.5 m depth in triplicate from different places in and around Chennai (Kanchipuram District - Muttukadu sea and backwater, Mamallapuram, Mudaliarpet boat house; Thiruvallur District - Pulicat backwater and seawater; Cuddalore District – Thalanguda; Villipuram District – Marakkanam; Pondicherry - Kurshikuppam) on the east coast. The water samples for heavy metals analysis were preserved by acidifying with nitric acid (Fig. 1).

In the experimental station of Central Institute of Brackishwater aquaculture (CIBA) at Muttukadu, a clean and empty 20,000 litre capacity cistern kept for drying got filled up by *tsunami* tidal waves on 26 December 2004. This water was considered as a representative sample of '*tsunami* water'. The collected water samples were analysed in the Environmental laboratory of CIBA for chemical parameters and major ionic concentrations, viz. pH, salinity, nitrite-nitrogen (NO_2-N), total ammonia - nitrogen (TAN), sodium (Na^+), potassium (K^+), calcium (Ca^{2+}) and magnesium (Mg^{2+}) using the standard methods (APHA, 1989). Most of the parameters were analysed using spectrophotometer, flame photometer.

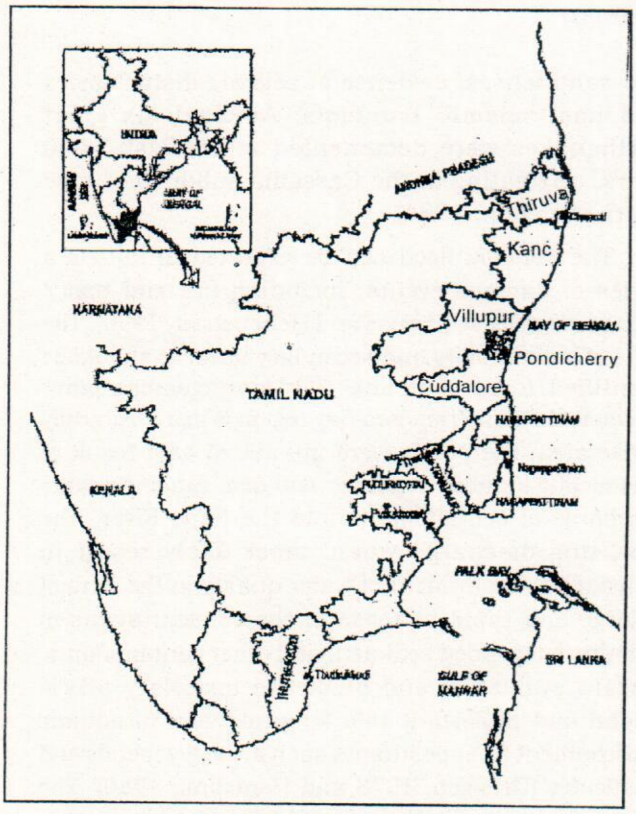

Fig. 1. Study area map

Water samples were also analysed for heavy metals, viz. lead (Pb), chromium (Cr), zinc (Zn), cadmium (Cd), mercury (Hg) and arsenic (As). The determination of heavy metals, such as cadmium, lead, chromium and zinc was carried out by extracting water with APDC/MIBK according to the method described by APHA (1989) using heated graphite atomiser on Atomic Absorption Spectrometer. Mercury was analysed by cold vapour generation followed by flameless atomic absorption technique using electro thermal atomizer. Arsenic as total was measured by electro thermal atomic absorption spectrometry with graphite furnace.

RESULTS AND DISCUSSION

Specialised analysis of recent satellite imagery of a *tsunami* ravaged section of Porto Nova, India, near Sri Lanka has revealed a devastating impact on local water quality. Contaminated sediment impacted a large number of inland water bodies in the area and was evident more than two kilometers offshore in the Indian Ocean. The influence of tsunami on the average chemical composition and concentration of major ions, heavy metals in seawater and backwaters are presented in Tables 1 and 2.

Chemical composition

The pH and salinity of seawater and backwater ranged from 7.23 to 8.18 and 30 to 35 ppt and 6.75 to 7.32 and 26 to 32 ppt, respectively (Table 1). The pH values in the present backwater samples were slightly lower than the normal reported values (Joseph *et al.*, 2002). The seven ions mainly Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, SO_4^{2-} and HCO_3^- contribute to the saline nature of water. TAN and nitrite- N values in the study area varied from 0.072 to 0.180 ppm and 0.001 to 0.076 ppm, respectively. The cationic values of Na, K, Ca and Mg in the water samples of these worst affected areas of Tamil Nadu were slightly lower than in the normal seawater. However in all the samples magnesium concentration was higher than the calcium and Ca/Mg ratio (0.270-0.305) was more or less same as that of normal seawater (0.296). High and low sodium concentrations of 10600 and 8200 ppm were observed in seawater at Mamallapuram and backwaters at Mudaliarpet. The normal level of

Table 1. *Salinity, pH and ionic concentration (ppm) of water samples collected from tsunami affected places in and around Chennai*

District	Collection site	pH	Salinity (ppt)	NO_2-N (ppm)	TAN (ppm)	Na (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
Kanchipuram	*Tsunami* water (Muttukadu)	8.18	33	0.074	0.116	10500	350	320	1176
	Muttukad seawater	7.98	32	0.076	0.118	10500	360	332	1194
	Muttukadu backwater	6.94	30	0.003	0.109	9000	350	280	1008
	Mamallapuram seawater	7.10	35	0.009	0.082	10600	340	376	1334
	Mudaliarpet boat house (backwater)	6.75	26	0.008	0.072	8200	280	264	946
Thiruvallur	Pulicat (backwater)	7.32	32	0.007	0.083	10000	350	320	1104
	Pulicat (seawater)	7.39	32	0.001	0.076	9200	370	328	1075
Cuddalore	Thalanguda (seawater)	7.33	31	0.017	0.180	10200	370	320	1080
Villipuram	Marakkanam (seawater)	7.23	31	0.005	0.079	10000	360	320	1080
Pondicherry	Kurshikuppam (seawater)	7.31	30	0.006	0.102	10400	290	304	1065

Table 2. *Concentration (ppb) of heavy metals in water samples collected from tsunami affected places in and around Chennai*

District	Collection point	Pb	Cr	Zn	Cd	Hg	As
Kanchipuram	*Tsunami* water (Muttukadu)	1.00	5.12	13.12	1.45	0.11	BDL
	Muttukad seawater	1.00	5.25	13.25	1.50	0.11	BDL
	Muttukadu backwater	BDL	8.25	5.35	6.65	15.33	BDL
	Mamallapuram seawater	4.00	22.25	15.18	11.90	10.68	BDL
	Mudaliarpet boat house (backwater)	3.5	5.50	3.15	3.38	6.56	BDL
Thiruvallur	Pulicat (backwater)	BDL	8.50	2.18	10.45	6.15	BDL
	Pulicat (seawater)	5.75	7.75	2.90	11.03	6.54	BDL
Cuddalore	Thalanguda (seawater)	BDL	8.25	12.70	BDL	1.63	21.75
Villipuram	Marakkanam (seawater)	BDL	8.75	12.30	BDL	2.28	38.25
Pondicherry	Kurshikuppam (seawater)	BDL	8.00	12.90	BDL	2.01	47.75
Criteria Maximum Concentration CMC)		210	1100	90	42	1.8	69
Criteria Continuous Concentration (CCC)		8.1	50	81	9.3	NA	36

BDL – Below detectable level

NA – Not available

cations in seawater of 35 ppt are 10500, 380, 400 and 1350 ppm for Na, K, Ca and Mg, respectively. The *'tsunami water'* appeared to be more or less similar to normal seawater though the values of Na, K, Ca and Mg were slightly in lower range in case of the former.

Heavy metal concentration

In Kanchipuram and Thiruvallur Districts slightly higher value of cadmium in the range 10.45-11.90 ppb was observed. Criteria Continuous Concentration (CCC- Highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time) and Criteria Maximum Concentration (CMC - Highest concentration of a pollutant to which aquatic life can be exposed for a short period) are used to assess the safe concentration of heavy metals. Except for the Muttukadu seawater sample, the observed values for mercury were higher than the normal value and previously recorded value of 0.3 ppb (Qasim and Sengupta, 1981) in most of the districts. The CMC value for mercury was 1.8 ppb but it is interesting to note that the concentration of mercury ranged from 6.50 to15.33 ppb, 6.15 to 6.54 ppb, 2.28 ppb and 2.01 ppb in the coastal areas of Kanchipuram, Thiruvallur, Villupuram and Pondicherry respectively. Though below the CCC value, a rise in concentration of cadmium when compared to previously recorded values (Qasim and Sengupta, 1981) was observed in samples from Mammallapuram, Muttukadu and Pulicat. The value for arsenic was high in Villupuram (38.2 ppb) and Pondicherry (47.75 ppb) whereas at other places it

Table 3. *Heavy metal concentration (ppb) in Muttukadu seawater before and after* tsunami

Period of collection	Pb	Cr	Zn	Cd	Hg	As
Dec, 1999	NA	BDL	16	0.17	BDL	BDL
Sep, 2000	NA	NA	19.5	0.17	0.1	NA
Feb, 2003	BDL	NA	7.0	BDL	BDL	NA
Dec, 2004*	1.00	5.12	13.12	1.45	0.11	BDL
Jan, 2005	1.00	5.25	13.25	1.5	0.11	BDL
Desired safe level	NA	1.00	100	2	0.01	0.2

*- *Tsunami* water

NA – Not available

BDL – Below detectable level

was in below detectable level. Areas where higher values were recorded for heavy metals were probably due to anthropogenic inputs in those places rather than impact of *tsunami*.

The values of Pb, Cr, Zn, Cd, Hg and As were lower in the '*tsunami* water' than those found in most of the places mentioned elsewhere. The values of these heavy metals were very low when compared with the CCC and CMC values of US Environmental Protection Agency. The safe levels of zinc, cadmium, mercury and chromium are 100, 2, 0.01 and 1.0 mg l^{-1}, respectively (MPEDA, 1991).

Comparison of heavy metal concentration in Muttukadu seawater before and after *tsunami*

The values of heavy metals in seawater at Muttukadu before and after *tsunami* were compared since 1999 (Table 3). No significant difference was noticed in the concentration of heavy metals in post-tsunami seawater except in cadmium (1.5 ppb) which was 8 times more. However this value of cadmium was much below the prescribed value for CCC (9.3 ppb).

The mean values of zinc and mercury in seawater at Muttukadu during 1999 (Muralidhar *et al.*, 2003) were below the Environmental Protection Agency's (EPA) safe limits (MPEDA, 1991) and WHO's standards (Qasim and Sengupta, 1981). Perhaps, this could be due to alkaline nature of waters with high concentration of bicarbonates and total hardness. Calcium and magnesium could reduce the toxicity of metals because of their competition for sites with cationic speciation form of heavy metals (Rai *et al.*, 1981).

From the results of the investigations it can be broadly concluded that the *tsunami* of December 26, 2004 has not brought about any significant changes in the quality of the coastal waters in general.

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REFERENCES

American Public Health Association (1989). *Standard Methods for the Examination of Water and Waste Water*, 17th Edn, American Public Health Association, Washington, D.C.

Anon. (2004). ftp://ftp.fao.org/FI/DOCUMENT/tsunamis_05/jan_07_2005 NACA/FAO/SEAFDEC/BOBP-IGO. Report *Update on the Situation of the Tsunami Affected Areas*.

Darienzo Mark, E., Peterson Curt and Clough Charles (1994). Stratigraphic evidence for great subduction-zone earthquakes at four estuaries in Northern Oregon, USA. *Journal of Coastal Research* **10**(4): 850-876.

Draggen, S. (1978). TSCA: The US attempt to control toxic chemicals in the environment. *Ambio* **7**: 260.

Federico Paez-Osuna, Saul, R., Guerrero-Galvan and Ruiz-Fernandez Ana, C. (1998). The environmental effect impact of shrimp aquaculture and the coastal pollution in Mexico. *Marine Pollution Bulletin* **36**(1): 65-75.

Hamelink, J. (1980). Bio-availability of chemicals in aquatic environments in biotransformation and fate of chemicals in the environment. *American Society of Microbiology*, A.W. Maki, K.L. Dickson & J. Cairns Jr.(eds.), Washington, D.C. 56p.

Joseph, K.O., Muralidhar, M.,.Gupta, B.P. and Krishnani, K.K. (2002). Characterisation of intake, pond and outlet water of creek and seawater based shrimp farms in Nellore district of Andhra Pradesh. *Aquaculture* **3**(1): 51-59.

MPEDA (1991). Aquaculture. *Drops for Farmers* **IV** (11&12): 2.

Muralidhar, M., Gupta, B.P., Krishnani, K.K. and Nagavel, A. (2003). Heavy metal and pesticide levels in shrimp culture areas of Nellore (Andhra Pradesh) and Tuticorin (Tamil Nadu). *Aquaculture* **4**(2): 153-159.

Preuss, Dr.J. and Hebenstreit, G.T. (1990). *Integrated Hazard Assessment for a Coastal Community, Grays Harbor, Washington*, Urban Regional Research, Seattle, Washington, USA. 36p.

Qasim, S.Z. and Sengupta, R. (1981). *Water Pollution and Management Reviews*, C.K Varshney (ed.), South Asian Publishers Pvt. Ltd Delhi. 139p.

Rai, L.O., Gaur, J.P. and Kumar, H.D. (1981). Phycology and heavy metal pollution. *Biological Review* **56**: 99-151.