

CHAPTER VI

EFFECT OF TSUNAMI ON THE QUALITY OF GROUND WATER

Kerala State Ground Water Department

6.1 Introduction

On December 26, the earthquake set off giant tsunami waves of 3 to 10 meters in height, which hit the southern and eastern coastal areas of India and penetrated inland up to 3 km, causing extensive damage. In Kerala, of the 176 people who died along the 590-km-long coast, 158 were from two villages – Alappad in Kollam district in the south and Arattupuzha in Alappuzha district in the north.

The two villages share a distinctive geography, sandwiched as they are between the sea and the backwaters of Kayamkulam. Both are thickly populated, especially on either side of a coastal road that barely separates the lake from the sea. Both are rich in mineral sands and have a long bridge at one end and ferryboats at the other end, the only links across the lake to the mainland. Both are idyllic coastal locations, serenely tucked away from the mainstream bustle of Kerala. But this uniqueness also makes them among the most vulnerable dangerous places to be in, when a tsunami strikes.

In the affected areas, the main sources of drinking water are ponds and dug wells. The sources got contaminated due to mixing of seawater, leading to the scarcity of drinking water. Reports from the tsunami affected coastal areas of Tamil Nadu indicate that the groundwater near the coastal area (up to approx 500 m) became highly saline. Salinity increased 10 to 100 fold. The open wells got completely overwhelmed.

We still have only a limited picture of the implications of the present and long-term impact on ground water resources. The technical issues are complex, the source data for many of the regions are poor and survey work after the event has been piecemeal.

6.2 Methodology

Just after the Tsunami attack, ie. at the end of December 2004/beginning of January 2005, water samples were collected for analysis from the Tsunami affected areas.

6.2.1 Kollam Coastal area

From Kollam district, 8 samples and from Alappad Panchayat area 9 samples were collected for general and microbiological analysis. The samples were drawn from tube wells and open wells.

Details of location of the wells and the types of wells are given in Table 1.

Table I

Location and type of well and the data on some of the chemical parameters of the water samples

Sl. No.	Location	EC (micromhos/cm)	Na (mg/L)	Cl (mg/L)	Salinity (ppt)
1.	Azheekkal north (TW)	880	26	74	0.37
2.	Pookottu Temple (OW)	35200	4550	2182	14
3.	Azheekkal old (TW)	1410	88	281	0.59
4.	Srayikkad Temple (OW)	82400	7500	1369	29.91
5.	Amrithananthamayi matt (TW)	1570	23	307	0.34
6.	Cheriyazheekkal (OW)	902	67	92	0.36
7.	Kuttimuttill (OW)	1620	120	197	0.72
8.	Pandarathuruthu (OW)	8730	850	1293	3.07
9.	Srayikkad (OW-AD)	627	16	12	0.27
10.	Azheekkal (TW-BD)	5480	540	593	1.7
11.	Azheekkal (TW-AD)	1060	76	96	0.46
12.	Kinarmukku (TW)	617	28	8	0.26
13.	Azheekkal (TW-BD)	1660	36	259	0.86
14.	Azheekkal (TW-AD)	822	26	56	0.34
15.	Pandarathuruthu (TW)	1620	104	166	0.71
16.	Kuzhithura (TW)	620	16	26	0.24
17.	Azheekkal north (TW)	1970	34	219	0.87

TW – tube well, OW – Open well, BD – Before developing, AD – After developing
KWA – Kerala Water Authority

These samples were analysed mainly for conductivity, sodium, chloride and salinity in addition to coliform (Table II and Table III). Conductivity values varied from

617 micromhos/cm to 82400 micromhos/cm. For all the parameters, the highest two values were observed for the open wells at Srayikkad Temple (Sl.No.4) Pookottu Temple (Sl. No.2) of Alappad Panchayat, both of which were submerged in the tidal waves. Next higher value was shown by open well at Pandarathuruthu (Sl. No.8). Among the tube wells, one at Azheekal (Sl.No.10) showed the highest value for electrical conductivity, sodium, chloride and salinity.

Four wells were developed after the Tsunami and samples from these wells were analysed. The well locations are at Srayikkad, Azheekal, Azheekkal Matsya fed Compound, and Azheekkal North. Water samples were taken before and after developing from the tube wells in Azheekkal (Sl.No.10 & 11) and Azheekkal Matsya fed Compound (Sl.No.13 & 14). These samples were compared for electrical conductivity, sodium, chloride and salinity values. Noticeable reduction was seen in the analysis values, after development. The difference in result are represented as percentage reduction (Table II).

Table II % Reduction in Chemical parameters after development

Sl. No.	Location	EC (redn in %)	Na (redn in %)	Cl (redn in %)	Salinity (redn in %)
10 and 11	Azheekkal I	81	86	84	73
13 and 14	Azheekkal II	50	28	78	60

The values for salinity are plotted in Figure 1. It is verified that the

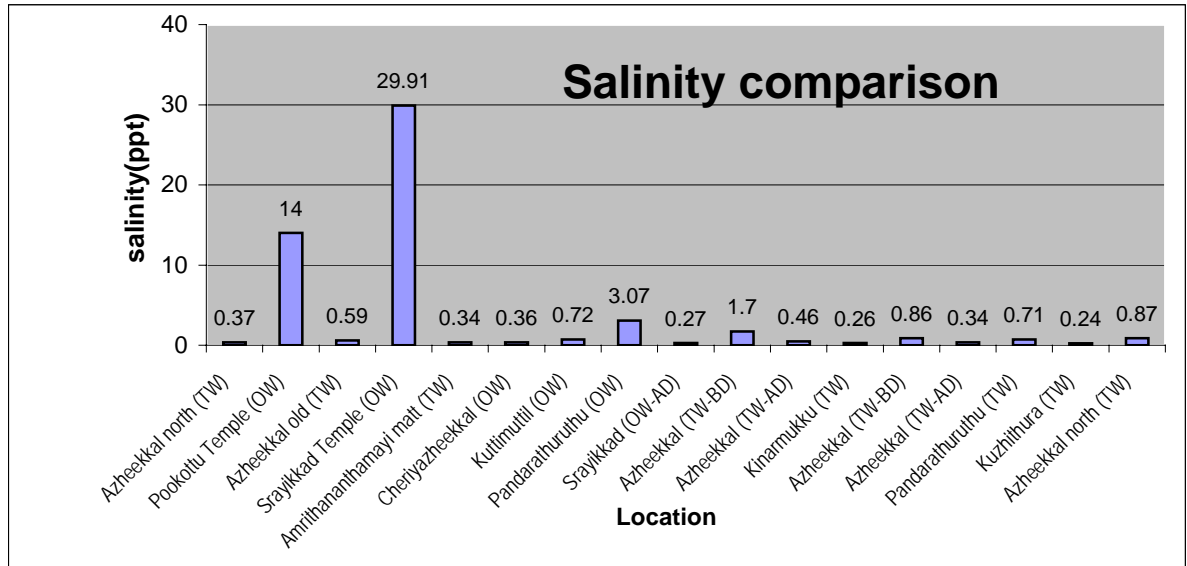


Figure 1 – Salinity profile of the well waters at different locations.

open wells of Srayikkad Temple, Pookottu Temple and in the compound of Sri. Thankarajan, Pandarathuruthu were showing values greater the 1-ppt.

Table III

Analysis data for microbiological parameters

SI No.	Location	Type of well	Total coliform (MPN/100 ml)	Faecal coliform (MPN/100 ml)
1.	Azheekkal north pump house	Tube well	30	17
2.	Pookottu Temple, Azheekkal	Open well	≥ 1600	≥ 1600
3.	Azheekkal old pump house	Tube well	900	140
4.	Srayikkad Temple	Open well	900	900
5.	Amrithananthamayi matt	Tube well	4	Nil
6.	Cheriyaazheekkal	Open well	1600	300
7.	Kuttimuttill	Open well	110	50
8.	Pandarathuruthu	Open well	≥ 1600	≥ 1600

As far as bacteriology was concerned samples from 6 open wells and 2 tube wells were analysed (Table III). (High values for faecal coliform were seen in all the open wells. Among the tube wells, only one tube well at Amrithananthamayi matt was free of faecal coleform. The other tube well is contaminated).

6.2.2 Alappuzha Coastal area

From the Alappuzha region, 31 water samples were collected just after the Tsunami attack. 23 samples (5 open wells and 18 tube wells) were from the departmental wells in the coastal side. The locations of these wells are given in Table IV.

Table IV
Location and type of water

SI No.	Well No.	Location	Type of well
1.	NHP – 17	Neerkunnam	TW
2.	NHP – 16	Ambalapuzha	TW
3.	OW – 5	Purakkad	OW
4.	NHP – 18	Purakkad	TW
5.	NHP – 3	Devikulangara	TW
6.	NHP – 8	Thrikunnapuzha	TW
7.	NHP – 1	Kayamkulam	TW
8.	OW – 1	Kayamkulam	OW
9.	NHP – 7	Nangyarkulangara	TW
10.	OW – 4	Nangyarkulangara	OW
11.	NHP – 14	Karuvatta	TW
12.	NHP – 20	DI Centre, Alappuzha	TW
13.	NHP – 23	Kattor (Mararikkulam)	TW
14.	NHP – 25	Thaikkal	TW
15.	NHP – 27	Pattanakkadu	TW
16.	NHP – 28	Thuravoor	TW
17.	OW – 9	Thuravoor	OW
18.	NHP – 29	Kuthiathode	TW

19.	NHP – 31	Ezhupunna	TW
20.	NHP – 30	Eramalloor	TW
21.	NHP – 22	Aryad South	TW
22.	OW – 7	Kalavoor	OW
23.	NHP - 21	Arattuvazhy	TW

(TW – Tube well, OW – Open well)

Besides, the 23 samples mentioned above, water samples were also drawn from wells located outside the departmental area

These samples were analysed mainly for electrical conductivity, sodium, chloride, salinity and coliform count. Since earlier data is available for some of the wells, a comparison was done for these wells based on conductance (Table V). Increase in trend for electrical conductivity values are shown by all the wells, when compared to the previous results. Though these wells show increasing trend, most of the values were within acceptable limits.

Table V

A comparative study on the Electrical conductivity values before and after tsunami (micromhos/cm)

Well ID	9/04	12/04 (after Tsunami)
NHP – 16	110	478
OW – 5	203	290
NHP – 8	1490	2080
NHP – 14	133	325
NHP – 23	618	937
NHP – 27	954	1910
NHP – 28	1010	1430
NHP – 30	790	2310

NHP – 22	914	1220
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The analytical data for chemical parameters for some of the wells are presented in Table VII. For sodium, values varied from 54 to 650 mg/L, chloride from 4 mg/L to 200 mg/L, and salinity from 0.05 ppt to 2.47 ppt. NHP 25 showed highest value for salinity. Increase in total hardness was also noted in some of the wells. The values varied from 233 mg/L to 592 mg/L.

Table VI

Sl. No.	Well No	EC (micromhos/cm)	TH as mg CaCO ₃ /l	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	TA as mg CaCO ₃ /l	CO ₃ (mg/l)	HCO ₃ (mg/l)	SO ₄ (mg/l)	Cl (mg/l)	Sal (ppt)
1.	NHP-8	2080	258	35	41	250	25	506	0	617	46.0	140	0.93
2.	NHP-23	937	233	83	36	75	5	182	0	222	6	100	0.45
3.	NHP-25	5700	592	85	19	650	27	428	41	429	11	25	2.47
4.	NHP-27	1910	321	103	15	128	16	312	0	356	5	200	0.07
5.	NHP-29	1620	365	83	38	90	15	282	22	178	20	4	0.1
6.	NHP-30	2310	277	85	15	120	19	408	0	497	5	38	0.93
7.	NHP-22	1220	302	98	13	54	10	278	17	305	62	13	0.49

(EC-Electrical Conductivity, TH-Total Hardness, Ca-Calcium, Na-Sodium, K-Pottassium, TA-Total alkalinity, CO₃-Carbonate, HCO₃-Bicarbonate, SO₄-Sulphate, Cl-Chloride, Sal-Salinity, ppt-parts per thousand)

In addition to the above results, the samples collected from 8 wells outside the departmental areas also analysed. The location of these wells are given in Table VII.

The analytical figures for Na, Cl, Salinity, Total Coliform and Faecal Coliform are given in Table VIII.

Table VII

Lab No.	Location	Type of well	Remarks
1382	Azheeka tharayil Gopi, Andhakaranazhi, Cherthala	OW	2 KM from Andhakaranazheekkal junction, op. to sea side along the side of road.
1383	Syrile, Mavelithayyil, Andhakaranazhi, Cherthala	OW	100 m from 1382/04 on the coastal side, sea wall is there.
1384	M.V. Prasad, Mavunkal, Andhakaranazhi, Cherthala	Open Pond	1-½ Km away from 1383/04. Domestic and drinking water supply for three wards (about 300 families). Near to the lagoon. Twice developed after the Tsunami attack and added bleaching powder. Most of the trees around this area have shedded leaves except coconut trees.
1385	Chandradasan, Valiya parambil padeettathil, Kallikkad, Arattupuzha Panchayath	OW	Used for al purpose, 50 m away from Andhakaranazhi coastal side.
1386	Podiyan, Chirayil Padeetathil, Kallikkadu, Arattupuzha	OW	Used for all purpose, 50 m away from 1385/04.
1387	KWA Pump House, Ramcheri	TW	2 Km away from 1386/04
1388	KWA Pump House, Valiyazheekkal	TW	Drinking water, used for all purposes
1389	Subramanyam Temple, Valiyazheekkal	OW	Seven attacks of Tsunami, 300 m from 1388/04, used for drinking purposes

Table VIII

Lab No.	Type of well	EC (micromhos /cm)	Na (mg/l)	Cl (mg/l)	Sal (ppt)	Total coliform (MPN/100 ml)	Faecal coliform (MPN/100 ml)
1382/04	Open well	1240	55	127	0.47	≥1600	≥1600
1383	Open well	11800	1100	1442	3.76	500	34
1384	Open well	29500	3000	5024	11.2	500	500
1385	Open well	15500	2400	3642	6.34	1600	900
1386	Open well	16600	2300	2886	6.77	500	500
1387	Tube well	752	41	87	0.43	Nil	Nil

1388	Tube well	665	19	17	0.29	1600	1600
1389/04	Open well	1240	67	78	0.56	≥1600	≥1600

(MPN/100 ml – maximum probable number per 100 millilitre)

It is seen from the results that all the wells except the one coded 1387, were contaminated.

After a month, second stages of studies were initiated, both in Kollam and Alappuzha.

The water samples were analysed for Electrical conductivity, chloride, salinity and coliform contamination. As salinity intrusion is the most expected outcome of the impact, the results of salinity studies were interpreted in detail. (fig.2). It can be seen that most of the wells are showing reduction in salinity values.

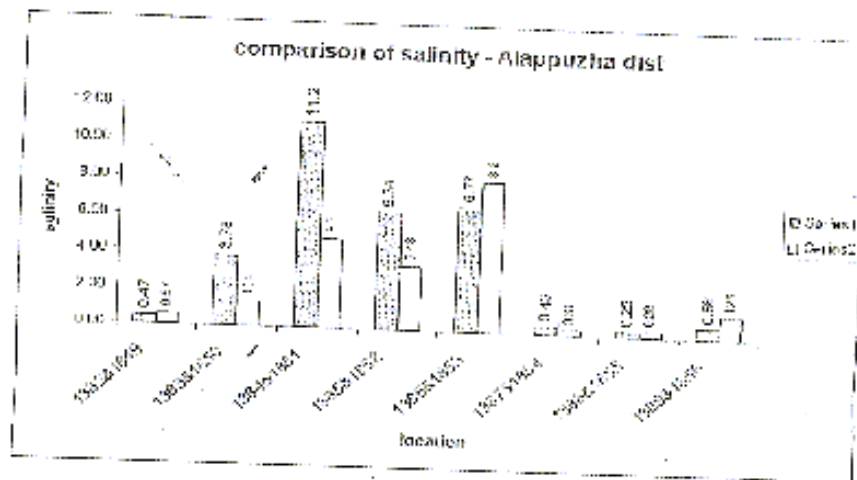


Figure 2

Coliform counts of all the above wells are compared and it is seen that most of the wells show reduction in values (Table IX).

The % reduction in salinity is also included in for the same table.

Table IX
% reduction in microbiological parameters in the second set of samples

Identification	TC I	TC II	TC reduction in %	FC I	FC II	FC read in %
1701	30	0	100	17	0	100
1702	≥1600	9000	--	≥1600	9000	--
1703	900	0	100	140	0	100
1704	900	11	99	900	4	100
1705	4	0	100	0	0	Same
1706	1600	1600	0	300	170	43
1707	110	50	55	50	50	0
1708	≥1600	9000	--	≥1600	1100	redn
1382	≥1600	700	redn	≥1600	700	redn
1383	500	13	97	34	8	76
1384	500	1600	increase	500	1600	increase
1385	1600	≥1600	increase	900	≥1600	increase
1386	500	≥1600	increase	500	≥1600	increase
1387	0	0	same	0	0	same
1388	≥1600	23	redn	≥1600	23	redn
1389	≥1600	900	redn	≥1600	70	redn

Here is also it can be seen that most of the wells show reduced number of coliform as compared to the previous results.

6.3 Conclusion

1. It is believed that the pressure of the wave was transmitted underground through the coastal aquifer ahead of the surface wave. Reports from Sri Lanka mention geysers appearing just before the land was flooded. Report from the Maldives mention wells filled with sand from below. Both events indicate a vertical upward pressure during the tsunami. More investigations are needed to understand the effects caused by these differences in pressure.
2. From the information collected by IGRAC (International Ground Resources Assessment Centre in the Netherlands) the following major impacts on the ground water resources were identified; salinization of shallow fresh groundwater, reduction in volume of freshwater lenses, landward shift of freshwater/saltwater mixing zones, pollution of groundwater by chemicals and other contaminants mobilized by flooding seawater.
3. From the present studies, it is found, after a month of the occurrence of Tsunami more than 80% of the wells are showing reduced values in salinity when compared to the samples collected just after the impact of the tidal waves of Tsunami.
4. With limited data, it is difficult to conclude that Tsunami had not affected the ground water permanently.