Saline Water Intrusion in *Bhadrak* and *Balasore* Districts of Orissa, India

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ABSTRACT

The Balasore coastal groundwater basin in Orissa, India is under a serious threat as regards to groundwater quantity and quality due to seawater intrusion. The soil of Balasore district is mostly alluvial and lateritic. The aquifer is severely contaminated by seawater intrusion within a 5 to 9km wide tract along the coastline, leaving the groundwater unfit for drinking and irrigation purposes. Chemical analysis of water samples of different blocks of Bhadrak and Balasore Districts of Orissa have been conducted. High values of chloride, iron and total dissolved solids have been noticed in the coastal area.
It is concluded that urgent measures are necessary to control saline water encroachment into the basin. Measures like rainwater harvesting, reducing pumping, rearrangement or re-distribution of points of extraction are needed.

INTRODUCTION

Balasore: Balasore is one of the coastal district of Orissa, lies on the northern most part of the state having 21 degree 03' to 21 degree 59' North Latitude & 86 degree 20' to 87 degree 29' East Longitude. Geographical area of the district is 36.34 Sq. KM. Midnapore district of West Bengal is in its North, the Bay of Bengal is on the east and Bhadrak district lies on the South whereas Mayurbhanj and Kendujhar districts are on its western side. Broadly, this district can be divided into three geographical regions, namely, the Coastal belt, the inner alluvial plain and the Northwestern hills. The coastal belt is about 26 km wide and shapes like a strip. In this region, sand dunes are noticed along the coast with some ridges. This region is mostly flooded with brackish water of estuarine rivers that is unsuitable for cultivation. However, presently this area is utilised for coconut

and betel cultivation. Two important rivers of Orissa, namely - Budhabalanga and Subarnarekha have passed through this district from west to east before surging into the Bay of Bengal.

The soil of Balasore district is mostly alluvial laterite. The soil of Central region is mostly clay, clay loam and sandy loam that is very fertile for paddy and other farm produces. Nilgiri Sub-division is mostly gravely and lateritic soil, which is less fertile. A small strip of saline soil is also seen along the extreme coastal part of the district.

Bhadrak: Situated at a distance of 159 km from Bhubaneswar, it has been separated from Balasore and thus is a new district born in the year 1993. Salandi River passes by this district.

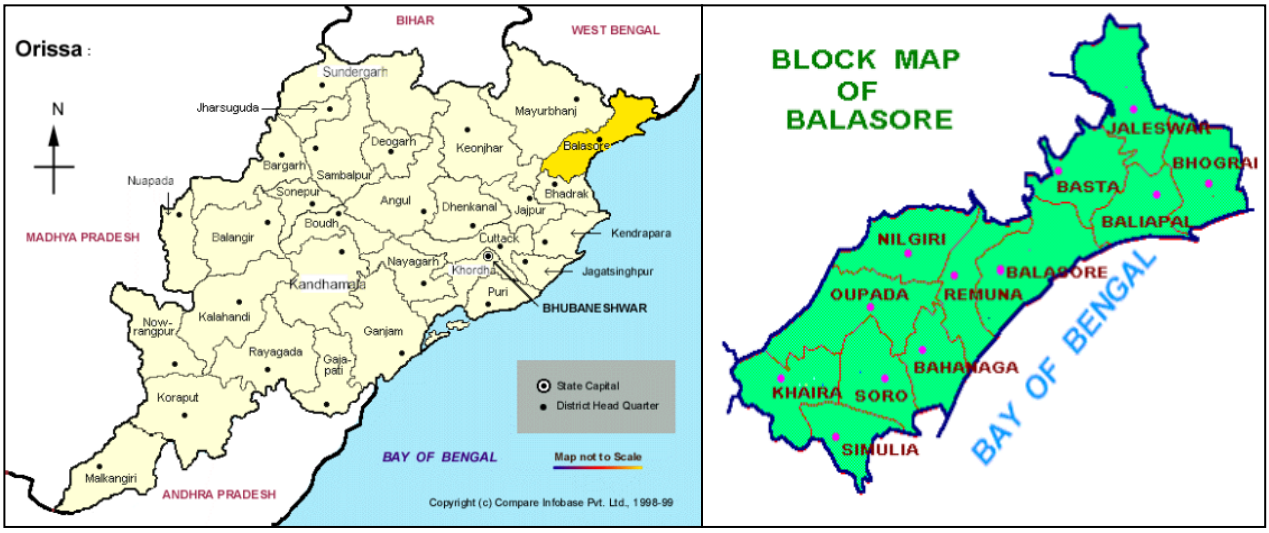

Figure 1: Map of Balasore district of Orissa

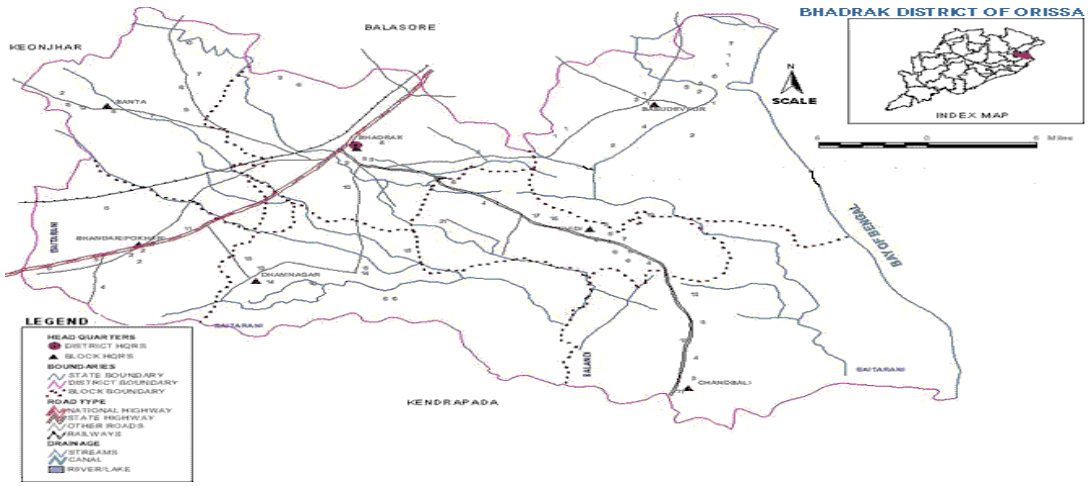

Figure 2: Map of Bhadrak district of Orissa

PHYSICO-CHEMICAL PROPERTIES OF WATER SAMPLES

Table 1*a*: The physico - chemical properties of samples in 22 wells at different location of Bhadrak & Balasore Districts of Orissa.

Name of the Wells And District	Source	pH	Specific Conductivity Micromhos /cm at 25^0	Carbonate ($Co_3^=$) in ppm	Bicarbonate ($HCo_3^=$) in ppm	Chloride (Cl^-) in ppm	Total Hardness in ppm	Iron Fe^{++} in ppm	Arsenic As In ppm	Total Dissolved Solids (TDS) In ppm
Permissible limit for drinking water		6.5-8.5	Below 780	------	------	250	300	0.3-1.0	0.05	500
01.Shimula, Bhadrak	Hand well	8.20	670	Nil	270	140	320	Nil	0.03	429
02. Chandbali Medical College, Bhadrak	Hand well	8.30	660	40	220	140	170	Nil	Nil	422
03. Arobinda School, Bhadrak	Hand well	8.27	650	Nil	270	130	160	Nil	Nil	416
04. Block Office Chandbali Bhadrak	Hand well	8.37	650	20	240	140	170	Nil	Nil	416
05. Shastrighat, Bhadrak	D.T.W.	8.00	710	Nil	320	160	240	Nil	Nil	454
06. Chandbali College, Bhadrak	Hand well	7.90	3900	Nil	120	1640	1170	0.3	Nil	2496
07.Panchapara Pump, Bhadrak	D.T.W.	8.19	690	Nil	310	150	200	Nil	Nil	442
08.Panchapara high School, Bhadrak	Hand well	8.17	670	Nil	270	130	240	0.1	Nil	429
09.RWSS Office, Bhadrak	D.T.W	8.27	1360	Nil	250	440	280	1.2	Nil	870
10.Basudevpur, Bhadrak	D.T.W	8.27	440	Nil	240	30	460	0.3	Nil	282
11.Mandari, Bhadrak	Hand well	8.07	620	Nil	380	40	290	Nil	Nil	397
12.Churasari, Bhadrak	Hand well	8.17	900	Nil	140	250	370	Nil	Nil	576
13.Parapukhri, Bhadrak	Hand well	8.50	720	40	230	150	310	Nil	Nil	461
14.Bidyapur, Bhadrak	D.T.W	8.37	550	40	260	140	140	0.1	Nil	352
15.Chandimaro, Bhadrak	Hand well	8.25	770	Nil	300	130	260	Nil	Nil	493
16.Allaghata, Bhadrak	Irrigation well	8.52	350	60	220	30	220	Nil	Nil	224
17.Sabrang, Bhadrak	Hand well	8.30	210	80	120	20	110	Nil	Nil	134
18.Soro, Balasore	Hand well	8.06	450	Nil	160	120	300	0.1	Nil	288
19.Sargar, Balasore	Hand well	8.09	240	Nil	130	40	90	0.1	Nil	154
20.Haldipara, Balasore	Hand well	8.77	1210	60	340	270	180	0.2	Nil	774
21.Rajghat, Balasore	Hand well	8.47	270	60	170	20	180	0.1	Nil	173
22.Damaria, Balasore	Hand well	8.30	290	60	180	30	170	0.1	Nil	186

GEOLOGICAL PROPERTIES OF AQUIFERS

Balasore

Table 1: Lithological Section of Borehole at Nurupur Road, Balasore, Orissa

Stratum	Depth in m.	Nature of formation	Hydraulic conductivity ,K m/day	Remarks
1	00.00m to 03.00m	Top Soil	$4.1x10^{-3}$	
2	03.00m to 06.00m	Sand	$4.1x10^{0}$	
3	06.00m to 15.00m	Yellowish Clay	$4.1x10^{-4}$	
4	15.00m to 20.00m	Fine Sand	$4.1x10^{0}$	
5	20.00m to 27.00m	Sand with Clay	$4.1x10^{1}$	
6	27.00m to 34.00m	Clay	$4.1x10^{-3}$	
7	34.00m to 40.00m	Coarse Sand	$1.84x10^{2}$	A (Zone)
8	40.00m to 50.00m	Sand with Clay	$4.1x10^{1}$	
9	50.00m to 80.00m	Medium to Coarse Sand	$4.1x10^{1}$	B (Zone)
10	80.00m to 100.00m	Sticky Clay	$4.1x10^{-3}$	

Table 2: Lithological Section of Borehole at Chandmaripadia, Balasore, Orissa

Stratum	Depth in m.	Nature of formation	Hydraulic conductivity in m/day	Remarks
1	00.00m to 05.00m	Top Soil	$4.1x10^{-3}$	
2	05.00m to 18.00m	Yellowish Clay	$4.1x10^{-4}$	
3	18.00m to 24.00m	Fine to medium Sand	$1.845x10^{2}$	
4	24.00m to 27.00m	Black Clay	$4.1x10^{-2}$	
5	27.00m to 29.00m	Fine Sand	$4.1x10^{0}$	
6	29.00m to 43.00m	Medium to Coarse Sand	$4.1x10^{1}$	A (Zone)
7	43.00m to 47.00m	Clay	$4.1x10^{-3}$	
8	47.00m to 60.00m	Fine to medium Sand	$1.845x10^{2}$	B (Zone)
9	60.00m to 66.00m	Sand with Clay	$4.1x10^{1}$	
10	66.00m to 100.00m	Black Sticky Clay	$4.1x10^{-2}$	

Filter position 1) 30m to 42m= 12m, 2) 48m to 58m= 10m

Table 3: Lithological Section of Borehole at inside Balasore Hoppital, Orissa

Stratum	Depth in m.	Nature of formation	Hydraulic conductivity in m/day	Remarks
1	00.00m to 03.00m	Top Soil	4.1x10-3	
2	03.00m to 15.00m	Clay	4.1x10-3	
3	15.00m to 27.00m	Fine to medium Sand	1.845x102	
4	27.00m to 36.00m	Clay with Sand	4.1x101	
5	36.00m to 41.00m	Medium to Coarse Sand	4.1x101	A (Zone)
6	41.00m to 45.00m	Sticky Clay	4.1x10-2	

7	45.00m to 71.00m	Medium to Coarse Sand	4.1x101	B (Zone)
8	71.00m to 85.00m	Sand with Clay	4.1x101	
9	85.00m to 91.00m	Fine Sand	4.1x100	
10	91.00m to 100.00m	Clay	4.1x10-3	

Filter position 1) 39m to 41m= 2m, 2) 47m to 71m= 24m

Bhadrak

Table 4: Lithological Section of Borehole of Kantabania, Bhadrak, Orissa

Stratum	Depth in m.	Nature of formation	Hydraulic conductivity in m/day	Remarks
1	00.00m to 07.50m	Yellowish Clay	4.1x10-4	
2	07.50m to 16.00m	Yellowish Clay with Sand	4.1x101	
3	16.00m to 21.00m	Sand mixed with Gravels	4.51x102	
4	21.00m to 33.00m	Coarse Sand mixed with Pebbles	6.56x102	
5	33.00m to 38.00m	Clay with Sand	4.1x101	
6	38.00m to 62.00m	Sticky Black Clay	4.1x10-2	
7	62.00m to 69.00m	Medium to Coarse Sand	4.1x101	A (Zone)
8	69.00m to 72.00m	Clay	4.1x10-3	
9	72.00m to 95.00m	Medium to Coarse Sand	4.1x101	B (Zone)
10	95.00m to 100.00m	Clay mixed with Sand	4.1x101	

Table 5: Lithological Section of Borehole of Bankamahal Bank near Sadabrata Nath, Bhadrak, Orissa

Stratum	Depth in m.	Nature of formation	Hydraulic conductivity in m/day	Remarks
1	00.00m to05.00m	Top Soil	4.1x10-3	
2	05.00m to08.00 m	Clay	4.1x10-3	
3	08.00m to 34.00m	Sand with Clay	4.1x101	
4	34.00m to 45.00m	Sand medium to coarse mixed with Gravels & Pebbles	6.56x102	
5	45.00m to 72.00m	Sticky black Clay	4.1x10-2	
6	72.00m to 86.00m	Sand medium to coarse	4.1x101	A (Zone)
7	86.00 m to 88.00m	Clay	4.1x10-3	
8	88.00m to 95.00m	Sand medium to coarse	4.1x101	B (Zone)
9	95.00m to 101.00m	Clay	4.1x10-3	

Table 6: Lithological Section of Borehole of near P.H.Pump House Bhadrak College, Bhadrak, Orissa

Stratum	Depth in m.	Nature of formation	Hydraulic conductivity in m/day	Remarks
1	00.00m to05.00m	Top Soil	4.1x10-3	
2	05.00m to16.00 m	Clay	4.1x10-3	
3	16.00m to 19.00m	Yellowish Sand	4.1x100	
4	19.00m to 25.00m	Sand with Clay	4.1x101	
5	25.00m to 38.00m	Clay	4.1x10-3	
6	38.00m to 44.00m	Clay with Sand	4.1x101	

7	44.00 m to 50.00m	Fine Sand	4.1x100	
8	50.00m to 55.00m	Clay	4.1x10-3	
9	55.00m to 73.00m	Medium to Coarse Sand	4.1x101	A (Zone)
10	73.00m to83.00m	Clay	4.1x10-3	
11	83.00m to 89.00m	Medium to Coarse Sand	4.1x101	B (Zone)
12	89.00m to 93.00m	Clay mixed with Sand	4.1x101	
13	93.00m to 101.00m	Medium to Coarse Sand	4.1x101	C (Zone)
14	101.00m to106.00m	Clay	4.1x10-3	

Filter position 1) 56m to 72m= 16m, 2) 84m to 88m= 4m, 3) 94 to 100m =6m
A (Zone), B (Zone) and C (Zone) are zones for granular sediments saturated with ground water.

RESULTS AND DISCUSSION

Chloride

Chlorides are normally present in water in the form of sodium chloride NaCl. Their concentration above 250mg/l produces a noticeable salt taste in drinking water. High chloride content indicates that the seawater intrusion takes places in these sites.

Iron (+++)

Both physico chemical and microbiological factors control the concentration of the iron in natural water. In ground water, iron generally occurs in two oxidation states i.e., Ferrous and Ferric. The presence of iron is within the tolerance limit as the upper limit setup by the World Health Organization (WHO) is 1.00 mg/l. According to the Indian Council of Medical Research, the maximum desirable limit is 0.1mg/l (ICMR, 1975). Iron in irrigation water should not exceed 20 mg/l in neutral or alkaline soils and 5mg/l in acidic soil.

Total Dissolved Solids (TDS)

The permissible limit of TDS in drinking water in ppm is 500ppm. The amount of TDS in Samples no.06, 09 and 20 have concentrations of 2496, 870, &774 ppm. From the above, it is obvious that the increase is due to the salt-water intrusion in the in coastal side. Based on the TDS present, the water samples were categorised as saline, brackish and fresh water.

CONCLUSIONS

For prevention and control of saline water intrusion, the following measures are to be implemented

- Collection of river water from upstream and distribution among different sectors after proper treatment.
- Reduction of pumping and rearrangement or redistribution of point of extraction
- Artificial recharge to create a freshwater ridge by injection wells or water spreading are implemented over the whole coastal basin.
- Relocation and redesign of wells and providing scavenger wells

- Development a pumping trough in the region between exploitation area of the coastal blocks. .
- At Rooftops rainwater are collected, used after light treatment.

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