

## Impact of dredging on coastal water quality of dhamra, Orissa

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Present investigation deals with the study of impact of dredging on water quality of Dhamra estuary, by evaluating the samples collected bi-monthly from various sampling stations during April-2008 to March-2010. Study revealed that the dredging operation has drastic impact on water quality of Dhamra, as total suspended solid and turbidity of both surface and bottom waters are high at dredging channel. Similarly, higher concentration of nutrients in dredging channel and disposal site shows clear impact of dredging. However, in certain points higher dissolved oxygen were observed in surface water at dredging channel may be due to higher phytoplankton production. But Biochemical Oxygen Demand of both surface and bottom water was intensely influenced by dredging due to release of organic rich sediment.

[**Keywords:** Dhamra estuary, Dredging, Physico-chemical parameters, Temporal variation, Water quality]

### Introduction

Rivers are the main inland water resources for domestic, industrial and irrigation purposes and often carry large municipal sewage, industrial wastewater and seasonal run-off from agricultural land to the coastal region<sup>1</sup>. Inflow of both seawater and freshwater provide high levels of nutrients in both the water column and sediment, making estuaries among the most productive natural habitats in the world<sup>2</sup>.

Dhamra port, the newly constructed and cost-effective port on the Eastern coast of India is located at Dhamra, Orissa. Proposed port site lies 04 kms from the river mouth along the landward coast of northern side. In recent years the various activities in port and harbour basically the dredging activities have certainly tremendous influence on the coastal and estuarine water quality of Dhamra. Dredging is a large-scale anthropogenic disturbance agent in coastal and estuarine habitats that can profoundly affect water quality<sup>3</sup>. Excavation, transportation and disposal of soft-bottom material lead to various adverse impacts on the marine environment<sup>4</sup>. The natural processes, such as precipitation inputs, erosion, and weathering of crystal materials, and anthropogenic influences such as urban, industrial, agricultural activities and increasing exploitation of water resources, all together

determine the water quality in a coastal region<sup>5</sup>. Dredging operation specifically has an adverse impact on water turbidity, suspended solids and nutrients. There is increase in suspended sediments and turbidity levels in marine water due to dredging and disposal operations under certain conditions which have adverse effects on marine animals and plants by reducing light penetration into the water column and by physical disturbance which causes reduction in the population of phytoplankton, zooplankton and also reduction in primary productivity in marine water. It is, therefore, suspected that the impacts on plankton and other organisms may be related to changes in the water physico-chemistry.

Considering the ecological importance of Dhamra region, the study was undertaken to assess the changes, if any, by evaluating the physico chemical parameters of both surface and bottom water samples collected bi-monthly from April 2008 to March 2010. Changes can also be ascertained by studying the seasonal variation with respect to various physico-chemical parameters of surface and bottom water samples.

### Materials and Methods

Dhamra estuary forms an important component of the Bhitara Kanika marine sanctuary on the northern coast of Orissa, India and its water

circulation is provided by two rivers namely Bramhani and Baitarani. To assess the impact of dredging on various physico-chemical parameters of Dharma estuary, a monitoring program was carried out during the period of dredging i.e. from April 2008 to March 2010. Sampling stations were selected along the stretch of the river starting from DRDO Jetty to a distance of 20 kilometers into the sea along the dredging channel of newly constructed Dhamra port. Station details like its position (Fig. 1) and the distance

(undisturbed zone). Stations 1, 2, 3 and 4 are nearer to the port area and considered as dredging channel whereas far off stations 5 and 6 are considered as marine zone.

To assess the impact of dredging, the surface and bottom water samples were collected bi-monthly from Dhamra estuary which is close to the dredging channel for a period of two years from April 2008 to March 2010. Surface and Bottom water samples were collected with the help of Niskin water sampler. Preservation and transportation of the water samples to the laboratory were as per standard methods<sup>6</sup>. Water temperature was measured on the site using mercury thermometer. pH, conductance and salinity were also analyzed on the spot by WTW model Multi 340i. Dissolved oxygen was fixed immediately after collection and then determined by Winkler's method. For the analysis of nutrients, surface water samples were collected in clean high density polythene bottles and kept in an ice box and transported immediately to the laboratory. Nutrients ( $\text{NH}_4^+$ ,  $\text{NO}_3^-$ ,  $\text{PO}_4^{3-}$ ) were determined by standard photometric method<sup>7</sup> using Varian 50 Bio UV visible spectrophotometer. Samples for BOD were incubated in laboratory for five days at  $20^\circ\text{C}$ <sup>8</sup> and then it was determined by same Winkler's method. Turbidity was measured by 2100P HACH Turbidimeter using 0.01, 20, 100 and 800 NTU standards. Total hardness was estimated by the complexometric titration with standard EDTA solution using Eriochrome Black T as indicator. The Total Suspended Solid was determined with the help of Cellulose nitrate membrane filter paper of pore size  $0.45\ \mu\text{m}$ .

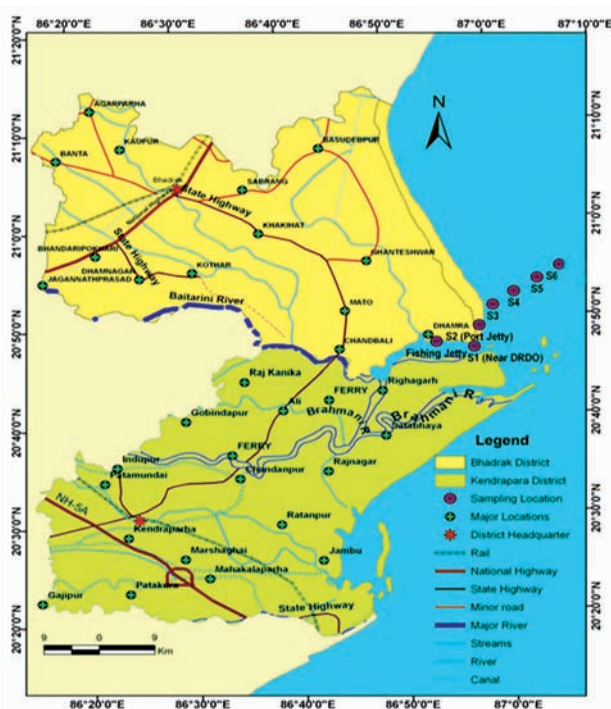


Fig. 1–Map showing Locations of Sampling Station.

of each station from port were presented in Table 1. Bottom water samples were collected at a varying depth which is also mentioned in the same table. The entire stations were divided into two zones, one is Dredging channel and the other is Marine zone and

## Results and Discussion

Dredging and disposal processes cause temporary increase in the level of suspended solids and turbidity, there-by, influencing the positive variation in other physico-chemical parameters. For better impact analysis and understanding, the entire sampling area

Table 1–Station Locations with distance from Coast and Sampling Depth

Station Locations	Latitude	Longitude	Distance from Port (kms)	Distance from Coast (kms)	Depth in Meter
Station 1(River mouth)	20°46' 55.5" N	86°57'40.5" E	4.19	0.52	6.0
Station 2(Port)	20°49' 05" N	86°58'14.3"E	0.0	0.27	9.8
Station 3	20°51'33.5" N	87°00'17.0"E	5.0	3.73	11.0
Station 4	20°52'55.8"N	87°02'44.9"E	10.0	8.23	13.0
Station 5	20°54'20.4"N	87°05'14"E	15.0	13.24	17.0
Station 6	20°54'54.3"N	87°06'13.8"E	17.0	17.86	19.0

were divided into two zones i.e. one is dredging zone and the other, the marine zone. As depicted in Fig. 1 the sampling stations 1 to 4 are near the vicinity of dredging channel and 5, 6 stations are in the marine zone, which are very much nearer to the disposal site of dredged materials. Irregular trend observed in marine zone with respect to various parameters is due to the discharge of dredged materials causing re-suspension of sediments.

The potential environmental effects of dredging arise due to the excavation of sediments at the sea bed, loss of material during transport to the disposal site and during disposal. Dredging has a strong impact on marine water environment, especially to the suspended solids and turbidity. Considering the temporal variations, the turbidity of surface water ranged from 2.3 to 319.25 NTU with the maximum value observed in the month of March 2010 in pre monsoon period at the dredging channel (Fig. 2(a))

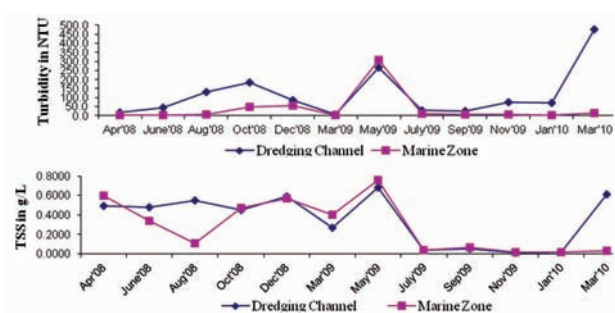


Fig. 2(a)–Temporal variations in Turbidity and TSS of Surface water during April'08 to March'10.

and similar trend was also observed in case of bottom water in March'2010 at dredging channel (Fig. 2 (b)). Minimum value was observed in Nov'09 at marine zone. This may be due to dredging as well as also due to higher current and tidal action which cause resuspension of sediments. Turbidity is mainly due to the dispersion of suspended particles and its abnormal

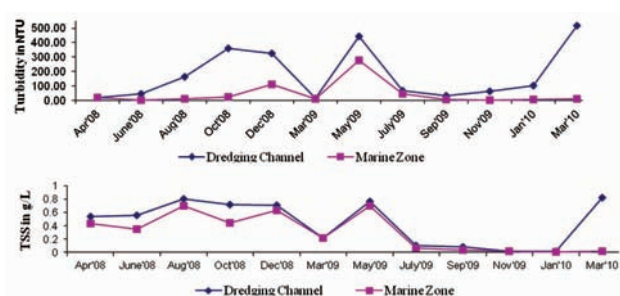


Fig. 2(b)–Temporal variations in Turbidity and TSS of Bottom water during April'08 to March'10.

values are usually due to the discharge of water, floating sediments carried by the river from different catchment areas<sup>9</sup>.

When dredging and disposing of sediment materials in estuaries and coastal waters occur, it eventually suspends the fine sediments and increases the water turbidity. So it was observed that the turbidity was usually higher in the dredging zone for both surface and bottom water in comparison to the marine region. Statistical analysis reveals that turbidity shows positive correlation with total suspended solid. By considering the Mean  $\pm$  SE graph (Box and Whisker's plot) for both surface and bottom water (Fig. 3(a), (b)), it was observed that in the dredging region the turbidity value was constantly high during April 2008 to March 2009 period during which major dredging operation was being carried out. While

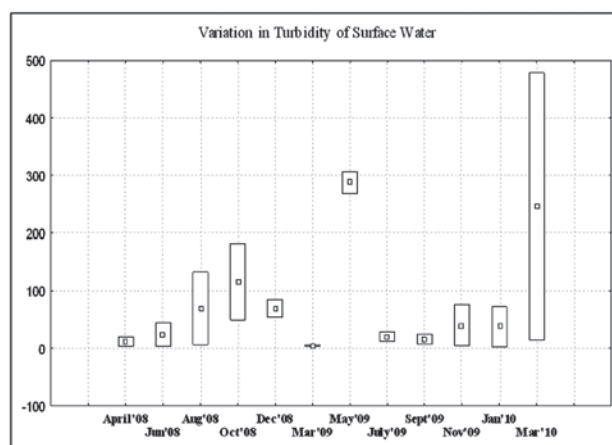


Fig. 3(a)–Mean  $\pm$  S.E. graph (Box and Whisker's plot) for Turbidity of Surface water at Dredging Channel.

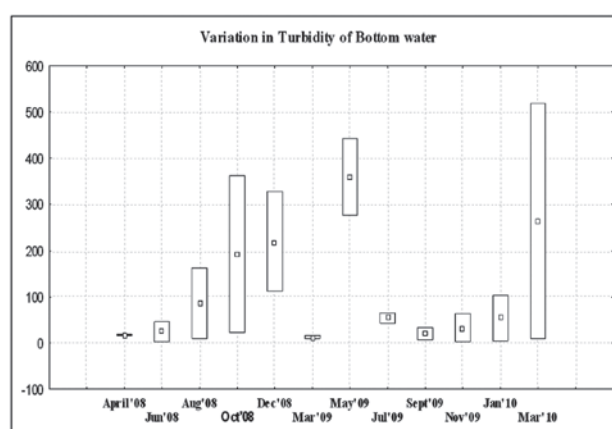


Fig. 3(b)–Mean  $\pm$  S.E. graph (Box and Whisker's plot) for Turbidity of Bottom water at Dredging Channel.

during April 2009 to March 2010, the values were low in comparison to previous years as the dredging operation was a minor one which was carried out to clear the silt and suspended sediments settled at the bottom of the approach channel for the shipping activity. Similar trend was observed in case of total suspended solid of surface and bottom samples as shown in Fig. 4(a), (b) of Mean  $\pm$  S.E. graph (Box and Whisker's plot). Dredging process also supplements the higher suspended solids in marine water as it causes re-suspension of sediments from the sea bottom during the excavation. Maintenance dredging is having near-field and temporary effects and lasting as long as dredging operations are taking place. Higher value of suspended solid for surface water was observed in the month of March 2010 in the dredging channel and the lower value was observed in November 2009 in marine zone (Fig. 2 (a)), whereas for bottom water, the higher value was observed in Mar'2010 at dredging

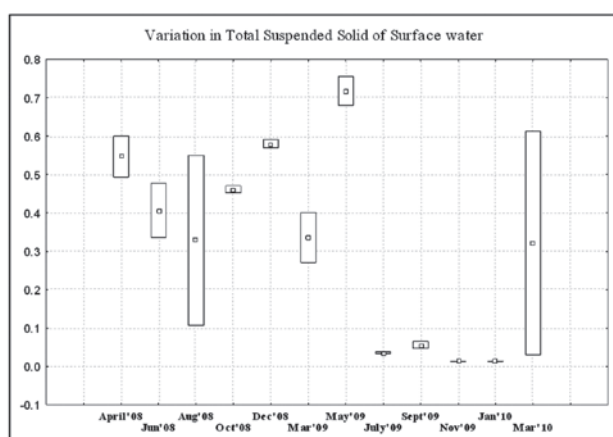


Fig. 4(a)–Mean  $\pm$  S.E. graph (Box and Whisker's plot) for Total Suspended Solids of Surface water at Dredging Channel.

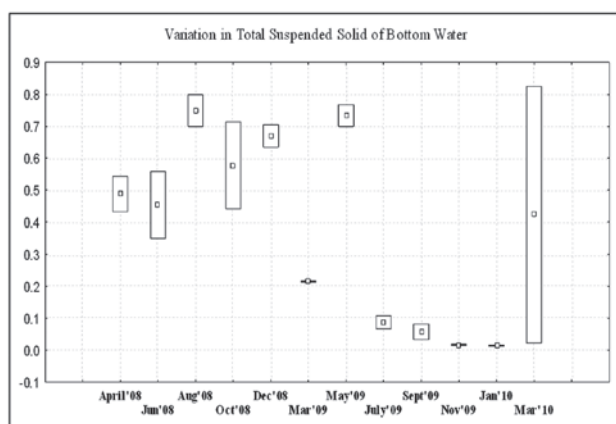


Fig. 4(b)–Mean  $\pm$  S.E. graph (Box and Whisker's plot) for Total Suspended Solids of Bottom water at Dredging Channel.

channel and lower value was observed in Jan'2010 at marine zone (Fig. 2 (b)). From temporal view the higher total suspended solid was observed in the pre-monsoon period due to heavier current and tidal action and lower was observed in the post monsoon period. However, the TSS and Turbidity values are also abnormally high even in marine zone at certain stations because of disposal of dredging material.

Usually the release of organic rich sediments during dredging or disposal results in localised oxygen depletion. Higher values of nutrient and TSS due to resuspension of sediments also cause low Dissolved Oxygen. Minimum DO value was observed in the month of March 2009, both in surface and bottom waters, which may be ascribed to dredging and higher bacterial activity at high temperature (Fig. 5 (a)). Bottom water was predominantly influenced by dredging as reflected in the lower values of DO in Mar'09 at dredging channel due to the resuspension of organic rich sediment. As Dissolved Oxygen variation is controlled by both Primary production and respiration, during this study period there was no such drastic anoxic condition as observed for surface water. This may be due to higher phytoplankton production which leads to high DO value. Maximum value of Dissolved Oxygen in surface water was observed in the month of January 2010 in the dredging channel, may be due to less maintenance dredging, winter cooling, lower bacterial activity and higher photosynthetic activity. Higher DO value was also observed in the month of Dec'08 at marine zone (Fig. 5 (b)). Maximum value of Biochemical Oxygen Demand of surface water was recorded in the month of September 2009 at dredging channel and certain higher values obtained for surface and bottom waters during April 2009 to March 2010 at dredging channel and marine zone may be due to the oxidation of re suspended organic matter and addition of sewage by river influx (Fig. 5 (a), (b)).

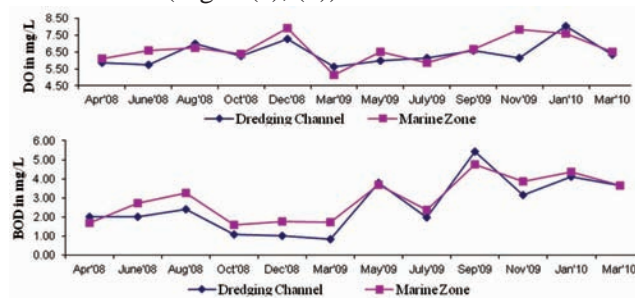


Fig. 5(a)–Temporal Variations in DO and BOD of Surface water during April'08 to March'10.

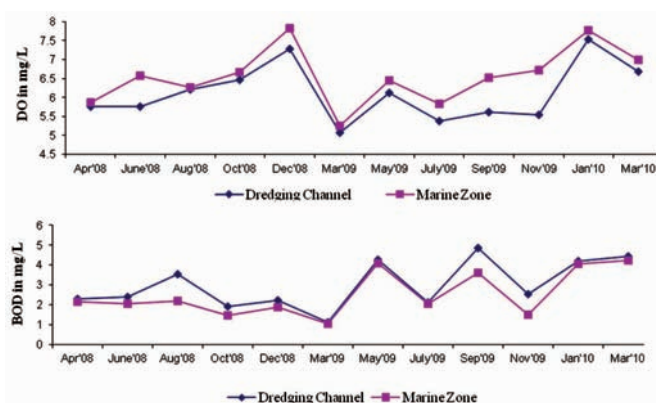


Fig. 5(b)-Temporal Variations in DO and BOD of Bottom water during April'08 to March'10.

River runoff and sediment transport is the main source of nutrients in the estuarine region. Besides, dredging operations certainly has influence on nutrients of marine water. Re-suspension of sediments during dredging and disposal resulted in an increase of the levels of organic matter and nutrients available to marine organisms. The study revealed that nutrients such as Nitrate and Phosphate values of surface water were higher in the dredging channel in comparison to marine zone, particularly in monsoon and post-monsoon, due to the increase in suspended sediment loads in water which releases nutrients to the water column due to the dredging<sup>3</sup>. Release of domestic and industrial wastes and use of fertilisers in the river catchment could also be the plausible reason for higher values. However, the concentration of ammonia of surface water did not seem to show any particular spatial variation during the period. Considering the seasonal trend, the nitrate values of surface water are higher in November 2009, may be largely due to the organic materials reception from the catchments area during rainfall<sup>10</sup>. Increasing nitrates level is also due to fresh water inflow and terrestrial run-off during the post-monsoon season<sup>11</sup>. Accumulation of organic sewage in estuary is a reason for higher nitrate value. Similarly, the higher values recorded in monsoon period i.e. in July 2009 and June 2008 for ammonia and phosphate were due to the river water influx, agricultural runoff, local sewage carried by river and industrial waste disposal which increased the level of phosphate<sup>12</sup> (Fig. 6 (a)). Similar observations even in certain far off stations in marine zone are obtained may be due to the disposal of dredging material. Bottom water of Dhamra estuary is undoubtedly predisposed by dredging as the higher values of nitrate

and phosphate were observed in monsoon i.e. in July 2009 at dredging channel and lower values were observed in January 2010 and March 2010 at

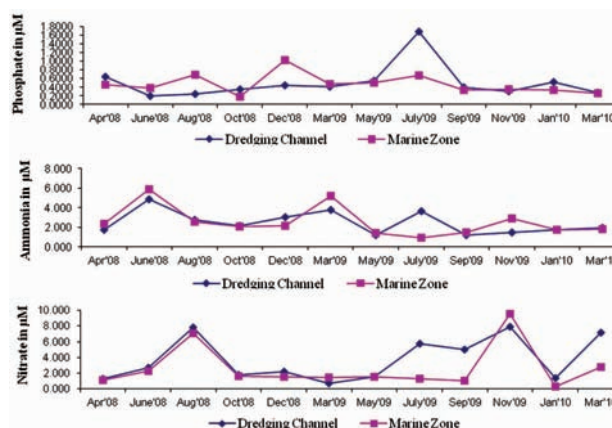


Fig. 6(a)-Temporal variations in Phosphate, Ammonia and Nitrate of Surface water during April'08 to March'10.

undisturbed zone respectively. Similarly the higher values of ammonia was observed in August 2008 at dredging channel and lower values was observed in May 2009 at marine zone which shows a clear impact of dredging on nutrients (Figure. 6 (b)).

The dredging action does not have any possible impact on water temperature as the entire stations showed similar trend with seasonal variations. Generally, surface water temperature is influenced by the intensity of solar radiation, evaporation, insolation, freshwater influx<sup>13</sup>. Maximum value of pH of surface water was observed in the month of November 2009 in the marine zone and the minimum value was observed in the month of May 2009 at dredging channel due to fresh water influx. Salinity is one of the key factors in marine environment. Considering the

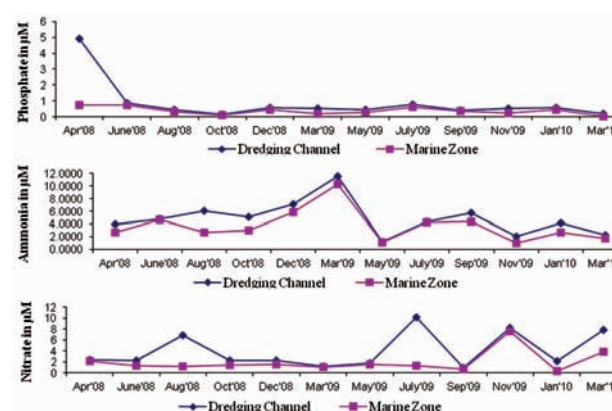


Fig. 6(b)-Temporal variations in Phosphate, Ammonia and Nitrate of Bottom water during April'08 to March'10.

seasonal trend, the maximum value of salinity of surface water was observed in the month of May 2009 which is in pre monsoon period due to the higher degree of evaporation and the minimum value was observed in the month of August 2008 which is in monsoon period due to the influence of heavy rainfall and the resultant river run-off.

### Conclusion

The dredging operation has a drastic impact on both total suspended solid and turbidity of surface and bottom water. Higher values were obtained at dredging channel during the dredging period. However, certain higher values of Turbidity and Total Suspended solids were also observed in marine zone during disposal of dredging material in the near vicinity. Dredging has also significant impact on DO, BOD and nutrients. Higher values of DO observed in surface water in certain stations were due to higher phytoplankton population. Nutrient values were high for both surface and bottom water at dredging channel in comparison to the undisturbed area, may be due to increase in suspended sediment loads in water which releases nutrients to the water column. Similar high concentrations even in certain far off stations in marine zone were observed due probably to the disposal of dredged material. Hence, impacts are site specific and difficult to quantify exactly the level of contribution from natural or man-induced.

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