Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 2 (12) November 2013: 13-20

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD

ORIGINAL ARTICLE

Seasonal and Spatial Distribution of the Hydro-chemical properties of Mahanadi estuary and influence near the Mahanadi and Paradip coastal Environment, East coast of India

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ABSTRACT
The distributions of Hydro-chemical parameters viz. Temperature, Salinity, Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Total Suspended Solid (TSS), nutrients [NO_2-N, NO_3-N, NH_4-N, PO_4-P, SiO_4-Si, Total nitrogen (TN), Total phosphorous (TP)] and Chlorophyll-a (Chl-a) were studied in the Mahanadi river and costal environment of Paradip in two different seasons i.e. post-monsoon and summer during year, 2009-2011. Results of nutrient concentrations were exhibited higher indicating that large inputs possibly from two major fertilizer plants, municipal sewage from Paradip town and agricultural runoff. The most of nutrients variation were showed higher values during post-monsoon in estuary as compared to the costal transect stations. The PO_4, TN, TP and SiO_4-Si showed a well-defined pattern of distribution with higher concentration in estuarine water of Mahanadi estuary during summer.
Key Words: *Hydro-Chemical; Pollution; Industrial wastes; Domestic sewage; Paradip Coastal; Mahanadi Coastal; Mahanadi estuary.*

Received 12.07.2013 Accepted 09.11.2013

INTRODUCTION

Pollution in the marine environment affects not only aquatic life as such but also poses a serious threat to all life on the planet. Estuary and coastal water are particularly at risk from such anthropogenic and industrial pollution [1]. The marine environment, especially costal and estuary form an essential component of the global life. Many estuaries are degraded all around the world because of industrial, agricultural, and urbanization activities [2-4]. The environmental pollution is the major problem in the marine environment. Industrialization and rapid increase in human population have resulted in transformation of the natural environment. The environment became hostile, posing many threats to health and welfare because of pollutants released into the environment [5]. The environmental impacts of municipal wastewater and industrial effluents discharge on receiving water are numerous and inputs of contaminants can affect the aquatic biota as well as the health of the coastal environment [6]. The surface water quality is very sensitive issue due to anthropogenic influence (Urban, industrial and agriculture activities, increasing consumption of water resources) as well as natural processes (changes in precipitation inputs, erosion, weathering of crustal materials) degrades surface water and impair use for drinking, industrial, agricultural, recreation and other purposes [7,8]. Estuaries constitute a major interface between land and the ocean and have been regarded as one of the most important aquatic system. The progressing of large industries in Paradip there is a threat to the health of the Mahanadi estuarine and coastal water environment. The sewage from urban areas and industrial wastages contributes a constant source of pollutants, where as the surface runoff is a seasonal phenomenon largely affects by climate in the basin. The urban inputs, agricultural runoff and industrial inputs play a vital role in nutrient cycling, water quality, eutrophication, biota abundance and overall food web dynamics in estuarine and near shore ecosystems. Apart from this, fishing activities near the estuary also influence the water quality parameters. Mahanadi is one of the major river in India and is the largest river of Orissa state having the annual discharge of 66,640mm^3. The average annual rainfall is 1572 mm, of which 70% is precipitated during the south east monsoon but mid June to mid October. The growth of industrialization

and urbanization in the upstream and estuarine region of Mahanadi, the largest river in Odisha is putting unique pressure on estuarine and coastal resources [9-12,6].

Although researchers have analyzed the Hydro-chemical parameters of Mahanadi river and estuarine system [6,8,9,13-18]. The Physico-chemical parameters influence in estuarine along with the coastal environment in Paradip have been studied for present analysis that based on the assessment on seasonal distribution of the Hydrographical properties.

OUTLINES OF STUDY SITE

Mahanadi drainage basin is the biggest along the east coast of India. The tidal estuarine part of the river covers a length of 10 km and has a basin area of 9 km^2 [18,19]. Tidal cycle is semi-diurnal and is principally a wave-dominated coast during the southwest monsoon season, while during the non-monsoon period it is mixed wave and tide dominated [9]. Paradip port situated at the northern end of Bay of Bengal and act as important shoreline harbours along the east coast of India. Apart fishing harbour activities at the estuary this affects the water quality greatly. The effluents in Mahanadi estuary mostly receive from fertilizer plants, small industries and domestic sewages of Paradip and surroundings. Atharbanki creek that flows to the Mahanadi estuary heavily loads with municipal sewage, phosphates and solid wastes. These come from phosphatic fertilizer plants to the estuary. The anthropogenic and port activities also largely influence the estuarine environment of Mahanadi and meets Bay of Bengal at Paradip coast as shown in (Fig. 1 & 2).

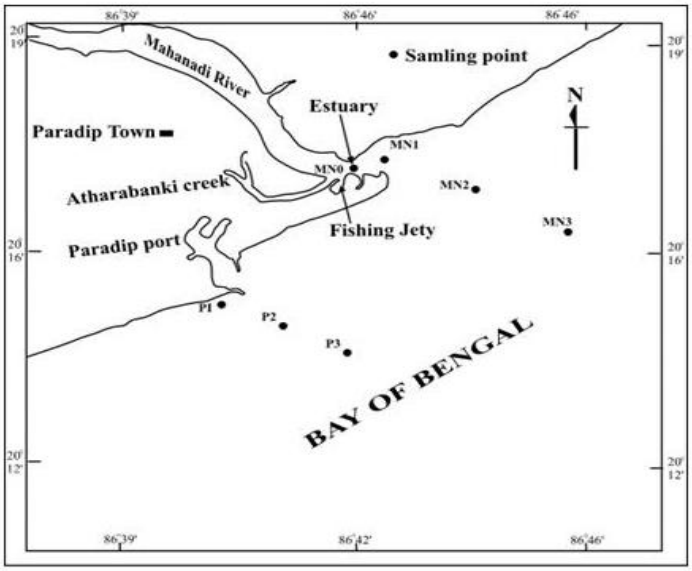

Fig: 1 Map location station of Mahanadi esuary, Mahanadi and Paradip transect

Fig.2. Map Showing Mahanadi Estuary (MN-0), Paradip Coastal (P-01 to P-05) and Mahanadi transect s(MN-01 to MN-05)of Sampling Point.

ANTHROPOGENIC STUDY OF THE AREA

Esturine and Coastal areas are complex and dynamic aquatic environment [20], when river water mixes with seawater, a large number of physical and chemical Processes takes place, Which may influence physico-chemical properties of that study site. The quality of surface water is sensitive issue. River plays a major role in assimilation of municipal and industrial waste water and runoff from agricultural land [21]. The river receives back the untreated Domestic waste water from the cities of Sambalpur, Boudh, cuttack Choudwar, Jagatpur and paradip and Effluents from some industries (Fertilizers, papers, Textiles, Distilleries and others) [6,11]. It also receives large amount of Agricultural runoff along its course. Human influences are pronounced at three major urban settlement on the banks of river namely Cuttack (Population above 0.50 million), Sambalpur (Population above 0.20 million) and Port city of Paradip (Population above 0.15 million), where the proliferation of industries and sewer discharges are prominent [18].

SITE DESCRIPTION AND METHODOLOGY

The two transects, Paradip and Mahanadi along Paradip coast which are perpendicular to the shoreline were selected for the present investigation at Mahanadi Stations, (Lat.$20^0$17′ 34″N and Long.$86^0$43′00″E) and Paradip coastal at (Lat.$20^0$15′30″N and Long.$86^0$40′34″E) and The Mahanadi river Mouth at a Station (Lat.$20^0$17′16″N and Long.$86^0$42′28″E) Shown in Fig. 1 & 2. Each transect comprises of three stations located at 0, 1, 3 and 5 Km from the shoreline (Fig.2). Water samples were collected during 2009-10 and 2010-11 from the stations of these Mahanadi and Paradip transects along with Mahanadi estuary during low and high tide periods. Surface water samples were collected with the help of "Aquatrap" water sampler. Water temperature and pH were measured by using WTW Kit in the field. The parameters Salinity, DO, BOD, and TSS were analysed by the standard methods [22]. The Nutrients and Chlorophyll-a pigment were determined by UV- Visible spectrophotometer (Perkin Elmer, Lambda 35) as described in methods of seawater analysis [23]. Chlorophyll-a pigment were analysed by Spectrophotometer after filtering one litre of water sample through GF/C filters and extracted by 90% acetone [24,25].

RESULT AND DISCUSSION

Seasonal and Spatial variation of Physico-chemical parameters in surface water at Paradip and Mahanadi coastal transect along with estuary are given in (Fig.2). All the physico-chemical parameters values (mean± S.D) are in Table.1 and were discussed in following manners. The Hydro chemical parameters and their seasonal and diurnal variations were shown in Fig.3.1 to Fig. 3.5.The water temperature in coastal water of Paradip and Mahanadi varied between 21.3 and 28.5ºC. Salinity varied from 1.62 to 31.36 PSU in surface water. The lowest salinity was found in estuary water in post-monsoon period. It showed an increasing trend in seaward direction, due to the river run off in this period and high dilution in the estuary (Fig.3.1).

	Mahanadi estuary	**Mahanadi coastal**	**Paradip coastal**
Parameters	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
WT	26.90 ± 1.52	24.70 ± 3.22	26.93 ± 1.23
SSC	17.00 ± 11.90	14.62 ± 8.19	11.55 ± 3.53
pH	7.83 ± 0.36	7.61 ± 1.64	8.50 ± 0.18
Salinity	19.06 ± 11.67	27.24 ± 3.97	23.70 ± 4.97
DO	6.68 ± 1.11	6.58 ± 0.30	6.99 ± 0.47
BOD	2.46 ± 0.73	2.29 ± 0.62	2.18 ± 0.68
NO_2-N	0.83 ± 0.33	0.50 ± 0.25	0.51 ± 0.23
NO_3-N	4.05 ± 0.90	3.07 ± 0.97	3.31 ± 1.87
NH_4-N	4.38 ± 1.41	3.41 ± 0.98	3.28 ± 1.19
TN	53.57 ± 5.71	47.35 ± 8.45	50.70 ± 7.54
IP	10.43 ± 3.85	6.30 ± 1.56	5.47 ± 1.20
TP	12.41 ± 2.84	8.16 ± 1.77	7.09 ± 1.87
SiO_4-Si	12.14 ± 1.53	7.01 ± 2.94	6.26 ± 2.10
Chlorophyll-a	1.42 ± 0.51	1.16 ± 0.30	0.93 ± 0.25

Table: 1. Variation of mean, standard deviation (SD) values of environmental variables in the Mahanadi and Paradip coastal water with Mahanadi estuary.

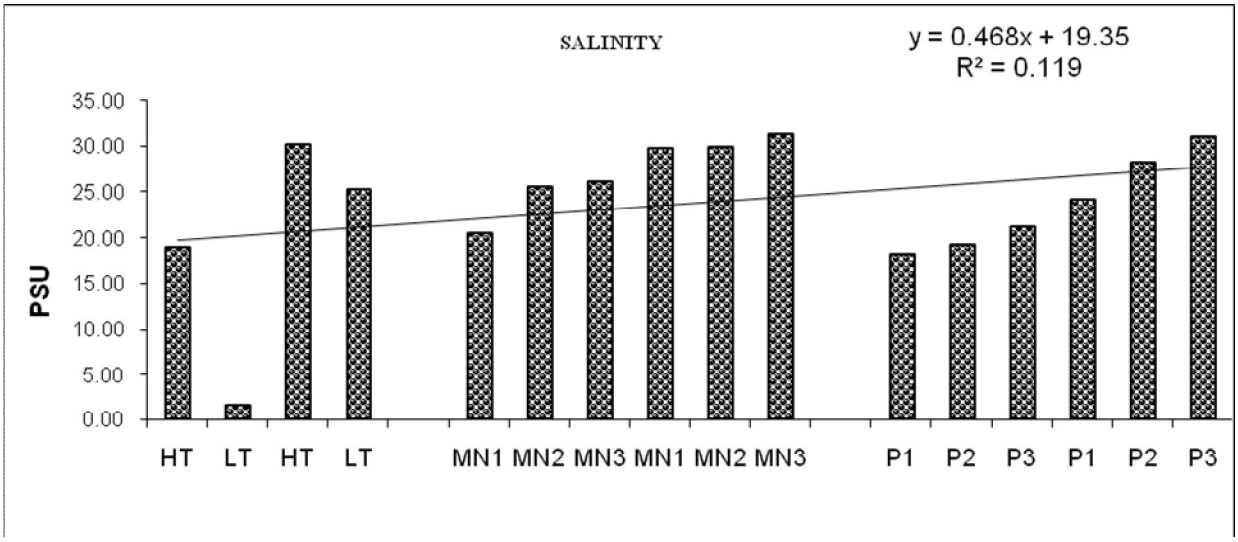

Fig.3.1 Salinity variation with regression values among two coastal bodies, Paradip (P1 to P3 stations) and Mahanadi coastal (MN1 to MN3 stations) in summer and post monsoon seasons with its diurnal impact of Mahanadi estuary[both Low tide(LT) and High tide(LT) conditions].

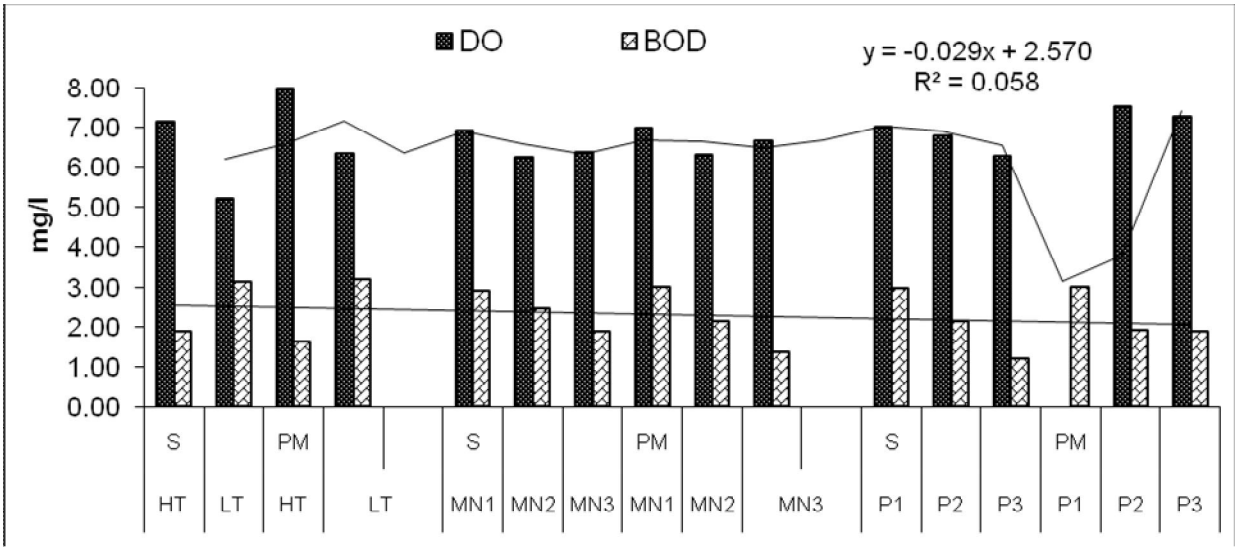

Fig.3.2. DO and BOD variation with regression values among two coastal bodies, Paradip (P1 to P3 station) and Mahanadi coastal(MN1 to MN3 stations) in summer(S) and post monsoon(PM) seasons with its diurnal impact of Mahanadi estuary[both LT and HT condition].

The pH in surface water was in the range of 7.25 to 8.42. Dissolved oxygen (DO) varied from 5.21 to 7.98 mg/l in surface water. Slightly lower values of DO were recorded estuarine water as compared to the coastal water indicates that a high organic load from the sewage of Paradip port, town ship as well as effluents from fertilizer industry situated upstream of the Mahanadi estuary [6]. The Biochemical oxygen Demand (BOD) ranged between 1.35 to 3.21 mg/l in coastal water. Higher BOD was found in estuary water as compared to the coastal water due to the large amount of municipal sewage wastes, effluents from industries. Atharbanki creek carries all the sewage Paradip township and industrial effluents from fertilizer industry direct in to the estuarine environment. Increase in the DO and decrease in BOD were observed from shore to offshore stations. Suspended solids varied from 6.96 to 35.35 mg/l that were well within the permissible limits [26]. The variations of nutrients concentrations in coastal water ranged between 0.36 µmol/l to 1.25 µmol/l of NO_2-N, 1.65 µmol/l to 5.32 µmol/l of NO_3-N, 2.69 µmol/l to 6.32 µmol/l of N-NH_4, 35.62 µmol/l to 62.35 µmol/l of TN, 6.21 µmol/l to 16.03 µmol/l of inorganic PO_4, 7.65 µmol/l to 16.31 µmol/l of TP and 5.21 µmol/l to 10.02 of µmol/l SiO_4-Si. In general the nutrient concentrations were higher in estuary water as compared the coastal water. The higher concentrations of Inorganic PO_4, TP, SiO_4-Si in Mahanadi transect compared to those in Paradip transect may be due to the impact of riverine discharges and effluents from phosphate fertilizer plants that situated near the

estuarine region [27]. The Chlorophyll-a (Chl-*a*) concentration ranged from 0.85 to 2.16 mg/m^3 in coastal transects of Mahanadi and Paradip. The Chl-*a* concentration was to be higher in estuarine water compared to the coastal transects, which could be due to the higher abundance of phytoplankton and nutrients.

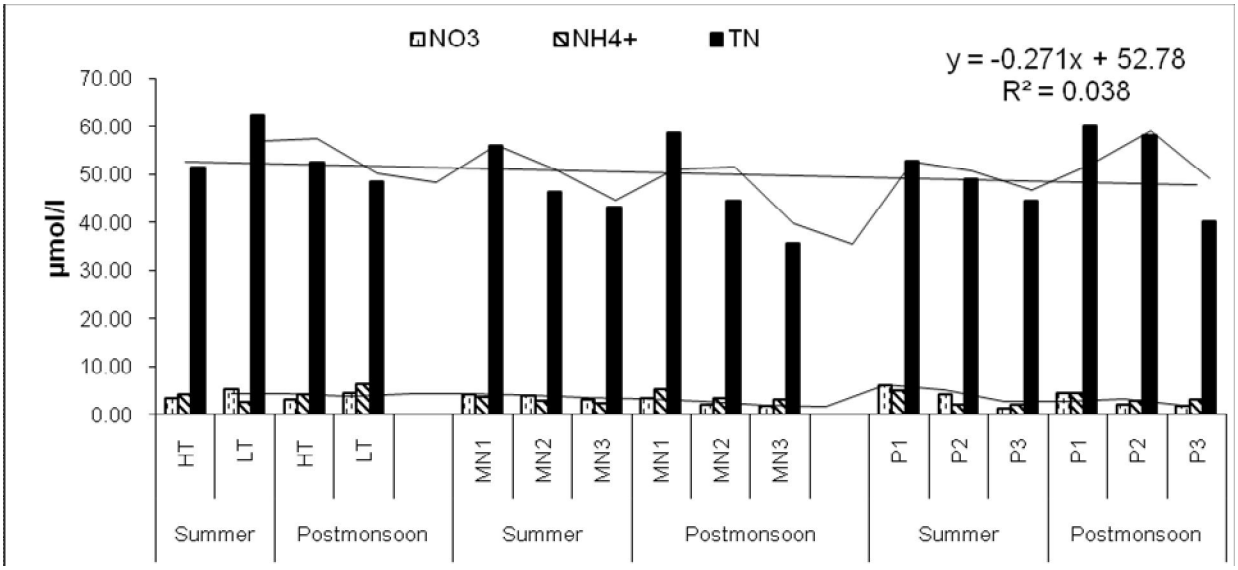

Fig.3.3. $N0_3$-N with NH_4^+-N and TN Variation with Regression values among two coastal bodies, Paradip and Mahanadi coastal in summer and post monsoon season with high and low tides influence on Mahanadi estuary.

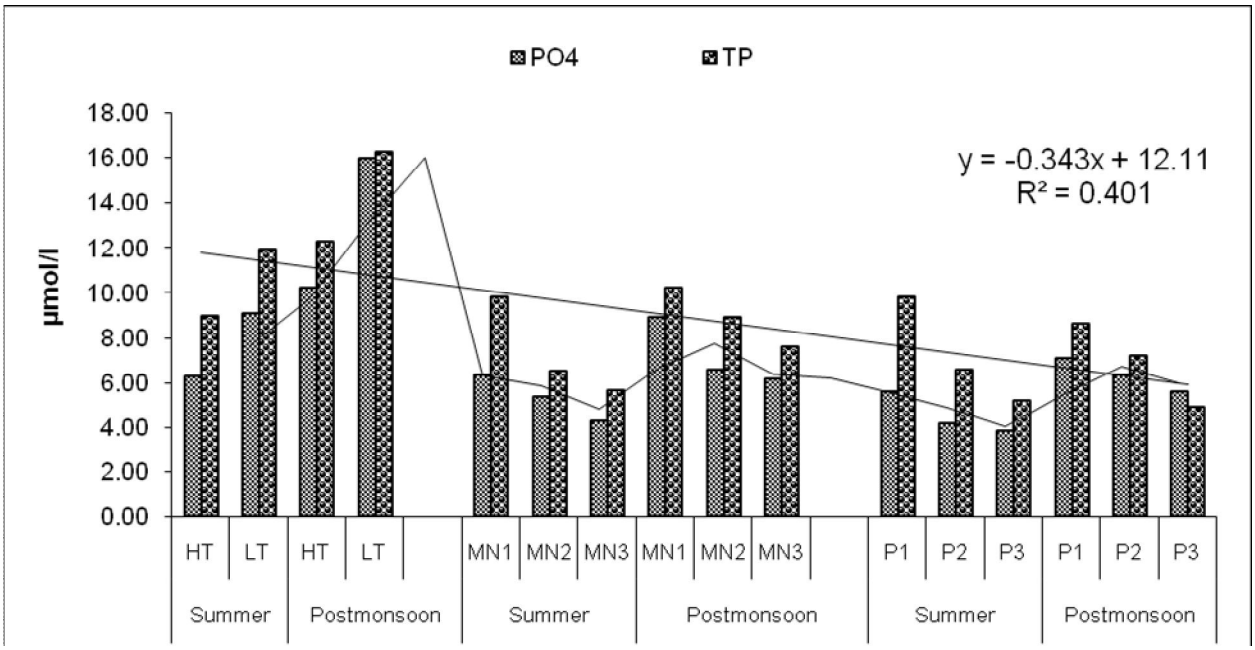

Fig.3.4. Inorganic Phosphate (PO_4) with Total Phosphorus (TP) variation and its regression values among two coastal bodies, Paradip and Mahanadi coastal in summer and post monsoon season with tidal impact on Mahanadi estuary[Low tide(LT) and High tide(HT) condition].

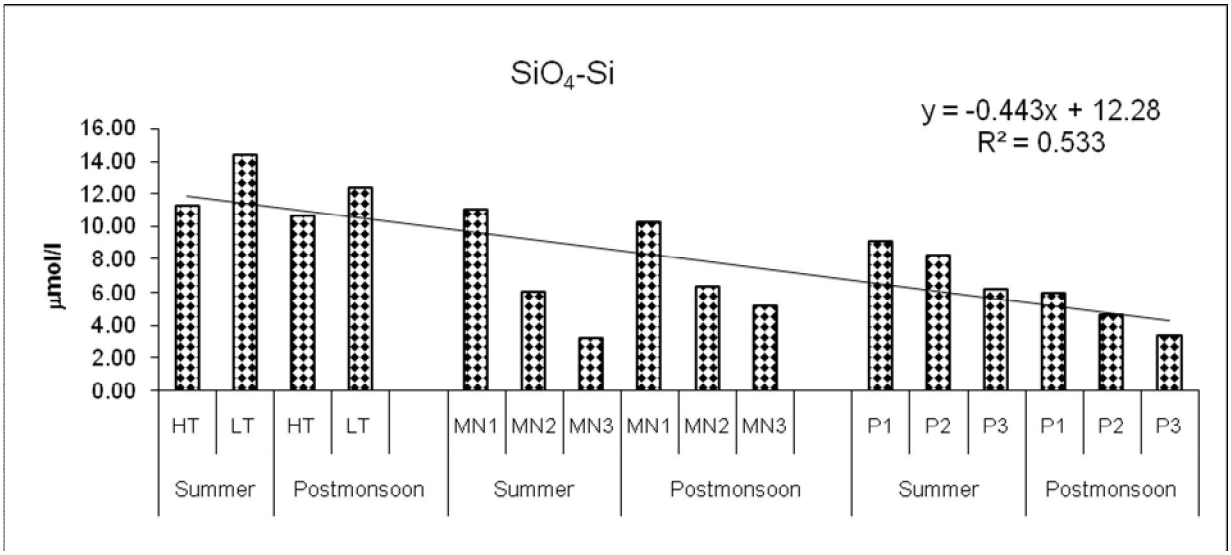

Fig.3.5. Silicate (SiO_4-Si) variation with regression values among two coastal bodies, Paradip and Mahanadi coastal in summer and post monsoon season with diurnal impact of Mahanadi estuary[Low tide(LT) and High tide(HT) condition].

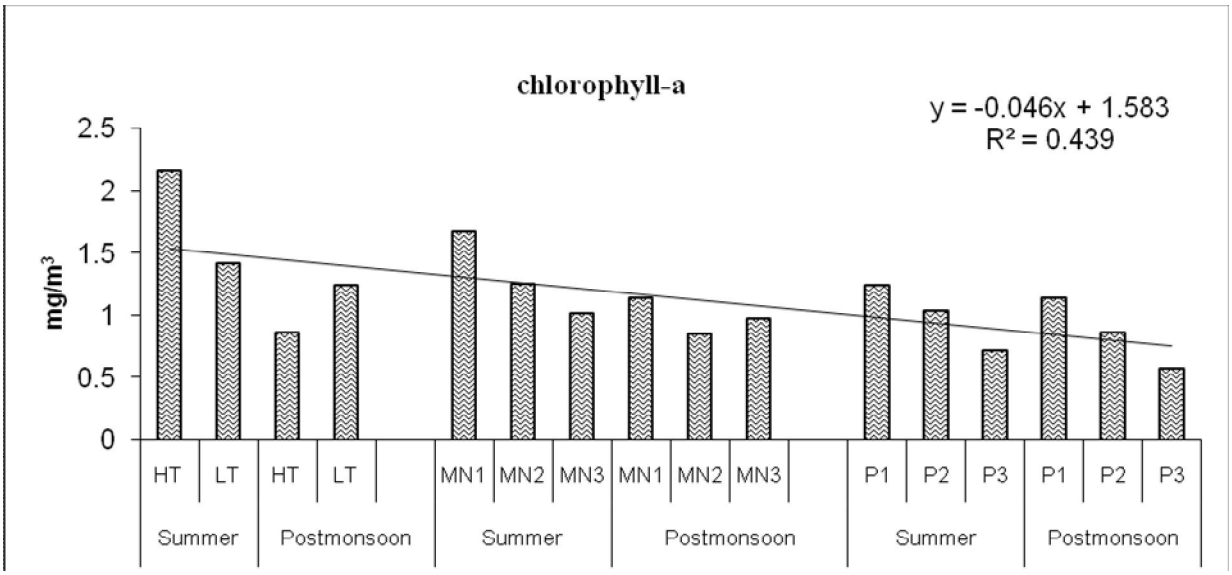

Fig.3.6. Chlorophyll-a variation with regression values among two coastal bodies, Paradip and Mahanadi coastal in summer and post monsoon seasons with diurnal impact of Mahanadi estuary[Low tide(LT) and High tide(HT) condition] .

CONCLUSION

The costal environment is under stress of municipal sewage and industrial effluent discharge by receiving huge water inputs of contaminates which could be hazardous to the living organisms. The organic sewage is reflected through the high BOD and lower DO in the Mahanadi estuary during low tide. The higher concentration of inorganic PO_4, TP, TN, SiO_4-Si and BOD in Mahanadi coastal water compared to the Paradip coastal water due to the effluent discharge by the industry and fertilizer plants. The seasonal nutrient variations exhibit higher value during post monsoon as compared to the summer, which might be due to river runoff. There were no regular variations of pH and water temperature in the water quality within 5 km from shoreline. The analysis need to be more thoroughly for finding the spatiotemporal changes in estuarine environment under time series observation for the sustainable ecosystem management as the contaminated with higher value of exceptional inorganic PO_4, TP, TN, and SiO_4-Si including physical and biological parameter input alter the ecology of the costal environment that causes greatly affecting the overall biotic community of the ecosystem.

ACKNOWLEDGEMENT

The author's are thankful to the Dean and Founder, KIIT University (Deemed University), Bhubaneswar for providing the necessary facilities and Special gratitude with thanks to the Director, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar for all regarding research and Publications encouragements.

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How to cite this article
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