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Baseline

Impact of seasonality on the nutrient concentrations in Gautami-Godavari Estuarine Mangrove Complex, Andhra Pradesh, India

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ABSTRACT

Spatiotemporal variations of dissolved nutrients were studied along Gautami-Godavari mangrove ecosystem to delineate their sources and fate. Average values of nitrate (NO_3^-), dissolved silica (DSi) and phosphate (PO_4^{3-}) is 2.09 mg/l, 12.7 mg/l and 0.16 mg/l in wet season and 0.47 mg/l, 6.96 mg/l and 0.29 mg/l in dry season respectively. In wet season river discharge has significant influence on NO_3^- and DSi. In dry season, NO_3^- and PO_4^{3-} are controlled by groundwater discharge, benthic exchange and various in situ processes owing to sediment redox condition. Mixing model shows net addition of phosphate in Coringa mangroves (95%) and Lower estuary (13%) and net removal of nitrate (24.79%) in Coringa mangrove and in estuary (58.9%). Thus present mangrove acts as net source for phosphate and net sink for nitrate and DSi. Nutrient ratio shows seasonal switching between potential Phosphorus and Nitrogen limitation in wet and dry season respectively.

The estuarine and coastal ecosystems receive the nutrient inputs per unit area which is considered to be > 1000 times greater than that of heavily fertilized agricultural fields (Nixon et al., 1986). The moderate input of nutrients in estuaries can be beneficial but excess nutrients can be highly damaging and may result in to the effects such as hypoxia and anoxia from eutrophication, nuisance algal bloom, and reduction in the population of fish and shell fish (Ryther, 1954; Rosenberg, 1985; Parker and O'Reilly, 1991; Smayda, 1992). Since the input of the nutrients to these coastal systems are increasing and likely to continue to increase in the future, so it is especially important to understand the relationship between loadings, fluxes, and cycling of dissolved inorganic nutrients.

This study is aimed to identify the role of the mangrove ecosystem in the dissolved nutrient dynamics. The objectives of the study are (a) to understand the spatial and temporal variation of the hydrogeochemistry along the Gautami-Godavari estuarine complex; (b) to delineate the sources and fate of nutrients in this ecosystem and their role in Bay of Bengal productivity.

The Gautami-Godavari mangroves are located at 16°32′N–16°55′N and 82°11′E–82°21′E (Fig. 1) in the East Godavari district. This mangrove complex is fed by Godavari River which branches out into two distributaries namely the Gautami-Godavari (major branch) and the Vasishta-Godavari (minor branch) at the township of Dowaleswaram. The present study has been conducted in the Gautami Godavari branch which is the major one between two estuaries.

Sampling was carried out during May 2015 (dry season) and August 2015 (wet season) in the Coringa, Gaderu and Matlapalem creek along with Kakinada Bay and Estuary. In the dry season, minimal fresh and tidal water mixing were occurring, and tidal insurgence governs much of the nutrient chemistry and loading in lean periods, thus making it ineligible for applying the mixing model in this season. Due to the high river discharge, the wet season data of the estuary is expected to contribute excess nutrient load to the coastal water, making it more interesting from the perspective of nutrient availability in the Bay of Bengal. Hence the mixing model approach has been made for the wet season. For modeling purpose, additional water samples were collected from the estuary considering the salinity zonation: Upper estuary (average salinity 0.52‰) and lower estuary (average salinity1.7‰) and Bay of Bengal (average salinity 28‰).

Salinity, electrical conductivity (EC), water temperature (T), pH, and total dissolved solids (TDS) were measured using Horiba multiparameter electrode. The bicarbonate (HCO_3^-) was determined by Metrohm 877 Titrino plus auto-titrator. Analysis of the nutrients was carried out following the standard spectrophotometric procedures (Grasshoff et al., 2009). Major cations (Na^+, K^+, Ca^{2+}, Mg^{2+}) were measured by Thermo scientific iCE™ 3000 Series Atomic Absorption Spectrophotometer. The precision of all measurements was within ± 1%.

The observed dataset was subjected to various statistical analysis viz. Correlation Matrices, Principle Component Analysis and one-way ANOVA using IBM SPSS Statistics 21.

Physico-chemical parameters (T, EC, Salinity, TDS) and major ions (Na^+, K^+, Ca^{2+}, Mg^{2+}, SO_4^{2-}, Cl^-) show higher value in the dry

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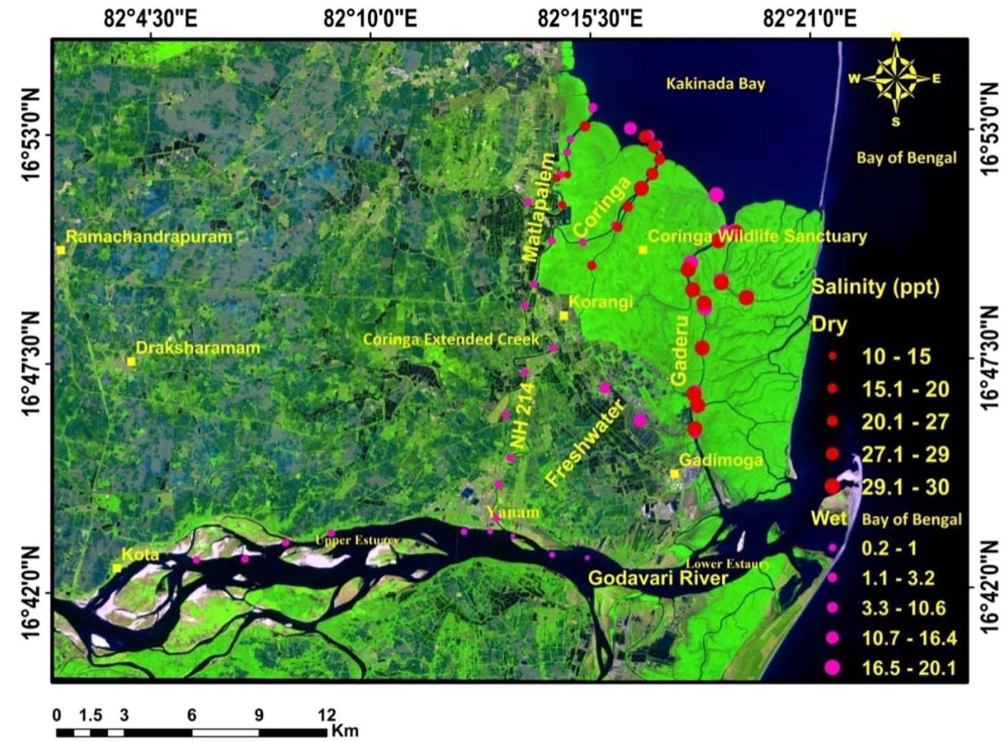

Fig. 1. Study area and sampling locations along Gautami-Godavari Estuarine Mangrove Complex.

season than that of the wet season (Table 1) which may be due to the mixing of sea water into these areas. The higher values of these parameters in Gaderu mangroves, in both the season, is due to its proximity to the Bay of Bengal. The good correlation of physical parameter and major ions with salinity (Tables 2a & 2b) in both the season confirms that the seawater is the main contributor of major ions.

The average value of nitrate and dissolved silica (DSi) is 2.09 mg/l and 12.7 mg/l in the wet season whereas it is 0.47 mg/l and 6.96 mg/l in the dry season. Their higher concentration in the wet season may be due to the influence of high river runoff. A good correlation (at $p < 0.01$) between nitrate and DSi (0.59) shows that they are being contributed by same sources, i.e. river runoff. Spatially NO_3^- (Fig. 2a) DSi (Fig. 2b) shows higher values along the upper estuary, and the concentration decreased on moving towards the mouth of the estuary.

On the contrary, phosphate shows higher concentration in dry than the wet season with an average value of 0.29 mg/l and 0.16 mg/l respectively. One of the sources of nutrients in dry season could be groundwater discharge as the concentration of NO_3^-, DSi, and PO_4^{3-} in groundwater has been reported to be in the range of 0.22–5.38 mg/l, 2–54.6 mg/l and 0.047–2.7 mg/l respectively (Rengarajan and Sarma, 2015) and is much higher than the range of nutrients in the surface water. Thus nutrient gradient which exists between ground water and estuarine water, may act as a potential source. In fact it has been reported that ground water shows substantial contribution to Phosphorus loading in the Godavari estuarine system (3–10% of riverine input) (Rengarajan and Sarma, 2015). Another source of DIP in the water column is its release during the degradation of organic matter in aquatic sediments which is also confirmed by good positive correlation of 0.55 (at $p < 0.01$) between PO_4^{3-} and HCO_3^- (Table 2a). High OM mineralization during the dry season is also indicated in PC2, showing high loading of temperature and HCO_3^- (Table 3). It has also been reported that this mangrove is an active site of organic matter mineralization (Bouillon et al., 2003). In the dry season DNRA (Dissimilatory Nitrogen Reduction to Ammonium) process is a major mechanism of nitrate removal than the denitrification (Fernandes et al., 2012). In some estuaries, benthic denitrification is capable of removing up to 32–44% of the oxidised nitrogen from the water column (Dong et al., 2000). Our system also shows removal of nitrate (mixing model), indicating denitrification or DNRA as the possible cause. Thus, OM mineralization supported by denitrification might be acting as an additional source for the increased phosphate. In addition to it the other source could be pore water exchange (Sarma et al., 2010) and sediment-water exchange as PO_4^{3-} is known to be bound to Ca and Fe in the estuaries (Stal et al., 1996; De Wit et al., 2001). The negative correlation of PO_4^{3-} with TSM (−0.63) in dry season due to enhanced concentration of TSM which leads to adsorption of PO_4^{3-} in this mangrove complex. In the wet season, the spatial distribution shows the higher concentration of phosphate along downstream of the estuary rather than upstream (Fig. 2c). Enrichment of PO_4^{3-} in high chlorinity region due to its desorption from the bottom sediments (Padmavathi and Satyanarayana, 1999).

In the dry season, Factor 1 of Principal Component Analysis, accounts for the largest proportion (64.79%) of the total variance with three factors (Table 3). PC1 shows significant positive loading of (> 0.5) of EC, salinity, TSM, TDS and major ions indicated that this component was dominated by sea water intrusion. PC2 explained 8.16% of the total variance with the moderate loading of HCO_3^-, NO_3^-, PO_4^{3-} and DSi indicating the association with biogeochemical processes like mineralization, pore water flux or groundwater nutrient discharge. The loading of temperature and HCO_3^- in the PC2 gives strong evidence of carbon mineralization as the rate of carbon mineralization increases with increase in temperature (Wang et al., 2013).