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Study on phytoplankton composition, abundance and the productivity of Patalganga estuary, Maharashtra, India

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Abstract
Industrial establishments along the head region of Patalganga River, at Raigad district, Maharashtra is developing since few decades. These manmade and natural stressors are destructing the ecological quality of Patalganga-Amba estuarine complex slowly. A study had conducted from October 2016 to December 2017 to know the phytoplankton abundance, distribution and its seasonal variations at Patalganga estuary. A total of 47 genera of phytoplankton were identified, out of that, 33 genera are diatoms (17 pennate and 16 centric diatom), 7 genera of din flagellate and 7 genera of other algae were observed from the study site. H' and J' observed were 2.503 to 2.506 and 0.94 to 0.97 respectively, indicates the study site was productive. The seasonal variations of physico-chemical qualities and the intrinsic properties of water body influence the sudden and frequent variations of phytoplankton population.

Keywords: Estuary, patalganga, phytoplankton, productivity, biodiversity

Introduction
Phytoplankton is tiny organisms have the ability to convert sunlight, water and minerals to edible nutrients [1, 2], so as to act as base of the aquatic food web [3]. These organisms are also responsible for creating the majority of the world's oxygen and support tiny zooplankton to large aquatic animals hence considered as biological wealth [4]. Phytoplankton plays an important role in maintaining global carbon cycle, reflects water quality in terms of certain pollutants, maintaining carbon dioxide budget, source of fossil fuel etc [5, 6, 7, 8].
Phytoplankton community shows high seasonal and spatial fluctuations in its abundance and diversity due to the physico-chemical changes in the water body [9, 10, 11]. Primary production in an aquatic system is significantly controlled by phytoplankton, which is influenced by a number of factors like season, temperature, turbidity, tides, salinity, river discharge, nutrient transport and recycling, grazing and geomorphology of the estuarine water body [12, 13].
Estuarine ecosystems are transitional zone between rivers and sea, providing a number of ecosystem services and social benefits [14, 15, 16]. Since estuaries are nutrient traps and have a wide variety of habitat for nesting and breeding sites, it serves as nursery and breeding ground for many aquatic and terrestrial fauna [17]. Brackish water nature of the estuaries with the influence of tides and currents are some of the essential features for the life cycle of many vertebrates and invertebrates.
Patalganga estuary is confluence with Amba Estuary and Karanja creek before meeting to the Arabian Sea at Raigad district, Maharashtra. Primary productivity, Phytoplankton composition, distribution, and abundance of Patalganga Estuary were studied to know the present status of phytoplankton diversity at the ecosystem, which will be used as baseline data for further studies.

Materials and Methods
Monthly sampling had done from October 2016 to December 2017 from four stations of Patalganga estuary. The first station (S1) was fixed at the middle of the estuarine complex where the Patalganga estuary, Amba estuary and Karanja creek joins. The second station (S2) fixed at Patalganga river mouth. Third station was at the first tributary (S3) and the fourth

(S3) and the fourth station (S4) was at the main branch were the traditional fishermen harbor their canoes (fig. 1). The average of 15 month data has concise to 5 periods, each consists of three months based on the water temperature observed. Ist period was from October, 16 to December, 16; IInd period from January, 17 to March, 17; IIIrd period from April, 17 to June, 17; IVth period from July, 17 to September, 17 and Vth period from October, 17 to December, 17.

Fig 1: Selected sampling sites at Patalganga

For collecting phytoplankton, water samples were collected in 1000 ml water bottle. Fix it with Lugol's solution immediately after the collection and brought to the laboratory, kept it for 24-48 hours. After settling plankton at the bottom, decant the surface water without disturbing the settled plankton, made a final volume of 50 to 100 ml. Diversity and abundance of phytoplankton were studied by using replicates of samples on slides. HUND inverted microscope, Stereoscopic microscope and Olympus FX 100 microscope were used for identifying plankton. Phytoplankton was identified up to Generic and/or species level using different standard keys. Sedgwick rafter was used for counting phytoplankton from the water samples.

For analyzing net primary productivity (NPP) and gross primary productivity (GPP) water samples were collected in light and Dark BOD bottles then brought to the laboratory. DO was used as Initial bottle, Light bottle was exposed to uniform light and Dark bottle covered with dark clothes and kept in dark place under simulated *in situ* environment at room (Normal) temperature during the incubation time. DO was estimated using Winkler's method. GPP and NPP can be measured by the following formula,

$$\text{GPP (mg C/m}^3\text{)} = \frac{(O_2LB - O_2DB)}{(PQ \times T)} \times 1000$$

$$\text{NPP(mg Cm}^3\text{)} = \frac{(O_2LB - O_2IB)}{(PQ \times T)} \times 1000$$

Where, O_2LB= DO concentration in light bottle; O_2DB=DO concentration in dark bottle; O_2IB= DO concentration in initial bottle; PQ= photosynthetic quotient (is a numerical constant *ie.*, 1.2); and T = time in hours for incubation.

Results and Discussion

The mean range of gross and net primary productivity recorded from the study area was 153.4 mgCm^{-3}day^{-1} and 60.7 mgCm^{-3} day^{-1} respectively. IIIrd (78.05 mgCm^{-3}day^{-1}) followed by IVth (66.96 mgCm^{-3}day^{-1}) and Vth (66.86 mgCm^{-3}day^{-1}) period were showing highest npp. While highest gpp recorded was in IVth period (186.43 mgCm^{-3}day^{-1}) followed by IIIrd (165.71 mgCm^{-3}day^{-1}) and IInd (156.67 mgCm^{-3}day^{-1}) period (fig. 2). The mean range of gpp was highest in S4 (167 mgCm^{-3}day^{-1}) followed by S3 (155 mgCm^{-3}day^{-1}) and S1 (152 mgCm^{-3}day^{-1}) while highest npp recorded were at S1 (64.82 mgCm^{-3}day^{-1}) followed by S4 (58.93 mgCm^{-3}day^{-1}) (fig. 3).

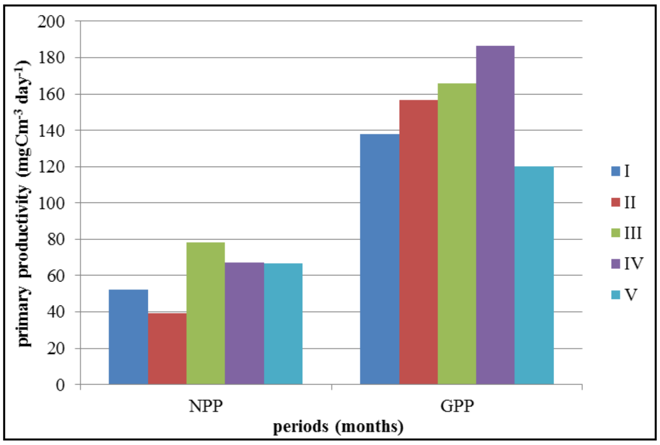

Fig 2: Temporal distribution of NPP (Net primary productivity) and GPP (Gross primary productivity) at Patalganga estuary;

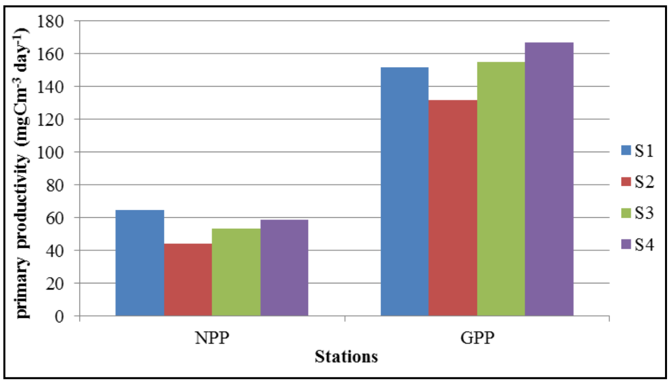

Fig 3: Spatial distribution of NPP and GPP.

The primary productivity of Patalganga estuary was less compared to the studies by Nair *et al*. [18] at Vasishti estuary, Meera and Nandan [19] at Valanthakad estuary and Madhu *et al*. [20] at Cochin estuary. The primary production was increased during rain fall, due to the abundance of nutrients as well as coastal upwelling [12, 19, 21]. The productivity of estuarine ecosystem is controlled by both biotic and abiotic factors as well as the intrinsic properties of that ecosystem [13, 22, 23].

Phytoplankton is the main representative of primary production in estuarine ecosystem [23]. A total of 47 genera of phytoplankton belonging to 40 families were identified from Patalganga estuary, of which, 33 genera represented by diatom (87.23%), 7 genera of dinoflagellate (3.71%) and 7 genera of other algae (9.07%) were observed. Out of 33 genera of diatom, 17 were pinnate (35.80% of total diatom) and 16 are centric diatom (64.20% of total diatom). Four genera of diatom belong to the family Bacillariaceae, two genera each of Chaetocerotaceae, Fragilariaceae, and Thalassiosiraceae. *Coscinodiscus* spp. (14.62%) was dominant in the water body followed by *Aulacoseira* spp. (8.31%), *Cyclotella* sp. (8.08%), and *Planktoniella* sp. (4.02%).

The pinnate diatom observed in Patalganga estuary was *Amphora* sp, *Bacillaria* sp, *Denticula* spp., *Fragilaria* sp., *Gyrosigma* spp., *Licmophora* sp., *Mastogloia* sp., *Navicula* spp., *Nitzschia* spp., *Pinnularia* spp., *Pleurosigma* spp., *Pseudonitzschia* sp., *Rhizosolenia* spp., *Surirella* sp., *Synedra* sp., *Thalassionema* spp., and *Thalassiosira* sp. on an average pinnate diatom were more during II nd period at S2. It was observed that the density of pinnate diatom was decreased towards the riverine side from S1 to S4. All the organisms were observed throughout the study period with varying density (Fig. 4).

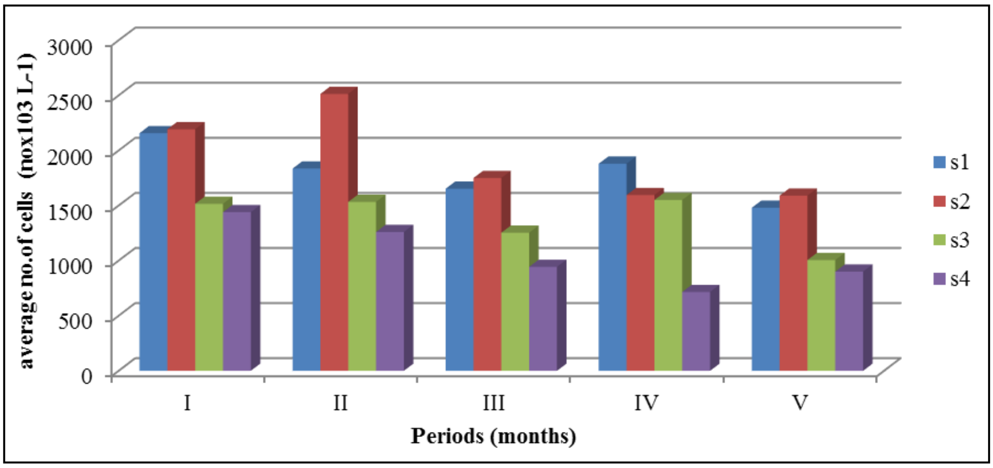

Fig 4: Spatial and temporal variations of pinnate diatom at Patalganga estuary

The centric diatom observed were *Aulacoseira* spp., *Bacteriastrum* sp., *Biddulphia* spp., *Corethron* sp., *Cerataulina* sp., *Chaetoceros* spp., *Coscinodiscus* spp., *Cyclotella* sp., *Ditylum* spp., *Grammatophora* spp., *Actinoptychus* sp., *Leptocylindrus* sp., *Melosira* spp., *Planktoniella* spp., *Skeletonema* sp., and *Triceratium* spp. centric diatom was more during IVth period and the density was decreased towards S4 (Fig. 5).

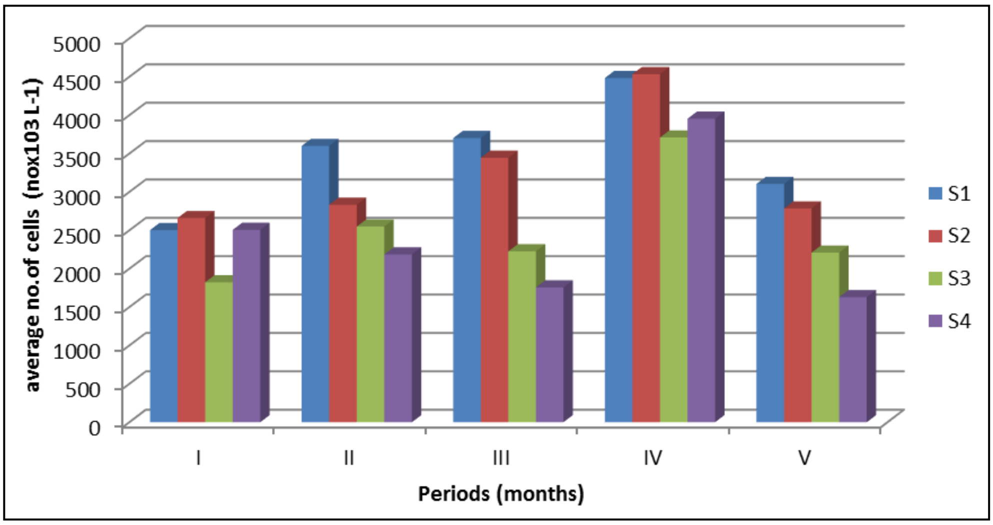

Fig 5: Spatial and temporal variations of centric diatom at Patalganga estuary

Seven genera of dinoflagellates were recorded, among which *Ceratium* spp. (3%) was dominant followed by *Gymnodinium* sp. (0.43%) and *Dinophysis* spp. (0.22%). Other genera include *Alexandrium* spp., *Gonyaulax* sp., *Prorocentrum* spp., and *Protoperidinium* sp. Dinoflagellates were more in S1 and S4 compared to S2 and S3 and its highest density was observed during IIIrd period (Fig 6).

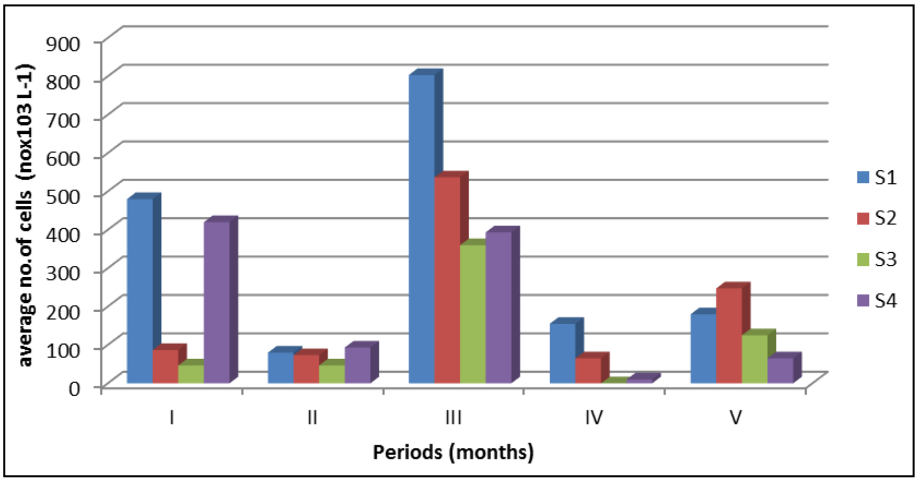

Fig 6: spatial and temporal variations of dinoflagellates in Patalganga estuary

Among other algae, *Chlorella* sp was dominant (2.88%) followed by *Pediastrum* spp. (1.56%) and *Scenedesmus* spp. (1.24%). *Microcystis* spp., *Oscillatoria* sp., *Spirulina* sp. and *Staurastrum* spp. are also observed among other algae. It was observed that, these organisms are mostly fresh water dominant, observed highest during IVth period and at S4 followed by S3, S2 and S1 (fig.7).

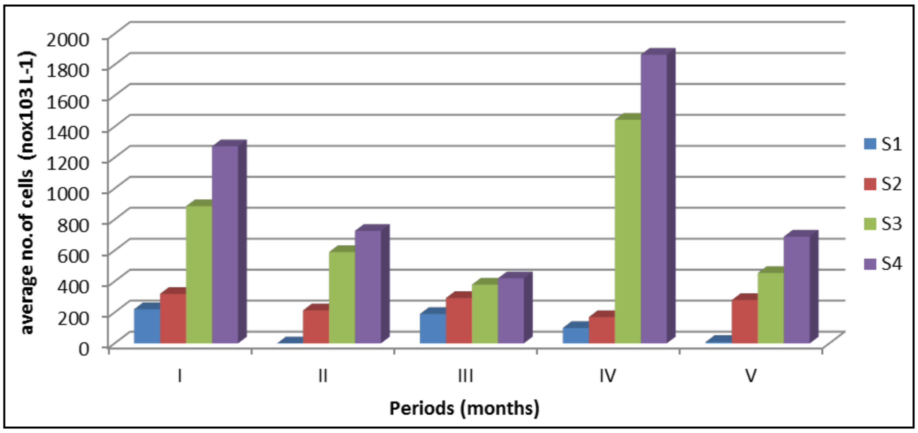

Fig 7: spatial and temporal variations of other algae observed in Patalganga estuary

Ramaiah and Ramaiah [24] reported 33 diatom and 4 Dinoflagellates from Bombay harbour-Thana-Bassein creek estuarine complex. Tiwari and Nair [25] reported 58 genera of phytoplankton including 46 diatoms (97.6%), 6 dinoflagellates (2%) and 6 other algae (0.4%) from Dharamtar creek adjoining Mumbai harbor. Dhumal and Rode [26] recorded 52 genera of phytoplankton from the coastal areas of Sindhudurg district, Maharashtra. Inter monsoon period sometimes allows diversification of estuary, which is influenced by tidal flushing, turbulence and salinity gradient [27]. Number and density of organism at the present study were lesser than the number and density of organisms reported by Tiwari and Nair [25] from Dharamtar creek, observed enormous variations in phytoplankton cell count with an average cell count of 266 x 10^3 L^{-1} (17-5980 x 10^3 L^{-1}). Kulkarni *et al.* [28] reported the phytoplankton count of 4.2 to 64.8 no.x 10^3 L^{-1} from the marine ecological habitat of projected thermal power plant around Dharamtar creek. Choudhary and Pal [29] observed the minimum count of phytoplankton at the Bhagirathi-Hooghly estuarine area than oceanic and freshwater zone (9- 203 cells/ml).

Shannon-Weiner diversity index (H’) based on phytoplankton ranged between 2.503 to 2.506 and the Simpsons’s index (J’) is in between 0.94 and 0.97, which comes under the same reported by Kulkarni *et al.* [28]; observed H’ and J’ was greater than 2 and 0.8945 respectively at Dharamtar estuary. When the Shannon index was converted to an effective number of species (ENS), indicated 11 to 12 equally common genera present in the community. If H’ is more than 2 and J’ is greater than 0.9 indicates the healthy diversity of the ecosystem [28].

Conclusion

The present study on phytoplankton composition at Patalganga estuary can be used as baseline data for the particular ecosystem, indicates the ecosystem is productive and healthy. The study observed that IVth station was productive compared to other stations as well as Ist station was less productive. This might be due to the intense anthropogenic pressure at the Ist station. Though it is compared with the studies conducted at another water bodies in Raigad district of Maharashtra, the productivity of the Patalganga estuary might be adversely affecting by the industrial developments along with the various types of pollution, sewage discharge, boat jetty construction, etc.

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