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Diversity of Phytoplankton and Zooplankton at Coastal Waters of Kakinada, East Coast of India: A Review

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***Abstract* - Marine plankton are also sensitive to changes in ocean temperature, acidity and nutrient availability, making them important indicators of climate change and changes in ecosystems. Studying these organisms helps scientists understand the broader impact of environmental changes on marine ecosystems and global biogeochemical cycles. Kakinada Coast is part of the Bay of Bengal, known for its biodiversity. The presence and abundance of plankton in the waters off the Kakinada coast can vary seasonally and respond to environmental factors such as water temperature, nutrient availability and the ocean flow. These plankton are not only important to the marine ecosystem but also play a vital role in fisheries and aquaculture in the region, as they form the foundation of the food web that supports species. The present review article focuses on evaluation of physiochemical parameters, diversity and distribution of phytoplankton and zooplankton of Kakinada coast of Andhra Pradesh, India. This can be correlated with the role of the plankton diversity for maintaining the ocean surface ecosystem.**

Keywords: Diversity of Phytoplankton, Zooplankton, Coastal Waters, East Coast of India.

I. INTRODUCTION

Marine plankton, characterized by their extensive diversity in terms of phylogenetic, biochemical, metabolic, and ecological attributes (Irigoien et al., 2004; De Long and Karl, 2005), are found abundantly throughout the upper ocean ecosystem. Marine plankton hold significant sway in governing the biological pump and influencing global biochemical cycles (Stemmann and Boss, 2012), at times even assuming a dominant role. The primary cause of global climate change is primarily attributed to human activities, and it is closely linked to concurrent phenomena such as ocean acidification, warming, eutrophication, stratification, hypoxia, and similar factors. These interconnected processes have far-reaching and significant ecological and biogeochemical consequences within marine ecosystems (Karl and Trenberth, 2003; Doney et al., 2012). Previous studies has shown that alterations in plankton communities are typically influenced by fluctuating physical, chemical, and predatory conditions in their ecosystems (Barton et al., 2013; De Senerpont Domis et al., 2013). Consequently, plankton within marine ecosystems are unavoidably impacted by the ongoing and ever-changing climate shifts (Cloern et al., 2016). A multitude of theoretical arguments, supported by findings from laboratory experiments, field observations, and modeling studies, have indicated that climate change in the ocean has profound effects on marine plankton and is expected to persist for several centuries (Doney et al., 2012; Edwards et al., 2013). As an example, ocean warming could potentially boost plankton diversity (Ibarbalz et al., 2019), yet the consequential impacts of eutrophication might outweigh the direct effects of warming, particularly when considering phytoplankton (De Senerpont Domis et al., 2013). Conversely, plankton dynamics serve as highly effective indicators of climate change within the marine environment, primarily owing to the strong connection between plankton dynamics and shifts in environmental conditions (Edwards and Richardson, 2004; Hays et al., 2005; Hutchins and Fu, 2017). Specifically, the non-linear reactions of plankton communities can magnify subtle environmental disruptions, making marine plankton, in certain instances, superior indicators of climate change compared to the actual environmental variables (Taylor et al., 2002). Moreover, the distribution of plankton across environmental gradients can offer essential insights into climate forcing, as species adjust their distributions to align with their physiological tolerances in response to shifting marine conditions (Hillyer and Silman, 2010). As a whole, plankton communities are confronting an unprecedented array of challenges in the contemporary ocean, particularly the ecosystem-wide consequences of climate change. Therefore, comprehending the interplay between ongoing human-induced climate change and the dynamics of plankton communities is of paramount significance, representing a critical global concern.

Furthermore, there is a growing body of evidence indicating that the outcomes and intensity of marine plankton responses to future environmental changes vary significantly, both within individual communities and across different communities (Edwards and Richardson, 2004; Barton et al.,

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2016). For example, A phytoplankton bloom in the coastal waters of Kakinada, situated along the eastern coast of India, utilizing the nFLH product derived from MODIS-A data. (Abbott & Letelier 1999) The hydrological parameters and levels of dissolved inorganic nutrients, such as PO4-P, NO3-N, NO2-N, and NH4-N, within three interconnected environments: freshwater, marine, and mangrove brackish water, all within the Kakinada coastal zone of Andhra Pradesh. (Gower et.al 1999) The seasonal diversity and fluctuations in zooplankton populations within the Corangi mangrove and Kakinada Bay, spanning from July 2013 to June 2014. (Gower & King 2007a). The trophic condition of a water body can be approximately determined by considering data on the phosphorus concentration (a limiting nutrient), chlorophyll levels (indicative of phytoplankton biomass), and transparency (influenced by algal biomass and sediment resuspension). These divergent reactions could potentially lead to alterations in the structure and functional groups within plankton communities, including the occurrence of harmful algal blooms. These blooms can have detrimental consequences on ecosystem stability, marine fisheries, and human health (De Senerpont Domis et al., 2013; Ibarbalz et al., 2019). Nevertheless, there is currently a shortage of data regarding the impact of present environmental shifts on intricate natural communities (Boyd et al., 2018; Gao et al., 2019). Therefore, it is crucial to exercise caution when evaluating how various plankton communities respond to concurrent environmental changes and the intricate interplay of multiple variables, whether in laboratory experiments or field investigations.

The varying degrees of impact that changing oceanic environments have on phytoplankton and zooplankton dynamics within plankton communities are a significant area of concern. This is because these taxa serve as the cornerstone of numerous aquatic food webs and hold crucial roles in various ecosystem processes (Hays et al., 2005; Stemmann and Boss, 2012; Edwards et al., 2013).

The present review article focuses on evaluation of physiochemical parameters, diversity and distribution of phytoplankton and zooplankton of Kakinada coast of Andhra Pradesh, India. This can be correlated with the role of the plankton diversity for maintaining the ocean surface ecosystem.

Hydrographical and Nutrient Parameters:

Studying hydrographical and nutrient parameters of marine ecosystem provide valuable insights for investigating the factors associated for alterations of these parameters.

A study investigated diurnal variation on hydrographical and nutritional parameters in the interconnected marine and mangrove biotopes of Kakinada coast.

The water temperature gradually increases at 06:00 hrs and the maximum peak was observed at 15:00 hrs. There is a slight increase in the temperature of mangrove waters than the marine water. The salinity ranges from 26% to 32% with semidiurnal pattern in marine waters. In marine water, the increase in the and rapid decrease of dissolved oxygen levels were observed during day and night time respectively. In contrast, the elevated levels were found in mangrove waters during night time, this may be due to high production rate of phytoplankton.

The concentration of phosphorous, ammonia, nitrogen, and nitrate were high in mangrove water than marine waters. The fourfold increase in the net primary production was observed in mangrove waters (Selvam et.al 1992).

Zooplankton and Its distribution:

Zooplankton are essential marine organisms and serves as a crucial link in marine food chains. They exhibit vertical movement i.e. migrating to deeper waters during day and surface during night. 13 groups of zooplankton diversity were observed at Kakinada bay and coringa mangrove area which includes Metazoa, ciliata, porifera and foraminifera etc.

In another study, the abundance was highest during pre-monsoon to monsoon whereas the lowest was observed in the post monsoon and winter seasons.

The seasonal variation of zooplankton abundance was also observed which two peaks during Jan-Feb and May. The type of zooplankton and its abundance (%) of Kakinada bay and Coringa mangrove forest which is depicted in table 1. (Kumar et.al 2013, A Yandamuri and AM Reddy 2019).

Table 1: Distribution of Zooplankton at different stations of Bay of Bengal, Kakinada coast

		STATIONS					
		KAKINADA BAY		MATLAPALEM		CORINGA	
Sl. No	Types of Zooplanktons	Species	Distribution percentage	Species	Distribution percentage	Species	Distribution percentage
1.	Foraminifera	13	15 %	14	15%	11	14%
2.	Coelentrata	5	6%	3	3%	1	2%

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3.	Rotifera	6	7%	8	8%	4	6%
4.	Cladocera	4	4%	4	4%	3	5%
5.	Calanoida	21	24%	30	31%	19	31%
6.	Cyclopoida	9	10%	10	10%	7	11%
7.	Harpacticoida	5	6%	6	6%	3	5%
8.	Doliolida	2	2%	2	2%		
9.	Appendicularia	3	3%	2	3%		
10.	Sagittoida	2	2%	2	2%	1	2%
11.	Pteropoda	1	1%	1	1%	1	2%
12.	Decapoda	1	1%	1	1%		
13.	Larval forms	17	19%	14	15%	11	18%
14.	Total Zooplanktons	89		97		61	

Phytoplankton blooms:

Ocean chlorophyll plays a crucial role in remote sensing, helping track coastal phytoplankton growth. However, the presence of materials like colored dissolved organic matter and suspended sediments affects ocean color data. Satellites typically use blue-to-green band ratios (440–560 nm) to estimate surface chlorophyll concentrations. Fluorescence measurement, particularly at specific wavelengths, is used to study phytoplankton physiology on a large scale. Fluorescence levels depend on complex factors like chlorophyll's light absorption and electron flow between PS II and PS I. Coastal waters near Kakinada are complex due to sediment load and phytoplankton blooms. A study focused on study focuses on using nFLH imagery to detect and monitor different phases of phytoplankton blooms in the Kakinada and Yanam regions and found that FLH is a reliable indicator for such blooms, with chlorophyll concentration ranging from 2 to 4 mg/m³ and FLH from 0.2 to 0.5 W m^{-2} μm^{-1} sr^{-1} in bloom areas. MODIS overestimated surface chlorophyll but showed close agreement between MODIS nFLH and in situ chlorophyll. Further validation with in situ data across different conditions and seasons is recommended, with potential applications for the Oceansat-3 OCM sensor (Uma maheshwara Rao et.al 2019).

Influence of river influx on phytoplankton community:

Coastal waters, like those along the Bay of Bengal's east coast in India, receive significant freshwater, sediment, and nutrient inputs, leading to environmental stratification. These regions display distinct phytoplankton patterns influenced by environmental changes. Despite comprehensive hydrographic studies, seasonal and interannual phytoplankton variations in response to freshwater influx remain understudied. This research examines interannual phytoplankton changes in Kakinada's coastal waters during the fall inter-monsoon of two consecutive years (October 2006 and October 2007) to better understand the impact of changing surface salinity from river discharge on phytoplankton biomass and productivity.

During October 2006 and 2007, phytoplankton composition was studied in coastal waters off Kakinada. A total of 24 species were identified in 2006 and 38 species in 2007. Diatoms like *Ditylumbrightwellii* and *Hemidiscushardmannianus* were prominent in 2007, with higher densities near the surface. Other diatom species included *Leptocylindrusdanicus* and *Thalassiossira subtilis*. Dinoflagellates such as *Protoperidiniumdepressum*, *Ceratiuminflatum*, and *Prorocentrummicans* were common. Notably, *H. hardmannianus* and *D. brightwellii* were absent in 2006 but present in 2007, resulting in significantly higher total phytoplankton counts in 2007. *T. subtilis, Liolomaelongatum, Triceratium favus, Gymnodiniumbrevi,* and *Gonyaulaxspinifera* were the prevalent diatom and dinoflagellate species, albeit in limited quantities. Phytoplankton counts in Oct. 2006 were 10 to 100 times lower than in Oct. 2007. The study also identified an inverse relationship between *H. hardmannianus* and *D. brightwellii*, likely due to differences in salinity preferences. *D. brightwellii* dominated in lower salinity conditions, while *H. hardmannianus* prevailed in higher salinity waters (Sooria et.al 2011).

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