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Impact of seasonal variation on zooplankton diversity and physico-chemical parameters of wetlands of Porbandar, Gujarat, India

Malay A Vyas, Jatin V Raval*
Department of Life Sciences, Bhakta Kavi Narsinh Mehta University, Junagadh, Gujarat, India

Abstract
The present study on zooplankton diversity and Physico-chemical parameters was carried out from July 2020 to June 2022 at the wetlands of Porbandar, Gujarat, India. During the research a total of 25 species of zooplanktons were observed belonging to 5 groups i.e., Protozoa (10), Rotiferal (7), Copepoda (4), Cladocera (3) and Ostracoda (1). Highest zooplankton diversity was observed in winter (24) and lowest zooplankton diversity was observed during monsoon (14). The three wetland sites are of Porbandar city, which is in the western part of Gujarat state in India. Rainwater is the major source of water for all the three selected sites, so environmental conditions get unfavourable with decreasing water levels. The Physico-chemical parameters such as pH, DO, BOD, TS, TDS and TSS were analysed for the selected sites. During the research, we observed that all the wetlands selected for the study, are present in the urban set up and under constant pressure by various anthropogenic activities. Thus, in order to conserve these waterbodies more efficiently, the knowledge about the impact of seasonal changes on zooplankton diversity can help us develop better understanding of these wetlands.

Keywords: rotifera, copepoda, chhaya wetland, karli wetland, Subhash Nagar wetland

Introduction
The aquatic system, which includes rivers, streams, ponds, lakes, oceans, bays, swamps and marshes, is the most diversified ecosystem in the entire globe. These bodies of water are the source of remarkable biological wealth that has yet to be fully discovered (Nath & Baruah.,2021) [17]. The demand on water bodies has increased due to an increase in human population, more agricultural land being used, and the establishment of new industries. Over time, people have recognized the importance of water conservation because there won't be enough water during the dry seasons (Ganesan, 2009) [10]. Although seasonal variations are a regular cause of ecosystem change, anthropogenic stress, which also has an impact on freshwater faunal biodiversity, causes these changes to occur more often (Dudgeon *et al*., 2006) [8]. Water is a primary requirement and an elixir of life because most biochemical processes use water as a medium. Water also nourishes life on earth and is the base around which the web of life is created. It controls how the natural world grows and works on Earth. The foundational elements of the aquatic ecosystem are phytoplankton and zooplankton (Mishra, 2014) [16]. Zooplankton plays a crucial role in this freshwater ecosystem. Any microscopic biota living in water and drifting at the whim of currents is referred to as zooplankton. It can range in size from microns to centimeters (CSIRO 2000) [7]. Due to their key position in food webs, zooplankton play an important role in lakes and have a substantial impact on water quality, algal densities, fish productivity, and the cycling of contaminants and nutrients (Sarang and Manoj, 2007) [19]. Zooplanktons are also impacted by seasonal changes. Within a year, the dominant phytoplankton species could change from season to season, this would influence changes mostly through the aquatic food chain (Carpenter *et al*., 1985) [4]. Understanding the ecological status of the biodiversity in any water reservoir, particularly freshwater, estuaries, and marine environments, requires study of zooplankton (Baxi *et al.,* 2018) [2]. Water quality assessment refers to the overall process of evaluating the physical, chemical, and biological characteristics of water in relation to the natural quality, biological effects, and intended uses, particularly the uses that may have an impact on human health and the health of the aquatic ecosystem itself (Chapman, 1996) [5].

Materials and methods
Study area
The Research was conducted on Chhaya wetland (21°37'21.02"N, 69°38'7.55"E), Karli wetland (21°37'47.83"N, 69°39'5.48"E) and Subhashnagar wetland (21°39'3.94"N, 69°36'47.65"E) which is located at Porbandar city in the western part of Gujarat state in India. The major source of water is rain which nourishes the wetland and other secondary water sources apart from rain are sewage water, waste water and industrial effluents from nearby households and industry respectively. The atmosphere of the territory is semi-arid (yearly rainfall is between 200 – 700 mm).

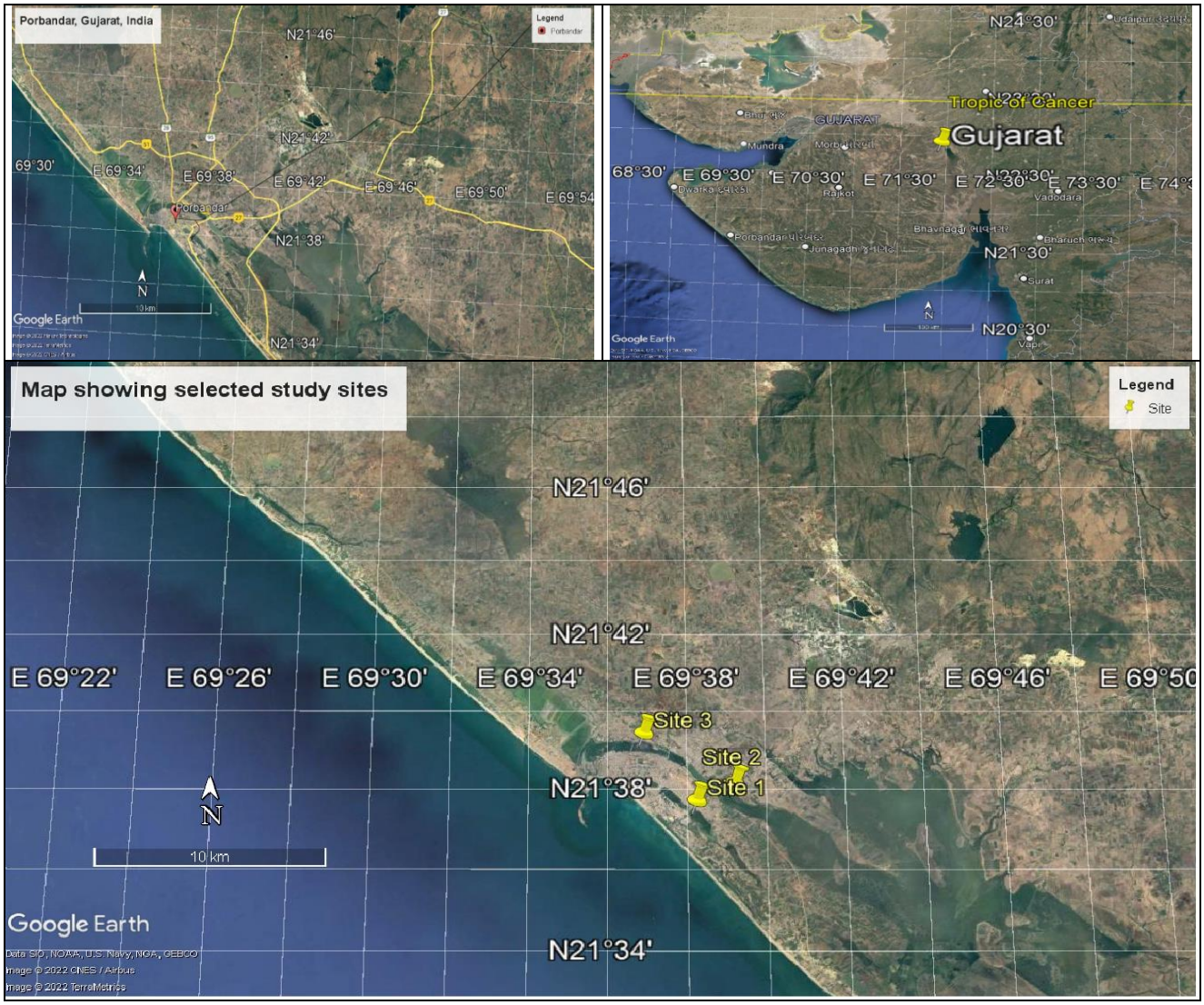

Fig 1: Location of selected sites of study: Porbandar, Gujarat, India (Source: https://earth.google.com/web/)

Sample collection

Physico-chemical parameters

Water samples were collected for physico-chemical test. Dissolved oxygen fixations were done at the sampling sites, while other parameters were analyzed in the laboratory. During the study period, total seven Parameters of these collected water Samples were analyzed. These parameters are pH, TS, TDS, TSS, DO, BOD. Analytical procedures for all water quality parameters were as per (APHA, 2012) [1]. The zooplankton samples were collected from surface water by filtering water through Nylon plankton Net (conical shape) with a mesh size of 60µ.

Study of seasonal abundance of zooplanktons in water

Zooplankton were identified with the help of various zooplankton identification manuals (Sharma, 1998; Thorp & Covich, 2009; Phan *et al.*, 2015; Conway *et al*, 2003; Kasturirangan, 1963; Michael & Sharma, 1988; Bick, 1972; Shiel, 1995; Khan, 2003) [20,22,18,6,12,15,3,21,13]. The samples were examined qualitatively using a compound microscope and a light microscope to examine various zooplankton species (Goswami & Mankodi, 2012) [11]. Hardy species were stored in formalin, which was used to preserve samples right away. The qualitative and quantitative examination of zooplankton was carried out by using the Lackey's drop method. Members of a few other groups, such as Rotifers and others, preservation, alter their morphological traits significantly suggesting their observation to be living condition (Mishra, 2014) [16].

Results and discussion

25 zooplankton species from 5 different groups have been observed throughout the research (Figure 2). i.e., Protozoa (10), Rotifera (7), Copepoda (4), Cladocera (3) and Ostracoda (1). Highest zooplankton diversity was observed in winter (24) and lowest zooplankton diversity was observed during monsoon (14) (Figure 6,7,8). Highest Zooplankton diversity was observed in site 2 and lowest diversity was noted from site 3 (Table 1). Baxi *et al.*, in 2018 observed highest zooplankton diversity in winter followed by summer and monsoon (Baxi *et al.*, 2018) [2]. Site 1 Shows highest protozoan species (10) compared to two other selected study sites may be due to sewage discharge and industrial pollution which results in toxic conditions of the wetland, it has been discovered that *Paramoecium caudatum and Paramoecium aurelia* can thrive in toxic water conditions by (Ferdous & Muktadir 2009) [9]. Rotifers and copepods were recorded highest from Site 1 and Site 2 respectively (Figure 2). Both these sites may have high sewage discharges from the surrounding household colonies. Zooplankton density was observed in winter (39.56%), followed by summer (38.46%) and

monsoon (21.97%), as per (Kuvadiya *et al*. 2020) [14]. Winter saw the highest zooplankton density values (no./L) and monsoon saw the lowest. (Goswami & Mankodi 2012) also stated that the dilution effect can be used to explain why all zooplankton components' densities decreased during the study period's rainy season. *Branchionus sp*. diversity and copepod presence are indicators of the influence of contaminants and domestic sewage discharges suggested by them [11]. Non-polluted waters are often characterized by high diversity and no single species dominating in numbers over others (Jani *et al*.,2022) [12].

(Figure 3,4,5) displays variations in the values of several physico-chemical characteristics at chosen sites. The highest pH was recorded during the winter and lowest was recorded in summer for all sites. Higher DO levels (Dissolved oxygen) were recorded in Monsoon and lowest were recorded in Summer for all sites. Vyas *et al*. in 2022 also recorded higher levels of DO in monsoon and lower levels of DO in Summer (Vyas *et al*.2022) [24]. Higher BOD levels (Biological oxygen demand) were recorded in winter and lowest were recorded in monsoon for all sites. TDS (Total dissolved solids) readings were highest in summer and lowest in monsoon for all sites. TSS (Total suspended solids) readings were highest in monsoon and lowest in summer for all sites. TS (Total solids) readings were highest in Summer and lowest in winter for all sites.

Higher values of BOD and zooplanktons in winter and lower values of BOD and zooplanktons in monsoon. This indicates that both zooplanktons and BOD were influenced by seasonal variations (Figure 6,7,8). Lower values of Dominance D and Berger-Parker while Higher values of Brillouin, Simpson_1-D, Shannon H, Margalef, Menhinick and Fisher_alpha indicate a good diversity of zooplanktons is observed at these wetlands. highest Values of Dominance were found in Site 3(0.101) and lowest in Site 1(0.065) and Site 2 (0.065). For other diversity indices, highest values were obtained from Site 2 and lowest from Site 3. This indicate that Dominance was found to be negatively correlated with other diversity indices. Simpson's index and Shannon wiener index was found to be highest in Site 1(1-D- 0.935, H-2.77), Site 2 (1-D- 0.934, H-2.75) and lowest in Site 3 (1-D-0.899, H-2.28) (Table.2). Hence, Site 3 shows least diversity and Site 1 and 2 shows highest diversity among three selected sites of Porbandar, Gujarat, India.

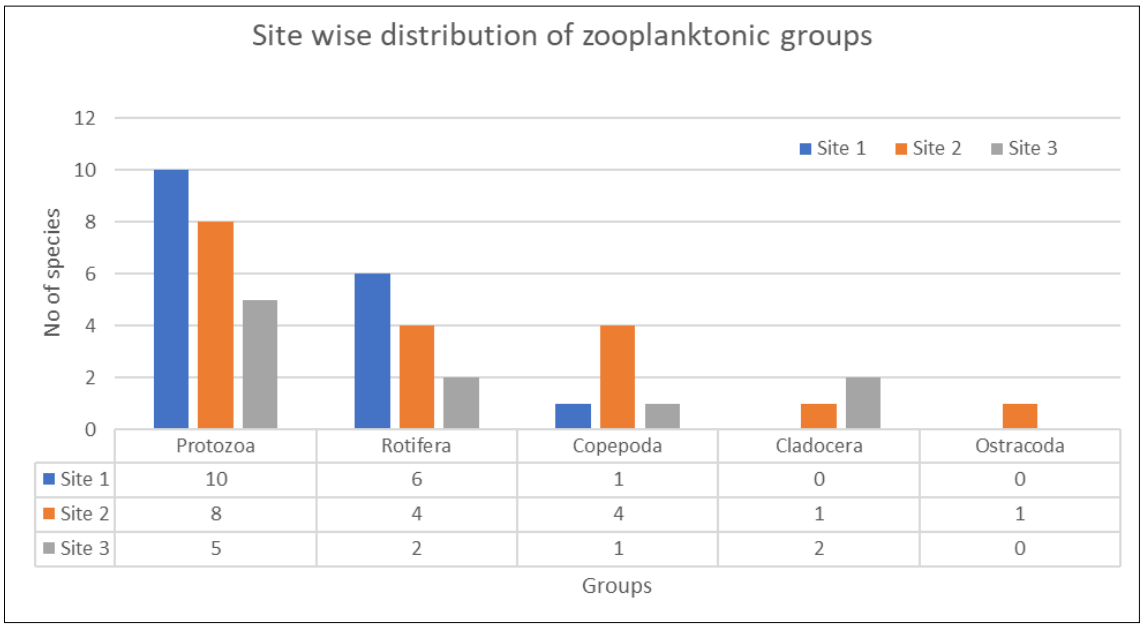

Fig 2: Site wise distribution of zooplanktonic groups. Site 1- Chhaya wetland, Site 2- Karli wetland and Site 3- Subhash Nagar wetland

Table 1: Comparative Zooplankton diversity of Porbandar, Gujarat, India. Site 1- Chhaya wetland, Site 2- Karli wetland and Site 3- Subhash Nagar wetland

Zooplankton species	Site 1	Site 2	Site 3
Euglena acus	+	+	+
Euglena virdis	+	+	+
Euglena gracilis	+	+	+
Coleps hirtus	+	+	+
Paramoecium aurelia	+	-	-
Paramoecium caudatum	+	+	+
Phacus sp	+	+	-
Stentor sp.	+	-	-
Vorticella campanula	+	+	-
Vorticella infusionum	+	-	-
Asplancha herrickii	+	-	-
Brachionus angularis angularis	+	+	-
Brachionus caylciflorus	+	+	+
Brachionus urceolaris	+	+	-
Brachionus rubens	+	+	-
Philodina sp.	-	-	+

Polyarthra vulgaris	+	-	-
Cyclops sp	+	+	+
Heliodiaptomus viddus	-	+	-
Nauplii sp	-	+	-
Acrocalanus gibber	-	+	-
Cirio daphnia sp.	-	-	+
Daphnia obtusa	-	-	+
Daphnia carinata	-	+	-
Hemicycpris anomala	-	+	-

Table 2: Diversity indices

Indices	Site 1	Site 2	Site 3
Dominance_D	0.06505	0.06512	0.101
Simpson_1-D	0.935	0.9349	0.899
Shannon_H	2.773	2.759	2.285
Brillouin	2.717	2.685	2.235
Berger-Parker	0.1171	0.1081	0.1326

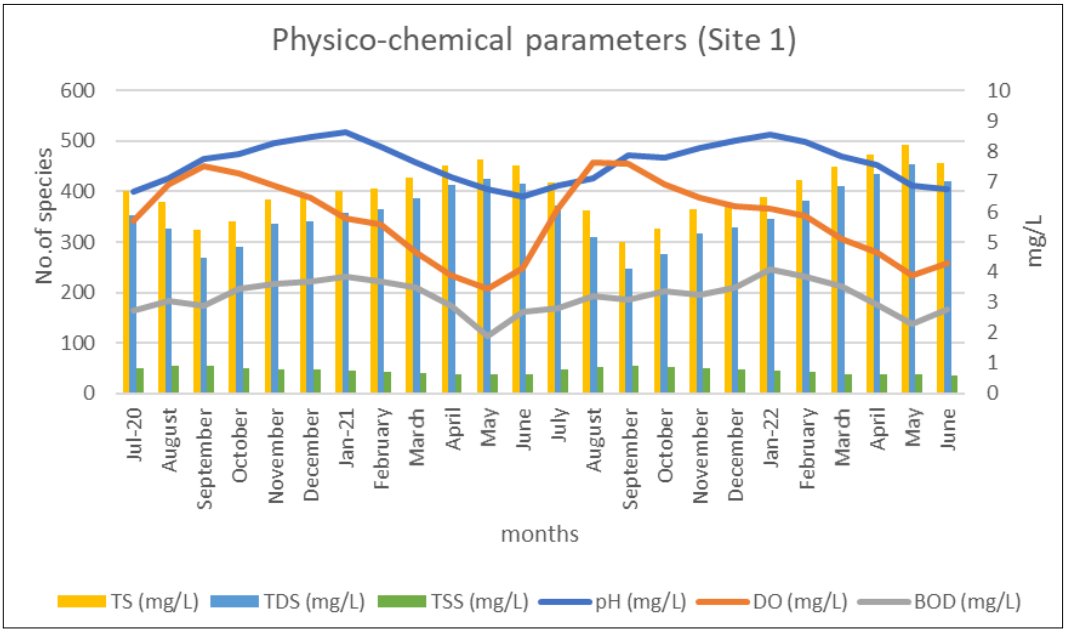

Fig 3: Physico-chemical Parameters of Site 1.

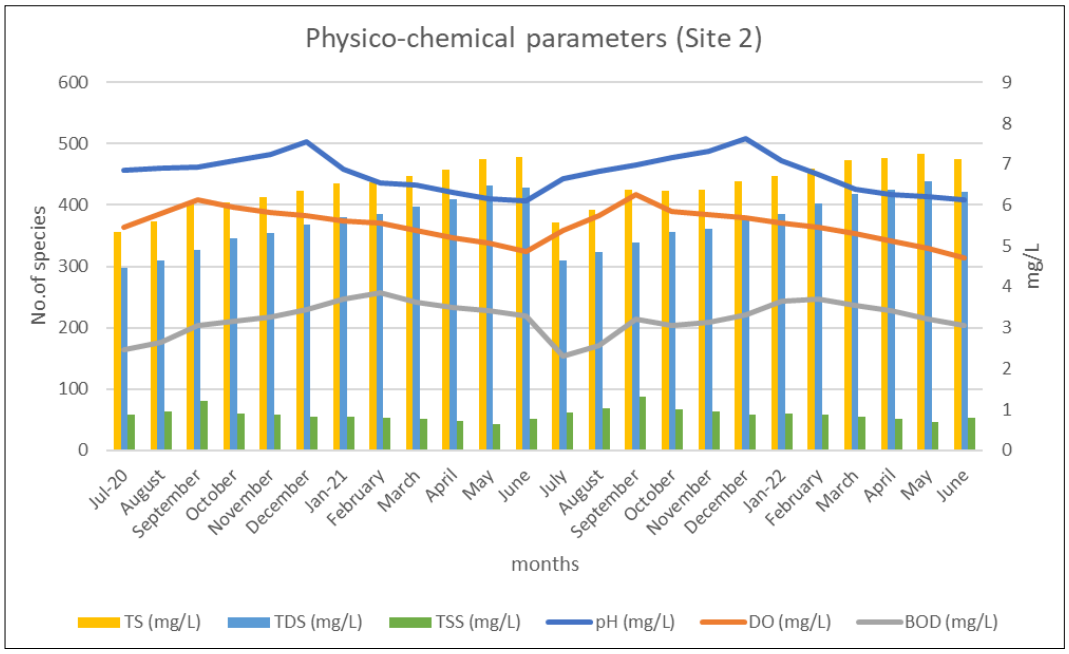

Fig 4: Physico-chemical Parameters of Site 2.

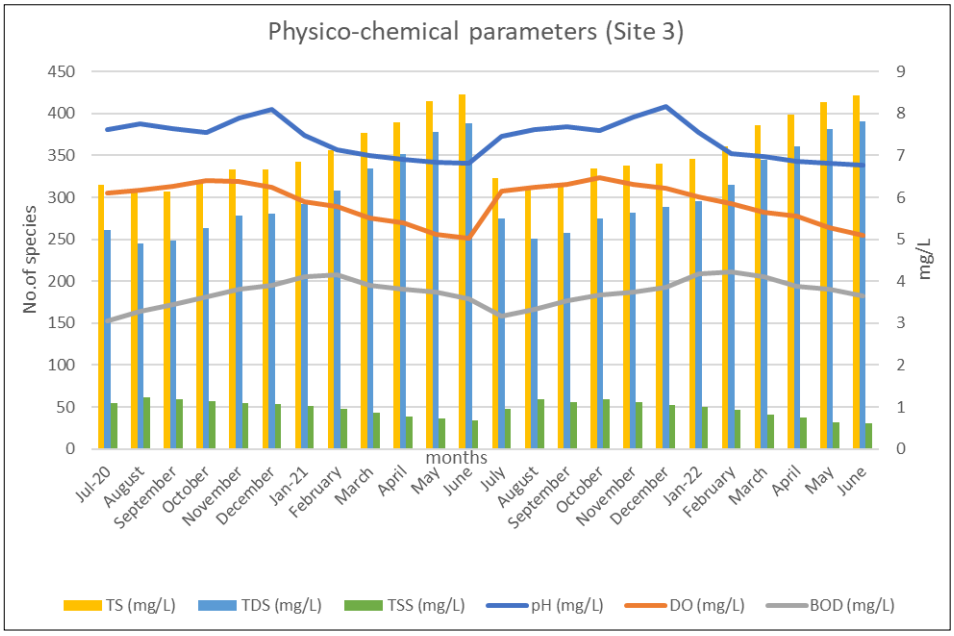

Fig 5: Physico-chemical Parameters of Site 3.

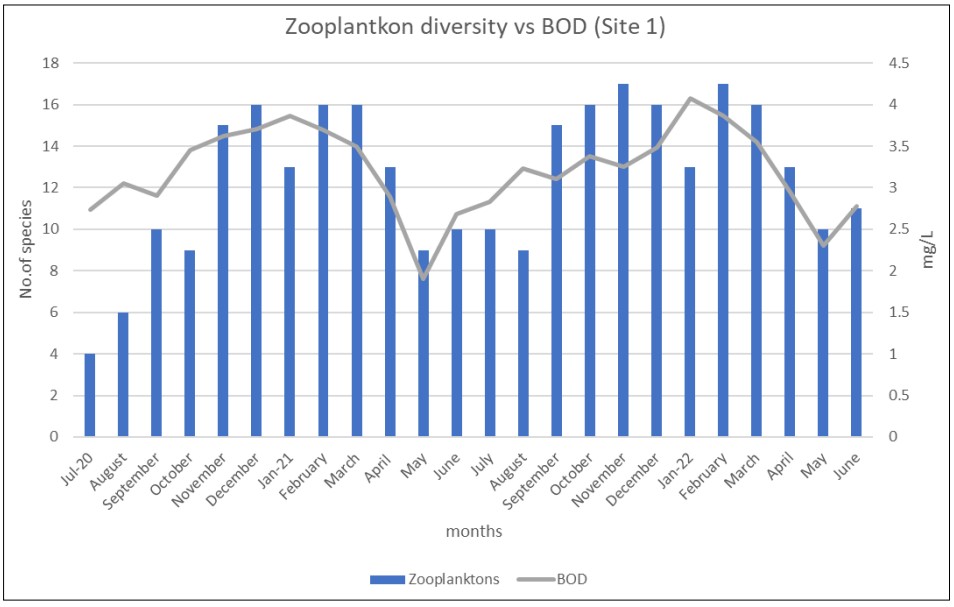

Fig 6: Co-relation between Zooplankton Diversity and BOD of Site 1.

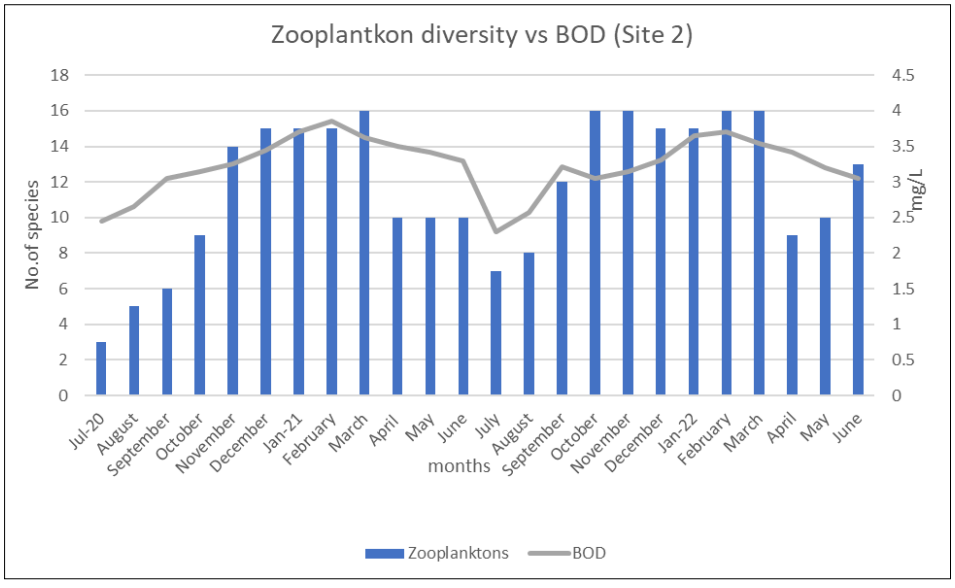

Fig 7: Co-relation between Zooplankton Diversity and BOD of Site 2.

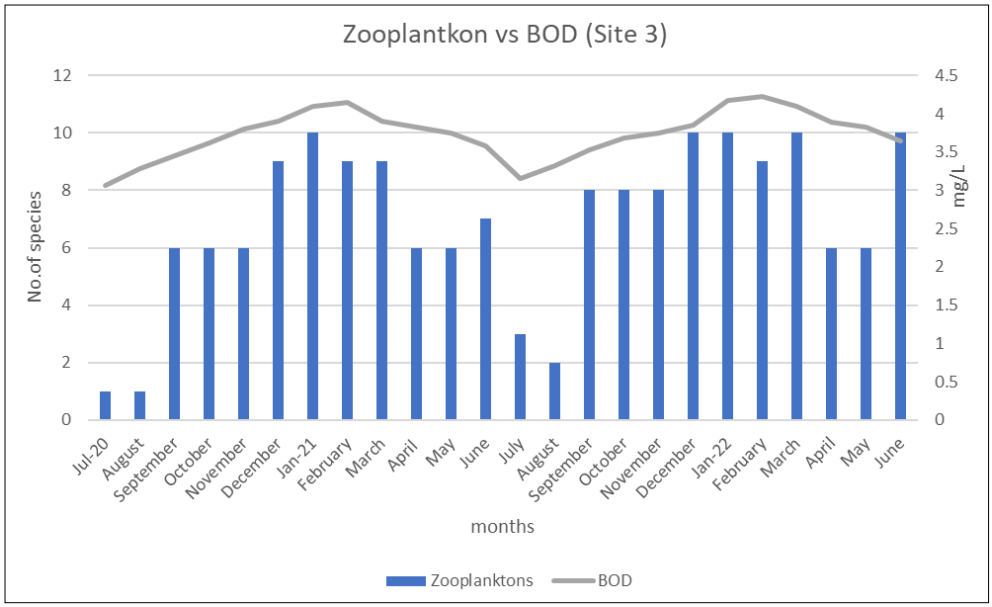

Fig 8: Co-relation between Zooplankton Diversity and BOD of Site 3.

Conclusion

This study on wetlands of Porbandar, Gujarat, India helped us understand the Diversity of Zooplanktons in the selected wetlands and the impact of seasonal variations on its diversity. 25 species of Zooplanktons (July 2020 to June 2022) were identified during the study period: 5 different groups have been observed throughout the research. i.e., Protozoa (10), Rotifera (7), Copepoda (4), Cladocera (3) and Ostracoda (1). Highest zooplankton diversity was observed in winter (24) and lowest zooplankton diversity was observed during monsoon (14). Thus, the seasonal variations were influencing the zooplankton diversity of the selected wetland sites for the research.

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