Research Article

A Preliminary Investigation of Phytoplankton and Zooplankton Diversity in Marine Water Ponds, Thatta, Sindh, Pakistan

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Abstract | The current study focuses on the physicochemical parameters including phytoplankton and zooplankton diversity of marine water ponds at Thatta district, Sindh, Pakistan. Water samples were collected monthly (Jan-Dec, 2019) from different sites of the ponds and studied the total abundance of plankton in each month. During the study, physicochemical parameters of the pond water like temperature, pH, dissolved oxygen, salinity, transparency, ammonia, phosphates, nitrates, potassium, calcium, total alkalinity and total hardness were determined. Overall, 61 species of plankton have been recorded from the studied ponds and categorized into 19 groups; of which 25 phytoplankton species belonged to four major groups, whereas, 36 zooplankton species belonged to 15 groups. Among them, Bacillariophyta (69.815%) and copepods (78.927%) were "most abundant" as compared to other groups of phytoplankton and zooplankton, respectively. Monthly abundance of phytoplankton and zooplankton was observed and the highest percentage was found in the month of November (18.559%) and July (16.560%), respectively. The optimal range of physicochemical parameters of the pond water with planktonic diversity indicates the productivity of water which is crucial for the growth of pond biota during pisciculture activities.

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Introduction

Phytoplankton serves as primary producers form the base of marine food web. They transfer energy to the higher trophic level species and there is no life in the aquatic system without them. While, zooplankton graze the phytoplankton found in varying depth in the pelagic environment. The occurrence of zooplankton mainly influences the pelagic fishery potentials, like fish grow and survive in those areas where the planktonic organisms are abundant, so that their young ones can get sufficient natural food. Zooplankton indicates ecological condition because they respond changes in the nutrient level and fish population, while population of phytoplankton is totally depending on the numerous environmental factors and varying nutrient transport seasonally (Yaqoob *et al*., 2013; Martins *et al*., 2020). It is verified that, plankton fulfill the nutritional requirement of farmed fish and shrimp species and also indicate the productivity of water (Coutinho *et al*., 2012; Gamboa-Delgado, 2014). The qualitative and quantitative abundance of plankton in a fish and shrimp pond has a great importance to manage the effective aquaculture operation, because they differ from place to place and pond to pond even within the similar location and ecological condition. Water quality of pond is necessary to determine the continuous limnological change and the optimal range of physicochemical parameters of water such as temperature, pH, total hardness, alkalinity, potassium, phosphate, nitrate, sulphate, DO, and BOD show appropriateness of water which are necessary for all aquatic life (Hossain *et al*., 2007; Durge *et al*., 2018). Moreover, water quality could directly affect the biological functions of fish such as feeding, breeding, swimming, metabolism and excretion (Shah *et al*., 2008; Kumar *et al*., 2017). Therefore, good quality of water is indispensable for better growth, survival and high production of fish for successful aquaculture (Ramanathan and Amsath, 2018). It is consider that, quality of pond water can be deteriorated by providing excessive commercial feed and fertilizers responsible for low concentrations of DO, high concentrations of NH_3, NO_2 and phosphorus (Tamizhazhagan and Pugazhendy, 2016; Bauer *et al*., 2017). Also, accumulation of excessive nutrients causes phytoplankton blooms in ponds, which are responsible for the polluted and anoxic condition (Wu *et al*., 2014). Apart from nutrients, fluctuation in temperature is responsible to curb primary productivity of water (Simmons *et al*., 2004). Several studies have been reported on the primary productivity and water quality assessment in fresh and brackish water bodies as well as in fish and shrimp ponds by (Hossain *et al*., 2007; Sahni and Yadav, 2012; Harney *et al*., 2013; Akter *et al*., 2015; Abbas *et al*., 2015; Abbasi *et al*., 2016; Durge *et al*., 2018; Ogbuagu *et al*., 2019; Akinpelu *et al*., 2019; Martins *et al*., 2020; Mermillod-Blondin, 2020; Khokhar *et al*., 2020). Worldwide, the study of planktonic abundance has been done under the priority in aquaculture ponds to assess the health of water but no prior study was reported on marine water ponds situated at Thatta district, Sindh, except coastal water of Arabian Sea, tidal creeks, lakes and fresh water ponds in Pakistan. For that reason, present study was conducted to evaluate the diversity and abundance of phytoplankton and zooplankton along with physicochemical parameters in semi-intensive marine water ponds.

Materials and Methods

Experimental site and sampling protocol

This study was investigated for a period of one year (Jan-Dec, 2019). A total of four semi-intensive marine water ponds (1.3 ha) were selected for proposed study located in Thatta district, Sindh, Pakistan (Figure 1). Seawater was directly pumped into the ponds from canal because water primarily store into the canals from thetidal creek. All ponds were stocked with commercial marine water fish juveniles (*Chanos chanos, Acanthopagrus berda*, and *A. latus*) for polyculture.

Figure 1: *Google earth view of the experimental ponds.*

Water samples were collected monthly between 10.00 AM to 12.00 PM noon. For the quantitative findings of plankton, water (16 liters) from different selected sites was filtered from each pond via conical plankton net (56 micron), and the depth of sampling was 10 to 25 cm. Sample (120 ml) were immediately fixed into plastic bottles with (5%) formalin. Samples were carried out into Aquaculture laboratory (CEMB, University of Karachi) and examined under a compound microscope (100x). Sample analysis was consisting of 1ml subsample for up to 6mL per sample for quantitative measurement through S-R counting chamber suggested by (Welch, 1948). Each row of chamber was carefully inspected and their total number per ml were noted and calculated as a mean value. Micro-pipetting method was used for in depth analysis of plankton by using a glass slide under microscope. Planktons were identified up to the genus level. Following key guide and literatures were used for the identification of plankton (Ward and Whipple, 1959; Newell and Newell, 1963; Pollock, 1998; Castellani and Edwards, 2017).

Physicochemical properties of selected pond water were examined on spot before providing test feed and collecting water samples, such as temperature (°C) with thermometer (digital), pH with meter (EzDO 6011, Taiwan), transparency (cm) by Secchi disk, salinity (ppt) by refractometer (Atago, S/Mill-E, 0.100‰, Japan), ammonia and DO (mgL^{-1}) were observed by portable test kits (Merck KGaA, 64271, Germany). Nitrate and phosphate were assessed by Boyd (1981). However, the data was analyzed through the Duncan's new multiple test range, and were presented as mean with the standard deviation (± SD) described by Steel *et al.* (1997).

Results and Discussion

Water quality of fish ponds

Present study was conducted for a period of one year from January to December, 2019 for the investigation of planktonic abundance along with physicochemical characteristics of marine water ponds. It is noted that, plankton diversity is fluctuated with the physicochemical parameters of the water. So, the physical and chemical environment of the water mainly controls the diversity, species richness and population dynamics of planktons. The combined result of the physicochemical properties is presented in (Table 3). During present study, the average temperature of marine water ponds was recorded in the range of24.5 to 38.4°C. Temperature is one of the important factor that influence the plankton succession by controlling their behavioral characteristics (Welch, 1952). High atmospheric temperature speed up the evaporation rate in the water and induce positive correlation with copepods (zooplankton), because the better development of copepods were notice in warmer monthsand then deteriorate quickly, this coincide with the study of Winkler (2002), Heerkloss *et al.* (2005), Persaud *et al.* (2007), Sarkar *et al.* (2020). Furthermore, 18 to 38.0°C is an optimal range of water temperature for the abundance of plankton, specified by (Pulle and Khan, 2003; Gardner *et al.*, 2008). Transparency is a physical parameter and it directly affects primary productivity of the water and also food web. In this study, transparency of water was recorded in the range of 27.1 to 44.8cm, while pH (7.0 to 8.5) was found in a suitable range as the pond water was well buffered and healthy during whole study period. It is reported that, pH of the pond water is likely to be higher during high photosynthetic activity by planktons (Abbas, 2001). DO value was found slightly higher (5.3 to 7.5 mgL^{-1}) and no harsh effects on plankton was recorded due to less fluctuation in DO. Although, Rukhsana *et al.* (2021) recommended the optimal range of DO (3.70-8.38 mg/l) for aquaculture ponds alongside Sindh coast. Similar, findings with above parameters were reported by Ali *et al.* (2007), Akter *et al.* (2015), Abbasi *et al.* (2016); Shoaib *et al.* (2017). They also specified that the temperature of the water may influence the DO level. Alkalinity can directly affect the development of plankton and the total alkalinity of our ponds was recorded in the range of 111.6 to 146.3mgL^{-1} (Table 3). However, the optimal alkalinity range of an average productive water of pond was 20 to 400 mg per liter as reported by Bhuiyan *et al.* (1970), Hossain *et al.* (2007); Martins *et al.* (2020) and Rukhsana *et al.* (2021). Nitrates range of our studied ponds was recorded lower (3.9 mg/l to 21.3 mg/l) than recommended range (20 to 100 mg/l) for aquaculture ponds (Pilay, 1992).

Plankton diversity

A total 61 species of plankton have been recorded from the studied ponds and categorized into 19 groups, out of which 25 species of phytoplankton were grouped into four major groups are presented in (Table 1). Among major groups, the most abundant group was Bacillariophyta comprising 18 species. In which, *Rhizosolenia* sp. was abundantly found in the month of (FEB31.761% to MAR-40.416%), and both *Skeletonema* sp. and *Chaetoceros* sp[1] in NOV (18.518% and 31.723%), respectively. Some taxa were found in all months such as (*Rhizosolenia* sp., *Bacillaria* sp., and *Oscillatoria* sp[1]). However, the other abundant group is Cyanophyta (*Oscillatoria*sp[1]) in the month of (MAY-45.721%, JULY-42.011% to AUG-50.710%). Meanwhile, the highest mean % was found in Bacillariophyta (69.815%)>Cyanophyta (28.302%) > Dinoflagellata (1.733%) > Prymnesiophyta (0.149%), mentioned in (Table 4).

Similarly, Harrison *et al.* (1997) and Yaqoob *et al.* (2013) reported the dominant phytoplankton species belonging to Bacillariophya group from the tidal creeks of Pakistan, and also indicating the export of nutrients from tidal creeks to coastal waters of Pakistan during NE monsoon winds. Although, some authors mentioned that the dominant group of phytoplankton is Cyanophyta as compared to Bacillariophyta by (Hossain *et al.*, 2007; Erondu and Solomon, 2017; Martins *et al.*, 2020). Because, Cyanophyta usually grow at high temperature while Bacillariphyta under low light or temperature as reported by (Vincent, 2009; Dai *et al.*, 2012; Bellinger and Sigee, 2015; Kumar *et al.*, 2017), this statement is similar to our study results.

Table 1: *Monthly distribution of Phytoplankton population (percentage of the total) in marine water ponds.*

Phytoplankton	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Bacillariophyta												
Bacillaria sp.	20.714	17.61	7.501	4.001	2.9412	8.53	4.4378	7.109	5.696	7.3089	3.864	2.38
Biddulphia sp.	-	-	-	0.571	1.872	-	1.479	-	3.165	2.325	-	4.761
Coscinodiscus sp.	5.714	-	-	-	0.534	-	0.592	0.948	-	-	-	-
Gyrosigma sp.	4.285	13.836	13.333	13.142	11.229	7.582	-	7.583	1.266	1.328	5.153	4.761
Nitzschia sp[1].	4.286	8.176	-	1.143	1.069	0.947	-	0.947	2.532	2.658	0.322	-
Nitzschia sp[2].	-	1.572	-	-	-	-	-	2.844	5.063	-	-	-
Rhizosolenia sp.	27.857	31.761	40.416	24.001	16.845	25.592	18.343	8.057	20.886	26.578	12.721	23.381
Skeletonema sp.	12.857	0.6289	-	15.143	5.882	9.004	10.059	-	4.43	6.312	18.518	-
Chaetoceros sp[1].	-	1.572	5.4166	1.429	3.475	0.947	3.846	-	3.164	3.986	31.723	-
Chaetoceros sp[2].	-	-	-	1.1429	-	-	1.775	-	-	2.657	-	-
Chaetoceros sp[3].	-	-	1.25	-	1.069	7.109	-	-	-	-	2.254	-
Navicula sp[1].	12.143	8.49	9.583	4.857	3.476	-	-	-	-	0.996	3.703	
Navicula sp[2].	-	0.943	1.666	1.142	-	-	-	-	-	0.664	-	
Cylindrotheca sp.	-	-	0.833	-	0.534	-	-	-	-	-	0.322	-
Cocconeis sp.	1.428	-	-	-	-	-	-	-	-	-	-	-
Eucampia sp.	-	-	-	6.571	0.534	1.421	8.579	18.483	13.291	8.97	8.212	-
Ditylum sp.	-	-	-	-	-	-	-	-	-	0.996	1.771	-
Thalassiosira sp.	2.857	0.943	-	-	-	-	-	-	-	-	2.254	28.571
Dinoflagellata												
Alexandrium sp.	-	-	2.083	-	-	-	-	-	-	-	-	-
Ceratium sp.	-	-	-	-	-	-	2.071	-	-	0.996	6.28	-
Polykrikos sp.	-			0.571	-		0.591	-	-	-	-	-
Cyanophyta												
Oscillatoria sp[1].	7.857	2.201	5	26.285	45.721	34.597	42.011	50.71	37.341	31.229	2.895	32.142
Oscillatoria sp[2].	-	-	9.583	-	3.475	4.265	5.621	2.843	1.265	2.325	-	-
Trichodesmium sp.	-	12.264	1.25	-	1.336	-	0.592	0.473	1.898	0.664	-	-
Prymnesiophyta												
Coccolithus sp.	-	-	2.083	-	-	-	-	-	-	-	-	-

**Values are the mean of all ponds. Jan- Dec means (January to December-2019); (-) indicated absent.*

About 36 zooplankton species belonging to fifteen major groups are presented in (Table 2). The most dominant group was found Copepoda (78.927%) mentioned in (Table 4). The abundance of copepod species have been reported globally by many authors (Hossain *et al*., 2007; Ajuonu *et al*., 2011; Erondu and Solomon, 2017; Huang *et al*., 2020). However, 68% to 74.9% copepod abundance was reported from Pakistani coastal areas (Yaqoob *et al*., 2013; Abbasi *et al*., 2016). Among copepods, the dominant order was Calanoida > Cyclopoida > Harpacticoida, and they were abundant in different months, while their females carrying egg sacs in different months. Present study coincides with the results of (Jacobsen and Dangles, 2017). Although, nauplii stage of copepods was abundantly found in the month of (FEB-39.895% to MAY 36.639%). Although, other dominant occurrences of zooplankton were medusa in the month of (JAN-67.049%), while their mean % was 7.576 after copepods (Table 4), Tintinnida (NOV30.707%) and Foraminiferans (OCT-10.311% to NOV-10.054%). Some taxa found in all months such as copepoda, nematoda and other unspecified taxa (unidentified eggs), shown in (Table 2). Our results indicated various planktonic forms specifies healthy ecological condition of the marine water fish ponds.

Overall percentage of phytoplankton and zooplankton diversity were recorded during sampling and their monthly distribution is presented in (Tables 5). The highest abundance of phytoplankton was found in the month of November (18.559%), while zooplankton in the month of July (16.560%). The lowest abundance

Table 2: *Monthly distribution of Zooplankton population (percentage of the total) in marine water ponds.*

Zooplankton	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Scyphozoa												
Medusae	67.049	1.214	0.281	0.418	1.619	1.734	0.649	-	0.125	0.693	13.315	7.017
Decapoda												
Penaeid mysis	3.302	1.474	0.337	-	-	-	-	-	0.125	-	-	-
Penaeid nauplii	-	-	-	-	-	-	0.173			0.347	0.543	
Lucifer sp.	-	-	-	-	-	-	-	-	-	0.173	-	-
Euphausiid juveniles (krill)	0.287	-	-	-	-	-	-	-	0.125	-	-	-
Brachyura larvae (crabs)	-	-	-	-	-	-	-	0.261	0.125	0.173	0.543	
Phyllosoma larvae (lobsters)	-	-	0.224	0.139	-	-	-	-	-	-	-	-
Copepoda												
Calanoid (commonly *Acartia, Pseudocalanus*)	6.891	13.53	20.911	51.012	26.417	18.497	57.885	63.992	48.185	31.369	11.141	12.28
Cyclopoid (commonly *Oithona*)	5.887	13.443	24.733	10.956	20.951	5.202	11.308	6.457	30.162	20.17	13.315	26.315
Harpacticoid (commonly *Clytemestra*)	2.727	14.223	17.201	4.676	3.846	20.809	6.239	2.478	5.569	1.126	2.717	1.754
Cyclopoid (F)	0.071	-	-	0.558	-	-	-	-	0.438	0.693	-	-
Calanoid (F)	0.143	-	0.112	-	0.101	0.578	-	-	0.062	0.433	-	-
Harpacticoid (F)	-	0.52	0.112	-	-	1.734	0.086	-	-	-	0.271	-
Nauplii stage	3.876	39.895	22.034	26.727	36.639	8.67	13.995	20.352	7.697	15.771	9.51	17.542
Egg sacs	-	-	0.393	0.069	0.202	1.734	-	-	-	0.173	-	-
Cladocera												
Evadne sp.	0.646	0.693	2.192	0.418	0.506	1.156	0.5199	0.391	-	-	-	-
Tintinnida												
Rhabdonella sp.	-	0.173	-	-	-	-	0.129	0.848	-	1.559	1.086	-
Tintinnopsis sp.	0.43	0.173	0.112	-	-	1.156	1.213	2.283	0.375	6.412	30.707	-
Foraminifera												
Globigerina sp.	-	-	0.224	0.348	0.303	1.156	1.949	0.717	0.188	-	0.543	15.789
Foraminiferans (Others)	3.0868	1.994	1.1804	2.163	1.315	12.716	1.1698	-	3.567	10.311	10.054	-
Doliolida												
Doliolium sp.	-	-	1.63	0.907	3.744	7.514	0.649	-	0.813	5.459	1.902	7.017
Rotifera												
Bdelloids	-	-	1.068	-	-	-	-	-	0.375	1.213	-	-
Polychaeta												
Trochophore larva	-	-	0.168	-	-	-	0.086	0.195				
Siphonid larva	-	-	0.168	-	-	-	-	-	-	-	-	-
Nereid larva	-	-	0.112	-	-	-	-	-	-	-	-	-
Pteropoda												
Limacina sp.	0.789	1.5611	0.843	0.1395	0.101	5.7803	0.563	0.065	0.125	0.346	0.815	-
Creseis sp.	-	1.908	-	0.279	-	-	-	-	-	-	-	-
Copelata												
Oikopleurid appendicularians	-	-	0.393	-	-	-	-	-	-	-	-	-
Amphipoda												
Hyperia	-	-	0.224	-	0.202	-	0.173	-	-	-	-	-
Salpida												
Thalia democratia	-	-	-	0.279	-	-	-	0.1304	-	-	-	-

Table continue on next pages...............

Zooplankton	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Nematoda												
Nematod worm	0.646	0.173	0.562	0.139	0.202	1.734	0.346	0.521	0.6258	0.519	0.2717	3.508
Aphragmophora												
Arrow worm (Sagitta)	0.071	0.086	-	0.069	-	-	0.043	-	-	0.259	1.358	-
Other unspecified taxa												
Eggs	1.866	4.336	1.686	0.209	2.935	8.092	2.512	1.239	0.3128	1.906	1.902	1.754
Worms	2.081	3.122	2.754	0.348	0.304	1.734	0.216	0.065	0.75	0.086	-	-
Larvae	0.143	1.474	-				0.086	-				
Fish larvae	-	-	-	0.139	0.202	-	-	-	0.25	0.173	-	-
Eggs with embryo inside	-	-	0.337	-	-	-	-	-	-	0.05	-	-

**Values are the mean of all ponds. Jan- Dec means (January to December-2019); F-females; (-) indicated absent.*

Table 3: *Physicochemical properties of marine water ponds.*

Water variables	Range	SD	Mean value
Temperature °C	24.5-38.4	4.4	32.3
Salinity ppt	33.9-39.1	1.2	36.1
pH	7.0-8.5	0.9	7.8
Transparency cm	27.1-44.8	5.6	33.0
Dissolved oxygen mgL^{-1}	5.3-7.5	0.5	6.1
Nitrates mgL^{-1}	3.9-21.3	4.1	10.4
Ammonia μgL^{-1}	19.6-69.2	11	42.9
Phosphates μgL^{-1}	5.0-92.6	32	62.7
Potassium mgL^{-1}	20.1-49.4	4.1	38.5
Calcium mgL^{-1}	26.4-50.5	5.3	41.5
Alkalinity mgL^{-1}	111.6-146.3	4.2	131.9
Total hardness gL^{-1}	18.09-26.21	0.70	19.2

**SD indicated standard deviation; Values are the mean of all ponds.*

was found in the month of December (2.51 and 0.41%, respectively), because a short period of light in winter months resulting a sharp decline of primary producers and then zooplankton as reported by (Sommer *et al*., 1986). According to Brien and Noyelles (1974), who observed nutrient concentration with planktic population in nutrient rich ponds, revealed that density of phytoplankton is totally depend on the environmental factors and seasonal nutrient transport into ponds while zooplankton density is totally reliant on the phytoplankton. The difference in planktonic population in our ponds might be due to the presence of variable amount of nutrient inputs in different months. Additionally, changing physicochemical properties of water causes fluctuation in abundance of plankton, because Pakistani water receives domestic, agriculture and industrial discharge that contain high amount of dissolve nutrients, specified by (Harrison *et al*., 1997; Abbas, 2001; Abbasi *et al*., 2016).

Table 4: *Mean percentage of Phytoplankton and Zooplankton in marine water ponds (Jan-Dec, 2019).*

Categories	Percentage (%)
Phytoplankton	
Bacillariophyta	69.815
Dinoflagellata	1.733
Cyanophyta	28.302
Prymnesiophyta	0.1494
Zooplankton	
Scyphozoa	7.576
Decapoda	0.7533
Copepoda	78.927
Cladocera	0.581
Tintinnida	1.909
Foraminifera	3.688
Doliolida	1.471
Rotifera	0.279
Polychaeta	0.0933
Pteropoda	0.818
Copelata	0.052
Amphipoda	0.072
Salpida	0.043
Nematoda	0.452
Aphragmophora	0.861
Others	3.201

**Values are the mean of all ponds.*

Table 5: *Average month wise distribution (%) of plankton in marine water ponds (Jan-Dec, 2019).*

Months	Phytoplankton (%)	Zooplankton (%)
January-2019	4.184	9.994
February	9.503	8.272
March	7.172	12.764
April	10.46	10.281
May	11.177	7.089
June	6.306	1.241
July	10.101	16.56
August	6.306	10.999
September	4.722	11.465
October	8.995	8.28
November	18.559	2.64
December-2019	2.5104	0.408

**Values are the mean of all ponds.*

Conclusions and Recommendations

In conclusion, the studied marine water fish ponds showed differ but high abundancy of planktons in different months because they receives nutrient rich water from tidal creek. Thus, present study will be supportive to farmers because ponds are productive and suitable for pisciculture activities. However, detailed study is needed by using different fertilizers linked with primary productivity and total production of these ponds.

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Novelty Statement

The current study investigates the phytoplankton and zooplankton diversity in marine water ponds will be supportive to farmers for pisciculture activities.

Author's Contribution

Asma Fatima: Performed the experiment, data analysis, and manuscript writing;
Ghulam Abbas: Supervised the research, helped in experimental setup and data analysis;
Shahnaz Rashid: Reviewed and edited the manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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