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Comparative Study of Hydrobiological Parameters Between Earthen and High-Density Polyethylene (HDPE) Brackishwater Shrimp Ponds in Ratnagiri, Maharashtra

S.S. Kawade, P. H. Sapkale, M.S. Sawant, H.B.Dhamagaye, S.S.Gangan, Sweksha Chauhan

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ABSTRACT

The current study was carried out to compare the hydrobiological characteristics of a selected shrimp farm in district Ratnagiri taking pond size, stocking density and culture practices into consideration. For sampling, four earthen and four high-density polyethylene (HDPE) ponds were chosen. Most of the water parameters showed significant difference with respect to different types of ponds (earthen and HDPE) viz. temperature, pH, salinity, dissolved oxygen, alkalinity and net primary productivity (NPP) of both crops ($p<0.05$). First crop showed significant difference among all water parameters except biochemical oxygen demand ($p<0.05$). Second crop (January-May) showed significant difference ($p<0.05$) among all parameters except hardness, ammonia, nitrite, gross primary productivity (GPP) and community respiration (CR). Phytoplankton showed significant difference ($p<0.05$) with respect to different types of ponds for both crops and zooplankton showed significant differences ($p<0.05$) only during first crop. Results indicated that high-density polyethylene (HDPE) ponds have greater consistency in water quality characteristics than earthen ponds, which could contribute to enhanced shrimp growth and survival.

Keywords Hydrobiological, Earthen, High-density polyethylene (HDPE), Phytoplankton, Productivity.

INTRODUCTION

India leads globally in shrimp production, driven by rapid growth rates, shorter cultivation periods, higher export value and increasing market demand (Venkateswarlu *et al.* 2019). The increasing demand for nutritious shrimp needs increased farming areas and innovative farming methods to improve productivity and bridge the supply-demand gap (Saraswathy *et al.* 2022). The successful production of shrimp is often limited by physico-chemical factors of the water as it directly influences the productivity of shrimp farm and the ambient water in which shrimp lives has a cumulative effect on growth performance and survival of shrimp with respect to the production (Jaganmohan and Kumari 2018). Simultaneously growth, survival

S.S. Kawade[1], P. H. Sapkale[2]*, M.S. Sawant[3], H.B.Dhamagaye[3], S.S.Gangan[4], Sweksha Chauhan[5]

[2]Associate Research Officer,
[3]Associate Professor, [4]Associate Research Officer
[1, 3, 5]Department of Fisheries Hydrography, College of Fisheries (DBSKKV), Ratnagiri Maharashtra 415629, India

[2, 4]Taraporevala Marine Biological Research Station, Third Floor, New Administrative Building, Government Colony, Bandra (East), Mumbai, Maharashtra 400051, India

Email : pravinsapkale@gmail.com
*Corresponding author

and health have been impacted enormously by the hydrogen ion concentration in the water (pH) and the soil at the bottom of ponds. Moreover, nutrient inputs retained and degraded in the water, which are turn to be potential causes for deterioration of water quality (Tran *et al.* 2013). Water quality needs to be regularly monitored for both the biology of cultivated organisms and overall productivity. Pond aquaculture requires careful management of water quality, but pond management has not got as much attention as it should. Since shrimp physiology is dependent on water temperature, culture methods and protocols must be adjusted for successful farming (Anna 2021).

Primary productivity in tropical and subtropical ecosystems is crucial for energy equilibrium and water quality, influenced by seasonal and climatological fluctuations in phytoplankton populations (Chinthada and Bandla 2010). Since phytoplankton can perform photosynthesis and produce oxygen that the water biota can use, they are also employed as indicators of the primary productivity of the water. Diversity in phytoplankton maintains the ecosystem equilibrium and provides shrimp cultivation in ponds with its natural food source (Abualreesh 2021). Zooplankton plays an essential role in the aquatic food chain by acting as a link between higher trophic levels and primary producers (Liu *et al.* 2013).

Poor soil quality and the possibility of diseases make it difficult to grow shrimp in earthen ponds. Alternative methods aim to reduce costs, increase productivity, increase financial viability and reduce the risk of disease. In order to raise shrimp in different kinds of soil, farmers recently started cultivate *P. vannamei* in lined ponds. Pond liners are technically feasible in *P. vannamei* culture, effective in disease-prone and acidic soils, out performing earthen ponds (Prawitwilaikul *et al.* 2006). In addition, high-density polyethylene (HDPE) ponds require less effort and less care than earthen ponds. Our study aims to compare earthen and high-density polyethylene (HDPE) ponds in terms of water quality parameters and planktonic productivity.

MATERIALS AND METHODS

The present study was conducted between June to October 2022 and January to May of 2023. Samples of water and plankton were collected from Kelbai Aqua farm Ranpar, Ratnagiri, including two consecutive crops from four earthen and four high-density polyethylene (HDPE) ponds, at Latitude 160° 89’ 49.095” N, Longitude 73° 30’ 94.562” E. Weekly water samples were collected from the farm, assessing pH, salinity, temperature, biochemical oxygen demand, dissolved oxygen, alkalinity, hardness, ammonia, nitrite-nitrogen by Strickland and Parsons (1972), Boyd (1979). Primary productivity using standard light and dark bottle method (Gaarder and Gran 1927).

Plankton sample collection

Plankton samples were collected at 7-day intervals from ponds by filtering 50 L of water using a 50 µm mesh net and preserved in Lugol’s solution and a 5% neutralized formalin solution for future analysis. In the laboratory analyzed phytoplankton and zooplankton qualitatively by pipetting 1 ml sample and quantitatively using Sedgewick-Rafter density per liter of water samples, observing under microscope at 10x and 40x magnification and identifying plankton using a taxonomic key (Newell and Newell 1977).

Statistical analysis

ANOVA was performed using SPSS 16.0 software to determine the statistical significance ($p<0.05$) of the effect of pond types and experiment days on water quality parameter, primary productivity and plankton.

RESULTS AND DISCUSSION

Water parameters

For both crops one and two, the ANOVA (Analysis of variance) showed a significant difference ($p<0.05$) in the temperature, pH, salinity, dissolved oxygen, alkalinity values in the water with respect to earthen and high-density polyethylene (HDPE) types of ponds (Tables 1–2). While total hardness, total ammonia, nitrite-nitrogen values in water, ANOVA (Table 1) showed a significant difference ($p<0.05$) and (Table 2) showed no significant difference with respect to

Table 1. Water parameters recorded from earthen and high-density polyethylene shrimp ponds during 1st crop. SD- Standard deviation, Min- Minimum, Max- Maximum, CV- Coefficient of variance.

Type of pond		Temperature (°C)	pH	Salinity (psu)	DO (mg L^{-1})	Alkalinity (mg L^{-1})	Hardness (mg L^{-1})	BOD (mg L^{-1})	Ammonia (mg L^{-1})	Nitrite (mg L^{-1})	GPP (mg C/ L/hr)	NPP (mg C/ L/hr)	CR (mg C/ L/hr)
Earthen	Mean	28.69	7.95	21.52	5.05	66.56	3334.7	3.33	0.68	0.50	0.8540	0.6896	0.1724
	SD	0.95	0.57	6.67	0.69	11.06	1186.76	1.62	0.44	0.07	0.649	0.641	0.10929
	Min	27	4.5	10	4	35	1600	0.4	0.10	0.008	0.119	0.059	0.059
	Max	31	8.5	36	7.6	100	6000	6	1.53	0.35	2.382	2.322	0.476
	CV%	3.34	7.20	31.0	13.8	16.6	35.5	48.8	65.1	14.8	76.4	94.3	64.2
HDPE	Mean	28.96	8.13	21.93	4.70	76.57	3379.8	3.38	0.42	0.16	1.0677	0.9254	0.1411
	SD	0.92	0.20	5.81	0.66	10.00	1087.92	1.55	0.24	0.17	0.790	0.779	0.07314
	Min	27	8	12	3.2	60	2000	0.4	0.13	0.008	0.059	0	0
	Max	31	8.5	35	7	110	5600	5.6	1.46	0.38	2.624	2.382	0.297
	CV%	3.18	2.45	26.5	14.1	13.0	32.1	45.9	58.7	109.5	74.5	84.6	52.2
	p value	0.001	0.013	0.000	0.000	0.000	0.003	0.588	0.000	0.000	0.000	0.000	0.010

types of ponds for crops one and two ($p>0.05$) and in biochemical oxygen demand (BOD) values, ANOVA (Table 1) showed no significant difference ($p>0.05$) and (Table 2) showed a significant difference with respect to types of ponds ($p<0.05$).

Primary productivity

ANOVA (Table 1) showed a significant difference ($p<0.05$) and (Table 2) showed no significant difference ($p>0.05$) in GPP and CR with respect to earthen and HDPE types of ponds for crops one and two. For NPP, ANOVA (Tables 1–2) showed a significant difference with respect to types of ponds for both crops one and two ($p<0.05$).

Plankton

ANOVA (Tables 3–4) showed a significant difference in the phytoplankton density with respect to earthen and HDPE types of ponds for both crops one and two ($p<0.05$). While in zooplankton, ANOVA (Table 3) showed a significant difference ($p<0.05$) and (Table 4) showed no significant difference ($p>0.05$) with respect to types of ponds for crops one and two.

Temperature

The morphology, development, behavior, reproduction, survival and metabolism of shrimp can all be impacted by the water temperature. During the present

Table 2. Water parameters recorded from earthen and high-density polyethylene shrimp ponds during 2nd crop. SD- Standard deviation, Min- Minimum, Max- Maximum, CV- Coefficient of variance.

Type of pond		Temperature (°C)	pH	Salinity (psu)	DO (mg L^{-1})	Alkalinity (mg L^{-1})	Hardness (mg L^{-1})	BOD (mg L^{-1})	Ammonia (mg L^{-1})	Nitrite (mg L^{-1})	GPP (mg C/ L/hr)	NPP (mg C/ L/hr)	CR (mg C/ L/hr)
Earthen	Mean	26.34	7.93	40.21	4.66	96.82	6313.0	4.06	0.61	0.11	0.9153	0.8353	0.0798
	SD	2.88	0.30	1.47	0.46	20.60	688.43	0.71	0.37	0.11	0.59960	0.59817	0.03385
	Min	22	7.5	35	3.2	60	4100	1.6	0.19	0.007	0.119	0.059	0.059
	Max	31	8.6	42	5.6	170	7400	5.2	1.53	0.37	2.263	2.203	0.178
	CV%	10.9	3.7	3.6	10.0	21.2	10.9	17.6	62.2	102.6	65.8	72.0	48.2
HDPE	Mean	26.93	8.10	39.58	5.32	115.50	6320.8	4.45	0.52	0.10	0.7991	0.6855	0.0929
	SD	2.58	0.28	1.45	0.83	18.07	662.51	1.07	0.33	0.100	0.6396	0.58568	0.05847
	Min	24	7.5	35	3.6	80	4400	0.8	0.18	0.007	0.059	0	0
	Max	31	8.7	42	8.4	170	7400	7.6	1.45	0.32	2.203	2.024	0.238
	CV%	9.6	3.5	3.6	15.6	15.6	10.4	24.0	63.8	100.4	80.9	86.1	0.52
	p value	0.000	0.000	0.033	0.000	0.000	0.699	0.010	0.065	0.302	0.082	0.019	0.168

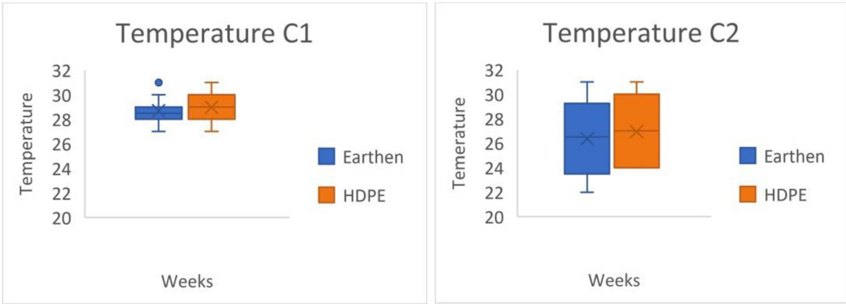

Fig. 1. Change in the temperature of crop 1 and 2 from earthen and high-density polyethylene ponds.

study, the range of temperature from different types of shrimp ponds were found between 27 to 31°C, 27 to 31°C and 22 to 31°C, 24 to 31°C, respectively. The temperature of the pond water undergoes variations based on factors such as the season, duration of the day, water depth and prevailing weather conditions (Zafer *et al.* 2015). Vannamei shrimp farming is still possible in ponds with an average temperature of 26 to 30°C (Harlina *et al.* 2022). Current investigations aim to identify the optimal temperature range for shrimp growth in earthen 26.34 to 28.69°C and 26.93 to 28.96°C for high-density polyethylene ponds, considering seasonal variations. Temperature correlated negatively with phytoplankton in the first crop and a positively with Gross Primary Productivity (GPP), Net Primary Productivity (NPP), Community Respiration (CR) and Zooplankton. In the same manner, temperature responded positively to both plankton and primary productivity throughout the second crop (Fig. 1).

pH

The pond water pH was consistent, within the 6.6 to 8.5 range that is ideal for shrimp cultivation (Anna 2021). During the present study, the range of water pH from different types of shrimp ponds were found between 4.5 to 8.5, 8 to 8.5 and 7.5 to 8.6, 7.5 to 8.7 respectively. Low pH water can result in decreased growth activity or weak habitat, which leads to low survival rates. The amount of CO_2 in the water had an impact on its pH value. The pH value in shrimp ponds is influenced by factors like water alkalinity, soil pH, water source, lime applications and phytoplankton bloom development (Venkateswarlu *et al.* 2019). According to Supriatna *et al.* (2020), drop in

Table 3. Plankton density recorded from earthen and high-density polyethylene shrimp ponds during 1st crop. SD- Standard deviation, Min-Minimum, Max-Maximum, CV- Coefficient of variance.

Type of pond		Phytoplankton (Nos L^{-1})	Zooplankton (Nos L^{-1})
Earthen	Mean	1250.7	133.22
	SD	988.92483	68.07064
	Min	80	30
	Max	3500	250
	CV%	79	51
HDPE	Mean	1477.7	152.53
	SD	1028.84084	77.43363
	Min	100	48
	Max	4520	320
	CV%	69.6	50.7
	p value	0.026	0.016

Table 4. Plankton density recorded from earthen and high-density polyethylene shrimp ponds during 2nd crop. SD- Standard deviation, Min- Minimum, Max- Maximum, CV- Coefficient of variance.

Type of pond		Phytoplankton (Nos L^{-1})	Zooplankton (Nos L^{-1})
Earthen	Mean	1287.9	121.96
	SD	862.41403	62.16893
	Min	112	40
	Max	3400	300
	CV%	66.9	50.9
HDPE	Mean	3247.8	117.93
	SD	1249.28876	57.27953
	Min	500	40
	Max	5550	280
	CV%	38.4	48.5
	p value	0.000	0.621

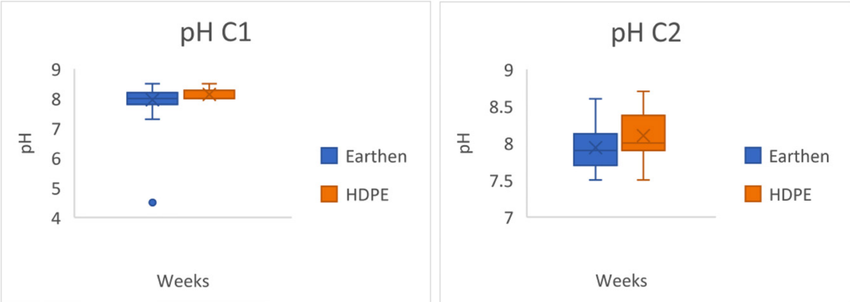

Fig. 2. Change in the pH of crop 1 and 2 from earthen and high-density polyethylene ponds.

pond water pH may be the result of microorganisms decomposing organic materials. There was no seasonal influence on pH. The pH of the water in the cultured pond of *L. vannamei* was determined to be slightly alkaline in its natural state and was observed to fall within the optimal range of 7.3 to 8.7 (Chittem and Kunda 2017). In current studies mean pH values for earthen and high-density polyethylene (HDPE) ponds ranged from 7.9 to 8.1, which was ideal for shrimp growth and showed a negative correlation with plankton and primary productivity during both crops (Fig. 2).

Salinity

Salinity, the concentration of total ions in water, significantly influences the growth and survival of shrimps (Chittem and Kunda 2017). During the present study, the range of water salinity from different types of shrimp ponds were found between 10 to 36 psu, 12 to 35 psu and 35 to 42 psu, 35 to 42 psu, respectively. High salinity in summer may be due to increased evaporation, while reduced saline conditions can be attributed to abundant rainfall during the southwest monsoon. Rahman *et al.* (2015) reported an increase in the salinity of shrimp ponds water during the summer, while a decrease was observed during the rainy season. Gunalan *et al.* (2010) indicated that the salinity range of 10 - 35 ppt exhibited an increased shrimp growth and survival rate. Bansode *et al.* (2020) documented the salinity levels of water in the range of 15 to 35.5 ppt, which were observed in brackishwater shrimp farms located in the Raigad district of Maharashtra. The salinity ranges found in the current research 21.52 to 40.21 psu for earthen and 21.93 to 39.58 psu for high-density polyethylene (HDPE) ponds are optimal for shrimp farming. Current study negatively correlated with primary productivity and plankton during both crops (Fig. 3).

Dissolved oxygen

In the present study dissolved oxygen fluctuated between 4 to 7.6 mg L^{-1}, 3.2 to 7 mg L^{-1} and 3.2 to 5.6 mg L^{-1}, 3.6 to 8.4 mg L^{-1}. Elevated dissolved oxygen concentrations in water are often caused by freshwater

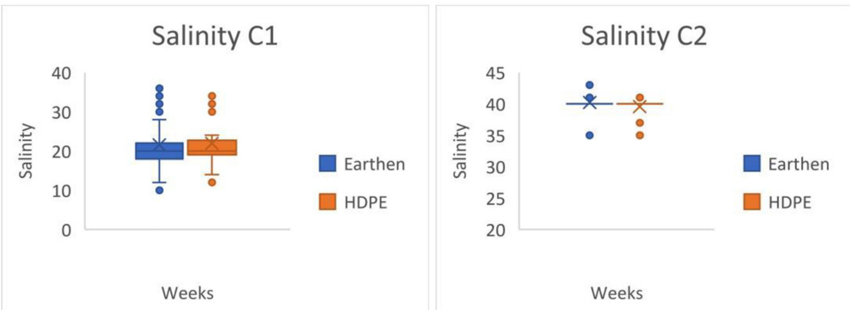

Fig. 3. Change in the salinity of crop 1 and 2 from earthen and high-density polyethylene ponds.

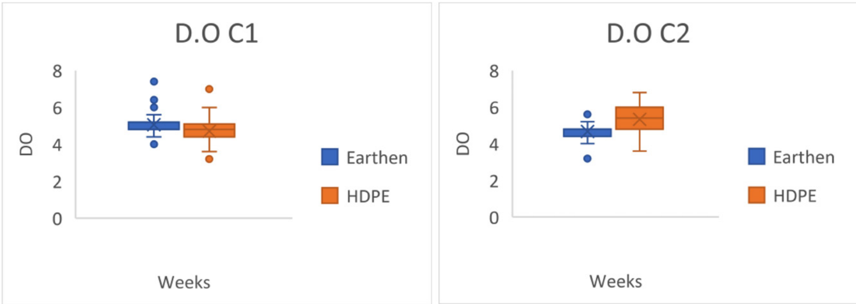

Fig. 4. Change in the dissolved oxygen of crop 1 and 2 from earthen and high-density polyethylene ponds.

influx, seawater intermingling, solar radiation, phytoplankton production and rainwater intermingling. Balakrishnan *et al.* (2011) have documented the levels of dissolved oxygen (DO) in each pond, which exhibited a range of 3.5 to 5.5 mg L^{-1} during the morning and 4.5 to 10.2 mg L^{-1} during the evening. Levels of dissolved oxygen varied between 6 ppm during the dry season and 4 ppm during the wet season in shrimp ponds. The decrease in oxygen levels may be due to the organic matter decomposition caused by bacteria in ponds. Azhar *et al.* (2016) discovered comparable findings regarding the dissolved oxygen content in water, ranging from 3.5 to 6 mg L^{-1}, within the shrimp farms located in Ratnagiri, Maharashtra. In the present investigations mean dissolved oxygen values ranged between 4.6 to 5.0 mg L^{-1} and 4.7 to 5.3 mg L^{-1} which were supposed to be the optimum limits for *L. vannamei* shrimp. Dissolved oxygen negatively correlated with phytoplankton and positively correlated with Gross Primary Productivity (GPP), Net Primary Productivity (NPP), Community Respiration (CR) and zooplankton. Similarly, during second crop, dissolved oxygen exhibited a positive correlation with Community Respiration (CR) and Phytoplankton and negative correlation with Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Zooplankton in the current study (Fig. 4).

Biochemical oxygen demand

Vijaya and Kumara (2014) measured a maximum Biochemical Oxygen Demand (BOD) content of 6.51 mg L^{-1} and low concentration of 0.1 mg L^{-1} in the mangrove waters of Kundapur. During the present study, Biochemical Oxygen Demand (BOD) mean values ranged between 3.33 to 4.06 mg L^{-1} and 3.38 to 4.45 mg L^{-1} respectively. As the BOD range was lower than 6 mg L^{-1} during the present studies, it indicated that ponds were suitable for shrimp culture. According to Ekubo and Abowei (2011) aquatic systems as having BOD levels between 1.0 and 2.0 mg L^{-1}, somewhat clean at 3.0 mg L^{-1}, questionable at 5.0 mg L^{-1} and definitely hazardous at 10.0 mg L^{-1}. Also, in present study Biochemical Oxygen Demand showed

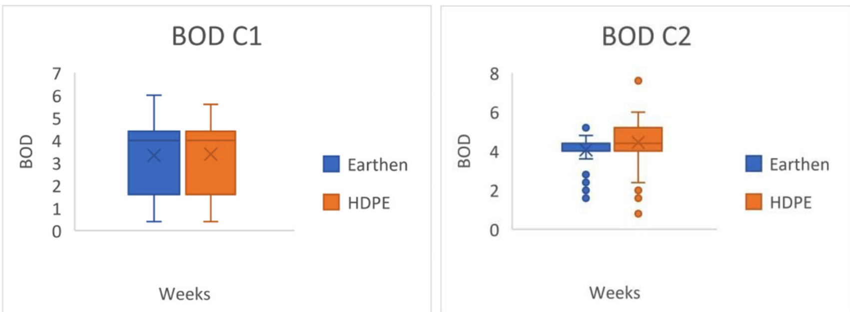

Fig. 5. Change in the biochemical oxygen demand of crop 1 and 2 from earthen and high-density polyethylene ponds.

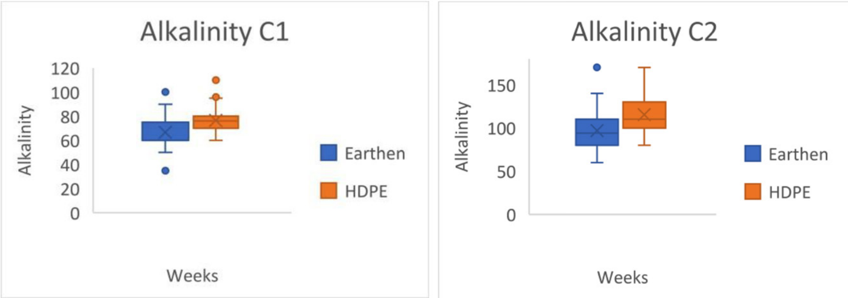

Fig. 6. Change in the alkalinity of crop 1 and 2 from earthen and high-density polyethylene ponds.

a positive correlation with primary productivity and plankton during both crops (Fig. 5).

Alkalinity

In the present study, alkalinity ranged between 35 to 100 mg L^{-1}, 60 to 110 mg L^{-1} and 60 to 170 mg L^{-1}, 80 to 170 mg L^{-1}. Low alkalinity can inhibit shrimp growth and mortality, while high alkalinity concentrations can inhibit moulting due to excessive salt loss. It also has indirect implications on the pond primary productivity (Venkateswarlu *et al.* 2019). According to Chakravarty *et al.* (2016) shrimp (*L. vannamei*) culture ponds in Narsapurapupeta, Kajuluru and Kaikavolu villages of East Godavari district, Andhra Pradesh were found total alkalinity values ranging from 120 to 500 mg L^{-1}, which exceeded the optimal range. The alkalinity ranged from 110 to 140 mg L^{-1} in the brackishwater shrimp farms of Ratnagiri is in accordance with Azhar *et al.* (2016). According to the current investigation, the mean alkalinity ranged between 66.56 and 96.82 mg L^{-1} for earthen and 76.57 and 115.50 mg L^{-1} for high-density polyethylene (HDPE) ponds, respectively. The observed data variability may be attributed to the introduction of freshwater into ponds during the monsoon season. Total alkalinity in the current study exhibited a positive correlation with plankton and primary productivity in both crops (Fig. 6).

Hardness

The level of hardness in water primarily relies on the existence of calcium and magnesiumions in the form of carbonates, bicarbonate, chloride and sulfate. In the present study, total hardness values of water ranged between 1600 to 6000 mg L^{-1}, 2000 to 5600 mg L^{-1} and 4100 to 7400 mg L^{-1}, 4400 to 7400 mg L^{-1}. Zafar *et al.* (2015) reported that the high level of hardness content in shrimp ponds was due to high salinity. In the context of semi- intensive *L. vannamie* culture ponds, Darwin *et al.* (2017) made the observation

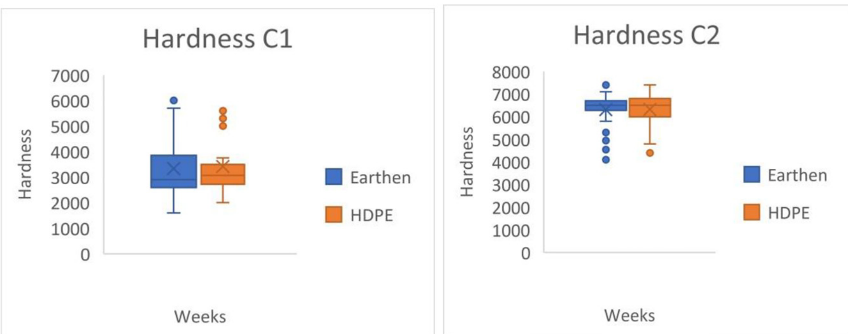

Fig. 7. Change in the hardness of crop 1 and 2 from earthen and high-density polyethylene ponds.

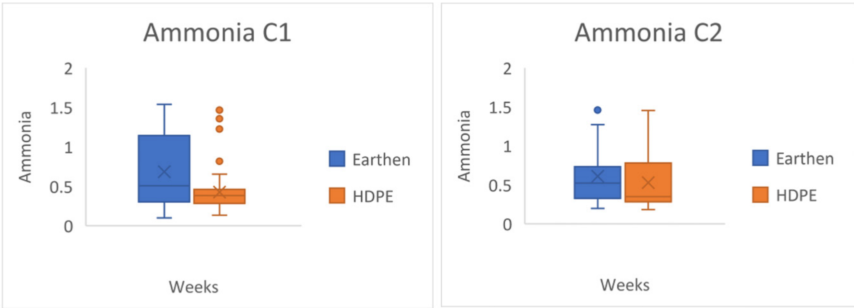

Fig. 8. Change in the ammonia of crop 1 and 2 from earthen and high-density polyethylene ponds.

that the water hardness exhibited fluctuations ranging from 2640 to 6722 mg L^{-1}. According to Bajaniya *et al.* (2019), total hardness in Gujarat ranged from 1990 to 12100 ppm and the recorded values exceeded the permitted norms. To lower hardness, Gujarat farmers applied water softeners. The investigation found that the total hardness means values for earthen and high-density polyethylene (HDPE) ponds varied from 3334.7 to 6313.0 mg L^{-1} and 3379.8 to 6320.8 mg L^{-1}, respectively. Hardness negatively correlated with plankton and primary productivity during first crop. In second crop, hardness also showed a negative correlation with Community Respiration (CR) and positive correlation with phytoplankton, zooplankton, Gross Primary Productivity (GPP) and Net Primary Productivity (NPP) (Fig. 7).

Ammonia

The growth of shrimp in shrimp culture ponds can be optimized by ensuring that the ammonia levels remain below the range of 0.05 to 0.01 ppm (Durai *et al.* 2021). In the present study, the amount of total ammonia concentration in water ranged between 0.1 to 1.5 mg L^{-1}, 0.1 - 1.4 mg L^{-1} and 1.0 to 1.5358 mg L^{-1} 0.9 - 1.4 mg L^{-1}. The balance of ionized and unionized ammonia is influenced by pH, temperature and salinity. Zeolite and soil probiotics help reduce hazardous gases. Ammonia concentration increases with culture duration, primarily due to pond bloom and organic waste decomposition. According to Chakravarty *et al.* (2016), the ammonia content in shrimp culture ponds in Andhra Pradesh was between 0.02 and 2 mg L^{-1}, which was within the range of ideal values. The ammonia levels in the earthen and high-density polyethylene (HDPE) shrimp ponds were observed to have a mean range of 0.6 to 0.7 mg L^{-1} and 0.4 to 0.5 mg L^{-1} respectively during the period of study. In order to mitigate the detrimental consequences of accumulated ammonia in ponds, water exchange is typically implemented. In present study ammonia exhibited a negative correlation with Community Respiration (CR) and positive correlation with Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Plankton during the first crop. During second crop, recorded a positive correlation with

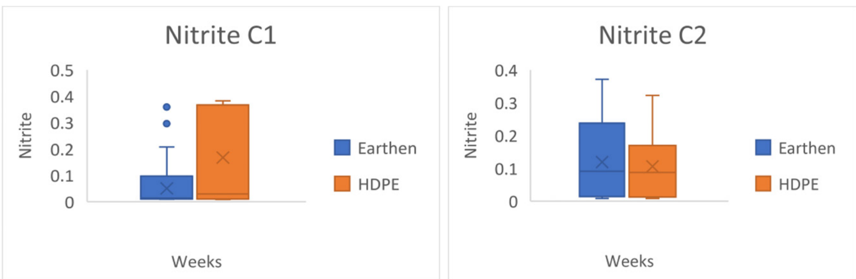

Fig. 9. Change in the nitrite of crop 1 and 2 from earthen and high-density polyethylene ponds.

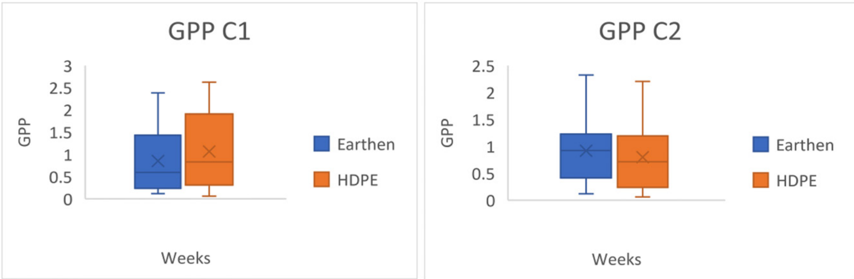

Fig. 10. Change in the gross primary productivity of crop 1 and 2 from earthen and high-density polyethylene ponds.

Primary Productivity and Plankton (Fig. 8).

Nitrite

Nitrite is typically found in intensive pond aquaculture systems as a result of the large supply of nitrogen in the form of prepared feed, fertilizer or manure. Additionally, phytoplankton die-off can cause ammonia levels to unexpectedly rise, which can cause nitrite to accumulate in water (Venkateswarlu *et al.* 2019). Chakravarty *et al.* (2016) made an observation that the concentration of nitrite in the shrimp farm located in Kajuluru village was recorded at 0.01 mg L^{-1} while in the culture ponds of Narasapurapupeta village it was measured at 0.80 mg L^{-1}. In the present study, amount of nitrite-nitrogen concentration in water ranged between 0.0085 - 0.3593 mg L^{-1}, 0.0081 - 0.3825 mg L^{-1} and 0.0076 - 0.3716 mg L^{-1}, 0.0076 - 0.3222 mg L^{-1}. The optimal concentration of nitrogen dioxide (NO_2) for the growth of white shrimp was observed to be approximately 0.01 to 0.1 parts per million (ppm) according to the study conducted by Ghufron *et al.* (2017). From the present studies it has been recorded that, mean values of nitrite concentration 0.1189 - 0.502 mg L^{-1} for earthen and 0.1056 - 0.1671 mg L^{-1} for high-density polyethylene (HDPE) ponds. According to the current study, nitrite exhibited a negative correlation with Community Respiration (CR) and positive correlation with Gross Primary Productivity (GPP), Net Primary Productivity (NPP) and Plankton during the first crop. Second crop, demonstrated a positive correlation with Primary Productivity and Plankton (Fig. 9).

Primary productivity

Gross primary productivity (GPP)

Temperature, solar radiation and nutrient availability can significantly impact primary production and seasonal variation in aquatic ecosystems. Phytoplankton primary productivity (gross primary productivity) was estimated 5.496 g C/m^2/day to 9.964 g C/m^2/day with mean value of 7.73 g C/m^2/day (Verma and Srivastava 2016). The gross primary production was ranged from 0.08 to 0.35 mg Cm^3 /hr in station I and 0.07

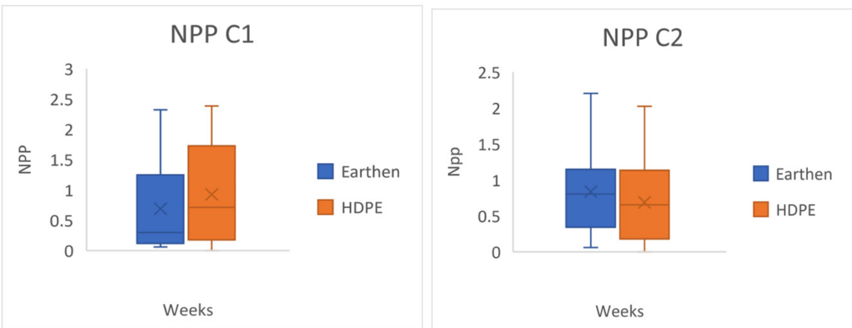

Fig. 11. Change in the net primary productivity of crop 1 and 2 from earthen and high-density polyethylene ponds.

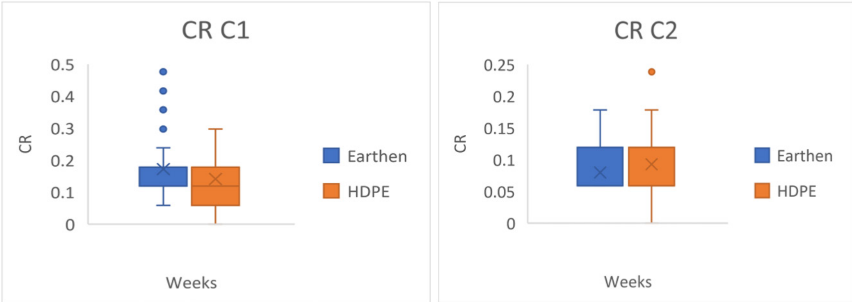

Fig. 12. Change in the community respiration of crop 1 and 2 from earthen and high-density polyethylene ponds.

to 0.34 mg Cm[3] /hr in station II (Thirunavukkarasu *et al.* 2013). The gross primary productivity (GPP) of the studied ponds was ranged from 0.119 – 2.382 mg C/L/hr, 0.059 – 2.624 mg C/L/hr and 0.119 – 2.263 mg C/L/hr, 0.059 – 2.203 mg C/L/hr. Primary productivity is higher in post-monsoon and monsoon seasons, while it decreases in summer and winter. Temperature significantly impacts productivity, with winter months experiencing lower productivity. From the present studies it has been recorded that, mean values of GPP were 0.8540 – 0.9153 mg C/L/hr for earthen and 0.7991 to 1.0677 mg C/L/hr for high-density polyethylene (HDPE) ponds. In general, seasonal fluctuation revealed that GPP was greatest during the pre - monsoon and lowest during the monsoon. Thomas and Abdul Azis (1995) found that the combination of light, temperature and phytoplankton population typically appears to be responsible for controlling the seasonal fluctuation in primary production. GPP showed the positive correlation with temperature, dissolved oxygen, alkalinity, biological oxygen demand, ammonia, nitrite and a negative correlation with pH, salinity and hardness during first crop. Similarly, second crop, GPP reported a positive correlation with temperature, alkalinity, hardness, biological oxygen demand, ammonia, nitrite and negative correlation with pH, salinity and dissolved oxygen (Fig. 10).

Net primary productivity (NPP)

Shivganga Ponds Net Primary Productivity (NPP) with its monthly variation, which ranged between 0.015 and 0.4425 mg C/l/hr (Patralekh and Patar 2016). Net primary production was ranged from 0.23 to 1.89 mg Cm[3] /hr in station I and 0.32 to 1.73 mg Cm[3] /hr in station II (Thirunavukkarasu *et al.* 2013). The net primary productivity (NPP) of the studied ponds was ranged from 0.059 – 2.322 mg C/L/hr, 0 – 2.382 mg C/L/hr and 0.059 – 2.203 mg C/L/hr, 0 – 2.024 mg C/L/hr. Winter and rainy seasons show decreased NPP levels due to increased turbidity and light penetration, while summer allows more light penetration and faster photosynthesis, leading to higher productivity. From the present studies it has

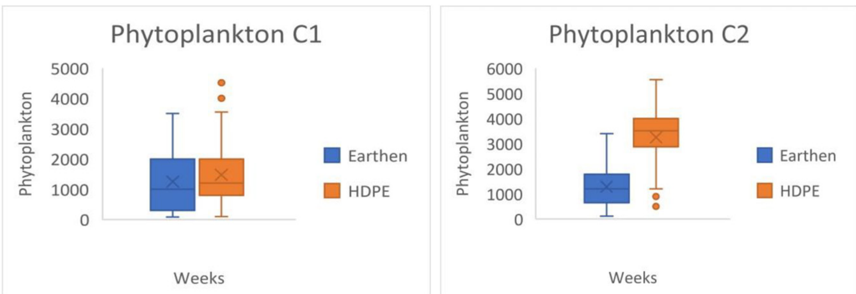

Fig. 13. Change in the phytoplankton of crop 1 and 2 from earthen and high-density polyethylene ponds.

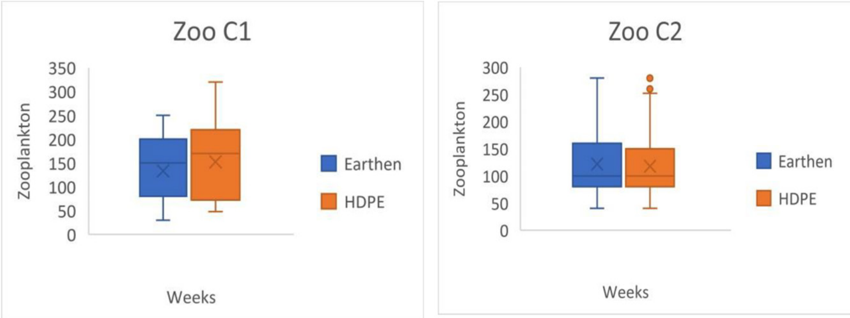

Fig. 14. Change in the zooplankton of crop 1 and 2 from earthen and high-density polyethylene ponds.

been recorded that, mean values of NPP were 0.6896 to 0.8353 mg C/L/hr and 0.6855 to 0.9254 mg C/L/hr for earthen and high-density polyethylene (HDPE) ponds, respectively and usually showed an increasing trend. NPP showed a positive correlation with temperature, dissolved oxygen, alkalinity, biological oxygen demand, ammonia, nitrite and negative correlation with pH, salinity and hardness during first crop. Similarly, during the second crop, NPP had a positive correlation with temperature, alkalinity, hardness, biological oxygen demand, ammonia, nitrite and negative correlation with pH, salinity and dissolved oxygen (Fig. 11).

Community respiration (CR)

The community respiration (CR) of the studied ponds was ranged from 0.059 - 0.476 mg C/L/hr, 0 - 0.297 mg C/L/hr and 0.059 - 0.178 mg C/L/hr, 0 - 0.238 mg C/L/hr. In October and November, community respiration maximum at 0.36 mg C/L/hr, while in the monsoon, it was at its lowest (Rathod and Chavan 2016). Similarly, CR ranged from 0.12±0.003 g Cm^{-3} h^{-1} to 0.20±0.05 g Cm^{-3} h^{-1} and exposed rising trend from the month of January to May (Flura *et al.* 2023). Monthly, variation in the amount of community respiration which fluctuated in between 0.0125 to 0.0937 mg C/m^2/day, in Shivganga pond (Patralekh and Patar 2016). The values of community respiration ranged from 0.023 to 0.025 g C/m^3/hr (Vasanthkumar and Vijaykumar 2011). In the present study, mean total CR values of water ranged between 0.0798 to 0.1724 mg C/L/hr and 0.0929 to 0.1411 mg C/L/hr for earthen and high-density polyethylene (HDPE) ponds, respectively during the cultivation period. Its higher amount might be due to greater biotic composition. CR showed a positive correlation with temperature, dissolved oxygen, alkalinity, biological oxygen demand and negative correlation with pH, salinity, hardness, ammonia and nitrite during the first crop. Similarly, during second crop, CR had a positive correlation with temperature, dissolved oxygen, alkalinity, biological oxygen demand, ammonia, nitrite and negative correlation with pH, salinity and hardness (Fig. 12).

Plankton

The primary donor of the nutritional supplement for the growth of aquatic larvae is considered to be periphytic cyanobacteria and diatoms (Khatoon *et al.* 2010). In the present study, phytoplankton density was observed in range from 80 to 3,500 Nos. L^{-1}, 100 to 4520 Nos. L^{-1} and 112 to 3400 Nos. L^{-1}, 500 to 5550 Nos. L^{-1} respectively. Similar results have been also observed from tiger shrimp culture ponds where quantitative status of phytoplankton recorded was in the range 418 Nos. L^{-1} to 460 Nos. L^{-1} (Ara *et al.* 2018). The groups Bacillariophyceae, Dinophyceae, Cyanophyceae and Chlorophyceae were followed by 27 species of phytoplankton from 15 separate shrimp production ponds throughout the Tamil Nadu and Puducherry coasts, according to Kumar *et al.* (2020). The Bacillariophyta class includes a number of species that were discovered during the culture period, including *Actinoptychus* sp., *Bacillaria* sp., *Biddulphia* sp., *Coscinodiscus* sp., *Navicula* sp., *Nitzchia* sp., *Pseudonitzchia* sp., *Thalassiosira* sp., *Pinnularia* sp., *Pleurosigma* sp. Species from the Cyanophyceae class *Oscillatoria* sp. and *Nostoc* sp., as well as species from the class Dinophyceae including *Gymnodinium* sp., *Peridinium* sp., *Prorocentrum* sp. In present study, zooplankton density observed was in the range from 30 to 250 Nos. L^{-1}, 48 to 320 Nos. L^{-1} and 40 to 300 Nos. L^{-1}, 40 to 280 L^{-1} for earthen and high-density polyethylene (HDPE) ponds, respectively. Protozoans, copepods (copepodities and nauplii) and rotifers made up the majority of the zooplankton species was observed. Protozoans were dominated by *Tintinnopsis* sp., *Favella* sp. and *Vorticella* sp. *Branchionus* sp., *Keratella* sp., *Lecane* sp. dominated the rotifer community, whereas *Acartia* sp., *Calanus* sp., *Cyclops* sp., and *Microsetella* sp. dominated the copepod community, Similarly, 12 species of zooplankton were reported from *L. vannamei* cultured ponds of Kancheepuram district of Tamilnadu, India. According to Dhanasekaran *et al.* (2017) 29 zooplankton species were found in the Hale Dharmapuri or Ramakkal lake in Tamilnadu. Rotifer, Cladocerans, Copepods and Ostracods made up the majority of the zooplankton species. Similar findings were also reported by Ara *et al.* (2018) found that copepods, rotifers, sergestidae, gastropod larvae, bivalve larvae, pelagic polychaetes, nematodes, crustacean nauplii, insects and mysidacea were the main categories of zooplankton seen in tiger shrimp cultivation ponds. Phytoplankton and zooplankton showed positive correlations during the first and second crops, with temperature, dissolved oxygen, alkalinity, hardness, biological oxygen demand, ammonia, nitrite and negative correlations for pH, salinity and hardness (Figs. 13–14).

CONCLUSION

The research included information on hydrobiological assessments and management role of shrimp farmers located in Ratnagiri, Maharashtra. The results of this investigation indicated that most hydrobiological parameters were within the optimal recommended ranges found in the published literature. It was observed that the shrimp growth and survival rates appeared to benefit for the high-density polyethylene (HDPE) ponds, which leads to increased production efficiency over traditional earthen ponds. The experimental observations recorded during the specified period can be utilized as reference by other enterpreneurs from the Konkan region of Maharashtra, as our findings provide them with the necessary information and knowledge to implement effective management practices for shrimp culture in the future.

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