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Water and soil studies in Shrimp aquaculture systems

Praveen Joshi H S ✉

Department of Aquatic Environment Management, Karnataka Veterinary, Animal and Fisheries Sciences University, College of Fisheries, Mangaluru, Karnataka, India

Ramachadra Naik A T

Department of Aquatic Environment Management, Karnataka Veterinary, Animal and Fisheries Sciences University, College of Fisheries, Mangaluru, Karnataka, India.

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ABSTRACT

***Litopeneaus vannamei* is the most preferable species for culture by shrimp producers due to short time crop, hardy species and high market value. Present investigation was carried out to comprehend the significance of the carbon and nitrogen ratio in shrimp farming systems at Ankola, Uttara Kannada (District) and Haleyangadi, Mangaluru (Taluk) and Dakshina kannada (District). The pond water characteristics namely temperature, pH, alkalinity, salinity, Dissolved oxygen, biological oxygen demand, total suspended solids, total dissolved solids, Ammonia, NO_2, NO_3, PO_4, SiO_3 were found to vary from 28 to 35°C, 6.9 to 9.4, 25 to 125 mg/l, 0 to 36 ppt, 0 to 4.20mg/l, 0.020 to 0.259mg/l, 1.63 to 81.24mg/l, 0.12 to 36.45µg at./l as micro-mole per litre, 0.09 to 11.12 µg at./l, 0.26 to 32.15µg at./1, 0.15 to 26.18µg at./l, 2.40 to 90.18µg at./l respectively. The pond soil characteristics comprising of pH, organic carbon were ranged from 6.5 to 8.6, 0.235 to 1.994%, respectively while texture comprising of sand content varied from 48.41 to 96.26%, clay 0.3 to 2.45% and silt 3.14 to 51.24%. C/N ratio is varied 1.084-11.450 during the research phase. The outcomes of the water quality parameters shown quite higher nutrient all selected ponds and Organic carbon showed high in all ponds along with day of culture that's impact data on water quality and influence on pond biomass and the C/N ratio. A culture system's ability to produce more can be greatly increased by maintaining the quality of the soil and water by removing toxicity though nitrification and continuous monitoring.**

Introduction

Shrimp aquaculture has increased recently in Southeast Asia has after decade fast expansion and also due to COVID-19 aqua farmers faced plenty of problems *viz* Seed and Feed purchase, marketing, labours etc. Particularly in aquaculture continues monitoring is very essential during the culture period. The primary principle of carbon and nitrogen is to reduce water exchange and promote heterotrophic organisms by utilising waste nitrogen that is assimilated within the pond or tank. Carbon and Nitrogen (C/N) ratio regularly fallowed in biofloc aquaculture system by addition of organic carbon as a source to the animal tank which is utilize by the inorganic nitrogen to aggregate the microorganisms. To maximise the growth of heterotrophic bacteria, the feed must have an ideal carbon to nitrogen ratio. A method of regulating the nitrogen content in water is the carbon to nitrogen ratio (CN Ratio). The most common CN ratios are 10:1 and 15:1, which indicates that for a CN Ratio of 10:1, 10 Carbon Sources are required to neutralise 1 Nitrogen. In aquaculture, total ammonia nitrogen and the protein percentage of feed are used to compute the CN Ratio. If the ratio of carbon to nitrogen in the solution is optimal, bacterial biomass will also be produced from organic nitrogenous waste and ammonium (Schneider *et al.,* 2005). Waste produced during culture, primarily faeces and leftover feed, causes harmful metabolites like ammonium and nitrite to build up and ruin the shrimp's habitat in intense aquaculture systems (Avnimelech and Ritvo, 2003;

Corresponding author E-mail: *hspraveenjoshi123@gmail.com*
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Piedrahita, 2003). In aquaculture ponds with increased stocking rates, water quality management is of utmost importance. Growth and survival are hampered by poor water quality. According to standard definitions, good quality water is appropriate or suitable for shrimp survival and growth. According to Avnimelech (1999) the pond's heterotrophic bacterial growth is boosted by the addition of carbohydrates, and nitrogen uptake occurs as a result of the creation of microbial proteins. Muthusamy (2016) reported reduced total nitrogen-ammonia ratio while preserving high water quality for shrimp farming in biofloc systems. In ponds with or without a carbohydrate-based diet for the shrimp, meticulous control was used to monitor the water purity and productivity (Hari *et al.* 2006). pH, salinity, carbonates, bicarbonates, total alkalinity, calcium, magnesium, total hardness, total ammonia, and nitrite are just a few of the factors that were examined, reported by Jaganmohan and Kumar (2017) to be kept at ideal levels that are suitable for *L. vannamei* farming. Islam *et al*. (2004) found that the salinity varied from 2.5 to 20.0 ppt in the southeast compared to 3.0 to 15.0 ppt in the southwest, and that the total ammonia-nitrogen was higher than the threshold recommended for shrimp cultivation in Bangladesh.

Material and Methods

Area of study: The current study was completed at Fisheries Research and Information Centre (Marine), which is situated in 14°65'96.5"N 74°28'22.1"E Ankola in Uttara kannada district (Earthen ponds) and Haleangadi or Haleyangady which is situated in 13°03'48.8"N 74°47'22.3"E Dakshina Kannada district of Karnataka's Mangalore taluk (Plastic lined and Biofloc ponds).

Altogether, three experiments were conducted triplicate. The first experiment was conducted in earthen ponds located Ankola, Uttara Kannada–dist. A total of three ponds were selected for the study *viz,* first and second ponds were from private farmers (ponds locations: 14°64'096.1"N 74°29'633.3"E) while the third pond selected was located at Fisheries Research and Information Centre (Marine), Bela, Ankola (pond location: 14°65'96.5"N 74°28'22.1"E). The second and third experiments were initiated at Haleyangady near Mangaluru taluk of Dakshina Kannada dist. (ponds locations: 13°03'48.8"N74°47'22.3"E).

Experiment 1: In the first experiment, three earthen shrimp aquaculture ponds were selected. All these were named as earthen pond 1 and designated as EP1, earthen pond 2 as EP2 and earthen pond 3 as EP3. In addition to these ponds, a water inlet channel was also selected and named as earthen pond channel and designated as EPC.

Experiment 2: In the second experiment, three plastic lined shrimp aquaculture ponds were selected. All these were named as plastic lined pond 1 and designated as PP1, plastic lined pond 2 as PP2 and plastic lined pond 3 as PP3. Addition to these ponds, a water inlet channel was also selected and named as plastic-lined pond channel and designated as PLC.

Experiment 3: In the third experiment, three biofloc shrimp aquaculture ponds were selected. All these were named as biofloc pond 1 and designated as BP1, biofloc pond 2 as BP2 and biofloc pond 3 as BP3. Addition to these ponds, a water inlet channel was also selected and named as biofloc pond channel and designated as BFC.

The geographical locations and map of the selected ponds for sampling are shown in Plate 1 and 2.

Carbon and Nitrogen ratio (C/N Ratio): Method was carried according to the procedure described by Nasrin islaam *et al.* (2016). Walkley and Black (1934) method was employed to ascertain soil organic carbon. Various physico-chemical characteristics of soil and water will be determined as per the standard procedure (APHA, 2005).

Results and Discussion

Present investigation, Water's physicochemical characteristics, soil and carbon and nitrogen ratio (C/N ratio) were recorded from different shrimp culture ponds. The detailed results on various parameters are outlined in table 1 to 7 and graphically predicted in figure 1 to 3.

Physico-chemical characteristics of selected shrimp pond water

In shrimp ponds, temperature is the most critical component that determines water quality and aquatic organism metabolic activity. The water temperature of the selected ponds was recorded ranged between 28 ºC and 35 ºC maximum water temperature recorded in the month of April 60^{th} day of culture in earthen ponds. The high temperature will cause the high organic load formation and

Plate 1: Google map showing earthen ponds, Ankola, Uttara Kannada

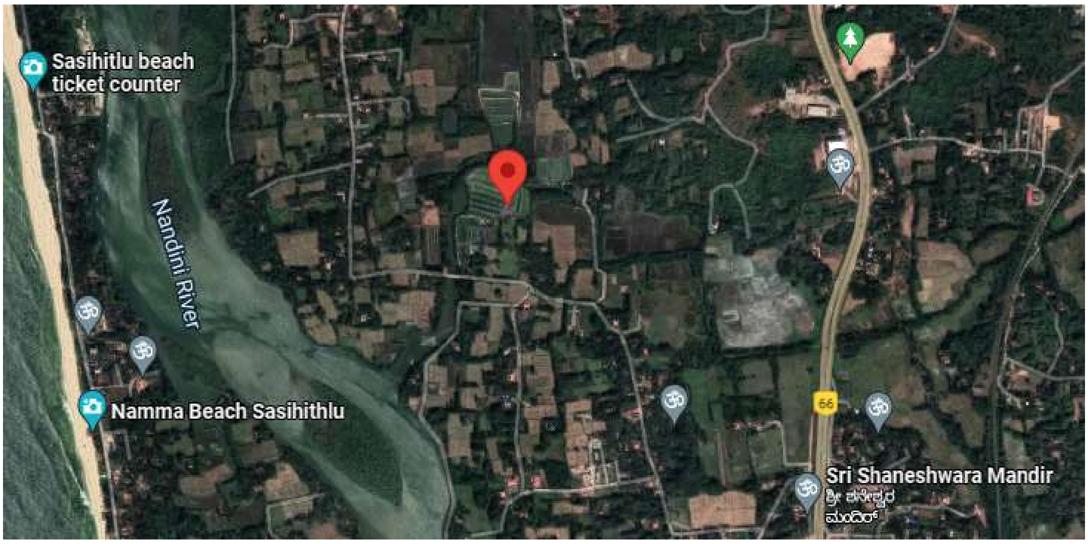

Plate 2: Google map showing plastic lined and biofloc ponds, Haleyangadi, Mnagaluru, Dakshina Kannada

Plate 3: Photographs showing collection of samples from cultured ponds

increase the bacterial loads in the culture ponds; Air temperature had the direct influence on the variation of water temperature. Alakinity plays very important role in aquatic environment because of its significance in the moulting process of shrimp, , alkalinity is very important in shrimp culture ponds. Low alkalinity causes wide pH changes in shrimp, resulting in stunted growth and even death. Due to excessive salt loss, high alkalinity levels may halt the moulting process in shrimp. In the present study minimum alkalinity recorded 25ppm in the month of June on 105th day of sampling in earthen ponds and maximum 125ppm recorded in the month of January on 60th day of sampling in biofloc ponds. Salinity recorded was ranged between 0-35ppt the salinities observed in the current investigation were suitable for *L. Vannamei*. However, it appears that the salinities exceeding 2 ppt were used for the majority of effective shrimp production (Roy *et al.,* 2010). Araneda *et al*. (2008) stated *L. vannamei*, a species used in cultivation, can withstand salinities of 0.5 to 45 ppt.

Table 1: Physico-chemical characteristics of water in earthen and plastic-lined shrimp ponds during the study period

Aquaculture systems	Earthen ponds				Plastic-lined ponds			
Ponds / Parameter	EP1	EP2	EP3	EPC	PP1	PP2	PP3	PLC
Temperature (°C)	31.0-33.0	30.5-32.5	28.5-35.0	29.0-35.0	28.5-33.0	28.5-32.5	29.0-33.0	28.0-30.5
pH	8.5-9.4	8.5-9.0	7.8-8.3	7.1-8.5	7.1-8.2	7.2-8.2	7.1-8.2	7.5-7.7
Alkalinity (mg/l)	85-118	82-123	76-116	25-118	84-112	82-105	80-109	77-121
Salinity (ppt)	23-26	22-28	15-36	0-35	16-28	15-27	18-26	12-25
DO (mg/l)	7.0-9.1	7.3-9.2	6.1-9.3	7.8-8.1	6.5-8.2	6.9-8.2	7.1-8.2	6.1-7.5
BOD (mg/l)	0-1.6	0-1.4	0.4-2.2	0-3.2	0.5-3.2	0.6-3.1	0.4-3.2	0.2-2.1
TSS (mg/l)	0.04-0.18	0.03-0.12	0.03-0.2	0.02-0.18	0.04-0.07	0.04-0.08	0.04-0.08	0.04-0.09
TDS (mg/l)	34.7-56.2	35.4-51.4	19.8-67.2	1.63-62.7	20.1-59.6	21.3-58.3	21.9-59.6	25.1-61.4
NH_3 (µg at./l)	3.2-27.40	4.2-27.50	0.12-5.74	0.50-4.98	5.3-12.41	5.1-13.41	4.9-13.11	1.1-5.64
NO_2 (µg at./l)	0.31-10.7	0.21-11.5	0.11-1.87	0.16-1.52	0.5-8.2	0.31-5.3	0.41-6.8	0.32-1.8
NO_3 (µg at./l)	1.59-24.8	2.13-22.8	0.53-3.71	0.26-4.24	0.9-22.13	0.57-23.5	0.91-24.1	0.47-8.51
PO_4 (µg at./l)	0.78-19.8	0.67-20.0	0.15-7.30	0.15-11.3	1.2-22.1	1.3-23.54	3.1-22.41	0.54-6.91
SiO_3 (µg at./l)	7.23-87.7	6.98-88.2	6.41-76.23	2.4-56.27	5.6-72.51	5.84-74.6	6.41-74.2	3.12-68.6

Table 2: Physico-chemical characteristics of water in biofloc shrimp ponds during the study period

Aquaculture system	Biofloc ponds			
Ponds / Parameter	BP1	BP2	BP3	BFC
Temperature (°C)	28.0-32.0	28.0-32.5	28.0-33.0	28.0-31.5
pH	6.9-8.3	7.1-8.3	7.2-8.4	7.1-7.7
Alkalinity (mg/l)	81-124	80-123	84-125	79-110
Salinity (ppt)	18-28	19-27	18-26	12-25
DO (mg/l)	7.1-9.4	7.8-9.5	7.6-9.2	7.2-7.9
BOD (mg/l)	0.5-4.2	0.4-3.9	0.9-3.6	0.4-1.8
TSS (mg/l)	0.04-0.24	0.04-0.21	0.04-0.25	0.04-0.10
TDS (mg/l)	26.4-81.2	27.8-77.4	23.9-80.0	22.3-55.1
NH_3 (µg at./l)	6.21-30.5	6.51-32.5	7.1-36.45	4.10-6.20
NO_2 (µg at./l)	0.51-11.1	0.54-9.44	0.61-8.12	0.47-2.56
NO_3 (µg at./l)	0.91-32.1	0.84-30.0	0.65-31.2	0.51-7.12
PO_4 (µg at./l)	0.94-24.1	0.94-25.9	1.11-26.1	0.54-26.0
SiO_3 (µg at./l)	8.22-90.1	8.11-88.2	9.65-90.3	3.21-92.7

µg at./l = Micro-mole per liter, mg/l = Milligram per litre, ppt = Parts per thousand

Table 3: Soil characteristics in earthen and plastic-lined shrimp ponds

Aquaculture systems	Earthen ponds				Plastic-lined ponds			
Ponds / Parameter	EP1	EP2	EP3	EPC	PP1	PP2	PP3	PLC
Soil pH	7.1-8.3	7.2-8.1	8.0-8.5	7.7-8.3	7.2-8.3	6.9-8.5	6.5-8.1	6.6-7.8
Organic carbon (%)	0.41-1.23	0.32-1.39	0.11-0.63	0.18-0.71	0.30-1.20	0.25-1.29	0.23-1.22	0.28-0.65
Avl. Nitrogen (mg/100gm)	2.05-3.15	2.10-3.25	2.01-3.02	2.0-2.62	1.17-3.25	2.21-3.90	2.20-3.51	1.05-2.19
Avl. Phosphorous (mg/100gm)	0.33-1.05	0.29-0.58	0.28-1.02	0.22-0.42	0.54-1.27	0.45-1.14	0.37-1.05	0.27-0.36

In the present study the dissolved oxygen values recorded ranged from 4.80 to 9.50 mg/l. The minimum concentration was recorded in the month of March in EPC on 30th and in EP3 in the month of April on 60th day of sampling while maximum was reported in the month of January at BP2 on 60th day of sampling. Duru *et al.* (2018) stated that the increase in temperature decreases the solubility of oxygen, while at lower temperature dissolved oxygen increases. The optimal range of dissolved oxygen for shrimp was found in prior research to be >4 ppm, which is remarkably comparable to the results of the current study (Lazur, 2007). The BOD concentration ranged from 0 to 4.2 mg/l. The minimum concentration was recorded in the month of March and April in EP1 and EP2 on 30th, 45th and 60th day of sampling while maximum was reported in the month of of April in EP3 on 60th and in the month of January in BP1 on 60th day of sampling. Maximum value of BOD level could be due to accumulation of uneaten feed settlement in pond bottom and increased excretion rate. Priyadarsani and Abraham (2016) recorded 6.45 mg/L in brackish water shrimp pond. The Ammonia level was ranged from 0.12 to 36.45 µg at/l. The minimum concentration was reported in the month of March in EP3 on 30th day while maximum was reported in the month of January BP3 during 60th day of sampling. Ammonia was recorded lowest value of that could be due to less organic load during the initial days of culture; maximum NH_3 was recorded might be due to increased metabolic rate in shrimp results in increased excretion. Krishnani *et al.* (2011) reported about Kerala's huge shrimp growing system has substantially higher levels of ammonia-N (0.27–0.35 ppm) occurred. According to Bhatnagar and Pooja (2019) ammonia levels greater than 0.1 mg/l, are likely to result in gill damage, the destruction of mucous-producing membranes, "sub-lethal" effects such as stunted growth, poor feed conversion, and decreased disease resistance at levels below lethal concentrations, as well as osmoregulatory imbalance and kidney failure. Ammonia poisoning usually makes fish or shrimp appear sluggish or frequently surface gasping for air. Nitrite-nitrogen content was ranged between 0.11 and 11.56 µg at./l as micro-mole per liter. The minimum concentration value was observed in the month of March in EP3 on 0th day of sampling while maximum was observed in the month of April in EP2 on 60th day of sampling. Nitrite is a by-product of the autotrophic Nitrosomonas bacteria's aerobic nitrification bacterial activity, which occurs when oxygen and ammonia are mixed. In shrimp (*Litopenaeus vannamei*) culture ponds at Narsapurapupeta, Kajuluru, and Kaikavolu villages of East Godavari district, Andhra Pradesh, Chakravarty *et al*. (2016) detected 0.01 to 0.80 mg/l. According to Maia *et al*. (2011), the top limits for marine shrimp culture systems should be below 0.2 mg/l and 0.3 mg/l, respectively. The Nitrate-nitrogen content was ranged between 0.26 and 32.15 µg at./l as micro-mole per liter. The minimum concentration value was observed in the month of March in EPC on 0th day while maximum was observed in the month of February in BP1 on 90th day of sampling. The autotrophic Nitrobacter bacteria combines oxygen and nitrite to generate nitrate, which is innocuous to fish where ammonia and nitrite were poisonous. According to Bhatnagar and Pooja (2019) Nitrate concentrations typically stabilise between 50 and 100 ppm. Meck (1996) said that its concentrations between 0 and 200 ppm are tolerable in a fish pond and that it is generally low harmful for some species, while particularly marine species are sensitive to its presence. In fish or shrimp culture water, Santhosh and Singh (2007) described the ideal range as being between 0.1 mg/l to 4.0 mg/l.

Table 4: Soil characteristics in biofloc shrimp ponds during the study period

Aquaculture system	Biofloc ponds			
Parameter \ Ponds	BP1	BP2	BP3	BFC
Soil pH	6.5-8.3	6.6-8.2	6.7-8.4	7.1-8.0
Organic carbon (%)	0.465-1.325	0.411-1.994	0.505-1.314	0.325-0.504
Avl. Nitrogen (mg/100gm)	1.54-4.12	1.98-4.05	1.25-3.75	1.01-2.10
Avl. Phosphorous (mg/100gm)	0.41-1.35	0.48-1.46	0.43-1.21	0.21-0.41

Table 5: Variation of carbon and nitrogen ratio in different earthen ponds during the study period

Pond \ Sampling day	Month								
	March 2021		April 2021		May 2021		June 2021		
	0	15	30	45	60	75	90	105	120
EP1	2.050	4.506	5.696	3.925	4.090	5.854	5.096	-	-
EP2	3.291	3.178	4.269	3.843	6.886	6.983	7.866	-	-
EP3	1.138	1.084	1.607	3.033	4.371	4.421	5.545	2.187	3.733
EPC	3.308	3.233	3.745	2.862	2.569	3.744	1.744	1.606	1.336

Table 6: Variation of carbon and nitrogen ratio in different plastic lined ponds during the study period

Pond \ Sampling day	Month						
	November 2021		December 2021		January 2022		February 2022
	0	15	30	45	60	75	90
PP1	2.014	3.625	5.479	4.897	4.117	5.845	6.264
PP2	2.015	3.167	4.156	4.289	5.986	7.097	7.447
PP3	2.138	2.654	2.611	3.014	3.587	3.901	4.524
PLC	1.314	2.417	3.001	2.964	2.667	2.805	3.214

Table 7: Variation of carbon and nitrogen ratio at different biofloc ponds during the study period

Pond \ Sampling day	Month						
	November 2021		December 2021		January 2022		February 2022
	0	15	30	45	60	75	90
BP1	5.535	7.271	10.428	9.518	11.450	10.192	10.550
BP2	5.074	5.924	10.721	10.107	10.925	7.617	9.495
BP3	5.260	7.358	12.752	10.950	11.020	9.850	10.755
BFC	3.316	3.484	4.181	3.868	4.463	5.538	3.436

The Phosphate-phosphorous content was ranged between 0.15 and 26.18 µg at./l as micro-mole per liter. The minimum concentration value was observed in the month of March in EP3 and EPC on 0th day of sampling while maximum was observed in the month of January in BP3 on 60th day of sampling. A macro-mineral called phosphorus is a crucial component for shrimp. Phosphorus, along with calcium, is a key element in the exoskeleton. It performs useful functions in numerous metabolic processes. As a crucial part of phospholipids (such as lecithin and cephalin), nucleic acids, phosphor proteins, high-energy substances (such as adenosine triphosphate), several metabolic intermediates, and co-enzymes. To keep the pH of intracellular and extracellular fluids at a normal level, inorganic phosphates are also crucial buffers. Therefore, it is doubtful that considerable amounts of phosphorus will be absorbed via water, making a nutritional supply crucial for the majority of aquatic organisms (Akiyama *et al*, 1992). For fish culture, a phosphate content of 0.06 mg/l is preferred, according to Stone and Thomforde (2004). Bhatnagar *et al*. (2004), 0.05-0.07 ppm is ideal and productive, while 1.0 ppm is beneficial for plankton and shrimp production. The Silicate content was ranged between 2.4 and 90.18 µg at./l. The minimum silicate value was observed in the month of March in EPC on 0^{th} day of sampling while maximum was observed in the month of January in BP1 on 60^{th} day of sampling. Ryther and Officer (1981) proposed that silica depletion and the eradication of diatoms from phytoplankton populations could result from the eutrophication of coastal waters by residential wastes that are relatively low in silica. Marine diatoms frequently develop faster and can out compete other algae species when silica levels are sufficient. In the experimental shrimp ponds, Natarajan and Deivasigamani (2017) found that the silicate concentration ranged from 0.0058 to 0.0131 ppm. Boyd (2003) recommended silicate concentrations greater than 1 mg/l. A high concentration of silicate is harmful to adjacent receiving environments, as it causes changes to the phytoplankton community.

Soil characteristics of selected shrimp farms

In the current study, earthen ponds soil pH content was ranged between 7.1 and 8.5, Plastic-lined ponds with 6.6 and 8.5 and biofloc ponds with 6.5 and 8.4. Chakravarty *et al*. (2016) reported the soil pH of 6.5 to 7.5 in Shrimp culture ponds in the Andhra Pradesh villages of East Godavari, Kogodu, and Atchutapuratrayam. Rahman *et al*. (2017) observed 7.7 to 7.8 in semi-intensive culture system of shrimp farms of Bangladesh. Boyd (2000) reported soil pH in shrimp ponds in the range from 6.5 to 7.5 and stated that in waterlogged soils, pH typically decreases as the redox potential increases result, the microbial activity in the absence of molecular oxygen. In the present experiment the earthen ponds soil organic carbon content was recorded between 0.112 and 1.391%, plastic-lined ponds with 0.235 and 1.291% and biofloc ponds with 0.325 and 1.994%. Vinothkumar *et al*. (2018) reported organic carbon content of 0.41 to 0.74%. Kunlapapuk *et al*. (2021) reported 1.87 to 3.06% of organic carbon, they believed that the carbon burial rate of sediment in the ponds was correlated with pond age, sediment depth, dry bulk density of sediment, and the amount of organic carbon in the Pacific white shrimp (*L. vannamei*) ponds in the Phetchaburi Province of the upper Gulf of Thailand. Nitrite concentrations in shrimp ponds are rarely high enough to kill the shrimp, although concentrations above 4 or 5 mg/l may have a negative impact on growth (Boyd and Fast, 1992). Earthen ponds soil available nitrogen content in the present study was recorded between 2.0 and 3.25 mg/100g, plastic-lined ponds with 1.05 and 3.90 mg/100g and biofloc ponds with 1.01 and 4.12 mg/100g. High range of available nitrogen content in soil was 18.2 to 20.00 mg/100g in shrimp ponds compared to the present study was observed. Vinothkumar *et al*. (2018) stated that In order to produce aquatic biomass, nitrogen must be present at an optimal level, which is highly desirable. In the present research, earthen pond soil available phosphorus content was recorded between 0.22 and 1.05 mg/100g, plastic-lined ponds with 0.27 and 1.27 mg/100g and biofloc pond with 0.21 and 1.46 mg/100g. According to Muhammad (2014), brackishwater ponds in Takalar Regency coastal areas had phosphorus contents that were relatively high. For shrimp farming, phosphorus levels should be between 30 and 60 mg/l. Phosphorus availability in brackishwater ponds is advised to be more than 60 mg/l and is regarded as modest or suitable and limiting factors when it meets these conditions. Rahman (2017) reported 13.41 to 17.28 µg/l in shrimp ponds, Bangladesh. Vasin (2011) observed 41.1 mg/kg available phosphorous in commercial shrimp farms, Chantaburi Province, Thailand. Even with strong phosphate fertilization, it can be challenging to start plankton blooms in semi-intensive shrimp ponds with heavy clay soils because high clay content in soil is related with a high phosphorus fixation capacity (Boyd and Munsiri, 1996). *Penaeid* shrimp have been reported to thrive and survive better on sandy surfaces (Bray and Lawrence 1993).

Carbon and Nitrogen ratio

Since many years ago, conventional agriculture has evaluated soil organic matter state and the value of livestock manure and other organic matter sources as soil amendments and fertilisers using the carbon to nitrogen (C/N) ratio. Indicators of pond bottom soil fertility and the quality of organic fertilisers used in aquaculture include the C/N ratio. The C/N ratio has served as a foundation for better biofloc production in aquaculture systems. To maximise the growth of heterotrophic bacteria, the feed must have an ideal carbon to nitrogen ratio. Controlling the amount of nitrogen in water is done by adjusting the C/N ratio. The most common C/N ratios are 10:1 and/or 15:1, which implies that 10 carbon sources must kill 1 nitrogen in order for a C/N ratio of 10:1 to exist. The C/N ratio in aquaculture is computed using the total ammonia nitrogen content of the feed and the feed's protein content. The carbon and nitrogen content was recorded in different shrimp ponds during the study period is given in Table 5, 6 and 7. Graphically depicted in Figure 1, 2 and 3.

The control of inorganic nitrogen accumulation in a biofloc system is dependent on carbon metabolism and nitrogen-immobilizing microbial activities (Avnimelech, 1999). While bacteria use inorganic nitrogen as nourishment to produce new cells

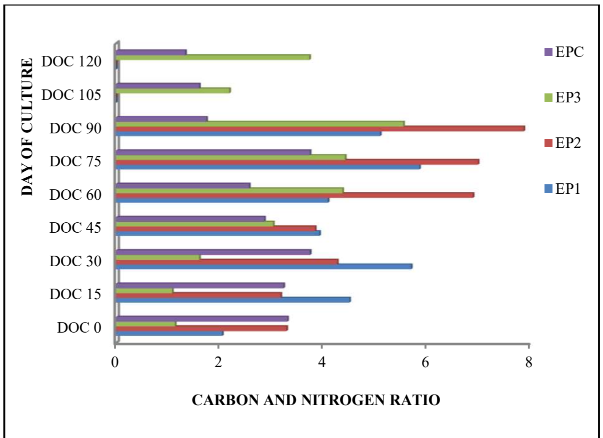

Figure 1: Variation of C/N Ratio in different earthen ponds during the study period

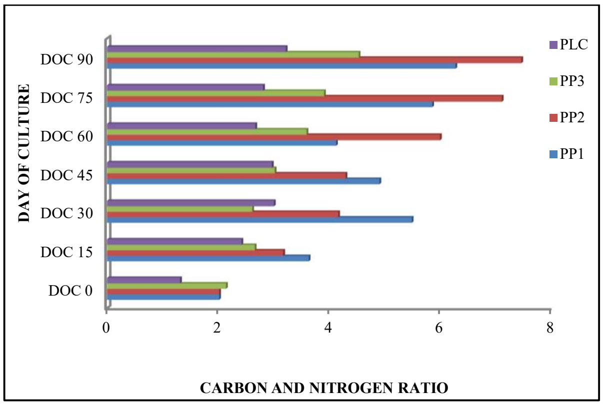

Figure 2: Variation of C/N Ratio in different plastic-lined ponds during the study period

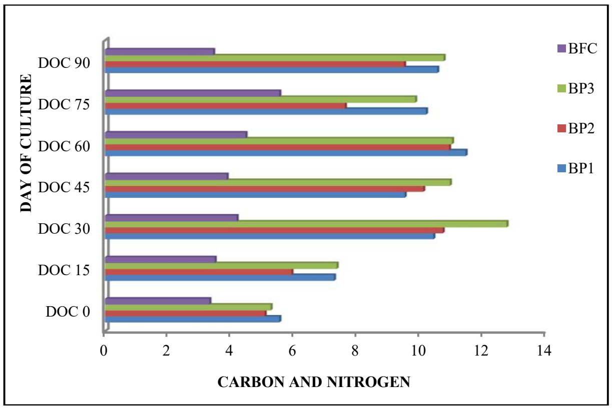

Figure 3: Variation of C/N Ratio in different biofloc ponds during the study period

throughout this process, carbon is required (Deng *et al.,* 2018; Hargreaves, 2006). The C/N ratio was recorded in earthen pond between 1.084 and 7.866 during the study. The least value was recorded in the month of March in EPC on 15th day of sampling while maximum was observed in the month of May in EP2 on 90th day of sampling. The C/N ratio was recorded in plastic-lined pond between 1.314 and 7.447 during the study dated. The minimum C/N ratio was recorded in the month of November in PLC on 1st day of sampling while maximum C/N ratio was observed in the month of February in PP2 on 90th day of sampling. The carbon and nitrogen ratio were recorded in biofloc culture ponds between 3.316 and 11.450. The minimum values were recorded in the month of November in BFC on 1st day of sampling while maximum was observed in the month of January in BP1 on 60th day of sampling. In the present investigation, earthen ponds reported C/N ratio between 1.084

and 7.866 while plastic-lined ponds had 1.314 and 7.447 and biofloc ponds with 3.316 and 11.450. Chakrapani *et al*. (2020) studied on three different carbon and nitrogen ratios for Pacific white shrimp. The overall results showed that raising *P. vannamei* shrimp in the biofloc system, particularly at a level of C/N ratio of 10 and 15, might result in enhanced water quality, greater productivity, and improved growth performance. Along these lines, in the present study too, showed good growth and survival rate of shrimps reared in biofloc culture system. Maximum C/N ratio 11:1 was observed in the month of January on 60^{th} day of sampling. Similarly, Mustafa *et al*. (2021) reported 2.65 to 11.19 in brackishwater pond soil at East Java Province, Indonesia. According to Banarjea (1967) the ideal C/N ratio in soil for pond culture ranged from 8:1 to 12:1.

Conclusion
Current growth rate of population explosion and the rate of anthropocentric encroachment of land, scientists have put forward a concern of challenges in production of food to meet the global demand. About 20% of human population consume fish, is being supplied majorly by aquaculture sector. The popular shrimp (*Litopeneaus vannamei*) is the most preferable species for culture by shrimp producers due to its short time crop, hardy species and high market value. However, a number of issues, including disease outbreaks, deteriorating water quality, and germplasm degradation, have been faced by the *L. vananmei* aquaculture business. Keeping the aspects in mind, present investigation was focussed to understand the productivity and C/N ratio in shrimp (*L. vannamei*) aquaculture systems at Ankola in Uttara Kannada district and Haleyangady in Dakshina Kannada district. The water and soil quality parameters and C/N ratio results shown higher deviation in biofloc ponds compared to earthen and plastic-lined ponds.

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Conflict of interest
The authors declare that they have no conflict of interest.

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