Original Research Article

Profiling of sediments from brackishwater shrimp ponds in Navsari, Gujarat

ABSTRACT

The present study was carried out to observe the soil characteristic of selected shrimp farms near Navsari, Gujarat considering pond size, stocking density and culture practice. Soil sampling was carried out for one summer crop during February to July 2022 from Aat, Karadi and Samapor shrimp farms, Navsari. Three ponds from each shrimp farm were selected for sampling. Soil parameters comprising pH, electrical conductivity(EC), organic carbon, available nitrogen and available phosphorus ranged from 8.04 to 9.86, 0.530 to 4.318 dS m^{-1}, 0.42 to 2.22%, 22.13 to 191.84 kg ha^{-1} and 29.26 to 97.70 kg ha^{-1}respectively. No significant difference ($p>0.05$) were observed in soil parameters with respect to locations except parameters electrical conductivity and available phosphorus ($p<0.05$). The current study demonstrated that pond size and stocking density both had a significant impact on characteristics of soil as duration of culture progressed.

*(**Key words**: Available nitrogen, Available phosphorus, Organic carbon, Soil characteristic, Stocking density)*

1. INTRODUCTION

Fisheries and aquaculture play a significant role in food production, ensuring the nutritional security of the food basket, enhancing exports and employing over 14 million people in India.Shrimp farming activities in India are mostly found in the coastal states of Gujarat, Andhra Pradesh, Maharashtra, Orissa, Karnataka, West Bengal, Kerala, Tamil Nadu and Goa (Bharathi and Kunda, 2017). Gujarat has the longest coastline in India of 1600 kilometers, with around 3.76 lakh hectares of brackish water area suitable for shrimp production from which only 7542 hectares of total area has been presently utilized for brackish water shrimp farming. Gujarat has 12 coastal districts, including the union territory of Diu, however, the top four shrimp-producing areas in the state are Valsad, Navsari, Surat and Bhavnagar. Since 2009, the pacific white shrimp *L. vannamei* has been the most important species cultured in brackishwater systems (Bajaniya et al., 2019). Farmers have responded enthusiastically to vannamei shrimp farming due to the availability of good quality SPF seed, the species susceptibility to high stocking density, faster growth rate, high disease resistance and the high production value obtained (Anna and Dinesh, 2021) compared to *P. monodon.* The characteristics of bottom soil sediment have a significant impact on the physical and chemical characteristics of pond water and the activities taking place at the soil-water interface are crucial for the health and development of shrimps in ponds. Nutrients and organic wastes tend to concentrate near the bottom and are therefore eliminated from the water phase to some extent. However, an excessive build-up over what may be considered the carrying capacity of the sediments may cause the pond system to degrade, because shrimps live in the soil-water transition zone, this type of development appears to be especially important for shrimp culture. When ponds are intensively stocked and nourished, anaerobic conditions start to develop in the sediments. As the pond gets more intense, the process becomes more obvious. Production is hampered by the emergence of anaerobic conditions, which also prevents further intensification. There is a change in the characteristics of the bottom soil as a result of the sedimentation of plankton and feed wastes, scouring of weakly consolidated soil, and deposition of fine particles on the bottom. Sludge is a term used to describe an accumulation of very soft, loose material that is relatively rich in organic matter that is frequently seen in the stagnant or deeper areas of ponds (Avnimelech and Ritvo, 2003).

Shrimps usually live on or near the bottom, where they are consequently exposed to environmental factors of the pond bottom. The productivity of the pond is significantly influenced by the soil quality. Pond pH, salinity and bottom stability are regulated by the soil. Properties of a particular soil type are influenced by its physical properties and nutrient content (George et al., 2010). The quantity of nutrients in pond water are significantly influenced by the pond soil. Understanding the nature, texture and characteristics of pond soil can help a farmer to develop effective management techniques that will increase productivity (Adhikari, 2003).

The current investigation was conducted to document the soil quality characteristics of the brackish water shrimp farms located in Navsari district, Gujarat.

2. MATERIALS AND METHODS

The present study was conducted between February and July of 2022. Soil was collected from the Aat, Karadi and Samapor brackish water shrimp farms in Navsari. The three different shrimp farms selected for sampling were Farm 1, Aat - Lat 20° 53' 51.79" ^{o}N,Long72° 50' 27.6" ^{o}E; Farm 2, Karadi -Lat 20° 56' 47.01" ^{o}N,Long 72° 50' 1.13" ^{o}E; Farm 3, Samapor - Lat 20° 54' 49.3" ^{o}N, Long 72° 49' 9.97" ^{o}E. Soil sampling was done from three ponds of every farm. The pond size ranged between 3000-8000 m^2, whereas the stocking density of *L. vannamei* at Aat, Karadi and Samapor shrimp ponds was 19, 33 and 42 No/m^2, respectively.

2.1. Soil sample collection and analysis

The soil samples were collected every month. Soil samples were obtained from the pond bottom's surface using a 12.5 cm diameter PVC pipe. The sampler collected a sediment column 10 cm deep from the soil-water interface. The soil was collected by pressing the PVC pipe directly into the bottom. Approximately 1 kg soil sample was collected from each pond. Then, the collected soil sample was mixed thoroughly to prepare a composite sample for analysis. The collected soil was oven-dried at 50ºC. With the help of a mortar and pestle, big and smaller particles were broken down and sieved through a 2 mm sieve. Analysis of soil parameters like pH, EC, organic carbon, available nitrogen and available phosphorus was done in the laboratory. Soil pH was estimated using a digital pH meter (Auto pH system PM300). The electrical conductivity of the soil was measured by using a conductivity meter (Conductivity TDS meter 308). The organic carbon of the soil sample was estimated by using the wet digestion method (Walkley and Black, 1934). The percentage of organic carbon in the soil was used to express the result. The available nitrogen in the soil was estimated by using the alkaline permanganate method (Subbiah and Asjia, 1956). Estimation of available phosphorus in soil was done by extraction with sodium bicarbonate (Olsen et al., 1954).

2.2. Statistical analysis

The effects of location and ponds on the means of soil parameters were examined using ANOVA. For each parameter, the mean, standard error and range were calculated. Statistical analysis was done using SAS (v 9.3).

3. RESULTS AND DISCUSSION

3.1. pH

According to Banerjea (1967), soil pH performs a very perilous role in aquaculture as it can affect other water parameters like mineralization of organic matter, absorption, release of essential nutrients etc. Several researchers reported that the pH of pond soil in the range of 7 to 9 was most suitable for better growth of cultured fish and shrimps (Schaeperclaus, 1933; Chakraborti et al., 1985;Soundarapandian and Gunalan, 2008). Boyd (1995) reported soil pH ranges between 7.5 and 8.5 encouraging organic matter decomposition of soil.

In the present study, soil pH was recorded in the range from 8.04 to 9.86, 8.31 to 9.29 and 8.17 to 9.02 for Aat, Karadi and Samapor farms respectively. Similarly, Gupta et al.(1999) also reported soil pH range between 5.2 - 8.4 at different ponds of Andhra Pradesh. The mean minimum soil pH was 8.51 (Samapor) and the maximum was 8.68 (Karadi). A more acidic or alkaline pH of soil affects the productivity of cultured fish and shrimps (Adhikari, 2000). The suitable soil pH should be in the range of 7.6 -8.6 for shrimp culture (Islam et al.,2003; Soundarapandian and Gunalan, 2008). As farmers maintain soil pH by adding lime, it did not significantly differ ($P>0.05$) during the culture duration in the Navsari region (Fig. 1a).

Soil pH values ranged between 7.5 and 8.3 from tiger shrimp farms from the Cuddalore district of Tamilnadu (Jayanthi, 2007). Soil pH of various shrimp pond range varied from 8 to 8.48 in Andhra Pradesh and Tamilnadu, 5.8 to 7.8 in Odisha and 6.92 to 7 in Kerala (Saraswathy et al.,2016). Bharathi and Kunda(2017) reported soil pH of *L. vannamei*cultured farms of coastal districts of Andhra Pradesh in the range between 6 - 9. Bansode et al. (2020) reported that the soil pH of brackish water shrimp farms ranged between 7 and 8.5 at Raigad district of Maharashtra. Anna and Dinesh (2021) reported soil pH range from 6.8 to 7.4 during the culture of *L. vannamei*in the Kerala region. In the present studies soil pH was higher (>8.5) than the optimum range at all the locations.

3.2. Electrical conductivity

According to Ogbeibu and Victor (1995) electrical conductivity indicate freshness of water because it is the index of total ionic content of water. It can also indicate the primary productivity of the pond. Boyd (1979) has stated that conductivity of soil depends on its ionic concentration, temperature and various dissolved solids. Soil electrical conductivity can improve by applying lime (Boyd, 1974).

In the present study, electrical conductivity of soil ranged from 0.530 to 3.757 dS m^{-1}, 1.040 to 3.972 dS m^{-1} and 1.407 to 4.318 dS m^{-1} for Aat, Karadi and Samapor farms respectively. The mean minimum electrical conductivity of soil was 1.745 dS m^{-1} (Karadi) and the maximum was 2.474 dS m^{-1} (Aat). Average electrical conductivity reported from cultured ponds ranged between 2.68 and 39.92 dS m^{-1} (Gupta, 1999). Chattopadhyay and Chakraborti (1986) reported that low lying coastal area ponds soils had high salinity and electrical conductivity. EC values are important to check deterioration in soil properties of brackish water ponds.

EC values of tiger shrimp farms from Tamilnadu observed the range from 6.18 to 15.75 dS m^{-1} (Jayanthi, 2007). EC values lower than 5 dS m^{-1} were found suitable for *L. vannamei* shrimp culture (Saraswathy et al., 2016). The EC values recorded in our studies have been found to be at optimum levels for *L. vannamei*shrimps.

Aat farm electrical conductivity ofsoil was significantly higher ($p<0.05$) than other locations (Karadi <Samapor< Aat) (Fig. 1b). From this study it has been recorded that negative trend of electrical conductivity was observed in the Navsari region during the culture period (Fig. 2b).

3.3. Organic carbon

According to Banerjea (1967), soil with less than 0.5% organic matter is low productive, 0.5 to 1.2% average productive, 1.5 to 2.5% highly productive and greater than 2.5% as less productive. Nevertheless, brackish water pond soils are known for poor organic carbon content. Boyd and Teichert-Coddington (1994) reported that organic carbon value 0.60-1.50% has been found to be highly suitable for aquaculture. Chakraborti et al.(1985) has observed 1.02 to 1.45% organic carbon content in prawn culture and has concluded that organic carbon >1% gives better growth for *P. monodon.* Boyd et al.(2002) suggested organic carbon range from 1.0 - 3.0% is the best range for coastal aquaculture.

In present study, organic carbon content in soil ranged from 0.42 to 2.22%, 0.77 to 2.02% and 0.62 to 1.97% for Aat, Karadi and Samapor farms respectively. Similarly, Ahmed (2004) also observed that organic carbon range 0.95 to 1.50% was the suitable range for aquaculture in Bangladesh. Siddique et al. (2012) reported that organic carbon content increased sharply with the increase of pond's age. Application of organic manure (cow dung) to the ponds increased the organic carbon content in the ponds during culture (Karthik et al.,2005). Saraswathy et al.(2016) reported that shrimp farms in Guntur and Tamilnadu had lower organic carbon than optimal values. In Bangladesh, the average value of organic carbon content was 2.88 to 3.23% in shrimp farms (Rahman et al.,2017) which was supposed to be slightly higher than the optimal range. During the culture period, it has been recorded that, there was a positive trend of organic carbon contentin the Navsari region (Fig. 2c).

3.4. Available nitrogen

Breakdown of organic matter leads to increase availability of nitrogen in ponds soil. This is due to conversion of organic matter into inorganic form by different bacteria which are present in soil. The presence of available nitrogen in pond soil determination indicates the fertility status of culture system as it can be directly used by primary producers of pond. Chakraborti et al. (1985) suggested that 0.012 to 0.016% available nitrogen was suitable for prawns.

In present study, the available nitrogen content in soil ranged between 22.13 - 191.84 kg ha^{-1}, 36.89 - 163.12 kg $ha^{-1}$and 79.60 - 156.30 kg ha^{-1} at Aat, Karadi and Samapor farms respectively. With regular use of fertilizers during culture period positive trend of available nitrogen content was observed in all the farms of Navsari region. No significant difference ($p>0.05$) in the available nitrogen contentvalueswith respect to locations (Fig. 1d). Islam et al.(2003) reported that the total nitrogen content ranged from 0.11 to 0.18% in shrimp farms at Bangladesh. In Andhra Pradesh and Tamilnadu shrimp farms available nitrogen ranged between 25 mg 100 g^{-1} and 3.02 - 4.47 mg 100 g^{-1} which were lower than optimal range due to non-utilization of fertilizers over the time (Saraswathy et al.,2016). In Bangladesh the average value of total nitrogen in shrimp farms was in the range between 0.135 - 0.184 % (Rahman et al.,2017). During the culture period, it has been recorded that, there was a positive trend of available nitrogencontentin the Navsari region (Fig. 2d).

3.5. Available phosphorus

Phosphorus available in soil and water was the most essential nutrient for the maintenance of pond productivity. In the present study, the available phosphorus content of soil ranged from 34.92 - 95.84 kg ha^{-1}, 29.26 - 65.18 kg ha^{-1} and 35.40 - 97.70 kg ha^{-1} for Aat, Karadi and Samapor farms respectively. Bharathi and Kunda (2017) reported similar values in *L. vannamei*shrimp farms from the coastal district ofAndhra Pradesh between 30 and 79.5 kg ha^{-1}.

The mean minimum available phosphorus content of soil was 47.87 kg ha^{-1} (Karadi) and the maximum was 66.50 kg/ha (Aat).In Andhra Pradesh low available phosphorus upto 1.5 mg 100 g^{-1} has been reported (Banerjea, 1967). Gupta et al. (1999) has observed that there was reduction in organic carbon, available nitrogen and available phosphorus values, if the soil samples were taken from greater depths.Saraswathy et al.(2016) reported lower available phosphorus concentration from Andhra Pradesh and Tamilnadu shrimp farms. The average phosphorous content ranged between 0.02 and 8.54 ppm in prawn and shrimp farms from Bangladesh (Rahman et al.2017).

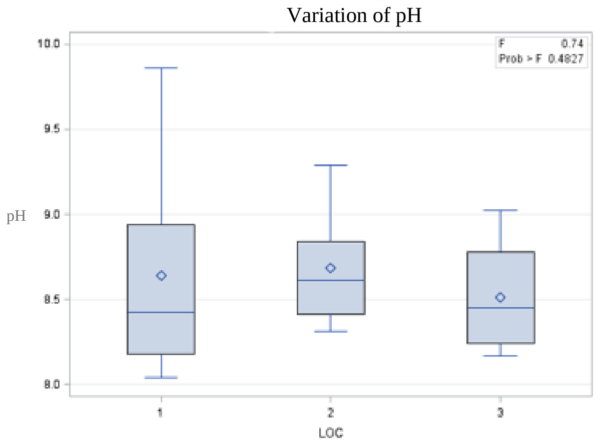
Aat farm available phosphoruscontent ofsoil was significantly higher ($p<0.05$) than other locations (Karadi <Samapor< Aat) (Fig. 1e). From this study it has been recorded that negative trend of available phosphorus contentwas observed in the Navsari region during the culture period (Fig. 2e).

Table 1. Soil parameters recorded from different shrimp farm locations, Aat, Karadi and Samapor from Navsari, Gujarat.

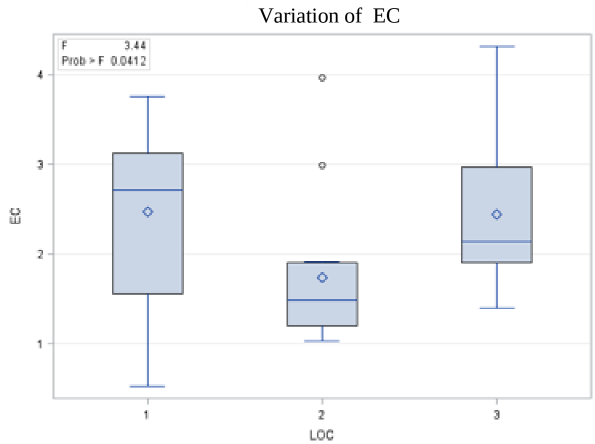
Location		pH	EC (dS m^{-1})	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})

Aat	**Mean**	8.64	2.474	1.21	100.02	66.50
	SD	0.56	0.988	0.57	49.27	17.79
	Min	8.04	0.530	0.42	22.13	34.92
	Max	9.86	3.757	2.22	191.84	95.84
	CV (%)	6.47	39.949	47.33	49.26	26.76
Karadi	**Mean**	8.68	1.745	1.32	109.51	47.87
	SD	0.28	0.783	0.49	36.33	11.68
	Min	8.31	1.040	0.77	36.89	29.26
	Max	9.29	3.972	2.02	163.12	65.18
	CV (%)	3.21	44.869	36.75	33.17	24.41
Samapor	**Mean**	8.51	2.445	0.95	115.22	63.70
	SD	0.28	0.799	0.34	22.74	16.32
	Min	8.17	1.407	0.62	79.60	35.40
	Max	9.02	4.318	1.97	156.30	97.70
	CV (%)	3.30	32.702	35.91	19.74	25.63
	F Value	0.74	3.44	2.36	0.31	6.31
	p Value	0.4827	0.0412	0.1072	0.738	0.004

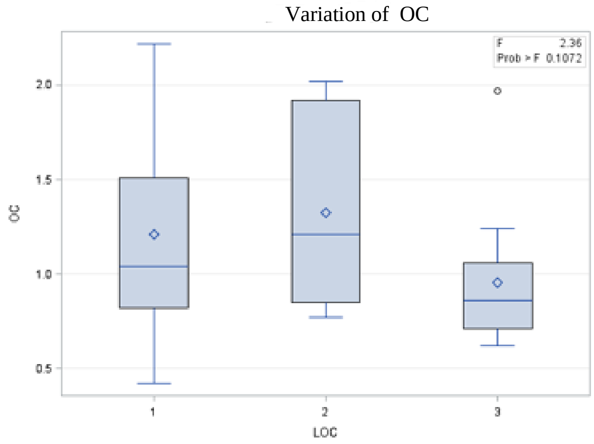
SD – Standard deviation, Min – Minimum, Max – Maximum, CV – Coefficient of variance



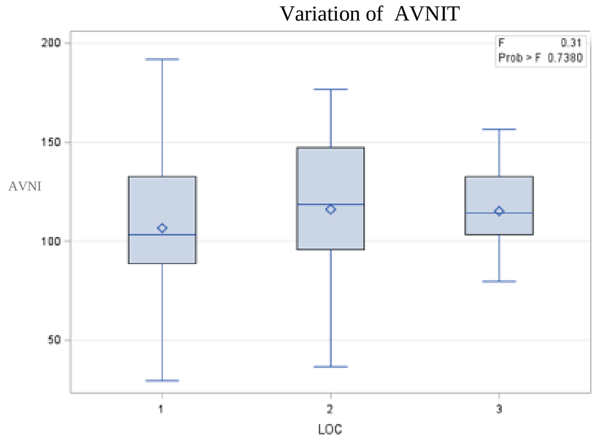
(a) pH



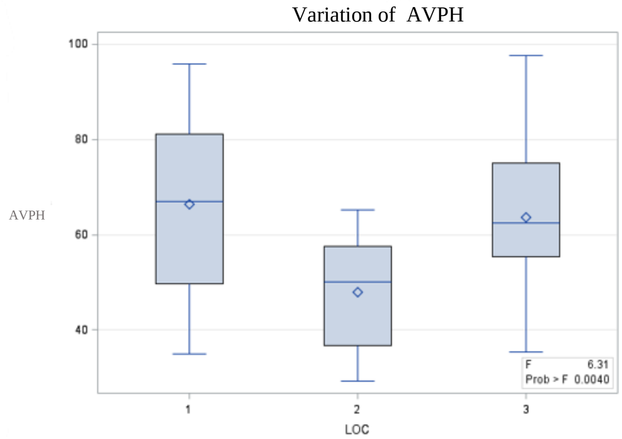
(b) Electrical conductivity (dS m^{-1})



(c) Organic carbon (%)

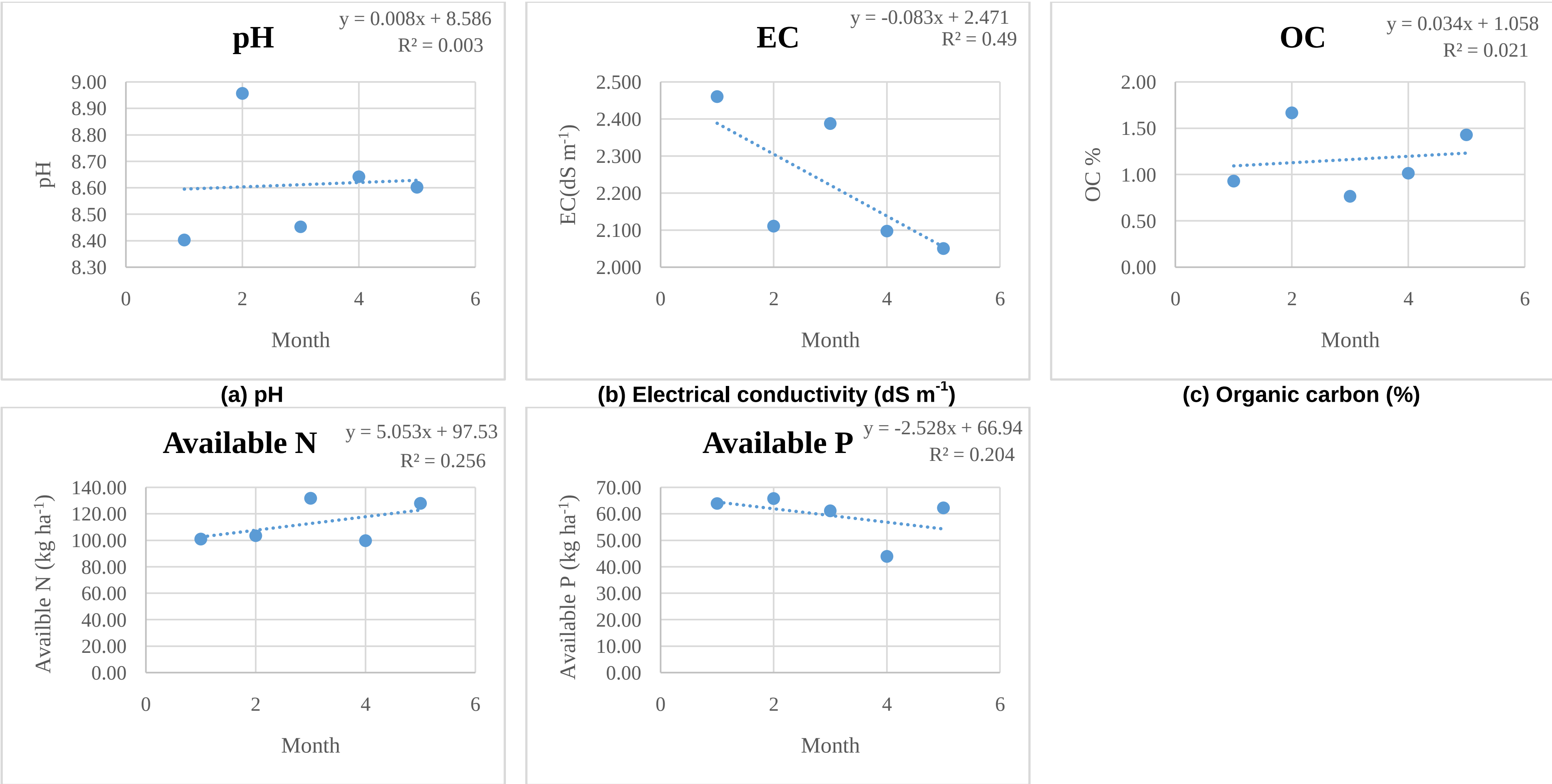


(d) Available nitrogen (Kg ha^{-1})



(e) Available phosphorus (Kg ha^{-1})

Fig. 1. Box plots showing the variation of soil parameters at different locations: Aat, Karadi and Samapor
***1 - Aat, 2 – Karadi and 3 – Samapor**



(a) pH **(b) Electrical conductivity (dS m^{-1})** **(c) Organic carbon (%)**

(d) Available nitrogen (kg ha^{-1}) **(e) Available phosphorus (kg ha^{-1})**

Fig. 2. Trends recorded in soil parameters from shrimp farms of Navsari, Gujarat region.

4. CONCLUSIONS

The study contributes significantly to understanding the soil composition in brackish water shrimp farms located in Navsari, Gujarat. This study has shown that the majority of the soil parameters conformed with the optimum recommended ranges observed in the published literature. However, the soil parameters of the shrimp farms were significantly influenced by the culture practices, stocking density, and location of the shrimp farms. Comprehending and controlling soil characteristics are crucial for implementing sustainable aquaculture methods, ensuring ideal circumstances for shrimp production and overall productivity of the farm. This research will be useful to all shrimp farmers from the Navsari region of Gujarat as a baseline study to follow proper management measures during culture to improve management techniques and environmental sustainability in shrimp farming operations.

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