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Do the Soil's Physiochemical Properties Fluctuate with Season and Soil Depth in the Ecological Critical Areas (ECA) of Sundarbans, Bangladesh?

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Abstract

The Ecological Critical Areas (ECA) of Sundarbans is located outside of Sundarbans Reserved Forest at 10 km extended landward, which is threatened to reach a critical state due to human activities. Aquaculture is the dominant land use in the ECA and the tree coverage is going to deplete at an alarming rate due to the deterioration of site conditions, which significantly influence the productivity of aquaculture and the establishment of the plantations on the dikes of the fishpond. The present study aimed to assess some static and dynamic soil physiochemical properties of the fishpond dikes located in the ECA of Sundarbans. Soil samples were collected from the western part (Satkhira district) of ECA of Sundarbans during the pre-monsoon and post-monsoon seasons. The bulk density, pH, and electrical conductivity of the studied areas varied from 1.05-1.18 g/cm3, 7.30-8.54, and 1.05-2.13 ms/cm respectively. However, the concentration of available form of Nitrogen, Phosphorus, Potassium and Sodium were 0.5-0.72 mg/g, 0.03-0.06 mg/g, 10.5-12.88 mg/g and 16.89-20.53 mg/g respectively. Some of these parameters showed significant variation among the zones, seasons, and soil layers. However, the stock of available nitrogen, phosphorus, potassium, sodium and organic carbon varied from 52.5- 84.96 kg/ha, 3.15-7.08 kg/ha, 1.10-1.52 t/ha, 1.77-2.42 t/ha and 173.47-199.43 t/ha respectively. As pond soil provides all the important nutrients with water, the findings of this study will help to take proper management interventions for the dike greening initiatives and productivity of fishponds in the ECA of Sundarbans.

Keywords: Physiochemical properties; Ecological critical areas (ECA); Sundarbans; Fishponds; Dike.

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1. Introduction

Aquaculture is an age-old practice in the coastal areas of Bangladesh. Traditionally, people enclosed tidal water in low-lying intertidal lands by constructing small dikes and harvested shrimp and fish after three to four months without any form of management [1]. After the independence of the country, peoples were interested in shrimp cultivation for its rising price and demand in international markets. The success stories of these early farmers encouraged others to involve in shrimp farming [1, 2]. Shrimp farming in Bangladesh has been recognized as a part of the Blue Revolution. Bangladesh has a huge coastal tidal area which is considered favourable for shrimp farming and 0.276 million hectares of land are currently under brackish water shrimp cultivation [3].

The coastal region of Bangladesh, especially the south-western part including Khulna, Bagherhat and Satkhira, is one of the most promising areas for shrimp farming due to the suitable habitat for shrimp [4]. Besides the overall contribution of shrimp cultivation to the national economy of Bangladesh, it has instigated severe threats to local ecological systems, such as soil and water quality deterioration, decrease of local variety of fish, saline water intrusion in groundwater, local water pollution and so on [3, 5] The expansion of shrimp farming has caused a loss of mangroves and its associated biodiversity [6-8] through the collection of shrimp fry from the natural sources [9, 10]. Rapid change in land use pattern in the south-western Bangladesh is the result of converting the agricultural lands to aquaculture [11, 12]. This conversion invites the loss of agro-biodiversity and livestock [13, 14] and change in soil salinity [15-18].

Among these problems, the increased salinity levels of both soil and water appears to be the most crucial threat to the natural environment. Salinization of the groundwater and saline water intrusion in the surrounding areas have caused serious ecological and socioeconomic damage in the coastal environment. Shrimp farming in south-western Bangladesh influences the soil and water salinity [19]. Salinity influences the physical and chemical properties of soil and water that causes massive loss of crop production, loss of floral and faunal biodiversity, crisis for drinking water and so on [18, 20, 21]. Moreover, these changes are likely to affect the microbial communities in soil and the ecosystem properties including organic matter decomposition, nutrient mineralization, and natural vegetation [22, 23]. Various authors have suggested that increased salinization from shrimp farming may be responsible for reductions in tree coverage [24-28]. Saline soil does not support plant growth primarily due to the stresses of excess salt in the soil solution which influences the survival of herbaceous plants, shrubs and trees, and resulted the stunting the growth of trees [29].

In Bangladesh perspective, aquaculture may be a good process to minimize the poverty and to meet the demand of animal protein [19] Now a days, Aqua culturists are beginning to seek information on pond soil management. In order to have a clear understanding of the various physio-chemical and biological processes and to make decisions on the suitability of sites for aquaculture as well as effective managements of the soils for increased productivity of the ponds, one needs to have good knowledge on the nature and properties of the soil [30]. Pond soil plays an important role in the balance of an aquaculture system and consequently on the growth and survival at aquatic organisms [30]. Although fishpond soils are involved in many processes that affect water quality. The most soil related problem facing by shrimp and fish farmers are organic soils or potential acid-sulphate soils, sedimentation, organic matter accumulation and attendant anaerobic conditions on pond bottoms. The productivity of a pond or lake depends upon the quality of water and soil.

The southwestern Bangladesh contains both fresh and brackish-water aquaculture. Interestingly, the dike of the aquaculture ponds of this area are barren. However, trees help to maintain biodiversity and well-being the environmental condition, and provide subsistence and income through the production of edible fruits, nuts, fodder, timber, and firewood. In this context, planting trees on the dikes of the aquaculture ponds may help to improve environmental conditions by increasing tree coverage. Until today, there is not much information on the chemical/ nutrient properties of the soil from the surrounding areas of Sundarbans of Bangladesh. However, planting of site-specific tree species and rotation of tree species is very important for achieving the sustainable productivity in production forestry [31]. Conversely, ideal growth and development of trees strongly depend on the physical and chemical properties of the soils [32]. Therefore, the physio-chemical properties of soil must be known before initiating any plantation for the production of wood, fodder, etc. In addition, the assessment of soil properties can also describe the site quality for establishing a plantation and restoration of natural forests [33].

An Ecological Critical Area (ECA) can be restored through plantation and management activities. However, the restoration of the degraded sites is very challenging, sometimes it becomes impossible to return the sites to its' original condition. Site quality is the function of soil properties (physical, chemical and biological), climatic conditions, and biota of a particular site. Plantation activities are able to improve the soil quality.

For these reasons, it is important to have in depth knowledge on soil physical and chemical properties before selecting the site-specific tree species for successful large-scale plantation. Therefore, present study was aimed to evaluate the fluctuation of the soil physical (Soil texture, bulk density) and chemical (Electrical Conductivity, pH, Organic Carbon, Nitrogen, Phosphorus, Potassium, Sodium) properties with seasons and soil depths of fish pond dikes in the south-western ECA of Sundarbans, Bangladesh. The outcome of this study can be a reference material for the forest management practitioners, researchers and students for taking management decisions and practicing Aquaculture in the study area.

2. Materials and Methods

2.1. Description of the Study Area

Shyamnagar Upazilla of Satkhira district, which is situated on the ECA of Sundarbans, was selected purposively for the study. A large number of shrimp farms and shrimp processing plants exist in the selected area. In this region, the practices of shrimp farming have caused massive loss of crop production, loss of fruit and other indigenous floral species, fresh water crisis for drinking and so on [18, 20]. Shyamnagar Upazilla is located between 22º36´ to 22º24´ N latitudes and 89º00´ to 89º19´ E longitudes at the edge of Sundarbans (Fig. 1). The mean annual temperature of the area is 24.8^{o}C with a range of minimum and maximum 8.4^{0} to 25^{o}C respectively [34]. Nevertheless, the mean annual rainfall is about 1374 mm. The mean monthly relative humidity is 77.2%. According to report of BBS [35], total 6754 fishponds are reported in Shyamnagar Upazilla that covers around 600 ha of land and the mean annual production of fish is about 6814 ton. About 2930 fishermen are involved in fishing and aquaculture production in that area. The main occupations of the people are agriculture, fishing, shrimp farming, crab fattening, day labor, and honey collection from the Sundarbans. The main crops are rice, jute, potato and vegetables and main export items are rice, fish (shrimp), and honey [35].

2.2. Selection of Sampling Sites

Systematic cluster sampling method was applied for the selection of fishponds. To facilitate the sampling procedure, the area of Shyamnagar Upazilla was sub-divided into three zones (Fig. 1) at increasing distance from the Sundarbans (i.e., Zone 1, 0-1 km; Zone 2, 4-5 km; and Zone 3, 9-10 km). Four grids were created from north to south with an interval of 10 km which intersect the Zones (1, 2 and 3) at four different points (total 12 points) with help of GOOGLE Earth Application and the geographical location of each point was recorded using a Geographical Position System (GPS). Then, one cluster of fishponds (consist of four ponds) was selected from each intersected point for the collection of soil samples. Thus, four clusters of fishponds (16 fishponds) were selected from each zone.

2.3. Collection of Soil Sample and Processing

Soil sample was collected from each dike of the selected fish ponds. The sample collection points were also selected systematically at the midpoint (lengthwise) of the dike. Thus four sampling points were selected for each sampled fishpond. Soil samples from each sampling points were collected at three depths (0 to 15 cm, 15 to 30 cm, 30 to 100 cm) using a stainless steel open-face core sampler of 5 cm diameter (Fig. 2) during pre-monsoon (March - April) and post-monsoon seasons (October - November). A total of 576 soil samples (4 ponds x 4 dike x 4 grid x 3 zone x 3 depth) were collected from the study area in each season. The collected samples were put into airtight plastic bags and labeled for the immediate transportation to the laboratory for further processing.

2.4. Sample Preparation

The collected soil samples were air-dried at room temperature (30-35°C) until constant weight. The air-dried samples were crushed using mechanical grinder and sieved through 2 mm mesh and stored in airtight labeled container according to Allen [36].

2.5. Soil Physical Properties

Parentage of soil particles (sand, silt and clay) was measured following the soil hydrometer method [37]. However, textural classes were determined by using Marshall's Triangular Coordinator system. Open-face soil auger of 5 cm diameter was used to collect the samples for soil bulk density at three depths (0 to 15 cm, 15-30 cm and 30-100 cm) [38].

2.6. Soil Chemical Properties

Soil pH and EC of the samples were measured from 1:2 soil and distilled water with 30 minute extraction at 200 rpm [36] using a high precision pH meter (Hach sensION 3) and a Conductivity Meter with ATC (Hanna Instruments HI-2315), respectively. Soil organic carbon of the samples was estimated by using loss on ignition method [36].

Plant available form of Nitrogen in the soil samples was extracted using strong electrolyte (eg.,1 N KCl solution) at 1:10 ratio according to Allen [36] and the concentration was determined by adopting colorimetric method [39]. The Olsen extraction method [36] were used for extraction of available form of soil Phosphorus. The calorimetric method of Timothy, *et al.* [40] was followed to determine the concentration of available form of phosphorus in the extracts. Finally, NH_4OAc (1N, pH-7) was used for extraction of available form of Potassium and Sodium [36]. Potassium and Sodium concentration in sample extracts was measured by Flame Photometer (Jenway PFP7).

2.7. Nutrients and Carbon Stock in Soil

Nutrients and carbon stock in soil up to a depth of 100 cm were estimated using their concentration and bulk density according to Hossain, *et al.* [41]. The soil volume was calculated for 0 to 15, 15 to 30 cm and 30 to 100 cm and then sum up to get stock upto 100 cm by using the following formula.

$$\text{Stock}\left(\frac{\text{t}}{\text{ha}}\right) = \frac{\text{Soil volume up to 30 cm depth }(\text{m}^3/\text{ha}) \text{ x Mean bulk density }\left(\frac{\text{t}}{\text{m}^3}\right) \text{ x Concentration }\left(\frac{\text{kg}}{\text{t}}\right)}{1000}$$

2.8. Statistical Analysis

Data were processed and analyzed by using Microsoft Excel Version 2013 and SPSS 20 using $p < 0.05$ level of significance. A two-way ANOVA analysis followed by DMRT (Duncan Multiple Range Test) were conducted to compare the soil physical and chemical properties among the zones, seasons and soil depths. All the statistical analysis was conducted by using SAS University Edition.

3. Results

3.1. Physical Properties

The silty clay soil texture was observed for the zone 1, which was closest to Sundarbans. However, less proportion of silt (37.55-37.67%) was observed for zone 2 and 3 (According to USDA texture classification, the soil texture is clay for zone 2 and 3 and silty clay for zone 1 (Table 1).

3.2. Bulk Density

Bulk density of the three Zones found to vary from 1.05 g/cm^3 to 1.18 g/ cm^3. Analysis of variance test showed no significant ($p > 0.05$) difference among the zones and depths of sample collection (Fig. 3).

3.3. Chemical Properties of Soil

Soil pH of the study area was neutral to slightly alkaline and ranged from 7.3-8.5 (Fig. 4). Comparatively ($p<0.05$) higher pH was observed for the zone 1, while similar ($p>0.05$) pH was observed for zone 2 and 3 (Table 2). However, there were no significant ($p>0.05$) variation in pH was observed for seasons and soil depths irrespective of the zones (Fig. 4).

The Electric Conductivity (EC) of the sampled soil ranged from 1.05-2.27 mS/cm. Comparatively ($p<0.05$) higher EC was observed at the top layer (0 to 15 cm) for zone 1 and 3. However, relatively higher EC was observed during the pre-monsoon seasons irrespective to zone and depths (Table 2). From ANOVA test, significant difference was found ($p<0.05$) in EC of soil among the 3 different zones and layers also (Fig. 5). EC was not varied significantly between zone 1 - 2, and zone 1- 3 but variation is found in zone 2 to zone 3. On the other hand, there was no significant ($p<0.05$) variation in soil layer 1-2 but significant variation ($p<0.05$) was found in layer 1-3 and layer 2-3.

3.4. Carbon Stock

The total Carbon stock was found 173.47 ton/ha in zone 1, 199.43 ton/ha in zone 2 and 183.81 ton/ha in zone 3. The average carbon stock was 29.61 ton/ha in 0-15 cm, 30.74 ton/ha in 15-30 cm and 125.22 ton/ha in 30-100 cm soil (Table 3). It was found that there was no significant ($p>0.05$) differences in carbon stock between three layers. Carbon stock was not significantly ($p>0.05$) varied among the three zones also. The average percentage of organic carbon in the study area was ranged from 1.5%-2.4% (Table 3). The average content was 1.66%, 1.93% and 1.61% for Zone-1, zone-2 and Zone-3 respectively.

3.5. Plant Available form of Nutrients (N, P, and K) and Sodium (Na)

3.5.1. Extractable Nitrogen

The extractable nitrogen concentration was varied from 0.5-0.72 mg/g in the study area. Significantly ($p<0.05$) higher concentration (0.72 mg/g) of nitrogen was detected for the top layer (0 to 15 cm) of zone 3. Generally top layer contained higher concentration of nitrogen and lower concentration was observed for the lowest (30 to 100 cm) layer (Fig. 6). But from the CRD test, there was no significant difference ($p>0.05$) was found among the zones (1, 2 and 3) and the soil layers also (Table 3).

3.5.2. Phosphorus (P)

Highest average value of available phosphorus was obtained in zone 3 which was far from Sundarbans in layer 1 (0-15 cm) at a concentration of 0.03-0.06 mg/g. Except one layer, phosphorus was found in similar range in all the dikes of the fishponds (Fig.7). It was observed that there was no significant ($p>0.05$) differences in phosphorus concentration among the zones, seasons and soil layers (Table 2).

3.5.3. Potassium (K)

Miller and Turk [42], reported that potassium is the third most common soil nutrient (nitrogen is the first and phosphorus is the second). In present study, potassium concentration was found 10.08-12.56 mg/g in pre monsoon season and 10.5-12.88 in post monsoon season (Fig. 8). From the analysis of variance, no significant ($p>0.05$)variation was found between two different seasons; among the three zones and soil layers (Table 2)

3.5.4. Sodium (Na)

Sodium concentration of the soil samples was varied from 16.89-20.53 mg/g in pre monsoon season and 16.83-19.72 mg/g in post monsoon season (Fig. 9). The concentration of sodium was higher in zone 1 than the other two zones. No significant difference ($p>0.05$) of sodium concentration was found among the zones (1, 2 and 3) and the soil layers also (Table 2).

3.6. Nutrients and Organic Carbon Stock in Soil

Comparatively higher stocks of carbon (173.47-199.43 t/ha), total nitrogen (52.5-84.96 kg/ha), total phosphorus (3.15-7.08 t/ha), total potassium (1.1.-1.52 t/ha), total sodium (1.77-2.42 t/ha) were found in the samples of study area. From the ANOVA analysis, it was found that there was no significant ($p>0.05$) differences in carbon stock between three layers. Organic carbon stock was not significantly ($p>0.05$) varied among the three zones also (Table 3).

4. Discussion

In the present study, the soil was mainly silty clay and clay type but according to Pudadera [43] sandy clay loam type of soil is the preferable kinds of soil type for Aquaculture. He also stated that sandy clay loam to sandy loam was preferred for the semi-intensive and intensive culture where artificial food was used as the main source of food. Ahmed [44], reported that sandy clay loam to sandy loam type of soil is suitable for coastal aquaculture in Bangladesh. Clay percentage was higher in the study area than sand and that would be the reason why organic matter was higher in study area which was also supported by the study of Khan and Amin [45]. Too heavier textured soils such as pure clay may not be satisfactory as they have very high absorptive property and thereby act as a sink for nutrients like phosphorus which may not be easily released to overlying water. These soils may form deep cracks when dry (on draining the pond) thereby allowing seepage losses of water.

In the study area, the bulk density results was ranged from 1.05 g/cm^3 to 1.18 g/cm^3. Bulk density greater than 1.8 g/cm^3 is considered as extremely bad for plant growth. For better plant growth bulk density should range around 1.4 g/cm^3 for clayey soil and 1.6 g/cm^3 for sandy soil [46]. So, the soil of the dikes from the fishponds of the study area is suitable for plantation.

The EC values of the soil samples of surveyed fishponds were in the range of 1.17 mS/cm to 2.27 mS/cm in pre monsoon and 1.05 mS/cm to 2.13 mS/cm in post monsoon season. An EC value less than 1.0 indicates that soils are highly suitable for cultivation, EC values of 1-3 is injurious to crop growth, EC values between 3 and 4 will definitely cause yield reduction and soil with EC values more than 4 are designated as saline soils and need to reclamation to restore them for cultivation [47]. Therefore, the result showed that EC of the soils was at injurious level and this situation will be worse in future. The salinity was also found higher in soil of the dikes in zone 3 (2.27 mS/cm) which was far from Sundarbans than the others. Again, no significant ($p>0.05$) difference was found in soil salinity in layer 1 (0-15 cm) to layer 2 (15-30 cm). But significant ($p<0.05$) difference was found in layer 1 to layer 3 (30-100 cm) and layer 2-layer 3 in all over the study area. According to Blaylock [48], the reasons behind the increase of soil salinity were poor drainage system, poor irrigation system, less rainfall, dumping toxic substances and others.

To measure the degree of soil acidity and alkalinity, soil pH is a very important variable and it helps to know about soil properties chemical, biological and indirectly physical environment including both nutrients and toxins. The ideal range of pH in soil is 6.0 to 6.5 because most of the plants' nutrients are available in this stage [49]. The Central Institute of Brackish Water Aquaculture (CIBA) 2001, had also been reported that the optimum pH value for aquaculture in soil is 6.5 -7.5. The present study found that the pH value ranged from 7.3 to 8.54 in the collected sample which was more than optimal value that was also reported by Boyd [50]. Accordingly, it was not suitable for shrimp cultivation and crop production. Previous study was suggested that the higher amount of alkalinity was harmful for the proper growth of shrimp and other cultivable species [51]. No significant ($p>0.05$) variations in soil pH was found in different layers of the soil in the present investigation. The reason may be that farmers continuously use lime to maintain the water quality of these ponds. To measure the degree of soil acidity and alkalinity, soil pH is a very important variable and it helps to know about soil properties chemical, biological and indirectly physical environment including both nutrients and toxins. Highest pH was found in the dikes of the fishponds which were closed to the Sundarbans and the pH was decreasing slightly in others. Throughout the study period, no statistical difference was found in pH values between the seasons. It is also noted that the pH below 8.5 indicates saline soil [52]. The high pH value of the study area corresponded to the larger amount of organic matter.

Boyd [50], reported that brackish water ponds had much higher concentrations of sodium and potassium in surface layers than freshwater ponds because of large inputs of ions in brackish water. In the study area, Available of sodium (Na), Phosphorus (P) and Potassium (K) of the soils are found 1.77-2.42 t/ha, 3.15-7.08 t/ha and 1.10-1.52 t/ha respectively. And there was no significant variation ($p>0.05$) among the zones and among the layers also which was also supported by Khan and Amin [45] who studied Na, P and K in the Sundarbans soil.

The average carbon content (%) in the study area ranges from 1.5-2.4 (Table 3). Ahmed [44] argued that organic carbon was rich in post monsoon and in monsoon period and it decrease with the depth of pond. According to Lamers and Junginger [53] the carbon stock above 2% was suitable for crop production or plantation. Top soil of the study area was lied in between 1.5 to 1.92, which was lower than the required level of crop production. Soil Organic Carbon is an indicator of soil health. Organic Carbon influences many soil characteristics including colour, nutrient holding capacity, nutrient turnover and stability, aeration and workability [54]. Generally, variation of soil organic carbon greatly depends on the nature of vegetation and the kind of humus and depth. But there is very limited vegetation or, trees on the dike of fish farm. no significant ($p>0.05$) difference was found in organic carbon content in three zones as well as layers. Anderson [55], Estcourt [56] and Mayer, *et al.* [57] reported that organic carbon is related to mud percentage in the soil. Mud percentage in the study areas were higher than sand and that is why organic matter was higher in the Sundarbans and its surrounding areas. Soil carbon storage and soil carbon sequestration is a vital ecosystem service and indicates the interactions of ecological processes [58]. Comparatively high amount of carbon stock was found in the study area.

5. Conclusion

Soil physicochemical properties are related to soil quality thus affect the growth of plants and also the other biodiversity of soil. Plantation of site specific tree species may enhance the soil quality of an area. On the other hand, such plantation program may contribute to increase the total tree coverage of the country. According to the national forest policy of Bangladesh, it is aimed to bring about 20% of the total land under the tree coverage. Thus the present research reveals that an immediate step is essential to stop further degradation of soil and water quality in fishponds through the improvement of soil quality. Plantation of site specific tree species may open a window to solve the issue. Saline tolerant agricultural crops and trees may be introduced in shrimp cultivated area. Sustainable fish cultivation should be maintained to ensure an opportunity to increase incomes for farmers and associated groups in spite of having some problems. So, a good management practice is needed considering all these parameters, which can change the present scenery of the fish farm. Above all, more research initiatives have to be conducted in order to identify better solutions of environmental issues induced by fish cultivation.

Declaration of Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Fig-1. Sample/ selected shrimp ponds locations in the study area

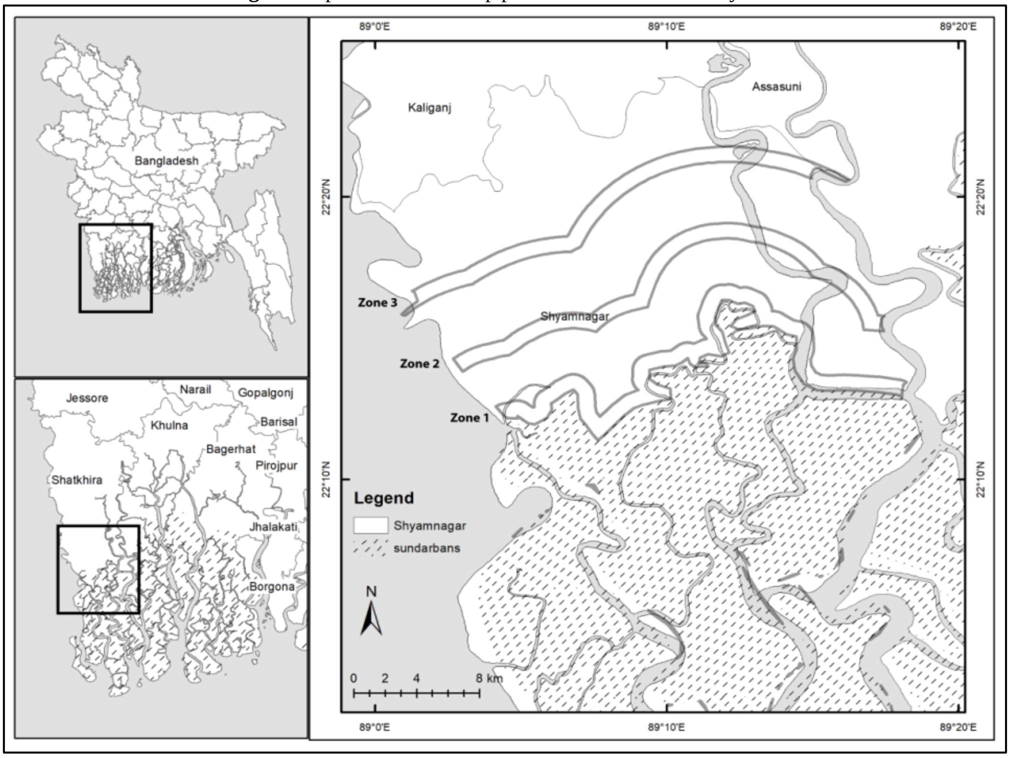

Fig-2. Soil sample collection points from a fish pond

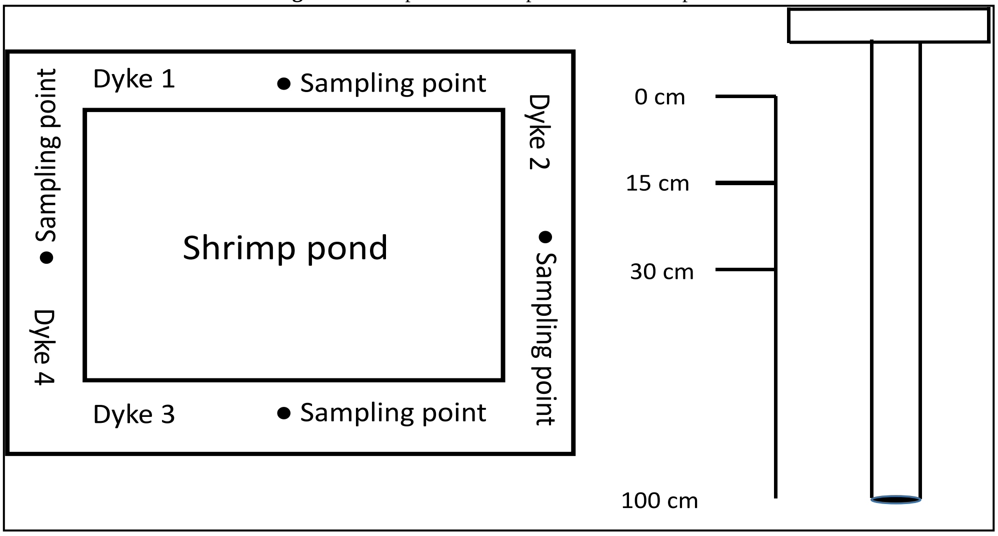

Fig-3. Soil bulk density (g/cm^3) of the study area according to depths and zones. Similar alphabet on the bars and zones showed no significant (p>0.05, DMRT) difference

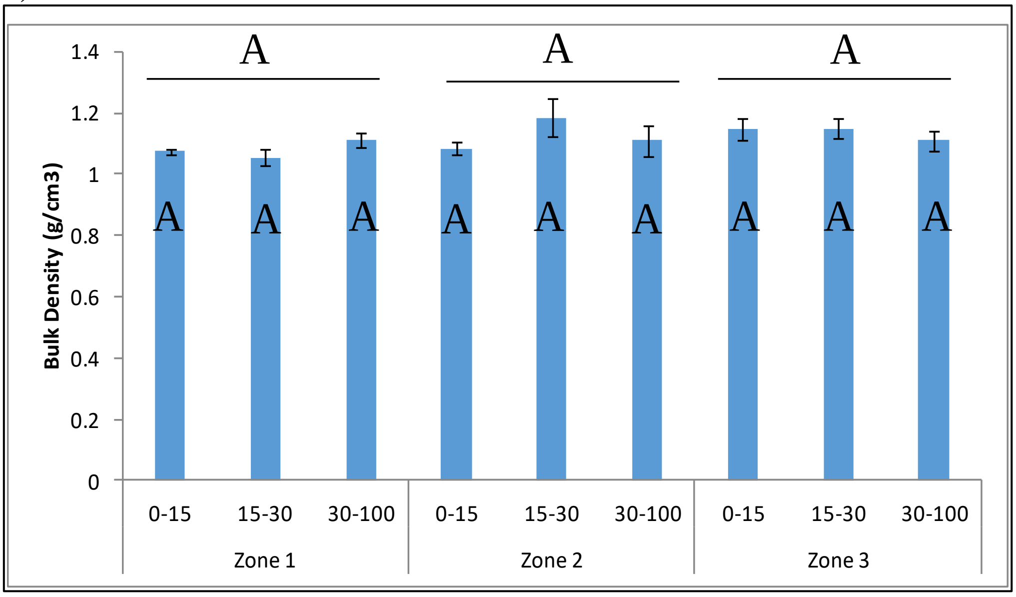

Fig-4. Soil pH of the study area according to depths and zones during the Pre monsoon and Post monsoon season

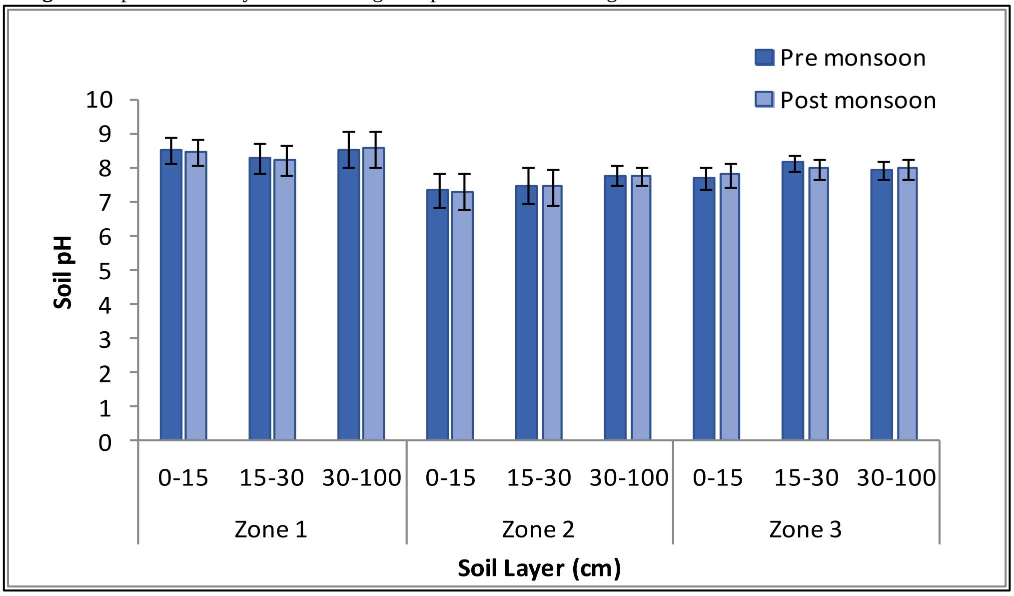

Fig-5. Electrical conductivity of the study area according to depths and zones during the Pre monsoon and Post monsoon season

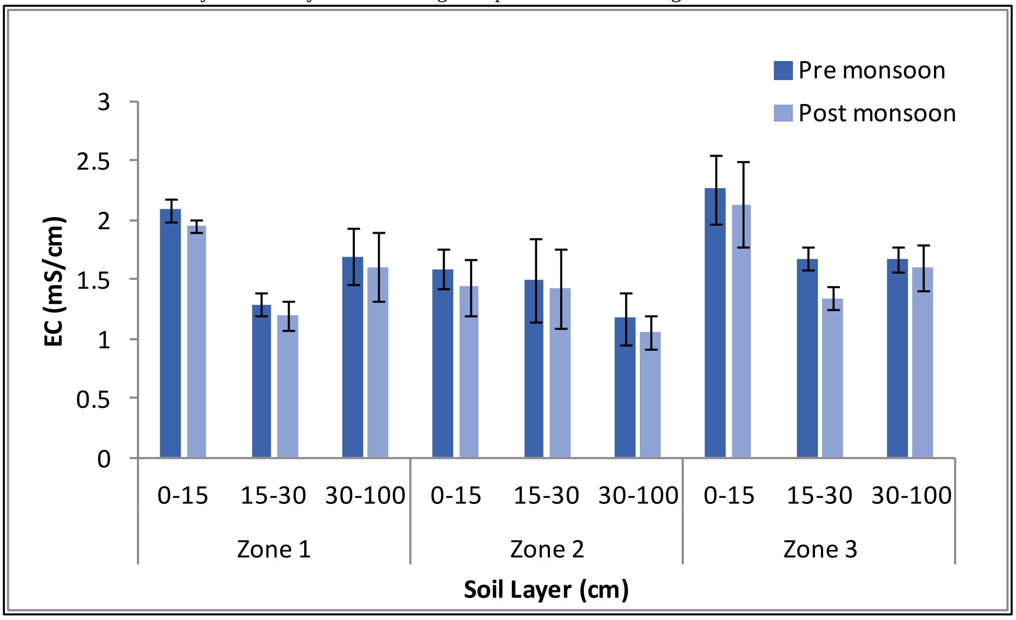

Fig-6. Mean concentration (mg/g) of exchangeable nitrogen of the study area according to depths and zones during the Pre monsoon and Post monsoon season

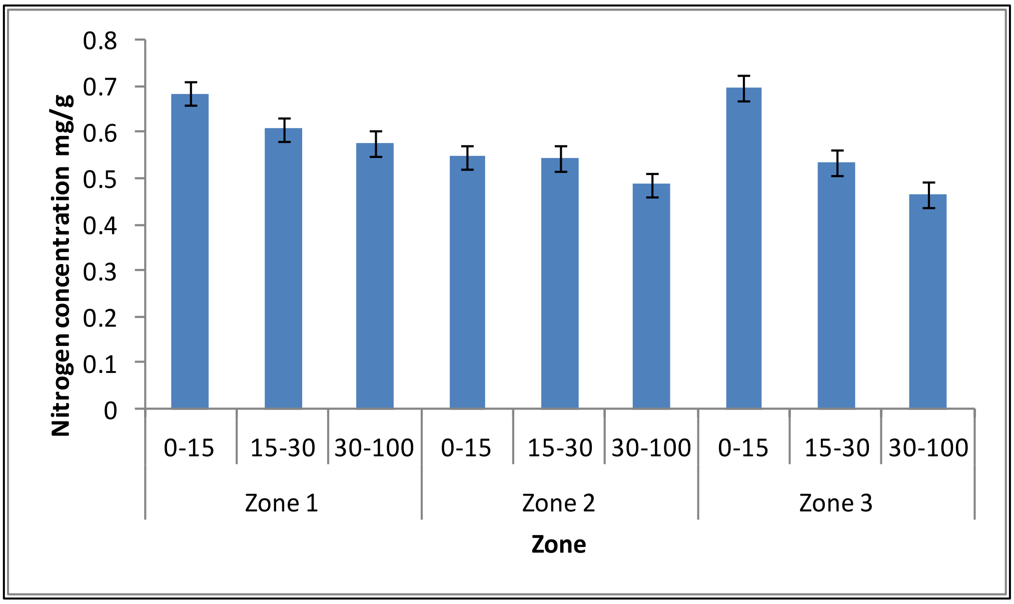

Fig-7. Mean concentration (mg/g) of extractable phosphorus of the study area according to depths and zones during the Pre monsoon and Post monsoon season

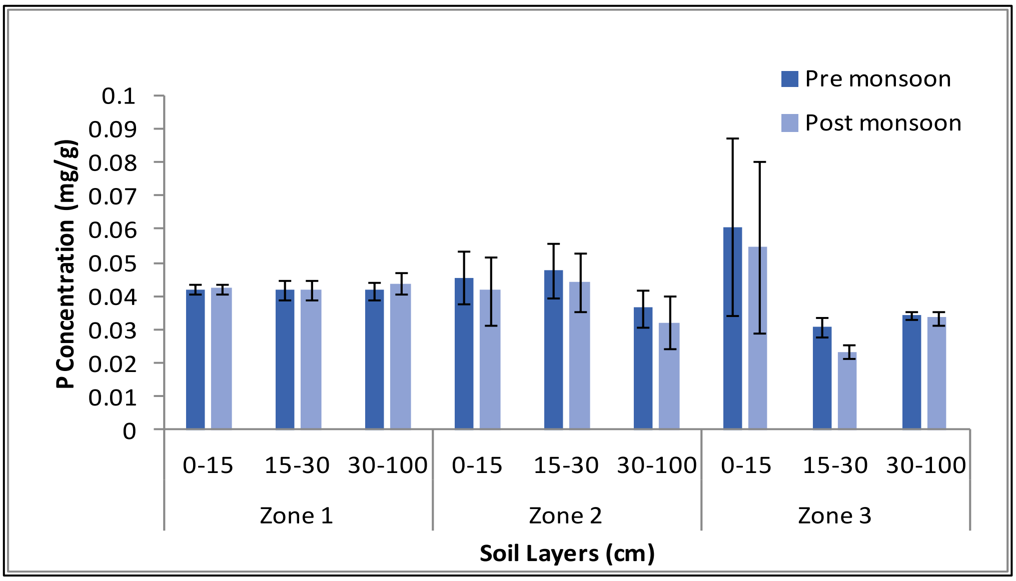

Fig-8. Mean concentration (mg/g) of Potassium of the study area according to depths and zones during the Pre monsoon and Post monsoon season

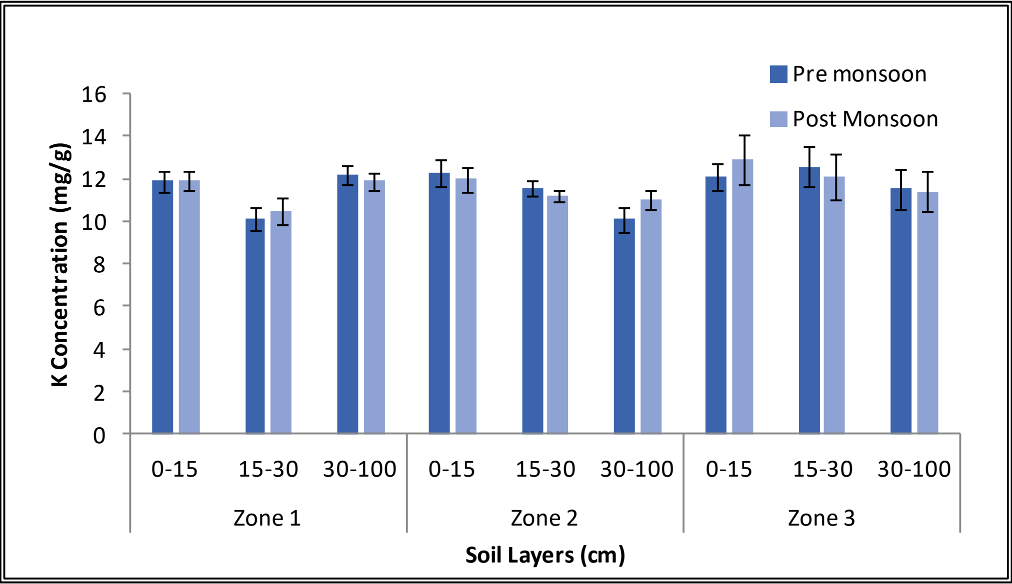

Fig-9. Mean concentration (mg/g) of Sodium of the study area according to depths and zones during the Pre monsoon and Post monsoon season

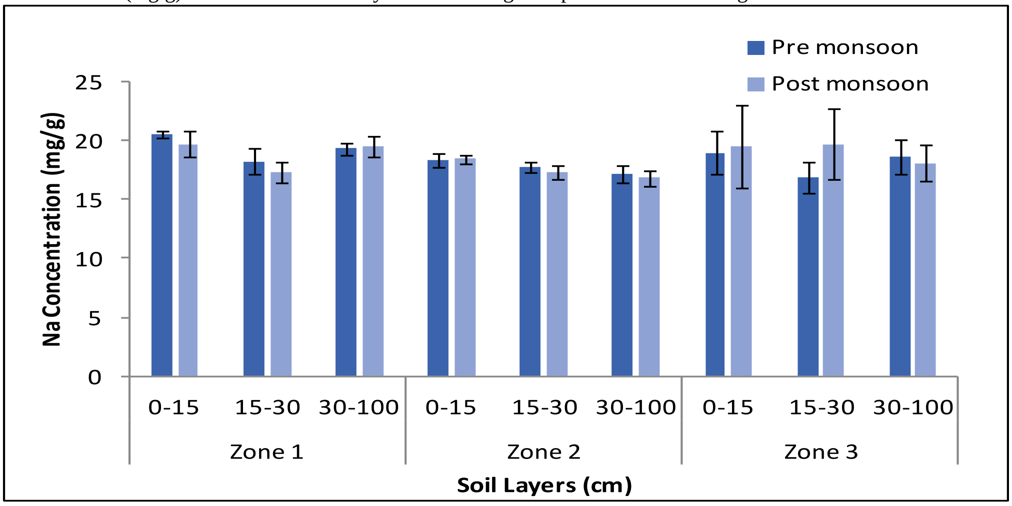

Table-1. Soil texture of the shrimp pond dike of the study area according to Zones.

Zone	Sand (%)	Clay (%)	Silt (%)	Soil texture
1	5.25±0.14	53.67±0.07	41.08±0.14	Silty Clay
2	5.39±0.09	56.94±0.08	37.67±0.12	Clay
3	4.27±0.12	58.18±0.07	37.55±0.12	Clay

Table-2. F value and level of significance for soil parameters according to zones, seasons and soil depths

Parameter	Zones		Season		Layers	
	F value	P > F	F value	P > F	F value	P > F
pH	8.73	0.0004	0.02	0.9020	0.59	0.5579
EC	6.63	0.0024	2.28	0.1360	8.41	0.0006
Organic carbon	0.86	0.433	0.73	0.3973	0.88	0.531
Nitrogen	1.02	0.3731	5.22	0.0256	1.94	0.1604
Phosphorus	0.12	0.8906	0.33	0.5694	2.18	0.1216
Potassium	2.17	0.1219	0.04	0.8479	2.92	0.0608
Sodium	1.82	0.1705	0.01	0.9335	1.71	0.1888

Table-3. Range of nutrients (N, P and K), sodium (Na) and organic carbon concentration in soil and their stock

Elements	Concentration (mg/g)	Stock
Nitrogen	0.50-0.72	52.50-84.96 (kg/ha)
Phosphorus	0.03-0.06	3.15-7.08 (kg/ha)
Potassium	10.5-12.88	1.10-1.52 (t/ha)
Sodium	16.89-20.53	1.77-2.42 (t/ha)
Organic carbon	1.5-2.4 (%)	157.50-283.20 (t/ha)