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ASSESSMENT OF SOIL QUALITY OF COASTAL SHRIMP CULTURE POND AT CHAKARIA, COX'S BAZAR

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Abstract

The present study was carried out to find the status of different soil quality variables of coastal shrimp culture pond at different tidal marks of Chakaria, Cox'Bazar during the period from August 2012 to July 2013. The values of different soil quality variables such as sand, silt, clay, pH, organic matter, NO_2-N, PO_4-P, exchangeable K^+, Soil compactness, bulk density, particle density, porosity and Field water capacity fluctuated between 2.04-43.88%, 30.80-55.36%, 23.98-49.94%, 5.9-8.9, 1.62-9.95%, 4.01-9.92 μg/Kg, 1.14-3.50 μg/Kg, 0.82-1.74 meq/100g, 14.00-31.5 cm, 0.80-1.21 gcm^{-3}, 2.11-2.74 gcm^{-3}, 52.7-65.97% and 44.27-78.18% respectively. Significant differences ($p<0.05$) in the values of sand, silt, clay, bulk density, porosity, NO_2-N and field water capacity of soil of the culture ponds at tide marks were observed. Strong correlations between soil bulk density vs sand (0.863), field water capacity vs clay (0.845), field water capacity vs silt (0.797), exchangeable K^+ vs PO_4-P (0.787), porosity vs field water capacity (0.769) and porosity vs clay (0.705) were found at 0.01% level of significance.

Key words: Soil quality, Shrimp culture, Tidal marks, Correlation matrix

Introduction

Soil composed of mineral matter, water, air, organic matter and living community which vary from one area to another at different periods (Mishra 2000). Soil quality controls pond bottom stability, pH, plant nutrients and salinity of water essential for the progression of phytoplankton which are known as the base of food chain of the fish (Hill 1976 and Ekubo and Abowei 2011). Moreover, soil can hold the water providing various nutrients as natural feed for the cultivated shrimp (Boyd 1995 and Soewardi 2002) and serve as a biological sieved through the absorption of the carbon-based remains of food, fish excretions and algal metabolites (Townsend 1982). The excellence of overlying water is strongly affected by pond bottom soil quality (Singh 1982) and is considered as the "chemical laboratory" of the pond (Adams and Evans 1962). Heavier textured soils pose problems of enlargements of deep cracks when dry resulting leakage losses of water (Welch *et al.* 1977). Sometimes, accumulation and decomposition of the organic matter release organic substances, acids and dissolute minerals harmful for biota (Singh 1982). Due to decomposition of organic matter, soils and sediment become anaerobic inducing

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growth of micro-organisms. These micro-organisms produce ammonia, nitrite, ferrous iron, hydrogen sulfide, methane and other reduced compounds (Patrick *et al.* 1963) which can damage species (Boyd and Musig 1992) because their habitats are closely connected with the sediment. Generally produced ammonia stressed the cultured organisms slowing down feeding activity and growth (Rappaport and Sarig 1975, 1979, Ravch and Avnimelech 1978 and Ram *et al.* 1981) and mortality (Nix and Ingols 1981). Since Chakaria coastal area under Cox's Bazar district is being extensively used as aquaculture farms by the local community, majority of the farmers involved in aquaculture activities have no adequate knowledge on the soil quality of the ponds of the study area. Therefore the research was carried out to find the soil quality variables of culture ponds.

Materials and Methods

The study was conducted at Chakaria Upazila (21°55' 20"-21°34'30"N and 91°56' 20"-91°13'20"E) under Cox's Bazar District in the Division of Chittagong, Bangladesh from August 2012 to July 2013. The selected shrimp culture ponds situated at Chouarfari area under Chakaria Upazila are regularly flooded due to tidal effect.

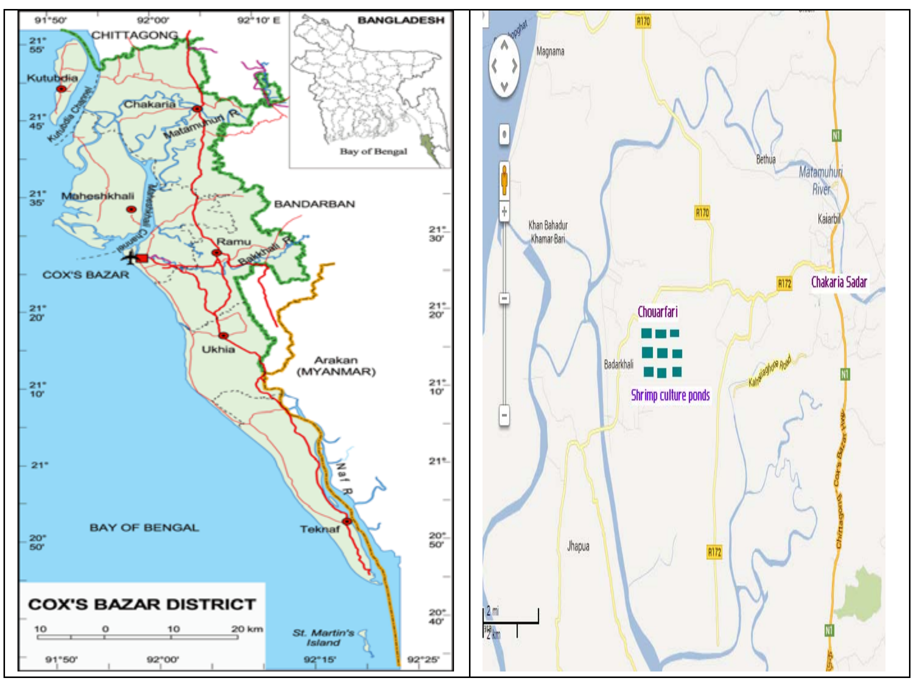

Fig 1. Map of Cox's Bazar District and Chakaria Upazila showing Chouarfari area.

Soil samples were collected from the study area by using transect method along with stratified random technique (Hale 2013). For soil sampling, three transects maintaining distances of 1km were placed at low tide, mid tide and high tide mark. Three culture ponds located in each transect were chosen maintaining an equidistance from one to another for the collection of soil sample. A hand held cylindrical corer (length: 30 cm, diameter: 3.7cm) was used for the collection of three replicated samples from each pond following 'S' shaped design.

The collected soil samples were air dried, powdered and passed through a 0.5mm mesh sieve. Before analysis, soil samples were finally dried in an oven at 105^0C for 24 hr. Soil pH and soil compactness were recorded in-situ condition. Soil pH was determined by soil pH meter. Other soil variables were analyzed at the Laboratory of Institute of Marine Sciences and Fisheries. The analysis for Exchangeable K^+ was done at Soil Resource Development Institute (SRDI). Soil organic matter (SOM) was measured by Walkey and Black wet oxidation method modified by Haq and Alam (2005).

Soil texture (% of sand, silt and clay) in the study area was analyzed by the hydrometer method described by Huq and Alam 2005, modified from Bouyoucos 1936. Phosphate-Phosphorus was determined by the method stated by Murphy and Riley (1961). Soil bulk density, field water capacity and soil particle density was determined by the method described by Huq and Alam 2005. Soil compactness was measured by the method described by Jones and Kunz (2004). Exchangeable K+ was determined by the method described by Peterson (2002). Soil sample was also collected by 5.3cm long and 1.9cm diameter plastic core for bulk density determination (Huq and Alam 2005).

Data analysis: One Way Analysis of Variance (ANOVA) test was performed to find out the significant ($p<0.05$) variation among different soil variables measured from different tidal marks in different seasons. A correlation matrix was executed to show the relationship among different soil variables.

Results and Discussion

The value (average ± SD) of different soil quality variables like texture, soil pH, Exchangeable K+, NO_2-N, PO_4-P, Soil organic matter, Bulk density, Particle density, Porosity, Field water capacity, Compactness of shrimp culture ponds situated at different tidal marks are presented in details in Table 1. The percentage of sand fluctuated between 6.17- 41.09 at the pond of different tide marks throughout the study period. The percentage of silt varied between 32.73- 51.47 and percentage of clay ranged between 25.08- 44.65 at the ponds of different tide marks. FAO (1985) reported that the soil of Ellisha Chakaria was mostly Silty Clay loam and Silty Clay. This is completely acquiesced with the mid tide mark and high tide mark soil texture of the present study.

Table 1. Soil quality variables of the study area.

	Low Tide Mark		Mid Tide Mark		High Tide Mark	
	Dry season	Wet season	Dry season	Wet season	Dry season	Wet season
Parameter	Average ±SD	Average ±SD	Average ±SD	Average ±SD	Average ±SD	Average ±SD
Sand (%)	41.09±1.99	38.98±0.60	14.52±6.52	14.08±6.11	6.67±3.41	6.17±2.81
Silt (%)	32.73±1.53	35.93±1.01	51.47±1.44	48.39±2.07	51.26±4.42	49.19±5.51
Clay (%)	26.18±0.70	25.08±0.77	34.00±5.87	37.53±7.00	42.07±2.48	44.65±4.26
Textural Name	Loam		Silty clay loam		Silty clay	
Soil pH	7.61±0.74	6.71±0.18	8.46±0.39	6.23±0.16	8.58±0.18	6.22±0.20
Organic Matter (%)	4.81±1.39	4.84±1.15	6.59±1.61	6.51±1.21	4.99±1.24	6.32±1.62
Organic Carbon (%)	2.53±0.73	2.54±0.60	3.47±0.85	3.43±0.64	2.63±0.65	3.34±0.85
NO_2-N (µg/Kg)	7.1±0.80	9.1±0.56	6.19±0.79	7.11±0.78	5.35±0.76	6.35±0.12
PO4-P (µg/Kg)	1.71±0.51	2.74±0.31	2.26±0.56	3.11±0.34	1.38±0.17	2.62±0.15
K+ (meq/100g)	0.88±0.06	1.43±0.07	1.39±0.05	1.66±0.05	1.14±0.03	1.61±0.05
Soil compactness (cm)	21.61±3.39	19.67±3.3	21.56±4.69	21.00±5.2	25.00±3.96	23.61±5.27
Bulk Density (gcm^{-3})	1.05±0.15	0.99±0.06	0.90±0.08	0.87±0.06	0.85±0.02	0.83±0.02
Particle Density (gcm^{-3})	2.51±0.17	2.42±0.14	2.40±0.17	2.38±0.18	2.36±0.04	2.34±0.04
Porosity (%)	58.50±5.24	58.99±1.2	62.29±5.95	63.10±5.2	64.01±0.75	64.33±0.59
Field water capacity (%)	51.48±8.18	52.17±7.8	60.94±5.91	62.18±6.2	69.86±5.88	71.68±4.88
NO_2-N (µg/Kg)	7.1±0.80	9.1±0.56	6.19±0.79	7.11±0.78	5.35±0.76	6.35±0.12

The soil pH fluctuated between 6.22- 8.58 of the ponds of different tidal marks. Pond bottom soil pH can range from less than 4 to more than 9 but the best pH for pond soils is considered to be about neutral pH 7 (Boyd 1995). Maximum availability of soil phosphorus usually occurrs at about pH between 6 and 7.5 (CFA 1995). Most soil microorganisms, and especially soil bacteria, function best at pH 7 to 8 (Boyd 1995). Recommended level of soil pH for aquaculture is 7.5-8.5. The percentage of soil organic matter fluctuated between 4.81- 6.59 at the ponds of different tide marks (Table 1). The recommended value of organic matter ranged between 4.0–20.0% suitable for shrimp farming according to feasibility criteria (Poernomo 1992 and Widigdo 2002). In the present study organic matter was found to be within the optimum level. Organic matter was found to increase cation exchange capacity that helped in decomposition of dead algae in pond bottom, consume oxygen and release toxic gas: CO_2, H_2S, and NH_3 (Colt and Armstrong 1981, Boyd 1995 and Camargo *et al.* 2005.)

The Nitrite-Nitrogen fluctuated between 5.35 to 9.1 µg/kg at the ponds of different tide marks. According to Townsend (1982), optimum level of nitrite nitrogen is (5-10) µg/kg, which is similar to the nitrite-nitrogen of the present study. The Phosphate-Phosphorus varied between 1.38 to 3.11 µg/kg at the ponds of different tide marks. Optimum level of phosphate-phosphorus is (0.50-1.50) µg/kg suitable for aquaculture (Townsend 1982). In the present study, amount of phosphate-phosphorus was found to be above the optimum level, which might be due to the deposition of phosphate into the soil which comes with tidal water. The exchangeable K+ fluctuated between 0.88 to 1.66 meq/ 100g at the ponds of different tide marks (Table 1). Exchangeable K+ at the range of (0.6-1.0) meq/100g is high and greater than 1.0 meq/100g. The Soil compactness fluctuated between 19.67 cm to 25 cm at the ponds of different tide marks. According to Municipality of central Saanich Resource Atlas, a clay layer at 20- 50 cm depth will restrict rooting, sub soiling at silty clay loam soil, which represents the compactness and it is similar to the present study. The percentage of soil bulk density fluctuated between 0.83 to 1.05 g cm^{-3} at the ponds of different tide marks. Bulk density of a mineral soil is normally between 1.0 and 1.6 g/ cm^3. Townsend (1982) reported that soils rich in organics and some friable clay may have a bulk density well below 1 g/cm^3 and this result is similar to the present study. The Soil particle density fluctuated between 2.34 to 2.51 g cm^{-3} at the ponds of different tide marks. According to Townsend 1982, the particle density of most mineral soil is in the range of 2.60 to 2.75 g cm^{-3}, which strongly supports particle density of the present study. The soil porosity ranged between 58.50 to 64.33% at these ponds. Total porosity values for unconsolidated materials lie in the range of 25%-70%. Porosity of silt is 35-50% and porosity of clay is 40-70% (Freeze and Cherry 1979). In the present study the porosity of soil is also in the range of 25-70%. The percentage of field water capacity varied between 51.48- 71.68 at these ponds. According to NRCCA (2010), the volumetric soil moisture content residual at field capacity is about 15 to 25% for sandy soils, 35 to 45% for loam soils, and 45 to 65% for silty clay loam soils and it can be more for silty clay and clay type soil. In the present study field capacity at mid tide mark and low tide mark are within the range of NRCCA (2010).

The interrelationship among soil variables found in the present study was measured at different significant levels. Significant positive correlations between soil bulk density vs sand (0.863), field water capacity vs clay (0.845), field water capacity vs silt (0.797), K+ vs PO_4-P (0.787), porosity vs field water capacity (0.769) and porosity vs clay (0.705) were observed at 1% level of significance. These results are similar to the results stated by NRCCA (2010). Moderate positive correlations were found between silt vs clay (0.541), silt vs porosity (0.542), organic matter vs silt (0.452), organic carbon vs silt (0.454). These results are similar to the results found by NRCCA (2010). Strong negative correlations were observed between field water capacity vs sand (-0.931), sand vs clay (-0.878), sand vs silt (-0.874), sand vs porosity (-0.698), silt vs bulk density (-0.741), clay vs bulk density (-0.792), bulk density vs porosity (-0.854), field water capacity vs bulk density (-0.821) at the level $p<0.05$. Rasool *et al* (2014) found the similar result between bulk density vs porosity.

Healthy and maximum growth of culture species in the coastal aquaculture pond depend mainly on the optimum level of sediment and water quality variables. Therefore the present result may help the local community for choosing a suitable culture pond for enhancing their aquaculture production in the Chouarfari area of Chakaria, Cox's Bazar.

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