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Effects of Pond Age and Depth on Bottom Soil Nutrients, pH and Salinity in Commercial Aquaculture Farm

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Abstract: Aquaculture is immensely increasing in Bangladesh to meet the growing fish protein demand due to availability of freshwater and marine ecosystems. This study was conducted to know the variation of physicochemical parameters of aquaculture farm with different pond age and depth. The culture ponds were divided into two distinct groups i.e. 1-5 years group pond and 6-10 years pond for analysis. The ponds were also divided based on depth (i.e. shallow pond (0.5-1 m) and deep pond (2-3.5m). The soil pH of different ponds was recorded and salinity sharply increased with pond's depth and age. Amount of organic matter and organic carbon also highly accumulated with the increasing of pond's age and depth. Sulfur and phosphorus decreases with pond's age and depth but nitrogen and potassium were found similar with age and depth of pond. The results will help us for our further understanding of the influence of pond processes on pond productivity.

Key words: Pond Age · Depth · Soil Quality · Nutrients · Salinity

INTRODUCTION

The pond soil is a function of buffer to the aquatic ecosystem and provides all the important nutrients with water and serves as a biological filter through the adsorption of the organic residues of feed, fish excretions and algal metabolites [1]. Depth of a pond has also an important factor which affects the physical and chemical qualities of water. The optimum level of pH and salinity of overlying water and concentrations of plant nutrients required for the growth of phytoplankton, which is the base of food chain of the fish [2- 4]. Low pH can retard decomposition of organic matter and permits its accumulation and cause a high oxygen demand in the surface layer of soil. Low concentration of nitrogen retards the decomposition of organic matter because soil microorganism can use oxygen from nitrate when molecular oxygen depleted. The accumulation of sediment enriched with nutrients and organic matter are thought to be a major factor causing the intensification of management problems in old ponds.

There have been a few studies linking pond age and bottom soil quality [5, 6]. Considering the above stated facts, the objectives of the current study were to assess soil nutrient content (i.e. organic carbon, organic matter, nitrogen, phosphorus, potassium, sulfur), pH and salinity in different aged and depth of ponds, to compare soil nutrient content, pH and salinity of ponds among different ages and depth of pond and to have a basic knowledge of soil condition of fish pond.

Therefore, this study was carried out to determine the relationships among pond age and depth with some key soil parameters to further our understanding of the influence of pond processes on pond productivity.

MATERIALS AND METHODS

Study Area and Selection of Ponds: Twelve fish ponds have been selected from Sonapur in Noakhali district near the Noakhali Science and Technology University (NSTU) campus. This study area was chosen due to required pond depth and age which were found together and has

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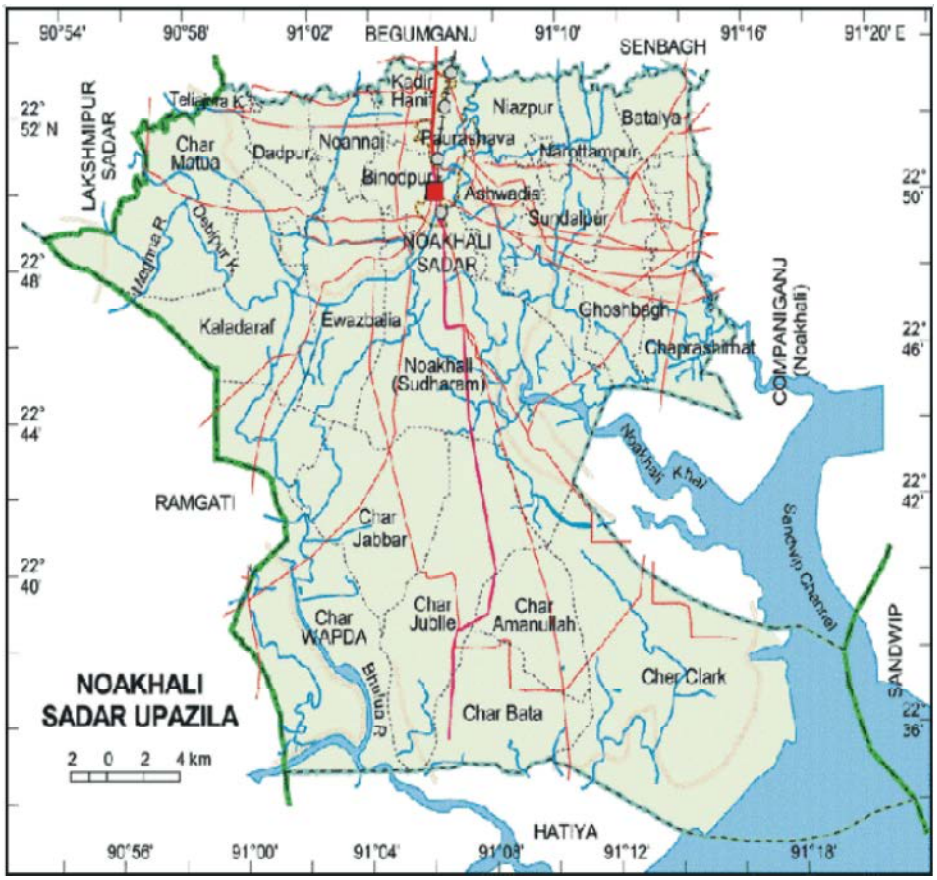

Fig. 1: Location map of the study area.

potential scope for aquaculture expansion (Figure 1). An attempt was taken to select ponds those are similar with respect to stocking densities, fertilization and feeding regimes and other management inputs. Only ponds those were in continuous production were selected. For this experiment, selected culture ponds have been divided into two distinct groups i.e. 1-5 years group pond and 6-10 years pond. We have also divided the ponds in two categories based on depth –shallow (0.5-1m) and deep pond (2-3.5m).

Soil Sample Collection: Bottom soils were collected from the selected ponds manually. To make the sample representative, a number of samples were collected from different places and mixed to have the final sample (Followed by "Z"-shaped sapling method). The samples were air dried, mixed thoroughly and sieved through 10 µm mesh sieve. The composite soil sample was stored in a clean plastic polyethine bag for chemical analyses. The soil samples were sent to the regional laboratory of Soil Resource Development Institute, Gabua, Noakhali, Bangladesh for analysis.

Soil Sample Analysis: The properties studied include pH, salinity, organic matter, organic carbon and nutrients (Total nitrogen and available phosphorus, potassium and sulfur content). The soil samples were analyzed following the standard methods. Soil pH was determined with the help of a Glass Electrode pH meter, the soil- water ratio was maintained as 1: 2.5 as described by Jackson [7]. Soil salinity was determined from electrical conductivity (EC). The determination of electrical conductivity was described by Rayment [8]. Organic carbon (OC) in soil sample was determined volumetrically by wet oxidation method of Walkley and Black [9]. The amount of soil organic matter (OM) was calculated by multiplying the value of organic carbon with the Van Bemmelen factor, 1.724 [10]. The total nitrogen (N) in the soil was determined by Kjeldahl method [11]. Available phosphorus (P) was extracted from the soil by the following the method of Bray and Kurtz [12]. Exchangeable potassium (K) of soil was determined by extraction with 1N ammonium acetate [13] and the ammonium acetate method was developed by Schollenberger and Simon [14]. Available sulfur (S)

content of soil was determined by extracting the soil with sulfur extracting solution and the extraction-turbidity method was described by Fox *et al.* [15]. The collected data were summarized and scrutinized carefully using the following software Microsoft Excel version 13.0 and Statistical Package for Social Science (SPSS) version 20.0.

RESULTS

All the physical parameters and soil nutrients of shallow pond and deep pond as well as in the 1-5 years pond and 6-10 years pond were given in Table 1. The average value of pH, electrical conductivity, organic matter, organic carbon, nitrogen, potassium, phosphorus and sulfur were recorded 7.65, 2.03 dS/m, 2.02 %, 1.19 %, 0.09 %, 0.28(meq/100g), 3.56 µg/g and 441.09 µg/g respectively.

The present investigation was found that soil pH moderately influenced by depth. The soil pH increases with depth of the pond and inverse relation with sulfur (Table 1). The pH of the soil is one of the most important factors for maintaining pond productivity since it controls most of the chemical reactions in the pond environment. Near neutral to slightly alkaline soil pH (7 and a little above) is considered to be the ideal for fish production. If the pH is too low (Strongly acidic), this can reduce the availability of key nutrients in the water and lower pond fertility [16]. The average pH of soil was found almost similar in different categories of pond (Table 1). The average pH 7.65 indicates the basic nature of pond soils. The reason is that farmers continuously use lime to maintain the water quality of these ponds.

Salinity is a major driving factor that affects the density and growth of aquatic organisms' population [17]. According to Meck [18] fresh and saltwater fish species generally show poor tolerance to large changes in water salinity. Often salinity limits vary species to species level. In the present study, we found that pond soil salinity become low with increasing age of the pond (Table 1). On the other hand, salinity of deep pond becomes higher than the shallow pond.

The average electrical conductivity of all selected pond soil was recorded 2.03 dS/m. It is apparent from the present study that salinity of the pond soil rapidly increases with comparatively higher depth but gradually decreases with increasing age of the pond.

In the present study, we found that organic matter sharply increases in bottom mud with age and depth of pond. The composition of the soil bottom is related to organic matter. It is observed that the accumulation of organic matter increases with age and depth of pond. The average accumulation of organic matter lies within 1.76 to 2.51 %.

Organic carbon increases with age and depth of the pond but a little dissimilarity found in (1-5) years ponds. Organic carbon acts as the source of energy for bacteria and other microbes that release nutrients through various biochemical processes. The average percentage of organic carbon recorded within 1.06 to 1.46 %. The reason is that farmers restore the pond bed, dry it and supply comparatively less supplementary feed.

The average nitrogen was recorded 0.09 % in present study. There have no noticeable change according to age and depth of pond. About 99% of the combined nitrogen in the soil is contained in the organic matte (Humus) in the form of amino acids, peptides and easily decomposed proteins. It may also be in the form of inorganic compounds such as NH_4^+ and NO_3 which are utilized by green plants (Phytoplankton). Anaerobic organisms (Bacteria) helps in the decomposition of organic matter into simple inorganic forms forming products such as CO_2, water and ammonia which influences directly or indirectly in pond productivity.

Table 1: Physical parameters and some nutrients were found in the experimented area

	1-5 years pond		6-10 years pond	
Parameters	Shallow (0.5-1m)	Deep (2-3.5m)	Shallow (0.5-1m)	Deep (2-3.5m)
pH	7.29±0.2	7.85±0.3	7.66±0.2	7.84±0.1
ECe (dS/m)	1.58±0.6	2.94±1.2	1.17±0.4	2.43±1.6
Organic matter (%)	1.76±0.5	1.83±0.4	1.98±0.3	2.51±0.4
Organic carbon (%)	1.09±0.2	1.06±0.2	1.14±0.2	1.46±0.2
Nitrogen (%)	0.09±0.03	0.09±0.02	0.1±0.02	0.07±0.02
Phosphorus (µg/g)	4.08±1.4	4.43±0.9	3.57±2.5	2.16±0.1
Potassium (meq/100g)	0.27±0.01	0.23±0.03	0.26±0.06	0.35±0.06
Sulfur (µg/g)	612.30±9.2	424.85±32.6	551.95±19.08	175.24±48.9

Values: Mean ± Standard deviation (M±SD)

Table 2: Pearson Correlation among the physical parameters and nutrients with pond age and depth

	Age	Depth	pH	ECe	O.M	O.C	N	P	K	S
Age										
Depth										
pH	0.373	0.671								
ECe	-0.190	0.714	0.287							
OM	0.535	0.432	0.305	0.301						
OC	0.534	0.384	0.171	0.267	0.973					
N	-0.196	-0.227	-0.189	-0.078	0.219	0.110				
P	-0.596	-0.109	-0.012	0.142	-0.445	-0.511	0.165			
K	0.472	0.398	0.159	0.364	0.597	0.682	-0.380	-0.144		
S	-0.529	-0.851	-0.663	-0.374	-0.533	-0.532	0.399	0.408	-0.505	

** ECe – Soil salinity; O.M – Organic matter; O.C – Organic carbon; N – Nitrogen; P – Phosphorus; K – Potassium and S - Sulfur

The present study identified that comparatively the amount of phosphorus was decreasing with age and depth of the pond though mismatched with deep ponds of (1-5) year pond group. The importance of soil phosphorus for increasing the aquatic productivity is well recognized. It is second only to nitrogen in frequency of use as a fertilizer element. The availability of phosphorus is important to aquatic productivity owing to the fact that PO_4 ions in soil form insoluble compounds with iron and aluminum under acidic conditions and with calcium under alkaline conditions, rendering the phosphorus ion unavailable to water body. Average value of phosphorus recorded 3.56 µg/g and which ranges 2.16 to 4.43 µg/g in different category ponds (Table 1).

The average percentage of potassium of all selected pond was recorded 0.28 (meq/100g). We have found almost similar value in different categories pond. Generally, relatively small amount of potassium is need in fish ponds. Optimum concentrations of this element are unknown. However, it is readily available absorbed by plant tissues and it is particularly effective in stimulating the growth of aquatic flora.

We recorded that sulfur in the pond soil has strongly inverse relation with age and depth of pond. The average sulfur of the all selected pond soil was recorded 441.09(µg/g) but in deep pond of 6-10 years old pond group have very low compare to other categories pond. The reason is that hydrogen sulphid gas concentration found more during pond construction but so long could soon be reduced by oxidizing.

DISCUSSION

In this research, we found that there was some effects of pond age and depth on physicochemical parameters of aquaculture farm. pH was moderately influenced by pond depth. Salinity was increasing with increasing pond depth. There was some dissimilarity found for organic carbon contents in pond soil with changing pond age and depth but organic phosphorus was decreasing with increasing pond age and depth. The average nitrogen and phosphorus was not changed noticeably with increasing pond age and depth but sulfur contents on pond soil was inversely related to pond age and depth. Rahman and Ahsan [19] found field soil pH 7.06 of Atkapalia, Noakhali, that is strongly supported present study. Rahman and Ahsan [19] recorded 2.32 dS/m salinity for crop land in southeastern part of Bangladesh that strongly supported with present study. We found that the presence of salinity in our study because of the following reason. The reason is that this area was reclaimed from the Meghna River. Meghna River is joined with the Bay of Bengal that's why there is some salinity effects presence. Jahiruddin and Satter [20] estimated 3.5 % organic matter of field soil in Noakhali district moderately supported the present study result. The reason is that selected pond farmer restores the pond regularly. BARC [21] recommended that a good soil should have at least 2.5% organic matter. Haque [22] estimated organic carbon (OC) range 0.46-1.8% in coastal regions of Bangladesh that almost support present study result. Boyd [23] also reported that organic carbon value 0.60-1.50 % is highly suitable for aquaculture. Ahmed [6] reported that organic carbon range 0.95 to 1.50 % is the suitable range for aquaculture of Bangladesh. Haque [22] estimated range 0.1-0.3% nitrogen in the coastal region of Bangladesh that supports the present study result. After all nitrogen is a very important element in pond fertility. The nitrogen content in soil 0.2 to 0.5% is good for fish production [24]. Jahiruddin and Satter [20] estimated 4 µg/g phosphorus of field soil in Noakhali district that supported the present study result. Soil phosphorus level below 3µg/g may be considered indicative of poor production and that between 3 and 6 µg/g of average production; ponds having available phosphorus above 6 µg/g are productive [24]. Rahman and Ahsan [19] estimated 0.23 meq/100g potassium at Atkapalia, Noakhali that highly supported present study.

There was significantly positive and negative correlation of soil pH with pond depth and sulfur respectively (Table 2). Soil salinity had significant positive correlation with pond depth but negative with pond age (Table 2). There had significant positive correlation with pond age, pond depth, organic carbon and potassium and negative correlation with phosphorus of organic matter (Table 2). Organic carbon had significant positive correlation with pond age and potassium (Table 2). Phosphorus had significant negative correlation with pond age but positive correlation with sulfur (Table 2). Sulfur had significant negative correlation with both pond age and pond depth (Table 2).

CONCLUSION

Sustainable aquaculture development can bring real and lasting benefits for aqua farmers and dependent communities. There is, therefore, an increasing need for good planning and management of aquaculture in our countries. In the above discussion it has shown that soil pH, alkalinity, organic carbon and organic matter more or less similar with some exception (Sulfur) to the standard level for aquaculture activity in Bangladesh. Public opinion is also more or less similar to the investigation. Considering the results of soil analysis it may be suggested that soil characteristics in the study area seems to be suitable for development of aquaculture. It has been found that very shallow and comparatively deeper ponds are not suitable for commercial aquaculture in this area.

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