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Comparison of soil nutrients, pH and electrical conductivity among fish ponds of different ages in Noakhali, Bangladesh

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Abstract

An experiment was conducted to detect aquaculture pond bottom soil nutrients, pH and electrical conductivity with a view to optimize production and to incorporate the scientific method of fish nursing, rearing and culturing at Noakhali district in Bangladesh. The soil samples were collected from the recently dug ponds (1 - 5 years) and older ponds (> 5 years). Samples were taken from five different spots in a Z shape from each pond and were mixed to get a composite sample. The composite samples from the ponds were collected in polyethylene bags and shipped to the laboratory for analysis. The soil samples were analyzed with respect to pH, electrical conductivity (EC), organic carbon (OC), organic matter (OM), nitrogen (N), phosphorous (P), potassium (K) and sulfur (S). The average value of pH, OC, OM, N, P, K and S were 7.43 ± 0.40, 2.21 ± 1.43%, 1.47 ± 0.53%, 2.52 ± 0.94 µg g^{-1}, 0.126 ± 0.047 µg g^{-1}, 3.84 ± 1.77 µg g^{-1}, 0.191 ± 0.106 µg g^{-1} and 306.72 ± 222.05 µg g^{-1} respectively, in Noakhali. The average EC, OC, OM, N and P contents were found to be higher in Subornachar than those in Sonapur. On the other hand pH, K and S were found to be higher in Sonapur than the values of Subornachar. The pH, EC, OC, OM, N and S contents were found to be higher in new ponds than old ponds whereas P and K contents were found to be higher in old pond than in new pond.

Keywords: electrical conductivity, pH, pond age, soil nutrients

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Introduction

The productivity of a pond or lake depends upon the quality of its water and soil (Biggs et al., 2015). The principal physical conditions such as depth, shore conditions, pressure and movement of water, temperature, turbidity and light are important for aquaculture (APHA, 1992). Similarly the chemical conditions such as oxygen, carbon dioxide, pH, total hardness of water, nitrates phosphates, conductivity, chlorides, and heavy metals are important. Furthermore, the productivity of a pond depends upon a large number of animal and plant communities living in its various zones. Aquatic organisms are dependent on water. Suitable water quality parameters play an important role on adaptability, growth and reproduction (Hubert et al., 1996). In turn, suitable water quality depends on the quality of the total environment of that geographic region. A pH of water 6.5 to 9 is suitable for pond fish culture and a pH above 9.5 is unsuitable because free CO_2 is not available (Banerjea, 1967). High benthic assemblages in pond bottoms with high sand content in ponds and attributed it to nutrient seepage into the under sediment layers (Boyd et al., 2002).

The presence of sulfur in structural and functional components is a very common feature of biological systems (Gomes, 2003). Sulfur is typically involved in redox processes (Falkowski and Raven, 1997). Sulfur was also one of the major sinks for photosynthetically generated chemical energy (Hopkins et al., 1993). If the bottom of a pond is treated properly fish production rises to a satisfaction level. Thus, the most important areas for research require determining these nutrients and parameters.

Materials and Methods

The study was done through experiments and community surveys by semi structured questionnaire. Assessment of the suitability of soil quality was done in a Soil Composition Analysis Laboratory. Physical, chemical, biological and meteorological factors that control water quality were determined by using different instruments.

The study was conducted in commercial fish farms located in south-eastern Bangladesh in the district of Noakhali.

Soil samples were collected randomly from five different spots forming Z-shape, and then mixed. A final sample was taken within the Z-shape and shipped into laboratory by using plastic bag. Sample dried under indirect sunlight. After drying, it was powdered and nutritional properties were measured.

Soil pH was determined by glass electrode pH meter as described by Jackson (1958).The position of the electrode was adjusted in the clamp of the electrode holder. The electrode was immersed into a partly settled soil suspension at a soil to water ration of 1:2.5 and pH was measured. The result was reported as soil pH measured in water.

The EC of collected soil samples was determined electrometrically (in a 1 : 5 soil to water ratio) by a conductivity meter using 0.01 M KCL solution to calibrate the meter following the procedure described by Ghosh et al. (1983).

Organic carbon was determined titrimetrically following Walkley and Black's method as modified by Ghosh et al. (1983).

Determination of organic carbon (OC) is necessary for the estimation of organic matter (OM). The latter is calculated by multiplying organic carbon by a factor of 1.724. The formula is as follows:

$$(OM)\ content = \%\ (OC) \times 1.724.$$

Total N content of the soil was determined by Micro Kjeldahl method where soil was digested with 30% H_2SO_4, and catalyst mixture. Nitrogen in the digest was determined by distillation with 40% NaOH followed by titration of the distillate trapped in H_3BO_3 with 0.01% NH_2SO_4 (Page et al., 1982).

Available soil P was determined by Olsen's methed (Olsen et al., 1954) using a spectrophometer at a 660 nm wave length (Jackson, 1958).

Exchangeable K content was determined with the help of flame emission spectrophotometer using K filters. Percent emission was recorded following the methods outlined by Ghosh et al. (1983).

Sulfur was determined by turbidimetric method (Wolf, 1982) using a spectrophotometer at 420 nm wave length after 20 minutes.

The collected data were summarized scrutinized and ecorded. Microsoft Word and Microsoft Excels were used for data analysis.

Results and Discussion

Soil pH

Soils are referred to as being acidic, neutral, or alkaline (basic), depending on their pH values on a scale of 0 to 14. A pH of 7.0 is neutral; less than 7.0 is acidic; and greater than 7.0 is alkaline (McCauley et al., 2003). The pH has both direct and indirect effects on other variables of the environment. For example, the proportion of total ammonia nitrogen existing in the toxic, un-ionized form (NH_3) increases as the pH increases. In water with low total alkalinity, pH is low resulting in a shortage of inorganic phosphorus and carbon dioxide for plant growth (Boyd and Tucker, 1998). However, in water of low alkalinity, rapid photosynthesis sometimes causes a dangerously high pH. Ponds are often treated with liming materials to increase alkalinity. Thunjai (2002) reported that tilapia ponds in Changrai and Samutprakarn, Thailand had average soil pH of 7.43 and 7.50, respectively. The soil pH was between 6.63 and 9.40 in Changrai and 6.62 and 7.90 in Samutprakarn. Banerjea (1967) suggested that the best pH range for pond soils is 6.5 to 7.5 while 5.5 to 8.5 is the acceptable pH range. Boyd and Tucker (1988) also pointed out that optimum pH for good health and high growth rate of freshwater animals in the range of 6.5 - 9.0. In this current study comparison is made between new pond and old pond bottom surface soil pH. The average pH value of this region was recorded as 7.43 ± 0.40 (Table 1). Analysis results clearly demonstrate that new pond is more basic or alkaline than the old pond although most of the ponds of this study exhibit alkaline condition. Most of the experimental ponds showed almost same and neutral pH value.

Table 1. Average value of pH, EC, OC, OM, N, P, K, and S of different categories of ponds.

Parameters	Age of the pond					
	New Pond < 5 years			Old Pond > 5years		
	Subornachar	Sonapur	Total	Subornachar	Sonapur	Total
pH value	7.45 ± 0.52	7.5 ± 0.33	7.47 ± 0.41	7.06 ± 0.23	7.73 ± 0.19	7.39 ± 0.41
EC (dS m^{-1})	3.34 ± 1.88	2.3 ± 1.22	2.82 ± 1.39	1.30 ± 0.15	1.88 ± 1.38	1.59 ± 0.97
OC (%)	2.05 ± 0.41	1.07 ± 0.19	1.56 ± 0.6	1.79 ± 0.15	0.99 ± 0.27	1.39 ± 0.47
OM (%)	3.53 ± 0.73	1.77 ± 0.45	2.65 ± 1.09	3.08 ± 0.27	1.70 ± 0.47	2.39 ± 0.80
N (μg g^{-1})	0.176 ± 0.04	0.088 ± 0.02	0.132 ± 0.05	0.154 ± 0.01	0.085 ± 0.02	0.119 ± 0.04
P (μg g^{-1})	2.47 ± 0.12	4.31 ± 1.15	3.39 ± 1.24	5.61 ± 1.53	2.97 ± 1.94	4.29 ± 2.15
K (μg g^{-1})	0.09 ± 0.01	0.262 ± 0.02	0.176 ± 0.09	0.104 ± 0.01	0.31 ± 0.085	0.207 ± 0.12
S (μg g^{-1})	235.3 ± 87.5	541.91 ± 98.3	388.6 ± 183.88	40.48 ± 8.17	412.03 ± 192.35	226.25 ± 100.26

Electrical conductivity (EC) analysis

There are many ways that EC can have a direct physiological effect on the aquatic animals although many animals have evolved mechanisms for regulating EC. The standard deviation of 1.88 in the new pond and standard deviation of ± 0.14 in the old pond indicate that the EC variability is much greater in the new old pond. Mean value of new pond (3.348 dS m^{-1}) is higher than the old pond (1.306 dS m^{-1}). According to Gul et al. (2015), the EC of the fish pond was 2.90 dS m^{-1} with in favorable range. It is interesting that the values of old ponds show that all value is close to each other, meaning that values are coming to a stabilizing condition. The average value was 2.21 ± 1.43 dS m^{-1} for all experimental ponds (Table 1).

Organic carbon (OC) analysis

Organic carbon acts as the source of energy for bacteria and other microbes that release nutrients through various biochemical processes. Pond soils with less than 0.5% organic carbon are considered unproductive while those in the ranges of 0.5 - 1.5% and 1.5 - 2.5% have medium and high productivity, respectively. Banerjea (1967) suggest that the acceptable range of organic carbon for aquaculture ponds is 0.5 to 2.5%. The optimal range is 1.5 to 2.5%. According to Boyd (1995), when soil pH is below 7.0 and organic carbon concentrations are above 2.5% (around 5% organic matter) within the S horizon, natural productivity that supports fish growth decreases in ponds. In the current study it was recorded the average OC value 1.47 ± 0.53% for all experimental ponds (Table 1).

Organic matter (OM) analysis

The composition of the soil bottom is related to organic matter. Soil organic matter is a key factor in maintaining long-term soil fertility since it is the reservoir of metabolic energy, which drives soil biological processes involved in nutrient availability. A good soil should have at least 2.5% organic matter, but in Bangladesh most of the soils have less than 1.5%, and some soils even less than 1% organic matter (BARC, 2005). The concentrations of organic matter in aquaculture pond soils range from less than 1% in highly leached mineral soils from extensive pisciculture ponds to over 20% in ponds constructed on organic soils (Boyd, 1995). In the current study the average OC value was recorded as 2.523 ± 0.94% for all experimental ponds (Table 1).

Nitrogen (N) content analysis

An increased availability of inorganic nitrogen in aquatic ecosystems can cause water acidification; eutrophication of fresh and saltwater systems; and toxicity issues for animals, including humans. Eutrophication often leads to lower dissolved oxygen levels in the water column, including hypoxic and anoxic conditions, which can cause death of aquatic fauna. Boyd and Tucker (1998) stated that application of nitrogen to fertilize ponds is usually in the form of urea, which rapidly hydrolyzes to ammonia, salts of ammonium and nitrate, or organic nitrogen in manure. Denitrification is an important pathway of nitrogen removal from ponds. The average calculated value was 0.12 ± 0.047 μg g^{-1} in the current study (Table 1). The mean nitrogen (N) content was higher in the new pond then the old pond. Also the average N content was found to be higher in Subornachar than in Sonapur.

Phosphorus (P) content analysis

Phosphorus can be toxic, but toxicity rarely occurs in nature and is generally not a concern. All algae and plants require phosphorus to grow. Pond sediments interact with the water column affecting the phosphorus cycle in natural waters (Reddy et al., 1999). This interaction is also a major factor in pond aquaculture (Boyd and Musig 1981; Boyd, 1995). The average content value was 3.84 ± 1.77 μg g^{-1} in the current study (Table 1). The average (P) content was higher in the new pond then the old pond. Also the average P content was found to be higher in Subornachar than the value in Sonapur.

Potassium (K) content analysis

Potassium reacts rapidly and intensely with water, forming a potassium hydroxide solution, which is colorless basic and hydrogen gas. Potassium is a dietary requirement for nearly any organism, except a number of bacteria, because it plays an important role in nerve functions (Tucker, 1985). From the standard deviation it is clear that there is no variation in the K contents of new pond. On the other hand that old pond shows some standard deviation. In the current study the average K value was recorded as 0.191 ± 0.106 μg g^{-1} for all experimental ponds (Table 1).

Sulfur (S) content analysis

Sulfur is an essential element for all organisms. Most of phototrophic organisms assimilate sulfur as SO_4^{2-}. The connection between photosynthesis and sulfur is therefore complex and has repercussions on many cell activities. In this current study the average S content was found to be lower in Subornachar than in Sonapur. The average sulfur value of 10 new ponds exhibited higher S contents than the 10 old ponds. Sulfur concentrations above 0.75% are indicative of acid-sulfate soils (Soil Survey Staff, 1994). Such soils tend to be highly acidic (Dent, 1986), and heavy applications of liming materials are necessary to counteract acidity from pyrite oxidation. The average (S) value was recorded for all experimental ponds were 306.73 ± 222.05 μg g^{-1} (Table 1). Likewise, the average value was recorded as 40.49 ± 8.17 μg g^{-1} for the old ponds of Subornachar.

Influence of pond age

Physical, chemical, biological and meteorological factors of ponds were variable in both old and new ages pond. Earlier studies (Tucker, 1985; Thunjai et al., 2004) found that pond age and total and organic carbon in pond soils were correlated, but the relationship did not account for much of the variation in organic carbon concentration. Munsiri et al. (1995) and Tepe and Boyd (2002) found that several soil quality variables increased in pond soils over time.

Conclusion

In the above discussion it was shown that soil pH, alkalinity, organic carbon and organic matter more are or less similar to the standard levels found in Bangladesh aquaculture. Considering results of soil analysis it may be suggested that soil characteristics in the study area seem to be suitable for the development of aquaculture. People of our experimental region are not conscious about pond bottom soil nutrients. Sustainable aquaculture development can bring real and lasting benefits for aqua farmers and dependent communities. If the farmer follows the standard level of soil nutrients and parameter the production will be increased in satisfactory level.

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