ASSESSMENT AND MANGEMENT OF SOUTH WESTERN NIGERIA PONDS FOR SUSTAINABLE AQUACULTURAL PRODUCTION

Aruleba J. O. and Agbebi F. O.
Faculty of Agricultural Sciences, University of Ado Ekiti, Nigeria
E-Mail: funmiomolara@gmail.com

ABSTARCT

Bottom soils of some ponds at the University of Ado-Ekiti were assessed regarding their physical and chemical properties that are important for their suitability evaluation for aquaculture production. The most important characteristics observed for delineating the ponds to their suitability classes are pH, organic carbon, clay content, permeability, bulk density, soil texture, phosphorus and nitrogen content etc. The bottom soils are acidic, organic matters are moderately present in pond 1 and 2 while deficient in pond 2 and 4. Total nitrogen values are low with a range between 0.020 to 0.2% and fluctuated irregularly with depth. Sand content dominates the surface soils. The bottom soils were found to be least suitable for aquacultural production. The major limitations of these pond soils are soil reaction (pH), poor texture and fertility (phosphorus and nitrogen content). The management techniques to improve the pond qualities for optimum aquaculture productivity were also discussed.

Keywords: fish, aquaculture production, ponds, bottom soils, assessment, suitability and management.

INTRODUCTION

Fish is an essential food requirement as being the good and cheap source of high quality animal protein considered as very vital for growth, good health and very much acceptable to man. The fisheries management is a systematic procedure of rational exploitation as the fishery resources are exploited, protected, conserved and economic benefit accrued to man. It also involves the combination of knowledge, socio- physical biological and natural science with in built model of fisheries population such that maximization of the net economic yield result creating a fish pond can be an easy and rewarding venture. The success of the fish pond relies greatly on the habitat you provide. The type of habitat you create will determine the type of fish that it can support. Adequate supply of good quality of fresh and salt water that is rich in oxygen, nutrient and free from pollutants must be available year round. The success of an aquaculture pond depends greatly on the good management of pond soil.

However, in the discussion of management of pond bottom, it refers to the sediment layers in the bottom of an aquaculture pond as pond soil. Water quality management has been considered one of the most important aspects of pond aquaculture for many years, but less attention has been given to the management of bottom soil quality. There is increasing evidence that the condition of pond bottoms and the exchange of substances between soil and water strongly influence water quality. It has been suggested that organic matter increase in bottom soils as pond, age until an equilibrium organic matter concentration is attained (Avnimelechi, 1984, Boyd,1995) Studies by Munsivi *et al*., 1995,1996) showed that new ponds have lower concentration of soil O.M than the older pond. However, no studies have shown the suitability rating of a pond and the management techniques in its relation to its bottom soils limiting factors. This information is needed to properly assess the pond to their suitability classes on the basis of their physical, biological and chemical qualities.

Research conducted in ponds at PD/ACRSP sites and vicinity has only demonstrated that aquaculture ponds typically develop profiles is discussed by (Munsiri *et al.*, 1995) and attain equilibrium concentration of soil organic matter within a few years. A procedure for classifying pond soil based on the characteristics of horizons has been formulated (Boyd *et al.*, 2002) but pond soil suitability evaluation is beyond the scope of this report. More over monitoring of soil and water quality condition can be valuable in aquaculture pond management of their physical and chemical quality limitation, which can aid and predicts the efficient techniques in the management of the pond bottom soil.

Therefore, the objectives of this study are:

a) To determine the physical and chemical characteristics of the ponds bottom of the study area;
b) To assess and classify the ponds into their various suitability classes; and
c) To recommend pond bottom soil management technique that considers limitations peculiar to each pond class.

MATERIALS AND METHODS

Study area

The study area (University of Ado- Ekiti Teaching and Research Farm) lies between Latitudes 7^{o}31 and 7^{o}49N and covers an area of about 20 hectares. The area experiences a tropical humid climate with distinct wet and dry seasons. The dry season begins from November and lasts till March. The rainy season is divided into two by a dry spell in late July to August. Mean annual total rainfall is about 1367mm received in average of 112 days. Mean annual temperature is 27°C with a maximum range of 9^{0}C. The soils are formed by the pre-cambium basement complex. The soil was an Oxic- Tropudalf- USDA Taxonomy or Ferruvic Luvisol- FAO/UNESCO.

The soil was well drained with appreciable amounts of quartz, stones, gravels and ironstone concretions down to 50cm. The mean annual total number of sunshine hours is about 2,000hrs with mean daily sunshine of about 5hrs while mean annual radiation is about 130kcal/cm^2. The area attains a maximum elevation of about 730m and relative relief of about 395m. The vegetation of the area is bush re-growth, grasses, creepers. Crops that are mostly cultivated include yam, cassava, rice, maize, vegetables and plantation crops like cocoa, oil palm and kolanut etc.

Soil mapping and sampling

A total of 4 different potential ponds at different locations at the University of Ado-Ekiti Teaching and Research Farm were selected. Each pond has a diameter of about 7 meters. The ponds were drained at the peak of dry season towards the end of March. Samples were taken in each of the ponds along an S-shape pattern to a depth of 5cm. About 10 equal volumes of samples were collected in each of the pond and are thoroughly mixed to provide a single composite sample for analysis.

Laboratory analysis

Soil samples were air dried and made to pass through 2mm sieve. Particle size and density analysis was according to the hydrometer method of Bouyoucos (1951) using sodium hexametaphosphate. Soil pH determination was at a ratio 1: 1 in distilled water. Organic carbon was determined by Walkey Black method and available P by Bray P, method. Total Nitrogen was determined following IITA, 1976 procedure.

Pond suitability assessment

The potential ponds were classified into a suitability classes by matching their characteristics with quality pond soil requirement of the tropical humid region (Aruleba, 2007). The suitability of the pond is that indicated by its most limited characteristics. The principle of limiting condition is simplest method with logic to its credit. It takes the least assessment as limiting. For example, if there are four important soil qualities rated respectively as $S_{1,}$ S_2, S3, and $S_{4,}$ the overall suitability is indicated by the quality assessed as S_4. The index of productivity a pond soil can be actual and potential. The actual productivity is the current position of the pond on assessment while the potential productivity of the pond is the status of the pond on management and correction or modification deficiency parameter that makes the ponds less suitable.

RESULTS AND DISCUSSIONS

Soil properties

The soils of the study area are developed from granitic materials (Fasina *et al*., 2004). The soils are sandy texturally in texture and structural are loosely packed which result in abundant large pore spaces. The sand content was high between 54 to 75.2%. The effective soil depth was relatively high ranged between (0-110cm). The pond bottom normally is subsoil low in organic carbon concentration between (0.19-2.21%) and the pH was low, between (4.5-5.5) and clay content relatively high between (11-25%), the ponds were moderately drained at peak of dry season when the soils were examined. The soils were leached especially at the lower horizon. The pond soils were classified as: Typic halaquet, Typic Endoquet, Plinthic acrudox and Plinthic Hapludox (USDA 2003) for the four pond soils respectively and are in line with the report of (Fasina *et al.*, 2004)

Pond suitability assessment

The following established soil qualities were taken into consideration in assessing the suitability of the ponds; organic carbon, pH, clay percent, soil texture, permeability, bulk density, effective soil depth. Soil nutrients content such as phosphorus and total nitrogen. The soil requirement (soil qualities/characteristics) for grouping ponds into suitability classes are given in Table-1. The matching of the soil qualities with characteristics of the ponds (Table-2) produced the various suitability classes for the pond production capabilities given in (Table-3). The data in Table-3 indicated that the ponds are least suitable due to one or more parameter limitations. Nearly all the ponds are inadequate in terms of current suitability and adequate in terms of potentials suitability of the ponds. This is because the ponds soils fertility (organic carbon, P, N, pH) pond soil may need some inorganic and organic fertilizer to supplement the current status of the fertility and other modifiable soil parameter to sustain the optimum production of the ponds.

It is clear from the data that organic carbon; clay content and P^H are the major constraints to poor performance of the ponds. These constraints are responsible for classifying the ponds to be least suitable for aqua cultural production. The ponds can be improved to be Highly Suitable (S_1) or Moderately Suitable (S_2) by ameliorating the soil parameters that are deficient.

Management of the ponds for optimum production

Pond I and II were currently least suitable (S_4) principally due to low pH and thus can be improved to be highly suitable (S_1) by the application of agricultural limestone which would increase the soil pH, increase concentrations of total alkalinity and total hardness in waters it would also increase the availability of inorganic carbon for photosynthesis and buffer water against inside diurnal changes in pH. The total nitrogen level that was low, which is one of the two most important nutrients in pond aquaculture. This would invariably limit the phytoplankton growth. This can be enriched by adding fertilizer, manure and feeds to the pond. Fertilizer nitrogen usually is in the form urea or ammonium and urea quickly hydrolyses to ammonium in pond water. Ammonium may be absorbed by phytoplankton converted to organic nitrogen and eventually transformed into nitrogen of fish protein organic nitrogen in plankton and in aquatic animal feaces may settle to bottom to become soil organic nitrogen. To maintain adequate nitrogen level in the ponds, efforts should be made to prevent loss of nitrogen through overflow, drainage for harvest, seepage, ammonia volatilization, denitrification and accumulation in the bottom soil.

Ponds III and IV were also least suitability due the soil reaction and fertility limitation. The fertility limitation (N and P) in pond IV can be improved for Nitrogen as discussed in for pond I and II above and the P deficiency must have been due to acidity of the pond for Phosphorous enrichment fertilizer such as Calcium or Ammonium phosphate can be added into the pond. Pond soil strongly adsorbs phosphorus, and the capacity of pond soil to adsorb phosphorous increasing clay content (Boyd and Munsiri, 1996).

From the Total phosphorous present in the ponds, only the loosely bound phosphorous i.e. water soluble ones only available for aquaculture. The pH of the pond must also be monitored to neutral to increase the availability of P in the pond. Boyd (1995) indicated that soils that are near neutral to in pH have less capacity to adsorb phosphorous and a greater tendency to release P than do acidic or alkaline soils. Apart from this p losses through overflow, and drainage seepage and uptake by mud should also be controlled. Clay materials of up to 20-30% also be apply after the construction of the pond to sealed up the macropores that would have caused seepage, this is in line with (Boyd and Bowman, 1997). This would go a long way to solve the problem of clay content limitation. Though clay content as low as 5 to 10% is preferable for construction of embankments (McCarthy, 1998).

Table-1. Soil quality requirement for pond productivity.

Parameter	**Critical level**	**Least/Not suitable** (S_4)	**Marginally suitable** (S_3)	**Moderately suitable** (S_2)	**Highly suitable** (S_1)
Org C (%)	1-2	<1	1-2	2-3	>3
pH	7.5	<6.8	6.8	6.9-7.5	>8
Clay %	20	<5	10	11-19	>20
Permeability (cm/hr)	10	<5	5-10	10	>10
Bulk density (g/cm^3)	1.4	>1.2	1.25-1.4	1.4	>1.4
P (mg.kg^{-1})	8	<6	6-7	7-8	>8
Total N (%)	0.15	<0.08	0.08-1.0	0.1-0.13	>1.5
Soil texture	SCL, L	LS, S	L	SL, SCL	CL
Depth (cm)	75	<50	50-75	75-100	>100

Table-2. Soil qualities of the ponds in University of Ado Ekiti Farm.

Soil qualities	**Pond I**	**Pond II**	**Pond III**	**Pond IV**
Org C (%)	2.21	2.8	1.7	0.19
pH	5.1	4.5	5.5	5.4
Clay %	25	30	11	7.4
Permeability (cm/hr)	12	11	10	5-10
Bulk density (g/cm^3)	1.3	1.4	1.3	1.1
Soil texture	SL-CL	CL-C	SL-LS	SL-LS
Effective soil depth (cm)	5	110	95	100
P (mg.kg^{-1})	14.3	11.9	10.3	4.1
Total N (%)	0.09	0.21	0.14	0.02
Drainage class	poor	poor	imperfect	imperfect
Slope (%)	3.5	5	5	3
Structural stability	high	high	high	high
Sand (%)	66	54	68	75.2
Silt (%)	14	16	21	17.4

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Table-3. Current and potential suitability productivity of ponds of the University of Ado-Ekiti.

	Pond I	Pond II	Pond III	Pond IV
Org C (%)	S_2	S_2	S_3	S_4
pH	S_4	S_4	S_4	S_4
Clay %	S_2	S_1	S_3	S_3
Permeability (cm/hr)	S_1	S_1	S_2	S_3
Bulk density (g/cm^3)	S_3	S_2	S_3	S_4
P (mg^{-kg-1})	S_1	S_1	S_1	S_4
Total N (%)	S_3	S_1	S_2	S_4
Soil texture	S_1	S_2	S_2	S_2
Effective soil depth (cm)	S_2	S_1	S_2	S_2
Current suitability	$S4_r$	$S4_r$	$S4_{cr}$	$S4_{fcr}$
Potential suitability	S_1	S_2	S_2	S_2

Key
S_1 high suitable
S_2 moderately suitable
S_3 marginally suitable
S_4 least/not suitable
S_{4cr} least suitable due to clay content and soil reaction limitation
S_{4cf} least suitable due to fertility status and clay content
S_{4r} least suitable due to soil reaction limitation.

CONCLUSIONS AND RECOMMENDATIONS

Ponds I and II are least suitable in terms of productivity with the soil reaction (soil pH) as the major limitation while pond III and IV are also least suitable as a result of clay content, soil reaction and fertility limitation. Fertility would lead to N and P nutrient deficiency for pond IV. And in other to improve the pond from least suitable ($S_4$$^)$ to high suitable (S_1) optimum productivity, a fertilizer programme, to raise the level of N and P is necessary and application of clay to pond bottom during construction. In general, for all the ponds, the pH of between 4.5-5.5, The agricultural limestone dose of 2,500kg/ha is recommended and these should be spread uniformly over bottoms of empty pond or alternatively, it may be spread uniformly over water surfaces. Agricultural limestone should be applied at the beginning of the crop and it should be applied at least one week before fertilization is initiated.

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