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A Review of Fishpond Soil Management Principles in Nigeria

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Abstract: The suitability of sites for culture fisheries depends on the soil. There is therefore the need to have proper background on the nature and properties of soils. The pond oils, soil functions in fish pond, soil characterization, components and soil mineral constituents, oil profile soil classification, soil fertility, nutrients, primary and secondary nutrients, soil organic matter, common soil problems, field and laboratory methods in acid sulphate soil identification, management of acid sulphate soil conditions, lime requirements for soils, alkalinity/sodicity, salinity, excess organic matter, soil sampling and analysis are reviewed in this article to provide the needed background in soil for effective culture fisheries management and practices.

Key words: Common soil problems, fish pond soil, pond soil analysis, pond soil management, soil properties

INTRODUCTION

The nature of a particle soil type depends on its physical properties and nutrients content (George *et al*., 2010). The nutrient content of soils is determined by fertility test. A soil fertility test involves principally, the determination of the various nutrients present and the levels of availability of each of the nutrients. Nutrient problems are diagnosed from the tests. Improvement of nutrient level of pond soils involves the addition of fixed amounts of lime, fertilizer and manures (USEPA, 2002).

The most obvious function of the pond soil is that it holds water; it is the pond substrate, and dyke building materials. Soil quality is an important factor in fish pond productivity as it controls pond bottom stability, pH and salinity. This means that pond soil can regulate the quality of the overlying water (Hill, 1976). Moderately heavy textured soils, because of, their surface area and high surface charge density, posses the above characteristics. Too heavy textured soils such as pure clay are satisfactory as they have high adsorption property and thereby act as a sin k for nutrients which may not be released to the overlying water. In general moderately heavy textured soil having pH, moderate organic matter content and low salinity levels are desirable for fish ponds (Welch *et al*., 1977).

The fish pond bottom is made up of sediments. Sediment is the loose sand, silt and other soil particles that settle at the bottom of a body of water (USEPA, 2002). It can come from soil erosion or from the decomposition of plants and animals. Wind, water and ice help to carry these particles to rivers, lakes and streams. Sediment strata serve as an important habitat for the benthic macro invertebrates whose metabolic activities contribute to aquatic productivity (Abowei and Sikoki, 2005). Sediment is also the major site for organic matter decomposition which is largely carried out by bacteria. Important macro-nutrients such as nitrogen and phosphorous are continuously being interchanged between sediment and overlying water (Abowei and Sikoki, 2005)

The type and intensity of agricultural land use determine sediment load which play a role in determining the insects which survive in a stream (Dance and Hynes, 1980). Intensive agricultural land use produces modifications which reduce the variety of macro-invertebrate taxa. Agricultural land drainage includes channelization of water courses and Hill (1976) points out that such drainage schemes can have a considerable impact on hydrology, sediment load, water temperature, chemistry and aquatic biology. Welch *et al*. (1977) found that fish and benthos were less abundant in streams near farms than in those flowing through natural and clear-out forests and they stated that chemical contamination and sedimentation had caused the reduction. Dance and Hynes (1980) stated that a comparison of historical and present day conditions indicates that modifications of the drainage basin have produced drastic effects on the stream which flows through the most intensively farmed basin.

Land activities may introduce large amounts of sediment into nearby streams and rivers (David *et al*.

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1981). Sediment input may impact stream communities through a variety of direct and indirect processes (Oschwald, 1972), including reduced light penetration, smothering, habitat reduction and introduction of absorbed pollutants (pesticides, metals, nutrients). Sediment addition has been found to affect benthos (Rosenberg and Snor, 1975). The effect of sediment addition is simply to reduce available habitat area (David *et al*., 1981). The structure of the sediments in the intertribal zone plays a major role in the distribution of the organisms that live in or on them (Barnes and Hughes, 1988; Ajao and Fagade, 1991; Khan *et al.*, 2003; Atabatele *et al.*, 2005). Benthic organisms show habitat preference for specific types of sediment (Atabatele *et al.*, 2005). The Physico-chemical parameters of the sediments such as salinity, dissolved oxygen, pH, and organic carbon could also influence the occurrence and abundance of species distributed in them (Mclusky and Eliot, 1981).

Mineral soils are often composed of inorganic particles of varying sizes called soil separates. The relative proportions of the various separate or size groups of individual soil grains in a mass of soil is referred to as soil texture. The soil texture specifically refers to the proportions of sand, silt and clay below 2000 μm (2 mm) in diameter in a mass of soil (Esu, 1999). Sand is generally coarse and gritty, silt is smooth like flour and clay is sticky and plastic when wet. The texture class determines the microbiological population of a soil and hence the biological and biochemical reactions taking place in such a soil (Esu, 1999).

Excess nutrients especially phosphates, sulphates and nitrates are classified as pollutants in waste water. Large tonnage of phosphate enters rivers and lakes through super phosphate fertilizer washed from soil and from chemicals used to improve the performance of detergents (Abowei and Sikoki, 2005). Phosphate is considered a pollutant principally because of Lake eutrophication resulting in algal bloom (Odiete, 1999; Abowei and Sikoki 2005). Braide *et al*. (2004) in George *et al*. (2010) reported range values of pH (6.9±0.07-7.8±0.14), Sulphate (36.7±9.23-92.9±5.62 mg/kg), Nitrate (0.62±0.28-2.83±0.13 mg/kg,), Total phosphorus (0.29±0.05-244±10.8 mg/kg), total hydrocarbon content (49.04±8.20-412.64±29.05 mg//kg) and mean conductivity level ranged between 79.0±1.07-225.0±4 μs/cm. Downstream stations recorded higher conductivity in the dry season than wet season. Conides and Parpoura (1997) attributed increase or decrease in hydrocarbon concentration to oil spillage rather than climatic conditions. The presence of hydrocarbon has been shown to have adverse effect on phytoplankton community structure and abundance Chinda and Braide, (2003).

The granulometric and mass properties of lake and marine muds are similar, although lacustrine sediments at a given depth are typically finer grained than marine sediments because of lack of tidal currents and higher sedimentation rates. Problems linked to the toxicity of freshwater sediments are the subject of increasing attention on the part of water managers (Literathy and Csanyi, 1994; Seymore *et al*., 1994; Johansson Anderson, 1995; Lim and Kiu, 1995). Prygiel *et al*. (2000) reported that management of contaminated sediments becomes a crucial problem due to past and present industrial activities. Physically complex substrate types (leaves, gravel or cobble, macrophytes, moss, wood) generally support more taxa than structurally simple substrates (Hawkins 1984; Hubert *et al.*, 1996) RPI, (1985), Chinda *et al*. (1999) and Chinda and Braide (2003) have reported low nutrient level for the Niger Delta river system.

Exception of sulphates, the bedrock of the Niger Delta drainage basin is not essentially rich phosphate and nitrate. In order to make decisions on the suitability of sites for culture fisheries, there is need to have proper background on the nature and properties of soils (Esu, 1999). This article reviews the pond oils, soil functions in fish pond, soil characterization, components and soil mineral constituents, oil profile soil classification, soil fertility, nutrients, primary and secondary nutrients, soil organic matter, common soil problems, field and laboratory methods in acid sulphate soil identification, management of acid sulphate soil conditions, lime requirements for soils, alkalinity/sodicity, salinity, excess organic matter, soil sampling and analysis are reviewed in this article to provide the needed background in soil for effective culture fisheries management and practices to provide the needed background for the management of culture fisheries.

THE POND SOILS

A few organisms spend much of their lives suspended in the air, and many spend their entire lives suspended in water (Abowei and Sikoki, 2005). But most land organisms and many aquatic ones spend much of their time attached to or moving upon a solid surface or substratum. The characteristics of that substratum are important components of the organisms' physical environment. Plants, for example, are often very sensitive to small differences in soils (David *et al*., 1981). These tend to vary in many characteristics, such as soil depth, physical properties, chemical content and origin. A vertical section of soil usually shows a thin layer of partly decomposed plant litter on the surface; a layer of top soil, usually well aerated and containing much organic material; a layer top soil, usually well aerated and containing much organic material, a layer of subsoil,which is less favorable for root growth (Fig. 1); and layers of parent material usually rock in various

Fig. 1: Fish pond soil less favourable for root growth

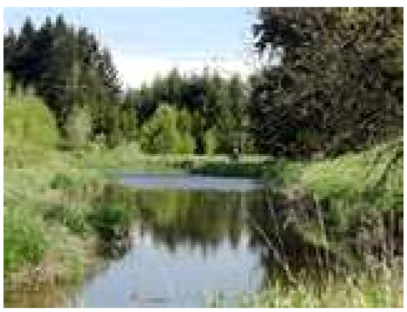

Fig. 2: Fish pond soil favourable for root growth

stages of weathering from which the soil particles are derived (Dance and Hynes, 1980).

The thickness of the topsoil is of great importance in determining plant growth. (Fig. 2) The composition of the topsoil is also of great importance. Most soils are a complex of mineral particles, organic materials, water, soluble chemical compounds, and air. In this complex, the dominant components are the mineral particles, which are composed largely of compounds of silicon and aluminum. They vary in size from tiny clay particles to coarse sand grains. One classification, according to the diameter of the particles is as follows: Sand (0.05-2.00 mm), Silt (0.002-0.05 mm) and Clay (less than 0.002 mm) (David *et al*., 1981).

The proportion of clay, silt and sand particles in any given soil determine many of its other characteristics. For example, sandy soil that contains less than 20% of silt and clay particles, have many air-filled spaces, but they are so porous and their particles have so little affinity for water that water rapidly drains through them and they are unsuitable for growth of many kinds of plants. As the percentage of clay particles increases, the water retention of the soil also increases until, in excessively clay soils, the drainage is so poor and the water is held so tightly to the particles that the air spaces become filled with water. Few plants can grow in such waterlogged soil (Fig. 3) (David *et al*., 1981).

Although different species of plants are adapted to different soil types, most plants do best in soils of the type known as *loams* (Fig. 4), which contain fairly high percentages of each size particle (e.g., 24% clay, 29% silt, 30% fine sand and 17% coarse sand). In such a soil, there is no excessive drainage, good aeration; the soil particles are surrounded by a shell of water, but are numerous air filled spaces between them (Esu, 1999).

Loams also contain considerable amounts of organic material (roughly 3-10%), mostly of plant origin. As this material decomposes, inorganic substances required for good plant growth are released into the soil. The organic material, contributes to soil fertility. It also plays another very important role. Since it has a rather porous spongy texture, it helps loosen clay soils and increases the proportion of pore spaces, thus promoting drainage and aeration (Esu, 1999).

This is particularly true when the organic material is in the form of humus, which is composed mostly of decomposition products from cellulose and lignin. It is interesting that humus has the opposite effect on sandy soils, where it tends to reduce pore size by binding the sand grains together, thereby increasing the amount of water held in the soil (Esu, 1999).

The proportion of clay particles is not only important in determining the physical structure of soils, its aeration and water holding capacity; it is also important in determining the amounts and the availability to plants of certain soil nutrients. This is in part because of the influence of the clay particles on water movement. If for example, water percolates downward through the soil very rapidly and in large quantities, it will tend to leach many important ions from the soil, carrying them deep into the underlying rock layers, where roots cannot reach them. Nitrate ions are especially susceptible to leaching. Sulphate, calcium, and potassium ions may also be rapidly removed from the soil (Seymore *et al*., 1994).

Excessive removal of calcium is not good because it tends to make the soil become more acidic. Although many plants grow best in slightly acidic soils, most plants do not do well in strongly acid ones. However, some species such as Rhododendrons and Crabbiness prefer very acidic conditions. The acidity of the soil influences the availability of iron, manganese, phosphate, and some other ions, as well as the activity of soil organisms (Seymore *et al*., 1994).

Chemical analyses that give the total amount of the variousi ons present in soil can be misleading because; a certain proportion of these ions are not free. Their availability to plants may be very different from what their air total amount might seem toimply.

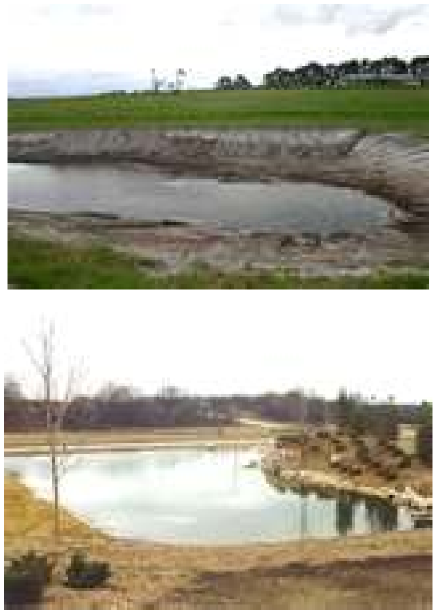

Fig. 3: Water logged fish pond soil

Fig. 4: Fish pond Soil of the type known as loam

A complex equilibrium generally exists between ions free in the soil water and ions adsorbed on the surface of colloidal clay and organic particles. Many factors, of which acidity is a prime example, can shift this equilibrium, either increasing the proportion of ions bound to the particles, and thus reducing availability, or increasing the proportion of free ions available in the soil condition (Seymore *et al*., 1994).

The va rious characteristics of soils briefly mentioned above play a part not only in determining how many and what kinds of plants are likely to grow in any given region, but also in influencing the occurrence of soil animals. Earthworms, nematode worms, and millipedes, are all sensitive to the structure, drainage, acidity, and chemical composition of soils. Animals that do not live in the soil are, of course, indirectly influenced in their distributions by soil types, because of their dependence upon plants as the source of high-energy organic nutrients (Seymore *et al*., 1994).

SOIL FUNCTIONS IN FISHPOND

The most obvious function of the pond soil is water retention. It is used as pond substrate and dyke building material. The quality of soil is an important factor in determining the productivity of fish in ponds. Soil controls pond bottom stability, $_{P}$H and salinity. In order words, pond soils regulate the overlying water quality (Hubert *et al.*, 1996).

Moderately heavy textured soils retain water because of their surface area and high surface charge density. When the soil texture is too heavy, the adsorptive rate is high. Such soils act as sink for nutrients. The nutrients are not released to the overlying water. Pure clay soils are therefore not recommended for fishponds. Moderately heavy soils with neutral pH, sufficient organic matter, and low salinity levels are preferred. The suitability of sites for fish culture demands a good soil. Hence the need for a good soil background for proper decision on a site for fish culture (Hubert *et al.*, 1996).

Soil characterization: The nature of a particular soil depends on its physical properties and nutrient content. These two depend on formation and profile of the soil. Based on this, soils are classified into categories. The physical properties of soils are based on the texture, color, structure, consistence, porosity, permeability and mineral constituents (Dance and Hynes, 1980).

Texture: This refers to the relative proportion of sand, silt and clay in soil. It is a very important soil parameter because it determines the suitability of a site for fish culture. Soil texture can be determined in the laboratory by particle size analysis using any of the three methods: Mechanical analysis, pipette method, hydrometer method (Dance and Hynes, 1980).

Mechanical analysis is the fastest method and is referred to as engineering test. An electrical sieve shaker with a graded series of sieves is the instrument commonly used. The sieves are arranged with the coarsest on top and finest at the bottom. Results of particle size analysis provide percentages for the three classes. The results are also used to assign either a particular texture class to each sample using the textural triangle method or prepare a particle size frequency curve from which one could draw conclusions for the suitability of soil for fish pond construction (Dance and Hynes, 1980).

The pipette and hydrometer methods are based on gravitational sedimentation. Soil particles are initially dispersed and then separated by gravitational sedimentation. Dispersion is through dispersing agents such as calgon (sodium hexametaphosphate). In the pipette method, the soil suspension is agitated and allowed to settle. Samples are pipette to a known depth at various time intervals. The pipette samples are dried. The hydrometer method is similar to that of the pipette method except for the manner of determination of the concentration of solids in suspension (Dance and Hynes, 1980).

Color: Soil color gives an indication of the various processes involved in the soil. It also indicates the presence of some of the minerals present in the soil. The red color is due to accumulation of decayed organic matter. Soil color is described by the parameters hue, value or chroma. *Hue* represents the wavelength or color of light. Value refers to the lightness of the color. Chroma is the relative purity or strength of the colour. The color of the soil in terms of the above parameters could be determined by comparison of the sample with a standard set of colour chips mounted on a booklet called "Munsel Soil Color Charts" (Dance and Hynes, 1980).

Structure: The term structure refers to the arrangement of the soil particles (sand, silt and clay). It is usually defined in terms of aggregates. Examples of types of structures are granular, platy, blood and sub angular.

Consistence: This describes the resistance of a soil to deformation. Soil consistence is determined by the cohesive and adhesive properties of the soil mass. This is an important property in pond construction because it gives an indication of the soil texture. For wet soil, the consistency can be described as: Sticky, non sticky, plastic and non-plastic.

Stickiness is the quality of adhesion of soil material to other objects. It is determined by observing the adherence of soil material when it is pressed between thumb and finger. A sticky soil adheres to both thumb and finger on the application of pressure. Non-sticky soil does not adhere to the thumb or finger on release of pressure.

Plasticity is the ability of the soil material to change shape continuously when stress is applied. The impressed shape is retained on removal of the stress. It is determined by rolling the soil material to form a ring. A soil is said to be plastic when the ring is easily formed. A lot of pressure is required for deformation of the soil mass.

Porosity: This is the ratio of the volume of voids to the total volume of the soil aggregates. The volume of voids refers to that portion of the volume of soil not occupied by mineral grains. Porosity is expressed in percentage as:

$$n = v \times 100a$$

where, v = total volume of soil aggregates; a = total volume of voids; n = porosity

Permeability: This is the rate at which water or gases passes through a cylindrical section of core. The co-efficient of permeability is measured using a constant head perimeter and is expressed in centimeter per seconds.

Components and soil mineral constituents: Soil components: Soil is a complex matter, composed of five major components:

- Mineral matter obtained by the disintegration and decomposition of rocks
- Organic matter, obtained by the decay of plant remains
- Water
- Air or gasses from: roots, microbes and chemicals in the soil
- Organisms such as: worms, insects and bacteria

Mineral constituents: The sand and silt fractions consist mainly of quartz and other primary minerals such as feldspars, micas, pyroxene and olivine. Oxides of iron such as limonite and hematite are also present as coatings on sand grains. The clay fraction is the most reactive part of the soil. It is the seat of soil fertility. The sand and silt fractions influence the physical properties of the soil. The organic component of the soil is distributed among the various size fractions. The un-decomposed and partially decomposed plant remains are in the silt fraction, while the thoroughly decomposed organic matter (humus) is in the reactive part of the soil. This is because it has colloidal properties of possessing electrical charges (Lim and Kiu, 1995).

Negative charge increases with increase in $_pH$ of the interstitial water (water surrounding the soil particles) while positive charges increase with decreasing pH. At very low pH, pond mud adsorbs anions and acts as a anion exchanger. At higher pH, it adsorbs cat ions and acts as a cat ion exchanger. When fertilizers are added to fishpond, cat ions are adsorbed on both negatively and positively charged sites of the mud and released slowly to the pond water over a long period of time (Lim and Kiu, 1995).

Although most ions are adsorbed on pond soils by electrostatic attraction, some ions are adsorbed by the formation of chemical bonds at natural sites in the mud. This type of adsorption gives rise to fixation of ions in the pond mud. These ions may not become available to phytoplankton in the water for a long time. Here, the mud acts as a temporary sink for nutrients (Lim and Kiu, 1995).

Soil formation: Soils are formed by, the weathering of rocks or materials deposited by rivers or wind. Five important factors are responsible for the kind, rate and extent of soil development. These are climate, organisms, parent material, topography and time. Soil varies from place to place due to the influence of the aforementioned factors (Prygiel *et al*., 2000).

Climate: The influence of climate is due to temperature and rainfall. High temperatures and rainfall increase the degree of weathering resulting in the extent of soil development. Rainfall increases organic matter content, decreases soil $_{P}$H and increases leaching of ions from the soil. Temperature increase results in increase in organic matter decomposition. This decreases its accumulation. Climate is also responsible for different vegetation zones. For example, grasslands produce soils that are very different from forests (Prygiel *et al*., 2000).

Organisms: The influence of organisms on soils is due to animal activities and microbial decomposition of the organic matter. The animals include man, worms and other detritus feeders.

Parent materials: The weathering of different types of parent materials result in different types of soil. These soils differ in their mineral content, physical and chemical composition.

Topography: This is related to the drainage system and land gradient. The quality of soil in a land with bad drainage system is different from the one with a good drainage system.

Time: Premature soils do not have much horizon differentiation and would not have reached the advanced state of soil development.

Soil profile: As weathering of the parent material progresses with the various factors of soil formation acting on it, a layering of the soil develops. This is known as horizons. A section from the surface through the various layers of soil to the parent material is called the soil profile. The purpose of soil description is to provide information, which will enable readers to obtain an understanding of the characteristics of a soil and to compare these characteristics with those of other soils. Comparison of soil description is greatly facilitated if, in each description, data are presented in the same order (Prygiel *et al*., 2000).

The texture, soil depth, colour, chemical and physical nature, structure and sequence of the various horizons characterize a soil. These determine a soil and its aqua cultural values. The various horizons are grouped into three major headings:

- A minimal horizon formed adjacent to the surface. It is the zone of maximum leaching.
- A mineral horizon in which, rock structure is obliterated or is faintly evident. The zone is also characterized by concentration of silicate, clay, iron, aluminum and humus.
- Unconsolidated mineral mass from which the above mentioned two horizons are developed.

The order of presentation for the description of individual soil profile include the three:

Information on the sample site: The information needed here are profile number, soil name, date of examination, authors of description, location, landform, vegetation and climate.

General information on the soil: Here the parent material, drainage, moisture condition in the soil and dept of ground water table are required.

Description of individual soil horizons: In this case the horizon symbol, depth of horizon, colour, texture, structure, consistence, content of root and $_{P}$H are required.

Soil classification: Soils are classified into categories according to their chemical properties. This is grouped into order, suborder, great soil group, soil series , soil types and soil phases. Two broad classification systems are those developed by the United States of America soil taxonomy and FAO-UNESCO classification. The systems permit the grouping of tropical soils according to their properties rather than genesis theories. There are other types of classification systems designed for special types of soils. For example, organic soils are classified as muck, peat and peaty muck. These soils are formed in lakes and swampy areas where plant remains accumulate instead of decomposing under anaerobic conditions in water (RPI, 1985).

Common soil problems: There are two main factors affecting soil fertility: Nutrients, and soil organic matter.

Nutrients: These are classified into 3 major groups: Primary nutrients consisting of: nitrogen, phosphorus and potassium. Secondary nutrients consisting of calcium, magnesium and sodium; and micronutrients consisting of: cobalt, copper, manganese, molybdium and zinc.

The primary and secondary nutrients are the most important because their deficiency in fishpond soils, lower the productivity of the ponds. These nutrients need be analyzed in the field using a soil kit such as the Rapid Nutrient Analyses Kit. More accurate analysis can be done in the laboratory.

Primary nutrients:

Nitrogen: Organic matter supplies quite a large amount of nitrogen present in the soil. Nitrogen undergoes many transformation and reactions in the pond soil. The transformations such as: nitrogen fixation, denitrification and nitrification are, controlled by soil organisms.

Total nitrogen (organic and inorganic forms) is determined in the laboratory by the semi-micro kjeldhl method. The method involves wet oxidation tetraoxosulphate (vi) acid (H_2SO_4). The nitrogen is converted into ammonium tetraoxosulphate (vi) ($(CNH_4)_2SO_4$). Ammonium ion (NH_4^+) is determined from the NH_3^+ liberated by distillation of the digest with an alkali (NaOH). The nitrogen content of the soil is calculated as a percentage (RPI, 1985). Ratings for total nitrogen in soil: Very low (>0.05%); Low (0.05-0.09%); moderately low (0.1-0.19%); Medium (0.15-0.20%); moderately high (0.20-0.25%); High(0.25-0.30%) and Very high (above 30%) (RPI, 1985).

Phosphorus: This is a very important nutrient. Its deficiency inhibits the growth of phytoplankton in fishponds. The total phosphorus content of a fishpond soil is of direct practical importance. It is the only available phosphorus that is important. This is because phosphorus is adsorbed on clays and humus particles of $_pH$ lower than 5.5 by forming chemical bonds enabling its fixation and unavailability to the phytoplankton in the pond. Available phosphorus is that portion of the soil phosphorus readily absorbed by phytoplankton and other organisms (RPI, 1985).

The available phosphorus in a soil sample is determined in the laboratory by the Bray and Kurtz No. 1 method. Soil phosphorus is extracted by agitating the soil with a solution of ammonium fluoride and hydrochloride acid. The colorimetric method (spectrophotometer) is used to determine the concentration of phosphorus in the soil extract (RPI, 1985).Ratings for available phosphorus in soil: Very low (>3ppm); Low (3-7 ppm); Moderate (7-20 ppm) and High (above 20 ppm) (RPI, 1985).

Potassium: This element is not as important as nitrogen and phosphorus. In brackish water conditions, potassium is of limited value due to the high natural salinity conditions in seawater (390 ppm). Concentration levels of potassium in soils can be determined by extraction with ammonium hydroxide (NH_4OH). The potassium extract is determined by flame photometry (RPI, 1985).

Secondary nutrient: These are referred to as exchangeable cat ions (Ca^{2+}, mg^{2+}, Na^+). These cat ions are present in large quantities in pond soils and are extracted from soil by agitating with ammonium hydroxide (NH_4OH). The concentration level of each cat ion in the extract is determined, using Atomic Absorption Spectrophotometer or flame photometry (RPI, 1985).

Soil organic matter: Soil organic matter consists of plant remains in varying states of decomposition. Organic matter of the soil plays a very important role in the biogeochemical cycle of nutrients in a pond. It contains large reserve of carbon, nitrogen, phosphorus and other algal nutrients. Soil microbes release these nutrients in forms available to algae. Another function of soil organic matter is its influence on the physical and chemical properties of the soil. It increases the soil capacity to retain water and provide sites for attachment of cat ions and anions. The organic matter content in a soil can easily be determined by the loss ignition method. In this method, a known weight of an oven dried soil sample is put in a muffle furnace and heated slowly to 420^0C for one hour. The sample is removed from the furnace and placed in desiccators to cool and weigh after cooling (Welch *et al*., 1977). The percentage organic matter (loss on ignition) can be calculated as:

Organic matter (%) = (weight of oven dry sample - weight of ample after ignition) / Weight of oven dry sample

Rating of organic matter: Very low (>0.7%); Low (0.7-1.7%); Moderate (1.7-2.6%); High (2.6-4%) and Very high (<4%) (Welch, *et al*., 1977).

Common soil problems: Some common soil problems that can hinder fish cultivation are acidity, alkalinity/ sodicity, salinity and excess organic matter (Dance and Hynes, 1980).Acidity: The major source of acidity in soils is due to the oxidation of sulphides resulting to acid sulphate soils. Acid sulphate soils are derived from marine and estuarine sediments, which upon drying and aeration show definite and severe acidifications due to the oxidation of sulphides that result in the formation of tetraoxosulphate (vi) acid (H_2SO_4) (Dance and Hynes, 1980).

$$4FeS_2+15O_2+2H_2 \rightarrow 2Fe(SO_4)_3+2H_2SO_4.$$

This process is brought about by a group of bacteria known as *Thiobacillus feroxidans*.

Acid sulphate soils are present in low coastal areas where sulphides are being accumulated in marine sediments as a result of bacterial reduction of seawater sulphates. In mangrove swamps, the formation of acid sulphate soils is common because of the abundant supply of sulphates and organic matter. A million hectares of saline mangrove swamps in the Niger Delta is affected by acid sulphate soil conditions. Acid sulphate soils also occur in old alluvial terrace deposits (Dance and Hynes, 1980).

Acid sulphate soils are extremely acidic. The pH values are less than 3.5 in some layers within the upper 50cm of the soil profile. The acidity is due to the free H_2SO_4 produced during sulphide oxidation when the soil is drained. The tetraoxosulphate (vi) acid (H_2SO_4) dissolves clay minerals and produces large amounts of aluminum in quantities toxic to phytoplankton and cultured organisms. Iron and aluminum are more soluble and form very insoluble phosphate compounds at low $_{P}$H. This means that dissolved phosphate would become unavailable for phytoplankton growth (Dance and Hynes, 1980).

Field and laboratory methods in Acid Sulphate soil identification: A number of criteria are proposed for the acid sulphate soil identification: The presence of yellow colored mottles of jarosite (a mineral product of sulphide oxidation) in the soil: It is a pale yellowish potassium iron III tetraoxosulphate (vi) compound (K $Fe_2(S_4O)_3$) (RPI, 1985). The presence of dense and firm dark peaty materials (roots of mangrove trees), which have the tendency to dry out completely,Vegetation type can indicate acid sulphate soils. For example, in brackish water environment of West Africa, the red mangrove, *Rhizophora racemosa* is associated with acid sulphate soils (RPI, 1985).

Measurement of soil pH. Acid sulphate soils when wet can have pH values near neutrality but when oxidized by air drying or concentrated hydrogen peroxide (H_2O_2), the PH drops by 3-4 units. The sulphate - sulphur (SO_4-S) content of acid sulphate soils is very high. This is determined in the laboratory by chemical methods (RPI, 1985).

Problems of fish culture in acid sulphate soils: Soil acidity may result in aluminum, iron and magnesium toxicities. Phosphorus is unavailable due to fixation. Total alkalinity is reduced. The reduction in total alkalinity decreases the buffering capacity of the soil and increases the quantity. Other problems associated with fish culture in ponds with acid sulphate soils include:

- Fish mortalities due to extreme acidity during heavy rainfall: This is because extreme acidic waters seep into the ponds from the surrounding dykes.
- The production of natural food is low because the levels of nutrients present in the soil are low.
- The fixation of phosphorus in pond soils result in poor fertilizer response.

The yield for cultured fish is low because of retarded fish growth (RPI, 1985).

Management of Acid Sulphate soil conditions: The commonest management technique used in reducing acidity is by extensive use of lime. RPI (1985) recommended the application of lime at rates of 2 tons/ha for reclaiming acid sulphate soil. But, the approaches seem to be expensive. Neutralizing the first 10 cm of pond bottom and the whole dyke body requires large quantities of lime. This is not economical because acid acid-sulphate soils have very high residual acidity, which could only be corrected by application of large amounts of lime for a long period.

Another method used in improving extreme acidic soils is by leaching. Leaching is done after pond preparation. It involves repeated sequence of flushing and draining the soil using tidal waters until an ideal pH of 6.0-6.5 is reached. After stocking the ponds, the pH of pond water is monitored regularly. If the pH decreases to as low as 5.0, half the volume of pond water is flushed out and replenished with tidal waters.

Fertilizers can be added to increase the nutrient levels of acidic soils. This can improve the physical properties of the soil. The recommended the application is 2 ton/ha of chicken manure; 60 kg/ha of urea for nitrogen and 120 kg/ha super phosphate fertilizer to improve an acid sulphate soil (RPI, 1985).

Lime requirements for soils: The lime requirements for soils vary from soil to soil. In cases where the acidity is very mild, application of the appropriate quantity of lime enhances fish production. When considering the usage of lime in a fishpond, it is important to establish the rate of application of the lime requirement of the soil. This minimizes cost, maximizes production and prevents over liming. Over liming is liming at rates higher than necessary to neutralize soil acidity in order to eliminate aluminum toxicity. Over liming induces phosphorus deficiency in pond waters due to the formation of insoluble calcium phosphate. The lime requirement of a soil is determined by two methods (Welch *et al.*, 1977):

- Buffer method. A sample of soil is added to a special buffer solution (p-nitro-phenol plus ca-acetate plus magnesium oxide). The reduction of the pH of the buffer is noted. The lime requirement is directly proportional to the reduction in the pH of the buffer. Each 0.1 reduction in pH indicates the need for 500 kg of lime per hectare.

- Lime rates based on exchange aluminum. The lime requirement of a soil can be based on the quantity of exchangeable aluminum in the soil.

Exchangeable aluminum in the soil is determined by, extracting with unbuffered normal salt (sodium chloride) and triturating the extract with a base (sodium hydroxide). Exchangeable aluminum is precipitated out of pH approximately 5.5. This means that exchangeable aluminum is scarcely present in soils with higher pH values. Lime rates can be calculated from the mill equivalent (meg) of aluminum precipitated. For every milli equivalent of exchangeable aluminum present in the soil, 1.5 tons/ha of $caco_3$ is needed for neutralization (Welch *et al*., 1977).

Alkalinity/sodicity: Alkaline soils are characterized by a pH higher than 8.5, with an exchangeable sodium percentage of more than 15%. These soils also have large quantities of sodium carbonate and bicarbonate. Alkaline soils are deficient in hydrogen, phosphorus, manganese and zinc. Alkaline soils are common in very dry areas. Reclamation of alkaline soil is by the application of gypsum to replace the exchangeable sodium with calcium and the removal of displaced sodium by leaching. This is due to the high $_{P}$H levels and sodium content (Welch *et al*., 1977).

Salinity: Saline soils are present in humid coastal areas such as basins of deltas and rivers utilized for irrigation. A saline soil contains sufficient salts (NaCl, Na_2SO_4, $CaCl_2$, $MgSO_4$, $NaHCO_3$) in the 10cm of the profile. The concentration of salts in a soil is determined by measuring the electrical conductivity of the soil extract (Welch *et al*., 1977).

Arid saline soils are very poor in nitrogen and available phosphorus, but well supplied with potassium. Coastal saline soils are rich in Ca, Mg, K and S but poor in phosphorus. Reclamation of saline soils is by draining and leaching the salt using fresh water (Welch *et al*., 1977).

Excess organic matter: Soils with excess organic matter are characterized by the presence of a surface layer of 30cm thick containing not less than 30% organic matter. The bulk density of the soil is very low. Apart from nitrogen, other nutrient levels are also low: Soil with excessive organic matter result in the production of organic acidic; hydrogen sulphate and ammonia in fishponds (Lim and Kiu, 1995).

Soil sampling and analysis: There is the need for an effective soil sampling and analysis before embarking on any major fishpond construction.

Table 1: Classification of soil particle size

Soil separate	Diameter in min	Diameter in microns
Very coarse sand	2.0-1.0	200-1000
Coarse sand	1.0-0.5	1000-500
Medium sand	0.5-0.25	500-250
Fine sand	0.25-0.125	250-125
Very fine sand	0.125-0.0625	125-62
Silt	0.0625-0.00391	62-4
Clay	0.00391 and below	4 and below

George *et al*. (2010)

Soil sampling: Let the site for soil profile be typical of the representation of the intended soil. Soil sample can be obtained from freshly dug pits not less than 100 cm deep. Apart from the soil profile, samples can be collected randomly from the area covered. A minimum of six samples per hectare at well spread intervals is recommended (RPI, 1985).

Soil analysis: Determination of soil texture and potential acidity is very important. An analyzed soil texture is presented in Table 1. Soil pH after oxidation gives a good estimate of potential acidity. Air-dry sub samples for a period of 30-40 days. The pH is monitored at 5-days interval during the period of exposure. A more accurate method of determining potential acidity can be carried out by, chemically oxidizing the soil sample with 30% hydrogen peroxide and triturating the quantity of acid produced. The pH of the oxidized material can also be measured. Accurate estimation of soil pH is useful in identifying acidity problems. An on the spot analysis of nutrients such as N, P, K Mg and Ca can be carried out using the Rapide Nutrient Analysis Kit (RPI, 1985).

CONCLUSION

Adequate knowledge on the pond oils, soil functions in fish pond, soil characterization, components and soil mineral constituents, oil profile soil classification, soil fertility, nutrients, primary and secondary nutrients, soil organic matter, common soil problems, field and laboratory methods in acid sulphate soil identification, management of acid sulphate soil conditions, lime requirements for soils, alkalinity/sodicity, salinity, excess organic matter, soil sampling and analysis are inevitable for effective culture fisheries management and practices.

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