WATER QUALITY MANAGEMENT

IN FISH CULTURE

Extension Bulletin No. 98

Fisheries Series No 3

Published
by

National Agricultural Extension and Research Liaison Services
Ahmadu Bello University,
Zaria.

1996

ACKNOWLEDGEMENT

Relevant scientific information pooled together for this bulletin were from differentnt sources National Institute for Freshwater Fisheries Research (NIFFR) New Bussa, is greatly acknowledged for providing the needed results of their research work.

The International Centre for Tropical Aquaculture, Auburn University, U.S.A, is hereby acknowledged for information given in "Water Harvesting Manuals", that greatly assisted in putting appropriate pictorial illustrations together for this bulletin.

The support of the Director and Management of NAERLS, the painstaking work of the Publication Review Committee of NAERLS, and the efforts of the Publication and Publicity Programme all combined made this bulletin production possible.

Bolorunduro, P. I., and Abba Y. Abdullah.

TABLE OF CONTENT

1.0 INTRODUCTION

Fish culture involves the controlled cultivation and harvesting of fish for either family consumption or sales in the market. Although fish culture is over fifty years old in Nigeria, it is yet to develop fully when compared with arable agriculture and to some extent livestock production.

A wide range of practices exist in culturing fish. Fish can be cultured in marine (seawater), brackish (mixture of sea and freshwater i.e. lagoons) or freshwater (rivers, streams and lakes in the inland). In Nigeria, freshwater fish culture is more widespread than brackish water fish culture. Depending on the facilities designed to serve as enclosures in rearing, fish can be grown in earthen ponds, concrete tanks, cages, pens, or runways. The level of management practices can make a fish farm to be extensive, semi-intensive, or intensive system. When species combinations are taken into consideration, culture systems can be either monoculture (rearing only one type of fish) or polyculuture (rearing two or more species of fish together).

A fish pond is an enclosure (earthen or concrete) built to retain water for the purpose of growing fish. Rearing fish in ponds from which they cannot escape allows feeding, breeding, growing and harvesting of the fish in a well-planned way.

The secrete of success in any fish farming operation depends to a large extent, on the ability of the fish farmer to closely manage the pond water by monitoring its physical, chemical and biological properties. Water supply and its quality is one of the limiting factors to fish culture. The water used for the cultivation of fish will not give maximum production if the conditions are not optimal for the fish and other aquatic organisms.

Water sources good for fresh water fish species culture include water diverted from rivers, streams and lakes, pond water (from rain fall inflow), well water, bore hole, spring water, and

treated pipe-borne water. The fish farmer should ensure that the water for fish pond is free of pollutants. Pollutants are substances like domestic effluents, oil, and industrial wastes, that are toxic to fish and eventually could cause the fish farmer economic loss.

2.0 POND CULTURE SYSTEMS

Fish ponds can be classified mainly using the following criteria:-

(a) Construction design
(b) Level of management input
(c) Fish culture practices
(d) Scale of production

2.1 Construction Design

1. Earthen Ponds: These are constructed by digging soil in a carefully selected site that is good enough to retain water for fish culture. Where the soil structure is weak to retain adequate water, dug out earthen ponds can be reinforced with concrete to make it suitable for fish culture (Figure. 1a).
2. Concrete/Embankment Ponds: This pond constructed on the ground, that is above the ground surface with concrete wall (Figure. 1b). Concrete ponds can be used to raise fish in place with porous or sandy soil.
3. Barrage Ponds: This type of pond constructed by building a wall across a stream in a low valley. The wall ensures enough water retention for fish growth (Fig. 1c.)
4. Diversion Pond: pond supplied by water diverted form a river/stream through a channel. Such a pond is also known as a Relief Pond (Figure. 1d)
5. Rosary Pond: When ponds are built in a string and each drains into the other and are all managed as a single unit due to their water connection, they are called Rosary System Ponds (Figure. 1e).

6. Parallel Ponds: These are ponds located in an area with each having its own inlet and outlet (Figure. 1f).

2.2 Level of Management Input:

Depending on the level of management inputs, especially in feeding, fertilization and liming, pond culture systems can be classified as Extensive, Semi-Intensive or Intensive.

1. Extensive Culture System: When food base in a pond is exclusively naturally occurring, without supplementation (either by feeds or fertilizer), the culture system is an extensive one.
2. Semi-Intensive Culture System: In this system, there is occasional supplementary feeds addition and natural productivity is augmented with manure.
3. Intensive Culture system: This demands the highest level of management input. Feeds and fertilizers are intensively applied following appropriate recommended rates. Suitable liming materials like agricultural lime are also applied to stimulate productivity and disinfect the pond of parasite and diseases. Fish grow very fast when intensively managed and grow least in extensive management. A recent development in Nigeria is the introduction of intensive recycling fish tanks. Through a system of biofiltration pond water is purified and recycled back for use. Aerators are also incporated to improve dissolved oxygen content of pond water stocking in this system (e.g. of catfish) can be as high as 300-400 fish per m3. Yield from recyclaory system can be very high. However a humanitarian imposed is power supply.

Figure 1a Earthen Ponds

Figure 1b ConcretePonds

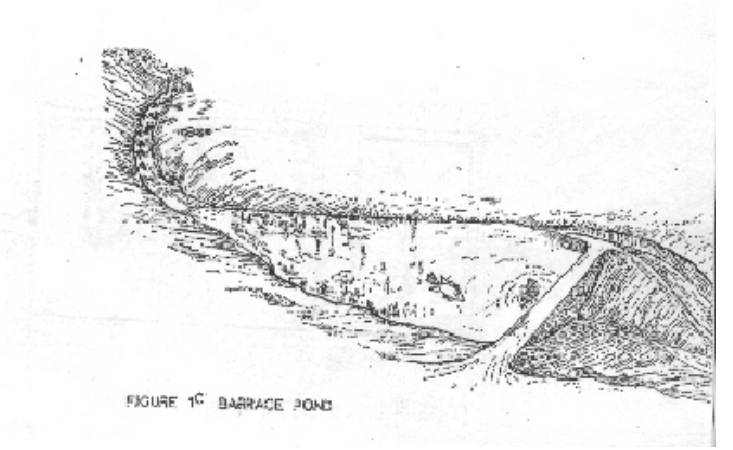


Figure 1c Barrage Pond

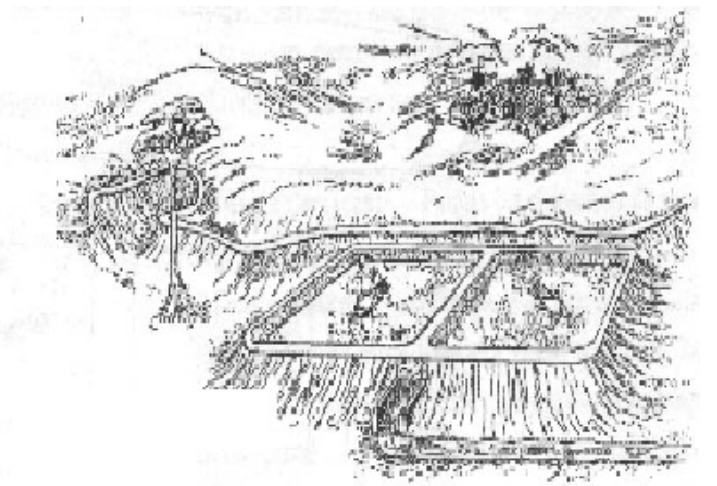


Figure 1 d Diversion Pond

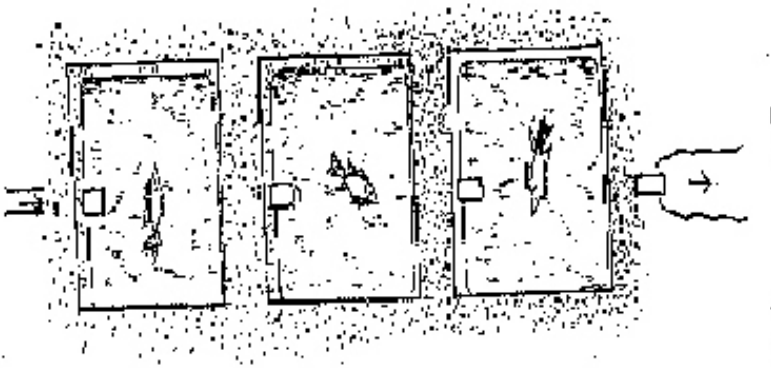


FIGURE 1E ROSARY SYSTEM PONDS

Figure 1 c Rosary System ponds

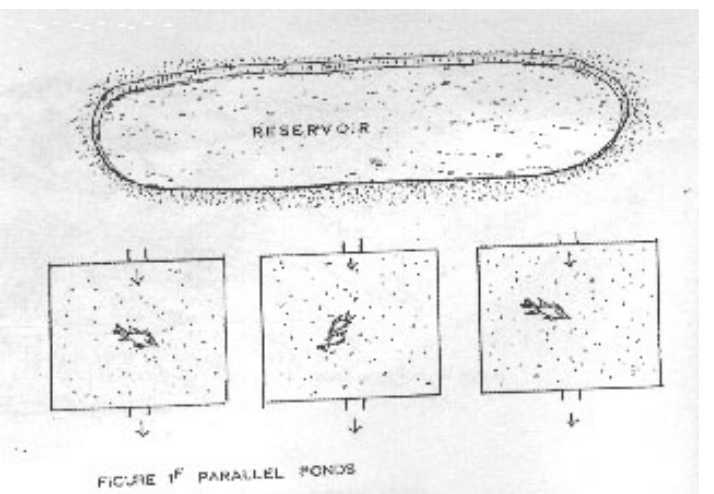


FIGURE 1F PARALLEL PONDS

Figure 1f Parallel ponds

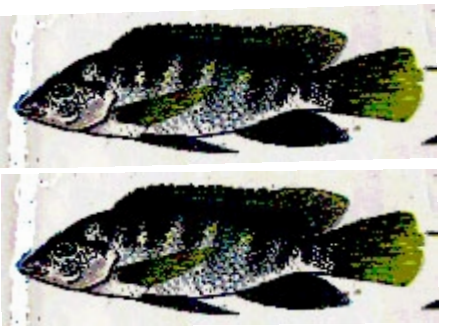


Figure 2a Monoculture; growing same type of fish in a pond (e.g. Tilapia)

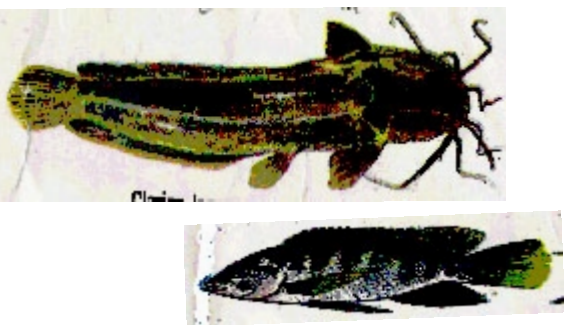


Figure 2b Polyculutre growing different fish species in a pond (e.g. Clarias and Tilapia)

2.3 Fish Culture Practices: Ponds can be classified as being monoculture or polyculture – type

1. Monoculture: This is the practice of culturing only one species of fish in a pond unit (Figure. 2a). under monoculture, a farmer may grow only Tilipia in the pond. He will be able to know more about the management of Tilapia than other species he is not growing.

2. Polyculture: This is the practice of culturing more than one species of fish in the same pond e.g. Clarias and Tilapia. Fish yield under polyculture (Figure. 2b) can be higher and foods in the pond properly utilized, since the different fish species exploit food at different levels in the pond.

2.4 Scale of Production:

1. Homestead/Backyard Ponds: This is a fish pond that is managed to augment family protein intake. The size of such a pond could vary according to land space available e.g. from 25-100m^2. They are normally located within living/office premises.
2. Commercial Fish Ponds/Farms: This, usually have an area of land not less than half hectare under culture.
   Such a farm will demand more attention form the fish farmer, since income generation is the major purpose behind its establishment.

3.0 COMMONLY CULTURED FISH SPECIES

Generally the purpose of rearing fish is to have enough to eat and generate additional income especially in commercial farms. Not all fish species perform creditably well under culture donations. For a profitable venture, the fish farmer's ideal candidate species must have some or all of these qualities:-

(i) Fast grower e.g Heterobranchus and Clarias
(ii) Accept and utilize supplementary feeds properly e.g Tilapia, clarias, Hetorobranchus.
(iii) Must be hardy and resistance to disease, e.g. Clarias
(iv) Must be tolerant to poor water quality e.g Clarias
(v) The fish must be easy to breed in captivity. e.g. Tilapia.
(vi) It must attract low production cost (Tilapia/Clarias)
(vii) Acceptable and marketable to consumers, e.g. Carp and Heterotis,Tilapia and Clarias

Some species inhabit the marine environment, but can be cultured in brackish water (Lagoons and Estuaries) (Plate 1.).

In Nigeria certain fish species are found only in freshwater bodies (that is rivers and lakes) and do very well under culture (Plate 2.).

Tables 1 and 2 show a list of some commonly cultural fish species in freshwater and brackish water ponds respectively.

TABLE 1: COMMONLY CULTURED FISH SPECIES IN FRESHWATER PONDS IN NIGERIA

COMMON NAME	SCIENTIFIC NAME
Tilapia*	*Oreochromis niloticus (Tilapia nilotica)*
	Tilapia guineensis
	Tilapia melanopleura
	Sarotherodon galilaeus
Mud Cat-fish*	*Clarias , garienpinus*
Common Carp*	*Cyprinus Carpio*
Spotted Cat fish **	*Heterobranchus bi-dorsalis*
Niger perch **	*Lates niloticus*
African bony tongue**	*Heterotis niloticus*
Grey cat-fish **	*Chryscichthys nigrodigitatus*
Trunk-fish**	*Gymnarchus niloticus*
Cat-fish**	*Bagrus bayad*
African Carp**	*Labeo coubie*
Moon fish**	*Citharinus citherus*

* Fingerlings readily available in hatcheries

** Fingerlings not readily available in hatcheries, but can be collected from the wild i.e. Rivers and Lakes/

Source – Ita E. O. 1989.

TABLE 2: COMMONLY CULTURED FISH SPECIES IN BRACKISH WATER PONDS

COMMON NAME	SCIENTIFIC NAME
Flat head grey mullet*	**Mugil cephalus**
Tilapia*	*Tilapia zilli*
	Tilapia guinensis
	Tilapia melanotheron
Atlantic Tarpon **	*Megalops atlanticus*
Ten Pounder**	
West African Lady Fish)	*Elops lacerta*
Grey Cat-fish**	*Chrysichthys nigrodigitatu*
African red Snapper**	*Lutjamus agennes*

* Fingerlings and feeds readily available

** Fingerlings nor readily available in hatcheries but can be obtained from the

Source – Ita E.O. 1989

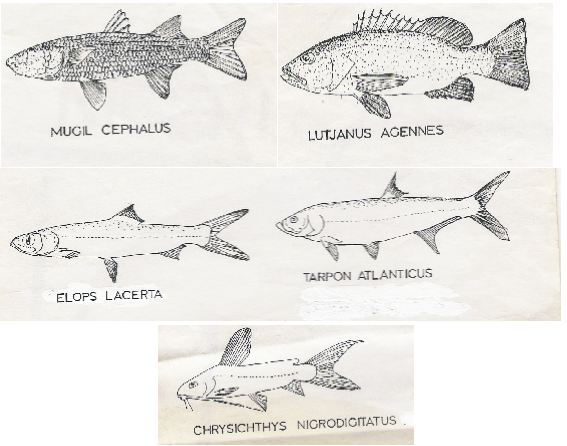
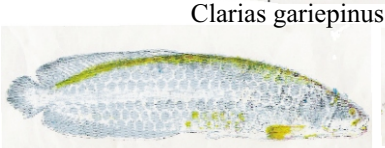
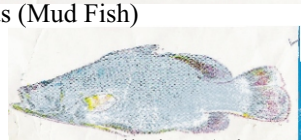


Plate 1 - Brackish water species

Clarias gariepinus (Mud Fish)



Heterotis niloticu (African bony tongue)



Lates niloticus (Niger perch)

Oreochromis niloticus

Chrysichthys nigrodigitatus *(catfish)*

Plate 2 - Freshwater species

4.0 POND CONSTRUCTION AND MAINTENANCE PRACTICES

Detail steps required in site selection and construction of fish ponds/farms, that can be financially rewarding to practicing and prospective farmers have been spelt out in ***NAERLS Extension Bulletin-Fish Pond Site Selection and Construction.*** However, it is worth re-emphasizing that post-construction maintenance practices such as impoundment and stocking are important in determining the success or otherwise of the whole fish culture business. This section will elaborate more on giving required practical hints on impoundment and stocking, while other maintenance practices of liming, fertilization, feeding and prevention/control of fish diseases will be discussed in later sections of this bulletin in relation to water quality management.

4.1 Pond Impoundment

Impoundment refers to a process of entrapping water (from a good source) into a constructed structure with the aim of retaining/replenishing the required water level for a viable and profitable fish culture. In relation to pond water quality, the entrapped water in pond structure will determine to a large extent, the nature and type of management/improvement practices the farmer will carry on to ensure that pond water is safe and rich enough (in nutrients) for fish to survive and grow well.

General Considerations on Impoundment

(i) Ensure that regular water source(s) is available to fill pond to required level (for most ponds, water level should not be below 1m).

(ii) Impounded water need improvement to be enriched with nutrients for fish to eat. Practices like liming, fertilization and feeding are very important.

(iii) Ensure that water source is free of pollutants. These are substances that are poisonous to the fish. Such include wastes from industries and domestic effluents, agricultural

chemicals and other dangerous substances.

(iv) Impounded water need improvement to be enriched with nutrients for fish to eat. Practices like liming, fertilization and feeding are very important.

(v) Common impounded problems to be avoided include:-

(a) Inflow of debris/mud stirring: This can be minimized/avoided by attaching sprinklers to inlet pipes into the pond or targeting pipe hose on solid structure like stone place at a particular position in the pond to break water speed.

(b) Tendency to over-flood the Pond: Care should be take to avoid over filling the pond with water. Fill pond to a level of between 30-50cm away form the dam level to avoid its cleavage and breakage. Provision should be made for a spillway in pond structure.

(c) Two sources of pond water loose are evaporation and seapages. This calls for regular check-up of pond water level.

(d) While impounding the pond structure don't allow predators like frogs, dragon fly, turtles etc. to gain access to the pond. These are natural enemies to the fish.

(e) Except for serious threat of pollution or water contamination, don't evacuate water and impound often. Water retained in earthern ponds require fairly long time to be enriched with natural fish foods.However for concrete ponds it is advisable to change water at internals of 2-4 weeks.

4.2 Stocking

Stocking is the introduction of fish (fingerlings or adult fish) into the new pond environment. Two sources of stocking fish are available. Fish can be collected from the wild (rivers, streams, lakes, etc) or from hatcheries/existing fish ponds. Stock from hatcheries are already adapted to culture condition and are preferable. The closer the source of getting the fish to the pond, the better, to reduce to the bearest minimum fish mortality during transportation and transportation. Fish should be collected with the water of the environment they have been used to. Hardly fish species like Clarias, Tilapia and Heterobranchus can be transported in plastic basins over a short distance (Figure. 3). For longer distances, fish fingerlings should be transported in polythene bags containing water and oxygen (Figure. 4). Test stocking (pre-stocking) should be practiced by introducing few fish into the new environment. Test stocking period ranges from two-three hours.. If the fish survive well, then the pond can be fully stocked.

Recommended stocking rate of fish (ratio of one species to another or male to female) and stocking density (number of fish per M3 of pond water) to avoid over-crowding, should be practiced. This will ease management problems and enhance the success of the fish culture. Some stocking combination of fish (recommended) under extensive or semi intensive culture in Nigeria are shown in Table 3. However stocking density of 80-100 fingerlings per m^2 of pond area is considered suitable for catfish.

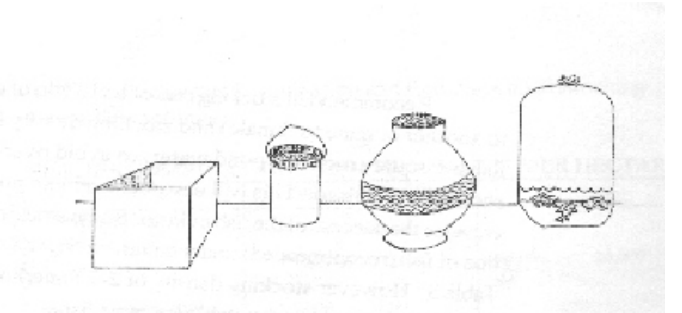


FIGURE 3 VARIOUS CONTAINERS ARE USED TO TRANSPORT FISH

Figure 3: Various containers used to transport fish

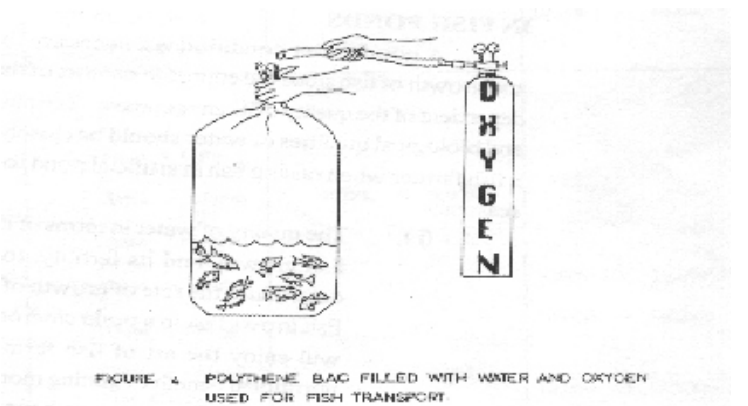


FIGURE 4 POLYTHENE BAG FILLED WITH WATER AND OXYGEN USED FOR FISH TRANSPORT

Figure 4 Polythene bag filled with water and ogygen used for fish transport

Table 3: Species combination and Recommended Stocking Rates (Fingerlings). (PER HECTARE) in extensive and semimi intensive culture

	FRESHWATER	BRACKISH WATER
1. **MONOCULTURE**		
Tilapia spp	10,000 – 20,000	10,000 – 20,000
Clarias (mudfish)	1, 000 – 5,000	-
Heterotis	500 – 1,000	-
Carp	3,000 – 6,000	-
Mugil Species	-	10,000 – 20,000
Grey Cat fish	7,000 - 8,000	
2. **POLYCULTURE**		
Tilapia + carp	2,000 – 3,000 + 2,500	-
Tilapia + Clarias	40,000 – 6,600	-
Tilapia + Tarpon	-	6,000 + 4,500
Tilapia + Mulet	-	8,000 + 10,000
Tilapia + Mugil	-	10,000 + 10,000
Tilapia + Mugil	-	
Tilapia + Mugil + Grey	-	10,000 + 2,500 + 1,000
Cat Fish	-	

Source - DFFRI 1988

5.0 IMPORTANCE OF WATER QUALITY MANAGEMENT IN FISH PONDS

A good water condition is a necessity for the survival and growth of fish is since the entire life process of the fish wholly dependent of the quality of its environment. The physical, chemical and biological qualities of water should be closely monitored by a fish farmer when raising fish in artificial pond for the following reasons:-

i. The quality of water in terms of its suitability for fish growth, and its fertility, to a large extent determines the rate of growth of the fish. When fish grows fast in a pond environment, a farmer will enjoy the art of fish farming both in the nutritional benefit of getting more protein for the family and the economic benefit of additional income from farm produce.

ii. A pond water that is poor in quality will endanger the health of the fish and a fish farmer will have to spend extra time and money to remedy the situation. It is better to prevent a poor quality water situation developing in a fish pond than to struggle to cure it. By this, production cost will be minimized.

iii. Where a farmer practices farming integration, for example, rearing livestock like sheep, goat or pig in the same fish pond environment, a polluted pond water can endanger the livestock as well, especially if they drink from such pond.

iv. When adequate water quality improvement practices are ensured, natural production of fish food organisms will be in abundance for the fish to eat. The farmer will therefore spend less on artificial feeds to supplement fish foods.

v. Eating fish harvested from polluted ponds could endanger the health of a fish farmer and his family. However; when fish are harvested from a good quality pond, eating them can be nourishing.

6.0. HOW TO DETECT POND WATER OF POOR QUALITY

The foI1owing should serve as guides in assisting a fish farmer to know when pond water is deteriorating in quality and therefore not suitable for fish growth.

(i) When water is clear, it indicates very low or absence of biological production. Such water is not fertile enough and fish will not grow well in it.

(ii) When water is muddy (that is a lot of clay particles are present), fish can have their gills blocked by the soil particles and this can result in death. Muddy water are not good for fish culture.

(iii) When water is deep green in colour, it indicate over-production of phytoplanktons and zooplantktons. Phytoplanktons are minute plant food for fish, while zoo-platoons are minute animals that serve as food for fish. Over production of planktons can result when a farmer apply more than enough fertilizers, manure or nutrient rich feeds to a pond.

(iv) When a fish pond gives an offensive odour, it indicates pollution of pond water . Sources of pollution include application of excess food stuff to the pond, or inflow of water from polluted rivers. Pollution can also result from application of chemicals to arable crops around the pond site.

(v) In an already stocked fishpond, if a farmer noticed the fish always struggling at the pond water surface to get oxygen, then there is low dissolved oxygen (DO) content in the water. DO is the amount of atmospheric oxygen present in water.

Since the farmer is in control of the environment of the fishpond, any observed anomaly in water quality can be corrected. This can only be done when the farmer understands the ideal physical, chemical and biological characteristics a pond water should possess and water quality improvement practices.

7.0. MANAGING PHYSICAL PROPERTIES OF POND WATER

The most important physical features of pond water are the transparency and colour; as well as the temperature.

7.1 Transparency and CoIour

Light is required to enable organisms (minute plants and animal) to develop. in the water. Water should be as transparent as possible. Turbid water which carry suspended matter soil particles, and vegetative materials)are not suitable for fish culture.. This is because light penetration is reduced and the implication of this, is the reduction of the abundance of natural food available to fish i.e. the rate of growth of the phytopankton is very low. Suspended matter can also affect fish health by sticking closely to their gill filaments and hinder fish from breathing.

Pale colour, light greenish or greenish waters are very suitable for fish culture.

7.1.1 Measurement of Transparency

(i) Use of Secchi Disk

A Secchi disk is a standard way of measuring visibility (transpar ency) in water. The disk measures 20cm in diameter and painted black and white in opposing quarters as shown in Figure 5. The fish farmer can make the disk from a round can lid or good wood. The disk is attached to a wooden stick or a rope marked off in centimeters. Transparency of plankton density is measured by lowering the disk into the water with the observer's back to the sun while viewing the disk directly from above. The depth at which the disk just disappears from sight is the secchi disk reading.

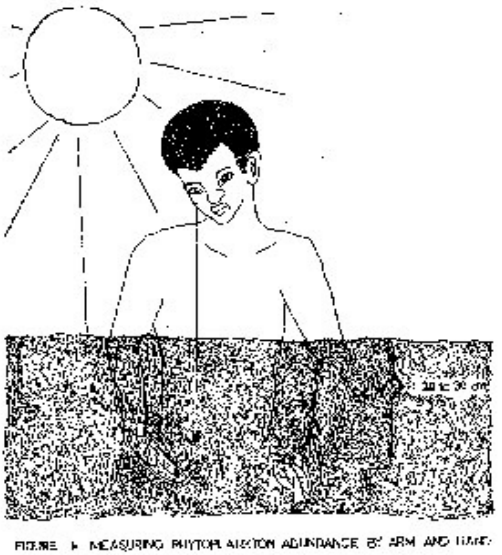
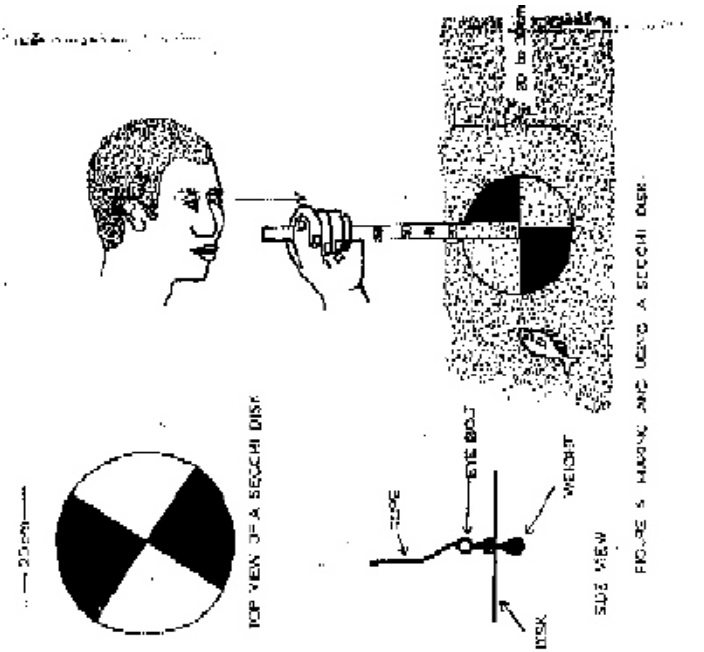


Fig 5: Measurig phytoplankton aboundance by arm and hand

(ii) Use of Arm:

It is often easier for a farmer to use his arm and hand instead of a secchi disk. The principle is the same. The person's arm becomes a meter stick and the up turn palm of the hand becomes the disk as illustrated in Figure 6.

Rules on how to interpret the result of the arm and hand or secchi disk and what management actions to take depend on what fish is been cultured and on the type of fertilization/manure being used.



7.1.2 Interpretinhg Secchi Disk Reading

Relationship between secchi disk reading and the density of plankton has been worked out by research scientists.

(a) If reading is below 20cm - This is undesirable. It indicate overproduction of plankton in the water which is not good or fish since there will be competition for the oxygen available in the water and inhibition of light penetration

(b) If reading is between 20 – 30cm. This is undesirable, but however there is no danger posed to fish health.

(c) If reading is between 40 80cm. This is acceptable for fish culture. It indicate optimal plankton production.

7.1.3. Pre-Cautions in Using Secchi Disk

(i) The fish farmer should ensure that the paint on the disk are not. easily dissolvable in water. i e. they should be permanent paints.

(ii) The sun should usually be behind the observer while measurements are made,

(Iii.) Secchi disk visibility readings often differ with time of measurements due to differences in illumination and roughness of the *water* surface. The farmer should therefore take an average of 3 daily readings i.e. in the morning, afternoon and evening. This will give a fair representation.

(iv.) The farmers should decide on a periodic measurement i.e.. either weekly, fortnightly or monthly. Record of the reading should be kept. This can help as reference for decision making.

7.2 TEMPERATURE

Temperature is one of the most important external factors which influence fish production. It has considerable influence on vital activities of fish such as breathing, feeding, growth and reproduction. Luckily, in our own environment fish farmers don't have to bother much on pond water temperature since all culturable freshwater/brackish water fish species found in Nigeria have a wide range of tolerance to temperature. Research has shown that a temperature range of between 25° to 32° is very suitable for fish culture.

7.2.1. Measuring Fish Pond Temperature

Temperature of ponds can be measured by using a simple mercury thermometer. It can be taken at the surface of pond water or at the bottom by fixing the thermometer to a sampling bottle. (Figure.7).

7.2.2. Controlling The Temperature of Pond Water

(i.) A farmer should ensure that the source of water to the pond is not likely to raise the pond water temperature.

For example, Industrial discharges to a stream or river that serves as source of pond water could raise the

temperature very high and this can cause fish death.

(ii) To a large extent, it is possible to influence the tempera ture of a pond by increasing or reducing the quantity a water admitted

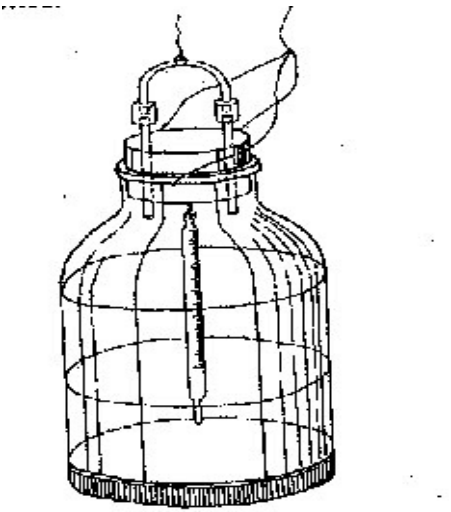


Fig 7 Water sampling bottle with a mecury thermometer

8.0. MANAGING POND WATER CHEMICAL PARAMETERS

In fish ponds, chemical properties of water include the hydrogen ion concentration (PH), the dissolved oxygen content (DO) the conductivity of the water, the carbon dioxide content ($C0_2$), and the amount of mineral elements like nitrogen and phosphorus and compounds like nitrite and nitrate, However the most important chemical properties managed in fish ponds are the PH (measure of total acidity and total alkalinity of pond water) and the DO (measure of the content of soluble atmospheric oxygen in Pond water).

8.1 Hydrogenion Concentration (PH)

The various sources of water used in fish culture are not chemically pure and contains, in solution, different substances which give it an acidic, neutral or alkaline reaction.. The intensity of these characteristics is measured by determining the exact quantity of the hydrogen (H±) ions. PH readings ranges from 1 (highly acidic) to 14 (Highly alkaline).

A PH reading of 7 indicate neutral point. Research has indicated that most of the fresh water/brackish water fish species in the tropics grow very well at a PH range of between 6.7 to 9.9 (Table 4)

TABLE 4: PH RANGE FOR FISH CULTURE

PH RANGE	INTERPRETATION	REMARKS
1.0 - 4.9	Extremely acidic	Toxic to fish
2.0 - 6.6	Moderately acidic	Low productivity
6.7 - 9.9	Suitable H + ion	Desirable for fish (High productivity)
9.1 - 11.0	Moderately Alkaline	Low productivity
11.1 - 14.0	Extremely Alkaline	Toxic to fish

8.1.1. Determination of PH

Two methods are mostly used to determine the PH of pond water. The more accurate and faster one is the use of PH meter (Electrometric method)., This apparatus is very expensive. However the current needs of fish cultivation can be met by using simple inexpensive method — the use of a PH paper (universal indicator).

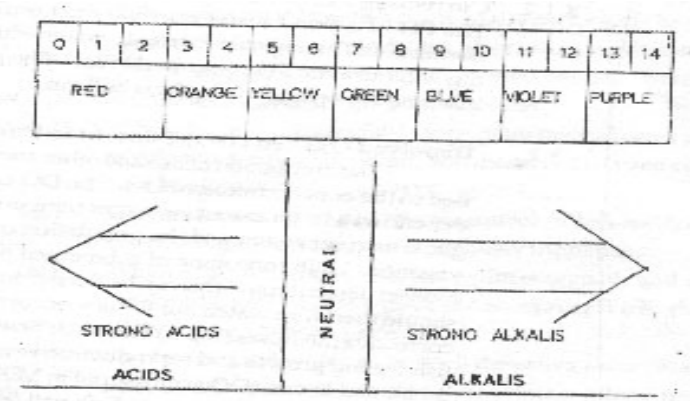


Figure 8 PH Range and Colour changes

8.1.2. Correcting PH in Pond Water

The PH of a pond water may vary according to a number of chemical and biological factors In water with low alkalinity liming will raise the PH to desired level. The practice of liming is discussed in section 10.1 of this bulletin.

8.2 Dissolved Oxygen (DO) Content in Ponds

The distribution of fish and other animals in water is strictly tied to the concentration of DO. The DO content of pond water depend to a large extent on water temperature, quantity of organic matter present and the population of sub-merged aquatic vegetation. High concentration of submerged plants lead to dissolved oxygen depletion and this can be dangerous to fish. A fish farmer should therefore watch out for any occurrence of these and effect corrective measures (82.3) Research Scientists have proved that fish feeling growth and reproduction is enhanced at DO level of 5m1/l and above (DO is measured in Milligram of aqueous oxygen per litre of pond water). Fish will feed poorly and starve at -low concentration of

DO, that is below 3mg/I. (Table 5). In ponds, low oxygen usually occur at night and is lowest just be fore dawn because of lack production of oxygen during the night by phytophntion

TABLE 5: TOLERANCE OF FISH TO DISSOLVED OXYGEN

Dissolved Oxygen Reading (Mg/L)	Remarks
Less than 1	Death of Fish
Less than 5	Fish survive but grow slowly and is sluggish
5 and above	Desirable. Fish respond to fast feeding, growth and reproduction

8.2.1. Indications of Low DO Content in Pond Water

(i) When oxygen is low, fish come to the surface of the water and appear to be gulping air They are trying to breath, This would be similar to a person who has been breathing under a cover for an extended time.

(ii.) If Secchi disk readings fall below 20cm this indicates that planktons are too abundant, and dissolved oxygen content is low.

(iii.) If a farmer discovers that large number of fish suddenly die overnight, low oxygen is probably the cause.

(iv.) When a farmer notices that fish swim sluggishly and are weakened, with visible sign of not accepting feeds, then a low oxygen problem exist

(v) Spit in the pond water and watch the saliva foam disappear. If DO is low, the foam remains intact after 5 minutes

8.2.2. How to Determine Pond Oxygen Content

By the use of water quality kit and Winkler's Method.

The kit is expensive, so also the apparatus for Winkler's. They are mostly used by researchers, A fish farmer can contact the nearest Extension Agent to liaise with Scientists Universities or

Research institutes nearby for water analysis in case serious problem is noticed in commercial farms.

8.2.3. Avoiding and Correcting Low Oxygen Problem

(i) Avoid over application of fertilizers and organic manure to pond water. Where the problem is caused by this action, apply lime to pond water to remedy the situation.

(ii) Employ physical control of aquatic plants submerged in the pond. Cutting such plants will promote penetration of light and more oxygen in water.

(iii) Water can be released into the pond by gravity flow. A pipe can be built few metres above the ponds when opened, water will splash into the pond (Figure 9). his help in stirring the pond water for aeration

(iv) A motorised boat or paddled canoe can be driven on the pond surface to stir the water for aeration

(v) Add fresh water to the pond immediately to revive the fish, and continue adding water until the fish stop gulping at the surface. While adding fresh water, drain some of the old water of the pond bottom. The bottom layers of water have the least oxygen.

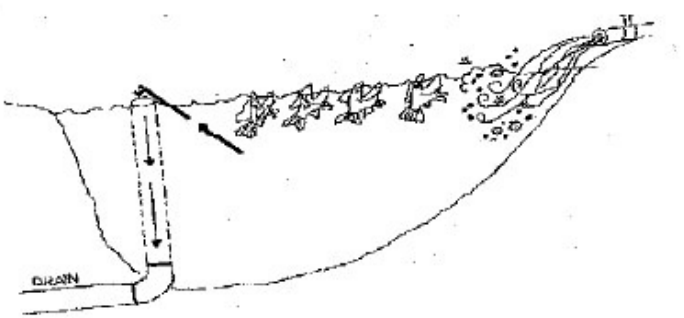


Figure 9: Pond with low oxygen and fish gasping at the surface fresh watert with high oxygen can be released from water

9.0. MANAGING POND WATER BIOLOGICAL FACTORS

One of the most important limiting factors to fish production in natural water bodies and fish ponds is food supply. Fish, especially their young ones have been shown to live and grow better on natural food than on artificial feeds. Microscopic green plants called algae or "Phytoplankton" form the base of the food chain for fish. Phytoplankton need light, proper temperature and nutrients for growth. These increase their abundance. As phytoplankton increase in pond water the water turns greenish.

Phytoplankton are drifted by water current and are not visible to the naked eyes, but can be observed under a microscope. As these plant microscopic organisms multiply, they are eated directly by some fish or mostly by other microscopic aquactic animals called zooplanktors. (Figure 10) Microscopic plants and animals are collectively called planktons. They also serve as food for larger aquatic organisms like insects, worms and molluscs which are in turn eaten by fish (figure 11)

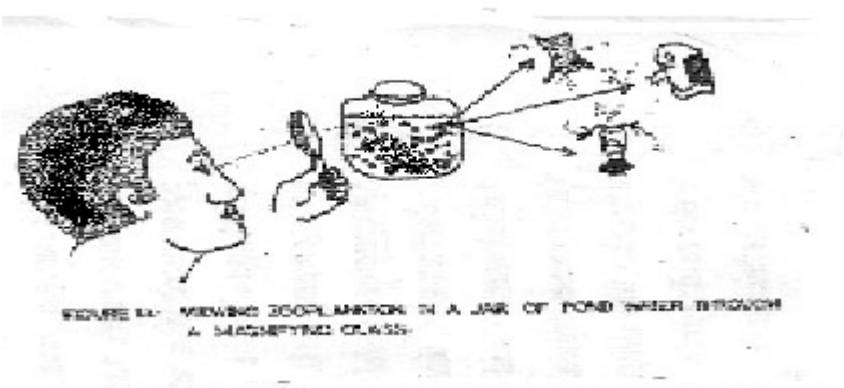


Figure 10: Viewing zooplankton in water jar with magnifying glass

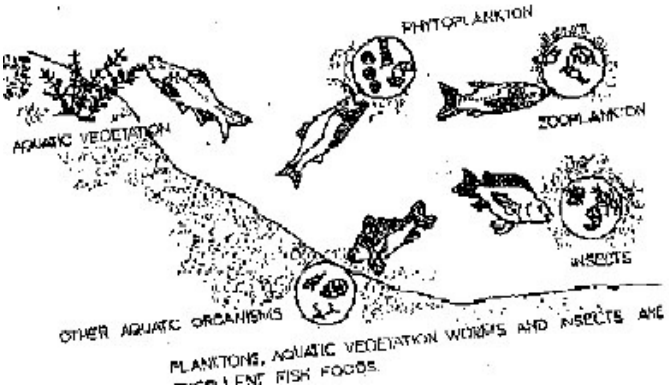


Figure 11

9.1. How To Increase Pond Water Biological Production

A fish farmer should take steps to improve the abundance of planktons and other aquatic organisms that serve as fish food in ponds. By doing this, less amount of money will be spent on purchase of supplementary food.

Fish can have abundant natural food through the following measures

(i.) A fish farmer should practice fertilization of pond(especially earthen pond) by use of organic manure and chemical fertilizers. Nutruents in chemical fertilizers (nitrogen, phosphrorus and potassium) are readily assimilated by phytoplankton, and their abundance, increases. Manure contains some nutrients and also worms for fish food.

(ii.) In Homestead (Backyard) fish ponds, an electric bulb can be connected either hanging over the pond or by the pond wall to attract insect into the pond at night (Figure. 12). This is good food supply free to the fish without cost to the farmer.

9.2 Pre-Caution to Fish Farmer

(i) In the bid to increase natural productivity (fertility) of pond water, a farmer should guide against over application of manure and fertilizers to fish ponds, because of the inherent danger of over production of plankton and dissolved oxygen depletion.

(ii) Fish should not just be left to natural food. Just as human beings need varieties of food in their diet for good growth, so fish need supplementary feeds.

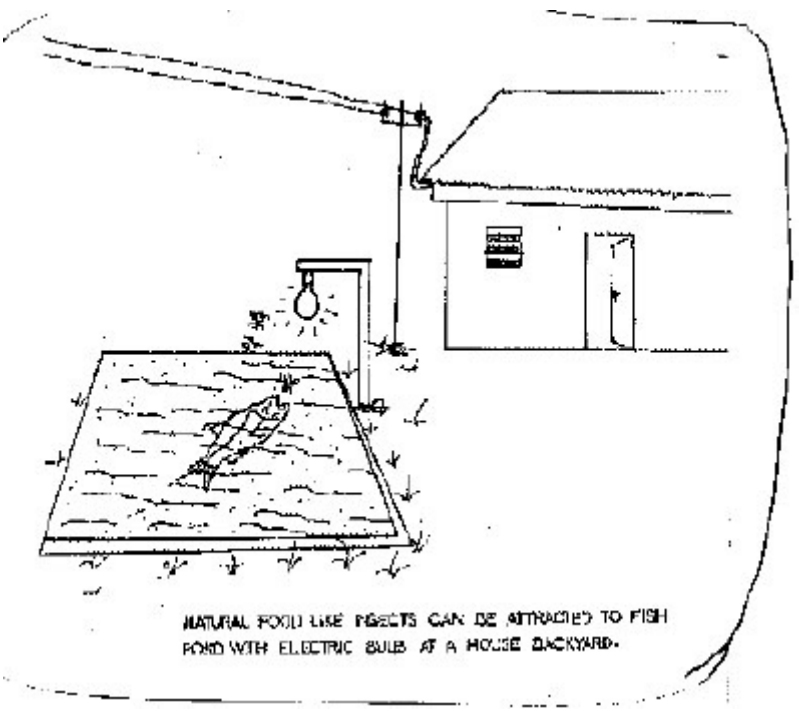


Figure 12

10.1 LIMING PRACTICES

In natural ponds (eartern), application of limes is important in correcting low PH, improve productivity of ponds and disinfect ponds of parasites and diseases.

10.1.1 Pre-Impoundment Application

The following steps should be followed in applying lime to pre pared pond.

i. If lime is lumps, break the lumps to fine powder by marching on the bag

ii. Spread the lime evenly on the pond bottom (Figure. 13)

iii. A disc harrow or rake can be used to mix the lime with the pond soil manually.

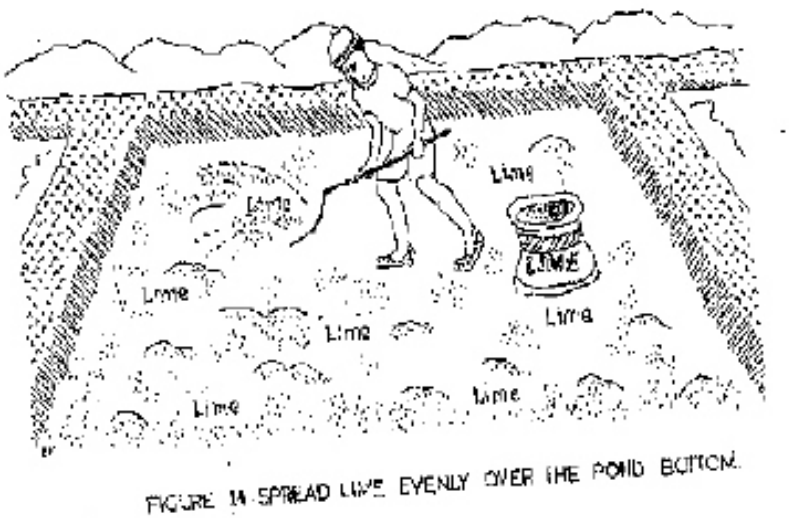


Figure 13: Spread lime evenly over the pond bottom

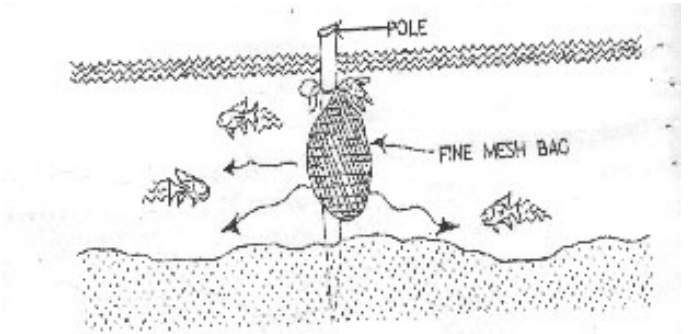


Figure 14: Lime/Fertilizer placed in bag and tied to a pole

10.1.2 Precautions

1. Wear prtoective clothes and shoes (preferably rain boot) in applying lime to pond bottom.
2. As much as possible, avoid inhaling the lime dust. This is dangerous to health.
3. After application, take a bath with soap.

10.1.3 Post-Impoundment Application

If the pond is already in-filled with water, then take the following steps.

1. Tie the mouth of the sack containing the lime material.
2. Tie the bag to a pole and allow the lime to sip freely into water (Fig. 15)
3. After about 48 hours (2 days) retrieve the sack from the pond. By this time, the lime material must have sipped completely into the pond.

10.1.4 Liming Materials Good for Fish Ponds

These include:-

(1) Limestone/Agricultural lime – $CaCO_3$

(2) Caustic/slacked or hydrated lime – $Ca(OH)_2$

(3) Quicklime – CaO

(4) Wood Ash

Wood Ash and agricultural lime are the best liming materials for fish pond. They are also the cheapest and most readily available. Agricultural limes are by-products of cement factories and can be obtained from such places.

10.1.5 Liming Rates

Wood Ash can generally be applied at the rate of 50-100kg/ha/month.

The recommended liming rate using agricultural lime is shown below in Table 6.

TABLE 6: LIMING RATES OF POND USING AGRICULTURAL LIME

SOIL TYPE	NEW PONDS	OLD PONDS
1. clay soil	1680 - 2240kg/ha/year	1120kg/ha/year
2. sandy soil	1120 - 1680kg/ha/year	560 - 1120kg/ha/year

10.2 FERTILIZATION

A fish farmer can increase pond productivity by applying organic manure or chemical fertilizers.

10.2.1 Organic Manure

Organic Manure from animal or plant waste are suitable for fish ponds. Manure from chickens, goats, sheep, ducks, pigs, rabbits, cattle and horses are excellent fertilizers for fish ponds

Research Scientists have worked out a suitable application rate for fish pond as shown in Table 7.Figures in parrenthesis indicate application rates of droppings in tons/ha/week of no of animals per ha/month.

TABLE 7: ANIMAL MANURE APPLICATION RATES AND NUMBER OF ANIMALS NEEDED FOR 100M2 OF POND

Manure source	Application rate (Kg/100m2/week)	No. of animals per 100m2 of pond
Cattle	10 (100)*	(a) 0.3 (all day) (30)*
Chicken	6 - 8 (600 - 800)*	(b) 0.6 (night only) (60) 10 – 15 (1000 – 1500)* 10 - 15 (100 – 1500)*
Duck	6 - 8 (600 - 800)*	(a) 4 (all day) (400)* (b) 8 (night only) (800)*
Pig	6 - 8 (600 - 800)*	0.5 (50)*

Source: MCA (1997)

10.2.2 How Manure Works

(i) They decompose and release nitrogen, phosphorus and potassium which are used by phytoplankton for growth and reproduction. In this way more natural food organisms are produced for fish to eat.

(ii) They provide nutrients and attachment sites for bacteria and other micro-organisms. These organisms provide nourishment for fish.

(iii) Undigested food in animal manure and plant manure are digestible and provide direct nutrition when eaten by fish.

10.2.3 Chemical Fertilizers

Chemical fertilizers are normally used to stimulate phytoplankton production in fish ponds; thus increasing fish yields. They contain important minerals, nitrogen (N), phosphorus (as P_2O_5) and potassium (as K_2O or potash) which are needed by phytoplankton in fish ponds. Fertilizers high in phosphorus are especially good for phytophlankton production in freshwater ponds. New freshwater ponds and salt water ponds also require nitrogen. After several years, the organic content in the mud of these ponds will increase and may provide sufficient nitrogen for phytoplankton growth. Only phosphorus may be needed for increased production in aged ponds.

NPK composition of several fertilizers used in fish ponds are shown in Table 8 and recommended application rates for some chemical fertilizers are shown in Table 9.

TABLE 8: NPK COMPOSITION OF SEVERAL FERTILIZERS USED IN FISH PONDS

Percent (N)		P_2O_5	Composition (K_2O)
Ammonium nitrate	33-35	0	0
Ammonium Sulphate	20-21	0	0
Ammonium Phosphate	16	20	0
Calcium nitrate	15-5	0	0
Diammonium Phosphate	18	48	0
Double Superphosphate	0	32-40	0
Muriate of potash	0	0	50-62
Potassium Nitrate	13	0	44
Potassium Sulphate	0	0	50
Sodium Nitrate	16	0	0
Superphosphate	0	18-20	0
Triple Superphosphate	0	44-45	0
Urea	42-47	0	0

Source:- ICA (1990)

TABLE 9: APPLICATION RATES FOR CHEMICAL FERTILIZERS

Fertilizer type	Application rate	Comments
1. Basic slag (15% of P_2O_5)	36kg/ha/month	To be applied one week after application of lime
2. Triple Supper Phosphate (T.S.P)	60kg/ha/month	Applied twice monthly
3. Ammonium Sulphate (A.S)	300 – 400kg/ha/month	Applied twice monthly
4. Mixture of T.S.P and A.S	133 - 238kg/ha/month	To be applied monthly for four months.

11.0 FEEDING OF POND FISH

Fish feed on a variety of foods. These include food produced from the natural pond environment and feeds given as supplement to the pond.

(a) Natural Fish Foods

Living organisms are natural fish foods and they are produced in the water where the fish live. Phytoplankton (microscopic plants), zooplankton (microscopic animals), and larger aquatic organisms like insects, crustacea, molluscs, and aquatic plants are all examples of natural foods (Figure. 15). Fertilization increases their abundance.

(b) Supplementary Feeds

When natural foods are not available in sufficient quanties to provide adequate nutrition for fish growth, feeds that are manufactured or grown outside of the fish pond may be fed at regular intervals (daily, weekly, etc). These feeds supplement natural foods. Supplementary feeds should include finely divided artificial food like egg yoke, bloodmeal, fish meal, shrimps flour, bean flour, oil cakes, bone meals, cereal brans, etc.

Adult fish prefer feeds available in pellet forms. Sinking pellets are more suitable to bottom feeders like Clarias and Heterotis spp, while for Tilapia, floating pellets are suitable. Pelleted feeds of 2mm-9mm in diameter is suitable for fish from juvenille to adult stages. It is recommended that fish be fed with pellets since the whole nutrients in the food will be readily taken by the fish. Good quality feed for fish farming purpose should at least have the following proximate composition – Protein (35%); minerals and vitamins (32-33%); fats (11%); carbohydrate (6-19%).

Feed stuffs that can be accepted by fish in pond include grain/cereal brans, bloodmeal, groundnut cake, etc. These

are readily available. Better quality supplemental feed may be made by combining ingredients. Fish should grow well on a feed containing 30 – 35% crude protein. When natural food is abundant and fish are stock at low densities, a 25 to 30% protein content is suitable.

Scientists recommended between 5 -8% of feeds, per body weight of fish (adult) to avoid feed wastages.

Feed ingredients should be free of toxicants, e.g. Haemagglutinins in raw soybeans and Gossypol in cotton seed meal. These toxicants can be removed by roasting the feedstuff. The following are hints for feeding fish in ponds.

(1) In polyculture, the feeding habits of fish species stocked should be considered. A combination of species like Tilapia, Clarias and Heterotis in the same pond will require sinking and floating pellets/crushed meals.

(2) Feed fish at definite points in the pond. This will make the fish to respond more to feeding spots.

(3) Feed fish on daily basis – best times are morning before 7.00 am and evening around 6.00 pm. Irregular feeding will retard the growth rate of fish.

(4) Feed stuff for fish should be rich in protein to avoid stunted growth.

(5) Suspend feeding your fish 1 day to harvest time.

(6) Avoid overstocking of pond with feeds. Overstocking can result in water pollution and death of fish. Feed fish according to the recommended rates. The recommended feed formular in preparing varying percentages of rich protein feeds is as shown in Table 10. When nutrients rich feed supplements are fed to fish intensively, fertilizers

and manure applications are not necessary especially in concrete tanks since all the nutrients required in feeds are already contained in the formulated feeds.

Table 10: Feed Formulae For Preparing Feeds For Various Crude Protien Levels Using Locally Available Feed Ingredients.

% Crude Total Protein	Palm Kenel Cake (Kg)	Corn Barn (Kg)	Rice Barn (Kg)	Fish Meal (Kg)	Soya Bean (Kg)	G/Nut Cake (Kg)	Weight
20	45-30	45.30	-	3.1	3.1	3.1	99.99
20	-	35.80	35.80	-	11.20	11.20	100.00
35	-	24.0	24.0	17.3	17.3	17.3	99.99
40	21.2	21.2	-	19.2	19.2	19.2	100.00

12.0 CONTROL OF DISEASES AND PREDATORS

(a) Common Fish Diseases

Fish diseases are caused mostly by fish parasites. Maintaining a hygienic pond environment is the best preventive method of checking diseases outbreak. Diseases can occur in fish pond due to:-

(1) Overcrowding, i.e. high density stocking

(2) Poor water quality resulting in fish kill

(3) Erratic feeding practices. Starved fish are highly susceptible to diseases attack.

(4) Intrusion of predators into the pond such as snakes, frogs, aquatic birds, dragon flies, etc. Most predators act as intermediate host to fish parasites.

(5) Over fertilization of pond water leading to high density algal bloom can reduce the amount of dissolved oxygen (DO), affecting fish health.

Broadly, diseases can be classified into:-

(i) Bacterial and viral
(ii) Fungal
(iii) Protozoan
(iv) Worms
(v) Crustacean
(vi) Environmental and
(vii) Nutritional

Common fish diseases, causative factors or agents, symptoms and treatment recommended are high lighted in Table 11.

Table 11

TABLE 11: COMMON FISH DISEASES, CAUSATIVE AGENTS, SYMPTOMS AND RECOMMENDED TREATMENT

1. **Bacterial** Infectious abdominal dropsy (I.A.D.)	Pseudomonas Puntata	Swelling of belly	Antibiotic such as chloraphenicol 1gm/kg of feed or 5ml injection
2. **Fungal** (a) Gill or Branchiomyiosis	Branchimyces Anguimis	Red spots on the gill	Avoid dense stocking. Remove affected fish
(b) Saprolegina infection		Appears as fussy, grey whitish blotches on skin	Isolate the fish and treat with $CUSO_4$ at 5-10mg/l of water
3. **Protozoan** Ichtyophthirriasis	Icthyophtirius	Red patches on gill and skin	Difficult to treat when parasites are in the skin layers. Drain and lime the pond
4. **Worm Diseases** (a) Fish Leeches	Pisicola Geomatra	Skin covered with the leach, causing excessive weakness	Drain the pond. Put fish in solution of 1ml Lysol and 5l of water for 5 seconds.
(b) Fish Fluke	Dactylogyrus vastator	Gills swells and turn grey	Drain the pond. Treat fish in salt, solution of 25gm per litre of water for 10 seconds.

Table 11 (Cont'd).

1. **Disease caused by Crusacean Argutus Infection**	Argutus foliaceus	The string of the fish lice cause red patches on fish skin	Drain the lime pond. Treat fish in solution of KmnO4 or Lysol both 1gm/L of water for 40 seconds.
2. **Environmental Diseases**			
(a) Acidic Water	Low PH above 5	Fish skin covered with whitish film, gills turn brownish. Mortality of fish	Apply 500kg of a $CaCO_3$/ha of pond.
(b) Alkaline Water	High PH below 9	Mortality of fish	
(c) Low DO	**Asphyxia**	Fish regularly come out to gasp for atmospheric air. Mass mortality of fish with wide open mouth and gills wide apart.	Apply lime in a sufficient quantity according to PH level. Drain pond and change water.
3. **Nutritional Diseases**	Enteritis	If abdomen is pressed lightly a yellow-red liquid flows from the anus. Intestine is red congested and highly inflamed	Use balance diet fed with high proportion of protein or vitamin to correct nutritional deficiency

(a) **Fish Predators**

Predators are natural enemies of fish. Common fish predators that should be prevented from causing fish losses in ponds include water snakes, turtles, frogs, water birds (king fisher and water duck, etc), crocodiles, crabs, etc.

(Figure. 16). Wild carnivorous fish intruding into ponds are also predators and as such should be prevented.

Control of Predators

(1) Ensure regular clearing of pond site. Predators hide in bushes.

(2) As much as possible, the farmer should fence the pond site and screen the top, especially concrte tanks.

(3) Most aquatic predators get into the pond through flood water measures should be taken to protect the pond from flood water.

(4) Hunt the predators, using traps or point blank killing.

13.0 CROPPING (HARVESTING) POND FISH

In fish pond culture system, three types of cropping are practiced in routine management.

(a) Test cropping
(b) Partial harvest
(c) Total pond harvest

(a) Test Cropping: Fish pond should be test cropped routinely to monitor fish growth and health. After examination, test cropped fish should be returned to the pond water. A scoop net is suitable for test cropping (Figure. 16). Harvesting material that can injure fish should be avoided.

(b) Partial Harvesting: When different age group of the same fish species or different species combination are reared together in pond, the fish are bound to mature to table sizes at different times. Partial harvest of pond should be done with appropriate mesh size. Matured fish can be selected for market sale or family consumption while undersized ones should be returned to the pond. Periodical harvesting of pond fish enables a farmer to generate revenue periodically. Draw net in most suitable for harvesting pond fish. (Figure. 17).

(c) Total Harvest: Ponds that have been used to rear fish for over 5 years can be totally drained and the whole fish harvested. Total pond harvest from management point of view can be carried out at the end of a production cycle or in cases of emergency like diseases out break. A Draw Net or Drag Net is most suitable for total cropping of pond fish. Nets should be cleaned and spread in the sun to dry after harvesting operation. This is to preserve and prolong their operational life span.

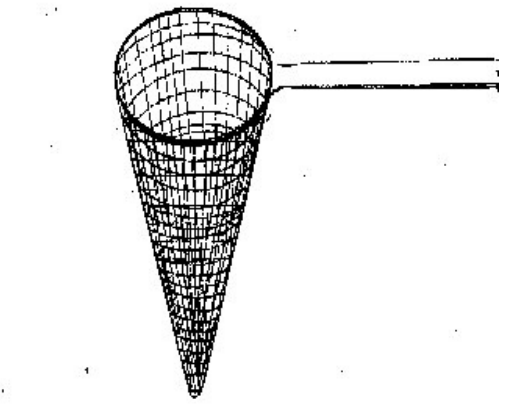


Figure 16 A scoope net for test harvesting

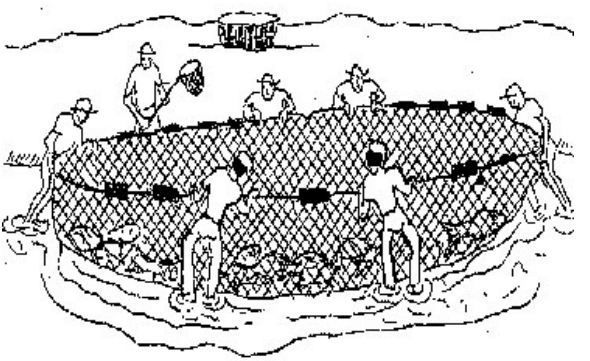


Figure 17 Nets are frequelty used to harvest ponds

14.0 KEEPING FARM RECORDS

It is important for fish farmers to keep record of events and statement of expenditures and income throughout the production cycle of the fish pond. Aspects of farm record keeping include the under-listed:-

(a) The Log Book: This should contain information on the following:-

(1) Location of fish pond
(2) Nature of soil at site or cement tank structure
(3) Pond ownership type (whether private, cooperative/communal)
(4) Pond area and depth
(5) Sources of water supply
(6) Date of commencement of construction
(7) Date of completion of construction
(8) Thickness of dam wall/concrete wall
(9) Agricultural/Economic activities practiced around
(10) Date of pond impoundment
(11) Sources of Fingerlings/breeders
(12) Stocking rate
(13) Species of fish stocked
(14) Date of stocking
(15) Water analysis results
(16) Fertilizers applied/fertilization practices (if appliable)
(17) Limes/liming practices.
(18) Supplementary feeds applied including sources and forms (i.e pellets or grounded). and trade names

(19) Water management practices (regularity of change)
(20) Diseases identified
(21) Record of fish mortality
(22) Staff strength on farm
(23) Number of days of contact with advisors, i.e Extension/Research staff or consultants.

(b) Total Expenditure: These includes cost.

(i) Fixed Cost

1. Land
2. Pumps/Tanks and farm equipment
3. Farm structures
4. Brood stocks

(ii) Variable Cost

1. Fish seed
2. Fertilizers
3. Limes
4. Feeds
5. Labour/maintenance
6. Medication
7. Transportation
8. Consultancy

(c) Income Statement

Income projection/record can be conclusive after harvest. Financial analysis for project profitability can be easily arrived at with proper records of expenditure and income. For details on profitability estimation, refer to NAERLS Extension Bulletins No. 55, Farm Management Series No 11 (Analysis of Farm Business) and No Economics of Aquaculture production.

BIBLIOGRAPHY

1. Annual Report 1989. National Institute for Freshwater Fisheries Research, New Bussa.

2. Bard, J.P., *et al*. 1976. Hand Book of Tropical Fish Culture. Centre Technique Forestier Tropical, France 165p.

3. DFRRI(1988). Water Quality Management in Fish Ponds. Extension Guide No 2.

4. ICA (1990). Chemical Fertilizers for fish Ponds. Water Harvesting Manuals FT3. International Centre for Aquaculture, Auburn University.

5. ICA (1990). Organic Fertilizers for Fishponds. Water Harvesting Manuals FT3. International Centre for Aquaculture, Auburn University.

6. Ita E.O. 1990. Principles and practices of integrated commercial fish farming in Nigeria. Technical Report Series no. 19, National Institute for Freshwater Fisheries Research NIFFR.

7. Viveen, W.J.A., *et al.* 1986. Practical manual for the culture of African Catfish (Clarias Garienpinus) 93p.