AQUACULTURE MAJOR

III SEMESTER

Course No.: 5

Basic Principles
of
Aquaculture

Syllabus

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7 Collection and study of aquatic weeds, aquatic insects, weed fish and larvivorous fish

8. Field visit to hatchery, nursery, rearing and stocking ponds of aqua farms.

UNIT-1

I.1 Definition and History of Aquaculture

What is aquaculture?

"Aquaculture is defined as the cultivation of fishes and other aquatic organisms in natural environments or artificial environments for the purposes of food.Aquaculture is a kind of agriculture in water using advanced technologies.Aquaculture is a branch of fisheries.Fisheries is of two types ,namely capture fisheries and culture fisheries .

"Aquaculture refers to the breeding,rearing,and harvesting of plants and animals in all types of water environments including ponds,rivers,lakes and the ocean"

Capture fisheries is the catching of fishes from the water.Culture fisheries is the cultivation of fishes and other aquatic organisms.it is also called as Aquaculture.

In this regard, it is important to note that currently, aquaculture is not only aimed at food production but also at obtaining bio-active compounds (anti carcinogens, essential fatty acids, proteins, etc.) through the cultivation of macro algae, sea cucumbers, or bio-fuels through the cultivation of micro-algae.

History of Aquaculture

The first aquaculture experiences date back 6,600 years with eel farming; likewise, other research found evidence of carp aquaculture in China in 6200 BC.The first Blue Revolution began 8,000 years ago in China. In 475 BC, Fan Lei wrote the first Aquaculture Treaty where he explained carp farming.The first evidence of some kind of control over the reproduction of Nile tilapia in captivity in irrigation ponds comes from paintings dating back to 1500 BC, found in The ban in Egypt. Likewise, the first evidence of aquaculture practices took place in Asia in 1000 BC, due to the desire of an emperor to have a constant supply of his favorites .The initial forms of aquaculture practiced involved confining wild aquatic animals in lakes, ponds, or small coastal lakes; there is evidence that tilapia was already being farmed in Egypt, and that Japanese, Greeks, and Romans farmed oysters.It was not until the 17th century that artificial breeding began through hatcheries, a practice that is very widespread today. In the 1960s, aquaculture gained greater prominence with the realization that fishing would not guarantee future protein supply, and the use of sea cages for salmon farming, a practice that is one of the most important in the world, grew.

What is the importance of aquaculture?

1. Aquaculture is an important source of proteins, providing essential amino acids that are crucial for human health and development.
2. Fish and other aquatic products are rich in omega-3 fatty acids, vitamins, and minerals, making them a valuable addition to a balanced diet.
3. Aquaculture helps alleviate malnutrition and improve micro nutrient deficiencies, particularly in developing regions.
4. According to Globe-fish, the apparent per capita consumption in 2019 was 20.5 kilograms, of which aquaculture accounts for 11.2 kilograms; in this regard, aquaculture is responsible for more than 50% of the fish and seafood we consume.
5. Aquaculture not only provides food but also plays an important role in producing bio-active compounds (fatty acids, proteins, vitamins, etc.) for the food and pharmaceutical industries, bio fuel production, the recovery of wild species (restocking), education, wastewater treatment, among others.

6. Aquaculture plays a crucial role in reducing pressure on over-exploited wild fisheries. By providing a sustainable alternative source of seafood.

7. Aquaculture helps conserve marine ecosystems and protect biodiversity.

8. As global demand for seafood continues to rise, aquaculture is poised to play an even more significant role in meeting this demand without compromising the health of wild fish populations.

9. Aquaculture solely as a food production activity but as an opportunity to produce a range of substances that can be integrated with other economic activities like agriculture.

10. Aquaculture is a powerful economic driver, especially in rural and coastal areas. The industry generates job opportunities, promotes economic diversification, and contributes to poverty reduction.

Challenges of Aquaculture

Aquaculture, like any human activity, is not without environmental challenges. Pollution caused by aquaculture operations, such as nutrient runoff and escaping fish, can affect water quality and harm ecosystems. Chary (2023) identified six priorities that could make aquaculture more circular:

1. Increasing production and demand for the most essential species,
2. Reducing food loss and waste at farm and post-harvest stages,
3. Supporting nutrient recycling practices on multiple scales,
4. Adapting aquaculture feed formulations,
5. Informing consumers about the benefits of low-trophic level species and other environmentally friendly aquatic foods, and
6. Addressing urgent research gaps.

Types of Aquaculture

Aquaculture can be classified into various production systems depending on the species raised, environmental characteristics, types of facilities, levels of intensification, among other factors. There are four approaches to aquaculture:

"**C**ommercial aquaculture,"

"**C**onservation aquaculture,"

"**R**estorative aquaculture," and

"**R**egenerative aquaculture."

By the environment in which it is practiced

Marine Aquaculture or Mariculture

Marine aquaculture refers to the breeding, rearing, and harvesting of aquatic plants and animals (primarily oysters, clams, mussels, shrimp, salmon, and other marine fish) in water with a salinity of more than 30 practical salinity units (PSU).

Freshwater Aquaculture

This is practiced in inland environments using freshwater. Freshwater is defined as water with less than 0.5 PSU.Freshwater aquaculture refers to the breeding and rearing of aquatic animals (fish, freshwater shrimp, crabs, bivalves, etc.) and native plants using ponds, reservoirs, lakes, rivers, and other inland water bodies.

Brackish Water Aquaculture

Technically, brackish water is a mixture of freshwater and seawater that usually occurs in coastal areas and typically has a salinity between 0.5 and 30 PSU. A characteristic of many surface brackish waters is that their salinity can vary significantly in space and time.

By the level of intensity or production systems

Extensive System

Conducted in ponds where fish feed on the primary production of the water body, which is enhanced by fertilization. These systems have low stocking densities, for example, 1 fish/m², and their yields are less than 500 kilograms per hectare.

Semi-intensive System

Conducted in constructed ponds that are fertilized (organically or chemically) and where animals are given supplementary balanced feed. The density ranges between 1 and 5 fish/m². Aeration is sometimes used, covering about 10 to 15% of the pond area.

Intensive System

Conducted in ponds, cages, raceways, or tanks with constant monitoring of water quality, feeding, and production. Aeration is typically used in at least 50% of the pond area. Feeding depends solely on artificial diets. The density ranges between 5 to 20 fish/m², depending on water exchange and aeration provided to the pond.

Super-intensive or Hyper-intensive System

Primarily conducted in tanks, under strict control of all factors, mainly water quality, aeration, and feeding. The stocking density is over 20 fish/m²; however, the peak production density achieved depends on the ability to maintain good water quality conditions for the cultured organisms.

By Number of Species

Monoculture : A single species is cultivated. For example, tilapia or trout farming.

Polyculture: Two or more species are cultivated in the same pond or system. The most important consideration in polyculture is the potential to increase fish production by better utilizing natural food or the area of the cultivation systems. For example, tilapia and shrimp farming, where tilapia inhabit the water column and shrimp live on the pond bottom.

Integrated Cultures: Organic waste from the cultivation of other animals like ducks or pigs is used to produce microalgae, which in turn feed the fish. Integrated cultures have advanced to concepts like rice-fish farming, biofloc technology, aquaponics, integrated multi-trophic aquaculture (IMTA), and aqua-mimicry.

I.2 Blue Revolution

1. Blue Revolution also called as Neel or Nili Kranti Mission in India was launched in 1985-1990 during the 7th Five-Year Plan.
2. The main objective is to develop, manage, and promote fisheries to double the farmers' income.
3. **Hiralal Chaudhuri and Dr. Arun Krishnsnan** are known as Father of Blue revolution.
4. The Blue Revolution in India was launched by Fish Farmers Development Agency (FFDA) by the Central Government of India.
5. Blue Revolution, the Neel Kranti Mission has the vision to achieve economic prosperity of the country and the fishers and fish farmers.

Introduction to the Blue Revolution

The Blue Revolution (Nili Kranti) is an initiative taken by the government for the growth of the aquaculture industry.

It started in China as it accounts for around two-thirds of the total aquaculture production worldwide.

Recently, the aquaculture industry has been growing at an average rate of 9% a year and India is one of the fastest growers.

The Neel Kranti Mission was the start of the Blue Revolution in India with the vision to achieve the economic prosperity of India keeping in view the sustainability, bio-security, and environmental concerns.

Nili Kranti in India

The Blue Revolution in India was launched during the 7th Five Year Plan (1985-1990) during the sponsorship of the Fish Farmers Development Agency (FFDA) by the Central Government of India. Later, during the 8th Five Year Plan (1992-97), the Intensive Marine Fisheries Program was launched, and eventually, the fishing harbours in

Vishakhapatnam, Kochi, Tuticorin, Porbandar, and Port Blair were also established over the time. This scheme focused on the development and management of fisheries controlled by the National Fisheries Development Board (NFDB).

The components that are included under the Blue Revolution Schemes are :

1. National Fisheries Development Board (NFDB) and its activities
2. Strengthening of Database & Geographical Information System of the Fisheries Sector
3. Development of Inland Fisheries and Aquaculture
4. National Scheme of Welfare of Fishermen
5. Development of Marine Fisheries, Infrastructure and Post-Harvest Operations
6. Monitoring, Control and Surveillance (MCS) and other need-based Interventions
7. Institutional Arrangement for the Fisheries Sector

Objectives of the Blue Revolution/Neel Kranti Mission

The Nili Kranti Mission aimed to enhance the economic condition of India through the augmentation of fisheries and thus contributing towards the food and nutritional security. The utilization of the water resources for the development of fisheries was done by the Neel Kranti Mission in a sustainable manner.

The objectives of the Nili Kranti mission are mentioned below:

1. Completely tapping the total fish potential of India on both islands as well as in the marine sector and to triple the production by the year 2020.
2. Transforming the fisheries sector into a modern industry through the utilization of new technologies and processes.
3. Doubling the income of the fishers through increased productivity and improving the post-harvest marketing infrastructure including e-commerce, technologies, and global best innovators.
4. To ensure the active participation of the fishers and the fish farmers in income enhancement.
5. Tripling the export earnings by the year 2020 with a major focus on the benefits covering the institutional mechanisms.
6. Developing the nutritional and food security of the nation.

Features of the Blue Revolution Scheme

Some of the salient features of the Blue Revolution Scheme are:

1. Providing suitable linkages and convergence with the 'Sagarmala Project' of the Mahatma Gandhi National Rural Employment Guarantee Scheme (MNREGA), Ministry of Shipping, National Rural Livelihoods Mission (NRLM), Rashtriya Krishi Vikas Yojana (RKVY), etc.
2. The Blue Revolution scheme concentrates mainly on enhancing the production and productivity of aquaculture and fisheries both from the inland and marine sources.
3. Promoting and encouraging the economically backward sections like the Scheduled Castes, Scheduled Tribes, Women, and their co-operatives to take up fishing.
4. The Blue Revolution Scheme also encourages entrepreneurship development, private investment, Public-Private Partnership (PPP), and better leveraging of institutional finance.

Blue Revolution in India – Outcomes

The Blue Revolution in India along with the Fish Farmers Development Agency (FFDA) brought an improvement in the aquaculture and fisheries sector with the introduction of new techniques of rearing, marketing, exporting, and fish breeding.

Some of the major outcomes of the Blue Revolution in India are mentioned below:

1. Currently, the Indian Fisheries Sector reached a production of 4.7 million tonnes of fish including 1.6 million tonnes of fish from freshwater aquaculture from a limit of 60,000 tonnes (50 years ago)

2. India is recorded to achieve an average annual growth of 14.8% as compared to the global average percentage of 7.5 in the production of fish and fish products.
3. The fishery has become India's largest agricultural export over the last five years with a growth rate of 6-10%.
4. India has become the world's second-largest producer of fish with exports worth more than 47,000 crore rupees.
5. The fisheries and aquaculture production contributes 1% and 5% to India's GDP and Agricultural GDP respectively.

PRADHAN MANTRI MATSYA SAMPADA YOJANA (PMMSY):

Vision :

Ecologically healthy, economically viable and socially inclusive fisheries sector that contributes towards economic prosperity and well-being of fishers, and fish farmers and other stakeholders, food and nutritional security of the country in a sustainable and responsible manner.

INTRODUCTION

The PMMSY is designed to address critical gaps in fish production and productivity, quality, technology, post-harvest infrastructure and management, modernisation and strengthening of value chain, traceability, establishing a robust fisheries management framework and fishers" welfare.

The PMMSY is an umbrella scheme with two separate components namely

(a) Central Sector Scheme (CS) and

(b) Centrally Sponsored Scheme (CSS).

The Centrally Sponsored Scheme (CSS) Component is further segregated into Non-beneficiary oriented and beneficiary orientated components/activities under the following three broad heads:

(i) Enhancement of Production and Productivity

(ii) Infrastructure and Post-harvest Management Fisheries Management and Regulatory Framework subPradhan Mantri Matsya Sampada has been approved at a total estimated investment of Rs. 20,050 crores comprising of Central share of Rs. 9407 crores, State share of Rs 4880 crores and Beneficiaries contribution of Rs. 5763 crores.

PMMSY will be implemented in all the States and Union Territories for a period of 5(five) years from FY 2020-21 to FY 2024-25.

AIMS AND OBJECTIVES (PMMSY) are:

1. Harnessing of fisheries potential in a sustainable, responsible, inclusive and equitable manner.
2. Enhancing of fish production and productivity through expansion, intensification, diversification and productive utilization of land and water.
3. Modernizing and strengthening of value chain - post-harvest management and quality improvement.
4. Doubling fishers and fish farmers' incomes and generation of employment.
5. Enhancing contribution to Agriculture GVA and exports
6. Social, physical and economic security for fishers and fish farmers.

The PMMSY would be implemented through the following agencies:

(i) Central Government and its entities including National Fisheries Development Board
(ii) State/UT Governments and their entities
(iii) State Fisheries Development Boards
(iv) Any other End Implementing Agencies as decided by Department of Fisheries

PMMSY targets :

- Fish production is likely to be enhanced from 13.75 million metric tons (2018-19) to 22 million metric tons by 2024-25.

- A sustained average annual growth of about 9% in fish production is expected.
- An increase in the contribution of GVA of the fishing sector to the Agriculture GVA from 7.28% in
- 2018-19 to about 9% by 2024-25.
- Double export earnings from the present Rs.46,589 crores (2018-19) to about Rs.1,00,000 crores by 2024-25.
- Enhancement of productivity in aquaculture from the present national average of 3 tons to about 5
- tons per hectare.
- Reduction of post-harvest losses from the reported 20-25% to about 10%.
- Doubling of incomes of fishers and fish farmers.
- Generation of about 15 lakhs direct gainful employment opportunities and thrice the number as
- indirect employment opportunities along the supply and value chain.
- Enhancement of the domestic fish consumption from about 5 kg to about 12 kg per capita.
- Encouragement of private investment and facilitation of growth of entrepreneurship in the fisheries sector.

I.3 Present status of Aquaculture – Global and National scenario

- ✓ India is the second largest fish producing country in the world with the current estimated fish production of 14.73 million metric tonnes during 2020-21.
- ✓ It contributes 7.56 % of global production.Fish and fish products have presently emerged as one of the largest groups in agricultural exports of India with 13.77 lakh tonnes in terms of quantity and Rs. 45,106.89 crore in value The fishery sector in India (culture and capture fisheries combined) contributes 5.23% to the Gross Domestic Production (GDP) of the agriculture sector and 1.07 % to the total GDP of the country.
- ✓ Fisheries and aquaculture provide employment to more than 43 million individuals worldwide. In India, Fisheries and aquaculture provide gainful employment and livelihood support to more than 28 million people by engaging them in different fisheries and related activities Fisheries in India is a very important economic activity and a flourishing sector with varied resources and potentials.
- ✓ There is a 20–fold increase that India achieved in fish production in just six decades, i.e. from 0.75 million tonnes in 1950-51 to 14.73 million tonnes during 2020–21.
- ✓ This made India the second Largest country in the world after China in aquaculture production. Freshwater aquaculture showed an overwhelming ten-fold growth from 0.37 million tonnes in 1980 to 4.03 million tonnes in 2010; The freshwater aquaculture comprises of the culture of carp fishes, culture of catfishes (air breathing and non-air breathing), culture of freshwater prawns, culture of pangasius, and culture of tilapia. The three Indian major carps, namely catla (Catla catla), rohu (Labeo rohita) and mrigal (Cirrhinus mrigala) contribute the bulk of production to the extent of 70 to 75 percent of the total fresh water fish production.
- ✓ Catfishes forming a second important group contributing the balance of 25 to 30 percent. It is estimated that only about 40 percent of the available area of 2.36 million hectares of ponds and tanks has been put to use and an immense scope for expansion of area exists under freshwater aquaculture In addition, in brackishwater sector, the aquaculture includes culture of shrimp varieties mainly, the native giant tiger prawn (Penaeus monodon) and exotic whitelegshrimp (Penaeus vannamei).
- ✓ The national mean production levels from still water ponds has gone up from about 600 kg/hectare/year in 1974 to over 2900 kg/hectare/annum at present and several farmers are even demonstrating higher production levels of 8–12 tonnes/hectare/year.
- ✓ The technologies of induced carp breeding and polyculture in static ponds and tanks virtually revolutionized the freshwater aquaculture sector and turned the sector into a fast growing commercial sector. The

freshwater prawn farming has received increased attention only in the last two decades due to its high consumer demand.

- ✓ The giant river prawn, Macrobrachium rosenbergii, the largest and fastest growing prawn species, is cultured either under monoculture or polyculture with major carps. Culture for mariculture species has been initiated in the country and is presently carried out to a limited extent for seaweeds, and mussels as a commercial activity and some fish species like seabass and cobia on an experimental basis to standardize the technology.
- ✓ In addition, there is contribution from cold water fisheries. They constitute about 1% of total fish production. Important food fishes of cold waters are tor tor, mahaseer etc. India has an estimated total estuarine area of 3.9 million hectares; Of this, about 15 percent of the potential area has been put into aquaculture purpose. Apart from the giant tiger prawn (P. monodon), certain marine/brackish water fish/shrimp species such as milkfish, pearl-spot and mullets have shown a lot of promises for commercial aquaculture India's aquaculture production basically can be classified into freshwater and brackish water production. Some of the important species cultured in India are the Indian major carps and shrimp.
- ✓ Besides these, ornamental fish culture and seaweed farming, are slowly gaining importance. Induced breeding of carps and catfishes helped in the rapid growth of aquaculture. Production of 4–5 tonnes under carp polyculture is quite common, farmers of several regions are able to produce 8–12 tonnes/ha/year. Integrated fish farming with livestock and horticulture has not only been able to utilize the by products/wastes as principal inputs, but also made the farming practice highly remunerative and farmers' friendly.
- ✓ Development of genitically improved rohu (Jayanti) through selective breeding with a record of 17 percent higher growth is a mile stone in indian carp industry.
- ✓ Availability of balanced supplementary feed for different life stages for various organisms also paved the way for the strengthning of this field.
- ✓ Mariculture in India, although limited to the farming of mussels and edible oysters undertaken in some coastal region of Kerala over the years, has successfully produced sea cage farming in recent years, initially with sea-bass and most recently cobia, which has shown the prospects of commercial mariculture in the country.

Indian Fisheries

Global position	3rd in Fisheries , 2nd in Aquaculture
Contribution of Fisheries to GDP (%) India 2021	1.07
Per capita fish availability (Kg.)	9.0
Employment in sector (million)	28.0

Resources

Coastline	8118 kms
Exclusive Economic Zone	2.02 million sq. km
Continental Shelf	0.530 million sq. km
Rivers and Canals	1,95,210 km
Reservoirs	3.150 million ha
Ponds and Tanks	2.414 million ha
Flood Plains lakes and derelict waters	0.798 million ha
Brackishwaters	1.240 million ha
Estuaries	0.290 million ha

Andhrapradesh fisheries

Andhra Pradesh has been contributing significantly to the fish basket of the country in the recent years through an effective strategy in both coastal and freshwater aquaculture and marketing. The state has 5.17 lakh ha of freshwater ponds and tanks, 11,514 km of rivers and canals, 4.58 lakh ha of reservoirs and 150,000 ha of water areas suitable for coastal aquaculture. The inland fish production is 6.8 lakh tonnes, with the mean yield of pond aquaculture is around 3.5 tonnes/ha/year, above the national average. Further, by virtue of its 974 km long coastline, the state produces 2.97 lakh tonnes of marine fish annually.

Some Facts

Present fish Production (Capture)	7.0 million metric tons
Inland	3.2 mmt
Marine	3.8 mmt
Potential fish production	8.4 mmts
Fish seed production	40,000 million fry
Hatcheries	1,604 units

I.4 Agriculture vs Aquaculture

Agriculture focuses on land-based farming and cultivation of crops, while aquaculture centers around the cultivation of aquatic organisms.

Agriculture majors gain expertise in soil science, plant breeding, and pest management, while aquaculture majors delve into fish nutrition, water quality management, and aquaculture production systems.
Both majors require a strong foundation in biology and chemistry.
Agriculture career opportunities include agricultural engineer, crop consultant, farm manager, and agricultural economist, while aquaculture career opportunities include aquaculture technician, fish farm manager, seafood quality assurance specialist, and aquaculture researcher.

Agriculture	Aquaculture
Crop Science	Fish and Shellfish Biology
Soil Science	Aquaculture Systems
Animal Science	Water Quality and Management
Agricultural Economics	Aquatic Ecology
Agribusiness Management	Aquatic Health and Disease

Similarities	Agriculture	Aquaculture
Resource use	Land, water, and energy	Water and energy
Environmental impact	Soil erosion, water pollution	Water pollution, habitat destruction
Economic importance	Employment opportunities, food production	Employment opportunities, food production

Both agriculture and aquaculture require the careful management of resources such as land, water, and energy. They also share common environmental concerns, including pollution and habitat destruction. Additionally, both industries play a significant role in providing employment opportunities and meeting the growing demand for food.

UNIT-2

II.1 Introduction:

Freshwater habitats can be classified by different factors, including temperature, light penetration, and vegetation. The freshwater ecosystems are generally classified into two major groups as, lentic and lotic ecosystems.

LENTIC SYSTEM :The term Lentic ecosystems is given to standing water bodies or still water bodies. The LENTIC Ecosystems includes all standing water bodies like Lakes, ponds, swamps or bogs.

LOTIC SYSTEM : The term lotic ecosystem is given to the flowing water bodies. The LOTIC Ecosystems include all flowing water bodies like river, springs, creek. The subject of study of freshwater ecosystems is known as **limnology**. Almost all ecological factors like temperature, light, pH, dissolved gases, dissolved salts in water, turbidity, alkalinity, depth and areal distribution, all of these parameters play an active role in controlling the habitat of aquatic ecosystems. Hence, it is necessary to study the freshwater ecosystems in detail.

Classification of ponds

Different kinds of pond

Freshwater fish ponds differ according to their source of water, the way in which water can be drained from the pond, the material and method used for construction and the method of use for fish farming. Their characteristics are usually defined by the features of the landscape in which they are built. Ponds can be described as follows.

- ### According to the water source

1.Ponds can be fed by groundwater:

(a) Spring-water ponds are supplied from a spring either in the pond or very close to it. The water supply may vary throughout the year but the quality of the water is usually constant.

(b) Seepage ponds are supplied from the water-table by seepage into the pond. The water level in the pond will vary with the level of the water-table.

2.Rain-fed ponds:Rain-fed ponds are supplied from rainfall and surface runoff. No water is supplied during the dry season. These ponds are often small depressions in impermeable soil, with a dike built at the lower side to retain more water.

3..Ponds can be fed from a water body such as a stream, a lake, a reservoir or an irrigation canal. These may be fed directly(e.g. barrage ponds), by water running straight out from the water body to the ponds, or indirectly (e.g. diversion ponds), by water entering a channel from which controlled amounts can be fed to the ponds.

4.Pump-fed ponds are normally higher than the water level and can be supplied from a well, spring, lake, reservoir or irrigation canal, by pumping.

According to the means of drainage

1. **Undrainable ponds** cannot be drained by gravity. They are generally fed by groundwater and/or surface runoff, and their water level may vary seasonally. Such ponds have two main origins.
2. **Drainable ponds** are set higher than the level to which the water is drained and can easily be drained by gravity*. They are generally fed by surface water such as runoff*, a spring or stream, or are pump-fed.
3. **Pump-drained ponds** be drainable by gravity to a certain level, and then the water has to be pumped out. Other ponds, similar to undrainable ponds, must be pumped out completely. These ponds are only used where groundwater does not seep back in to any extent.

According to the construction materials

1. **Earthen ponds** are entirely constructed from soil materials. They are the most common, and you will learn primarily about these ponds in this manual.
2. **Walled ponds** are usually surrounded by blocks, brick or concrete walls. Sometimes wooden planking or corrugated metal is used.
3. **Lined ponds** are earthen ponds lined with an impervious material such as a plastic or rubber sheet.

According to the construction method

A. **Dug-out ponds** are constructed by excavating soil from an area to form a hole which is then filled with water. They are usually undrainable and fed by rainfall, surface runoff or groundwater.

B. **Embankment ponds** are formed without excavation by building one or more dikes above ground level to impound water. They are usually drainable and fed by gravity flow of water or by pumping.

C. **Cut-and-fill ponds** are built by a mix of excavation and embankment on sloping ground. They are usually drainable, and water, which is impounded within the dikes, is fed by gravity or by pumping.

II.2 Functional classification of the ponds(According to the use)

1. Spawning ponds for the production of eggs and small fry;
2. Nursery ponds for the production of larger juveniles;
3. Brood ponds for brood-stock rearing;
4. Storage ponds for holding fish temporarily, often prior to marketing;
5. Fattening ponds, for the production of food fish;
6. Integrated ponds which have crops, animals or other fish ponds around them to supply waste materials to the pond as feed or fertilizer;
7. Wintering ponds for holding fish during the cold season.

- **Nursery pond :**From hatchery spawn which is a 3 day old larvae are produced. The larvae are reared till fry stage (2-3 cm length) for 11 to 30 days. During this period, they are reared in nursery ponds. The ideal size of each fry pond is 0.01 to 0.05 ha and their number varies in accordance to target production with a water depth of 1-1.5 m. The shape of a nursery pond is regular as a rectangle and flat even bottom for easy netting operation.

- ✓ **Rearing tank :** Similarly the fry are reared to fingerling stage in the rearing tank (10-15 cm length) and the time period taken varies from 2-3 months. The size of each fingerling pond varies from 0.05 ha to 0.1 ha with water depth of 1.5 - 2 m and their number varies in accordance to target production of fingerlings. The shape of a fingerling pond is rectangular with flat even bottom for easy netting-operation.
- ✓ **Stocking pond :**The stocking pond, each having an area of 1 ha to 2 ha is considered to be an optimal size for intensive culture of food fish with water depth of 2.5 - 3 meter. Fingerlings of 10-15 cm length are stocked in this pond until it reaches table size or marketable sized fish.The number of stocking ponds varies according to the target fish production. The time period of rearing varies from 8-10 months. The stocking ponds are used as breeding pond or brooder raising pond as per the requirements. However, there is no hard and fast rule regarding the size of the ponds.
- ✓ **Bio pond or treatment ponds :**Nowadays apart from the above mentioned fish pond in a fish farm a special type of pond- Bio pond is also seen in some farms. It acts as a large settling tank, where the water used for fish ponds of a farm is purified biologically. On need basis it may be used as stocking pond also. The area covered by this type of pond is 7- 10% of the total productive area of a fish farm.

Three basic pond types

Ponds can be conveniently grouped into three basic types depending on the way the pond fits in with the features of the local landscape.

SUNKEN POND:

- ✓ The pond floor is generally below the level of the surrounding land.
- ✓ 2.The pond is directly fed by groundwater, rainfall and/or surface runoff.It can be but is not normally supplemented by pumping.
- ✓ 3.The sunken pond is undrainable or only partially drainable, having been built either as a DUG-OUT PONDor to make use of an EXISTING HOLLOWor DEPRESSION in the ground, sometimes with ADDITIONAL EMBANKMENTS to increase depth.

BARRAGE POND:

- ✓ They are created in the bottom of a valley by building a DAMacross the lower end of the valley. They may be built in a series down the valley.
- ✓ The barrage pond is drainable through the old river bed.
- ✓ If large floods are present, the excess water is normally diverted around one side of the pond to keep the level in the pond constant. A DIVERSION CANALis built for this purpose; the pond water supply is then controlled through a structure called the WATER INTAKE.
- ✓ Directly fed from a nearby spring, stream or reservoir, the water enters the pond at a point called the INLETand it flows out at a point called the outlet.
- ✓ To protect the dike from floods, a SPILLWAYshould be built.

DIVERSION POND:

- ✓ The diversion pond is fed indirectly by gravity or by pumping through a diversion canal (which becomes the MAIN FEEDER CANAL), from a spring, stream, lake or reservoir. The water flow is controlled through a water intake. There is an inlet and an outlet for each pond.
- ✓ The diversion pond can be constructed:
- ✓ either on sloping ground as a cut-and-fill pond;
- ✓ or on flat ground as a four-dike embankment pond sometimes called a PADDY POND.
- ✓ It is usually drainable through a drainage canal..

II.3 Wintering Pond,Quarentine pond and Isolation Pond

Wintering Pond:

1. These are used for during the winter.
2. These keeping adult and young fish are also known as hibernating ponds.

3. In favorable wintering conditions with well-fed fish, carp fingerlings weighing 25 to 30 g are stocked in the pond @ 3,50,000 to 4,00,000 fish per hectare or crucial carp fry at 600,000-700,000 per ha.
4. Mostly the wintering pond are located in temperate countries.

Quarentine or Isolation Ponds:

1. Quarantine is one of the most important animal management and biosecurity measures.
2. Quarantine is the procedure by which an individual or population is isolated, acclimated, observed and, if necessary, treated for specific diseases before its release onto the farm or for live market sale (e.g., for growout or for aquarium fish stores).
3. The principles of quarantine apply for new fish coming into a facility, fish moving from one area or system to another within the facility, and resident fish that become diseased.
4. Well-designed quarantine systems physically separate incoming fish from the rest of the farm.
5. Water in quarantine systems also should be separate from that on the main farm, and discharges should be handled appropriately.
6. Proper quarantine not only protects established populations from potential exposure to pathogens but also gives the new animals time to acclimate to water, feeds and management and to recover from handling and transport.
7. Handling and transport have been shown to reduce disease resistance and recovery may take weeks.
8. Fish in the general population that become sick may have to be isolated in tanks in the same system or room as their healthy counterparts; signs or other methods should be used to alert employees that the population is diseased.
9. Major components of quarantine include all-in-allout stocking, isolation or separation, observation and diet adjustment, and sampling and treatment.

All-in-all-out stocking.

This involves bringing animals in as a group from only one original source population and maintaining them as a group throughout the quarantine period.

It prevents exposure to other pathogens not currently in thatpopulation.

Ideally, no new animals should be added to a group currently in quarantine.

All-in-all-out quarantine may involve an entire facility, room or system.

Isolation or separation.

1. A group of animals in quarantine should be physically isolated from other quarantined populations and from the resident populations.
2. Methods of isolation should be built into the facility and system design.
3. If logistics prevent complete isolation, populations should at least be separated by tank or vat.
4. Regardless of the level of isolation, appropriate sanitation and disinfection measures must be used to reduce cross-contamination between quarantined and established populations and between separate populations in quarantine. Observation and diet adjustment.
5. Animals should be observed for normal and abnormal appearance and behaviors throughout the quarantine period so disease problems can be detected early.
6. Loss of appetite, for example, is a very common, early sign of disease.
7. Good nutrition will increase disease resistance and careful adjustment from the diet of origin to the on-farm diet will reduce problems from sudden changes.
8. Sampling and treatment. Fish in quarantine should be sampled for specific diseases of concern at the beginning and end of the quarantine period and at any time that disease signs develop.

9. Although complete necropsy evaluation of a number of specimens is best, limited sampling of more valuable specimens can be done without sacrificing the animals by examining small sections of skin, fin and gills for parasites and doing a blood culture for systemic bacterial infections.
10. The results can then be used to improve quarantine methods and the use of drugs. Consult with a fish health professional to assist with this.
11. Legal issues associated with drug usage should be considered before treatment.
12. Pathogen Management Not all pathogens (disease-causing organisms such as bacteria, parasites, viruses and fungi) are of equal concern.
13. Pathogens vary in their regulatory significance, survivability in reservoirs, pathogenicity (how easily they can infect and cause disease), diagnostics, and control.
14. Although some pathogens cause disease more readily than others, environmental and host factors—especially the species and its immune status—will ultimately determine whether fish become sick.
15. Regulatory significance. Some diseases and pathogens are considered important internationally and listed by the OIE (World Organization for Animal Health) because of their economic or environmental importance.
16. Many of these, or others, are also currently regulated or under regulatory consideration by the USDA?APHIS and/or by state and local governments.
17. Outbreaks of some of these diseases require depopulation, which will greatly affect the operation.
18. The proper authorities (local, state and federal) must be notified if a reportable disease is suspected or diagnosed on your facility.
19. Work with a fish health professional to determine if your species is susceptible to any regulated diseases, and get professional assistance with disease diagnostics and management. For Quarentine Purpose the fishes can be stocked in quarantine/Isolation ponds

UNIT -3

III.1 Important factors in the construction of an ideal fish pond

Ponds are very small and shallow of quiet standing water with slight wave action and may be naturally created or man-made. Man-made or artificial ponds are created to serve diverse purpose, like, Fish Farming, Duck Rearing, Ornamental, cultivation of Nelumbo or any aquatic weeds. The ponds used exclusively for fish culture purposes are designed and managed scientifically . These are better called as fish ponds. Fish farm is the site where different types of ponds are constructed for rearing various stages of the selected species on scientific lines. Aquaculture activities start with the construction of ponds till the harvest of table-sized fish.

Components (ponds) of a fish farm:

1.Site selection criteria for fish farm: One of the most important aspects of the planning of fish farms is the selection of the site for fish ponds. If the site of the ponds is well chosen, the pond can be more productive than the land itself. When considering a site for the fish ponds, following aspects have to be considered.
1. Availability of land in a continuous suitable shaped plot of optimum size with all facilities.
2. The site should have assured water supply of adequate quality either surface or ground water
3. The soil and water of the site must be suitable for fish culture.
4. The site should be free from floods
5. The site should have good transport facilities and approach roads
6. The site should have electrical and telephone connections
7. The fish seed should be available easily and in plenty in that area
8. The site should be away from populated areas
9. The site should be connected to a drainage system
10. The site should be away from polluted areas.
11. The fisherman or labour should be available near the site.

2.Topography:
It is used to describe the shape of the land, whether it is flat or hilly, upland or lowland etc. The ideal topography of a fish farm site is a gently sloping terrain, that can be drained easily. Shaped area with high lands on the three sides and with a narrow outlet on the fourth side is preferable. The ponds should generally be flat or gently sloping towards the outlets.

3.Soil type:
The soil of the pond must be able to hold water. The best soil for a pond is one that contains lot of clay or clay mixed with silt. Clay soils hold water well. Porous and peaty soil must be avoided as they do not retain water.

Rocky and sandy soil as well as limestone areas are to be avoided. Soil rich in minerals like iron, magnesium lime etc. is highly favoured as the minerals are useful for quick growth of the fish. Soil must be slightly alkaline with a pH of 7-9.

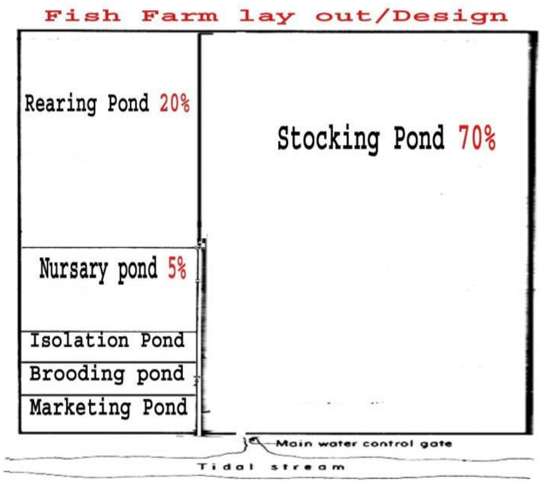
4.Water supply:

The availability of adequate supply of water is an important requisite for site selection. The dependable sources of water supply are. (a) Lake or Reservoirs (b) Springs (c) Rivers (d) Streams (e) Canals (f) Surface run off (g) Wells (h) Tube wells.Big tanks, reservoirs and lakes are perhaps the best source of water. Dams provide the cheapest and canals are also satisfactory source of water, provided the flow is enough to fill the ponds. The source of water should be free from all pollution.

III.2 *Lay out and arrangement of ponds in a fish farm*

Fish farm layout

Fish farm layouts that are properly engineered to balance economy, functionality and maximum utilization of the land available. Specific kinds of ponds are required for specific life stage development of fishes - such as nursery, rearing, stocking, treatment and broodstock pond. The rectangular pond is preferred than round-shaped corners as it prevents the fish escape during harvest. An ideal length and breadth ratio of the pond is 3:1 is ideal, with breadth not more than 30 - 50 m. The total farm area can be divided as - nursery - 5 % of total farm area, rearing pond - 20 %, stocking pond - 70 %, and treatment pond - 5 % of the total farm area.



• **Hatching ponds**: These are also called as spawning ponds. These are small pits of 8’x4’x2’ (feet) and are used for hatching the fertilized eggs. Hapas are fixed in these ponds. Hapas made of cloth hanged in pond are used for this purpose. The eggs are collected and kept in the hapas for hatching. The fertilized eggs are transferred into these hapas for hatching. After 2 to 15 hours the fertilized eggs are hatched.

Nursery ponds: These ponds have a size of 50’x50x’3’ or 4’ and are used for keeping spawn or fry @ rate of about 50 ‘Iakhs per ha and are reared for a period of of a few hours to 3 days The main object is to create a suitable condition of food availability and growth of fry because at this stage they are most susceptible to hazards like the wave action and predators.

The larvae are reared till fry stage (2-3 cm length) for 11 to 30 days. The ideal size of each fry pond is 0.01 to 0.05 ha and their number varies in accordance to target production with a water depth of 1-1.5 m. In practice about 10 million spawn per hectare are stocked in nursery ponds.The shape of a nursery pond is regular as a rectangle and flat even bottom for easy netting operation. Nursary pond should be supplied with good circulating water. These should be predator free. Artificial feed may be supplied. These are transported to rearing pond for next development.

• **Rearing ponds:** These ponds are of 90’x30'x4’ size and are used for rearing advanced fry or early fingerlings. The stocking rate is 12 Iakhs per hectare. Similarly the fry are reared to fingerling stage in the rearing tank (10-15 cm length) and the time period taken varies from 2-3 months. The size of each fingerling pond varies from 0.05 ha to 0.1 ha with water depth of 1.5 - 2 m

and their number varies in ac-cordance to target production of fingerlings. The shape of a fingerling pond is rectangular

with flat even bottom for easy netting-operation. After the fingerlings attain maximum length (15-20 cm) they are transported to stocking ponds.

Stocking ponds: These ponds have a fairly large size. These are also referred as production ponds. Fingerlings of 10-15

cm length are stocked in this pond until it reaches table size or marketable sized fish. The stocking rate is usually 5000/ha. The stocking pond, each having an area of 1 ha to 2 ha is considered to be an optimal size for intensive culture of food fish with water depth of 2.5 - 3 meter. The number of stocking ponds varies according to the target fish production. The time period of rearing varies from 8-10 months. The stocking ponds are used as breeding pond or brooder raising pond as per the requirements.
However, there is no hard and fast rule regarding the size of the ponds. Artificial feed is given for better growth. Fertilizers are used to grow phyto plankton in the pond which act as natural food.
• **broodstock ponds:** These ponds are used for keeping the brood fishes to be used for breeding to get pure seed. The size is generally 50'x20'x8"-1 2".
• **Quarantine pond** or Treatment pond: Quarantine is one of the most important animal management and biosecurity measures. Quarantine is the procedure by which anindividual or population is isolated, acclimated, observed and, if necessary, treatedforspecific diseases before its release onto the farm or for live market sale The principles of quarantine apply for newfish coming into a facility, fish moving from one area or system to another withinthe facility, and resident fish that become diseased. Proper quarantine not only protects established populations from potential exposure pathogens but also gives the new animals time to acclimate to water, feeds andmanagement and to recover from handling and transport. The length of time for quarantine will depend upon the diseases of concern. The ideal quarantine period is 30 to 60 days. Sizeof the quarantine pond depends on the size of the entire fish farm. Usually it is around 1% of the total farm land. Quarantine pond is also referred as biopond or treatment pond.
• **Marketing ponds** These ponds are used for keeping marketable size fish for selling in live condition.
Head pond : This pond is usually constructed near a perennial source of water. The main purpose of the pond is to meet the water requirements of the entire farm, taking into consideration the losses through seepage, evaporation etc.

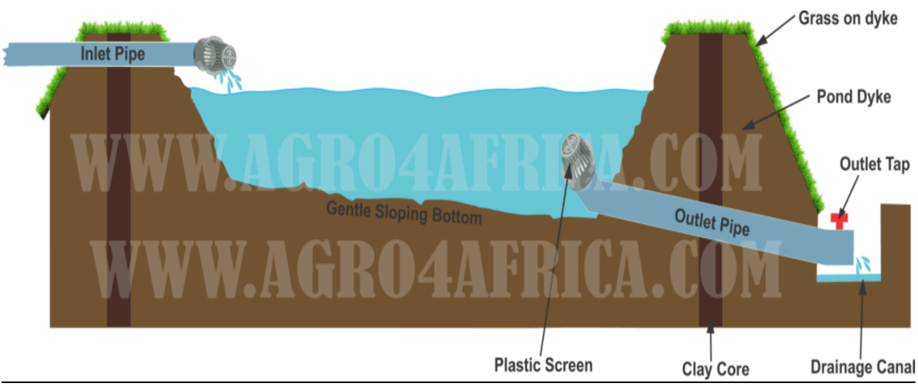
Preparations of pond :

STEP 1: PREPARE THE SITE:

Clear all vegetation around the spot for the pond and move the trash far away from the pond location. The reason is that you don't want to use soil that has plants in it to construct the pond dykes.After that, remove the topsoil from the site.In hilly areas, try to measure the slope of the land with a level or stick to find the best suitable site and orientation for the pond.Measure and stake out the length and width of the pond.

STEP 2: PEG OUT THE POND AREA:

After measuring the pond length and width, use pegs to mark out the pond area.Decide on the dyke slope and width and determine core trenches pegging.The pond dykes should be about 0.5m above the water level (also called 'freeboard'), to prevent the fish from jumping out.As a recommendation, make your pond dykes have a gentle slope of about 2:1. This makes them strong and prevents them from undercutting and collapsing into the pond.However, this ratio depends on the size of the pond. Larger ponds need to have a gentler slope.



STEP 3: CONSTRUCT CLAY CORES:

A clay core is a foundation for the pond dyke which makes it strong and prevents water leaks.If you suspect the dyke or pond bottom soil to be highly permeable, dig a core trench, in the same way as you would dig the foundation for a house, under the dykes around the pond.Pack the core trenches with impermeable clay and compact it well.

STEP 4: EXCAVATE THE POND AND CONSTRUCT DYKES:

Decide the depth of the pond and begin the digging process.Use the excavated soil to build the pond dykes. Do this gradually, and compact each layer of soil added to the dyke before the next layer.Try not to use sandy/rocky soil or soil that contain roots, grasses, sticks, or leaves. These will decay later and leave a weak spot in the dyke through which water can leak outOnce the dyke is constructed, it is better to plant grass on it. The grassroots help to hold the wall together and prevent erosion of the soil.If you have the resources, then you can go for stone-pitched dykes. By using concrete blocks, stones, or bricks the earthen dykes will be protected more permanently from crab or rat holes.

STEP 5: INSTALL DRAINAGE SYSTEM:

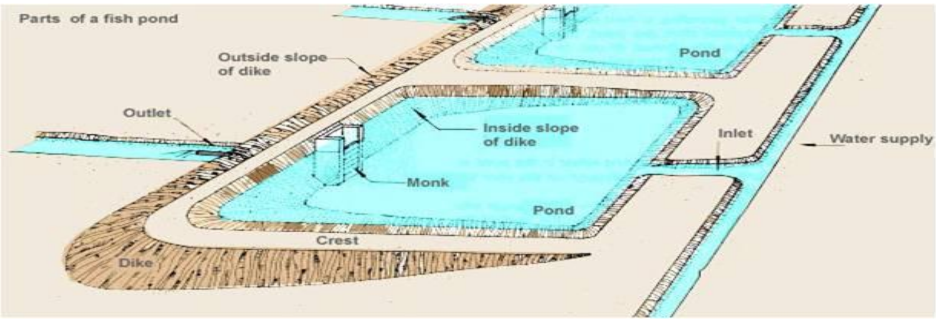
The essence of the drainage system is to empty the pond when there is a need to change the pond water or harvest fish.It consists of the outlet system for letting water out of the pond and the drainage ditches which carry the water away from the pond.The best and easiest way to have a good drainage system is to build the pond in a place that provides a good slope.The drainage system must be built before the pond dyke because some drainage devices go through the walls.One of the easiest ways to drain the pond is to place a bamboo or plastic (PVC) pipe through the base of the wall into the deepest part of the pond.An overflow pipe can be installed at an angle into the pond. This should be used only in emergencies. During heavy rains, the overflow pipe takes excess rainwater and runoff water out of the pond.The end of the pipe, which is inside the pond, should have a screen over it to keep fish from entering the pipe. The other end of the pipe is plugged with wood or clay or it can be fitted with a tap head. To drain the pond during harvest time, the plug is pulled out.Install the intake of the drain pipe underwater. This will prevent the screen from clogging with debris that may be floating on the pond surface.The use of pumps and siphon are other methods of draining water from the pond.

STEP 6: INSTALL WATER INLET PIPE:

All ponds, except for those filled directly by a spring or by rainwater, need water inlets.If your water source is a river or stream, use filters (screens) to cover the inlet pipes so that unwanted fish and other materials do not enter the pond.A water inlet can be as simple as a bamboo/plastic pipe of good diameter running from a water source through the wall into the pond.The inlet pipe should be placed about 0.15m above the water level so that the incoming water splashes down into the pond. This helps to mix air (thereby introducing oxygen) into the water. It also prevents fish from escaping by swimming into the inlet pipe.

III. 3 *construction of an ideal fish pond*

Construction of an ideal fish pond



Fish pond preparation is the basic and first step in freshwater fish farming. Pond preparation is to be done intensively to enhance the fish production of the pond. Without proper preparation of the pond bottom if we start the fish culture technique it will create a huge problem and production will be of poor quality. In the case of the pond preparation process, good management practices are the basic solution for obtaining better fish yield. Sustainable methods should always be chosen to make pond preparation more suitable for environment-friendly fish farming technique.

Fish Pond construction

Survey

1. Before constructing the pond, land is surveyed to find out determine its topography.
2. Marking the area of proposed pond is the first step in the construction of a fish pond.

3. The natural slope where the main wall is to be built should be ascertained.
4. The main wall should be marked off at the lower end of the pond, where the slope is the greatest.

Designing

1. The first step while designing fish ponds should be to study the soil type, topography and water supply.
2. In designing the fish farm, it should be decided as to where and how many nursery, rearing and stocking ponds are to be constructed.
3. In case of a fish farm constructed solely for the purpose of seed production, only nursery and rearing ponds may be constructed, with a nominal area for the brood stock ponds.
4. In case of grow-out farm, more stocking ponds will be constructed to produce table size fish after stocking fingerlings.
5. For a composite fish farm all three types of ponds are required and their number should be based on the intended stocking density.
6. Fish ponds should be at least one surface acre in size. Ponds smaller than one acre seldom support a satisfactory fish population over many years. They usually require much more intensive fish management and may not justify the costs.
7. It is important to know the exact size, maximum depth, average depth, and water volume of the pond. This information becomes useful in calculating the amount of herbicide needed for weed control and the number of fish fingerlings needed for stocking.

Construction

- ✓ After the designing, it is necessary to prepare detailed estimates of the items of work to be carried out as per the design.
- ✓ The approximate cost of construction is also to be estimated.

Construction time

- ✓ The construction time of the pond is an important factor for pond management.
- ✓ If the construction of the ponds is completed in summer, the pond can be used for farming immediately for next season (monsoon).

Preparation of the site

1. The site should be cleared before the construction.
2. All the bushes and small plants, etc. should be cut and removed along with their roots. The roots should be totally removed; otherwise the leakage problem will arise later on.
3. If there are any trees near the construction site, it is better to cut the branches overhanging the ponds, so that the sunlight is not blocked and the leaves do not fall in the water.
4. It is better to have trees near the ponds, but only 5m away from the pond.

Mark out the ponds

1. When the pond area is cleaned, it is necessary to mark the outlines of ponds and dykes.
2. Mark out the main wall or dyke and other walls with stakes. The walls should be wide.
3. Plan the depth of the pond and height of walls.
4. The walls should always be at least 30 cm higher than the water level for a small pond, and at least 50 cm higher for a larger pond.

Excavation of the pond

1. It can be carried out either by manual labour or by bulldozers (JCBs).
2. The sides and bottom of ponds should be properly finished and trimmed until a good slope for drainage is made.
3. The pond bottom should usually have a slope of 2-5%.
4. The most important feature is to have the pond bottom slope such that the pond can be drained.

5. If the pond site has a natural slope, the dyke or main wall should be constructed at the low level side.
6. When the pond walls are constructed, the excavated soil can be placed on the top and planted with grass.
7. This fertile top soil will root grass easily and this will help keep the walls from eroding.
8. The pond bottom must be cleared by removing small rocks, roots, and stumps to prevent the nets from getting caught and torn during harvesting.
9. If grass is found in the pond bottom, it need not be removed, because after filling up the pond with water the grass will die and add nutrients to the water.
10. When the stakes have been established for construction of dykes, about 2' top soil should be removed as it consists of large amounts of roots and other organic material.
11. The core trench is cut immediately after the removal of the top soil. If the soil is porous, the seepage problem may arise at a later stage. It would be essential to provide a clay core in order to prevent seepage.
12. A soil which is a mixture of sand and clay is best.
13. Pure clay soil will crack and leak.
14. If pure clay is to be used, it must be mixed with other soil before it can be used.
15. Turf, humus or peaty soils should not be used.
16. All stones, wood pieces and other material which may rot or weaken the wall must be removed before building begins.

Construction of dyke

1. The filling of earth should be done in layers not exceeding 20 cm in height and consolidate each layer by watering and ramming.
2. The earth work for the dykes should be thoroughly compacted so that even minor seepage can be checked.
3. If the fish farmer is economically sound, he can go for stone pitched dykes.
4. The dykes of a pond should be strong enough to withstand weather action.
5. In big ponds erosion of dykes is a problem which requires regular attention.
6. Brick or stone pitching may be provided to arrest erosion of dykes.
7. Earthen dykes can be protected from erosions with bamboo piling.
8. Holes should be closed immediately with stiff clay mixed with lime and cementing material and should be compacted properly.
9. By using concrete blocks, stones or bricks the earthen dykes will be protected more permanently from crab or rat holes.
10. Side slopes of embankments depend upon the nature of material used for construction. The slopes should be flatter than the angle.
11. Soil with a lot of clay in it can have a greater slope on the outside wall than on the inside wall.
12. A typical embankment is built with an outside slope of 1:1 and an inside slope of 1:2.
13. A slope of 1:2 means that for every increase in 2m width there is a change of 1 m in height.
14. Once the embankment is constructed, it is better to plant grass on it.
15. The grass roots help to hold the wall together and prevent erosion of the soil.

Water inlet

1. All the ponds, except for those filled directly by a spring or by rainwater, need water inlets.
2. During the construction of inlets, filters should be used in the channel so that the unwanted fish or other materials do not enter into the pond and the water is clean.
3. A water inlet can be as simple as a bamboo pipe of good diameter running from a water source through the wall into the pond.
4. The inlet pipe should be placed above the water level.
5. A wire screen makes a good filter.

6. The horizontal screen is very effective.
7. A nylon mesh bag makes a good filter and can be fixed to the inlet pipe.
8. A sand and gravel filter is also used, but it requires a small tank at the water inlet, it is more effective and economical.
9. If the water is muddy, or has plenty of leaves or grass in it, the wire screen is better.
10. If the water source is free from organic material, the mesh bag will work.
11. If the water contains unwanted fish and more organic matter, sand and gravel filters are best.

Inlet canals : Feeder canals are essential, except for those ponds which are filled directly by spring or by rainwater. Feeder canal should be constructed in such a way to provide the required quantity and quality of water to the pond. The inlet pipe should be placed above the maximum water holding level of the pond. The inlet pipe should be provided with screen to filter the pumping water.

Standard inlet pipe size used based on the size of the pond

POND SIZE (m2)	INSIDE DIAMETER OF PIPE (cm)
<200	not less than 10
200-400	10-15
400-1 000	15-20
1 000-2 000	20-25
2 000-5 000	25-30
>5 000	40 or more

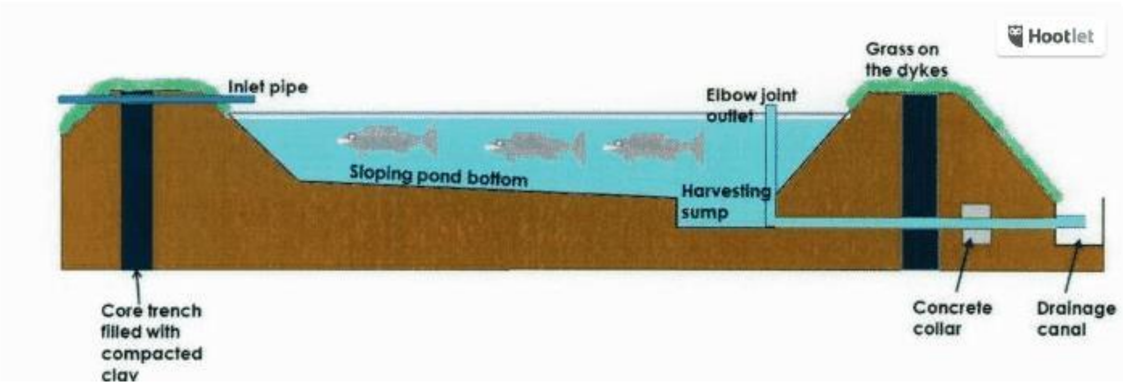
Sealing the pond bottom

Leaking Ponds

One of the most common farm pond problems is heavy water loss through leakage. The ability of the pond to retain water depends largely on the characteristics of the soil at the pond site. Most leaky pond problems can and should be prevented by cautious site selection. Before building a pond, be sure to test the capacity of the soil to hold water. Soils with a high clay content will minimize seepage since clay particles tend to swell when wet and, thereby, provide a good bottom seal.

- ✓ If the soil has more clay in it, no special sealing is needed.
- ✓ If the bottom is sandy, it should be sealed to hold the water. To seal the bottom a clay core lining is built over the pond bottom.
- ✓ Another method of sealing the pond bottom is with cement blocks, but it is expensive.
- ✓ The most commonly used pond sealant is bentonite clay. Bentonite is most effective on sandy soils that contain insufficient amounts of clay. For best results, bentonite should be spread evenly over the dry pond bottom at a rate of 50 lbs/100 ft (20,000 lbs/acre) mixed with the existing soil, moistened, and then compacted with a roller.
- ✓ Sealing with flexible plastic sheeting of polyethylene, or plastic or vinyl, or butyl or rubber sheet liner at least 2 mm thick is another method of sealing.
- ✓ The pond liners should be covered by at least 6 inches of sand or fine soil.
- ✓ Technique developed in the USSR, is called gley or biological plastic. In this method, the pond bottom is covered with animal manure after cleaning the bottom. The animal manure layer is then covered with banana leaves, cut grasses or any vegetable matter, and a layer of soil is put on it. The layers are rammed down very well and 2-3 weeks are allowed to elapse before filling the pond.

Drainage system



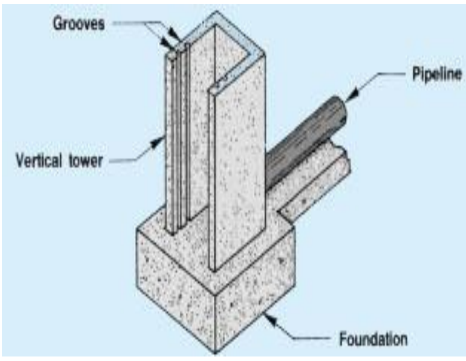
1. A drainage system is used to empty the pond.
2. It consists of the outlet system for letting water out of the pond and the drainage ditches which carry the water away from the pond.

Drainage of the pond water

1. The best and easiest way to have a good drainage system is to build the pond in a place which provides a good slope.
2. The drainage system must be built before the pond embankment because some drainage devices go through the walls.
3. One of the easiest ways to drain the pond is to place a bamboo or plastic pipe through the base of the wall into the middle of the pond.
4. The end of the pipe, which is inside the pond, should have a screen over it to keep fish from entering the pipe. The other end of the pipe is plugged with wood or clay. To drain the pond during harvest time, the plug is pulled out.
5. Other methods of draining the ponds are the siphon and the pump.

Drainage of the pond

Sluice



1. The sluice can be a screened gate in a water channel going into the pond or drainage gate leading water out of the pond.
2. The sluice can be made of wood, cement and brick. It can be made up of one or two wooden gates which are removed to empty or fill the pond.
3. A sluice also has a screen gate to keep unwanted fish from entering at the inlet and pond fish from leaving at the outlet.

Outlet canals : Outlet system or the drainage canal is used to empty the pond during harvest or for partial draining of the pond water for exchange of water during culture period to maintain the water quality of the pond. An outlet was constructed before construction of the pond dyke.

<u>**Different outlet canals or draining systems**</u>

a. Rivaldi valve : Rivaldi valve is flexible pipe system named after the farmer from Paraguay, who first used this drainage system. The flexible is placed on the ground before construction of dyke and the pipe is turned up and tied to a stake or a pole above the pond's maximum filling level. At the time of draining the stake is removed and the pipe is lied down. This also allows the excess water to flow out during heavy rainy season.

b. Sluice : Sluice can function as both an inlet and outlet canal based on placement in the pond. A sluice is a cement structure mostly used as an outlet system of a pond; it consists of different slots or grooves structures which are closed by wooden gates. The wooden gates are normally made of different pieces which are placed in the groves and the space between the two wooden gates is filled with earth. Apart from this, a wooden framed meshed gate is also placed in one of the grooves to avoid escapement of fish during exchange.

c. Monk : Monk is similar to that of the sluice but built inside the pond dyke and on the dyke of the pond. Monk can never be used as an inlet as a sluice can be. The monk structure consists of a horizontal drainage pipe and the vertical structure, or monk. The drainage pipe runs from the back side of the monk. The monk structure is constructed in such a way it is closed on three sides and open on one side. The two parallel sides and the bottom of the cement structure have grooves, which are placed with wooden and meshed gates.

Maintenance In course of fish culture practice, the pond bottom accumulates considerable amount of silt and organic matter. Which need to be removed periodically in every 3 to 4 years. If excessive pond silt is there, it should be desilted. It is better to expose the dry pond bottom to sunlight by drying.

UNIT -4

✓ **Freshwater Aquaculture**

This is practiced in inland environments using freshwater. Freshwater is defined as water with less than 0.5 PSU.Freshwater aquaculture refers to the breeding and rearing of aquatic animals (fish, freshwater shrimp, crabs, bivalves, etc.) and native plants using ponds, reservoirs, lakes, rivers, and other inland water bodies.

✓ **Brackish Water Aquaculture**

Technically, brackish water is a mixture of freshwater and seawater that usually occurs in coastal areas and typically has a salinity between 0.5 and 30 PSU. A characteristic of many surface brackish waters is that their salinity can vary significantly in space and time.

✓ **Mariculture**

Mariculture is a specialized branch of aquaculture involving the cultivation of marine organisms for food and other products in the open ocean, an enclosed section of the ocean, or in tanks, ponds or raceways which are filled with seawater. An example of the latter is the farming of marine fish, including finfish and shellfish like prawns, or oysters and seawater in saltwater ponds. Non-food products produced by mariculture include: fish meal, nutrient agar, jewellery .Mariculture refers to the cultivation of aquatic organisms in sea water where the salinity range is 30 to 32 PSU.it is the sea farming.It is also called *marine aquaculture*.Mariculture is of two types, namely

1. Coastal aquaculture
2. Offshore aquaculture (Deep sea aquaculture)

Coastal aquaculture : Culture of aquatic organisms along the sea coast is called coastal aquaculture.

Offshore Aquaculture :Culture of aquatic organisms in the deep sea coast is called Offshore aquaculture.

A pond is a small, still, land-based body of water formed by pooling inside a depression, either naturally or artificially. A pond is smaller than a lake and there are no official criteria distinguishing the two, although defining a pond to be less than 5 hectares (12 acres) in area, less than 5 metres (16 ft) in depth and with less than 30% with emergent vegetation helps in distinguishing the ecology of ponds from those of lakes and wetlands. Depth of ponds often varies greatly with the time of year; many ponds are produced by spring flooding from rivers. Ponds are usually freshwater but may be brackish in nature. Saltwater pools, with a direct connection to the sea to maintain full salinity, Ponds are typically shallow water bodies with varying abundances of aquatic plants and animals. Depth, seasonal water level variations, nutrient fluxes, amount of light reaching the ponds, the shape, the presence of visiting large mammals, the composition of any fish communities and salinity can all affect the types of plant and animal communities present.Ponds are frequently man made or expanded beyond their original depths and bounds by anthropogenic causes. Apart from their role as highly biodiverse, fundamentally natural, freshwater ecosystems ponds have had, and still have, many uses, including providing water for agriculture, livestock and communities, aiding in habitat restoration, serving as breeding grounds for local and migrating species, decorative components of landscape architecture, flood control basins, general urbanization, interception basins for pollutants and sources and sinks of greenhouse gases.

A raceway culture is the culture of aquatic organisms in constructed flowing water systems. The raceways may be earthen or concrete .The earthen raceways are lined with plastic materials to reduce loss of water through seepage. A raceway farm contains a number of segments ,15 to 20 or more .Each segment has 30 m length ,3 m width and 1 m depth.The segments are straight without curves.The mouth of the raceway farm is constructed with a storage reservoir.It receives water from rivers ,streams or dams.The segments receives water from storage reservoir through feeder channels. There are separate feeder channels for each segment.Each feeder channel has a water control structure.The receways provided with outlets to discharge out water.Trouts and Tilapia can be cultured in raceways.

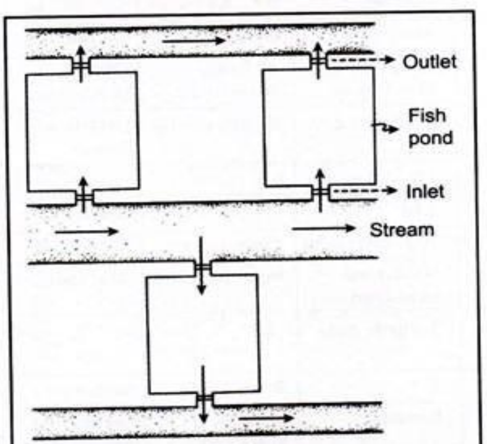
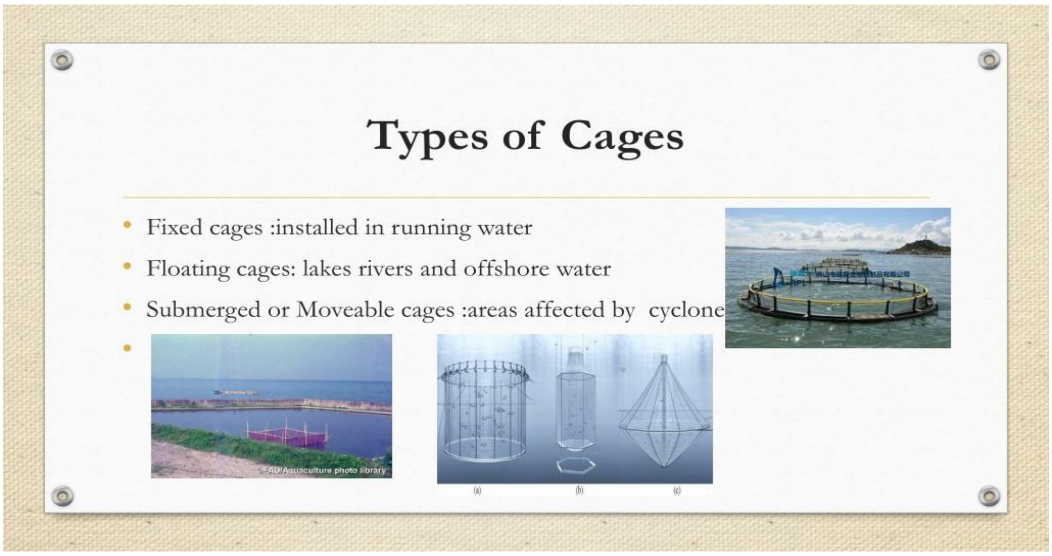


Fig. 6.6. Raceway

Cage Culture :



Culture of fishes in meshed boxes placed in water called cage culture. It is a intensive method of aquaculture.Cage culture is practiced in areas where there is sufficient water movement. It is done in rivers ,esturies and seas.

Cage culture originated in Kampuchia about 200 years ago.originally cage were used to transport fishes alive from the capture area to market area by trailing the cages behind the fishing boats. Now cage culture is practiced in the Kampuchia,Japan,Thailand,India,Indonasia,Norway,vietnam,Spain and USA.

Strucure of Cage : The cage may be square or rectangular ,circular,6-sided or 8 Sided in shape.The normal size of the cage is 20 to 60 m3 .The smallest cage is 1 m3.The largest cage is 10,000 m3.
The cage contains of nets ,frames,floats,sinkers and feeders. The net is made up of nylon or weld mesh or woven split bamboo. The frame is made up of wood or Iron or PVC pipes. The float is made of empty barrels or polthene balls.Sinkers are made of stone ,concrete or metal.feeders are installed inside the cages .
Based on installation ,the cages are grouped into four types.
They are
1. Fixed cages
2. Floating cages
3. Submerged cages
4. Movable cages.

Fixed cages are installed in fast flowing waters such as rivers,streams,etc.

Floating cage are installed in lakes,rivers and offshore waters.
Submerged and movable cages are installed in areas effected by cyclone.They are largely used in Japan.
In a cage farm ,a series of cges may be arranged in an order and are linked together by flexible joints.The cage may be anchored to jetty. They may be passege ways and floating houses for caring the cages.

Advantages of cage culture:

1. Fishes can be stocked at high density.
2. Flowing water brings in food and carries away the waste.
3. More volume of water is available to fish.
4. No need for own land.
5. Daily observaation is easy.
6. Predators are easily controlled.
7. Fish mortality is less.
8. Fish parasites are easily controlled.
9. Harvesting is easy.
10. Complete harvesting is possible.
11. Initial investment is less.
12. Fish can be transported alive.

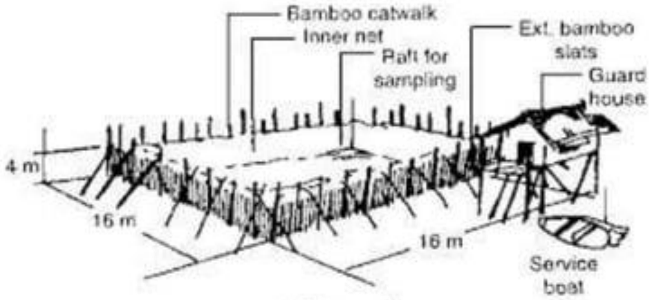
Disadvantages of cage culture:

1. Cage farms disrupt navigation.
2. Cages increase sedimentation in that area.
3. Cages alter water flow.
4. Cage farms alter the flora and fauna of that area.
5. The release of uneaten food affect the water quality.
6. High dissolved O2content is to be maintained.
7. High quality balenced food is needed.
8. Theft is increased.
9. Adequate renewal of water is needed.
10. Flouling agents like snails have to be removed frequently.
11. Cage culture needs frequent examination of water quality.
12. Frequent removal of dirts attached to the cage nets.

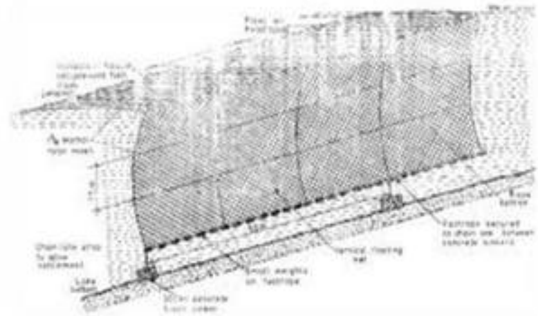
PEN CULTURE

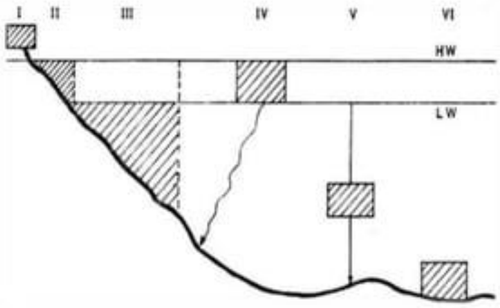
Pen is an enclosure in water made of nylon netting for the culture of fin fish and shell fish.Pen resembles a duckfence on land.

Pen culture is practiced in the coastal areas of Kovalam,Mandapam,Killai,Pulicat and Chilka lake. The pens may be cylindrical of rectangular or square.The pens may have single or double layerd enclousre.Single layer pen is used for adults and double layerd pen is used for juvenilles. In aquaculture ,a pen is samll body of water separated from a large area by barriers along narrow regions.Pen culture is a transitional device between pond cultutre and cage culture.A pen is formed by damming a river ,lake,reservoir,pond,estuary or sea.The barrier may be consturcted on one side or two sides or three sides .The other sides are formed by the shore.The barrier made of concrete,sand,stone or clay with screens.The screens may be nylon net, weld mesh or bamboo splits. A bamboo split screen is made of bamboo splits of 2.5 m high and 5 to 10 cm wide.They are interwoven by ropes with 1 cm interspace.The scaffold so obtained is planted is planted in the mud. The scaffold is strenghtened by horizontal bars.



(A) Perspective





A nylon net screen is supported by causuarina or palmyra poles.One end of these poles are driven into the mud 50cm and are palnted at an interval of 1.5 m apart.A nail is driven at the top of the poles.A rope is attached along the nails .This rope is called head rope.Similarly another rope is tied along the bottom of the poles.Concrete stones are attached to the foot rope as sinkers at an interval of 1.5m.The nylon net is fixed between the head rope and foot rope.The screen allow free flow of water in and out of the screens. The water current brings in O2 ,nutrients and feed organisms.It is also washes away debris.It prevent escape of the fish.

Merits of Pen culture:

1. Water is renewed automatically.
2. Rich supply of O2.
3. Rich supply of food.
4. Movement is resrtricted,hence more energy is stored.
5. Toxic metabolites are flushed regularly.

Demerits of pen culture:

1. floods may damage the pens.
2. "Red tide " of dinoflagellates may harm the occupants of pen.
3. Molluscan borers may damage the poles.
4. Aquatic weed may clog the nets.
5. Crabs may cut and damage the nets.

RAFTS

The raft system, also known as the Deep Water Culture or floating raft system, utilizes floating rafts to support plant growth in nutrient-rich water. It follows the basic principles of aquaponics, where fish produce ammonia-rich waste that serves as a natural fertilizer for the plants, and the plants, in return, purify the water for the fish.

Key Characteristics of the Raft System

The Raft System is characterized by several key features that distinguish it within the realm of aquaponics:

1. **Floating Rafts:** The main feature of the raft system is its floating raft beds. These rafts, typically made of buoyant materials like expanded polystyrene (EPS), are positioned on the surface of the aquaponic water. Plants are inserted into holes or cups within these rafts, allowing their roots to dangle into the water below.
2. **Continuous Flow:** Unlike other aquaponic systems, the raft system typically operates with a continuous water flow. The nutrient-rich water from the fish tank flows into the raft beds, providing a steady supply of nutrients to the plants.
3. **Ideal Plants for raft systems:** The raft system aquaponics is well-suited for various plants, particularly those that have smaller root systems and thrive in water-logging environments. Leafy greens, such as lettuce, kale, and Swiss chard, are commonly grown in raft systems because of their size and ability to efficiently absorb nutrients from the water. Although it may require additional support, herbs, and some fruiting plants can also be cultivated in this system.

Components and Structure of the Raft Aquaponics System

The raft aquaponics system consists of several key components:

Fish Tank: This is where the fish are housed. The fish tank provides a suitable environment for the fish to thrive and produce waste.
Filtration System: The water from the fish tank goes through a filtration system to remove solid waste and ensure water quality.
Grow Beds: These grow beds contain floating rafts that support the plants.
Floating Rafts: The floating rafts are typically made of food-grade material and provide a buoyant platform for the plants. The rafts have holes or pockets where the plants' seedlings or net pots can be placed, allowing their roots to dangle into the water.
Water Pump and Aeration: A water pump circulates water from the fish tank to the grow beds, providing the plants with a constant supply of nutrients.

Advantages of Using the Raft Aquaponics System:

1. Simple and can be the most economical to build of all aquaponics systems.
2. Plants are easier to harvest since roots are submerged in water, not in any media.
3. The water volume in a raft system ensures it is more stable in water quality and temperature than in other systems.
4. Easy maintenance as raft beds is easy to clean. Since rafts can be placed in the tank itself, it allows for the efficient use of space.
5. It is suited for home gardens, hobby applications, and commercial production.
6. It allows for a higher stocking of fish.

Disadvantages of Using the Raft Aquaponics System:

1. It is limited to growing small rooted plants like leafy greens, lettuce, and basil.
2. It can be a mosquito breeding ground if not designed correctly. (these may be controlled by using guppies or mosquito fish)
3. Water can evaporate at the gaps between raft edges and the tank it is kept in.
4. It needs a filtration system since the roots are entirely immersed, which can increase the start-up and maintenance costs of the system.
5. Roots are susceptible to microbial attacks or may be consumed by herbivorous fish.
6. There is little surface area for beneficial bacteria to grow.

Running water Aquaculture

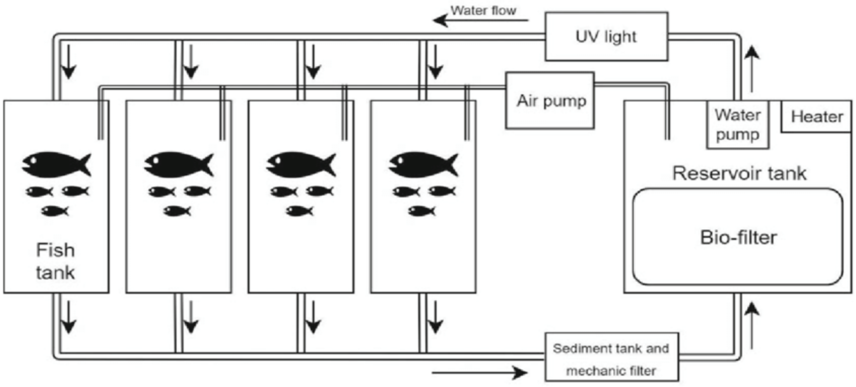
In general, the running water aquaculture system involves setting up the culture tank or pond near the seashore or a river. The rearing water is drawn from the environment, and the used water is pumped back, thus polluting the environment with feed residue, feces, and urine.

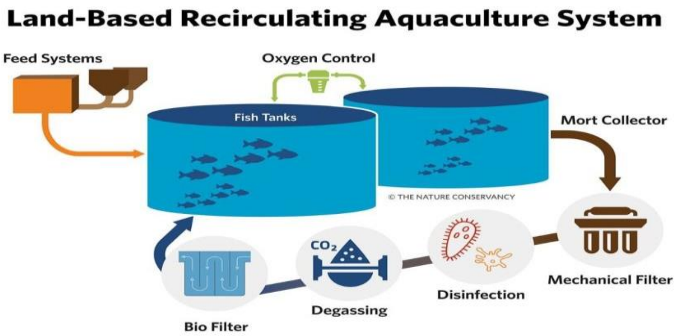
Water recirculating system/ RAS (Recirculated Aquaculture Systems)

Introduction : Recirculatory Aquaculture System (RAS) is a technology where water is recycled and reused after mechanical and biological filtration and removal of suspended matter and metabolites. This method is used for high- density culture of various species of fish, utilizing minimum land area and water.
It is an intensive high density fish culture unlike other aquaculture production systems. Instead of the traditional method of growing fish outdoors in open ponds and raceways, in this system fish are typically reared in indoor/outdoor tanks in a controlled environment. Recirculating systems filter and clean the water by recycling it back to fish culture tanks. The technology is based on the use of mechanical and biological filters and the method can be used for any species grown in aquaculture. New water is added to the tanks only to make up for splash out, evaporation and that used to flush out waste materials. The reconditioned water circulates through the system and

not more than 10% of the total water volume of the system is replaced daily. In order to compete economically and to efficiently use the substantial capital investment in the recirculation system, the fish farmer needs to grow as much fish as possible in the inbuilt capacity. The management of recirculating systems relies heavily on the quantity and quality of feed and the type of filtration. Numerous filter designs are used in recirculating systems, but the overall goal of all filtration is to remove metabolic wastes, excess nutrients, and solids from the water and provide good water quality for the aquatic organisms. It is important to consider all factors when designing and investing in aquaculture systems.
However, in order to encourage small-scale fish farmers and entrepreneurs and also to facilitate fish production in urban and semi-urban areas where land and water are scarce, it is proposed to promote Backyard Recirculation Aquaculture Systems.

Water recirculating system





Advantage of RAS

- Extended durability of tanks and equipment
- Reduced dependency on antibiotics and therapeutants hence, advantage of getting high quality fish.
- Reduction of direct operational costs associated with feed, predator control and parasites.
- Potentially eliminate release of parasites to recipient waters.
- Risk reduction due to climatic factors, disease and parasite impacts
- RAS production can promote flexibility in terms of location for farming, proximity to market.
- Enable production of a broad range of species irrespective of temperature requirements.
- Feed management is considerably enhanced in RAS when feeding can be closely monitored for 24 hrs.
- Exposure of stock to stress on RAS can be reduced for some factors such as adverse weather, unfavourable temperature conditions, external pollution and predation.
- Enable secure production of non-endemic species.
- Judicial use of water and land areas

Disadvantages of RAS

- Constant uninterrupted power supply is required if electric power fails than backup of electricity is required
- Capital cost of starting a recirculating aquaculture system is high as compared to ponds and raceways.

Species suitable for RAS

- Baramundi/ Asian Seabass/Bhetki (Lates calcarifer)
- Cobia (Rachycentron canadum)
- Silver/Indian Pompano (Trichinotus Blochii/ Trichinotus mookalee)
- Tilapia (Oreochromis niloticus)
- Pearl spot/Karimeen (Etroplus suratensis)
- Pangasius (Pangasianodon hypophthalmus)
- Rainbow Trout (Oncorhynchus mykiss), especially in Hilly/cold water Region

Components of RAS

- Insulated shed/ Building
- Store cum office for feed and accessories
- Pump house
- Grow out tanks: Circular cement tanks/ FRP tanks, including inlet, outlet central drainage
- Settling tanks for sludge
- Water Storage (sump) tanks
- Overhead tanks.
- Mechanical (Hydraulic) filters, Drum filter, Glass wool/ muslin cloth filter
- Pumps and motors
- Power generator
- Sludge collector, settelable/ solid collectors
- Biofilters, UV units
- Electrification
- Automatic feeder (wherever required)
- Aeration system (air/ oxygen), Carbon dioxide trapper system (degasser)
- Water testing kit
- Water supply system, bore well etc. (wherever required)
- Inputs such as Seed, Feed, additives and supplements, electricity/ Diesel, man power etc.

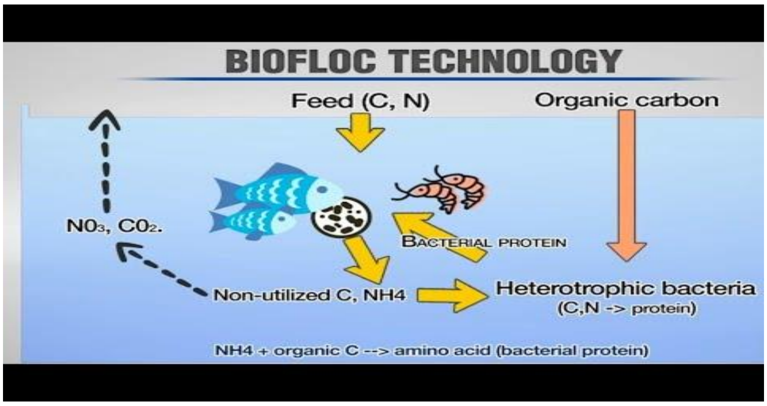
Feed

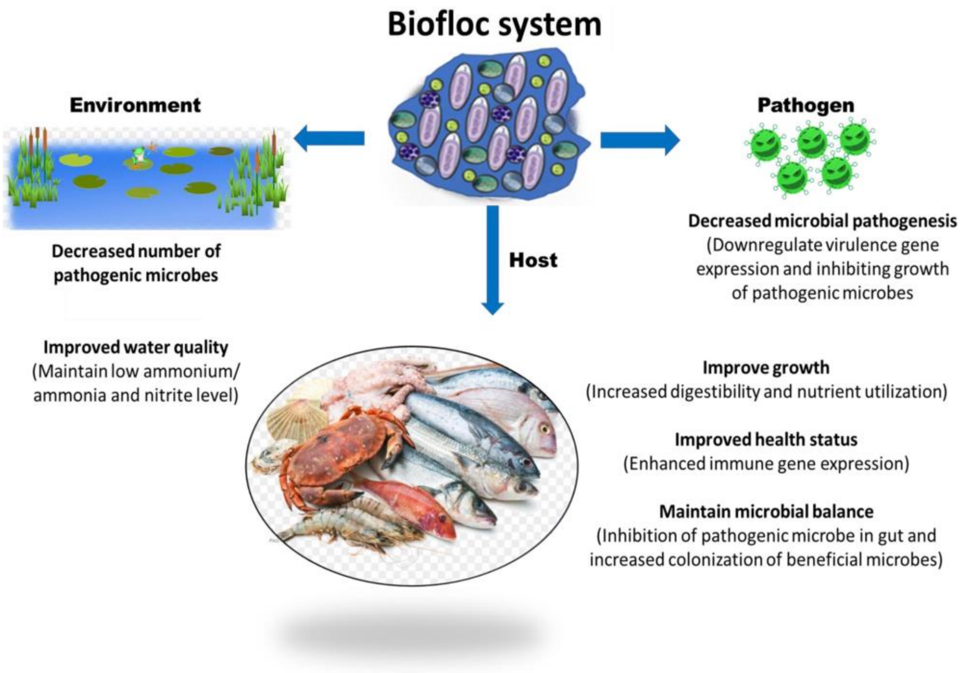
- A high protein feed, containing all the essential minerals and vitamins
- Species specific feed
- Feeding can be done @ 3-5 % of the body weight of the fish depending on the quality and protein content of feed.
- More frequent feedings (several times per day) shall result in better growth rates and thus improved feed conversion ratio.

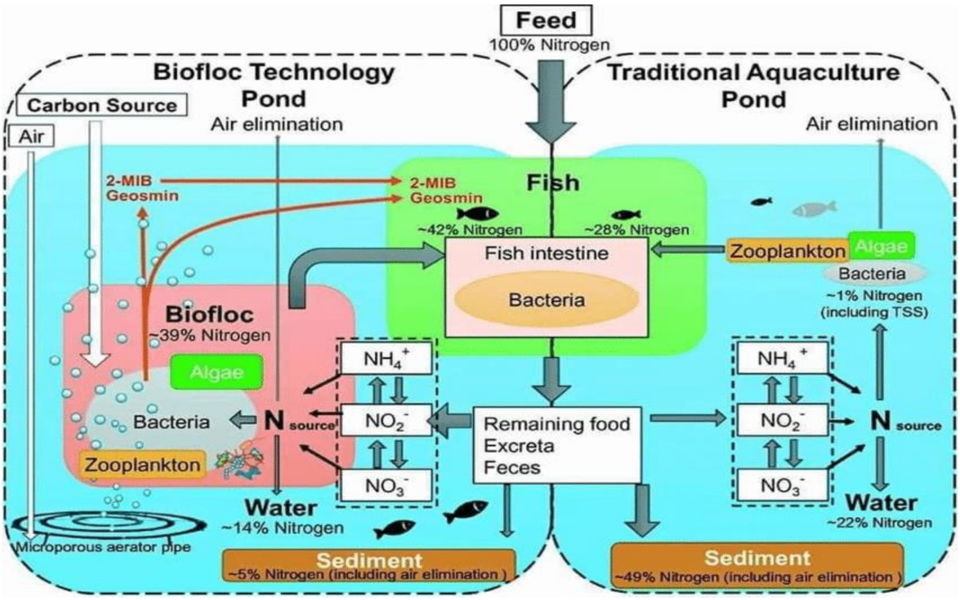
Biofloc technology (BFT) may offer a promising solution to some of these challenges by promoting a cleaner and sustainable production system. BFT converts waste into bioflocs, which serve as a natural food source for fish and shrimp within the culture system, reducing the need for external inputs, such as feed and chemicals. Moreover, BFT has the potential to improve yields and economic performance while promoting efficient resource utilization, such as water and energy. Despite its numerous advantages, BFT presents several challenges, such as high energy demand, high initial/running costs, waste (effluent, suspended solids, and sludge) management, opportunistic pathogens (*vibrio*) spread, and a lack of understanding of operational/aquatic/microbial dynamics. However, with further training, research, and innovation, these challenges can be overcome, and BFT can become a more widely understood and adopted technique, acting as an effective method for sustainable aquaculture. In summary, BFT offers a cleaner production option that promotes circularity practices while enhancing performance and economic benefits. This technique has the potential to address several challenges faced by the aquaculture industry while ensuring its continued growth and protecting the environment. A more broad BFT adoption can contribute to meeting the increasing demand for aquaculture products while reducing the industry's negative impact on the environment and natural resources. In this context, this review provides an overview of the advantages and challenges of BFT and highlights key technical, biological, and economic aspects to optimize its application, promote further adoption, and overcome the current challenges.

Aquatic environmental factors such as temperature, pH, dissolved oxygen, salinity, and nutrient levels can have significant effects on the growth and survival of aquatic organisms . Aquaculture's success is dependent on developing sustainable production systems and management practices that prioritize environmental and biological well-being, as well as ethical and biosecurity considerations. Achieving sustainability in aquaculture means identifying appropriate social, environmental, and financial ratios. In this context, BFT is a microbial-based production system, in which in situ microorganisms present three main roles:
(i) water quality maintenance, recycling undesirable toxic N-compounds via key heterotrophic and chemoautotrophic microbial processes;

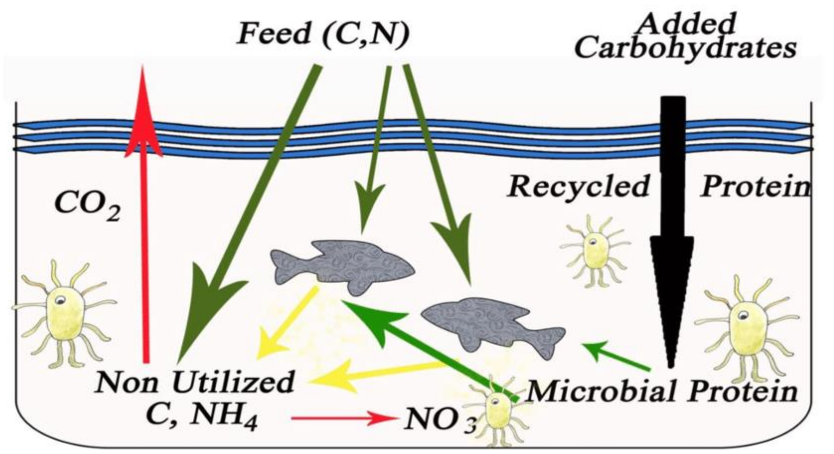
(ii) natural food source provision, decreasing feed conversion ratios (FCR); and
pathogen competition, acting as a natural probiotic . Microorganisms such as bacteria, fungi, algae, and/or protists accumulate due to restricted water exchanges and proper water movement These proprieties have been shown to minimize environmental impacts with no or minimal effluent to the natural surroundings . To produce microbial aggregates, balancing carbon and nitrogen is necessary, with traditional aquafeeds being the main source of nitrogen and carbon, and affordable products such as sugar cane molasses and grains, as well as inorganic fertilizers, providing the remainder of carbon fraction and other key nutrients . Proteinaceous microbial-based food source containing vitamins, lipids, and carbohydrates is produced in situ and can reduce aquafeed consumption by up to 20% . This positive impact on FCR ratios associated with improved growth and survival is crucial aspects for the system's feasibility, contributing to reduce one of the most significant expenses in aquaculture production , while boosting circularity and enhancing green credentials . BFT has been implemented in several countries and regions worldwide, including Vietnam, Brazil, the United States, Iran, Belize, Indonesia, Thailand, Malaysia, Australia, Tahiti, South Korea, Italy, China, as well as Latin and Central American countries , although levels of adoption and success can vary drastically . In terms of species.
BFT is most suitable for those that
(i) can tolerate a relatively higher levels of N-compounds suspended solids concentrations in the water;
(ii) possess morphological adaptations to capture and/or filter the microbial particles; and
(iii) support crowding conditions . However, with R&D advances and emerging of hybrid techniques (e.g., BioRAS), the culture environment has been greatly improved with consistent water quality , allowing more broad species and culture phases to be explored in BFT (e.g., hatchery Litopenaeus vannamei , Oreochromis niloticus.
Pacific white shrimp and Nile tilapia have been widely used as benchmarks in BFT . However, the successful application of biofloc systems has also been observed in other species such as African catfish (Clarias gariepinus), mullet , freshwater prawns (Macrobrachium rosenbergii), black tiger shrimp (Penaeus monodon) , banana shrimp (Penaeus merguiensis) , giant gourami (Osphronemus goramy) , common carp (Cyprinus carpio), rohu (Labeo rohita) and bluegill (Lepomis macrochirus) . In addition to these individual species, an integrated approach such as polyculture, combining species like catfish and tilapia , aquaponics or FLOCponics , and integrated multitrophic aquaculture (IMTA) has also shown promising results in recent developments.







3-C System



Pond culture practices

Traditional Fish Culture :

Fishing and Aquaculture practices in India has a long history.Koutilya's " Arthashashsthra" BC(321-300) and king Someswara's Manasoothra (AD1127) refer about fish cultural practice. In eastern India hundreds years ago the culturing fishes on small ponds was practiced.Comprises Bhasha bada fishery in West Bengal and Pokkalai shrimp farming in Kerala.These practices not use any additional knowledge and technologies rather than trapping of naturally breaded juaniles of fish and prawns.

<u>three types :</u>

1. Paddy cultivation during rainy season (June -September) followed by fish and shrimp culture. Ex.Pokkali
2. Fish or Shrimp culture throughout the year .This is on deep fields in eastern India.
3. Paddy cum fish culture mainly on west Bengal and Goa.

On the basis of intensity of input and stocking density aquaculture is categorized as follows.

1. Extensive fish farming system
2. Semi-intensive fish farming system
3. Intensive fish farming system and
4. Integrated aquaculture system

Extensive fish farming system:

1. The extensive fish farming system is the least managed form of fish farming, in which little care is taken.
2. This system involves large ponds measuring 1 to 5 ha in area with stocking density limited to only less than 5000 fishes/ha.

3. No supplemental feeding or fertilisation is provided. Fish depends only on natural foods.
4. Yield is poor (500 to 2ton/ha), and survival is low.
5. The labour and investment costs are low, and this system results in minimum income.
6. In extensive level of aquaculture, low stocking densities (e.g. 5000 carp fry/ha or 5000 to 10,000 shrimps post larvae (PL/ha/crop) are used and no supplemental feed is given.
7. Fertilization (addition of fertilizer) may be done to stimulate the growth and production of natural food in the water.
8. Carp culture does not require water replacement during culture period, while shrimp culture does which is done through tidal flushings i.e. new water is let in during high tide and used water is drained out during low tide.
9. The ponds used for extensive aquaculture are usually large (more than two hectare). The production is generally low, less than 0.5 ton/ha/year in the case of shrimps and 1 to 3 ton/ha/year in the case of carps.

Modified extensive level

- The modified extensive aquaculture system lies in between extensive and semiintensive culture systems.
- In this system the size of ponds varies between 1.0 to 2.0 ha.
- The stocking densities are more than extensive and less than semi-intensive (i.e. 30,000 to 40,000 shrimp PL/ha or 5,000 to 7,500 carp fingerlings/ha).
- In this system ponds are fertilized with organic and inorganic fertilizers and phase manuring is done once a month. Supplementary feed is given at low to moderate amounts.
- In the case of carp culture, water replacement is done once in two to three months @ IOta 20%, while in shrimp culture water is replaced once in two weeks @ IOta 20% from the second month onwards. The production averages about 1.0 ton/ha in case of shrimp and 4 to 5 tons/ha in carp culture.

Semi-intensive fish farming system:

- Semi-intensive fish culture system is more prevalent and involves rather small ponds (0.5 to 1 hectare in an area) with higher stocking density (10000 to 15000 fish/ha).
- In this system, care is taken to develop natural foods by fertilisation with/without supplemental feeding.
- However, the major food source is natural food. Yield is moderate (3 to 10 ton/ha), and survival is high.
- Semi-intensive aquaculture uses medium sized ponds of 0.5 ha each with comparatively higher stocking densities than extensive aquaculture (i.e. 50,000 to1,00,000 shrimp PLiha or 10,000 carp fingerlings/ha).
- Supplementary feeding is done in moderate amounts. In the case of carp culture, water replacement is done once or twice a month @ 10%, while in shrimp culture, it is done once or twice every week @ IOta 20%. The production averages around 1.5 ton/ha in shrimp culture and 5 to 7 ton/ha in the case of carps.

Intensive fish farming system:

- An intensive fish farming system is the well-managed form of fish farming, in which all attempts are made to achieve maximum production of fish from a minimum quantity of water.
- This system involves small ponds/tanks/raceways with very high stocking density (10-50 fish/m3 of water). Fish are fed wholly formulated feed. Proper management is undertaken to control water quality by use of aerators and nutrition by use of highly nutritious feed.
- The yield obtained ranges from 15 to 100 ton/ha or more. Although the cost of investment is high, the return from the yield of fish exceeds to ensure the profit.
- In intensive level of aquaculture the pond size for the case of operational convenience is generally small about 0.2 ha approximately. In intensive level of aquacuIture, very high density of culture organisms i.e. 300,000 to 500,000 shrimp PL/ha or 20,000 to 25,000 carp fingerlings/ha are stocked.
- The system is totally dependent on the use offormulated feeds. Feeding ofthe stock is done at regular intervals. In intensive shrimp culture, the computed daily feed ration is given in equal amounts from as low as three to as high as six times a day.
- Water replacement under intensive culture is effected on a daily basis approximately @25 to 30%. , Production under intensive level of aquaculture is much higher, for example, 8 to 10 ton/ha/crop in shrimp culture and about 12 to 15 ton/ha in carp culture.

Super Intensive Level

- Super-intensive aquaculture needs almost running water.
- Daily all the water is exchanged. This system is mostly practiced in cement tanks, fibre glass tanks, race ways etc.
- which are fitted with high efficiency biological filters for continuous recirculation of water.
- The size of the tank ranges between 50-100 m'.

FIN FISH CULTURED METHODS

MONOCULTURE IN FISHERIES In order to fulfill the single species based needs of food, scientific experiments and sports etc. single species of fishes are cultured in a fish farm/pond At times, single species culture is promoted because of their high demand in markets. Thus, 'monoculture' refers to the culture and breeding of a single fish species in a farm. Breeding performance of a single species can be easily observed and recorded in a monoculture system. Additionally, it doesn't involve any competition for feed and space among fishes. The culture of trout, tilapia, catfish, and carps are typical examples of monoculture. Monoculture in intensive system is commonly practiced for high value, marketable fish species. It is the only method of culture used in re-circulating system, running water system and in cages wherever the supply of natural food is limited.

Categories of monoculture: □

Freshwater culture □

Marine water culture □

Brackish water culture

Advantages of Monoculture:

1. Easy to feed fishes.
2. Permits great control over size, age and sex.
3. Easy to monitor.
4. Selective harvest of marketable fish can be employed.
5. Suitable for farmers having limited land resources.

Disadvantages of Monoculture:

1. Natural productivity of pond is not fully utilized.
2. Available space/ ecological niches in water column are not fully utilized.
3. In case of disease outbreaks greater chances of yield loss are there.

POLY CULTURE

Culturing two or more species in one physical space at the same time is known as polyculture. One of the main aims of polyculture is production of multiple products that are economically valuable. It is comprised of combination of animals, plants and animals, aquatic species only, or aquatic and terrestrial species

Indian Polyculture System :

In India, initially the multi species culture was started with Indian major carps-rohu (Labeo rohita), catla (Catla catla) and mrigal (Cirrhinus mrigala) alone. Later, the major carps were stocked in combination with calbasu (Labeo calbasu), sometimes with bata (L.bata) and with pearl spot (Etroplus suratensis), gorami (Osphronemus gorami) and acclimatized milk fish (Chanos chanos). (Sinha, 1985; http://www.fao.org). Alikunhi (1957) have listed an exhaustive list of cultivable fish species in India. As far as stocking ratio in earliest composite fish culture is concerned, Indian major carps were introduced at different rates

Sl. No.	Catla	Rohu	Mrigal	Reference	Pond area
1	03	03	04	Alikunhi, 1957	
2	1975	3750	625	Hora and Pillay, 1962	One hectare
3	04	03	03	CIFRI, 1960s	@ 3750 per hectare density
4	03	03	03	CIFRI, 1960s	
5	01	01	01	CIFRI, 1960s	@ 15,000 per hactare
6	04	03	03	Chakrabarty et al., 1979c	

Following reasons may be attributed for selection of Indian major carps in mixed fish culture

- Catla (Catla catla) being a surface feeds on planktonic organisms particularly zooplanktons.
- Rohu (Labeo rohita) is a column feeder, consumes vegetable matter including decaying aquatic plants, algae, etc.
- Mrigal (Cirrhinus mrigala) a bottom feeder, preferres decayed plant and animal matter, algae, detritus, organic matter, etc.
- Calbasu (Labeo calbasu), being a bottom feeder utilizes selectively benthic and epiphytic organisms and organic debris as its feed.

Objectives of polyculture

Polyculture should fulfill the following prime objectives □

1. Raising healthy and economically viable fish crop. □
2. Maximum yield or fish production per hectare/ season. □
3. Production of multiple and economically valuable products. □
4. Utilization of full potential of pond"s productivity. □
5. Utilization of different types of food available in all available ecological niches. □
6. Proper financial return to the farmers. □
7. Aggressive marketing strategy. □
8. Appropriate ecological balance of the pond. □
9. Acceptance of low-cost feed by culturable fishes. □
10. Preference of compatible and pond fertilizing fishes, e.g. grass carp.

Advantages of polyculture

1. Increases employment opportunities.
2. Intensive polyculture of fish is fully controlled by the farmer.
3. More fish can be cultivated and produced within a small water body.
4. Fish polyculture enhances the pond productivity.
5. Maintains water quality.
6. No competition among cultured fishes for food and space in the same water body.
7. Complete utilization of spatio-trophic habitats.

8. Fishes can be grown as per market preference.
9. Various species combined in polyculture framework adequately contribute to improve the health of the pond.
10. Defecated semi-digested food of grass carp serves both as a feed for bottom –dwellers and a pond fertilizer with high cellulose-digesting microbes.

Monosex Culture

Mono-sex refers to the culture of either all-male or all-female populations, a sought after approach in aquaculture.
Monosex refers to the culture of either all-male or all-female populations, a sought after approach in aquaculture.
For example, if the female of a fish species is generally more prominent than the male, so that in aquaculture perfecting the production of all-female populations on a big scale would be great and more beneficial than mixed sex culture.The most suitable techniques for production of monosex population are direct hormonal sex reversal and combination of sex reversal and use of neomales to produce all-female progeny.

Monosex population culture is desired for several reasons. In most species there are sexually dimorphic patterns of favorable traits that are more accentuated in either males or females. In the more established poultry industry, for example, the production of all females for eggs and the production of all males for meat are desirable.

Integrated fish farming (IFF)

Integrated fish farming is based on the concept that 'there is no waste', and waste is only a misplaced resource which can become a valuable material for another product (FAO, 1977). In integrated farming, the basic principles involve the utilization of the synergetic effects of inter-related farm activities and the conservation, including the full utilization of farm wastes.It is assumed that all the constituents of the system would benefit from such a combination. However, in most cases, the main beneficiary is the fishes which utilises the animal and agricultural wastes directly or indirectly as food. As integrated farming involves the recycling of wastes, it has been considered an economic and efficient means of environmental management.
Integrated fish farming (IFF) is a sustainable system of aquaculture where sequential linkages between two or more farming activities are utilized with fish farming as the major component. IFF ensures maximum utilization of resources, reduces risk of crop failure and provides additional income to farmers and food for small scale farming household.

Types of Integrated Fish Farming:

1. Paddy-Cum-Fish Culture:
Rice fields which are water-logged for 3-8 months in a year, there is always small population of fishes that gain access to such waters. This probably had given rise to the practice of deliberate stocking of fishes and harvesting. The trapping of prawns and fishes with the help of 'gamcha or dhoti' in fallow paddy-fields has been an age old practice in India.

The advantages of simultaneous cultivation are:
(1) There is no additional cost for fish production.
(2) Fishes contribute to the enhancement of paddy production by destroying weeds, causing tillering and mineral enrichment by their digging activity, and for the fertilisation of soil by their excrement and also by the unutilised artificial feed.
(3) Due to fish cultivation paddy production gets increased by 5 to 15%.

The disadvantages are:
(1) The water depth being shallow hinders better fish raising.
(2) For fear of harmful effect on fishes, herbicides and insecticides uses in paddy-field is generally prevented which ultimately limits paddy production.
(3) Due to abrupt changes in temperature and dissolved oxygen, inadequate space and presence of piscivore birds, there is great loss of fishes which may be about 20-60%.
Progressive agricultural areas have slowly discarded paddy-fish cultivation in favour of the rotation of paddy and fish crops.

2. Duck-Cum-Fish Farming:
Although duck and fish farming have been in practice in eastern Europe and China and their compatible nature being recognised since long, the interaction and benefits of the association have been understood only a few years back. Undoubtedly, such a combined culture is highly profitable as it greatly increases the production of protein in terms of fish and duck per unit area.The combination of duck and fish farming is seen presently as a means of reducing the cost of feed for ducks, at one hand, and on the other, the excreta of ducks acts in an inexpensive way of fertilizing ponds, which results in production of fish food organisms.Thus, ducks can be said to be 'living manuring machines'. The duck droppings contain 25 per cent organic and 20 per cent inorgaic substances along with a number of elements such as carbon, nitrogen, phosphorus, potassium, calcium, etc.Moreover, ducks by agitating the shore areas of the pond, help to release nutrients. Besides this, ducks feed on a variety of organisms such as weeds, snails, unwanted harmful insects and their larvae , tadpoles, frogs and water-borne disease-causing organisms infecting man, whose eradication is one of the important aspects of farm management.

(i) Advantages:
(1) There is practically less additional cost for fish culture, as the excreta of the ducks fertilises the pond water.

(2) Ducks by agitating the shore areas of the ponds help to release nutrients.
(3) The cost of feed for the ducks gets reduced.
(4) The ducks help to eradicate vectors of fish pathogenic organisms and water borne diseases — causing organisms infecting man, as they feed on a variety of organisms such as weeds, snails, unwanted harmful insects and their larvae, tadpole, frog, etc.

(ii) Disadvantages:

(1) The fingerlings released should be of more than 10 cm size, otherwise the ducks may feed on the fingerlings.
(2) While foraging for food, ducks sometimes damages the earthen dykes. This problem can be solved with proper maintenance.

<u>3. Fish-Cum-Poultry Farmings:</u>

Integrated fish farming with poultry is generally cultured as the poultry manure is a very efficient fertilizer for fish ponds. The poultry droppings comprises 2% nitrogen, 1.25% phosphoric acid and 0.75% potash. The low feeding cost per individual bird makes poultry farming along with fish, a common investment for poor farmers.

(i) Advantages:

(1) Chicken manure is a very efficient fertiliser, so no chemical fertiliser is needed for fertilising the pond water. This cuts down the expenditure of rearing fishes.
(2) No supplementary fish feed is required.
(3) The purchase and feeding cost per bird is low.
(4) Chicks are readily available and their productivity can be improved with simple and cheap management.

(ii) Disadvantages:

(1) Chicks should be examined from time to time and diseased one should be isolated, otherwise they will destroy the entire stock.
(2) Sufficient time should be given from one stocking of chicks to the next for renovation of the house and disinfectioning it.

<u>4.Fish-Cum-Pig Culture:</u>

In integrated fish farming with pig, the 'pig dung' is useful for conditioning the soil and providing the necessary nutrients required for fertilising the pond water. Fish-cum-pig culture is practised at large in China where pigs are considered as **"costless fertiliser factories".**

Pig dung contains about 70 percent digestible feed for fishes. The feed while passing down the pig's alimentary canal, gets mixed up with enzymes which continue to act even after defecation. Such undigested solids serve as direct food source for tilapia and common carp.

In tropical fish ponds, weeds are a major problem in fish culture. Such vegetation's are considered as valuable food resource for pigs.

(i) Advantages:

(1) Such integrated farming increases the productivity per area and thus, the farmers income becomes doubled or more.
(2) Pig dung conditions the soil of a new pond and provides ready-made organic matter, containing the necessary nutrients.
(3) Pig dung contains about 70 per cent digestible feed for fishes. The undigested solids present in the faeces of pig serves as direct feed source for tilapia and common carp.
(4) Pigs aptly plays a role in biological control of weeds, as weeds are considered as valuable food source for pigs.

(ii) Disadvantages:

(1) Addition of too much pig manure may lead to increased nutrient load resulting in pollution of the water body and mortality of the fishes.
(2) Considerable care and management skills are required to prevent pollution. It has been found that satisfactory fish production can be obtained with much lower manuring.

5. Other Animals in Fish Systems of Integrated Farming:

(a) Fish-Cum-Cattle Farming:

Cattle wastes and washings from the cattle sheds are conveyed through pipes into the ponds which acts as good fertiliser. Cattle wastes are generally collected in a pit for later use. In addition to fish yield, production of milk from cattle and beef adds to the economy.

(b) Fish-Cum-Rabbit Farming:

Rabbit farming has been found to be ideal for integration with small- scale fish culture. Rabbit manure have greater value as a direct food for fish compared to other livestock wastes.

(c) Fish-Cum-Mulberry Farming:

Mulberry plants are raised on the dikes of the fish farm and in the neighbouring fields for silkworm production. The mulberry wastes and silkworm larvae and pupae (after removal of silk) are used as feed for the fishes. It also fertilises the pond water.

Advantages of Integrated Fish Farming:

The advantages of integrated fish farming are as follows:

(1) Full utilization of farm wastes.
(2) Utilization of the cooperative effects of interrelated farm activities.
(3) It increases employment opportunities.
(4) It increases nutritional source for the farmer's family.
(5) It gives higher and stable farm productivity and there is less risk (biologically and economically).
(6) It increases the income of rural population.

(7) It is a means of land reclamation in certain areas.
(8) It is an efficient and economic means of environmental management.

Disadvantages of Integrated Fish Farming:

- Recently, controversy has arisen among scientists on the public health aspects of integrated farming. Speculations are ripe that integrated fish farming with pigs and poultry may be a cause of influenza pandemic.
- This may be, as the pigs would act as 'mixing vessels' for avian and human influenza viruses, it can create new lethal strains of viruses by mutation.
- In such an act, fishes themselves do not play any role. However, there is no conclusive evidence that integrated farming can become a public health hazard. For safety measures, pig-poultry combinations in integrated fish culture should thus be avoided.

UNIT- 5

5.1. Draining, drying, Ploughing and Liming

Draining and drying : Pond needs to be drained a dried before culture operations begin

Drying facilitates in
1.Oxidation of organic matter
2.Degassing of toxic gases such as ammonia and hydrogen sulphide
3.It kills pathogenic micro organisms
4.Kills predatory and weed fish
5.Kills unwanted aquatic plants

Ponds should be dried for 7-10 days till the soil cracks the ponds with clayey soil; in sandy soils they should be dried till the soil supports a person and foot prints do not form on the soil.
Ploughing
The ponds should be ploughed using wooden ploughs or power tillers or tractors Ploughing helps in
1.Mixing up of soil which helps in oxidation of organic matter
2.Proper degassing of soil from toxic gases
3.Mineralization of nutrients.

Liming

The productivity of fish ponds depends on soil qualities such as

1.Texture
2.Water retention
3.pH
4.Organic carbon
5.Available nitrogen
6.Available phosphorous

Pond bottom is important for productivity since process of mineralization of organic matter and release of nutrients to the overlying water takes place
Liming helps in improving the quality of the pond soil, thus enhancing productivity.It also corrects soil pH; the desirable pH is 6.5 - 7.00

A range of liming materials are used such as
1.Agricultural lime or calcite (CaCO3)
2.Dolomite [CaMg{CO3)]
3.Calcium hydroxide/slaked line Ca(OH)2
4.Calcium oxide/quicklime - Cao

The dose of a particular variety of lime depends on its effectiveness and soil pH.Generally 200-500 kg/ha of line is used for application to pond soil After application, the lime should be mixed with the top soil with light ploughing.Quick lime is preferred for applying to soil and calcite agricultural lime for application to water after stocking of the ponds Liming helps in

1.Correcting soil pH
2.Mineralization of organic matter
3.Release of soil sound phosphorous to water
4.Disinfection of the pond bottom

5.2 Predators ,weeds and weed fish in culture ponds.

1.Predatory fish severely affect survival of fish primarily in nursery and rearing ponds.
2.Weed fish compete with stocked fish for food, space and oxygen and result in reduction in production of desirable fish.
3.Common predatory fish are murrels (Snakeheads), Catfishes such as Wallago attu, Clarias batrachus, Heteropneustis fossilis, Ompak sp. Etc.,
4.Weed fish include Puntius, Barbas Danio, Aplocheilus, Anabas etc.,
5.Most predatory and weed fish breed prior to the onset of carp breeding
6.They infest the ponds before carp fry and fingerlings are stocked
7.Hence their eradication prior to stocking of carps is necessary
8.Dewatering followed by sun drying is most effective way to control weed and predatory fish.
9.In ponds which cannot be dewatered, piscicides are used.

kingfisher

monitor-lizard

Predators and their control in fish culture

Birds, fish and mammals are known predators of cultured fish. Bird predation is the major source of fish loss at aquaculture facilities. Predatory fish can also be a major concern to fish stocks, followed by mammal predation to a much lesser extent. Predators are a major source of stress to fish and can also cause significant losses.

1. **Predators can affect fish culture by following effects:**
2. Consume the fish in the pond,
3. Consume the fish's feed,
4. May transmit parasites and other infections to fish,
5. Scare the fish when they are chasing them up
6. Cause physical injury to several fish in the process of hunting.
7. May trans-locate fish to a different pond

Insects and insect larvae: feeds on Juvenile fish and eggs and fish just hatched.
Control : Oil emulsion to prevent aerial breathing.Use of fish that feed on insect larvae especially that can remain in the bottom.

Eradication of predatory insects

1. Many aquatic insects in their larval and/or adult stages, prey upon fish hatchlings and fry and also compete with them for food.
2. The common insect predators are beetles, bugs and dragonfly nymphs (Fig. 36). Among beetles, diving beetle (Cybister), water scavenger beetle (Sternolophus) and whirling beetle (Gyrinus) are more dangerous forms.
3. Back swimmers (Anisops) appear in swarms in manured ponds during rainy season and cause heavy damage. Other predatory members of this group are water scorpion (Laccotrephes), giant water bug (Belostoma) and water stick insect (Ranatra).
4. Dragonfly nymphs are highly predatory on carp spawn.
5. Proper prepration of nursery ponds for stocking with spawn thus also aims at total eradication of such predatory insects.
6. The basic method is to apply a thin oily film over the pond surface which chokes the respiratory tubes of aquatic insects.
7. The spawn and fish food organisms remain unaffected. Some of the common treatment methods are presented in the following table

Treatment method	Dose/ha
Soap oil emulsion	56 kg vegetable oil + 18 kg soap
Diesel oil	50 – 60 1
Kerosene oil	80 – 100 1
Turpentine oil	75 1
Diesel emulsifier	Diesel 50 1 * emulsifier 37.5 ml + water 2 1.

- ✓ Except for soap-oil emulsion other mixtures or emulsion are easily prepared by simple mixing.
- ✓ For making soap-oil emulsion, the soap is mixed with oil and gently heated for some time with vigorous stirring. These emulsions are applied by spraying over the pond surface about 12–24 hours prior to stocking of spawn.
- ✓ It is the film of the emulsion which is important and hence care is taken not to disturb the film for a few hours. Windy days should be avoided as it will break the film.
- ✓ Malathion application in nursery ponds also controls the predatory insects population and hence subsequent treatment for control of insect is not required.
- ✓ However, if swarms of these predatory insects are seen in the nursery pond, treatment should be applied immediately.

Eradication of unwanted fish /Predatory Fishes:

Hile or Bhoti,Mungri or Magur ,Singhi or Kande ,Badhari,Dhare Barn.They are carnivorous in nature. There are numerous predators which pray on small fishes than on larger ones. They also compete for oxygen, space and feed.

1. Predatory fish prey upon the spawn, fry and fingerlings of carps and the weed fish compete with carp for food, space and oxygen.
2. Therefore predatory and weed fish should be completely eradicated from nursery, rearing and stocking ponds before these ponds are stocked.
3. The commonly encountered predatory and weed fish in undrainable ponds.Absolute removal of these unwanted fish by thorough and repeated netting is not possible and hence dewatering and poisoning the pond are the only alternative methods.
4. If situation permits, dewatering should be the preference as it ensures complete eradication of unwanted fishes and disinfects the pond bottom.
5. Dewatering also offers the opportunity to desilt the pond bottom. However, where it is not possible, which is true in most situations, the pond should be treated with fish poison.
6. From an economic point of view the poisoning should be done during pre-monsoon season when the water level is usually low, requiring the minimum quantity of poison material.
7. The date of poisoning, however, should be fixed about three weeks before the anticipated date of stocking. Seasonal ponds which dry up during summer months need not be treated with fish toxicants.

Predatory fish	Weed fish
Channa spp.	Puntius spp.
Clarias batrachus	Oxygaster spp.
Heteropneustes fossilis	Gudusia chapra
Pangasius pangasius	Amblypharyngodon mola
Mystus spp.	Laubuca spp.
Ompok spp.	Esomus danricus
Wallago attu	Osteobrama cotio
Glossogobius giuris	
Mastocembelus spp.	
Amphipnous cuchia	

Control:

1. Netting though is conventional method it can reduce predatory fishes.
2. Using fish hooks,
3. Draining out and drying the pond if possible,
4. Keep screen filter in inlet pipe,
5. Repair the damage portion of pond dike before rainy season

A suitable piscicides should have the following characteristics
1.Effective at low dose
2.Not injurious to people and animals
3.Doesn't make fish unsuitable for human consumption
4.Gets detoxified quickly
5.Easily available and economical

Types of piscicides

Following are the three types of piscicides that can be used to eradicate weed fish and predatory fish
- Plant origin
- Chemicals
- Pesticides (Chlorinate hydro carbons and organophosphates)

Piscicides of plant origin

Derris root powder
1.Rotenone is the active ingredient
2.It is a contact poison
3.Lethal to other organisms also such as zooplankton, Benthos and insects
4.Dosage is 4-20 ppm {mg/I)
5.The powder is mixed thoroughly with water and sprayed all over the pond
6.It is effective only on sunny days when the temperature is above 250C
7.It is less effective in cold waters.

Mahua oilcake

1.The active ingredient is saponin
2.It causes lysis of the RBC and kills fish, frogs, snakes and turtles
3.Dosage is 250 ppm
4.The cake is soaked in water for 2-3 hrs and applied all over the pond.
5.Detoxification takes about 25 days
6.The toxicity can be reduced to 10 days through aeration and application of oxidizing agents.
7.The other less widely use fish toxicants of plant origin are
8.Tea seed cake - 60 ppm
9.Tamarind seed husk - 50-100 ppm
10.Jaggery - 1%

- **Frogs and snakes:** destroy larval and juvenile fish·The populations of frogs and snakes can be controlled by keeping premises around clean and clear.

1.Do not allow bushes to grow around the ponds.
2.Water channels should also be kept clean and clear.
3.Screen the ponds as recommended. Screens within the water channels also help reduce frogs' access to the ponds.
4.Frogs tend to come into pond areas via the water channels.
5.Short grass around the ponds reduces hiding places for the snakes and frogs, which makes them more vulnerable to predation by hawks.

- **Crocodiles, alligators and large lizards.**

All types of fish· Proper fencing and keeping dense bushes cut down. Set traps to catch monitor lizards. Turtlesprey on fish· Fencing around pond with wire mesh, trapping.

- **Birds:**

1.Wading birds eg. herons and egrets
2.Diving birds.
3.Kingfisher, fish eagle

All types of fish and at all stages especially in shallow waters. Birds feed on fish just after the fish are fed- when they are most concentrated.·
To control wading birds, ensure pond average water depths of 1 meter so

that the birds are unable to stand in the pond.
Tying string at close intervals over the pond prevents diving birds from being able to fly away once they have come down or dive through the strings.
Scarecrows or sudden loud noises may be used to scare away birds.
Do not leave any dead animals or feed, etc. lying around ponds because birds may come to feed upon them.One may also train dogs on the farm to scare away birds

- **Otters**

Prey on large fish at night killing more than they can eat. They burrow and live under the roots of trees near the water. Otters are very clever that they can even open latches on gates.·
Proper fencing around the ponds.
The otters can also be trapped using special light traps set in their passages.
Guard by use of trained dogs.

- **Man (theft)AII** types of fish.

This is also considered among the major predators through which fish are lost.Extremely difficult to control and is most common in cage culture and other intensive fish farming.
Can however be controlled by:
1.Employing security personnel
2.Use of trained dogs
3.Hidden obstruction to prevent pond seining.
4.Fence the farm and lock securely.
5.Burglar alarms or electrified fence

Aquatic weeds

- Aquatic weeds are the unwanted plants of uncontrolled growth that interfere the growth of other plants in aquatic habitat.
- They are the primary producer in aquatic ecosystem and provide basic needs to the aquatic animals.
- In recent days, aquatic weeds show a wide range of utilization.
- Some aquatic weeds are used as human food, animal feed supplement and fish feed in aquaculture practice.
- Their nutritive and medicinal property also have been studied.They are also used in fuel and production of fertilizer. Their excess growth hampers the growth of other species by cutting sunlight, declining oxygen and nutrients.Growth of weed creates many problems.

Classification of Aquatic Weeds

Aquatic weeds are classified into different categories according to various habitats in which they grow, reproduce and disseminate. Broadly, they are divided in to two groups, microphytes and macrophytes.

1.Microphytes: Mostly the microphytes are algae.Algae range from microscopic form to filamentous form. Microscopic forms are planktons and their growth results in to algal blooms.

e.g., Oscillatoria, Microcystis, Anabaena,Volvox etc. Death and decay of these algae causes water pollution which affect the health of aquatic animal. On the other hand, the growth of filamentous algae forms a mat like structure on the bottom of the water bodies. Some common filamentous algae in pond are Spirogyra, Oedogonium, Pithophora, Nitella, and Chara etc

Fig 1. Blue green algae

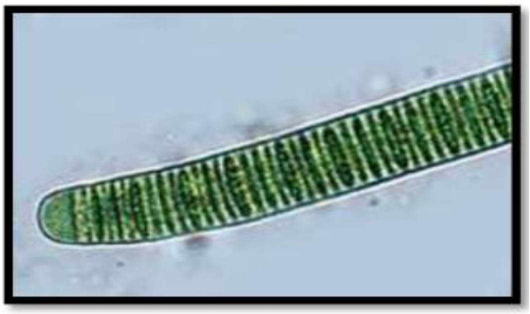


Fig 2. *Oscillatoria*

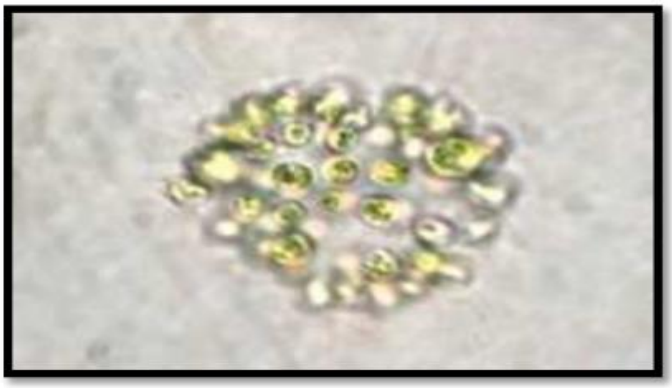


Fig 3. *Microcystis*

Fig 4. *Anabaena*

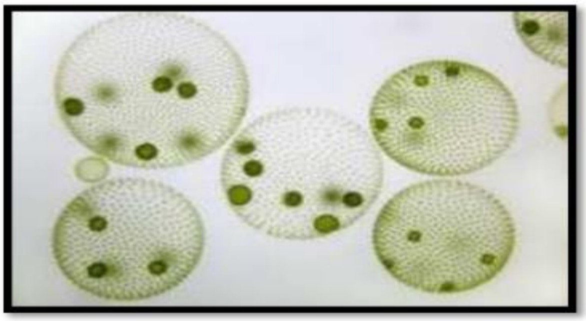


Fig 5. *Volvox*

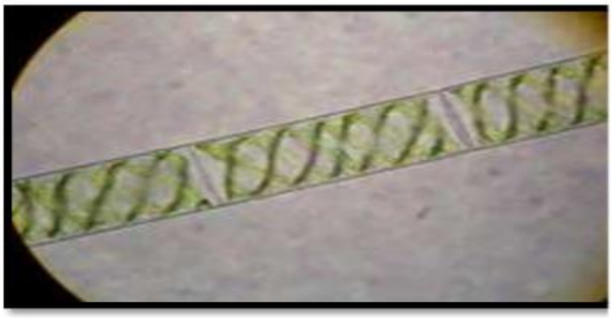


Fig 6. *Spirogyra*

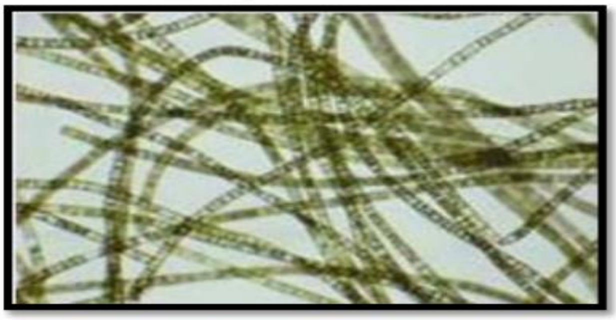


Fig 7. *Oedogonium*

Fig 8. *Pithophora* sp.

2. Macrophytes:

Macrophytes are classified in to following three types,

1. Floating weeds

Floating weeds are found on the surface of water bodies. They may be free floating or floating rooted. The free-floating weeds can float and move to a long distance, while floating rooted weeds can't move as they anchor down to soil in bottom of the water. Some important species of this group are, Azolla pinnata, Pistia stratiotes, Lemna polyrhiza, Nelumbo nucifera, Salvinia molesta, Eichhornia crassipes, Ipomoea aquatica and Nymphaea nauchali.

2. Submerged weeds

Submerged weeds are found below the water surface. They may be rooted or floating. As these weeds are not visible, their growth causes maximum damage (Jayan and Sathyanathan, 2012). Some important species of this group are,Hydrilla verticillata, Najas, Ceratophyllum, Utricularia, Potamogeton pectinatus, Potamogeton perfoliatus and Potamogeton crispus.

3. Emergent weeds

Emergent weeds are rooted plants found in shallow water. They grow and stand above the water surface. Some important species of this group are, Nymphaea, Myriophyllum, Vallisneria, Polygonum glabrum, Ludwigia, Eclipta prostrata, Typha angustata, and Otellia.

4. Marginal weeds

Marginal weeds grow on the margins or on the shore line of the water body. They are mostly rooted in water logged area. E. g., Typha, Marsilia, Ipomoea etc.

Fig 10. *Azolla*

Fig 11. *Pistia*

Fig 12. *Lemna*

Fig 13. *Hudrilla*

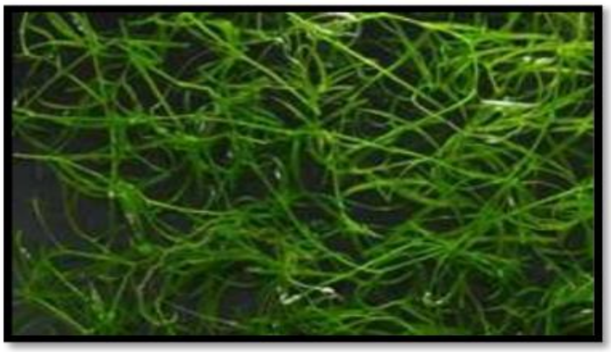


Fig 14. *Najas*

Fig 15. *Ceratophyllum*

Fig 16. *Utricularia*

Fig 17. *Nymphaea*

Fig 18. *Myriophyllum*

Fig 19. *Vallisneria*

Fig 20. *Polygonum*

Fig 21. *Ludwigia*

Fig 22. *Typha*

Fig 23. *Marsilia*

Fig 24. *Ipomoea*

Fig 25. *Nelumbo*

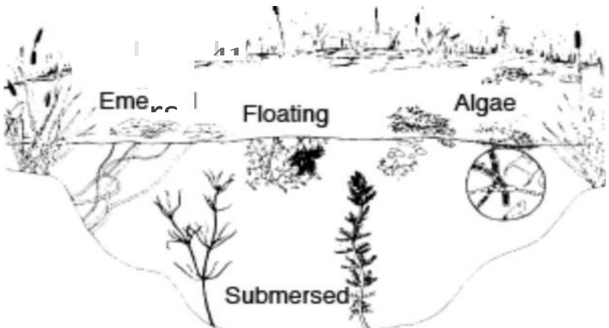
Advantages of Aquatic Weeds

Aquatic weeds form natural food of many species of fish
They fertilize the pond when decayed
They provide shade and shelter to many fish
They oxygenate the water
They reduce turbidity
They provide spawning beds for fishes

Disadvantages of Aquatic Weeds

Aquatic weeds occupy more space and restrict space for fish life
They reduce the level of oxygen and increase the level of carbon dioxide by forming dense mat on the surface of the pond.
They increase the evapotranspiration of water.
They alter the chemistry of water by changing the PH.
They retard the free movement of fish.
They reduce the plankton production.
They prevent the penetration of light.
They provide shelter for predators and parasites.
They produce Hydrogen Sulphide (H2S) and Methane (CH4) which are harmful to fishes.
They consume more nutrients.
They obstruct fishing operations.

Management of Aquatic Weeds



Preventive Methods

1. It is easier and less costly to prevent weed problems than it is to control them once they develop.
2. Careful pond site selection and proper pond construction practices are the first steps in preventing aquatic weed problems.
3. Rooted aquatic weeds and algae usually begin growing in shallow water (< 2 feet).
4. Edges of new and existing ponds should be deepened so shallow water areas are minimized.
5. Fertilization is also an effective and economical way to prevent the growth of many aquatic weeds.
6. Fertilization stimulates the growth of plankton algae. This algal growth is known as a bloom.
7. The bloom blocks sunlight from reaching the pond bottom which limits the establishment of rooted aquatic weeds.
8. The key to successful control of aquatic weeds with fertilization is to establish and maintain a bloom before rooted weeds begin spring growth.
9. Decreasing the pond water level exposes shallow areas to freezing temperatures and drying and can effectively limit certain types of submersed weeds.
10. Some weeds, such as hydrilla and cattail (*Typha* spp.), are tolerant to drawdown and cannot be controlled by this method.

Biological Control

The grass carp is a practical and economical way to control certain types of pond weeds. Grass carp effectively control weeds with tender succulent vegetation such as filamentous algae and duckweed, but are ineffective in controlling weeds that have tough, woody vegetation such as waterlily and cattail. Many states regulate the use of grass carp. Contact your Department of Natural Resources representative for state regulations on the use of grass carp.

Mechanical Methods

Various types of aquatic weed cutters and harvesters have been developed for canals and large reservoirs. Use of these machines is not practical in fish ponds. Early manual removal of weeds by seining or raking can prevent some weed problems.

Chemical Control

Herbicides may be used to control weeds in commercial fish ponds. The first step in successful chemical control is accurate identification of the problem weed.
Weed identification assistance is available through county Extension and Department of Natural Resources offices.
After the weed has been identified, a herbicide that is labeled for commercial fish ponds may be selected.
The herbicide label must be read and fully understood by the user prior to application to the pond. SRAC-361, Aquatic Weed Management -Herbicides, contains information on commercial fish pond herbicides.

Integrated Weed Management

Herbicides should be considered as a temporary control method. Depending upon the herbicide selection and the weed species, duration of control can range from a few weeks to several months. Long-term weed control can be achieved by using a combination of recommended aquatic weed methods. For example, use of the proper herbicides followed by grass carp stocking will effectively control and prevent the reoccurrence of most submersed weed problems.

5.3.Algal blooms and their control

Blooms are formed in both, marine and freshwater by wide-range of phytoplankton including diatoms, dinoflagellates, and cyanobacteria that float to the surface and accumulate, eliciting water discoloration ranging from greenish to red depending on their species. These HABs are also found to contaminate the air by the release of toxins.Cyanobacteria, which are already present into the water body, consume nitrogen and phosphorous to flourish.

What is algae?

1.Algae is a term used for a large group of photosynthetic plants that can form colonies or mats on the surfaces of a body of water.
2.Algae colonies or mats can fragment into small pieces and continue to grow and spread across a body of water.
3.There are as many as one million algae species.
4.Good algae, which make up the majority of algae species and often referred to as green algae and diatoms, serve as a foundation food source for numerous aquatic organisms.
5.Bad algae, which are fewer and referred to as cyanobacteria, blue- green algae (BGA), or harmful algal blooms (HAB), do not serve as a food source for aquatic organisms.

What major concerns are there with algae?

The most important concern is with the occurrence of algal blooms.
1.Algae blooms are a characteristic of bad algae (BGA or HAB). BGA cells clump together to form surface scum which appears on top of the water like chopped grass blades, or as thin blue/green mats, or as green paint spilled.
2.Algae blooms have become a major concern for many lake and pond owners with outbreaks reported to have increased by 18 percent between 2018 and 2019 alone.
3.Algae blooms typically occur in the summer months when there is a lot of light, long days, warm days, and stagnant conditions.

What are Some Major Factors that Cause Algae Blooms?

Pollution

1.BGA/HAB feed on a steady diet of phosphorus and nitrogen. When phosphorus and nitrogen fertilizers applied in excess, these nutrients can enter water bodies via chemical runoff or soil erosion.
2.Poor sewage management also introduces phosphorus and nitrogen into surface water systems.

Light Exposure and Water Movement

1.Like all other photosynthesizing organisms, algae require the right amount of light to thrive.
2.Unlike good algae which thrive best in clear waters that are shallow, BGA/HAB have the ability to move throughout the pond or lake and adapt to variable conditions.

Turbidity and Temperature

1.Turbidity is a measure of how clear or cloudy a body of water is and impacts light exposure and temperature of the water.
2.The more turbid the water, the warmer the water will be, allowing the algae to grow faster.
3.As algae blooms continue to grow, the water becomes increasingly turbid, which fosters an environment for algae blooms to thrive.

Climate change

1.Higher air temperatures have a corresponding effect on raising water temperatures.
2.Higher water temperatures combined with increased stormwater runoff packed with nutrients can result in conditions favorable for algal blooms.

3.With a changing climate, HABs can occur more often in freshwater bodies and may become more intense.

What are the Consequences of Harmful Algae Blooms in Ponds and Lakes?

1.HABs known to produce and release toxins that kill fish and other animals.
2.Harmful Algae Blooms can hurt aquatic life by blocking out sunlight within water bodies and clogging fish gills.
3.HABs can create 'dead-zones', which are areas in water with little to no oxygen where aquatic life cannot survive.
4.Toxins produced by HABs can be harmful to humans and pose a threat to public health through diminishing water quality or through affecting individuals with respiratory conditions.
5.HABs can make water unsafe to drink. Furthermore, when water is tainted with HABs, it becomes much more expensive and challenging to treat before it is safe to consume.
6.Even after it is deemed safe to consume, the water may have an off-putting smell or aftertaste.

How can you Prevent Algae Blooms from Taking Over your Pond or Lake?

Now that you know
(i) the difference between good and bad algae,
(ii) how harmful algal blooms can have devastating effects on aquatic life, and
(iii) how toxins released in water by HABs can harm animals and humans, let us look at how to prevent, manage, or control algae.
There are three methods used to manage algae:
Chemical - which involves the application of algaecides. For example:
1. *Copper salts and water soluble copper based algaecides.* Copper sulfate, an old standby, disrupts the cell membranes in algae, which is inexpensive.
2. It is less effective in hard water (which has high calcium and magnesium content), is toxic to fish at low pH, and most effective when water temperatures are above 60 F.
3.Water soluble copper based algaecides disrupt cell membranes in algae and are relatively expensive.
4.These algaecides can prevent copper from precipitating out of solution in hard water, and are most effective when water temperatures are above 60 F.
Physical or mechanical - which involves raking or dredging, mowing, and harvesting the algae.
1.On a small scale this method can be highly effective. However, for large ponds or lakes, physical removal of algae blooms requires expensive harvesting equipment.
2.When algae is removed physically, the material needs to be taken out of the water and disposed of where the nutrients and fragments cannot re-enter the pond or lake.
3Repeat physical removal may be necessary during the growing season.
Biological - which involves introducing plants or animals that compete with or feed on the algae.
1.Some type of carp fish will feed on mat forming algae when their food source is depleted.
2.The use of carp to control algae is variable and will limit the potential to use copper-based algaecides.

5.4 Stocking Management

One or two days prior to stocking, a hapa should be fixed in the pond and some stocking materials should be put inside the hapa. Absence of distress and mortality after 24 hours confirm complete detoxification and the pond should be regarded as ready for stocking.

Stocking of nursery ponds

- Carp spawn requires natural feed immediately after stocking and hence it is essential to have a minimum plankton value of 30-40 ml/m3 in case of stocking at a moderate rate (1.5-2.5 million/ha).
- When a higher stocking rate is to be adopted, plankton population is also required to be increased accordingly.
- In case the stocking density is over 5 million/ha, the plankton volume should be around 100 ml/m3.
- Self-produced or procured 3-4 days old spawn should be stocked in the morning at the rate of 4-6 million/ha.
- The stocking density must be according to the condition of the pond and the amount of fish food organisms available.
- The rate of stocking in a well prepared nursery pond with adequate fish food organisms can be as high as 10 million/ha.
- However, the survival level decreases with the increase in stocking density

Survival of carp fry at various stocking densities

Survival level (%)	**Stocking density** (million/ha)
87.3.	2.5
74.6.	3.75
62.0.	6.25

66.2.	10.00

- Combined rearing of two or more species of spawn should not be done in nursery ponds.
- The pond should be stocked after three days of hatching when their sizes range from 0.6-0.75 cm and counts on an average about 500 numbers/ml.
- The required number of spawn are measured with the help of metallic or plastic sieve cups of known volume.
- Spawn are reared in nursery ponds up to fry stage for about 2-3 weeks
- when they usually attain 2-3.5 cm in length and 0.15-0.75 g in weight. At higher stocking density the growth is relatively slow.
- It is possible to raise 3-4 crops of fry from the same pond during the same breeding season and in addition, the pond can also be utilized for rearing of common carp seed during January to March.

Stocking of rearing ponds

1. Rearing of fry to fingerling stage is done in rearing ponds where fry are stocked at the rate of 0.25-0.30 million/ha with a survival level of 60- 80% under proper pond conditions. Either monoculture or polyculture methods can be adopted for this rearing.
2. In the case of polyculture the species combination and their ratio should be decided on the basis of their habit, feeding, availability of feed, etc.
3. Some of the possible combinations are - catla, rohu, mrigal, common carp (3:4:1:3); silver carp, grass carp (1:1); silver carp, grass carp, common carp (4:3:3); catla, rohu, mrigal, grass carp (4:3:1.5); silver carp, grass carp, common carp, rohu (3:1.5:2.5:3), etc.
4. Combination of too many species should be avoided as it invites excessive handling at the time of harvesting for species segregation.
5. Fry are reared in ponds for about 3 months when they usually attain 100- 150 mm in length and 15-40 g in weight.
6. For healthy fry rearing it is recommended that the size of the fry at the time of stocking in the rearing pond should be as uniform as possible. This can be done by size grading at the time of fry harvesting from nursery ponds. Prior to stocking the rearing ponds the pond waters must have a plankton level of about 30-50 ml/m3.

Stocking of grow-out/stocking ponds

- After proper preparation, the pond should be stocked with 100-150 mm long fingerlings of desired carp species.
- In case the fingerlings are not available, the pond can also be stocked with advanced fry or early fingerlings in absolutely predator-free ponds. The stocking rate depends primarily upon the volume of water and on the oxygen balance of the pond.
- Quality of available natural fish food in the pond and the capacity of the farmer to provide supplementary feed, are also matters for consideration.
- Usually a pond having average water depth of 1.5-2.5 m should be stocked at the rate of 5 000 fingerlings/ha.
- The volume of water available for fish in an undrainable pond should not be less than 2 m3/fish if there is no provision of artificial aeration. In composite fish culture, rearing of six species of carps, viz. catla
- (Catla catla), rohu (Labeo rohita), mrigal(Cirrhinus mrigala), silver carp (Hypophthalmichthys molitrix), grass carp (Ctenopharyngodon idella) and common carp (Cyprinus carpio) is considered to be the ideal combination.
- However, depending on the availability of quality fingerlings of these carp species, three or four species combinations can also be taken up. Ratio of different species in the combination is also equally important. However, there are certain general guidelines for selecting species combinations

Different species combinations and theirstocking ratios for composite fish culture:
Species combinationSurface feederColumn feederBottom feederMacrophyte feeder Catla Silver carp Rohu Mrigal Common carp Grass carp

- Catla 40- Rohu 30 - Mrigal 30
- Catla 30-40- Rohu 20-30 - Mrigal 15-20 - Common20-25
- Catla 10-15 Silver 20-30- Rohu 15-30- Mrigal 15-20 - Common 20-25- Grass 5-15

- ✓ Based on the performance of individual species in the combination and availability of seed, combinations can be modified in subsequent years. Silver carp, however, should be stocked 1 or 2 months later.
- ✓ Interspecies competition for food between catla and silver carp to some extent is the key point for such differential stocking. The stocking pond also should have a desired level of plankton population of about

30-50 ml/m3.

Method of stocking

- Stocking of spawn, fry and fingerlings should be done very carefully to avoid any post-stocking mortality due to shock or infections.
- To minimize post-stocking mortality the fry/fingerlings should be slowly and gradually acclimatized to the temperature and quality of the water in the stocking pond.
- To do so, open the mouth of the seed transport bag/container and gradually add the pond water in phases and after 15-20 minutes slowly dip and tilt the bag/container in the pond so that the spawn/fry/ fingerlings are free to swim out.
- Stocking should preferably be done in the cool evening hours. Apply prophylactic treatment to seed prior to their release so as to avoid any post-stocking infections .

5.5 Post-stocking management

- ✓ Post-stocking management involves harnessing the pond productivity in the form of natural fish food, maintenance of pond environment congenial to the cultivated fish and fish husandry, mainly feeding and health care.

FERTILIZATION

1. Fertilization as a means of increasing fish production is well accepted. The natural productivity of a pond can be greatly enhanced by the use of fertilizers.
2. It stimulates the growth of natural food by providing some essential elements.
3. which found to be deficient in pond. Elements added as fertilizers or manures are utilized by phytoplankton which are the primary producers in aquatic environment.
4. Once the primary production is increased, the whole of the food chain is activated resulting finally in increased productivity.
5. Nitrogen, phosphorus and carbon are the major important elements added to ponds either as inorganic fertilizers or organic manures.
6. Fertilizing ponds with organic manures was an old practice, but with the introduction of inorganic fertilizers the practice, has been changed from purely organic to inorganic or a combination of both.
7. Besides the use of major elements like N,P,K and carbon, use of micronutrients in enhancing productivity have also gained importance in recent years.
8. The significance of micronutrients like sine, molybdenom, cobalt, born, venadium and manganese in plankton production.
9. An increase in plankton weight by about 14 per cent due to manganese alone.
10. The mode and frequency of application of fertilizers and manures are of significance for proper maintenance of nutrient levels for production of aquatic organisms.
11. The total quantity of fertilizers or manures are usually applied in split doses at periodic intervals during the entire growing period.
12. While fortnightly application of inorganic fertilizers are resorted, monthly application of organic manures are prefered and alternately when both are used, since the chemical, biological and economic factors restrict the dose of added fertilizers.

Liming

- ✓ The first step in fertilization is the application of lime. Liming raise the soil pH to a desirable level for establishing a strong buffer system, stimulates microbial decomposition of organic matter which favours mineralization of nitrogen and other nutrients from organic matter.
- ✓ It reduces toxicity of harmful compounds including disinfecting the environment. The bottom of ponds that have been drained with Cao or Ca(OH)2 will destroy parasites and other undesirable organisms.
- ✓ Concentration of calcium sometimes calcium and magnessium increases following liming which favours the precipitation of collodial matter.

- ✓ Generally ground limestone (CaCo3) is extensively used and applied either to the pond soil while dry or broadcast over the water surface in a single application or in several equal instalments. Acccording to the soil pH lime at the following rates are usually applied to ponds.

Organic manures

- A variety of agricultural wastes, dung of various farm animals (Cow, pig, buffalo, sheep, horse, poultry and duck) and also domestic sewage are used as organic manures for fertilizing fish ponds.
- These manures serve as direct source. of food for invertebrate fish food organisms and fish.
- Organic manures are especially efficient in increasing the abundance of zooplankton and benthic organisms.
- It also improves the cation exchanges capacity and buffering action of soil.
- The nutrients contained in organic manures are generally low compared to inorganic fertilizers and remain

mostly in complex forms.

- These are made available only after their breakdown to simple inorganic compounds through microbial action.
- Thus, the release of nutrients from organic manures are slow and their availability remain for a longer period depending on the rate of decomposition which in turn is dependent on the C/N ratio of the added organic manures.
- Plant materials in general have a wide C/N ratio compared to animal manures.
- When such materials are used on initial depression of mineral nitrogen occurs due to their appropriation by soil microbes, while with narrow C/N ratio mineralization of nitrogen occurs during the process of decomposition.
- So, to avoid such immobilization of mineral nitrogen, ammonium compounds are sometimes added to organic manures having high C/N ratio.
- In composite fish culture, the normal dose, of cowdung varies from 5000-10,000 kg/ha/yr. depending on the organic carbon content of the soil. In absence of supplementary feeding, this is raised to 10,000-20,000 kg/ha/yr depending the productivity of ponds.
- Though organic manures are useful in enhancing fish production, it has some **disadvantages** such as low and variable nutrient contents, their availability due to other alternate uses and ecological problems. Being composite in nature the results of their use are often unpredictable.
- They offend cesthetic value of a pond and are liable to transmit parasites and diseases. To avoid the chances of pollution and depletion of oxygen, organic manures are applied in heaps under water in split doses at monthly intervals during the culture period.

Inorganic fertilizers

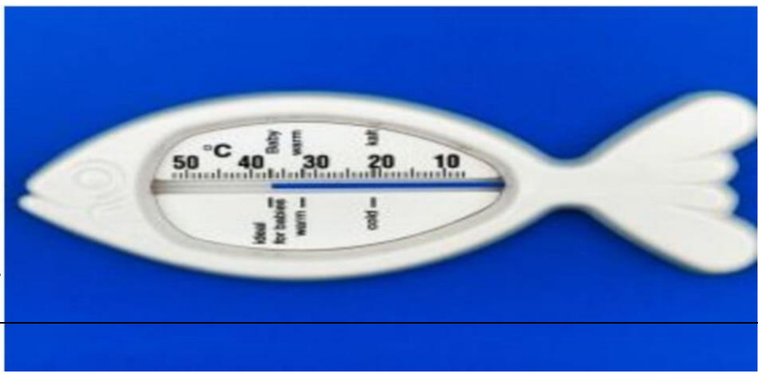
- Inorganic fertilizers have a definite and constant chemical composition of nutrient elements.
- Fertilizers certain these elements in the form of soulble or readily available chemical composition.
- They are sometimes called 'chemical' or 'artificial' manures. The fertilizers are usually classified according to the particular nutrient element which forms their principal constituent.
- They may thus be grouped as nitrogenous fertilizers, phosphate fertilizers, potassic fertilizers and sonon.
- Some fertilizers with specific grades are made by mixing appropriate quantities of two or more groups of fertilizers.
- These are known as mixed fertilizers, while fertilizers containing more than one of the three principal elements in a single compound are called compound fertilizers.
- Inorganic fertilizers are usually contain a high and fixed percentage of one or the other element as compared to organic manures and are customarilly expressed as percentage of available nutrient elements like nitrogen **(N),** phosphosic acid (P_2O_5) potash (K_2O). Liquid inorganic fertilizers have also been used and offer several advantages over the conventional granular or powdered NPK fertilizers.
- Due to high solubility of these fertilizers, the nutrients are readily available soon after their application to the pond and are rapidly utilized thus necessiates their application frequently.
- The dose of nitrogen, phsophorus and potassium usually varies from 100-200 kg N, 50-100 kg P_2O_5 and 25-50 kg K_2O/ha/yr on the basis of low, medium or high productive ponds.

5.6 Water Quality

- Water quality can quickly decline in fish ponds as fish use the water to live, feed, reproduce, grow and excrete waste into. Fish farmers who wish to be successful should therefore understand the quality of their water, the needs of the fish and how to manage water quality factors.
- Here are some of the most important chemical and physical things that farmers should pay attention to in their fish ponds' water.

Temperature

- Controlling temperature is very important for fish welfare as it can affect their behavior, feeding, growth, and reproduction. Metabolic rates in fish double for each 18°F rise in temperature.
- Average temperature ranges for the optimal growth of fish vary depending on whether the fish is coldwater, coolwater or warmwater and the fish you pick for your pond should depend on the temperature of the water you have available.For coldwater fish, such as salmon and trout, the optimal temperature range for growth is between 48-65°F.



- Coolwater species, like yellow perch, prefer water between 60° and 85°F and warmwater fish like catfish and tilapia prefer between 75-90°F. **Suspended solids**
- Plankton, fish wastes, uneaten feed, or clay particles suspended in the water can all cause problems, especially in recirculating aquaculture systems.
- Fish waste particles can be a major source of poor water quality as they may contain up to 70 percent of the nitrogen load in the system and can irritate the fish's gills. As a rule, one pound of fish waste is produced forevery pound of fish produced.
- Turbidity caused by clay or soil particles can restrict light penetration and limit photosynthesis. Sedimentation of soil particles may also smother fish eggs and destroy beneficial communities of bottom organisms such as bacteria.
- Removal of clay turbidity can be accomplished by adding materials that attach to the negative charges of the clay particles, forming particles heavy enough to settle to the bottom.
- Common remedies for clay turbidity are 7-10 square bales of hay per surface acre, or 300-500 pounds of gypsum per surface acre. Gypsum applications may be repeated at two week intervals if ponds do not clear.
- To determine un-ionized ammonia concentration, multiply total ammonia concentration by the percentage which is closest to the observed temperature and pH of the water sample. For example, a total ammonia concentration of 5 ppm at pH 9 and 680 F would be: 5 ppm total ammonia X 28.5% = 1.43 ppm.
- Toxicity levels for un-ionized ammonia depend on the individual species; however, levels below 0.02 ppm are considered safe. Dangerously high ammonia concentrations are usually limited to water recirculation system or hauling tanks where water is continually recycled and in pond culture after phytoplankton die-offs.
- However, the intermediate form of ammonia--nitrite--has been known to occur at toxic levels (brown- blood disease) in fish ponds.

Buffering systems

- A buffering system to avoid wide swings in pH is essential in aquaculture. Without some means of storing carbon dioxide released from plant and animal respiration, pH levels may fluctuate in ponds from approximately 4-5 to over 10 during the day.
- In recirculating systems constant fish respiration can raise carbon dioxide levels high enough to interfere with oxygen intake by fish, in addition to lowering the pH of the water.

Table 3. Percentage of total ammonia that is un-ionized at various temperatures and pH.

pH	54 F	62 F	68 F	75 F	82 F	90 F
7.0	0.2	0.3	0.4	0.5	0.7	1.0
7.4	0.5	0.7	1.0	1.3	1.7	2.4
7.8	1.4	1.8	2.5	3.2	4.2	5.7
8.2	3.3	4.5	5.9	7.7	11.0	13.2
8.6	7.9	10.6	13.7	17.3	21.8	27.7
9.0	17.8	22.9	28.5	34.4	41.2	49.0
9.2	35.2	42.7	50.0	56.9	63.8	70.8
9.6	57.7	65.2	71.5	76.8	81.6	85.9
10.0	68.4	74.8	79.9	84.0	87.5	90.6

pH

The quantity of hydrogen ions (H+) in water will determine if it is acidic or basic. The scale for measuring the degree of acidity is called the pH scale, which ranges from 1 to 14.

- A value of 7 is considered neutral, neither acidic or basic; values below 7 are considered acidic; above 7, basic. The acceptable range for fish culture is normally between pH 6.5-9.0.

Alkalinity

- Alkalinity is the capacity of water to neutralize acids without an increase in pH. This parameter is a measure of the bases, bicarbonates (HC03-), carbonates (C03--) and, in rare instances, hydroxide (OH-). Total alkalinity is the sum of the carbonate and bicarbonate alkalinities. Some waters may contain only bicarbonate alkalinity and no carbonate alkalinity.

- The carbonate buffering system is important to the fish farmer regardless of the production method used. In pond production, where photosynthesis is the primary natural source of oxygen, carbonates and bicarbonates are storage area for surplus carbon dioxide. By storing carbon dioxide in the buffering system, it is never a limiting factor that could reduce photosynthesis, and in turn, reduce oxygen production.
- Also, by storing carbon dioxide, the buffering system prevents wide daily pH fluctuations.

- Without a buffering system, free carbon dioxide will form large amounts of a weak acid (carbonic acid) that may potentially decrease the night- time pH level to 4.5. During peak periods of photosynthesis, most of the free carbon dioxide will be consumed by the phytoplankton and, as a result, drive the pH levels above 10. As discussed, fish grow within a narrow range of pH values and either of the above extremes will be lethal to them.

- In recirculating systems where photosynthesis is practically non- existent, a good buffering capacity can prevent excessive build-ups of carbon dioxide and lethal decreases in pH. It is recommended that the fish farmer maintain total alkalinity values of at least 20 ppm for catfish production. Higher alkalinities of at least 80-100 ppm are suggested for hybrid striped bass. For water supplies that have naturally low alkalinities, agriculture lime can be added to increase the buffering capacity of the water.

Hardness

- Water hardness is similar to alkalinity but represents different measurements. Hardness is chiefly a measure of calcium and magnesium, but other ions such as aluminium, iron, manganese, strontium, zinc, and hydrogen ions are also included.

- When the hardness level is equal to the combined carbonate and bicarbonate alkalinity, it is referred to as carbonate hardness. Hardness values greater than the sum of the carbonate and bicarbonate alkalinity are referred to as non-carbonated hardness.

- Hardness values of at least 20 ppm should be maintained for optimum growth of aquatic organisms. Low-hardness levels can be increased with the addition of ground agriculture lime.

Other metals and gases

- Other metals such as iron and sodium, and gases, such as hydrogen sulfide, may sometimes present special problems to the fish farmer. Most complications arising from these can be prevented by properly pre- treating the water prior to adding it to ponds or tanks.

- The range of treatments may be as simple as aeration, which removes hydrogen sulfide gas, to the expensive use of iron removal units.
- Normally iron will precipitate out of solution upon exposure to adequate concentrations of oxygen at a pH greater than 7.0.