1. Introduction to Aquaculture

Aquaculture is *the rearing of aquatic organisms.*

Eg. *Culture of Catla, prawns, edible oyster, pearl oyster,* etc.

Aquaculture is the ***farming in water.*** It is the Agriculture in water.

The product of aquaculture is called ***aqua food.***

The aim of aquaculture is to produce ***blue revolution*** just like ***green revolution*** produced in agriculture.

The aquaculture is a branch of fisheries. It is also called ***culture fisheries.***

The persons who are engaged in aquaculture are called ***fish farmers.***

Fisheries *is an occupation or industry of catching and culturing fishes and other aquatic organisms for human welfare.*

Fisheries may be ***inland fisheries, brackish water fisheries*** and ***marine fisheries.***

Inland fisheries is the fishing in freshwater. Brackish water fisheries is the fishing in backwaters and estuaries. Marine fisheries in the sea.

Fisheries may be ***capture fisheries*** and ***culture fisheries.***

Capture fisheries is the ***catching of fishes.*** Culture fisheries is the ***cultivation of fishes***. It is also called ***Pisciculture*** or ***Aquaculture.***

Scope of Aquaculture

Aquaculture provides the following scopes:

1. Provides ***aqua food.*** Aquafood is rich in protein.
2. It provides employment opportunity.
3. ***Pearl*** is produced on a large scale.
4. ***Agar*** is extracted from seaweeds.
5. Sewage is used for aquaculture.
6. Fishery byproducts are used as raw materials in poultry and cattle feed.
7. Ornamental fishes are produced.

2. Aquaculture in India

Aquaculture *is the rearing of aquatic organisms for human welfare.* It is the ***farming*** of aquatic organisms.

Aquaculture is a kind of ***agriculture*** in water.

The product of aquaculture is called ***aqua food.***

The aim of aquaculture is to produce ***blue revolution.***

Aquaculture is the ***culture fisheries.*** It is the culture of fishes and other aquatic organism using advanced technologies. It is an ***industry*** or ***occupation.***

Aquaculture is a branch of ***fisheries.*** *Fisheries is an occupation or industry of catching and culturing fishes and other aquatic organisms.*

Fisheries is of two types, namely ***capture fisheries*** and ***culture fisheries.***

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 ***Aquaculture.*** The term ***Pisciculture*** is used specifically for the culture of fishes.

Role of Aquaculture in Economic Development

- Aquaculture generates employment.
- It improves nutritional status of the people.
- It increases food supply.
- It earns foreign exchange.

Constraints in Aquaculture

The following problems met within Aquaculture.

- Poor financial allotment
- Low investment
- Poor infrastructure

Catla

Mrigal

Grass carp

Common carp

Rohu

Silver carp

Other carps

Anabas testudineus

Clarius spp

Onchorhynchus mykiss

Shrimps

Others

Total quantity (t)

Total value (US$)

In freshwater, Indian major carps, exotic carps, tilapia, cat fishes, air breathing fishes, freshwater prawns, etc. are reared.

The freshwater aquaculture is classified into the following types:

1. *Pond culture*
2. *Riverine fish culture*
3. *Dam culture*
4. *Lake culture*
5. *Coldwater fish culture*

1. Pond Culture

Rearing of aquatic organisms in pond water is called ***pond culture.***

India has ***2.21 mh*** of freshwater ponds.

In ponds, Indian major carps, exotic carps, tilapia, cat fishes, air breathing fishes, freshwater prawns, etc. are cultured.

The ponds may be

1. *Nursery ponds*
2. *Culture ponds*
3. *Stocking ponds*

In nursery ponds, the ***hatchlings*** (newly hatched fish lar vae) are reared. The hatchlings grow into fingerlings in th nursery ponds.

In culture ponds, the ***fingerlings*** are reared.

In stocking ponds, the young fishes are reared till thei harvest.

In ponds, a number of culture practices such as ***monocul ture, monosex culture, polyculture, integrated fish culture*** are practiced.

2. Riverine Fish Culture

Rearing of fishes in running water is called ***riverine fish culture.*** The following are the important rivers used fo aquaculture in India.

Ganga, Yamuna, Godavari, Krishna, Bhramaputra, Sindhu Cauvery and Mahanadhi.

The rivers of India have an area of 3.12 million sq.km.

In rivers, Indian major carps such as catla, rohu, mrigal, etc. are cultured.

3. Dam Culture

Dams are *artificial man-made constructed reservoirs.* There are about 6 million hectare area of reservoir in India. The important dams in India are the following:

1. ***Hirakud*** dam in Orissa at Mahanadhi
2. ***Mettur*** dam in Tamilnadu at Cauvery
3. ***Bhavanisagar*** in Tamilnadu at Bhavani
4. ***Tungabhatra*** dam in Karnataka at Krishna
5. ***Neyyar*** dam in Kerala at Neyyar river

The important fishes reared in dams are Indian major carps, channa, wallago, mystus, etc.

Fig.2.3: Dam Culture.

4. Lake Culture

Rearing of aquatic organisms in lakes is called ***lake culture.***

Lakes are large standing water formations larger than ponds. Eg. *Chilka lake in Orissa.* They are natural water formations. India has an area of about 0.75 million hectare lakes

3. Mahseer - *Tor putitora*
4. Indian major carps - *Catla, rohu, mrigal*

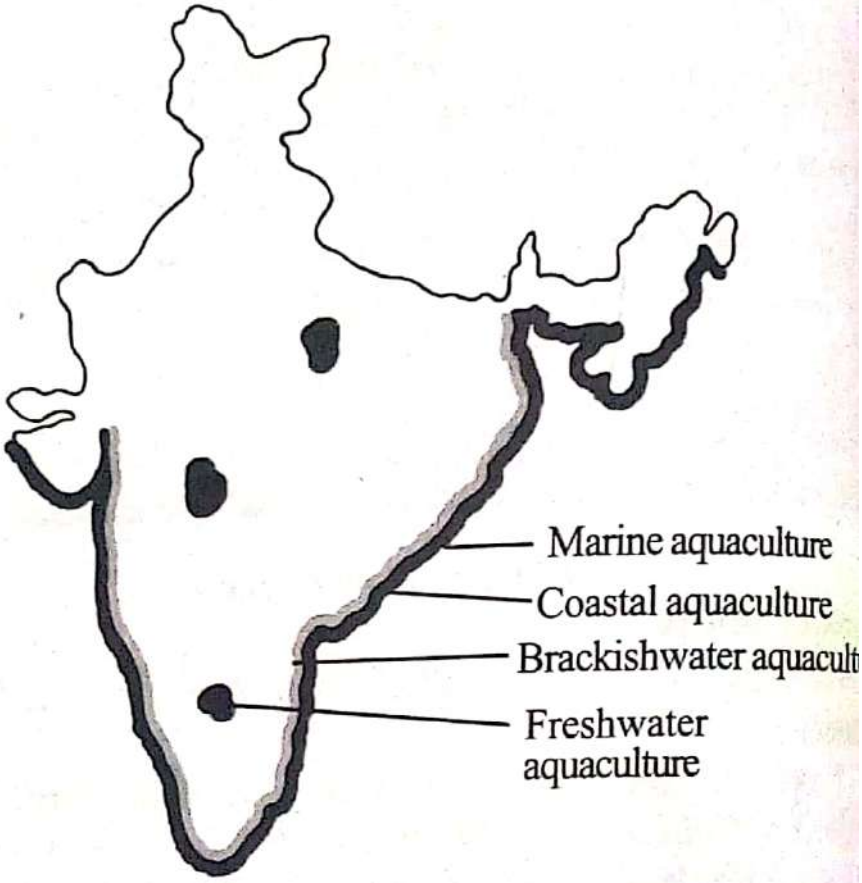


Fig.2.4: Aquaculture in India.

2. Brackishwater Aquaculture

Rearing of aquatic organisms in brackishwater is cal ***brackishwater.*** In brackishwater aquaculture, the organis are cultured in water where the salinity is more than 1 and l than 32 $^{0}/_{00}$.

The brackishwater formation includes estuaries, backv ters, lagoons, etc. It is practiced along sea coast.

The following are the important areas where bracki water aquaculture is practiced:

1. Veli lake - Trivandrum
2. Colorone estuary - Thanjavur District

The important organisms cultured in brackishwater aqu ulture are the following:

1. *Tilapia*
2. *Etroplus*
3. *Chanos*
4. *Mugil*
5. *Penaeus monodon*
6. *Penaeus indicus*
7. Spiny lobsters - *Palinurus*
8. Crabs

3. Mariculture

Mariculture refers to the cultivation of aquatic organisms in sea water where the salinity range is 30 to 32‰. It is the ***sea farming.*** It is also called ***marine aquaculture*** or ***marine culture fisheries.***

Mariculture is of two types, namely

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

1. Coastal Aquaculture

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

2. Offshore Aquaculture

Culture of aquatic organisms in the deep sea is called ***offshore aquaculture.***

A number of marine organisms are cultured in the sea. They are

1. Shrimp (marine prawn)
2. Edible oysters
3. Pearl oysters
4. Mussels
5. Sea weeds
6. Fin fishes :

Salmon	Pangasius
Trouts	Gouramis
Yellow tail	Rabbit fishes
Sea Bass	Sea breams
Groupers	Milk fish
Murrels	Mullets

Culture and Capture Fisheries

Fisheries is of two types, namely ***culture fisheries*** and ***capture fisheries.***

Rearing of fishes in extensive and intensive methods is called ***culture fisheries***. It is also called ***aquaculture.*** Capturing of wild fishes with crafts and gears is called ***capture fisheries.***

Types of Fisheries

World fisheries is of 4 main types. They are

1. *Inland fisheries*
2. *Marine fisheries*
3. *Coastal fisheries*
4. *Metahaline fisheries*

1. Inland Fisheries

Inland fisheries is the culture and capture of fishes in freshwater. It is also called ***freshwater fisheries.*** The total area of the freshwater is 2.5 million sq. km.

The freshwater catch is more potential than that of the sea. It was 12 kg/ha for freshwater and only 1.1 for the sea.

In freshwater World fisheries, ***China*** ranks first. ***USSR*** comes next.

Other important countries involved in inland fisheries are ***South-east Asia, North Europe, USA, Canada, Africa, South America, Norway, Sweden, Philippines, Malaya***, etc.

Inland sources of fish consist of great river systems, lakes, ponds, dams, canals, paddy fields, etc. They are the following:

Ganga	Lake Victoria
Nile	Lake Nyasa
Amazon	Chilka lake, etc.

2. Marine Fisheries

Culture and capture of fishes in the sea is called ***marine fisheries.***

About 70% of the Earth's surface is occupied by the sea. It covers an area of 510 million sq.km. Seawater is twice as productive per acre as any area of the land.

3. Coastal Fisheries

Rearing and capture of aquatic organisms in brackishwater is called ***coastal fisheries.*** In coastal aquaculture, the organisms are cultured in water where the salinity is more than 1 and less than 32 $^{0}/_{00}$.

The brackishwater formation include estuaries, backwaters, lagoons, etc. Coastal aquaculture is practiced along sea coast.

The important organisms captured in coastal waters are the following:

1. *Tilapia*
2. *Etroplus*
3. *Chanos*
4. *Mugil*
5. *Penaeus monodon*
6. *Penaeus indicus*
7. Spiny lobsters - *Palinurus*
8. Crabs

4. Metahaline Fisheries

Culture and capture of aquatic organisms in water containing high salt content (more than 32 ppt) is called ***metahaline fisheries.*** It is practiced in salt pans.

Artemia salina is the important organism cultured in metahaline aquaculture.

Artemia is a crustacean used as feed organism.

Culture Practices in the World

The following culture practices are adopted in the World fisheries:

1. Monoculture
2. Monosex culture
3. Polyculture
4. Paddy cum fish culture
5. Poultry cum fish culture
6. Dairy cum fish culture
7. Piggery cum fish culture
8. Integrated fish culture
9. On bottom culture
10. Off bottom culture

5. Water Quality Management

Water is a ***liquid gold.*** It is the ***medium*** for aquaculture The health and growth of the aquatic organisms depend on the water quality.

The quality of water is determined by ***physical factors, chemical factors, biological factors*** and ***nutrients***. They are the following:-

1. Visibility } Physical Factors
2. Temperature }
3. Oxygen
4. Carbon di-oxide
5. Salinity } Chemical Factors
6. pH
7. Biological Oxygen Demand
8. Plankton — Biological Factor
9. Nitrogen
10. Potassium } Nutrients
11. Phosphorus

1. Visibility

Visibility is due to the penetration of light into the wate It is also called ***transparency*** or ***turbidity***.

Visibility depends upon the suspended particles prese on the surface of the water. These particles prevent the pe etration of light.

When the suspended particles are more, the light pe etrates to minimum depth. So the water is said to be mo turbid and less transparent.

The turbidity can be measured by ***Secchi disc.*** Secchi disc is a metal disc. It has four quarters painted white and black alternately. The disc is tied to a rope.

For aquaculture, high visibility is required. The light is used by algae and phytoplankton for ***photosynthesis.***

The transparency should not be less than 20 cm.

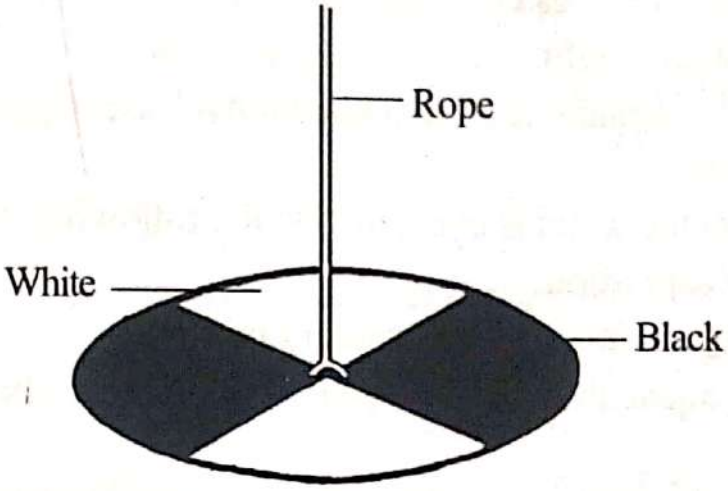


Fig.5.1: Secchi disc.

2. Temperature

Temperature is the intensity aspect of heat. The surface water temperature is always high and the bottom temperature is low.

In a pond, the water has three layers, depending upon the temperature. They are upper ***epilimnion***, lower ***hypolimnion*** and middle ***thermocline***. This is called ***thermal stratification.***

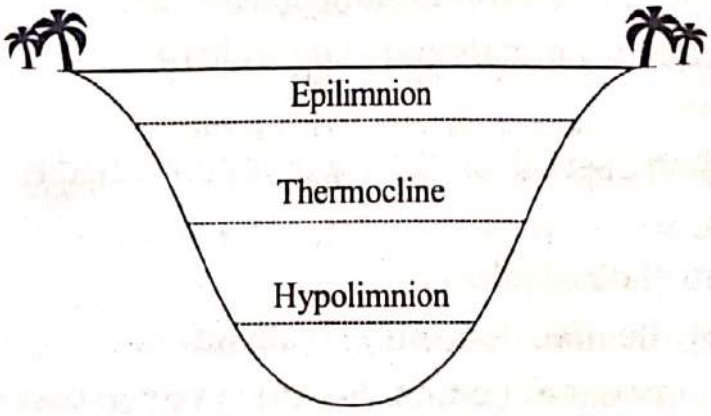


Fig.5.2: Thermal stratification in a fish pond.

Indian major carps require 20-25°C. When tempera
increases, O_2 content decreases.

3. Oxygen (O_2)

Oxygen is the ***vital gas***. It is used for the ***respiratio***
aquatic organisms.

Water receives O_2 by the following methods:

i. Direct diffusion of atmospheric air.

ii. Water plants and phytoplankton release oxygen by p
tosynthesis.

O_2 in the water is consumed in the following ways:

i. Respiration

ii. Decomposition of dead organisms.

For aquaculture, the oxygen level should be above 5m
lit.

For extensive aquaculture, oxygen available in natural
ter is sufficient.

For intensive aquaculture, additional oxygen should
provided by

i. Aerators

ii. Recirculation of water by the inflow of freshwater

4. Carbon di-oxide (CO_2)

Carbon di-oxide is essential for ***photosynthesis.***

Water gains carbon di-oxide by the following ways:

i. Direct diffusion of atmospheric air.

ii. Aquatic animals and plants release carbon di-oxide
respiration.

Carbon di-oxide in the water is consumed in the follo
ing ways:-

i. By photosynthesis

ii. By the lime depositing bacteria.

The amount of carbon di-oxide in pond water should
less than 5ml/lit.

of Indian Major Carps, the salinity should be less than 0.02 *ppt.*

6. pH

pH is the hydrogen ion concentration. When the pH is 7, the water is ***neutral***. When the pH is less than 7, the water is ***acidic***. When the pH of the water is more than 7, the water is ***alkaline***.

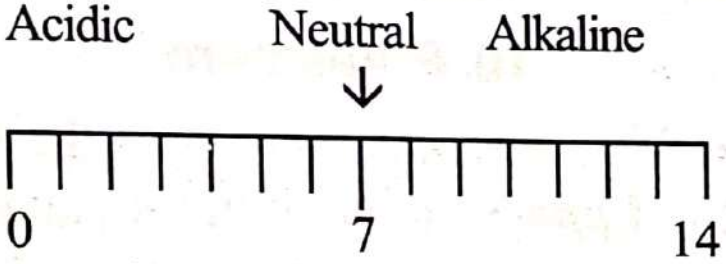


Fig.5.3: pH scale.

The Indian Major Carps need water with pH 7 to 8. It is the alkaline pH.

When the pH of the water is acidic, the pH is corrected by ***liming***.

When the pH of the water is alkaline, the pH is corrected by adding ***alum***.

7. Biological Oxygen Demand (BOD)

BOD is the ***Biological Oxygen Demand***.

It is the amount of oxygen required by the micro-organisms living in water.

BOD is higher in sewage water and lesser in drinking water.

8. Plankton

When the water contains large amount of phytoplankto the water turns green. This is due to the plankton bloom. T plankton bloom is not suitable for aquaculture.

9. Nitrogen (N_2)

Nitrogen is a nutrient. It increases the fertility of wat

Water gets nitrogen by ***nitrification***. Nitrification m be due to electrochemical reactions or biological phenor enon. The nitrogen content of water should be ***4 ppm***.

10. Potassium

Potassium is a nutrient. It increases the fertility of w ter. Water needs ***1 ppm*** of potassium for aquaculture.

11. Phosphorus

Phosphorus is another nutrient. It is released from de organisms. Water needs ***1 ppm*** of phosphorus for aquac ture.

Assessment of Water Quality

The water quality for aquaculture is assessed by the fo lowing methods.

1. Discolouration of water
2. Mass mortality of fishes

1. Discolouration of Water

Discolouration may be due to clay brought in by surfa run off or due to phytoplankton blooms. This causes ***turbi ity.*** Hence light penetration decreases leading to low visib ity.

The turbidity is measured by ***Secchi disc*** or ***turbidomet***

a. Secchi Disc

Secchi disc is a circular metal disc of 20 cm in diamet It is painted white and black in opposite quarters. It is tied to rope.

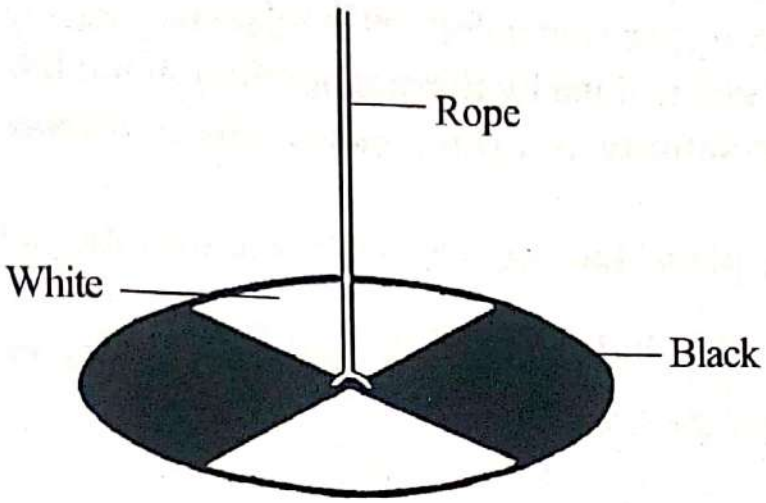


Fig.5.4: Secchi disc.

The disc is lowered into the water gradually until the disc just disappears. The depth is noted. The disc is then slowly lifted. The depth is noted when the disc appears. The average of the two readings is the transparency of water.

b. Turbidometer

The turbidometer is used to measure the transparency of water. The turbidometer consists of a ***tripod,*** a ***graduated cylinder*** and a ***candle.*** The cylinder is placed on the tripod. The cylinder is surrounded by a metal sheath having an opening at the bottom. The candle is placed under the cylinder. The sample water is poured into the cylinder. The turbidometer is placed in darkness.

The flame of the candle is viewed from the top through the water sample. Water is added continually until the flame is not visible. The level of water on the cylinder is noted. This reading is the value of turbidity in ppm.

2. Mass Mortality

Large scale mortality of fish and feed organisms is an indication of pollution. It may be due to

- Depletion of oxygen
- Increase in salinity
- Decrease in pH
- Toxins

The oxygen content of fish pond is analyzed by *Winkl* ***method*** as it is done by titration method in the lab.

The salinity is estimated by ***silver nitrate titra*** method.

The pH of the water is analyzed with the help of a meter.

The toxicity of the water is estimated by ***mean to*** ***ance limit*** method.

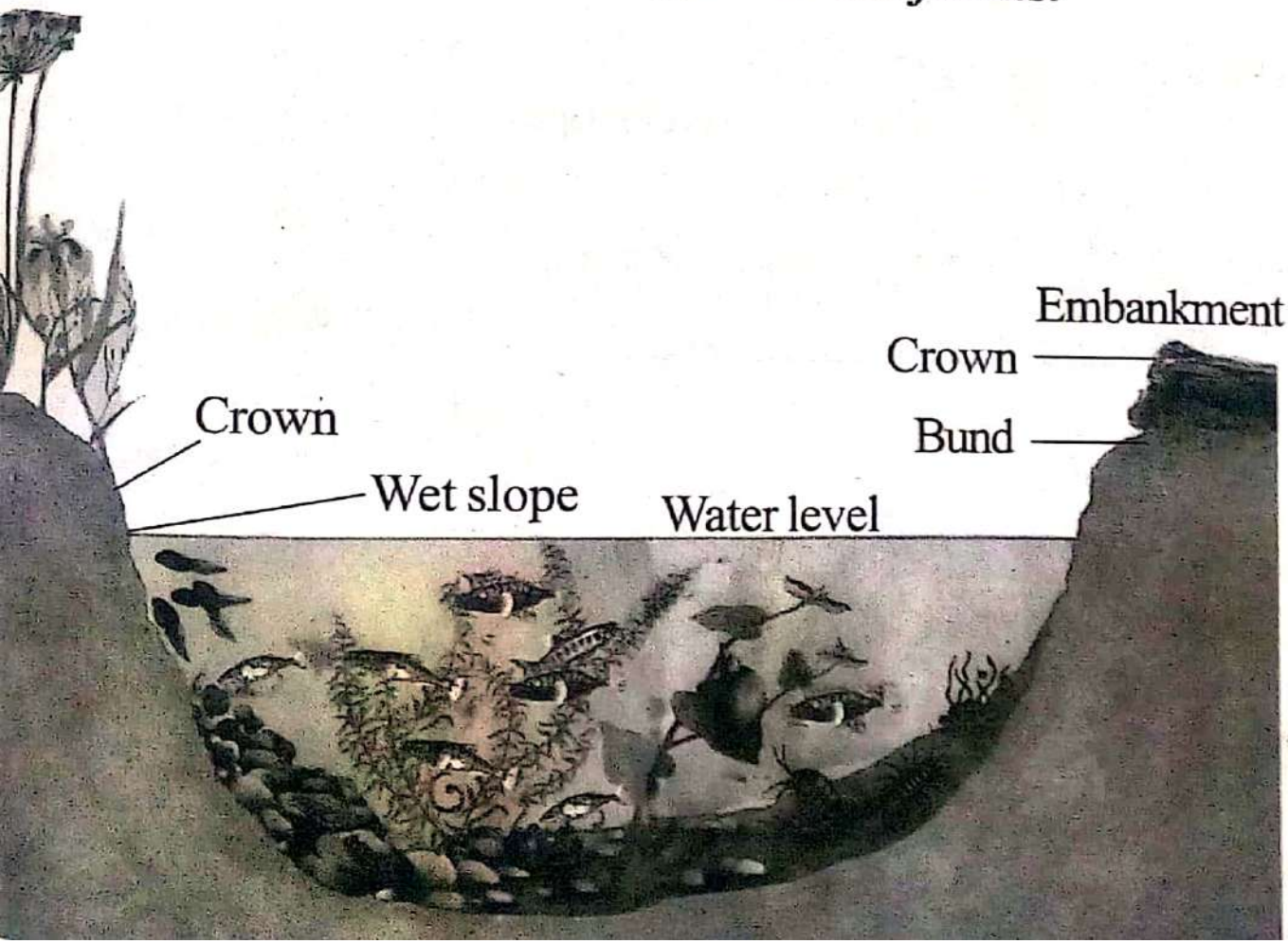
Fish farming needs good planning and wise ide
fish farm consists of four different types of ponds, na

1. *Breeding ponds*
2. *Nursery ponds*
3. *Rearing ponds*
4. *Culture ponds*

Selection of Site

Sustainable fish farming depends on the selecti
suitable site. The fish farm is selected based on techn
...mic criteria, considering the following f

water pressure and high enough to ***avoid floods.***



The life span and strength of the embankment dep
on the slope and the width of the crest.

The slope means the distance in horizontal axis for e
foot of height. If the height of the bund is 1 m and the ba
width of it's one side is 2 m, then the slope is said to be
The slope on the inner side of the pond is called
slope and the slope on the outer side is called ***dry slope.***

In cross section, the slope is ***trapezoid*** in shape.

In a fish pond of 0.5 ha, the wet slope may be 1:1.5 a
the dry slope may be 1:1.

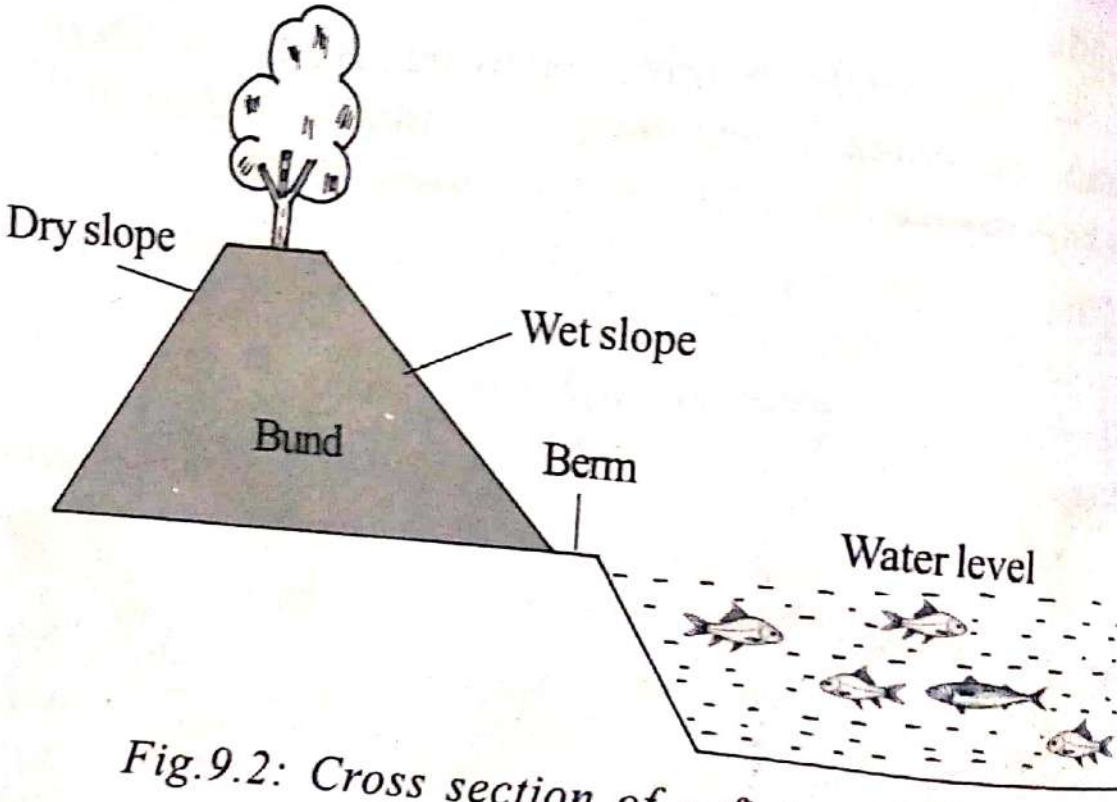


Fig.9.2: Cross section of a fish pond showing embankment.

Berm

A platform-like space between the wet slope and water area is known as a ***berm.*** It serves as a walkable space for the fish farmers. It also protects the bund from direct contact with water.

Inlets and Outlets

The inlets allow water into the pond and the outlets drain the water out of the pond. The inlet must be constructed on the elevated part of the pond. The outlet is constructed at the lowest level of the pond. The inlets and outlets are

with *screens* to prevent the escape of fish as well as entry of predators.

Nursery Pond

Nursery pond is used to rear hatchlings into fry for a period of one month till the fry attains the size of 2 to 2.5 cm. It is a small pond. The size should be 4 x 1.25 x 0.5 m. 3% of the water area is allotted for this pond. The depth of the water column should be 1 to 1.5 m.

Rearing Pond

Rearing pond is used to rear fry into fingerlings for a period of 2 months until the fry attain the size of 4 to 10 cm. The size of the rearing pond should be 25x12x1 m. The depth of the water column should be 1.5 to 2 m

Culture Pond

In the culture pond, the fingerlings are reared upto the marketable size. The size of the pond varies from 1 to 2 ha. The depth of the water column may be from 2 to 3 m.

Cemented Cisterns for Breeding

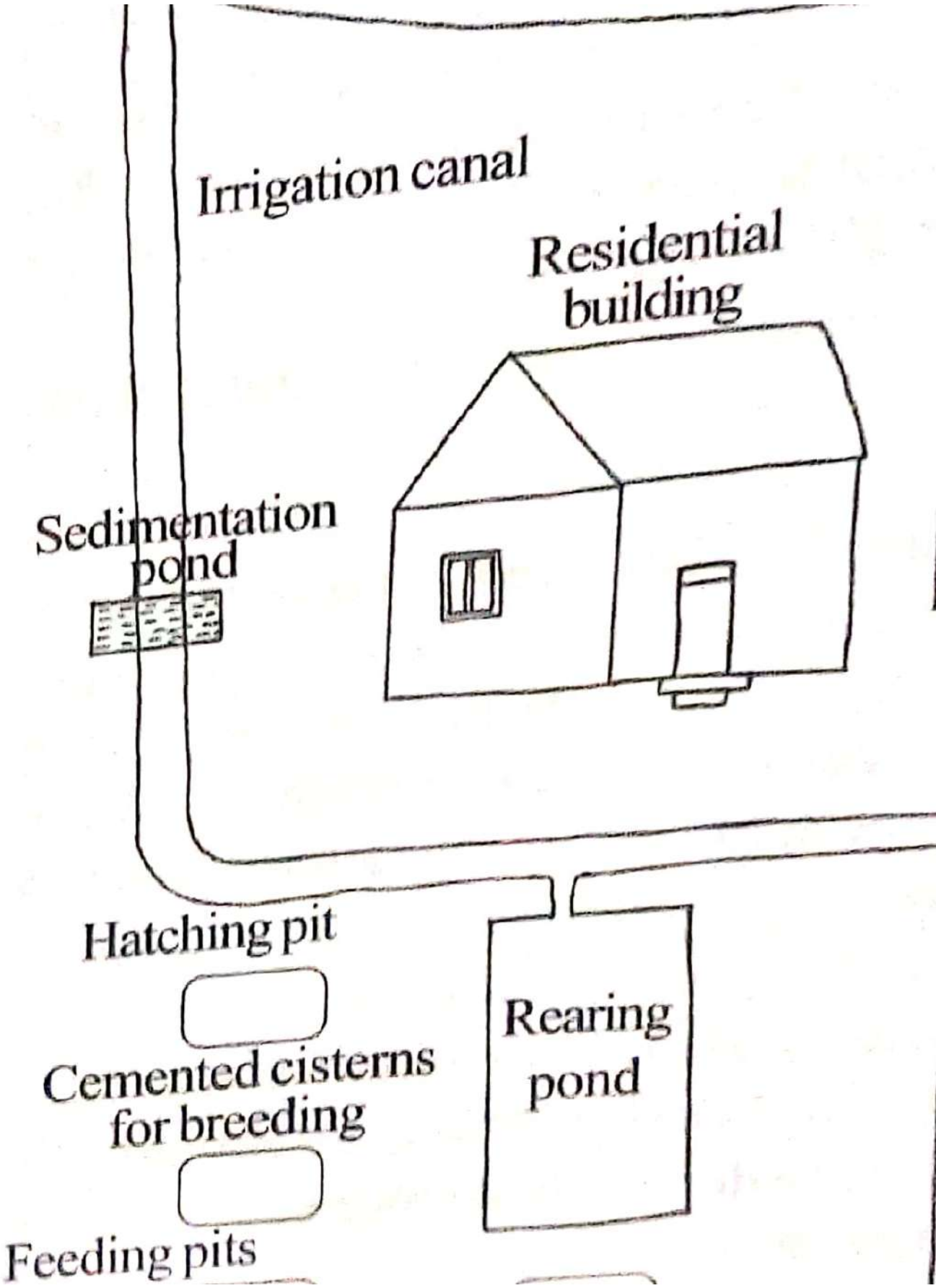
Cemented cisterns of about 4x2x1 m dimension are constructed for breeding purposes.

Hatching Pits

Hatching pits are used to hatch eggs collected from bundhs. The size of a pit may be 2.25 x 1.25 x 1 m. The hatching pits may be arranged in series near the nursery pond. There should be facility for proper irrigation and drainage. Water circulation ensures proper aeration, which is necessary for the development of eggs.

Feeding Pits

Feeding pits are used to culture plankton. Plankton form live feed for hatchlings. The size of a feeding pit should be 1 x 1 x 0.6 m. A number of feeding pits are constructed near the nursery pond. In these pits, plankton are cultured using cow dung, stable refuse, oil cakes, decaying vegetation, etc.



Major carps grown in muddy and weedy ponds have unpleasant smell in their flesh. This muddy taste is not acceptable to some people. The flavour of major carp can be improved by keeping them in marketable ponds where they may be fed with suitable artificial feed. To stimulate fast growth, fattening food may also be given.

The marketable fish can also be stored for some time in the marketable pond until the availability of fish is low in the market. This will fetch high price for the fish.

Sedimentation Pond

A sedimentation pond may be constructed with layers of gravel, sand and mud to filter the turbid water before it's entry into the fish ponds.

Monk

A monk is a water letting device in culture ponds. It allows water in and out. It prevents debris into the pond and prevents the escape of fry and fish.

Monk is used for the discharge of small quantity of water whereas sluice is used for the discharge of large quantity of water.

A monk is constructed out of ***concrete*** or ***wood.***

It is constructed in the dike wall. It is an integral part of dike wall.

It is in the form of a ***vertical tower*** in the dike wall.

It consists of two ***lateral walls*** perpendicular to the dike wall and a ***back wall*** parallel to the dike wall. The back wall is facing out of the pond.

The lateral walls are provided with three ***grooves.*** The groove facing the pond is fitted with a ***screen*** made of ***metal sheet***. It prevents the debris from entering the pond and fish from escaping.

The two other grooves are inserted with ***flashboards.*** The space between the two flashboards is filled tightly with

wet clay to prevent seepage of water. Rubber liners
used on the grooves to prevent lateral leakage of water

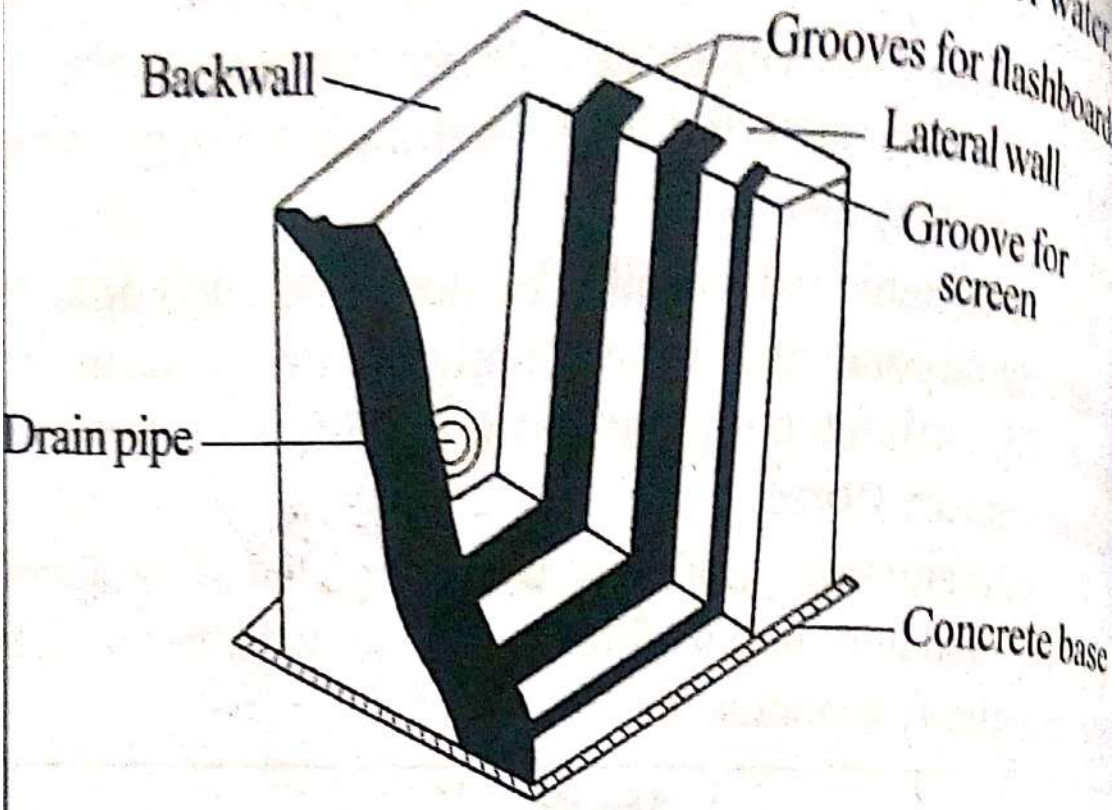


Fig.9.4: Sectional view of a Monk to show the grooves in the lateral walls and a drain pipe in the backwall.

The water level of the pond can be regulated by adjusting the flashboards. When the flashboards are lifted, the sluice opens and water is let out. When the flashboards are brought down, the sluice is closed.

The base of the back wall is fitted with a ***horizontal pipe*** of 40cm wide for draining the water.

Sluice Gate

Sluice gate is a water letting device in ***culture ponds.*** It allows water in and out of the pond, but prevents the escape of fish and fry.

Sluice gate is used where there is large discharge of water whereas monk is used to discharge small quantity of water.

Sluice gate is the enlargement of a monk.

It is constructed in the dike wall. It is an integral part of the dike. It is made of concrete or wood

A sluice gate is like a tower in the dike. It consists of two ***lateral walls*** remaining perpendicular to the dike. They face each other. Each lateral wall has three ***longitudinal grooves.***

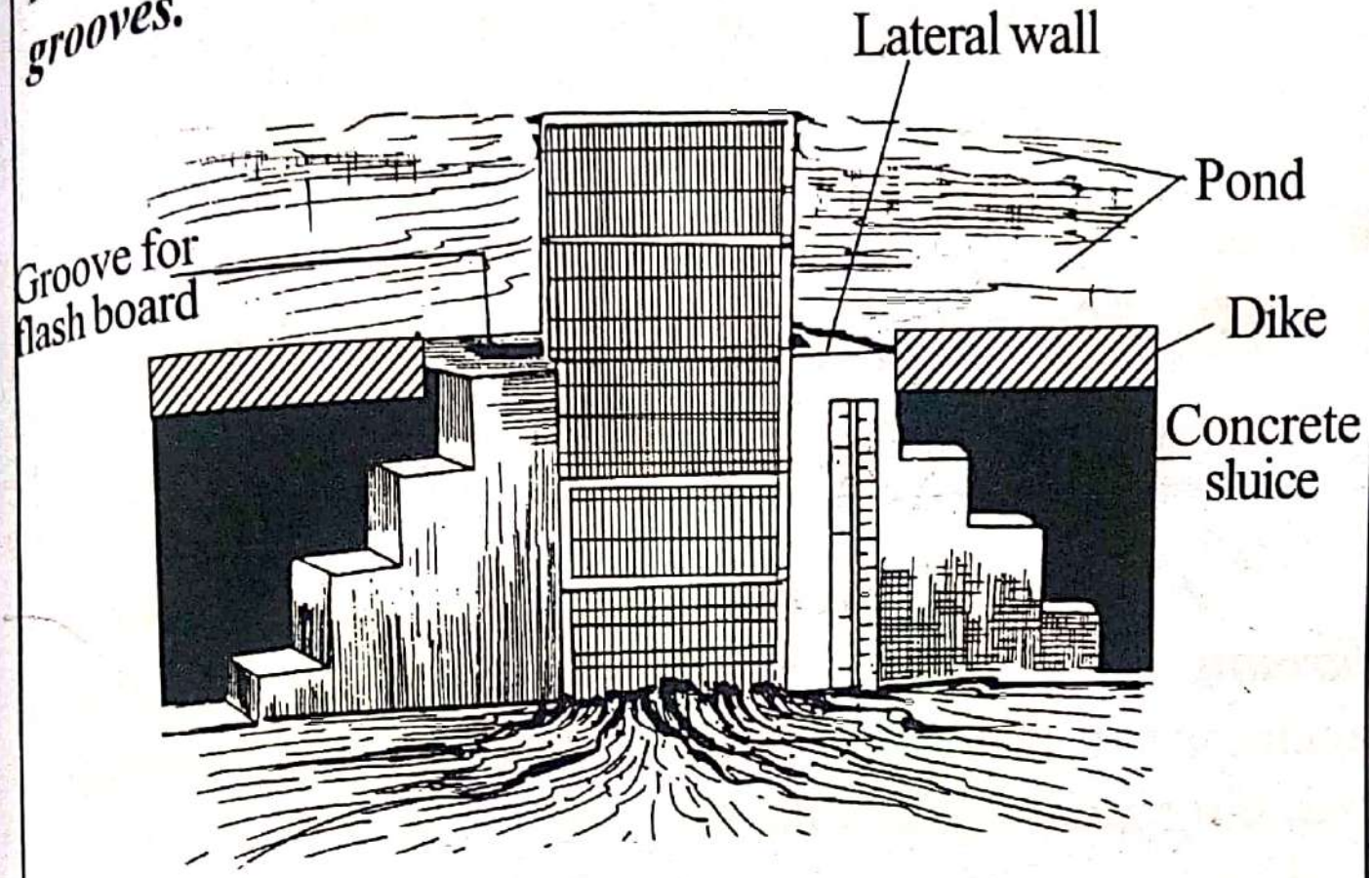


Fig.9.5: Diagrammatic presentation of a concrete sluice gate fitted with a bamboo screen on the outer face.

Two grooves are fitted with ***flashboards*** or ***vertical lift gates.*** A rubber liner is used in the grooves to prevent leakage of water from the lateral walls. The space between the flashboards is filled tightly with wet clay to prevent leakage.

The water level of the pond can be regulated by adjusting the flashboards. When the flashboards are lifted, the sluice opens and water is let out. When the flashboards are brought down, the sluice is closed.

The third groove is facing outward of the pond and is fixed with a ***bamboo screen.*** It prevents the escape of fish.

10. Management of Fish Farms
(Maintenance of Fish Farms)

The large scale rearing of fish in ponds is called ***farming.*** The success of fish farming depends on skillful m agement and maintenance of fish farm. The managemer fish farm involves the following steps:

1. Selection of site
2. Construction
3. Ploughing
4. Liming
5. Irrigation
6. Fertilization
7. Water quality management
8. Weed control
9. Predator control
10. Stocking
11. Supplementary feed
12. Disease control
13. Caring fishes
14. Fish pond implemen
15. Fish pond record
16. Harvesting
17. Marketing
18. Preservation

1. Selection of Site

The suitable site for fish farm is selected based on tec nical and economic criteria. There should be

ploughing. After 15 days of liming water is filled in the pond.

Lime can be added at the rate of 200 kg/ha. If the soil is acidic, the amount of lime may be increased. The lime does the following functions.

1. It increases pH which enhances the growth of phytoplankton and fish.
2. It neutralizes the toxic effect of old organic deposits of the bottom.
3. It increases the calcium content of the water.
4. It increases the bicarbonate content of the water.
5. It counteracts the poisonous effects of ions like magnesium and sodium.

5. Irrigation

After liming, some amount of water is allowed into the pond. The lime dissolves in water and the water becomes milky. After 15 days, the milky water is drained out and the bottom is dried. The pond is then refilled with abundant water of good quality.

6. Fertilization

Fertilization is the addition of fertilizer (manure). The manure enhances the growth of phytoplankton and zooplankton which form the feed for the fish.

The fertilizers may be organic or inorganic (chemical fertilizer).

The organic fertilizer includes cow dung, pigdung, poultry manure, green manure, compost, mahua oil cake, sewage, etc.

The inorganic fertilizers include urea, ammonium phosphate and super phosphate.

Fertilizers are applied 15 days after liming.

Pond water is the medium for the fish. It is the home for the fish.

The carps require an optimum ***temperature*** range from 20^0 to 25^0C.

The dissolved O_2 should be above 5mg/l.

The CO_2 should be 3mg/l of water

The ***visibility*** of the pond should be more than 30cm.

The ***pH*** should be on the alkaline side from 6.5 to 9.

8. Weed Control

Weeds are unwanted aquatic plants growing in the fish pond.

The aquatic plants must be present in the fish pond but in small quantity. When their number increases, they become detrimental to the life of fish.

The aquatic weeds may be ***microphytes*** or ***macrophytes.***

The ***microphytes*** are microscopic algae. Eg. *Volvox, Chlamydomonas, Euglena, Peridinium, Microcystis,* etc.

The luxuriant growth of algae causes ***algal blooms.***

The ***macrophytes*** are large aquatic plants. Eg. *Pistia, Hydrilla, etc.*

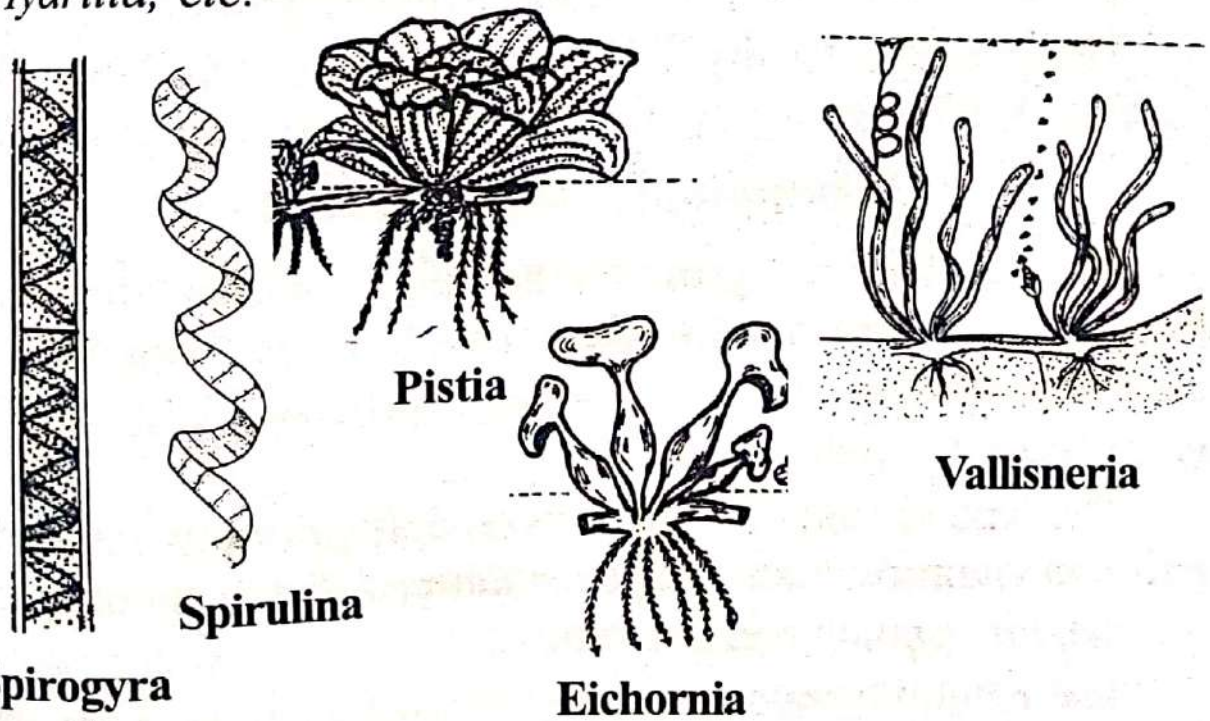


Fig 10.2: Some aquatic weeds.

ponds to control weeds.

9. Predator Control

The fish eaters of ponds are the predators. Eg. *Inse*
crabs, large fishes, snakes, birds, etc. Predatory insects
controlled by netting and spraying vegetable oils.

Vertebrates are controlled by nets which prevent the
try into ponds.

More than 50% of insect present in the pond are remov
by ***chemical*** or ***biological method.***

10. Stocking

Stocking is the release of hatchlings, fry and fingerlin
into the nursery, rearing

feed is given 2 to 3 times a day. The feed is placed in bamboo baskets in shallow areas.

In the beginning, the baby fish are fed at the rate of twice the weight of hatchlings. After a week, it is increased to three times the weight of baby fish. After two weeks, it is increased to four times the weight of the fish.

The fry are fed with artificial feed. It is a balanced food. It contains carbohydrate, protein, fat, minerals, vitamins, antibiotics, yeast, cobalt chloride, etc.

The feed is given three times in a day. The feed is made into small balls and are placed in bamboo baskets. The bamboo baskets containing the feed are placed in shallow waters in three or four places.

In the beginning, artificial feed is given at the rate of 1% of the body weight of the fry fish. It is gradually increased to 2 to 3%.

The fingerlings are fed like that of fry.

12. Disease Control

Diseases cause great loss to fish farmers. Hygienic conditions, prevention of diseases, precautions, identification of diseases, correct treatment, etc. save fish from diseases.

The following managerial activities should be followed for disease control:

1. The pond should be dried and ploughed now and then.
2. Liming should be carried out.
3. The pond should be filled with good quality water.
4. Silt and weeds may be controlled.
5. Fish may be given a ***salt bath*** in 100*l* of water having 1.5kg of salt for 1 to 2 hours before stocking.
6. When there is disease outbreak, the fish are treated with ***potassium***

hours to ***warm*** themselves, to play above and to hunt their breakfast. By about 8 am as the water gets warm on the surface they will go down. This is their normal behaviour, when they are comfortable.

When the baby fish are uncomfortable, they will be restless and remain on the surface. Then there is something wrong. This may be due to

- Some enemies in the bottom
- Over crowding
- Excess of putrification at the bottom
- Foul water
- Shortage of food

The remedy is

- A net is dragged to search for the enemy
- Some of the baby fishes may be transferred to other ponds to reduce overcrowding.
- If the water is not suitable, the impure water is drained and good quality water is refilled.

2. Diseased and sick fishes must be transferred to hospitable pond and treated.

3. Some ***poles*** are fixed in the middle of the ponds. They will help the fish to remove external parasites by rubbing its body against the poles.

4. A few ***stones*** may be placed at the bottom. This will provide shelter for the fish in the pond.

5. ***Plantation*** may be raised on the northern and western end of the

...ty of food, disease outbreak, overcrowding or ab... mal physico-chemical parametres of the pond. One of the ... reasons may be low oxygen content of the water. The de... tion of oxygen may be due to

- Putrification of bottom organic debris
- Slow rate of photosynthesis on cloudy days relea... less oxygen.
- This oxygen is exhausted in respiration during ni... hours.

1. Raker
2. Nets
3. Hapas
4. pH meter
5. Thermometer
6. Secchi disc
7. Plankton net
8. Water sampler
9. Soil sampler
10. Analysis kit
11. Small boat or a float

15. Fish Pond Record

Maintaining record of fish farm helps to improve the farming in the succeeding year.

Ponds should be numbered.

Dates of manuring, stocking, feeding, netting, marketing, size and weight are to be entered in a register regularly.

Expenditure on various items and income should be registered. The profit is calculated.

16. Harvesting

The harvesting of fish should be done at the right time. It should not be postponed. Before harvesting, the fish are given fattening feed. This will change the flavour and colour of the fish.

17. Marketing

The marketable fish can also be stored for some time in the marketable pond until the availability of fish is low in the market. This will fetch high price for the fish.

18. Preservation

The unsold carps can be preserved in ice or salt drying.

Feed plays a vital role in Aquaculture. Growth and
tivities of fish mainly depend on the food they consu
nature, different feeding habits can be observed in finfis
shellfish species. They feed on zooplankton, phytopla
filamentous algae, macrophytes, detritus matters, mol
small crustaceans and other small fish species. Many o
feed on more than one type of food.

Though all the culturable species of fish mainly de
on a variety of natural feed and supplementary feeds a
quired for intensive and semi-intensive culture systems

fishes. They are also called ***balanced feed*** or ***complete feed.*** They include a mixture of different ingredients like trash fish, slaughter house waste or mixtures of powdered ingredients.

The ingredients used for the formulating fish feed should be based on their qualities such as protein content, energy level, type of aminoacid, etc. Major ingredients commonly used are

- corn meal
- ground nut oil cake
- soy bean powder
- rice bran
- wheat bran
- fish meal
- shrimp meal
- slaughter house waste
- silk worm-pupae
- cowdung
- tapioca flour
- wheat flour
- dried algae, etc.

Selection of ingredients for the preparation of feed is based more on the availability than on the nutritional value.

The finished form of the artificial feed are of different forms.

They may be

1. Dry, moist or wet
2. Floating or non-floating type
3. Granules, crumbles, balls, cakes, flakes, pellets or paste.

Nutritional Requirements of Fish

The aim of aquaculture is to produce more ***flesh*** from fish. The flesh is got by growth. Growth is determined by the feed. Food with the greatest ***calorific*** value, gives most rapid growth. At the same time, vitamins and minerals regulate growth.

Carbohydrate provide 4kcal/g of energy. Proteins have 5kcal/g of energy and lipids have 9kcal/g of energy. Minerals and vitamins regulate the metabolism. ***Calcium and phosphorus*** are essential for the growth of bones.

Composition of an ideal Fish Feed

Ingredients	Quantity in Kg
Tapioca flour	9
Rice bran	27
Fish meal	23
Groundnut oil cake	14
Silk worm pupae	26
Vitamins and Minerals	1
Feed additive, Preservative, Chemo attractants	Trace amount
Total	100 Kg

Qualities of good Artificial feed

A good quality feed must have the following characters.

1. It should contain balanced nutrients
2. It should be readily acceptable.
3. It must be adequately stable in the medium.
4. It should have required attractants, stimulants, etc.
5. It must not have anti-nutritional effects.
6. The granules and pellets should be in an acceptable size and shape.
7. The ingredients used should not produce any adverse environmental factors.
8. The ingredients should be available at minimal cost.
9. The time taken for manufacturing the feed should be low.

Food Conversion Ratio (FCR)

amount of dry feed necessary to

Total wet - weight gain (growth of fish)

Principles of Feed Formulation

1. The feed must be a ***balanced diet.***

2. The feed should produce ***optimum growth rate.***

3. The feed should contain all the ***essential amino acids*** and essential ***fatty acids. Fish meal*** is a good source of essential amino acids and essential fatty acids. Hence fish meal should be compulsorily included in the feed.

4. Ingredients of ***plant origin*** and ***animal origin*** should be included.

5. The feed must be in ***low cost*** but in ***good quality.***

6. In semi-intensive system, certain vitamins and minerals may be excluded as the fish may get them from natural feed sources. But for intensive culture all the ingredients must be included.

7. The feed must be ***acceptable*** by the fish.

8. The typical adult feed should contain ***more protein*** but less ***carbohydrate***. In the case of fingerlings, the ***fats*** should be less.

9. It should contain all the nutrients essential for life activities. The following nutrients should be included in the artificial feed.

- Carbohydrates
- Proteins
- Fats
- Vitamins
- Minerals
- Additives - binders
- Preservatives
- Chemo attractants

10. The feed should contain

The following are the sources for carbohydrate (energy urce)

1. Rice bran
2. Tapioca flour
3. Wheat bran
4. Corn bran
5. Sorghum, etc.

11. ***Proteins*** are the ***body builders.*** An ideal feed should ntain 40% protein. The energy value of protein is 4.5kcal/ The ingredients containing protein are the following:

- Fish meal
- Silk worm pupae
- Blood meal
- Prawn waste
- Clam meat
- Slaughter house waste
- Ground nut oil cake
- Cotton seed cake
- Coconut oil cake
- Gingelly oil cake
- Linseed cake
- Sunflower cake

12. The fish feed must contain ***fats.*** The fats are the ***energy producers.*** They contain more energy than that of carbohydrate and protein. The energy value of fats is **9**kcal/g. The following are the fat source of fish feed.

- Vegetable oils
- Fish oils

13. The feed must contain ***Vitamins.*** The following vitamins

14. The ***minerals*** are essential for vital activities of
The fish feed should contain the following mine
trace amount.

- Calcium
- Sodium
- Potassium
- Phosphorus
- Magnesium
- Copper
- Iron
- Zinc
- Cobalt

The vitamins and minerals are purchased from the m
cal store and added to the feed.

15. The ***additives*** are added to make the ***feed*** sta
When additives are added the feed will ***not dissolve*** and
appear in the water. They bind the feed ingredients. So they
also called ***binders***. Eg. *Tapioca flour, Rice flour, agar,* et
16. ***Preservatives*** are added to prevent the decay of
feed.

17. ***Chemo attractants*** are added to add ***flavour*** and ***ta***
to the fish feed.

18. The ingredients are selected according to their ***av***
ability and ***cost.***

19. The ingredients are ground well and mixed thorough

20. They are made into ***pellets, dried*** and ***stocked.***

The following is a typical artificial feed formula.

Tapioca flour	- 9 kg
Rice bran	- 27 kg
Fish meal	- 23 kg
Ground oil cake	- 14 kg
Silk worm pupae	- 26 kg
Vitamins, Minerals	- 1 kg
Feed additive, Preservative, Chemo attractants	- Trace amount
Total	100 kg

...ngredients ...stocking

The ingredients are selected to fulfil the following requirements of fish.

1. Energy
2. Protein
3. Fats
4. Vitamins
5. Minerals

The feed ingredients also should include ***additives, preservatives*** and ***chemoattractants.***

Locally available ingredients should be selected. They should be at ***low cost*** but in ***good quality.***

2. Grinding

The various ingredients of the fish feed are collected and dried. They are ground into powder in a ***hammer*** mill.

Grinding reduces ***particle size,*** facilitates ***easy digestion*** and hence increases the ***nutritive value*** of ingredients.

3. Sieving

The ground ingredients are sieved through a mesh of ***177µm.*** The dust may be controlled by spraying oil.

4. Ratio

The ingredients are weighed individually according to the feed formula and kept as heaps.

5. Mixing

The weighed ingredients are placed as a ***heap***. They are mixed thoroughly.

6. Steaming

The feed ingredients are pass... ...mbi... ***chamber*** where 5% water or ***steam*** is added. Water provi... lubrication for pellet making.

Steaming helps in the killing of bacteria and other path... gens and improves digestibility. The steam also helps to chan... the starch into ***gelatin*** which helps in more adhesion of pa... ticles.

7. Pelleting

Pelleting is the conversion of conditioned feed into pel... ***lets.***

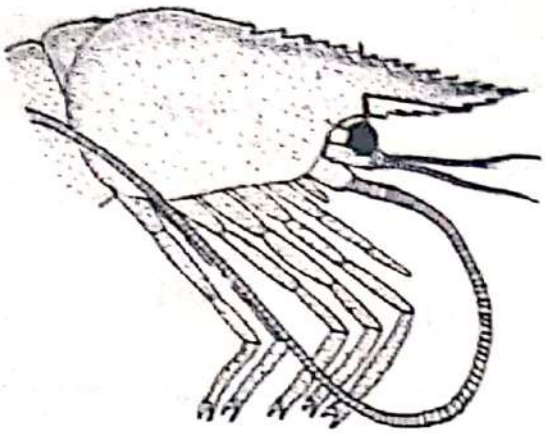
Pelleting is done on a machine called ***pelletizer.***

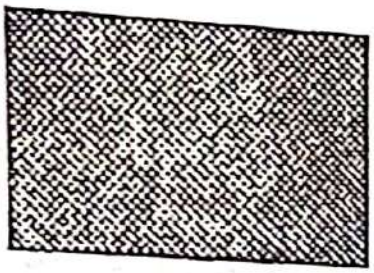
In the pelletizer different dyes are used to produce dif... ferent types of pellets.

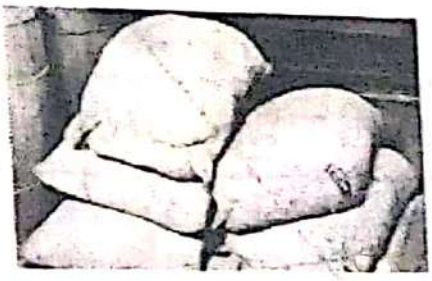
Inside the pelletizer, the feed is first air dried and then given 15 to 16% moisture at 80 to 90°C. Then the mixture is compressed and extruded th...

...ic acid, ... etc. ...nutrients, such as

Ingredients
↓
Grinding
↓
Sieving
↓
Ratios
↓
Mixing
↓
Steaming
↓
Pelleting
↓
Drying
↓
Packing
↓
Stocking







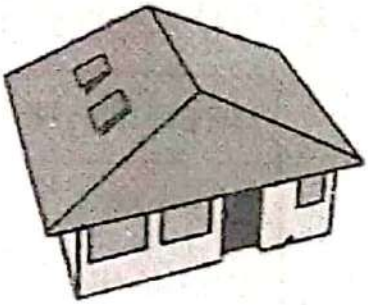


Fig.25.1: Steps in the preparation of ingredients.

Types of Artificial Feed

...d for the

h Pellets Wet M

2. Based on the ***nutrient level*** and ***size,*** the artificial
ouped into
i. Starter feed
i. Grower feed
ii. Finisher feed
v. Broodstock feed

Feed type	Level of protein (%)
Starter	40 to 45
Grower	35-40
Finisher	30-35
Broodstock	40-45

The dry and powdered form of feed is called ***mash*** or
. It is mostly used in hatchery and nursery ponds.
In ***pellet feeds***, the formulated feed ingredients are
ed, cooked and extruded in the form of noodles.
The pellet feed are further grouped into

i. Floating feed
ii. Non-floating feed

Floating feed will float on the surface of the water. This
d will be consumed by surface feeding fishes.

Non-floating feed will sink to the bottom of the pond.
is feed will be consumed by bottom feeding fishes.

If the non-floating pellet feeds are crumbled into uni-
rm particles, they are called ***crumbles*** or ***granules.*** The
ze of this feed may vary. It is used in nursery and ornamental
sh culture.

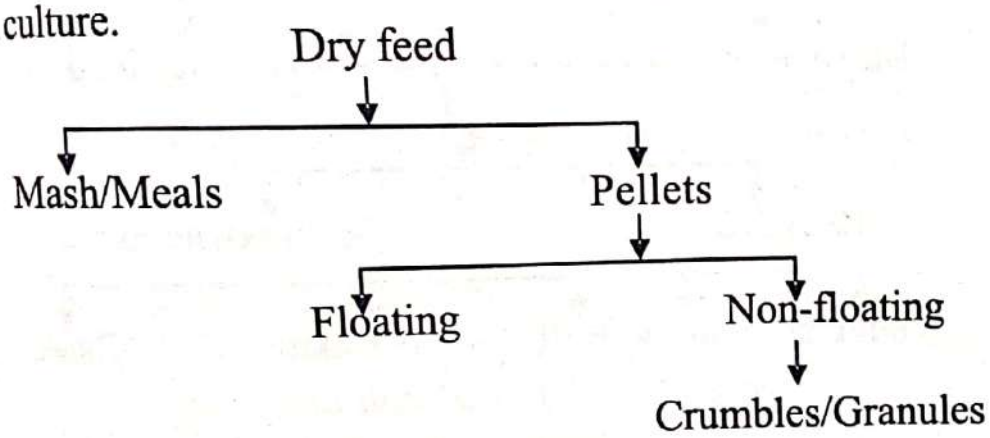


Fig.25.2: Types of dry feeds.

Non-dry feed

Non-dry feed has high content of moisture.
Non-dry feed are classified into

1. Wet feed
2. Moist feed

Wet feed will have the moisture content of 18 to 45%.
Moist feed will have the moisture content of 45 - 70%.
Both wet and moist feeds are prepared by using moist feed ingredients.

The wet and moist feed are again grouped into ***extruded*** and ***non-extruded*** forms.

i. Balls

ii. Cakes and

iii. Pastes

Extruded forms include *pellets* and *flakes*.

1. Pellets

Pellets are in the form of *noodles*.

2. Flakes

Flakes are non-dry feeds in the form of corn flakes. Flakes are prepared by using large number of feed ingredients. It is a balanced feed. It is used in nursery and ornamental fish culture.

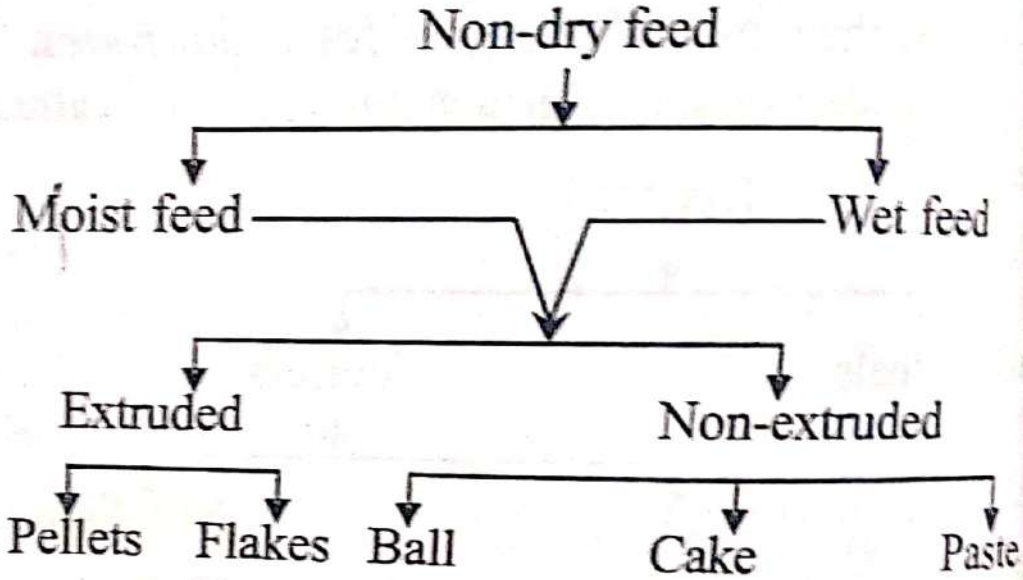


Fig.25.3: Types of non-dry feed.

Feeding Rates

The amount of feed required by the fish is decided by the weight of the fish. Generally, ***feed requirement decreases with the increase in the weight of the fish.*** The young fish require more feed but the adults require less feed. For example a fry of 0.25g requires 10% of their weight daily; but a fish of 4g may require only 5% of the body weight daily.

Feeding Schedule

The fish are fed two times in a day. Morning and evening hours are suitable. The fish are fed in ***specified timings*** and in ***fixed places.***

The fish feed are kept in ***shallow***

The feed may be ***sprayed*** on surface waters or kept in ***earthern vessels*** or ***bamboo baskets.***

Feeding Methods

The fish are fed with artificial feed by any one of the following methods:

1. Manual feeding
2. Automatic feeding
3. Demand feeding
4. Computer feeding

1. Manual Feeding

Manual feeding is the ***hand feeding.*** The feed are collected from the store room and placed in the feeding sites manually.

2. Automatic Feeding

In automatic feeding, the required amount of feed drop into the water automatically, at the required intervals. It is operated by electric and electronic timing devices.

3. Demand Feeding

In demand feeding, the fish gets the feed, when it operates a device connected to the feeder.

The feed is stored in the feeder suspended above the water. A rod or plate hangs from the feeder into the water. When the moving fish touches the rod a small amount of feed is released.

4. Computer Feeding

Feeding the fish with the aid of computer programming is called ***computer feeding***. The amount of feed and the time interval are automatically programmed by the computer based on the density of fish, growth rate, age of the fish, temperature, etc.

Problems in Artificial Feed

The following problems are faced during the formulation and preparation of artificial feed.

a. Non-availability of needed feed ingredients
b. Low stability of the feed
c. Less feed conversion ratio (FCR) values

Pellets

Pellets are ***artificial feed*** made into the shape noodles. They are ***hard, floating*** and ***stable*** in water.

Pellets form a ***balanced fish feed.*** They contain ma feed ingredients such as ***fish meal, plant cakes, vitamin minerals, feed additives,*** etc.

Pelleting is enhanced by the addition of ***binders*** in t feed. ***Starch*** is a binding agent; ***Gelatin, algin,*** etc. are al

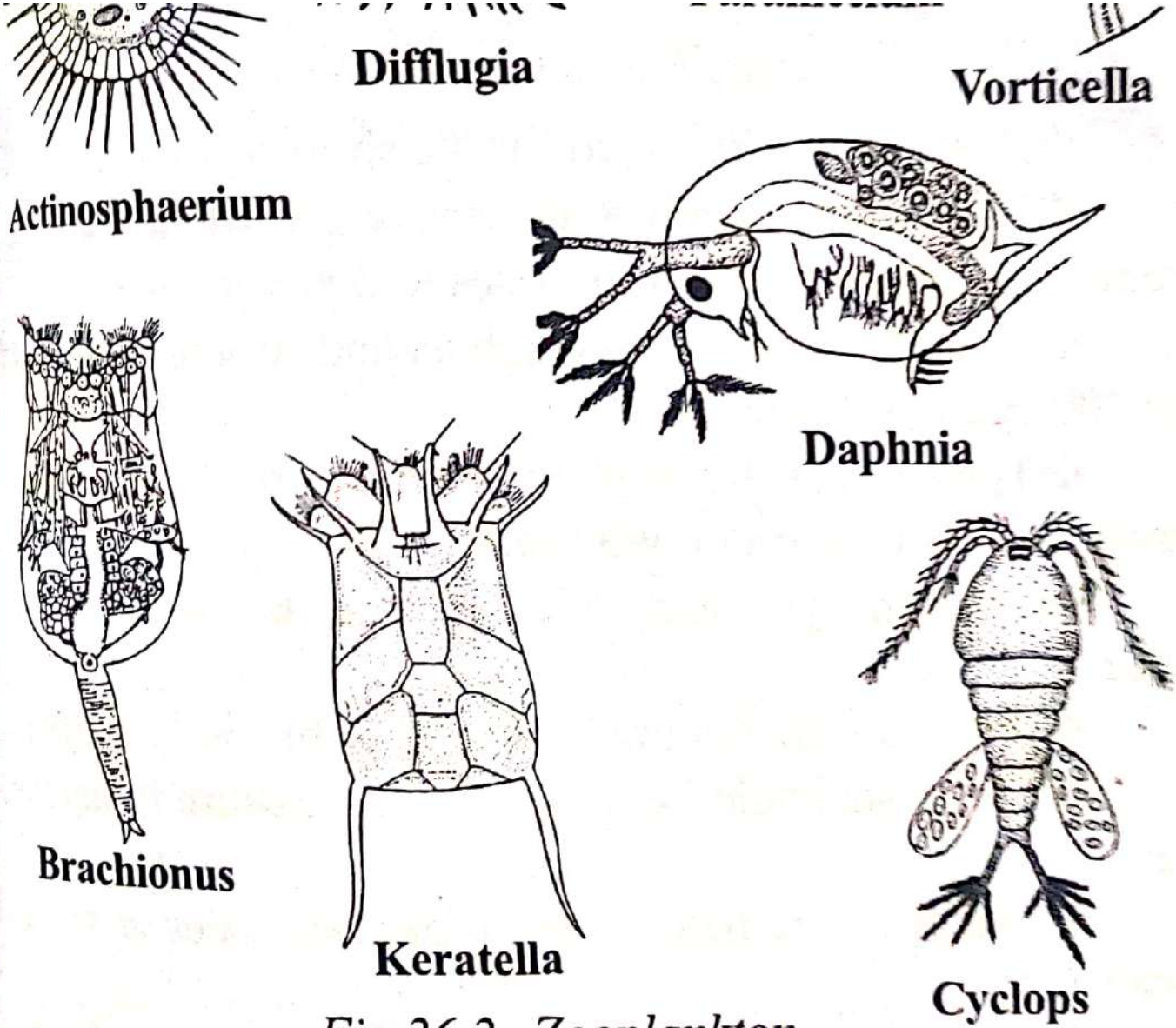


Fig.26.2: Zooplankton.

1. Artemia Culture

❖ *Artemia* is commonly called ***brine shrimp*** or ***sea monkey.***

❖ It is a ***branchiopod crustacean.***

❖ It lives in ***salt pans.***

❖ It is ***saffron red*** in colour.

Fig.26.3: Artemia salina.

❖ *Artemia* is a live feed for the shrimp post-larvae

❖ The suitable salinity for *Artemia* is 100 to 110 ppt reproduces when the salinity rises to 200 ppt.

❖ The adult *Artemia* has high fecundity of producing to 300 eggs in a clutch.

❖ The eggs of *Artemia* are called ***cysts*** which could main dormant for about two years.

❖ *Artemia* cysts are collected from the shores of lakes.

❖ Dry cysts are commercially available in the market

❖ The cysts could be used for mass culture in hatch ies.

❖ The cysts are hatched at 30 ppt salt water or norm seawater.

❖ Some of the *Artemia* species commonly found are

A. salina, *A. monica,*

A. fansiscana, *A. persimilis,*

A. parthenogenetica, *A. tunisiana,*

❖ In the lab, the cysts are hatched in one litre of norm tapwater with two teaspoons of common salt.

❖ A density less than 10g cysts per litre is recommend for hatching.

Fig.26.4: Brine shrimp nauplii.

- The water is aerated well.
- For optimal results a continuous illumination of 1000 is maintained.
- The nauplii, post-nauplii and pre-adult are used as feed.
- They could be collected using light as attractant.
- They can be stored frozen for future use.
- *Artemia* can be cultivated by ***extensive*** and ***intensive*** culture methods.
- *Artemia* is cultured in two methods:
  1. *Culture in salterns.*
  2. *Culture in raceway tanks.*
- *Artemia* is present in the ***salterns.***
- The main food of *Artemia* is micro algae growing in salterns.

1. Culture of Artemia in Salterns

- *Artemia* is cultured in salt pans to produce cysts.
- It is an ***extensive culture*** of *Artemia.*
- A suitable salt pan is selected as a ***culture pond.***
- *Artemia nauplii* are inoculated in this saltern.
- The pond salinity is maintained at 36 ppt with a temperature of 28 ^{0}C.

g.26.5: *Culture of Artemia in salterns.*

r 12 to 14 days, the nauplii attain maturity and

g.

the salinity is increased to 100 to 110 ppt.

r 51 days, the cysts are collected.

collected cysts are cleaned, washed, dried a

olythene bags and stored.

cysts are hatched in normal seawater when requi

hatched nauplii are used as feed.

of Artemia in Raceway Tanks

mia can be cultured in ***cement tanks*** by ***intensi***

thod.

is method, nauplii, post-nauplii and pre-adult a

tank with 5 to 500 litre capacity is filled with nat

enriched with bicarbonate (2g of $NaHCO_3/l$).

water for the culture should have the salinity o

tank is well aerated.

hly hatched nauplii are inoculated at a rate of abou