Animal Science

Aquaculture and Fisheries

Grade 10

Government of Nepal
Ministry of Education, Science and Technology
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Technical and Vocational Stream
Learning Resource Material

Aquaculture and Fisheries

(Grade 10)

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Preface

The curriculum and curricular materials have been developed and revised on a regular basis with the aim of making education objective-oriented, practical, relevant and job oriented. It is necessary to instill the feelings of nationalism, national integrity and democratic spirit in students and equip them with morality, discipline, self-reliance, creativity and thoughtfulness. It is essential to develop linguistic and mathematical skills, knowledge of science, information and communication technology, environment, health and population and life skills in students. It is also necessary to bring the feeling of preserving and promoting arts and aesthetics, humanistic norms, values and ideals. It has become the need of the present time to make them aware of respect for ethnicity, gender, disabilities, languages, religions, cultures, regional diversity, human rights and social values to make them capable of playing the role of responsible citizens with applied technical and vocational knowledge and skills. This learning resource material for Animal Science has been developed in line with the Secondary Level Animal Science Curriculum with an aim to facilitate the students in their study and learning on the subject by incorporating the recommendations and feedback obtained from various schools, workshops, seminars and interaction programs attended by teachers, students and parents.

In bringing out the learning resource material in this form, the contribution of the Director General of CDC Mr. Yubaraj Paudel and members of the subject committee Dr. Manraj Kolakshpati, Madhukumari Tiwari, Lavdev Bhatta is highly acknowledged. The learning resource material is written by Dr. Ganesh Gautam Dr. Shibalal Bhandari and Dr. Asis Mahat the subject matter of the materials, was edited by Mr. Badrinath Timsina and Mr. Khilanath Dhamala and language was edited by Mr. Bijaya Kumar Ranabhat. CDC extends sincere thanks to all those who have contributed to developing this material in this form.

This learning resource material contains a wide coverage of subject matters and sample exercises which will help the learners to achieve the competencies and learning outcomes set in the curriculum. Each chapter in the material clearly and concisely deals with the subject matters required for the accomplishment of the learning outcomes. The Curriculum Development Centre always welcomes constructive feedback for the betterment of the material.

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Table of Content

Guidelines to Teachers

A. Facilitation Methods

The goal of this course is to combine the theoretical and practical aspects of the contents needed for the subject. The nature of contents included in this course demands the use of practical or learner focused facilitation processes. Therefore, the practical side of the facilitation process has been focused much. The instructor is expected to design and conduct a variety of practical methods, strategies or techniques which encourage students engage in the process of reflection, sharing, collaboration, exploration and innovation new ideas or learning. For this, the following teaching methods, strategies or techniques are suggested to adopt as per the course content nature and context.

Brainstorming

Brainstorming is a technique of teaching which is creative thinking process. In this technique, students freely speak or share their ideas on a given topic. The instructor does not judge students' ideas as being right or wrong, but rather encourages them to think and speak creatively and innovatively. In brainstorming time, the instructor expects students to generate their tentative and rough ideas on a given topic which are not judgmental. It is, therefore, brainstorming is free-wheeling, non-judgmental and unstructured in nature. Students or participants are encouraged to freely express their ideas throughout the brainstorming time. Whiteboard and other visual aids can be used to help organize the ideas as they are developed. Following the brainstorming session, concepts are examined and ranked in order of importance, opening the door for more development and execution. Brainstorming is an effective technique for problem-solving, invention, and decision-making because it taps into the group's combined knowledge and creative ideas.

Demonstration

Demonstration is a practical method of teaching in which the instructor shows

or demonstrates the actions, materials, or processes. While demonstrating something the students in the class see, observe, discuss and share ideas on a given topic. Most importantly, abstract and complicated concepts can be presented into visible form through demonstration. Visualization bridges the gap between abstract ideas and concrete manifestations by utilizing the innate human ability to think visually. This enables students to make better decisions, develop their creative potential, and obtain deeper insights across a variety of subject areas.

Peer Discussion

Peer conversation is a cooperative process where students converse with their peers to exchange viewpoints, share ideas, and jointly investigate subjects that are relevant or of mutual interest. Peer discussion is an effective teaching strategy used in the classroom to encourage critical thinking, active learning, and knowledge development. Peer discussions encourage students to express their ideas clearly, listen to opposing points of view, and participate in debate or dialogue, all of which contribute to a deeper comprehension and memory of the course material. Peer discussions also help participants develop critical communication and teamwork skills by teaching them how to effectively articulate their views, persuasively defend their positions, and constructively respond to criticism.

Peer conversation is essential for professional growth and community building outside of the classroom because it allows practitioners to share best practices, work together, and solve problems as a group. In addition to expanding their knowledge horizon and deepening their understanding, peer discussions help students build lasting relationships and a feeling of community within their peer networks.

Group Work

Group work is a technique of teaching where more than two students or participants work together to complete a task, solve a problem or discuss on a

given topic collaboratively. Group work is also a cooperative working process where students join and share their perspectives, abilities, and knowledge to take on challenging job or project. Group work in academic contexts promotes active learning, peer teaching, and the development of collaboration and communication skills. Group work helps individuals to do more together than they might individually do or achieve.

Gallery Walk

Gallery walk is a critical thinking strategy. It creates interactive learning environment in the classroom. It offers participants or students a structured way to observe exhibition or presentation and also provides opportunity to share ideas. It promotes peer-to-peer or group-to-group engagement by encouraging participants to observe, evaluate and comment on each other's work or ideas. Students who engage in this process improve their communication and critical thinking abilities in addition to their comprehension of the subject matter, which leads to a deeper and more sophisticated investigation of the subjects at hand.

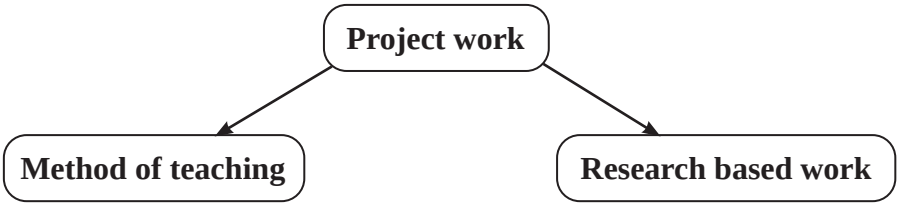
Interaction

The dynamic sharing of ideas, knowledge, and experiences between people or things is referred to as interaction, and it frequently takes place in social, academic, or professional settings. It includes a broad range of activities such as dialogue, collaboration or team work, negotiation, problem solving, etc. Mutual understanding, knowledge sharing, and interpersonal relationships are all facilitated by effective interaction. Interaction is essential for building relationships, encouraging learning, and stimulating creativity in both in-person and virtual contexts. Students can broaden their viewpoints, hone their abilities, and jointly achieve solutions to difficult problems by actively interacting with others.

Project Work

Project work is a special kind of work that consists of a problematic situation which requires systematic investigation to explore innovative ideas and solutions.

Project work can be used in two senses. First, it is a method of teaching in regular class. The next is: it is a research work that requires planned investigation to explore something new. This concept can be presented in the following figure.



Project work entails individuals or teams working together to achieve particular educational objectives. It consists of a number of organized tasks, activities, and deliverables. The end product is important for project work. Generally, project work will be carried out in three stages. They are:

- Planning
- Investigation
- Reporting

B. Instructional Materials

Instructional materials are the tools and resources that teachers use to help students. These resources/materials engage students, strengthen learning, and improve conceptual comprehension while supporting the educational goals of a course or program. Different learning styles and preferences can be accommodated by the variety of instructional resources available. Here are a few examples of typical educational resource types:

- Daily used materials
- Related Pictures
- Reference books
- **Slides and Presentation:** PowerPoint slides, keynote presentations, or other visual aids that help convey information in a visually appealing and organized manner.
- **Audiovisual Materials:** Videos, animations, podcasts, and other

multimedia resources that bring concepts to life and cater to auditory and visual learners.

- **Online Resources:** Websites, online articles, e-books, and other web-based materials that can be accessed for further reading and research.

Maps, Charts, and Graphs: Visual representations that help learners understand relationships, patterns, and trends in different subjects.

Real-life Examples and Case Studies: Stories, examples, or case studies that illustrate the practical application of theoretical concepts and principles.

C. Assessment

Formative Test

Classroom discussions: Engage students in discussions to assess their understanding of concepts.

Quizzes and polls: Use short quizzes or polls to check comprehension during or after a lesson.

Homework exercises: Assign tasks that provide ongoing feedback on individual progress.

Peer review: Have students review and provide feedback on each other's work.

Summative Test

Exams: Conduct comprehensive exams at the end of a unit or semester.

Final projects: Assign projects that demonstrate overall understanding of the subject.

Peer Assessment

Group projects: Evaluate individual contributions within a group project.

Peer feedback forms: Provide structured forms for students to assess their peers.

Classroom presentations: Have students assess each other's presentations.

Objective Test

Multiple-choice tests: Use multiple-choice questions to assess knowledge.

True/False questions: Assess factual understanding with true/false questions.

Matching exercises: Evaluate associations between concepts or terms.

Portfolio Assessment

Compilation of work: Collect and assess a variety of student work samples.

Reflection statements: Ask students to write reflective statements about their work.

Showcase events: Organize events where students present their portfolios to peers or instructors.

Observational Assessment

Classroom observations: Observe students' behavior and engagement during class.

Performance observations: Assess practical skills through direct observation.

Field trips: Evaluate students' ability to apply knowledge in real-world settings.

Introduction and Scope of Fish Farming

Unit 1

1.1 History, Scope and Importance of Fish Farming in Nepal

History of Fish Farming in Nepal

Fish farming in Nepal has its origins in the mid-20th century. Traditional fishing practices were common among rural communities near rivers and lakes, but systematic aquaculture began in the 1940s. Initially, Nepal imported fish species such as *common carp* and *Indian major carps* (Rohu, Catla, and Mrigal) from India. The first government-supported fish farm was established in the 1950s in Janakpur to promote aquaculture.

Over the decades, the government implemented various programs to expand fish farming. By the 1980s, semi-intensive and intensive aquaculture practices gained traction, supported by research and extension services. Introduction of cold-water fish species like trout in the Himalayan regions and warm-water species in the Terai further diversified the industry.

Scope of Fish Farming in Nepal

1. **Geographical Diversity:** Nepal's topography, with its varying climatic zones, provides a unique environment for cultivating different fish species.
   - Warm-Water Fish: Carp species thrive in the Terai plains.
   - Cold-Water Fish: Trout and snow trout are suitable for the mid-hills and Himalayan regions.
2. **Water Resources:** Nepal is rich in freshwater resources, with numerous rivers, lakes, reservoirs, and ponds, offering immense potential for fish farming.
3. **Rural Livelihood:** Fish farming provides an alternative income source for rural communities, particularly those with limited agricultural land.

4. **Integration with Agriculture:** Integrated farming systems, such as fish-rice farming and fish-vegetable farming, are increasingly adopted, enhancing overall farm productivity.
5. **Demand for Fish:** Rising awareness about the nutritional benefits of fish has led to increased domestic demand. Fish farming also has the potential to reduce the country's dependency on imported fish products.
6. **Eco-Tourism:** In areas like Pokhara, fish farming in lakes is not only a livelihood activity but also an attraction for tourists.

Importance of Fish Farming in Nepal

1. **Economic Benefits:** Fish farming contributes significantly to the agricultural GDP of Nepal. It creates employment opportunities in rural areas.
2. **Nutritional Security:** Fish is a rich source of protein, omega-3 fatty acids, and other nutrients, playing a critical role in improving the nutritional status of the population.
3. **Environmental Sustainability:** Sustainable aquaculture practices help utilize underutilized water bodies and promote biodiversity conservation.
4. **Export Potential:** With improved farming practices, Nepal has the potential to export fish to neighbouring countries, especially India and China.
5. **Cultural Value:** Fish holds cultural and religious significance in Nepal, featuring prominently in festivals and rituals.

1.2 Terminologies Related to Fish Farming

Aquaculture: The farming of aquatic organisms, including fish, crustaceans, mollusks, and plants, under controlled conditions.

Brood stock: Mature fish used for breeding.

Cage Culture: Raising fish in enclosed nets or cages submerged in water bodies like lakes or oceans.

Capture Fisheries: Harvesting aquatic species from natural habitats, such as oceans, rivers, and lakes.

Dissolved Oxygen (DO): The amount of oxygen gas that is dissolved in water and available for aquatic organisms to breathe.

Fingerlings: Juvenile fish that are larger than fry but not yet mature.

Fisheries: The industry or activity of catching, processing, and selling fish or other aquatic species from natural water bodies.

Fry: Recently hatched fish that have not developed scales or fins.

Hatchery: A facility for breeding and rearing fish larvae or fry.

Hypophysation: A technique used to induce spawning in fish by administering pituitary gland extracts, which contain gonadotropins that stimulate the reproductive processes.

Larvae: The early developmental stage after hatching in fish and shellfish.

Pond Culture: Rearing fish in man-made or natural ponds.

Spawn: The eggs or sperm released by fish during reproduction.

Turbidity: The cloudiness of water, often caused by suspended particles.

1.3 Zoological Classification of Fish

Kingdom: Animalia

Phylum: Chordata

Subphylum: Vertebrata

Superclass: Pisces

Classification Based on Habitat

1. **Freshwater Fish:** They live in rivers, lakes, and ponds (e.g., Rohu, Catla).
2. **Marine Fish:** They live in oceans and seas (e.g., Tuna, Mackerel).
3. **Brackish Water Fish:** They are found in estuaries (e.g., Tilapia).

Classification Based on Physiology

1. **Bony Fish** (*Class Osteichthyes*): Fish with a bony skeleton (e.g., Carp, Trout).
2. **Cartilaginous Fish** (*Class Chondrichthyes*): Fish with a cartilaginous skeleton (e.g., Sharks, Rays).

1.4 Economic Importance of Fish

Fish have significant economic importance globally, contributing to various industries and sectors. Here are key aspects of their economic value:

1. **Food Security and Nutrition**
   - **Source of Protein:** Fish is a rich source of high-quality protein, essential for human nutrition. It is particularly important in regions where other protein sources are limited or expensive.
   - **Essential Nutrients:** Fish provides essential nutrients like omega-3 fatty acids, vitamins (A, D, B12), minerals (zinc, iodine), and amino acids that are crucial for human health.
   - **Global Consumption:** Fish is a staple food in many coastal and inland regions, with millions of people relying on it as their primary source of animal protein.

2. **Commercial Fisheries**
   - **Employment:** The fishing industry provides livelihood for millions of people worldwide, including those involved in catching, processing, marketing, and distribution.
   - **Fishing Fleet:** Commercial fishing fleets are a significant part of the global economy, especially in countries with large coastal areas like China, Japan, and Norway.
   - **Economic Contributions:** In many countries, the fishing industry generates substantial revenue through the sale of fish and seafood products, both domestically and internationally.

3. **Aquaculture (Fish Farming)**

- **Growing Industry:** Aquaculture, or fish farming, is one of the fastest-growing sectors of global food production. It provides a controlled, sustainable way to produce fish for food, especially in regions where wild fish stocks are declining.
- **Global Market**: Countries like China, India, and Norway are major players in the aquaculture industry, producing large quantities of farmed fish such as tilapia, salmon, and catfish.
- **Sustainability and Supply**: Aquaculture helps meet the increasing global demand for seafood, reducing pressure on wild fish populations.

4. **Trade and Export**

- **International Trade:** Fish and seafood are major export commodities for many countries. Nations like Thailand, Vietnam, and Ecuador export large quantities of fish and shellfish to global markets, contributing significantly to their economies.
- **Global Supply Chains:** Fish is a valuable export product that supports global trade and economic ties between countries. This is particularly evident in the trade of high-value species such as tuna, shrimp, and salmon.

5. **Tourism and Recreation**

- **Fishing Tourism:** Many countries rely on recreational fishing as a tourism attraction, which boosts local economies. Popular fishing destinations, such as the Great Barrier Reef or Alaska, attract anglers from around the world.
- **Eco-Tourism:** In addition to fishing, marine ecosystems that support fish populations are integral to eco-tourism. Coral reefs, for instance, draw visitors for snorkeling and diving, creating economic benefits for coastal communities.

6. **By-products and Other Uses**

- **Fish Products:** Fish by-products, such as fishmeal and fish oil, are used in the feed industry (both for animals and aquaculture), pharmaceuticals, and cosmetics.
- **Non-food Products:** Fish skins, bones, and other by-products are used in the production of leather goods, gelatin, and fertilizers, contributing to diverse industries.

7. **Cultural and Social Value**

- **Cultural Significance**: Fish are an integral part of the culture and traditions of many coastal and island communities, supporting local economies through festivals, cuisine, and artisanal fishing practices.

Sustainable Livelihoods: For many small-scale fishers, fishing represents not just an economic activity but also a cultural identity, often linked to local traditions and community life.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following is the major benefit of fish farming?
   a. Soil conservation
   b. Protein source
   c. Greenhouse gas emissions
   d. Tourism

2. Which fish species is widely farmed in Nepal's cold-water regions?
   a. Rohu
   b. Trout
   c. Catla
   d. Mackerel

3. Integrated farming involves fish farming combined with.....
   a. Livestock
   b. Crops
   c. Both A and B
   d. None of the above

4. When did systematic fish farming begin in Nepal?
   a. 1920s
   b. 1940s
   c. 1950s
   d. 1980s

5. Which of the following fish species is the most commonly farmed in Nepal's warm waters?
   a. Trout
   b. Rohu
   c. Salmon
   d. Mackerel

6. Which region of Nepal is the most suitable for trout farming?
   a. Terai
   b. Mid-hills
   c. High Himalayas
   d. Kathmandu Valley

7. Which of the following is an integrated fish farming method commonly practiced in Nepal?
   a. Fish-duck farming
   b. Fish-rice farming
   c. Fish-livestock farming
   d. All of the above

8. What is the main source of water for fish farming in Nepal?

a. Rainwater harvesting
b. Rivers and lakes
c. Underground wells
d. Desalinated seawater

9. Which government institution primarily supports aquaculture in Nepal?

a. Department of Livestock Services
b. Department of Agriculture
c. Ministry of Tourism
d. Nepal Fisheries Council

10. What is the major challenge faced by fish farmers in Nepal?

a. Water scarcity
b. Lack of technical knowledge
c. High fish mortality
d. All of the above

Write short answer to the following questions.

1. Write in short about history of fish farming in Nepal.
2. Discuss the importance and scope of fish farming in Nepal.
3. Classify fish.

Write long answer to the following questions.

1. Describe the economic importance of fish in detail.

Project Work

1. Make a chart showing zoological classification of the fish.

Fish Biodiversity in Nepal

Unit 2

2.1 Indigenous Fish Species and Their Identification

Nepal is home of a diverse range of indigenous fish species, many of which are found in its rivers, lakes, and wetlands, especially in the Himalayan region. These fish species are important for local ecosystems, cultures, and the economy, particularly for fisheries and aquaculture. Here is an overview of some notable indigenous fish of Nepal and their identification:

Table 1: Indigenous fish species of Nepal & their present status

S.N	Scientific name	Local Name	Status
1	*Labeo rohita*	Rohu	Well established, warm water fish
2.	*Cirrhinus mrigla*	Naini	Well established, warm water fish
3.	*Catla catla*	Bhakur	Well established, warm water fish
4.	*Tor tor*	Sahar	Confined to research station, cool water
5.	*Nelissocheilus hexagonolepis*	Katle	Confined to research station, cool water
6.	*Labeo dyocheilus*	Gardi	Not in culture
7.	*Tor putitora*	Mahaseer	Culture in limited scale, cool water

1. Rohu: Labeo Rohita

Rohu is considered as tastier fish species among the cultivated carps in Nepal. It is characterized by an elongated and cylindrical body; the body colour is dull reddish on the sides and whitish on belly. The big fish attains to 2' - 3' in length. Head is small than its body size and other characteristic are as follows:

— Sub-terminal mouth parts and pair of maxillary barbells, the lips are thick and fringed

— Column feeder, herbivorous in feeding nature. The fish feed on small plants and decomposed materials of the pond and grows to a large size.

— It attains size of 900 gm at first year and up to 30 kg at maturity.

— Sexual maturity is attained towards the end of the second year.

— Rohu is seasonal breeder and artificial breeding is done by hypophysation. The breeding season is June to August when temperature is 25-30˚C.

Fig.1: Rohu (Labeo rohita)

2. Catla/Bhakur: *Catla Catla*

Catla is a fast growing fish among the indigenous cultivated carps. The barbells are absent and lips are non-fringed. Body colour is grayish to silvery on upper sides and whitish on belly and other characteristic of Catla/Bhakur are as follows:

— Fast growing fish, deep laterally compressed body with massive head.

— Large upturn mouth.

— It is surface Zooplankton feeder but young ones feed both zooplankton and phytoplankton.

— It attains 1-1.5 kg at first year over 1.5 m length and size up to 45 kg.

— Catle is seasonal breeder and artificial breeding is done by hypophysation.

The season of breeding is June to August when the temperature is 25-30˚C.

Fig.2: Catla/Bhakur(Catla catla)

*Source**:** www.google.com.np/search?q=Catla*

3. Mrigal/Naini: *Cirrhinus Mrigal*

Among indigenous fish species, mrigal is next in importance to Rohu and Catla for culture. This fish is characterized by elongated and cylindrical body and other important characteristics of the Mrigal/Naini are as follows:

— Small head and sub-terminal mouth one pairs of small barbells are present.

— Thin non fringed lips,

— Upper jaw is longer than lower jaw.

— Marginal and bottom feeder, omnivorous in nature and feeds on detritus mud organisms, decaying plant and animal matter however young ones feed on zooplankton.

— Largest size attains up to 90 cm and 30 kg .time maturity and breeding behaviour is similar to Rohu and Catla

Fig.3: Naini (Cirrhinus mrigal)

2.2 Exotic Fish Species and Their Identification

Exotic fish species are those species that were native to any other place or region, but have been introduced or imported into a new place. An exotic fish is a species that didn't originate in thath place. It was brought from a foreign place, region or country for culturing.

The exotic and indigenous fish species of Nepal and their present status is given below in the table:

Table 2: Exotic fish species of Nepal & their present status

S.N.	Scientific Name	Common Name	Status
1.	*Cyprinus carpio* *-Var communis* *-Var specularis*	Common carp German carp/ Scale carp Mirror carp/ Isreali carp	Well established in warm water culture
2.	*Ctenopharyngodon idella*	Grass carp	Well established in warm water culture
3.	*Hypophthalmichthys molitrix*	silver carp	Well established in warm water culture
4.	*Aristichthys nobilis*	Bighead carp	Well established in warm water culture
5.	*Oreochromis niloticus*	Nile Tilapia	Culture in limited scale (warm water)
6.	*Oreochromis mossamibcus*	Tilapia	unauthorized introduction by farmers (Warm water)
7.	*Pontius gonionotus*	Silver barb(Tawes)	Confined to government farm (Warm water)
8.	*Carassius carassius*	Gold fish	Decorative use

9.	*Clarias gariepinus*	African catfish	Culture in limited scale by farmer, warm water fish.
10.	*Oncorhynchus mykiss*	Rainbow trout	Well established in cold water.
11.	*Pangasius hypopsthalmus*	Pangasius/Pangas catfish	Culture in limited scale by farmer, warm water fish.
12.	*Macrobrachium rosenbergii*	Fresh water prawn	Confind to research station.

1. Common carp: *Cyprinus Carpio*

Common carp is the most important cultivated fish in the world. Common carp was introduced in Nepal in 1956 and 1960 from India and Israel respectively. There are lots of morphological variations through artificial breeding and natural selection of this species. The general characteristic of the Common carp are as follows:

Under this species, two varieties are available i.e. German carp (*Cyprinus carpio var communis*) and Israeli carp (*Cyprinus carpio var* specularis)

— Flat and deep body, small and short head

— Protractile mouth two pairs of maxillary barbells.

— Dorsal fins is long with a sharp spine

— It is a bottom feeder, omnivorous and feeds on insect larvae, worms, molluscs, and detritus, fresh and decayed vegetation and accepts formulated feed too.

— It attains 1-2 kg sizes in first year. It is found up to 18 kg in natural water bodies.

— It attains sexual maturity after 1-2 year.

— Common carp is a multiple breeder and can breed up to 5 times a year

— It can breed naturally on stagnant water but semi natural breeding is carried

from Falgun to Baisakh.

— It is bottom feeder fish that feed on detritus, mud and organic matter.

— Two types of common carp are found in Nepal. They are;

a) Scale carp/German (Cyprinus carpio var. communis)

b) Mirror carp/Israeli carp (Cyprinus carpio var. specularis)

Fig. 4: Scale carp/German (Cyprinus carpio var. communis)

Fig. 5 : Mirror carp/Israeli carp (Cyprinus carpio var. specularis)

2. Grass Carp: *Ctenopharyngodon Idella*

Grass carps are exotic fish which was introduced in Nepal from India and Japan in 1967 and 1968 respectively. The grass carp is one of the largest members of the minnow family. The body is oblong with moderately large scales, while the head has no scales. There are three simple and seven branched rays on the dorsal fin. Grass carps are silvery to olive in color, lacking the golden hue of common carp, and they have no barbells.

— This is warm water fish, thus require water temperature about 22 to 27^0c for successful culture.

— Elongated and cylindrical with large greenish scale.

— It has tooth less mouth but has specialized pharyngeal teeth for grasping aquatic vegetation.

— Mouth is sub-terminal with upper jaw slightly longer then lower jaw.

— Gill rakers are short & sparse.

— Grass carp is a column/marginal feeder, Feed aquatic vegetation, column and marginal feeder, herbivorous in feeding habit.

— Fry of grass carp feeds on protozoa, rotifers, Nauplius larvae & minute aquatic plants.

— Grass Carp is a voracious feeder and can consume 50 to 60% weight of grass per day of its body weight.

— Digestion of grass carp is incomplete and about half of the food material ingested is excreted as feces.

— It is said to be biological weed controller fish.

— It grows 1-2 kg in first year and up to 50 kg at maturity.

— After 2-3 year, it takes sexual maturity for breeding. Artificial breeding is carried out in the month of Jestha – Ashad.

Fig.6: Grass Carp (Ctenopharyngodon idella)

3. Silver Carp: Hypophthalmichthys Molitrix

It is an exotic fish introduced in Nepal from India and Japan in 1967 and 1968 respectively. The general descriptions of silver carp are as follows;

— It is warm fish which grow best on 22 to 28^{o} c temperature.

— It is surface feeder.

— It is phytoplankton feeder but young fry feed on zooplanktons.

— Laterally compressed body covered by small silvery scale

— Small head, barbells absents

— Mouth upturned with lower jaw longer then upper jaw

— It attains 1-2 kg at the first year and the largest size found up to 40-50 kg.

— It takes sexual maturity in 2-3 year of rearing & artificial breeding is done in controlled environment.

— It is highly sensitive fish during handling period. Improper handling leads to high mortality rate in this fish.

Fig.7: silver carp (Hypophthalmichthys molitrix)

4. Bighead Carp: Aristichthys Nobilis

This is exotic fish introduced to Nepal from America and Hungary in 1969 and 1972, respectively. The general characteristics of the bighead carp are as follows;

— Flat body, laterally compressed and covered by small silvery scales brownish above

— Head long and massive head barbells absents

— Large mouth, upturn with lower jaw longer than upper jaw and the abdominal keel is incomplete.

— The posterior margin of the pectoral fin extends beyond the base of the pelvic fin

— Surface feeder, feed Zooplankton but larvae mainly feed on unicellular phytoplankton, rotifers and nauplii.

— It grows 1-2 kg first year up to 40 -50 kg, maturity 2-3 year

— Artificial breeding is done by hypophysation. The breeding season is May to

— July when the temperature is 24-28^{o}c

— It is a docile and hardy fish for transportation and handling.

Fig. 8: Bighead carp (Aristichthys nobilis)

5. Nile tilapia: Orechromis Niloticus

Nile tilapia is native to most major northern and central African river systems and has been distributed widely throughout the world. This fish was introduced in Nepal from Thailand in 1985. This fish is characterized by,

- The presence of long spiny dorsal fin interrupted lateral line.
- The presence of distinct black stripes on the body and tails
- Presence of long spine dorsal fins interrupted lateral line and presence of distinct black strips on body and tails
- Phytoplankton feeder but also feed on insects.

Fig.9: Nile Tilapia (Orechromis niloticus)

6. Rainbow Trout: *Oncorhynchus mykiss*

The rainbow trout is a high-valued cold water fish and is a member of salmon family. It is native to the USA, but is now farmed globally. It was introduced to Nepal in 1998 from Japan. General description of rainbow trout is as follow:

— Body is elongated and laterally compressed with rounded snout. The upper side of the head is blue-green, yellow-green or almost brown.

— The sides are silvery and marked with a bright pink blush to red band and many small black spots.

— Rainbow trout is highly carnivorous and a predator with a varied diet. It feeds on animal matter like insects, mollusks, fish eggs and small fishes etc.

— It needs high protein content feed for culture.

— It attains 200-300g in the first year.

— It is a seasonal breeder matured in 3-4 years and artificial breeding is done by hypophysation. The breeding season is November to January when the temperature is 9 - 12 degree centrigate.

Fig.10: Rainbow Trout (oncorhynchus mykiss)

2.3 External Body Parts of Fish with Function of Each Parts

1. Head

Mouth: Used for feeding and, in some species, for sucking or filtering food.

Nostrils (Nares): Detects odors in the water; important for finding food and sensing the environment.

Eyes: Enables vision underwater; adapted for detecting movement and light.

Operculum (Gill Cover): Protects the gills and assists in respiration by regulating water flow over the gills.

2. Body

Scales: Protects the fish's body from physical damage and parasites; provides a streamlined surface.

Lateral Line: A sensory organ that detects vibrations, water currents, and movement in the surrounding environment.

Skin: Often contains mucous glands that reduce friction in water and provide protection against infections.

3. Fins

Dorsal Fin: Located on the back, it provides stability and prevents rolling during swimming.

Caudal Fin (Tail Fin): Generates thrust and propels the fish forward.

Anal Fin: Provides stability and prevents rolling, similar to the dorsal fin.

Pectoral Fins: Located on either side of the body, these fins aid in steering, balance, and slow swimming.

Pelvic Fins: Found on the ventral side, they assist in balance, turning, and braking.

Adipose Fin (in some species): A small, fleshy fin located between the dorsal and caudal fins; its function is not well-defined but may play a role in stability.

4. Tail (Caudal Peduncle): Connects the main body to the caudal fin and

provides a base for the tail's powerful swimming motion.

5. **Gills:** Located under the operculum, these organs extract oxygen from water and expel carbon dioxide.
6. **Anus (Vent):** The opening through which waste is excreted and, in some species, through which eggs or sperm are released.
7. **Barbels (in some species):** Whisker-like structures near the mouth that are rich in taste buds, used to locate food, especially in murky waters.

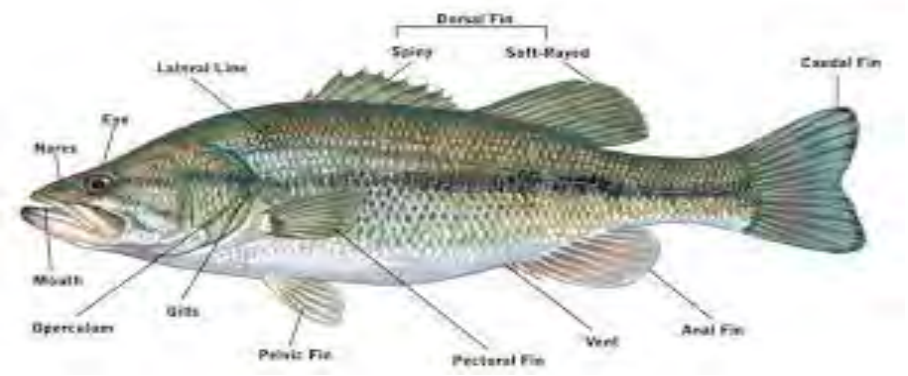


Fig : External body parts of a fish

2.4 Type of Fish Kept in Aquarium

Aquarium fish are fish species that are kept in tanks or aquariums for decoration, enjoyment, or as a hobby due to their colourful appearance, unique patterns, and interesting behaviors.

Common Aquarium Fish in Nepal

Here are some common ornamental fish kept in aquariums in Nepal:

1. **Goldfish (Carassius auratus)**
   - Popular due to their bright orange, red, and white colors.
   - Easy to maintain and suitable for beginners.
2. **Guppy (Poecilia reticulata)**
   - Known for their vibrant colors and flowing tails.
   - Hardy and prolific breeders.

3. **Betta (Betta splendens)**
   - Also known as Siamese fighting fish.
   - Known for their vivid colors and aggressive nature (especially males).

4. **Angelfish (Pterophyllum scalare)**
   - Valued for their elegant shape and striped or spotted patterns.
   - Peaceful and thrive in community aquariums.

5. **Tetra (e.g., Neon Tetra, Paracheirodon innesi)**
   - Small, brightly colored fish with shimmering blue and red stripes.
   - Popular for community tanks due to their peaceful nature.

6. **Mollies (Poecilia sphenops)**
   - Hardy fish with various colour varieties such as black, silver, and orange.
   - Thrive in both fresh and brackish water.

7. **Zebra Danio (Danio rerio)**
   - Striped patterns resembling zebra lines.
   - Active and schooling fish, ideal for beginners.

8. **Koi Carp (Cyprinus carpio)**
   - Though primarily kept in outdoor ponds, smaller varieties are also kept in aquariums.
   - Valued for their long lifespan and cultural significance.

2.5 Integrated Fish Farming (Fish cum livestock) and its Importance

Integrated fish farming is a sustainable farming practice that combines aquaculture (fish farming) with livestock or agricultural activities. It maximizes resource use efficiency by recycling waste products from one system as inputs for another, creating a synergistic relationship between fish, livestock, and crops.

Components of Fish-Cum-Livestock Farming

1. **Fish Farming:** Raising fish in ponds or tanks as the primary activity.
2. **Livestock Integration**
    - **Poultry (e.g., ducks, chickens):** Waste and droppings act as organic fertilizer for pond water, promoting plankton growth for fish feed.
    - **Cattle or Buffaloes:** Manure is used to fertilize the pond, enhancing natural fish food production.
    - **Pigs:** Pig waste is a nutrient-rich organic fertilizer for fish ponds.
3. **Crop Production (optional): Water from fish ponds can irrigate and fertilize crops.**

Importance of Integrated Fish Farming

1. **Efficient Resource Utilization**
    - Converts livestock waste into nutrients for fish pond productivity.
    - Reduces reliance on chemical fertilizers and external fish feed.
2. **Cost-Effectiveness**
    - Lowers production costs by utilizing by-products and waste as resources.
    - Produces multiple outputs (fish, livestock, and crop) on the same piece of land.
3. **Sustainability**
    - Promotes eco-friendly practices by recycling waste and reducing environmental pollution.
    - Minimizes carbon footprint compared to standalone farming systems.
4. **Increased Productivity**
    - Enhances fish production by improving the pond's natural food supply through organic fertilization.
    - Provides diversified income sources (fish, meat, eggs, crops).

5. **Income Generation and Employment**
   - Ensures year-round income from multiple farm products.
   - Creates jobs in rural areas, especially for smallholder farmers.

6. **Food Security**
   - Produces a variety of nutritious food (fish, meat, eggs, and crops) to meet family and market demands.

7. **Resilience to Market Risks**
   - Diversification reduces dependence on a single product, protecting farmers from price volatility.

Common Integrated Fish Farming Models

1. **Fish-Cum-Duck Farming:** Ducks swim in the pond, aerating the water and feeding on aquatic weeds, while their droppings fertilize the pond.

2. **Fish-Cum-Pig Farming:** Pig sheds are built near ponds to allow easy waste collection, which serves as pond fertilizer.

3. **Fish-Cum-Cattle Farming:** Manure from cattle sheds is applied to fish ponds.

4. **Fish-Cum-Rice Farming:** Water from fish ponds irrigates rice fields, while rice paddies act as fish habitats during the growing season.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following is an indigenous fish species found in Nepal?
   a. Sahar (Tor putitora)
   b. Tilapia
   c. Common carp (Cyprinus carpio)
   d. Grass carp (Ctenopharyngodon idella)

2. Indigenous fish species in Nepal are commonly found in.....
   a. Marine waters
   b. Cold-water rivers and lakes
   c. Brackish water systems
   d. Artificial fish ponds

3. Which of the following is NOT an indigenous fish species in Nepal?
   a. Asla (Schizothorax spp.)
   b. Katle (Neolissocheilus hexagonolepis)
   c. Silver carp (Hypophthalmichthys molitrix)
   d. Buduna (Labeo dero)

4. Which of the following is an exotic fish species introduced in Nepal?
   a. Sahar (Tor putitora)
   b. Silver carp (Hypophthalmichthys molitrix)
   c. Katle (Neolissocheilus hexagonolepis)
   d. Buduna (Labeo dero)

5. Exotic fish species are introduced in Nepal primarily for.....
   a. Ornamental purposes
   b. Increasing fish production in aquaculture
   c. Preserving biodiversity
   d. Recreational fishing

6. Which of the following exotic fish species is commonly used for controlling aquatic weeds in Nepal?

   a. Tilapia (Oreochromis spp.)

   b. Grass carp (Ctenopharyngodon idella)

   c. Rohu (Labeo rohita)

   d. Common carp (Cyprinus carpio)

7. Which of these exotic fish species has been introduced in Nepal as a fast-growing species for aquaculture?

   a. Rohu (Labeo rohita)

   b. Tilapia (Oreochromis spp.)

   c. Katle (Neolissocheilus hexagonolepis)

   d. Asla (Schizothorax spp.)

8. What is the primary function of the lateral line in a fish?

   a Locomotion

   b. Sensing vibrations and water movement

   c. Breathing

   d. Protecting the gills

9. Which external body part of a fish is responsible for propulsion?

   a. Pectoral fin b. Caudal fin

   c. Dorsal fin d. Anal fin

10. What is the main role of the operculum in fish?

    a. Protecting and aiding gill function for breathing

    b. Steering the fish while swimming

    c. Helping in reproduction

    d. Absorbing nutrients

11. The pectoral fins in fish are primarily used for .....

a. Balance and maneuvering
b. Digestion
c. Propulsion
d. Protection

12. The anal fin in fish is located .....

a. Near the head
b. On the ventral side, behind the anus
c. At the tail
d. On the dorsal side

13. What is the primary function of the scales in fish?

a. Locomotion
b. Protection against predators and environmental damage
c. Reproduction
d. Absorbing oxygen from water

14. What is the function of the gills in fish?

a. To detect water currents
b. To help in reproduction
c. To extract oxygen from water and remove carbon dioxide
d. To filter food particles

15. Integrated fish farming in Nepal combines fish farming with.....

a. Livestock and crop farming
b. Mining activities
c. Industrial production
d. Urban gardening

16. Which of the following is a major benefit of integrated fish farming in Nepal?

a. High dependency on chemical fertilizers
b. Efficient use of resources and waste recycling
c. Elimination of all fish diseases
d. Reduced biodiversity in the system

17. In integrated fish farming in Nepal, duck farming is combined with fish farming because .....

    a. Ducks eat aquatic weeds and fertilize the water with their droppings

    b. Ducks protect the fish from predators

    c. Ducks consume fish feed, reducing feed waste

    d. Ducks increase the oxygen level in the water

18. Which of the following is NOT a component of integrated fish farming in Nepal?

    a. Paddy cultivation with fish farming

    b. Vegetable farming with aquaponics

    c. Monoculture of exotic fish species

    d. Livestock waste being used as fish pond fertilizer

Write short answer to the following questions.

1. List the indigenous species of fish in Nepal and explain any two of them.
2. List the indigenous species of fish in Nepal and explain any two of them.
3. Describe the external body parts of fish with their function.
4. Define integrated fish farming. Write any five examples of aquarium fish.

Write long answer to the following questions.

1. Describe the indigenous fish species of Nepal with their characters.
2. Describe the exotic fish species of Nepal with their characters.
3. Explain the integrated fish farming with examples and write the advantages of integrated fish farming.

Project Work

1. Visit nearby fish farm and learn general characterstic of indigenous and exotic fish species.

Unit 3

Different Types of Fish Ponds, its Construction and Management

3.1 Pond Survey and Layout Plan

A pond survey and a layout plan are crucial steps in establishing an efficient fish farming system. These processes ensure that the pond is designed to optimize water use, fish productivity, and maintenance while minimizing environmental impacts.

1. Pond Survey

A pond survey involves assessing the physical, topographical, and hydrological conditions of the site to determine its suitability for fish farming.

Steps in Pond Survey

1. **Site Selection**
   - Choose a site with clay or loamy soil to prevent seepage.
   - Ensure a reliable water source (river, canal, or groundwater).
   - The site should be located in a low-lying area to allow gravity flow of water.
2. **Topographical Survey**
   - Measure slope and elevation to facilitate proper drainage and water management.
   - Identify the direction of natural water flow.
3. **Soil Analysis**
   - Test soil for permeability and pH (optimal pH: 6.5–8.5).
   - Ensure the soil has enough clay content to retain water.

4. **Water Quality Assessment**
    - Test the water for pH, temperature, dissolved oxygen, and chemical contaminants.

5. **Climatic Assessment**
    - Analyze temperature, rainfall, and wind direction, as they affect fish growth and pond management.

2. Pond Layout Plan

The layout plan is a blueprint for constructing the pond and related infrastructure. It ensures efficient water flow, easy management, and integration with other farm components.

Key Components of a Pond Layout Plan

1. **Pond Design**
    - **Shape**: Rectangular ponds are preferred for ease of management and harvesting.
    - **Size**: Depends on the type of fish farming (e.g., nursery pond: 0.01–0.05 ha; grow-out pond: 0.1–1 ha).
    - **Depth**: Ideal depth is 1.5–2.5 meters.

2. **Water Inlet and Outlet**
    - **Inlet**: Located at the highest point to allow gravity-fed water flow.
    - **Outlet**: Positioned at the lowest point for easy drainage and water renewal.

3. **Dikes and Embankments**
    - Construct sturdy embankments to prevent seepage and erosion.
    - Embankments should have a gentle slope (2:1 or 3:1) to facilitate stability and maintenance.

4. **Partitioning**
    - Divide the pond into different sections for nursery, rearing, and grow-out stages if needed.
    - Use screens or nets to separate fish of different sizes.
5. **Drainage System**
    - Design proper drainage to allow complete drying of the pond during maintenance.
    - Include sluice gates or pipes for water control.
6. **Access Roads**
    - Build roads for easy transportation of feed, fish, and equipment.
7. **Support Facilities**
    - Include areas for feed storage, hatcheries, and equipment storage.
    - Provide shaded areas or floating platforms for fish to avoid direct sunlight.

Best Practices

- Use a contour map to visualize the site's topography and water flow patterns.
- Ensure the layout allows for efficient water use and minimizing waste.
- Maintain a buffer zone with vegetation around the pond to prevent erosion and filter runoff.
- Plan for **aeration systems** to ensure sufficient oxygen levels.

Importance of Pond Survey and Layout Plan

1. **Maximizes Productivity:** Ensures proper water management and healthy fish growth.
2. **Minimizes Costs:** Avoids costly mistakes in pond construction and maintenance.
3. **Environmental Sustainability:** Reduces water wastage and soil erosion.

4. **Facilitates Maintenance:** Well-planned ponds are easier to manage and clean.
5. **Enhances Profitability:** Optimized pond design improves yields and reduces resource wastage.

3.2 Appropriate Land for Fish Culture

Choosing the right land for fish culture is essential to ensure optimal productivity, cost-efficiency, and sustainability. Here are the key factors to consider:

1. **Soil Characteristics**
   - **Clayey or Loamy Soil:** Ideal for pond construction as it holds water well and minimizes seepage.
   - **Permeability:** Soil should have low permeability to reduce water loss.
   - **pH Range:** Soil with a pH of 6.5–8.5 is preferred for maintaining a healthy pond ecosystem.
   - **Organic Content:** Moderate organic matter is beneficial for natural fish food production.
   - **Testing:** Perform a soil test to ensure suitability.
2. **Topography**
   - **Low-Lying Areas:** Natural depressions are ideal as they reduce construction costs and ensure easy water retention.
   - **Gentle Slope:** Facilitates proper drainage and water flow.
   - **Flood-Free Zones:** The land should not be prone to flooding to prevent fish escape and pond damage.
3. **Water Availability**
   - **Reliable Water Source:** A consistent and clean water supply is crucial, such as from rivers, canals, reservoirs, or groundwater.
   - **Water Quality**
   - **pH:** 6.5–8.5 for freshwater fish.
   - **Dissolved Oxygen:** At least 5 ppm for healthy fish growth.

- Free from pollutants like pesticides, industrial waste, and heavy metals.
- **Water Volume:** Adequate to maintain desired pond depth (1.5–2.5 meters).

4. Accessibility

- **Proximity to Markets:** Land near markets reduces transportation costs for fish and feed.
- **Road Connectivity:** Easy access for transporting equipment, feed, and fish.
- **Electricity Supply:** Availability of power for pumps, aerators, and other machinery.

5. Climatic Conditions

- **Temperature:** Suitable for the type of fish being cultured (e.g., warm-water species thrive in 25–30°C).
- **Rainfall:** Moderate rainfall is ideal to replenish pond water but avoid excessive rainfall areas prone to flooding.
- **Wind Direction:** Consider wind patterns for aeration and water flow.

6. Land Size and Shape

- **Size:** The land should be large enough to accommodate desired pond sizes (e.g., nursery, grow-out ponds).
- **Shape:** Prefer rectangular or square-shaped areas for ease of construction and water management.

7. Drainage System

- **Proper Drainage:** Land should allow easy water inflow and outflow without causing erosion.
- **Sluice Gates:** The include in the design to control water levels effectively.

8. Environmental Sustainability

- **Ecosystem Balance:** Select land that avoids excessive deforestation or destruction of natural habitats.
- **Buffer Zones:** Maintain vegetative buffer zones around the pond to filter runoff and prevent pollution.

9. Cost Considerations

- **Affordable Land:** Choose land within your budget but ensure it meets technical requirements.
- **Ease of Construction:** Select land that minimizes the need for extensive earthwork or leveling.

Unsuitable Land for Fish Culture

- Sandy or gravelly soils with high permeability.
- Land prone to seasonal flooding or waterlogging.
- Regions with poor-quality or contaminated water sources.
- Areas with steep slopes or irregular terrain requiring extensive modification.

3.3 Types of Pond used in Aqua Culture

In aquaculture, ponds are critical for creating controlled environments for the growth and cultivation of aquatic organisms. Different types of ponds are used depending on the species being cultured, farming system, and production goals.

1. On the basis of Purpose

a. Nursery Pond

- **Purpose:** Used for raising fish fry (young fish) to fingerling size (juvenile stage).
- **Size:** Small, usually 0.01–0.05 hectares.
- **Depth:** 0.5–1.0 meter.
- **Key Features**
  - Well-prepared and fertilized to ensure plankton growth for fish fry.
  - Regular monitoring and protection from predators.

b. Rearing Pond

- **Purpose:** Used for growing fingerlings to a suitable size for stocking in grow-out ponds.
- **Size:** Medium, typically 0.05–0.2 hectares.
- **Depth:** 1–1.5 meters.
- **Key Features**
  - Transitional pond between nursery and grow-out ponds.
  - Requires good feed and water quality management.

c. Grow-Out Pond

- **Purpose:** Used for raising fish to marketable size.
- **Size:** Large, ranging from 0.1 to several hectares.
- **Depth:** 1.5–2.5 meters.
- **Key Features**
  - Designed for maximum production.
  - Requires aeration, feeding, and water quality management.

d. Breeding Pond

- **Purpose:** Used for fish spawning and breeding.
- **Size:** Small to medium, typically 0.02–0.1 hectares.
- **Depth:** 1.0–1.5 meters.
- **Key Features**
  - Suitable for inducing natural or artificial breeding.
  - Ensures protection of broodstock (mature fish used for breeding).

e. Quarantine Pond

- **Purpose:** Used for isolating newly acquired fish or sick fish to prevent the spread of diseases.
- **Key Features**

- Short-term use.
- Easy drainage and disinfection.

2. On the basis of Farming System

a. Monoculture Pond

- **Purpose**: Used to culture a single species of fish.
- **Advantages**: Easier management and feeding strategies.
- **Example**: Tilapia, Catfish, or Carp ponds.

b. Polyculture Pond

- **Purpose**: Used to culture multiple species in the same pond to utilize different ecological niches.
- **Advantages**: Better resource utilization and higher productivity.
- **Example**: Carp polyculture with surface-feeding, mid-water-feeding, and bottom-feeding species.

3. On the basis of Water Flow

a. Static Pond

- **Purpose**: Maintains water with minimal exchange, relying on natural or mechanical aeration.
- **Advantages**: Cost-effective, commonly used for freshwater fish farming.
- **Challenges**: Requires regular monitoring to prevent water quality degradation.

b. Flow-Through Pond

- **Purpose**: Maintains a continuous flow of fresh water to keep water quality high.
- **Advantages**: Suitable for species needing high oxygen levels.
- **Challenges**: Requires a reliable water source and high water availability.

c. Recirculating Pond

- **Purpose**: Water is treated and reused within the system.
- **Advantages**: Eco-friendly and minimizes water use.
- **Challenges**: High setup and maintenance costs.

4. On the basis of Pond Construction

a. Earthen Pond

- **Description**: Made by digging into the ground and utilizing natural soil.
- **Advantages**: Cost-effective and promotes natural food production.
- **Challenges**: Prone to seepage and requires regular maintenance.

b. Concrete Pond

- **Description**: Built with concrete for better durability and water control.
- **Advantages**: Ideal for intensive farming systems and disease control.
- **Challenges**: Higher construction costs.

c. Lined Pond

- **Description**: Constructed with plastic, rubber, or HDPE liners to prevent seepage.
- **Advantages**: Better water retention and suitable for areas with poor soil quality.
- **Challenges**: High installation costs and potential damage to liners.

3.4 Preparation and Management of Fish Ponds

Proper preparation and effective management of fish ponds are essential for successful aquaculture. This ensures optimal fish growth, good water quality, and sustainable production. Below are the key steps involved:

1. Pond Preparation

a. Drying the Pond

- **Purpose**: Eliminates unwanted organisms, pests, and pathogens.
- **Method**: Drain the pond completely and allow it to dry until the soil cracks (5–7 days, depending on weather).
- **If Drying is Not Possible**: Use chemicals like lime or rotenone to remove unwanted fish and pests.

b. Repair and Maintenance

- Check and repair embankments, inlet and outlet structures, and sluice gates to prevent leaks and ensure proper water flow.

c. Liming

- **Purpose**: Neutralizes soil acidity, improves soil quality, and promotes plankton growth.
- **Lime Application Rates**
  - **Acidic soil (pH < 6)**: 1,000–2,000 kg/ha.
  - **Neutral soil (pH 6–7)**: 500–1,000 kg/ha.
  - **Alkaline soil (pH > 7)**: No lime required.
- **Application**: Spread lime evenly over the pond bottom and embankments.

d. Fertilization

- **Purpose**: Promotes the growth of phytoplankton and zooplankton, which serve as natural fish food.
- **Types of Fertilizers**
  - **Organic**: Cow dung, poultry manure (2,000–5,000 kg/ha).
  - **Inorganic**: Urea (20–50 kg/ha) and superphosphate (10–25 kg/ha).
- Apply fertilizers evenly over the pond bottom.

e. Filling the Pond

- Fill the pond with water gradually to the desired depth (1.5–2.5 meters).
- Use a fine mesh screen on inlet pipes to prevent entry of predators or unwanted species.

2. Stocking Management

a. Selecting Fish Species

- Choose species based on pond type, climate, and market demand. Examples:
- **Monoculture**: Catfish, Tilapia, Carp.
- **Polyculture**: A combination of surface-feeding, mid-water-feeding, and bottom-feeding species (e.g., Indian Major Carps like Rohu, Catla, and Mrigal).

b. Stocking Density

- Maintain optimal stocking density to prevent overcrowding.
  - **Nursery ponds**: 50–100 fry/m².
  - **Grow-out ponds**: 3,000–10,000 fish/ha.

c. Acclimatization

- Gradually acclimate fish to pond water temperature and quality before releasing them.

3. Water Quality Management

a. Monitoring Parameters

- **Dissolved Oxygen (DO)**: Maintain above 5 ppm; use aerators if necessary.
- **pH**: Maintain between 6.5–8.5.
- **Temperature**: Ideal range depends on species (e.g., 25–30°C for tropical fish).
- **Ammonia**: Avoid high levels (>0.02 ppm); manage through regular

water exchange and proper feeding.

b. Water Exchange

- Replace 10–30% of water periodically to maintain quality and prevent waste accumulation.

c. Algae Control

- Avoid excessive fertilization that leads to algal blooms. Use shading or mechanical removal if needed.

4. Feeding Management

a. Natural Food

- Promote natural food production through fertilization and proper pond preparation.

b. Supplemental Feed

- Use formulated feeds with balanced nutrients.
- Feed quantity depends on fish size and age:
  - **Fry**: 6–8% of body weight/day.
  - **Fingerlings**: 4–6% of body weight/day.
  - **Adult fish**: 2–3% of body weight/day.

c. Feeding Schedule

- Feed twice daily (morning and evening) for optimal growth.

5. Disease Management

a. Preventive Measures

- Use disease-free fingerlings.
- Maintain water quality and avoid overstocking.
- Quarantine new fish before stocking.

b. Treatment

- Apply appropriate chemicals or antibiotics as recommended by

aquaculture experts in case of disease outbreaks.

6. Harvesting and Post-Harvest Management

a. Harvesting

- Use nets for partial or complete harvesting depending on fish size and market demand.
- Avoid stress during harvesting by handling fish carefully.

b. Post-Harvest

- Sort, clean, and grade fish before transport or storage.
- Use proper storage techniques (e.g., ice or refrigerated transport) to preserve freshness.

7. Record Keeping

Maintain records of:

- water quality parameters.
- stocking density and species.
- feed quantity and cost.
- harvested fish quantity and sales.

Importance of Pond Preparation and Management

1. **Increased Productivity**: Ensures optimal conditions for fish growth.
2. **Cost Efficiency**: Reduces the need for expensive interventions.
3. **Disease Prevention**: Maintains a healthy pond environment.
4. **Sustainability**: Promotes eco-friendly practices.

Exercise

Choose the correct answer from the given alternatives.

1. What is the primary purpose of a pond survey in aquaculture?
   a. To measure water temperature
   b. To assess land suitability for fish farming
   c. To test fish feed quality
   d. To monitor fish health

2. Which of the following is considered in a pond layout plan?
   a. Water inlet and outlet systems
   b. Location of feeding platforms
   c. Drainage and embankments
   d. All of the above

3. A well-designed fish pond layout should include .....
   a. A deep area for breeding
   b. Shallow edges for oxygenation
   c. Proper water flow and drainage systems
   d. Shade from tall trees

4. What type of soil is most suitable for fish pond construction?
   a. Sandy soil
   b. Rocky soil
   c. Clay or clay-loam soil
   d. Saline soil

5. The best location for fish culture is.....
   a. Low-lying areas with a reliable water source
   b. High-altitude regions with cold water
   c. Dry lands with no water availability
   d. Urban areas with limited land

6. Which of the following factors is crucial for selecting land for fish culture?

   a. Proximity to urban markets

   b. Soil permeability and water retention

   c. Distance from forested areas

   d. Availability of concrete structures

7. Which type of pond is commonly used for breeding fish?

   a. Nursery pond b. Stocking pond

   c. Rearing pond d. Harvest pond

8. A pond used for raising fish from fingerlings to market size is called .....

   a. Breeding pond b. Rearing pond

   c. Stocking pond d. Sedimentation pond

9. What is the primary purpose of a stocking pond in aquaculture?

   a. To store water for emergencies

   b. To grow fish until they reach harvest size

   c. To maintain broodstock for breeding

   d. To collect fish during harvest

10. A multipurpose pond used for fish culture and irrigation is referred to as...

    a. Monoculture pond b. Polyculture pond

    c. Integrated pond d. Irrigation pond

11. The first step in preparing a new fish pond is.....

    a. Fertilizing the pond

    b. Filling the pond with water

    c. Clearing vegetation and leveling the bottom

    d. Stocking the pond with fish

12. Liming of fish ponds is done to.....
    a. Reduce acidity and improve water quality
    b. Increase the oxygen content in water
    c. Attract more fish naturally
    d. Add nutrients to the water

13. What is the purpose of fertilizing a fish pond?
    a. To increase the pond's water retention capacity
    b. To promote the growth of natural food (plankton) for fish
    c. To disinfect the pond before stocking fish
    d. To control predators

14. Regular pond maintenance includes.....
    a. Monitoring water quality and pH levels
    b. Removing excess aquatic weeds
    c. Ensuring proper feeding schedules
    d. All of the above

15. Overpopulation of fish in a pond can result in.....
    a. Improved water quality
    b. Faster growth of fish
    c. Reduced oxygen levels and slower growth
    d. Increased disease resistance

Write short answer to the following questions.

1. Write in short about pond survey and layout plans.
2. How is fish pond prepared and managed?
3. Write the criteria for selecting appropriate land for fish culture.

Write long answer to the following questions.

1. Describe in detail about different types of fish pond.

Project Work

1. What are the factors to be considered while conducting pond survey and layout make a list of them.

Feed, Feeding and Water Quality for Fish Culture

Unit 4

4.1 Feeding Habit of Different Fishes

Fish have diverse feeding habits based on their natural habitat and dietary preferences. Here is a breakdown of the feeding habits of different fish:

1. **Herbivorous Fish**
   - **Diet:** Primarily consume plants, algae, and other plant-based materials.
   - **Examples:**
     - **Grass Carp (Ctenopharyngodon idella):** Feeds on aquatic weeds and algae.
     - **Tilapia (Oreochromis spp.):** Consumes plankton, algae, and vegetable matter.
2. **Carnivorous Fish**
   - **Diet:** Feed on other fish, insects, crustaceans, and meat-based foods.
   - **Examples:**
     - **Snakehead (Channa spp.):** Predatory fish that eat smaller fish and frogs.
     - **Sahar (Tor putitora):** Consumes small fish and aquatic invertebrates.
3. **Omnivorous Fish**
   - **Diet:** Consume both plant-based and animal-based food sources.
   - **Examples:**
     - **Common Carp (Cyprinus carpio):** Eats detritus, algae, small

invertebrates, and plant matter.

- **Catfish (Clarias spp.):** Feeds on plants, insects, small fish, and organic debris.

4. **Planktivorous Fish**
   - **Diet:** Feed mainly on plankton (microscopic plants and animals).
   - **Examples:**
     - **Silver Carp (Hypophthalmichthys molitrix):** Filters and feeds on phytoplankton and zooplankton.
     - **Indian Major Carps (Labeo rohita):** Juveniles are planktivorous before transitioning to other diets.

5. **Detritivorous Fish**
   - **Diet:** Feed on decomposed organic matter and detritus at the bottom of water bodies.
   - **Examples:**
     - **Mrigal Carp (Cirrhinus mrigala):** Consumes organic debris and bottom sediments.

6. **Filter Feeders**
   - **Diet:** Strain small organisms like plankton from water using specialized filtering structures.
   - **Examples:**
     - **Silver Carp (Hypophthalmichthys molitrix):** Filters plankton from water using gill rakers.

7. **Insectivorous Fish**
   - **Diet:** Feed on insects and their larvae.
   - **Examples:**
     - **Trout (Oncorhynchus spp.):** Eats aquatic insects and their larvae.

- **Killifish (Fundulus spp.):** Prefers small insects and insect larvae.

8. **Piscivorous Fish**
   - **Diet:** Specialized carnivores that feed primarily on other fish.
   - **Examples:**
     - **Pike (Esox spp.):** Feeds on smaller fish.
     - **Snakehead (Channa spp.):** Predatory fish that targets other fish species.

4.2 Feeding Requirement for Different Stages of Fish

Feeding requirements for fish vary across different stages of their life cycle due to changes in their nutritional needs and feeding habits. Here is an overview of feeding requirements at various stages of fish growth:

1. **Larval Stage**
   - **Characteristics**
     - Larvae have underdeveloped digestive systems and depend on easily digestible and nutrient-rich food.
   - **Feeding Requirements**
     - High protein and lipid content to support rapid growth.
     - Small-sized feed particles that are easily ingested.
     - Natural food like plankton, rotifers, and Artemia (brine shrimp).
   - **Feeding Frequency:** 6–8 times per day to match their continuous feeding behavior.

2. **Fry Stage (Juvenile fish after larvae stage)**
   - **Characteristics**
     - Developing digestive systems capable of handling more complex foods.
   - **Feeding Requirements**
     - Protein-rich diets for growth (40–50% protein).

- Small pellet feed or powdered feed.
- Natural food like zooplankton and finely ground feed supplements.

- **Feeding Frequency:** 4–6 times per day to maximize growth.

3. **Fingerling Stage (Intermediate size, ready for stocking in grow-out ponds)**
   - **Characteristics**
     - Well-developed digestive systems with increasing dietary flexibility.
   - **Feeding Requirements**
     - Balanced diet with 35–40% protein.
     - Crumble or small-sized pellets.
     - Incorporation of carbohydrates and vitamins for better immunity.
   - **Feeding Frequency:** 3–4 times per day.
4. **Grow-Out Stage (Fish raised to market size)**
   - **Characteristics**
     - Primary growth phase requiring maintenance and muscle building.
   - **Feeding Requirements**
     - Energy-rich diets with moderate protein (25–35%).
     - Pellet feeds or farm-made feed blends.
     - Occasional supplementation with natural food like aquatic plants for herbivorous fish.
   - **Feeding Frequency:** 2–3 times per day, depending on fish species and temperature.
5. **Broodstock Stage (Mature fish used for breeding)**
   - **Characteristics**
     - Nutritional needs focus on reproduction and gamete quality.

- **Feeding Requirements**
  - High protein (30–40%) and lipid diets to enhance reproductive success.
  - Supplementation with vitamins (especially Vitamin E) and minerals.
  - Natural foods like worms, insects, and aquatic plants for some species.
- **Feeding Frequency:** 1–2 times per day, with increased feeding before spawning.

4.3 Improved Fodder Grass Used in Feeding Fish

In aquaculture, improved fodder grasses are used to supplement fish diets, especially for herbivorous and omnivorous fish species. These grasses help provide necessary nutrients, promote better growth, and improve water quality by contributing organic matter. Here are some commonly used improved fodder grasses for fish feeding:

1. **Cynodon dactylon (Bermuda Grass)**
   - **Characteristics**
     - High in fiber, which helps improve digestion in herbivorous fish.
     - Grows quickly in tropical and subtropical climates.
     - Can be cultivated easily in ponds or around water bodies.
   - **Nutritional Value**
     - Provides a good source of carbohydrates and some protein.
     - Rich in minerals like calcium and phosphorus, essential for fish growth.
2. **Pennisetum Purpureum (Napier Grass or Elephant Grass)**
   - **Characteristics**
     - A highly productive grass that grows rapidly and can tolerate various climatic conditions.

- Often used as a forage crop for livestock, but can also be fed to fish.

- **Nutritional Value**
  - High in crude fiber and moderate in protein, making it suitable for feeding herbivorous fish.
  - Rich in vitamins and minerals, promoting healthy fish growth.

3. **Brachiaria spp. (Para Grass)**

- **Characteristics**
  - Tolerates wet conditions and is commonly grown in aquatic environments.
  - Often used for integrated fish farming systems, where livestock and fish farming are combined.

- **Nutritional Value**
  - Rich in protein and energy, it helps fish grow efficiently.
  - Contains fiber that aids in digestion.

4. **Leucaena Leucocephala (Leucaena or White Leadtree)**

- **Characteristics**
  - A leguminous tree that is used as fodder for both livestock and fish.
  - Leaves are rich in protein, making them highly suitable for herbivorous and omnivorous fish.

- **Nutritional Value**
  - High protein content (30–40%) and good fiber content.
  - It also provides essential amino acids, promoting faster growth in fish

5. **Azolla spp. (Azolla or Water Fern)**

- **Characteristics**
  - A floating aquatic fern that grows in waterlogged areas, especially

in fish ponds and rice fields.

- Used in aquaponics and integrated fish farming systems.

- **Nutritional Value**
  - Rich in proteins, vitamins, and minerals.
  - Contains about 25–35% protein and is an excellent feed for herbivorous fish and as a supplement for omnivorous species.

6. **Vigna unguiculata (Cowpea)**
   - **Characteristics**
     - A leguminous plant used for feeding both livestock and fish.
     - Easily grown in tropical regions and can be cultivated along the periphery of fish ponds.
   - **Nutritional Value**
     - High in protein and carbohydrates.
     - Promotes optimal growth and development in fish.
7. **Chloris Gayana (Rhodes Grass)**
   - **Characteristics**
     - A drought-resistant grass that thrives in a wide range of soil types.
     - Provides good forage for fish farming, especially in integrated farming systems.
   - **Nutritional Value**
     - High in fiber, contributing to the overall health and digestive efficiency of fish.
     - Moderate protein levels, beneficial for growth and maintenance.

4.4 Water Quality (Physical and chemical parameters)

Water quality is crucial for the health and growth of fish in aquaculture systems. It directly impacts fish metabolism, growth, reproduction, and disease resistance. Both physical and chemical parameters of water must be regularly monitored and maintained at optimal levels to ensure a healthy environment for fish.

Physical Parameters of Water in Fish Ponds

1. **Temperature**
   - **Importance:** Temperature influences fish metabolism, feeding, and growth rates.
   - **Ideal Range**
     - Most fish species thrive in water temperatures between 18°C to 30°C (64°F to 86°F), but the optimal range varies by species.
     - Coldwater fish (e.g., trout) require cooler water (10°C to 18°C), while warmwater species (e.g., tilapia) prefer higher temperatures (25°C to 30°C).
   - **Effects of Temperature**
     - Higher temperatures increase metabolic rates but can also lower dissolved oxygen levels.
     - Lower temperatures can reduce growth rates and immune function.
2. **Dissolved Oxygen (DO)**
   - **Importance:** Oxygen is vital for fish respiration and the decomposition of organic matter in the pond.
   - **Ideal Range:** 5-7 mg/L for most fish species.
   - **Effects of Low DO**
     - Low oxygen levels can stress fish, reduce feeding, and lead to fish kills if levels drop below 2-3 mg/L.
     - Fish in poorly oxygenated water are more susceptible to diseases.
   - **Effects of High DO:** High DO is rarely harmful, but can lead to

supersaturation, which may cause gas bubble disease in fish.

3. **Turbidity**
   - **Importance:** Turbidity refers to the clarity of water, influenced by suspended particles like plankton, algae, and organic matter.
   - **Ideal Range:** Less than 50 NTU (Nephelometric Turbidity Units), though some species tolerate higher turbidity.
   - **Effects**
     - High turbidity can reduce light penetration, affecting photosynthesis in aquatic plants.
     - It can also cause stress to fish and increase the risk of disease by reducing visibility and promoting bacterial growth.

4. **Salinity**
   - **Importance:** Salinity levels affect the osmoregulation of fish, particularly in brackish water and marine aquaculture.
   - **Ideal Range:** 0–35 ppt (parts per thousand) depending on species.
   - **Effects of High Salinity:**
     - Most freshwater fish are stressed by saline water.
     - Marine species can tolerate varying levels of salinity but can be affected by abrupt changes.

5. **Water Color**
   - **Importance:** The color of water can be influenced by the presence of algae, plankton, or organic materials.
   - **Ideal Range:** Clear water is generally preferred, but slightly greenish water due to algae can be normal in some ponds.
   - **Effects**
     - Excessive algae growth (green or brown water) can lead to oxygen depletion, especially at night.

- Water with high organic material or tannins may indicate poor water quality.

Chemical Parameters of Water in Fish Ponds

1. pH

- **Importance:** pH measures the acidity or alkalinity of water, which affects fish health, nutrient availability, and microbial activity.
- **Ideal Range:** 6.5–8.5 for most fish species.
- **Effects of Low pH**
  - Acidic water can lead to fish stress, reduced feeding, and the release of toxic substances like ammonia.
- **Effects of High pH**
  - Alkaline water can reduce the availability of essential minerals and decrease fish growth.

2. Ammonia (NH_3 and NH_4^+)

- **Importance:** Ammonia is a waste product excreted by fish and decomposing organic matter. It can be toxic, especially in its un-ionized form (NH_3).
- **Ideal Range**
  - Total ammonia ($NH_3 + NH_4^+$) should be less than 0.02 mg/L.
  - Ammonia is more toxic at higher pH and temperatures.
- **Effects of High Ammonia**
  - High ammonia levels can lead to gill damage, reduced growth, poor health, and even fish kills.

3. Nitrite (NO_2)

- **Importance:** Nitrites are produced during the breakdown of ammonia by bacteria (nitrification process). Nitrite is toxic to fish at high levels.
- **Ideal Range:** Less than 0.1 mg/L.

- **Effects of High Nitrite**
  - Nitrite interferes with oxygen transport in fish, causing "brown blood disease" and suffocation.

4. **Nitrate (NO_3^-)**
   - **Importance:** Nitrate is the final product of the nitrification process and is less toxic than ammonia and nitrite, but high levels can cause stress and reduced growth.
   - **Ideal Range:** 0–50 mg/L.
   - **Effects of High Nitrate**
     - Elevated nitrate levels can reduce fish's ability to grow and reproduce and affect water quality by promoting excessive algae growth.

5. **Carbon Dioxide (CO_2)**
   - **Importance:** CO_2 is produced by fish respiration and organic decomposition.
   - **Ideal Range:** Less than 15 mg/L.
   - **Effects of High CO_2**
     - High CO_2 levels can lead to acidosis in fish, reducing feeding and growth rates.
     - It also lowers dissolved oxygen levels, exacerbating hypoxia.

6. **Hardness (Calcium and Magnesium Ions)**
   - **Importance:** Water hardness affects the osmoregulation of fish and the availability of essential minerals like calcium, which is vital for bone and shell development.
   - **Ideal Range:** 50–150 mg/L.
   - **Effects of Low Hardness**
     - Soft water can cause fish to have difficulty regulating their body salts and can make them more susceptible to diseases.

- **Effects of High Hardness**
  - Hard water can lead to scale formation on fish and aquarium surfaces, affecting water quality.

7. Phosphates (PO_4^{3-})

- **Importance:** Phosphates come from fish waste, uneaten food, and organic matter. They contribute to algae growth.
- **Ideal Range:** Less than 0.1 mg/L.
- **Effects of High Phosphates**
  - Excessive phosphates can cause algal blooms, deplete oxygen levels, and reduce overall water quality.

4.5 Importance of Water Quality in Fish Culture

Water quality is a critical factor in the success of fish culture (aquaculture). It directly affects the health, growth, reproduction, and overall productivity of fish. The importance of maintaining good water quality in fish culture can be outlined as follows:

1. Ensures Optimal Fish Growth and Health

- **Nutrient Availability:** Fish require a balanced supply of nutrients, which are directly influenced by water quality. For example, adequate levels of oxygen and proper pH support normal metabolic functions, leading to optimal growth.
- **Disease Prevention:** Poor water quality can stress fish, weakening their immune systems and making them more susceptible to diseases. Consistently good water quality helps prevent outbreaks of bacterial, viral, or parasitic infections.
- **Stress Reduction:** Fish living in conditions where water parameters are optimal experience less stress, which can enhance their appetite, improve feeding efficiency, and promote faster growth.

2. **Maintains Oxygen Levels**

- **Respiration:** Fish depend on Dissolved Oxygen (DO) for respiration. If oxygen levels fall too low, fish can suffocate, leading to mortality.
- **Aeration:** Maintaining good water quality involves proper aeration systems to ensure adequate oxygen levels for fish and other organisms in the system.

3. **Promotes Efficient Feeding and Digestion**

- **Feeding Efficiency:** Water quality directly influences feeding behavior and digestion. For instance, high ammonia or nitrite levels can reduce appetite and feeding efficiency.
- **Better Conversion:** With proper water quality, fish can convert feed into body mass more efficiently, improving feed conversion ratios and reducing feed wastage.

4. **Supports Reproductive Success**

- **Breeding Conditions:** Optimal water quality is essential for fish to breed successfully. Parameters like pH, temperature, and oxygen levels affect the reproductive health of fish.
- **Egg and Larvae Development:** Poor water quality can lead to poor egg fertilization and high mortality in larvae. Clean, balanced water promotes healthy development and better survival rates of offspring.

5. **Reduces Toxicity**

- **Ammonia and Nitrite Toxicity:** Ammonia and nitrite are toxic to fish, and their accumulation in water can lead to poisoning. Good water quality management, including regular water changes and filtration, prevents these toxins from reaching harmful levels.
- **Controlling Chemical Imbalance:** Imbalances in chemicals like phosphates, nitrates, or heavy metals can be detrimental to fish health. Regular monitoring and management help maintain chemical stability

in the water.

6. **Prevents Algal Blooms and Eutrophication**

- **Algae Control:** High levels of nutrients like nitrogen and phosphorus, often from fish waste, uneaten feed, or fertilizers, can lead to excessive algal growth (algal blooms). These blooms deplete oxygen, block sunlight, and can cause fish kills.
- **Eutrophication Prevention:** Proper water quality management prevents the process of eutrophication, where excess nutrients lead to oxygen depletion, harming fish and other aquatic organisms.

7. **Enhances Water Reuse and Sustainability**

- **Water Recycling:** Good water quality management can reduce the need for frequent water exchanges, allowing for more sustainable aquaculture practices. Recycled water can be treated and reused effectively, reducing environmental impact.
- **Eco-friendly Practices:** Healthy water quality ensures that aquaculture operations are more sustainable by reducing waste buildup and minimizing the need for chemicals and antibiotics.

8. **Improves Environmental Balance**

- **Healthy Ecosystem:** Water quality management maintains a healthy balance of organisms within the fish pond, such as beneficial bacteria that break down organic waste. This contributes to a healthier overall ecosystem.
- **Support for Aquatic Plants:** Proper water quality supports aquatic plants that help in nutrient cycling, oxygen production, and providing natural food sources for fish.

9. **Increases Productivity and Profitability**

- **Optimal Growth Conditions:** By providing the ideal conditions for fish growth, good water quality can maximize productivity and reduce costs associated with disease management, feed waste, and fish

mortality.

- **Reduced Operational Costs:** By reducing the incidence of disease, promoting growth, and improving feed efficiency, maintaining water quality can lead to significant cost savings in aquaculture operations.
- **Market Quality:** Fish grown in optimal conditions with good water quality are healthier, more robust, and often have better market quality, making them more desirable to consumers and more profitable to farm.

10. Facilitates Compliance with Environmental Regulations

- **Regulatory Standards:** In many regions, aquaculture operations are required to meet specific water quality standards to reduce their environmental impact. Maintaining proper water quality helps operators comply with these standards and avoid fines or penalties.
- **Minimizing Pollution:** By ensuring water quality in fish farms, operators can minimize the release of harmful substances like excess nutrients, organic waste, or chemicals into the surrounding environment.

Exerxise

Choose the correct answer from the given alternatives.

1. Which of the following fish species is primarily carnivorous?

   a. Grass carp b. Tilapia

   c. Trout d. Catfish

2. Which type of fish feed primarily on plants and algae?

   a. Omnivores b. Herbivores

   c. Carnivores d. Filter feeders

3. What type of fish primarily consume both plant and animal matter?

   a. Carnivores b. Herbivores

   c. Omnivores d. Filter feeders

4. At the larva stage, fish require a diet that is.....

   a. High in carbohydrates b. High in protein and fat

   c. Low in protein d. High in fiber

5. At the juvenile stage, fish require a diet that supports.....

   a. Immune system development and rapid growth

   b. Maintenance of energy

   c. Low levels of protein

   d. Reproductive development

6. Which type of fish is commonly fed with PaPara Grass?

   a. Herbivorous fish

   b. Carnivorous fish

   c. Omnivorous fish

   d. Filter-feeding fish

7. What is the ideal pH range of water for most fish species in aquaculture?

   a. 4.5-5.5 b. 5.5-6.5

   c. 6.5-8.5 d. 8.5-9.5

8. Which of the following is a physical parameter of water quality?

   a. pH b. Ammonia

   c. Temperature d. Nitrate

9. Why is maintaining good water quality crucial for fish health?

   a. It helps in better breeding

   b. It ensures optimal growth and prevents diseases

   c. It increases the cost of operation

   d. It reduces the need for feeding

10. What effect does poor water quality have on fish?

    a. It can enhance their immune system

    b. It can cause stress, diseases, and reduced growth

    c. It improves reproduction rates

    d. It increases oxygen levels

Write short answer to the following questions.

1. What are the different feeding habits of fish? Explain briefly.
2. Name some improved fodder grasses used for feeding fish.
3. Explain the feeding requirements for different stages of fish.
4. Why is water quality important in fish culture?

Write long answer to the following questions.

1. Explain the physical and chemical parameters of water.

Project Work

1. Make a visit to a hear by fish farm and learn physical and chemical parameters of fish pound water.

Unit 5

Fish Culture System

5.1 Monoculture and Polyculture of Fish and its Importance

Monoculture of Fish

Definition: Monoculture refers to the farming of a single species of fish in a pond or system. All fish in the pond are of the same species and often of the same size and age.

Examples:

- Farming of tilapia, catfish, or salmon.

Advantages of Monoculture

1. **Efficiency in Management**
   - Easier to manage as only one species with similar habitat and nutritional requirements is farmed.
   - Simplifies feeding practices, disease management, and breeding.
2. **Higher Yield (per species)**
   - Higher densities of a single species can be maintained, often leading to higher production.
3. **Market Consistency**
   - Easier to market one specific species due to consistent size and uniform product.
4. **Focus on Specialization**
   - Allows farmers to specialize in one species and refine practices for that species, such as breeding, feeding, and disease control.

Disadvantages of Monoculture

1. **Risk of Disease Outbreaks**
    - The entire stock is vulnerable to diseases or environmental changes that affect that specific species.
2. **Nutrient Imbalance**
    - Large amounts of fish waste and feed can lead to nutrient imbalances in the water.
3. **Genetic Homogeneity**
    - Risk of inbreeding and loss of genetic diversity, especially in small-scale farms.

Polyculture of Fish

Definition: Polyculture is the practice of farming multiple species of fish (and sometimes other aquatic animals or plants) together in the same pond or system. The different species often have complementary ecological requirements.

Examples:

- **Carp polyculture:** Mixing species like common carp, grass carp, and silver carp together.
- **Fish and shrimp farming**: Combining fish with shrimp or other aquaculture species in integrated systems.

Advantages of Polyculture

1. **Diverse Ecosystem**
    - Different species occupy different niches, reducing competition for food and space.
    - Natural balancing of waste by species that feed on different types of food or waste products.
2. **Improved Resource Utilization**
    - Different species may use different layers of water, different food

sources, or occupy different feeding habits, thus optimizing space and nutrients.

3. **Reduced Risk of Disease**
   - The presence of multiple species can prevent the spread of disease specific to one species and reduce the overall vulnerability of the system.

4. **Increased Sustainability**
   - By integrating different species, the overall system may be more resilient, and resources (like water, nutrients, and food) are used more efficiently.

5. **Economic Diversification**
   - Farmers can diversify their income by harvesting multiple species, potentially leading to higher profits and reduced financial risks.

Disadvantages of Polyculture

1. **Management Complexity**
   - Requires more complex management, as different species have different feeding habits, space requirements, and care.

2. **Disease Transmission**
   - While disease risk is lower for single-species populations, polyculture systems can have a higher chance of cross-species disease transmission.

3. **Competition for Resources**
   - If not properly planned, different species might compete for the same resources (e.g., food or oxygen), reducing efficiency and growth.

Importance of Monoculture and Polyculture in Fish Farming

- **Monoculture**
  - **Specialization and High Yield:** Monoculture is important for

specialized farming where efficiency, controlled environments, and consistent production are key. It is suitable for commercial operations focusing on one species for consistent market demand.

- **Polyculture**
  - **Sustainability and Resilience:** Polyculture plays a significant role in sustainable aquaculture by promoting biodiversity, reducing risks associated with disease outbreaks, and optimizing the use of resources. It is particularly useful in integrated farming systems, where fish are farmed alongside livestock or crops.

5.2 Fingering Production in Paddy Field

Fingering production in a paddy field refers to the practice of growing fish fry or fingerlings (young fish) in rice paddies, also known as "rice-fish farming". This method is a form of integrated farming where rice cultivation and fish farming are combined in the same agricultural space. It is a form of agro-aquaculture that uses the natural environment of the paddy field to produce both rice and fish, thus optimizing land and water resources.

Key Aspects of Fingering Production in Paddy Fields

1. **Types of Fish for Fingering Production**
   - **Common fish species** grown in paddy fields include:
     - Carp species (such as common carp, grass carp, and silver carp).
     - Tilapia.
     - Catfish.
     - **Shrimp** or other small aquatic organisms.

2. **The Process of Fingering Production**
   - **Stocking:** Fish fry or fingerlings are introduced into the paddy fields during the early stages of rice cultivation. Usually, this happens when the water level is high enough to sustain the fish.

- **Growth and Development:** The fish are left to grow in the paddy field alongside the rice. The fish feed on natural food available in the field, including algae, small invertebrates, and organic matter that is present in the rice-growing environment.
- **Water Management:** Maintaining the right water level is essential. A certain amount of water is required for rice cultivation, and this water can also sustain the fish. The paddy fields provide a productive environment for both rice and fish by maintaining suitable oxygen levels, pH, and nutrient availability.
- **Fingering Production:** The young fish (fry) grow into fingerlings (juvenile fish) during the growing season. These fingerlings can be harvested once they reach a marketable size or used for restocking other ponds or aquaculture systems.

3. Advantages of Fingering Production in Paddy Fields

- **Increased Productivity:** By integrating fish production with rice farming, both food crops and fish are produced simultaneously, maximizing land use and increasing overall farm productivity.
- **Nutrient Cycling:** Fish waste provides nutrients that can fertilize the rice crop, promoting better rice growth without the need for synthetic fertilizers.
- **Reduced Pest Control Costs:** Fish help control pests in the rice fields by feeding on insects and larvae, reducing the need for chemical pesticides.
- **Sustainability:** This system is environmentally sustainable as it uses natural resources efficiently, combining aquatic and terrestrial farming systems.
- **Improved Soil Fertility:** Fish waste and organic matter enrich the soil, improving the fertility of the rice paddy.

5.3 Nursing Methods of Hatchling, Fry and Fingerlings

In aquaculture, proper nursing of fish at different life stages—hatchlings, fry, and fingerlings—is crucial for their growth, survival, and health. Each stage requires specific care and attention to ensure optimal development. Below are the nursing methods for each stage of fish development:

1. Nursing of Hatchlings

Hatchlings are newly hatched fish that have absorbed their yolk sac and are not yet capable of feeding independently. Proper nursing methods during this stage are critical for survival.

Key Aspects

- **Water Quality**
  - Maintain high-quality water with appropriate temperature, pH, dissolved oxygen, and low levels of ammonia and nitrites. Freshwater fish typically require temperatures between 24°C to 28°C.
  - Ensure oxygen-rich water through aeration or water circulation to support the high metabolic needs of hatchlings.
- **Feeding**
  - Hatchlings primarily rely on yolk reserves at first. After absorbing the yolk, they can begin feeding on infusoria (tiny aquatic organisms) or rotifers, which are small and nutritious enough for them to consume.
  - Microalgae and artemia nauplii (brine shrimp) are also suitable for feeding at this stage.
- **Stocking Density**
  - Avoid overcrowding, which can lead to stress, poor water quality, and disease. Maintain optimal stocking densities to ensure the fry have enough space to swim freely.

- **Protection**
    - Hatchlings are vulnerable to predation and environmental stress. Providing protective enclosures or shading can help shield them from excessive light, predators, or sudden changes in water parameters.

2. Nursing of Fry

Fry are juvenile fish that have transitioned from the hatchling stage, are now capable of independent feeding, and are typically larger than hatchlings.

Key Aspects

- **Water Quality**
    - Ensure stable water parameters: the temperature should remain consistent, typically between 24°C to 30°C depending on species.
    - Regular water exchange and aeration are crucial to remove waste products and maintain dissolved oxygen levels.
- **Feeding**
    - As fry grow, they begin feeding on small zooplankton, rotifers, and artemia (brine shrimp) at the early stages.
    - Artificial feeds (like finely ground pellets or starter feeds) are introduced once they are large enough to consume them.
    - Feeding frequency should be increased during this stage to support rapid growth, offering small quantities multiple times a day.
- **Stocking Density**
    - Keep stocking densities moderate to ensure optimal growth rates and reduce stress. This will also help prevent disease outbreaks.
    - Regularly monitor and adjust stocking densities as the fry grow larger.

- **Environment**
  - Provide shelter and hiding spots to reduce stress and competition.
  - Avoid excessive handling of fry, as they are very sensitive to stress and may be prone to disease.

3. Nursing of Fingerlings

Fingerlings are fish that have grown from fry and have developed more identifiable characteristics, such as scales and fins. They are now able to feed on larger food particles and are more resilient than fry.

Key Aspects

- **Water Quality**
  - Water quality is still critical for fingerlings. Maintain optimal temperature (usually between 24°C and 28°C) and low levels of ammonia to prevent stress.
  - Aeration and filtration are essential to ensure sufficient oxygen levels and clean water.

- **Feeding**
  - At this stage, fish can be fed artificial pellet feeds (commercial feeds designed for fingerlings), which should contain balanced levels of protein, fat, and fiber to support their growth.
  - Live feeds (such as small fish or insects) can still be offered, but artificial pellets can now form the primary diet.
  - Feed multiple times a day to maximize growth potential and ensure nutritional needs are met.

- **Stocking Density**
  - As fingerlings grow, they can be stocked at higher densities compared to fry but still require sufficient space to avoid overcrowding.
  - Regular monitoring is required to prevent excessive waste buildup and maintain optimal growth conditions.

- **Health and Disease Management**
  - Regularly inspect for signs of disease, parasites, or deformities.
  - Provide vaccinations or treatments for common fish diseases, such as bacterial or parasitic infections, as necessary.
- Gradual Transition to Larger Ponds or Tanks
  - Fingerlings may need to be gradually transferred to larger ponds or tanks where they can continue to grow until they reach marketable size.

5.4 Introduce Breeding of Fish

Fish breeding is the controlled process of propagating fish species under natural or artificial conditions to produce offspring. It is a crucial component of aquaculture, helping to sustain fish populations, meet market demand, and preserve biodiversity. Breeding can be carried out in both natural water bodies (such as rivers, lakes, or ponds) and artificial setups (such as hatcheries or controlled tanks).

5.5 Types of Breeding

1. Natural Breeding

- Fish are allowed to reproduce naturally in their habitat without significant human intervention.
- Conditions such as water quality, temperature, and the presence of spawning substrates are optimized to encourage reproduction.
- Common in wild fisheries and extensive aquaculture systems.

2. Artificial Breeding

- Fish breeding is facilitated by human intervention to increase reproduction rates and ensure genetic quality.
- Includes techniques such as induced breeding, hormone injections, and controlled incubation.

Methods of Fish Breeding

1. Induced Breeding

- A widely used technique in aquaculture where external stimuli, such as hormones, are administered to fish to stimulate spawning.
- Common hormones used include Human Chorionic Gonadotropin (HCG) or Synthetic Gonadotropin-Releasing Hormones (GnRH).
- Ensures synchronized breeding and high fertilization rates.

2. Spawning in Hatcheries

- Fish are bred in controlled environments like hatcheries, where water quality, temperature, and light are regulated to mimic natural spawning conditions.
- Eggs are collected and incubated in hatcheries until they hatch.

3. Selective Breeding

- Fish with desirable traits (e.g., faster growth, disease resistance, or better meat quality) are selected to breed.
- Ensures improved offspring quality and better yields in aquaculture.

4. Crossbreeding

- Breeding between different species or strains of fish to create hybrids with specific traits.
- For example, hybrid catfish or tilapia.

Conditions for Successful Fish Breeding

1. Water Quality

- Optimal temperature, pH, oxygen levels, and clean water are essential for successful reproduction.

2. Availability of Spawning Substrates

- Many fish species require specific substrates for laying eggs, such as rocks, aquatic plants, or sand.

3. Stock Selection

- Healthy and sexually mature fish with good genetic traits should be chosen for breeding.

4. Seasonality

- Many fish breed during specific seasons, often influenced by environmental factors such as temperature, rainfall, and photoperiod.

Importance of Fish Breeding

1. Sustainable Fish Production

- Ensures a steady supply of fish for consumption and aquaculture.

2. Biodiversity Conservation

- Helps maintain or restore populations of endangered or overfished species.

3. Economic Benefits

- Supports aquaculture industries by providing high-quality seeds for farming.

4. Genetic Improvement

- Allows the development of fish strains with desirable traits, such as rapid growth or disease resistance.

5.6 Explain Nursing Methods of Hatchling, Fry and Fingerling

(It has been discussed earlier in 5.3)

Exercise

Choose the correct answer from the given alternatives.

1. What is monoculture in fish farming?
   a. Cultivating multiple species of fish in the same pond
   b. Cultivating a single species of fish in a pond
   c. Breeding fish in paddy fields
   d. Cultivating aquatic plants alongside fish

2. Which is a key benefit of polyculture in aquaculture?
   a. Reduced risk of disease
   b. Optimal use of pond resources
   c. Lower competition for food
   d. Faster growth of one species

3. A combination of surface feeders, middle feeders, and bottom feeders is an example of.....
   a. Monoculture
   b. Polyculture
   c. Integrated farming
   d. Cage culture

4. What is the primary purpose of fingerling production in paddy fields?
   a. To harvest market-sized fish
   b. To grow young fish for restocking or aquaculture
   c. To cultivate fish alongside rice for biodiversity
   d. To reduce pest populations in paddy fields

5. Which fish species is commonly used for fingerling production in paddy fields?
   a. Grass carp
   b. Tilapia
   c. Common carp
   d. All of the above

6. What is the main environmental condition required for fingerling production in paddy fields?

a. High salinity levels
b. Low oxygen concentration
c. Adequate water levels and flow
d. Complete drainage of the field

7. What is the primary feed for hatchlings during the first few days?

a. Pellets
b. Artemia
c. Yolk sac reserves
d. Zooplankton

8. Which stage of fish requires frequent water quality monitoring and small, frequent feedings?

a. Adult fish
b. Hatchlings and fry
c. Fingerlings only
d. Breeding adults

9. What type of feed is most commonly used for nursing fingerlings?

a. Zooplankton
b. Finely ground artificial feed
c. Algae blooms
d. Yolk sac reserves

10. Which of the following is a method of artificial fish breeding?

a. Natural spawning
b. Selective crossbreeding
c. Hormonal induction
d. Both b and c

11. Which hormone is commonly used in induced fish breeding?

a. Insulin
b. Gonadotropin-releasing hormone (GnRH)
c. Thyroxine
d. Estrogen

12. Fish breeding that occurs naturally without human intervention is called...

a. Induced breeding
b. Hatchery breeding
c. Natural breeding
d. Artificial insemination

13. What is crossbreeding in fish?

a. Mating fish of the same species

b. Mating fish from two different species or strains

c. Mating fish with deformities

d. Mating fish in natural conditions

14. Which of the following is NOT a type of fish breeding?

a. Natural breeding b. Induced breeding

c. Artificial insemination d. Selective breeding

15. What is the primary advantage of selective breeding in aquaculture?

a. Faster reproduction rates

b. Disease resistance and better growth rates

c. Reduced need for artificial feeding

d. Better water quality

Write short answer to the following questions.

1. Define monoculture and polyculture system of fish farming.
2. Write short notes on Fish breeding.
3. How is fingerling produced in paddy fields?
4. Explain about nursing methods of hatchling, fry and fingerling.

Write long answer to the following questions.

1. Explain in detail about monoculture and polyculture system of fish farming with their advantages and disadvantages.
2. Describe the methods of fish breeding with examples.

Unit 6

Management of Fish Pond

6.1 Cleaning and Maintenance and Use of Lime in Fish Pond

Proper cleaning and maintenance of fish ponds are crucial for ensuring a healthy environment for fish, improving growth rates, and preventing diseases. Below are the key steps:

1. Cleaning Fish Ponds

Before Stocking Fish

- **Removal of Debris**

  Clear the pond of unwanted plants, leaves, or other organic matter that could decompose and reduce water quality.

- **Eradication of Predatory and Weed Fish**

  Drain the pond and use chemicals like rotenone or teaseed cake to eliminate harmful fish or pests.

- **Desilting**

  Remove accumulated silt or mud from the pond bottom, as it may contain harmful gases and reduce the water depth.

- **Liming**

  Apply lime (calcium oxide or calcium carbonate) to neutralize acidity, kill pathogens, and improve the overall pond environment.

During Stocking

- Regularly monitor the pond for debris, excessive algae growth, or waste accumulation, and remove them manually or using nets.

After Harvesting

- Completely drain the pond, remove waste materials, and let the pond dry under sunlight for 1-2 weeks. Sunlight helps eliminate pathogens and parasites.

2. Maintenance of Fish Ponds

- **Water Quality Management**
  - Regularly check and maintain proper pH (6.5–8.5), dissolved oxygen (above 5 mg/L), and temperature (species-specific, typically 24–30°C).
  - Remove excess feed and waste to prevent ammonia buildup.
- **Control of Aquatic Weeds and Algae**
  - Remove aquatic weeds manually or use chemical or biological control methods.
  - Avoid overfeeding, as it can lead to nutrient buildup, causing algal blooms.
- **Aeration**
  - Use aerators to maintain oxygen levels, especially in intensive aquaculture systems or during high fish density periods.
- **Disease Management**
  - Inspect fish regularly for signs of disease and take preventive measures like vaccination or adding salt or potassium permanganate to the water.
- **Regular Water Exchange**
  - Replace part of the pond water periodically to dilute waste and improve water quality.

Use of Lime in Fish Ponds

Lime is an essential material used in fish pond management. Its application plays a significant role in maintaining water quality and supporting fish health.

1. Types of Lime Used

- Quicklime (Calcium Oxide, CaO)

  Fast-acting; used for acidic soils or to kill pathogens.
- Slaked Lime (Calcium Hydroxide, $Ca(OH)_2$)

  Less reactive than quicklime, used to neutralize water acidity.
- Agricultural Lime (Calcium Carbonate, $CaCO_3$)

  Slow-releasing; ideal for long-term pH maintenance.

2. Functions of Lime in Fish Ponds

- **Neutralizing Acidity**
  - Lime raises the pH of acidic water and soil, creating a favorable environment for fish and microorganisms.
- **Disinfection**
  - Quicklime can kill harmful pathogens, parasites, and pest organisms.
- **Enhancing Soil Fertility**
  - Lime improves the availability of nutrients (like phosphorus) in the pond soil, boosting plankton growth, which serves as natural fish feed.
- **Improving Water Quality**
  - Lime reduces turbidity by coagulating suspended particles and enhances the buffering capacity of the water, stabilizing pH fluctuations.
- **Preventing Ammonia Toxicity**
  - Lime reduces ammonia levels in the water, improving the overall environment for fish.

3. Application of Lime

- **Pre-Stocking Application**

  Apply lime during pond preparation at a rate of 200–500 kg/ha, depending on soil acidity.

- **Maintenance Application**

  Apply lime at **100–200 kg/ha** annually or as needed, based on water quality and pH testing.

- **During Pond Drying**

  Spread lime evenly over the pond bottom after drying for disinfection and soil improvement.

Precautions

- Avoid excessive lime application, as it can lead to high pH levels, which are harmful to fish.
- Apply lime gradually and evenly to prevent sudden changes in water chemistry.

6.2 Preparation and Management of Fish Pond

Proper preparation and management of fish ponds are essential to ensure optimal fish growth, maintain water quality, and achieve high productivity in aquaculture. Below is a comprehensive guide:

1. Preparation of Fish Ponds

A. Selection of Pond Site

- Choose a location with:
  - Adequate water supply.
  - Clay or loamy soil to retain water.
  - Protection from flooding and predators.
  - Sufficient sunlight for natural productivity.

B. Pond Construction

- **Pond Type:** Decide on earthen, concrete, or lined ponds based on the species and scale of aquaculture.
- **Shape and Size:** The pond shape can be rectangular or square, with a size depending on the fish species and stocking density.
- **Depth:** Maintain a depth of 1.5–2.5 meters for effective temperature regulation and oxygen availability.
- **Inlet and Outlet:** Install proper inlets and outlets with screens to control water flow and prevent entry of predators.

C. Pond Cleaning and Drying

- Drain the pond completely and remove debris, silt, and aquatic weeds.
- Dry the pond bottom under sunlight for 1–2 weeks to kill harmful organisms.

D. Liming

- Apply lime (calcium carbonate or calcium hydroxide) at a rate of 200–500 kg/ha to:
  - neutralize soil acidity.
  - disinfect the pond bottom.
  - improve soil fertility.

E. Fertilization

- Organic Fertilizer: Use cow dung or poultry manure at 1,000–2,000 kg/ha to boost natural food production (plankton).
- Inorganic Fertilizer: Apply urea and superphosphate (20–30 kg/ha) to maintain nutrient levels.

F. Water Filling

- Fill the pond gradually with clean water to a depth of 1.5–2 meters.
- Allow plankton to bloom for 1–2 weeks before stocking fish.

2. Management of Fish Ponds

A. Stocking

- **Selection of Fish Species**
  - Choose species based on monoculture or polyculture systems, such as carp, tilapia, catfish, or trout.
- **Stocking Density**
  - Typically, 5,000–10,000 fingerlings/ha for extensive systems.
- **Timing**
  - Stock fish when water temperature and quality are suitable.

B. Feeding

- Feed fish with a balanced diet that includes:
  - **Natural Food:** Plankton and detritus produced in the pond.
  - **Supplementary Feed:** Rice bran, oil cakes, or formulated pellets based on fish species and growth stage.
- Follow a feeding schedule, providing 2–5% of fish body weight daily.

C. Water Quality Management

- Maintain optimal parameters:
  - **Dissolved Oxygen (DO):** Above 5 mg/L.
  - **pH:** Between 6.5 and 8.5.
  - **Temperature:** 24–30°C for most tropical fish.
  - **Transparency:** Use a Secchi disk to measure turbidity; ideal visibility is 30–40 cm.
- Conduct partial water exchange to remove toxic substances and replenish oxygen.

D. Weed and Predator Control

- Remove aquatic weeds manually or chemically.
- Use nets and barriers to prevent entry of predators (birds, snakes, etc.).

E. Aeration

- Use mechanical aerators or paddle wheels in intensive systems to maintain oxygen levels.
- Ensure good water circulation to prevent stagnation.

F. Disease Management

- Regularly monitor fish health and behavior.
- Remove diseased or dead fish immediately to prevent the spread of infections.
- Apply treatments such as salt baths, potassium permanganate, or antibiotics if necessary.

G. Harvesting

- Plan harvesting based on market demand and fish growth rates.
- Use seines or nets for partial or complete harvesting.

H. Record-Keeping

- Maintain records of stocking, feeding, water quality, and harvesting for better management and performance evaluation.

6.3 Use of Feed and Fertilizer in Fish Pond and its Importance

Proper feeding and fertilization are critical for ensuring high productivity in aquaculture. They help maintain a balanced ecosystem, promote fish growth, and optimize the pond's nutrient content.

1. Use of Feed in Fish Ponds

Fish feed supplies essential nutrients for fish growth and sustains their health and reproduction. There are two main types of feed used in fish ponds:

A. Natural Feed

- Derived from biological productivity in the pond, including:
  - Phytoplankton and Zooplankton (microscopic algae and aquatic

organisms).

- Detritus (decomposed organic material).
- Aquatic plants and other microorganisms.

- Natural feed is enhanced by proper fertilization of the pond.

B. Supplementary Feed

- Provided to meet additional nutritional needs of fish and includes:
  - **Homemade Feed:** Rice bran, wheat bran, oil cakes, etc.
  - **Formulated Feed:** Commercially prepared pellets or granules designed to meet species-specific nutritional requirements.

Feeding Practices

- Provide 2–5% of fish body weight per day, depending on the species and growth stage.
- Distribute feed evenly to avoid waste and competition.
- Use floating feed to observe fish feeding behavior and adjust feed quantity accordingly.

2. Use of Fertilizers in Fish Ponds

Fertilizers enhance natural food production by boosting plankton growth, which forms the primary food source for many fish species.

A. Types of Fertilizers

1. Organic Fertilizers

- **Examples:** Cow dung, poultry manure, compost.
- Rich in nutrients, they decompose slowly, providing a steady release of nutrients.
- **Application rate:** 500–1,000 kg/ha depending on pond conditions.

2. Inorganic Fertilizers

- **Examples:** Urea, superphosphate, ammonium nitrate.

- Provide specific nutrients like nitrogen (N) and phosphorus (P) for plankton growth.
- Application rate: 20–30 kg/ha for urea and 10–20 kg/ha for superphosphate.

3. Importance of Feed in Fish Ponds

- **Promotes Growth:** Supplies protein, carbohydrates, fats, vitamins, and minerals essential for fish development.
- **Improves Survival Rates:** Balanced nutrition strengthens fish immunity and reduces mortality.
- **Increases Productivity:** Faster growth leads to shorter production cycles and higher yields.
- **Prevents Competition:** Reduces reliance on natural food, preventing competition among fish.
- **Supports High Stocking Density:** Supplementary feed is necessary in intensive systems with limited natural food.

4. Importance of Fertilizers in Fish Ponds

- **Boosts Natural Productivity:** Fertilizers stimulate plankton growth, ensuring a continuous supply of natural food for fish.
- **Enhances Pond Fertility:** Organic and inorganic fertilizers enrich the pond soil and water with essential nutrients.
- **Cost-Effective Nutrition:** Reduces dependency on expensive supplementary feed.
- **Balances Ecosystem:** Promotes biodiversity by encouraging the growth of beneficial organisms.
- **Improves Water Quality:** Organic fertilizers increase microbial activity, aiding in nutrient recycling.

5. Combined Use of Feed and Fertilizer

- Fertilization creates a foundation for natural food production, while

supplementary feeding provides additional nutrients, ensuring optimal fish growth.

- A balanced approach minimizes feed waste and nutrient overload, maintaining water quality.

6. Best Practices for Feeding and Fertilization

- Test water quality regularly to avoid over-fertilization, which can lead to eutrophication.
- Apply fertilizers evenly across the pond and in recommended amounts.
- Use high-quality, species-specific feed to optimize growth and health.
- Monitor fish behavior to adjust feeding schedules and quantities.

6.4 Organic Fertilizer

Organic fertilizers play a crucial role in enhancing the productivity of fish ponds by promoting the growth of natural food sources such as phytoplankton, zooplankton, and detritus. These natural feeds form the primary diet for many fish species, especially in semi-intensive and extensive aquaculture systems.

1. Common Types of Organic Fertilizers

1. Animal Manure

- **Examples:** Cow dung, poultry manure, pig manure, goat manure.
- Rich in organic matter, nitrogen, and phosphorus.

2. Compost

- Decomposed plant and animal residues.
- Used to improve the organic content of pond soil.

3. Green Manure

- Plant-based fertilizers such as Azolla and leguminous plants.
- Decompose quickly to release nutrients.

4. **Other Organic Materials**
    - Agricultural waste, kitchen waste, and fishmeal byproducts.

2. **Application of Organic Fertilizers**
    - **Before Stocking**
        - Organic fertilizers are applied during pond preparation to enhance the growth of plankton.
        - **Rate:** 1,000–2,000 kg/ha for cow dung or other manures, depending on soil fertility.
        - Evenly spread manure over the pond bottom and allow it to decompose for 1–2 weeks before adding water.
    - **After Stocking**
        - Periodic application of organic manure is done to maintain plankton productivity.
        - Use in small doses to avoid water quality deterioration.

3. **Advantages of Using Organic Fertilizers**

1. **Promotes Natural Food Production**
    - Stimulates the growth of phytoplankton and zooplankton, which serve as primary food for fish.

2. **Improves Soil Fertility**
    - Increases the organic content and microbial activity in the pond soil, enhancing nutrient cycling.

3. **Cost-Effective**
    - Readily available and inexpensive compared to inorganic fertilizers.

4. **Environmentally Friendly**
    - Natural and biodegradable, reducing the risk of water pollution.

5. **Sustains Fish Growth**
    - Ensures a continuous supply of natural food, supporting fish growth and health.

6.5 Chemical fertilizer

Chemical fertilizers are used in fish ponds to enhance the growth of natural food sources such as phytoplankton and zooplankton. These fertilizers supply essential nutrients like nitrogen, phosphorus, and potassium that stimulate the productivity of aquatic ecosystems, making them a vital part of semi-intensive and intensive aquaculture systems.

1. **Common Types of Chemical Fertilizers**

    1. **Nitrogen Fertilizers**
        - **Examples:** Urea (46% N), Ammonium nitrate, Ammonium sulfate.
        - Promote the growth of phytoplankton by supplying nitrogen, an essential nutrient for photosynthesis.

    2. **Phosphorus Fertilizers**
        - **Examples:** Single superphosphate (SSP), Triple superphosphate (TSP), Di-ammonium phosphate (DAP).
        - Enhance root development in aquatic plants and stimulate phytoplankton blooms.

    3. **Potassium Fertilizers**
        - **Examples:** Potassium chloride, Potassium sulfate.
        - Support overall plant health and balance nutrient cycles.

    4. **Compound Fertilizers**
        - **Examples:** NPK (Nitrogen-Phosphorus-Potassium) blends like 10:26:26 or 20:10:10.
        - Provide a balanced supply of multiple nutrients.

6.6 Pellet Feed

Pellet feed is a key component in modern aquaculture, providing balanced nutrition for fish at various stages of their growth. It is manufactured in the form of small, uniform pellets that are easy for fish to consume and digest, making it highly efficient in feeding and promoting optimal growth.

1. Types of Pellet Feed

There are different types of pellet feed used in fish farming, depending on the species of fish, their feeding habits, and the farming system. Some common types include:

A. Floating Pellets

- These pellets float on the water surface, allowing farmers to observe fish feeding behavior and adjust feeding accordingly.
- Ideal for species like tilapia, catfish, and trout.

B. Sinking Pellets

- These pellets sink to the bottom of the pond, making them suitable for bottom-feeding species like carp.
- They are formulated to release nutrients gradually, allowing fish to feed over an extended period.

C. Slow-Sinking Pellets

- These pellets sink slowly, providing fish with access to feed throughout the water column.
- Commonly used for species like salmon and shrimp that feed at various depths.

D. Crumble or Starter Pellets

- These are small-sized pellets designed for fry and fingerlings in the early stages of growth.
- They are easy for young fish to consume and digest.

6.7 Aquatic Weeds and its Control Method

Aquatic weeds are plants that grow in or around water bodies, such as ponds, lakes, and rivers, and can negatively affect aquatic ecosystems, fish farming, and water quality. While some aquatic plants are beneficial for maintaining the ecological balance, invasive or excessive growth of weeds can lead to various problems such as oxygen depletion, poor water circulation, and reduced fish growth.

Methods of Controlling Aquatic Weeds

A. Physical Methods

1. Manual Removal

- Weeds can be manually removed by pulling, raking, or cutting them. This method is effective for small-scale ponds or areas with light weed infestation.
- **Pros:** No chemicals involved, simple and immediate action.
- **Cons:** Labor-intensive and may not completely eradicate weeds.

2. Mechanical Harvesting

- Mechanical devices like weed cutters, harvesters, and underwater mowers are used to cut and collect weeds.
- **Pros:** Effective for large infestations, especially in commercial fish ponds.
- **Cons:** Requires equipment investment and may not eliminate the root system.

3. Mowing or Cutting

- Regular cutting of aquatic weeds prevents them from reaching the surface, reducing the chance of excessive growth.
- **Pros:** Reduces the spread and oxygen consumption.
- **Cons:** Requires continuous maintenance.

4. **Dredging**
    - Removal of the mud and sediment from the bottom of the pond can help remove weed seeds and roots.
    - **Pros:** Useful in ponds with heavy weed infestations and nutrient buildup.
    - **Cons:** Expensive and disruptive to pond ecosystems.

B. Chemical Methods

1. **Herbicides**
    - Chemical herbicides can be applied to control aquatic weeds. These chemicals are specific to types of plants and can target both submerged and floating weeds.

- **Common Herbicides**
    - *Glyphosate*: Kills most types of aquatic plants.
    - *2,4-D*: Effective against broad-leaved aquatic weeds.
    - *Copper Sulfate*: Controls algae and certain submerged weeds.
    - **Pros:** Effective and quick in controlling large-scale infestations.
    - **Cons:** Potential risks to water quality, fish, and other non-target organisms. Requires careful application and adherence to regulations.

2. **Algicides**
    - Used to control algae (a type of aquatic weed) in water bodies. Examples include *Copper-based compounds*.
    - **Pros:** Quickly reduces algae growth and clears water.
    - **Cons:** May harm fish and beneficial microorganisms if overused.

C. Biological Methods

1. **Introduction of Herbivorous Fish**
    - Certain fish species, like *Grass carp (Ctenopharyngodon idella)*,

feed on aquatic plants and can help control weed growth.

- **Pros:** Eco-friendly, requires minimal maintenance.
- **Cons:** Not all fish are effective for all weed types, and overstocking can cause ecological imbalances.

2. Insects and Other Biological Control Agents

- Insects like *water weevils (Euhrychiopsis lecontei)* and *fish weevils* can be used to feed on aquatic plants, specifically weeds like *water hyacinth*.
- **Pros:** Long-term, sustainable solution.
- **Cons:** Control can be slow and may require careful monitoring to avoid overpopulation or unintended consequences on the ecosystem.

D. Preventive Methods

1. Water Management

- Proper pond water management practices such as regulating water flow, depth, and nutrient levels can help control weed growth. For example, reducing nutrient loading (nitrogen and phosphorus) can limit the growth of aquatic weeds.
- **Pros:** Sustainable long-term solution.
- **Cons:** Requires continuous monitoring and management.

2. Shade Structures

- Installing floating mats or other structures that reduce sunlight penetration into the water can prevent weed growth.
- **Pros:** Reduces weed growth by limiting photosynthesis.
- **Cons:** May require significant upfront investment.

3. Barriers and Nets

- Use of barriers or nets to prevent weeds from spreading into specific areas of the pond.

- **Pros:** Prevents weed spread and is a non-invasive solution.
- **Cons:** May require maintenance and monitoring.

6.8 Fish Predators and Control Methods

Fish predators can significantly impact aquaculture by consuming fish, eggs, or juvenile stages, which reduces fish stock, slows growth, and increases production costs. Various birds, mammals, reptiles, and even other fish species can be considered predators in fish farming systems. Managing these predators is crucial for the sustainability and productivity of aquaculture operations.

1. Common Fish Predators in Aquaculture

A. Birds

1. **Cormorants:** Cormorants are the large water birds known for diving and eating fish. They can decimate fish stocks, particularly in ponds or lakes.
2. **Herons:** Wading birds that hunt for fish, especially in shallow ponds or along the edges.
3. **Kingfishers:** Smaller birds that dive into the water to catch fish.
4. **Egrets:** Wading birds similar to herons, feeding on fish in shallow waters.

B. Mammals

1. **Otters:** Known to consume large quantities of fish and can damage aquaculture systems by tearing through nets or barriers.
2. **Raccoons:** They often feed on fish and eggs, especially in freshwater ponds or near shorelines.
3. **Bats:** Some species of bats feed on fish, especially insects that fall into the water and attract fish.
4. **Mink:** Can attack fish farms, especially when water is shallow or fish are near the surface.

C. Reptiles

1. **Snakes:** Some species, such as water snakes, can prey on small fish, particularly in small ponds or cages.
2. **Crocodiles and Alligators:** In tropical and subtropical areas, they may feed on fish or even attack larger farmed fish.

D. Other Fish Species

1. **Predatory Fish:** Species like bass, pike, or certain catfish that feed on smaller or juvenile fish in aquaculture settings.
2. **Cannibalism in Fish:** Certain farmed fish species, like tilapia or trout, may prey on smaller or weaker individuals of the same species.

2. Control Methods for Fish Predators

A. Physical Barriers

1. Netting

- Use of mesh or netting to create barriers around fish ponds, cages, or tanks can prevent predators like birds, otters, and fish-eating mammals from accessing fish.
- **Types:** Anti-bird nets, predator-proof fences, or cage nets.
- **Pros:** Effective in preventing access and can be used in combination with other methods.
- **Cons:** Can be costly to install and maintain; regular inspections are required to avoid wear and tear.

2. Floating Barriers

- Floating fences or barriers can be placed on water surfaces to prevent large predators (e.g., otters, birds) from entering the pond or cage.
- **Pros:** Effective in keeping larger predators away from fish.

- **Cons:** Can obstruct water flow and may be expensive for large-scale farms.

B. Deterrents

1. Bird Scaring Devices

- **Scarecrows, kites, or balloons** can be used to scare away birds like herons, cormorants, and kingfishers.
- **Sound Devices:** High-frequency sound generators or distress calls can deter birds.
- **Reflective Materials:** Items like foil strips or reflective tape can disorient and scare birds.
- **Pros:** Low cost and easy to set up.
- **Cons:** Predators can become accustomed to the deterrents over time, reducing effectiveness.

2. Electric Fencing

- Electric fences can be used around the perimeter of fish ponds or farms to deter land-based predators like otters and raccoons.
- **Pros:** Effective for terrestrial predators.
- **Cons:** Requires regular maintenance and monitoring.

C. Chemical Repellents

1. Non-Toxic Chemicals

- There are repellents available that can be sprayed around fish farms to keep predators like otters or birds away.
- **Pros:** Non-toxic and safe for the environment.
- **Cons:** Needs frequent reapplication, especially after rain.

D. Biological Control

1. Introducing Predators of the Predators

- In some cases, natural predators or competitors can help control

the predator population. For example, introducing species that can threaten or outcompete predatory fish species.

- **Pros:** A long-term, natural solution to predator control.
- **Cons:** Can alter the ecosystem and may lead to unintended consequences.

2. Fish Stock Management

- Some aquaculture operations use species that are less susceptible to predation, or can actively defend against predators (e.g., larger fish in the same pond that can outcompete or resist attacks).
- **Pros:** Cost-effective and low-maintenance.
- **Cons:** May not fully eliminate the problem, especially in ponds with smaller fish.

E. Trapping and Removal

1. Live Traps

- Live traps can be set for mammals like otters, raccoons, or mink. The captured animals can then be relocated.
- **Pros:** Humane and effective for individual predators.
- **Cons:** Requires ongoing monitoring and regular relocation.

2. Predator Control Programs

- Governments or environmental agencies may implement programs to control certain predator populations, such as otters or raccoons, to protect aquaculture.
- **Pros:** Organized and professional management of predator populations.
- **Cons:** May be subject to legal restrictions and regulations.

F. Habitat Management

1. Vegetation Control

- Reducing vegetation around ponds and farms can make the area less attractive for certain predators, particularly birds like herons or raccoons.
- **Pros:** Inexpensive and simple to implement.
- **Cons:** May reduce habitat for beneficial wildlife and can alter the ecosystem.

3. Integrated Approaches to Predator Control

For long-term predator management, an integrated approach combining several of the above methods is often most effective. For example:

- Using physical barriers (netting) together with scare devices (reflective tape or noise makers) to deter both bird and mammal predators.
- Combining electric fencing with habitat management (removing surrounding vegetation) to keep predators away from the farm.

Exercise

Choose the correct answer from the given alternatives.

1. What is the primary purpose of cleaning a fish pond before stocking fish?
   a. To improve fish growth
   b. To remove disease-causing agents and predators
   c. To increase oxygen levels in water
   d. To add nutrients to the water

2. Why is lime commonly applied to fish ponds?
   a. To kill fish predators
   b. To enhance the water's pH and reduce acidity
   c. To promote aquatic weed growth
   d. To increase the oxygen supply

3. Which type of lime is commonly used in fish ponds for maintenance?
   a. Slaked lime
   b. Quicklime
   c. Agricultural lime
   d. Dolomite lime

4. What is the first step in preparing a fish pond for stocking?
   a. Fertilizer application
   b. Water filling
   c. Cleaning and drying the pond bed
   d. Liming the pond

5. Which of the following is NOT a recommended practice for fish pond management?
   a. Regular removal of debris
   b. Overstocking fish to maximize production
   c. Monitoring water quality frequently
   d. Controlling aquatic weeds

6. Why are fertilizers used in fish ponds?

a. To increase fish biomass directly

b. To enhance the growth of phytoplankton and zooplankton

c. To reduce water evaporation

d. To improve water transparency

7. Which type of feed provides balanced nutrition for fish growth?

a. Raw vegetable waste b. Commercial pellet feed

c. Organic fertilizer d. Decomposing plant matter

8. What is an example of an organic fertilizer used in fish ponds?

a. Urea b. Poultry manure

c. Ammonium nitrate d. Superphosphate

9. Organic fertilizers are mainly used in fish ponds to.....

a. Directly feed the fish

b. Promote plankton growth for fish consumption

c. Reduce water pH

d. Prevent algae growth

10. Which chemical fertilizer is used as a nitrogen source in fish ponds?

a. Urea b. Potassium chloride

c. Superphosphate d. Ammonium sulfate

11. Overuse of chemical fertilizers in fish ponds can lead to.....

a. Reduced fish growth b. Eutrophication and oxygen depletion

c. Increased plankton diversity d. Improved water quality

12. Floating pellet feed is advantageous because.....

a. It sinks quickly to the pond bottom.

b. It helps monitor fish feeding activity.

c. It decomposes faster.

d. It requires less production cost.

13. What is the primary benefit of pellet feed in fish farming?

a. Reduces labor costs

b. Provides balanced nutrients for optimal fish growth

c. Prevents predation

d. Enhances pond aeration

14. Which of the following is a biological method to control aquatic weeds?

a. Application of herbicides b. Mechanical harvesting

c. Introducing grass carp d. Using aeration devices

15. A common problem caused by excessive aquatic weeds in fish ponds is.....

a. Improved water clarity b. Oxygen depletion in water

c. Faster fish growth d. Increase in pond temperature

16. Which of the following is an effective way to prevent bird predation in fish ponds?

a. Adding lime to water b. Covering the pond with nets

c. Increasing fish density d. Using herbicides

17. What is a natural way to control aquatic predatory fish in a pond?

a. Introducing scarecrows b. Using traps or fishing

c. Applying pesticides d. Draining the pond entirely

18. Which predator is most likely to attack fish in shallow water areas of the pond?

a. Birds b. Snakes

c. Aquatic insects d. Frogs

Write short answer to the following questions.

1. Write the process of cleaning fish pond.
2. Why is lime used in a fish pond?
3. Write in short about use of organic fertilizers in a fish pond.
4. Explain the common chemical fertilizers used in a fish pond.
5. What is pellet feed? Write the importance of using pellet feed in fish feeding.
6. How is aquatic weeds controlled in a fish pond?

Write long answer to the following questions.

1. Define fish predators with its types. Explain the different techniques to control fish predators.

Project Work

1. Visit nearby fish feed formulating plant and learn different feeds used for different age groups of fish.

Common Fish Disease, Prevention and Treatment

Unit 7

7.1 Fish Disease Caused by Parasite, their Treatment and Control Measure

1. Protozoan Parasites

Examples:

1. Ichthyophthirius multifiliis (Ich or White Spot Disease):

- **Symptoms:** White spots on skin, gills, and fins; rubbing against surfaces; lethargy.
- **Treatment**
  - Formalin, malachite green, or copper sulfate bath.
  - Salt baths (for freshwater fish): 1–3 g/L for 15–30 minutes.
- **Control**
  - Maintain water quality and temperature stability.
  - Quarantine new fish.

2. Trichodina spp.

- **Symptoms:** Mucus production, gill irritation, respiratory distress.
- **Treatment**
  - Formalin or potassium permanganate baths.
- **Control**
  - Regular cleaning of tanks and filtration systems.

2. Monogenean Parasites

Examples:

- **Gyrodactylus and Dactylogyrus spp. (Flukes)**
  - **Symptoms:** Skin and gill damage, mucus secretion, poor growth.
  - **Treatment**
    - Praziquantel or formalin bath.
  - **Control**
    - Remove dead fish promptly.
    - Regular monitoring of fish health.

3. Cestodes (Tapeworms)

Examples:

- **Bothriocephalus acheilognathi (Asian Tapeworm)**
  - **Symptoms:** Weight loss, intestinal blockage, poor growth.
  - **Treatment**
    - Praziquantel at 5–10 mg/L in water or incorporated in feed.
  - **Control**
    - Avoid feeding live or untreated feed that may harbor tapeworm larvae.

4. Trematodes (Flukes)

Examples:

- **Diplostomum spp. (Eye Fluke)**
  - **Symptoms:** Cataracts, blindness.
  - **Treatment**
    - Triclabendazole or praziquantel in feed.
  - **Control**
    - Remove snail intermediate hosts.
    - Use predator-proof netting to minimize bird hosts.

5. Nematodes (Roundworms)

Examples:

- **Camallanus spp.**
  - **Symptoms:** Protruding worms from the anus, reduced feeding.
  - **Treatment**
    - Levamisole or fenbendazole in feed.
  - **Control**
    - Avoid feeding live feed from infected sources.

6. Copepods (Crustacean Parasites)

Examples:

- **Lernaea spp. (Anchor Worm)**
  - **Symptoms:** Ulcers, inflammation around the parasite attachment site.
  - **Treatment**
    - Potassium permanganate dip.
    - Manual removal combined with antibiotics for secondary infections.
  - **Control**
    - Regular cleaning of water systems.
- **Argulus spp. (Fish Lice)**
  - **Symptoms:** Skin irritation, ulcers, lethargy.
  - **Treatment**
    - Organophosphate dips (e.g., trichlorfon).
  - **Control**
    - Quarantine infected fish.

7.2 Bacterial and Viral Disease, their Treatment and Control Measures

7.2.1 Bacterial Disease

1. Tail Rot Disease

Etiology

- Caused by opportunistic bacterial pathogens, primarily *Aeromonas* spp., *Pseudomonas* spp., or *Flexibacter columnaris*.
- Poor water quality, overcrowding, injuries, or stress predispose fish to this infection.

Clinical Signs

- Progressive fraying or necrosis of the tail and fins, starting at the edges.
- Fins may appear opaque, ragged, or discolored.
- In advanced cases, the infection spreads to the fin base and muscle tissue.

Treatment

- Secondary fungal infections might develop.
- **Isolation:** Quarantine affected fish to prevent the spread of infection.
- **Antibacterial Treatment**
  - Use broad-spectrum antibiotics like oxytetracycline or amoxicillin in the water or feed.
  - Apply medicated baths with potassium permanganate (2–4 mg/L) or salt (5–10 g/L) to reduce bacterial load.
- **Improve Water Quality**
  - Regular water changes and filtration to maintain optimal parameters.

Control Measures

- Maintain good water quality and avoid overcrowding.
- Minimize fish stress by reducing handling and providing hiding spots.

- Ensure proper nutrition and supplementation to boost immunity.
- Quarantine new fish before introducing them to the main tank.

2. Dropsy Disease

Etiology

- A symptom of underlying systemic infections, typically caused by bacteria (*Aeromonas hydrophila*, *Vibrio spp.*), viruses, or kidney/liver dysfunction.
- Poor water quality, sudden temperature changes, or stress weaken the immune system.

Clinical Signs

- Swollen or bloated abdomen due to fluid accumulation (ascites).
- Protruding scales (pinecone appearance).
- Bulging eyes (exophthalmos).
- Lethargy, loss of appetite, and abnormal swimming behavior.
- Redness or sores on the body in advanced cases.

Treatment

- **Isolation:** Separate affected fish immediately.
- **Antibacterial Treatment**
  - Use antibiotics like erythromycin, kanamycin, or tetracycline in feed or water.
  - Salt baths (5–10 g/L) can reduce osmotic stress and help fish expel excess fluids.
- **Supportive Care**
  - Improve water quality and maintain optimal parameters.
  - Provide a high-quality, easily digestible diet to boost recovery.

Control Measures

- Maintain high water quality (low ammonia, nitrate, and nitrite levels).
- Avoid sudden temperature or pH changes.
- Regularly clean tanks or ponds and avoid overfeeding.
- Quarantine new fish to prevent introducing pathogens into the system.
- Use probiotics or immune boosters in feed as preventive measures.

7.2.2 Viral Disease

Fish viral diseases vary by species and geographic region, but common examples include Infectious Hematopoietic Necrosis (IHN), Infectious Pancreatic Necrosis (IPN), Koi Herpesvirus Disease (KHVD), and Viral Hemorrhagic Septicemia (VHS).

1. Etiology

Viral diseases in fish are caused by various fish-specific viruses, including:

- **Rhabdoviruses**: Cause Viral Hemorrhagic Septicemia (VHS) and Infectious Hematopoietic Necrosis (IHN).
- **Herpesviruses**: Cause Koi Herpesvirus Disease (KHVD).
- **Birnaviruses**: Cause Infectious Pancreatic Necrosis (IPN).
- **Iridoviruses**: Affect marine and freshwater species, causing systemic infections.

Viruses spread through contaminated water, direct contact with infected fish, and vectors like birds or equipment.

2. Clinical Signs

Clinical signs vary depending on the virus, but common symptoms include:

- **General Symptoms**
  - Lethargy, loss of appetite, abnormal swimming behavior.
  - Increased mucus production and darkening of the body.

- **Specific Symptoms for Major Viral Diseases**
  - **VHS:** Hemorrhages on the skin, eyes, gills, and internal organs. Distended abdomen and pop-eye (exophthalmos).
  - **IHN:** Anemia, pale gills, and liquefied internal organs.
  - **KHVD:** Severe gill necrosis, erratic swimming, and high mortality in koi and common carp.
  - **IPN:** Abdominal distension, pale liver, and spiral swimming.

3. Treatment

There are **no direct antiviral treatments** for most fish viral diseases. Management focuses on supportive care and containment:

- **Quarantine:** Immediately isolate infected fish to prevent spread.
- **Improve Water Quality:** Maintain optimal water parameters (e.g., temperature, pH, dissolved oxygen).
- **Reduce Stress:** Minimize handling and avoid overcrowding.
- **Supportive Care**
  - Use salt baths (2–3 g/L) to alleviate osmotic stress.
  - Provide a high-quality diet to support the immune response.

4. Control Measures

Control focuses on prevention and biosecurity:

- **Hygiene**
  - Disinfect equipment, tanks, and water systems regularly.
  - Avoid sharing equipment between tanks or ponds.
- **Quarantine New Stock:** Keep new fish in isolation for at least 2–4 weeks before introducing them to existing populations.
- **Vaccination**
  - Effective vaccines are available for some viral diseases (e.g.,

KHVD and IPN in certain regions).

  - Vaccination should be tailored to species, age, and local disease risks.

- **Biosecurity Practices**
  - Prevent entry of wild fish or animals into cultured systems.
  - Use pathogen-free water sources.
  - Control movement of personnel and equipment between facilities.
- **Selective Breeding:** Use disease-resistant fish strains where available.
- **Early Detection:** Regular monitoring and diagnostic tests (e.g., PCR, ELISA) help detect viral outbreaks early.

Exercise

Choose the correct answer from the given alternatives.

1. Which of the following is a common parasitic disease in fish?
   a. Ichthyophthiriasis (*Ich*, white spot disease)
   b. Infectious Pancreatic Necrosis
   c. Koi Herpesvirus Disease
   d. Viral Hemorrhagic Septicemia

2. What is the primary treatment for *Ichthyophthirius multifiliis* (Ich)?
   a. Antibiotics
   b. Formalin, malachite green, or salt bath treatments
   c. Vaccination
   d. None of the above

3. Which of the following is a preventive measure for parasitic diseases in fish?
   a. Maintaining water quality and reducing fish stress
   b. Using antibiotics in feed
   c. Applying vaccination
   d. None of the above

4. Cause gill flukes in fish?
   a. Ichthyophthirius multifiliis
   b. Dactylogyrus
   c. Aeromonas hydrophila
   d. Pseudomonas spp.

5. Which treatment is effective against gill flukes?
   a. Antibiotics
   b. Praziquantel or potassium permanganate baths
   c. Vaccines
   d. None of the above

6. What is the causative agent of Columnaris Disease in fish?

a. Aeromonas hydrophila
b. Flexibacter columnaris
c. Pseudomonas fluorescens
d. Vibrio anguillarum

7. Which antibiotic is commonly used to treat bacterial infections in fish?

a. Erythromycin
b. Kanamycin
c. Oxytetracycline
d. All of the above

8. Which viral disease in fish is caused by a herpesvirus?

a. Viral Hemorrhagic Septicemia (VHS)
b. Infectious Hematopoietic Necrosis (IHN)
c. Koi Herpesvirus Disease (KHVD)
d. None of the above

9. How are bacterial diseases in fish commonly prevented?

a. Regular disinfection and maintaining water quality
b. Vaccination against specific bacteria
c. Quarantining new stock before introduction
d. All of the above

10. What is the main control strategy for viral fish diseases?

a. Antiviral medications
b. Supportive care, vaccination, and biosecurity measures
c. Formalin treatment
d. None of the above

11. What is a symptom of Viral Hemorrhagic Septicemia (VHS) in fish?

a. Hemorrhages on the skin and organs
b. White spots on the body
c. Frayed fins
d. Swollen abdomen

12. Which of the following is not a bacterial disease in fish?

a. Columnaris disease
b. Fin Rot
c. Dropsy
d. Koi Herpesvirus Disease

13. Which disinfectant is effective in controlling viral outbreaks in aquaculture?

a. Potassium permanganate
b. Chlorine
c. Iodophor
d. All of the above

14. What is the causative agent of Edwardsiellosis in fish?

a. Edwardsiella tarda
b. Vibrio anguillarum
c. Aeromonas salmonicida
d. Pseudomonas fluorescens

15. How can viral fish diseases be diagnosed?

a. Visual inspection
b. PCR or ELISA tests
c. Water quality testing
d. None of the above

Write short answer to the following questions.

1. Write the etiology, general symptoms, treatment, and control measures of White spot disease.
2. Write the etiology, general symptoms, treatment, and control measures of Tail rot disease.
3. Write the etiology, general symptoms, treatment, and control measures of Dropsy.

Write long answer to the following questions.

1. List any four viral disease of fish and explain the symptoms and control measures.
2. Write the etiology, clinical signs, treatment and control measures of Tail rot and White spot disease.

Unit 8

Harvesting, Marketing and Preservation of Fish

8.1 Stage and Time of Harvesting

The stage and timing of fish harvesting are crucial factors in determining the quality and value of the fish. Here are the main stages and considerations for harvesting fish:

1. Growth Stage

- **Fingerlings to Juvenile**: This is the early stage after hatching, and the fish are typically not ready for harvest. They are generally raised in hatcheries or ponds until they reach a certain size.
- **Market Size**: The fish reach the appropriate size and weight for market consumption. This is the stage when harvesting occurs. The timing for this stage depends on the species and the farming system.

2. Time of Harvesting

- **Harvest Timing for Different Species**: The optimal harvesting time varies by species. For instance:
  - **Salmon**: Harvested after 18 to 24 months of farming.
  - **Tilapia**: Typically harvested between 6 to 9 months.
  - **Catfish**: Usually harvested when they reach around 1 to 1.5 kg, which could take 6 to 12 months depending on farming conditions.
  - **Trout**: Usually harvested after 9 to 12 months, depending on environmental conditions.
  - **Seasonal Considerations**: In many cases, fish are harvested based on seasonal cycles, with specific attention paid to factors such as water temperature, oxygen levels, and feeding regimes.

- **Market Demand**: Harvesting may also depend on market conditions, where farmers harvest when prices are favorable or demand is high.

3. **Harvest Methods**
   - **Netting**: Fish can be captured with nets, particularly in ponds or lakes.
   - **Aquaculture Systems**: In systems like recirculating aquaculture systems (RAS), fish are often harvested manually or with mechanical systems.

4. **Timing for Optimal Quality**
   - **Before Spawning**: Fish are usually harvested before they spawn to avoid the energy depletion associated with reproduction, which can affect the quality and texture of the meat.
   - Post-Feeding: Fish are often harvested after a feeding cycle when they have the most body mass. Harvesting too early can result in lower yields.

8.2 Methods of Harvesting Using Nets: Fry Net, Drag Net, Gill Net, Cast Net, Majhi Jal

Here's a breakdown of the various methods of harvesting fish using nets:

1. **Fry Net**
   - **Purpose**: Fry nets are used for collecting very young fish, often called fry, right after hatching or during their early stages of growth.
   - **Design**: These nets typically have very fine mesh sizes to catch small fish without letting them escape. They are often used in hatcheries or nurseries.
   - **Method**: The fry net is gently dragged through the water to capture the small fish. It is used when the fish are still too small to be captured with larger nets.

2. **Drag Net**

- **Purpose**: Drag nets (or trawl nets) are used to harvest fish in large quantities, particularly in deep or open water.
- **Design**: This is a large net that is typically dragged behind a boat. The net can be dragged along the bottom (bottom trawling) or in midwater (pelagic trawling), depending on the target fish species.
- **Method**: A drag net is towed behind a boat or dragged by hand, and the fish are captured as the net moves through the water. This method is commonly used in both commercial fishing and aquaculture.

3. **Gill Net**

- **Purpose**: Gill nets are used to catch fish by entangling them in the mesh of the net. They are highly effective for targeting specific fish species based on their size and behaviour.
- **Design**: Gill nets have mesh sizes that are designed to catch fish by their gills, allowing their heads to pass through but not their bodies. The fish get stuck as they try to swim through the net.
- **Method**: The net is set vertically in the water, usually near the surface or at varying depths depending on the species being targeted. The fish swim into the net and get caught by their gills.

4. **Cast Net**

- **Purpose**: Cast nets are primarily used for catching small schools of fish in shallow waters. They are often used in ponds, rivers, or coastal areas.
- **Design**: Cast nets are circular with weights around the edge, which help them sink when thrown into the water.
- **Method**: The net is thrown by hand into the water, and when it sinks, it traps fish within its circular form. The fisherman then pulls the net back in to retrieve the catch. Cast nets are often used for catching baitfish or small fish.

5. Majhi Jal (or Mahajala)

- **Purpose**: Majhi jal is a traditional fishing method commonly used in South Asia, particularly in coastal areas of India, Bangladesh and Nepal.
- **Design**: It is a type of seine net, typically a large, long net with weights along the bottom and floats on the top, designed to encircle fish.
- **Method**: The net is deployed from a boat or by a group of people standing in water. One end of the net is placed in the water, and the other end is pulled towards the shore or a boat, trapping the fish inside. It is a very effective method for harvesting fish in shallow coastal waters.

8.3 Care and Maintenance of Fish Nets, Fishing Hook

Proper care and maintenance of fish nets and fishing hooks are essential for prolonging their lifespan, maintaining their effectiveness, and ensuring safety during fishing operations. Here is a guide to the care and maintenance of both:

Care and Maintenance of Fish Nets

1. Cleaning

- **After Use**: Clean the nets immediately after use to remove dirt, debris, algae, saltwater (for marine nets), or any fish residue. Use fresh water to rinse them off, especially if they have been used in saltwater, as salt can corrode the net fibers over time.
- **Washing**: For deep cleaning, soak the net in a mild detergent solution or use a soft brush to scrub off stubborn dirt. Avoid harsh chemicals or bleach, as they can degrade the net is material.
- **Drying**: After washing, hang the nets in a shaded area to dry completely. Avoid direct sunlight for prolonged periods, as UV rays can weaken the fibers of the net, especially nylon or polyethylene nets.

2. **Storage**

- **Proper Drying**: Always ensure the net is fully dry before storing it. Storing wet nets can lead to mold and mildew growth, which can degrade the material.
- **Cool, Dry Place**: Store nets in a cool, dry place to prevent exposure to heat or humidity, which can weaken the fibers. A storage bag or box can help protect them from dust and dirt.
- **Avoid Overstretched Storage**: Do not store nets in a manner that stretches them. Over-stretching can distort the net's mesh size and reduce its ability to catch fish.

3. **Repairs**

- **Check for Damage**: After each use, inspect the net for holes, tears, or frayed edges. Regularly check for wear and tear, especially on the net's edges and areas where fish tend to get entangled.
- **Mending Small Holes**: Small holes or frays can be repaired with a needle and thread, using netting twine that matches the original material. For larger tears, it might be the best to sew in a patch or replace the damaged section.
- **Reinforce Weakened Areas**: Areas of the net that experience heavy wear (e.g., the leadline or floatline) should be reinforced with additional twine or material to extend the net's lifespan.

4. **Avoiding Entanglement**

- **Untangle Knots**: Before storing, carefully untangle any knots that may have formed in the net to avoid permanent damage to the mesh.

Care and Maintenance of Fishing Hooks

1. **Cleaning**

- **Remove Salt and Debris**: After use in saltwater, rinse fishing hooks

with fresh water to remove salt and prevent corrosion. For hooks used in freshwater, rinse off mud, algae, or fish slime.

- **Drying**: After rinsing, dry the hooks thoroughly with a towel. Moisture left on hooks can lead to rusting, especially in hooks made of steel or iron.

2. **Storage**

- **Proper Storage**: Store hooks in a dry, cool place to prevent rust. A tackle box with individual compartments or a hook organizer is ideal for keeping hooks separated and easily accessible.
- **Rust Prevention**: To prevent rust, you can store hooks in an airtight container or use silica gel packs to absorb moisture. For additional protection, consider coating the hooks lightly with oil (e.g., vegetable or mineral oil) to create a barrier against moisture.

3. **Sharpness**

- **Sharpening**: Over time, fishing hooks can lose their sharpness. Use a hook sharpening tool or file to maintain a sharp point. A dull hook will struggle to penetrate the fish's mouth and can result in lost catches.
- **Testing for Sharpness**: To test a hook's sharpness, gently drag it across a piece of paper or your nail. If the hook does not catch, it needs sharpening.

4. **Inspection for Damage**

- **Check for Bends**: Hooks can become bent during fishing. Inspect hooks regularly to ensure they maintain their shape. If a hook is bent, use pliers to gently straighten it.
- **Check the Barb**: Ensure the barb is intact and free from damage. A damaged barb can cause the hook to lose its grip on the fish.

5. **Preventing Corrosion**

- **Use Anti-Corrosive Hooks**: Some hooks are coated with anti-corrosive

materials like nickel or stainless steel. These hooks are more durable and less prone to rust.

- **Avoid Exposure to Excessive Moisture**: When fishing in wet conditions, avoid leaving hooks exposed to rain or humidity. Wipe off hooks and tools after each use.

8.4 Harvesting Method

Fish harvesting methods vary depending on the type of fishing (e.g., commercial, aquaculture, recreational) and the environment (e.g., freshwater, saltwater). Here are some common methods used to harvest fish:

1. Nets

Nets are the most commonly used method for harvesting fish, whether in aquaculture or wild fishing. These include:

- **Gill Nets**
  - **Method**: Fish get caught by their gills in the mesh of the net. The mesh size is designed to catch fish of specific sizes.
  - **Use**: Popular for catching fish in lakes, rivers, or oceans. Often used for targeting larger fish like salmon or trout.
- **Drag Nets (Trawling)**
  - **Method**: A large net is towed behind a boat, either along the bottom (bottom trawl) or in mid-water (pelagic trawl). The fish are trapped as the net moves through the water.
  - **Use**: Commonly used in commercial fishing for large-scale fish harvests in deep water.
- **Cast Nets**
  - **Method**: A circular net with weights is thrown by hand into the water, spreading out like a disc. The net then sinks and traps fish within its perimeter.
  - **Use**: Effective for catching small fish in shallow waters or for catching baitfish.

- **Seine Nets (e.g., Majhi Jal)**
  - **Method**: A large net is deployed and pulled through the water by hand or boat, forming a barrier that traps fish. The net is typically drawn towards a shore or boat.
  - **Use**: Used for harvesting fish in shallow coastal areas, ponds, and rivers.
- **Fry Nets**
  - **Method**: Very fine mesh nets are used to catch juvenile or fry fish.
  - **Use**: Often used in aquaculture settings to collect young fish after hatching.

2. Hooks and Lines

- **Hand Lines**
  - **Method**: A fishing line with a hook is cast into the water. The fish is caught when it bites the hook.
  - **Use**: Common for recreational fishing and small-scale commercial fishing.
- **Long Lines**
  - **Method**: A main line with multiple baited hooks (sometimes hundreds) is set in the water to catch fish.
  - **Use**: Primarily used in commercial fishing for species like tuna or swordfish.
- **Traps and Pots**
  - **Method**: Fish traps or pots are baited and placed in the water, capturing fish when they swim inside.
  - **Use**: Used for catching specific fish species such as crabs, lobsters.

3. Aquaculture Harvesting Methods

- **Net Cages or Pens**

- **Method**: Fish are raised in floating pens or net cages in bodies of water (e.g., lakes, seas). When harvesting, the fish are removed from the netted areas using specialized equipment like seine nets or by hand.
- **Use**: Common in aquaculture for species like salmon, trout, or tilapia.

- **Harvesting by Grabbing or Using Scoops**
  - **Method**: In smaller-scale or hatchery operations, fish can be captured manually using scoops, nets, or other tools.
  - **Use**: Often employed for harvesting fish from ponds or small tanks.

4. **Electric Fishing**
   - **Method**: Electric current is applied to the water to temporarily stun fish, making them easier to collect.
   - **Use**: Mostly used for research or in areas where other methods are difficult or prohibited, such as catching invasive species.

5. **Spearfishing**
   - **Method**: Fish are caught using a spear, which is either thrown by hand or attached to a pole or spear gun.
   - **Use**: Recreational or artisanal fishing, often for larger fish or in specific environments like coral reefs.

6. **Trapping**
   - **Method**: Fish traps, often with bait, are placed in strategic locations. The traps are designed to allow fish to enter but make it difficult for them to escape.
   - **Use**: Common for species that are easier to trap than catch with nets or hooks, such as certain crustaceans and bottom-dwelling fish.

7. **Fish Harvesting in Ponds and Lakes**
    - **Method**
        - **Seining**: Large nets are used to surround and capture fish in ponds or lakes.
        - **Hand Harvesting**: In smaller systems or for specialty fish, fish may be caught by hand or with smaller nets.
    - **Use**: This is often done in fish farms or for capturing fish raised in controlled environments.

8. **Shocking (Electric Shocking)**
    - **Method**: Fish are stunned by an electrical current and then collected.
    - **Use**: Used in both research and fish farming, as well as in controlling invasive species or gathering fish from areas where nets are impractical.

9. **Hook and Line Harvesting (Sport Fishing)**
    - **Method**: This method involves catching fish one by one using rods, reels, and baited hooks.
    - **Use**: This method is primarily for recreational or small-scale commercial fishing. This method allows for selectivity and targeting specific fish species.

10. **Fish Farming Harvesting Methods**
    - **Net Harvesting**: When fish are raised in cages or ponds, they are typically harvested using large nets or scoops, removing fish in batches.
    - **Method**: Fish are removed from the cages by hand or with a mechanical system (e.g., nets, pumps).

8.5 Use of Ice for Fish Transport

Ice is commonly used for fish transport to keep the fish fresh and prevent spoilage during transit. Here's how ice helps in the transportation process:

1. **Temperature Control**: Fish are highly perishable, and their quality

deteriorates rapidly if not kept at a low temperature. Ice keeps the fish chilled, slowing down the growth of bacteria and the breakdown of proteins, which helps preserve freshness.

2. **Water Absorption**: During transport, fish can excrete liquids. Ice, especially when packed in crushed or flake form, absorbs this liquid while maintaining a cold environment, preventing water contamination and keeping the fish dry.
3. **Reducing Stress**: Lowering the temperature during transport helps reduce stress on the fish, which can affect both their quality and survival rate. This is particularly important for live fish transport.
4. **Preservation Time**: By keeping the fish at temperatures near freezing, ice can extend the time before spoilage occurs, allowing for longer transport times. It also reduces the need for refrigeration units, which can be more costly.
5. **Transport in Different Forms**: Ice can be used in various forms:
    - **Block Ice**: Slow-melting, keeps fish cold for longer trips but requires careful handling to avoid breaking the fish.
    - **Crushed Ice**: Rapid cooling and easier to pack around the fish, but melts faster.
    - **Gel Packs or Ice Packs**: Used in smaller-scale or packaged fish shipments.
6. **Environmental Control**: In addition to cooling the fish, ice also helps maintain a stable environment inside transport containers, preventing fluctuations in temperature that can lead to spoilage.

8.6 Fish Packaging Method

Fish packaging is crucial for maintaining freshness, quality, and safety during transportation and storage. There are several methods used to package fish depending on the type of fish, the transport duration, and the intended market. Here are some common fish packaging methods:

1. **Ice Pack Packaging**
   - **Description**: Fish are packed in boxes with ice to maintain a low temperature. The fish are usually placed in polyethylene bags, or plastic or waxed cardboard boxes with ice placed around or on top of the fish.
   - **Purpose**: To keep the fish chilled during transit, preventing spoilage.
   - **Common Uses**: For both fresh and frozen fish; typically used in bulk transport.
   - **Advantages**: Inexpensive and effective for short- to medium-distance transport.
   - **Considerations**: Requires careful handling of ice to prevent excess moisture from affecting the fish.

2. **Vacuum Packaging**
   - **Description**: Fish are sealed in a vacuum-sealed plastic bag that removes air, which helps extend shelf life by reducing the growth of bacteria and preserving flavor.
   - **Purpose**: To prevent oxygen exposure, which can lead to spoilage, and to reduce freezer burn.
   - **Common Uses**: For fresh or frozen fish, particularly fillets and individual portions.
   - **Advantages**: Longer shelf life, improved presentation, and reduced risk of contamination.
   - **Considerations**: More expensive than ice packaging and requires specialized equipment.

3. **Modified Atmosphere Packaging (MAP)**
   - **Description**: This method replaces the air in the package with a gas mixture (usually a combination of oxygen, carbon dioxide, and nitrogen) to slow down the decay process.
   - **Purpose**: To preserve freshness and extend shelf life without freezing

the fish.

- **Common Uses**: For fresh fish that need to be stored for extended periods without freezing (e.g., supermarket fresh displays).
- **Advantages**: Extends shelf life and maintains the fish's texture and taste.
- **Considerations**: Requires specialized equipment and gas mixtures.

4. Frozen Packaging

- **Description**: Fish are frozen and then packaged in materials like plastic wrap, vacuum-sealed bags, or plastic containers.
- **Purpose**: To preserve the fish for long periods, preventing bacterial growth and maintaining quality.
- **Common Uses**: For both whole fish and fillets, especially in bulk or long-distance shipments.
- **Advantages**: Long shelf life, easier to store, and often reduces the cost of transportation.
- **Considerations**: Risk of freezer burn and possible loss of texture.

5. Canned Packaging

- **Description**: Fish are packed in metal cans along with brine, oil, or water and then sealed and heat-processed to kill bacteria and extend shelf life.
- **Purpose**: To preserve fish for long-term storage at room temperature.
- **Common Uses**: Canned fish products like tuna, sardines, and salmon.
- **Advantages**: Very long shelf life, easy to store and transport.
- **Considerations**: Once opened, the fish must be consumed quickly, and there are environmental concerns with canned packaging.

6. Polystyrene or Styrofoam Boxes

- **Description**: Fish are packaged in Styrofoam boxes that provide

insulation and help maintain low temperatures during transport.

- **Purpose**: To protect fish from temperature fluctuations and physical damage during transport.
- **Common Uses**: Widely used for both fresh and frozen fish, especially in bulk shipments.
- **Advantages**: Cost-effective, lightweight, and excellent thermal insulation properties.
- **Considerations**: Styrofoam is not environmentally friendly and is not biodegradable.

7. Corrugated Cardboard Boxes

- **Description**: Fish are packaged in sturdy, corrugated cardboard boxes, often lined with waxed paper or plastic for moisture protection.
- **Purpose**: To protect fish from physical damage during transport while allowing for proper ventilation.
- **Common Uses**: For bulk shipments of fresh fish, often in combination with ice or gel packs.
- **Advantages**: Lightweight, cost-effective, and recyclable.
- **Considerations**: Less insulation than Styrofoam, which may require additional cooling methods.

8. Gel Packs or Ice Gel Packaging

- **Description**: Gel packs are used to provide temperature control, often placed in sealed bags or boxes along with the fish.
- **Purpose**: To maintain a consistent cold temperature, especially for smaller shipments or when ice alone may not suffice.
- **Common Uses**: For small fish shipments or when exact temperature control is needed.
- **Advantages**: More flexible and reusable than traditional ice.
- **Considerations**: Typically more expensive than traditional ice.

9. Thermoform Packaging

- **Description**: Fish are placed in molded plastic trays, and the packaging is sealed with a clear plastic film.
- **Purpose**: To provide a convenient, attractive display while maintaining freshness.
- **Common Uses**: For retail fish packaging, especially fillets and other processed fish products.
- **Advantages**: Offers clear visibility for consumers and is convenient for handling.
- **Considerations**: Requires specialized equipment for molding and sealing.

8.7 Explain Fish Preservation Methods: Salting, Smoking, Freezing and Canning

Fish preservation methods like salting, smoking, freezing, and canning have been used for centuries to extend the shelf life of fish and make it safe for consumption over long periods. Here is an overview of each method:

1. Salting

- **Description**: Salting is a method of preservation where salt is applied to fish, either by dry salting (rubbing salt directly on the fish) or wet salting (soaking the fish in a brine solution). The salt draws out moisture from the fish, which inhibits the growth of bacteria and other spoilage microorganisms.
- **Process**
  - **Dry Salting**: Fish are coated with salt and stacked, often with layers of salt in between.
  - **Brining**: Fish are immersed in a solution of saltwater, sometimes with added spices or flavorings.
  - **Purpose**: Salt reduces the water activity in the fish, making it

inhospitable for bacteria and enzymes that cause spoilage.

- **Common Uses**: Used for both small and large fish, such as cod, herring, and anchovies. Often a precursor to other methods like smoking or drying.

- **Advantages**
  - Extended shelf life without refrigeration.
  - Provides unique flavor (e.g., in salted cod).
- **Considerations**
  - Salted fish can be very salty, requiring soaking or rinsing before cooking.
  - Requires proper storage in a cool, dry place.

2. Smoking

- **Description**: Smoking fish involves exposing it to smoke from burning wood, usually in a smoker or smokehouse. The smoke acts as a preservative by inhibiting bacterial growth and adding flavor to the fish.
- **Process**
  - **Cold Smoking**: Fish is smoked at temperatures below 90°F (32°C), which imparts flavor without cooking the fish.
  - **Hot Smoking**: Fish is smoked at higher temperatures (around 150°F–185°F or 65°C–85°C), cooking the fish while also preserving it.
- **Purpose**: Smoking dries the fish and creates a protective layer of compounds that prevent spoilage.
- **Common Uses**: Salmon, mackerel, trout, and herring are commonly smoked.
- **Advantages**
  - Enhances flavor with a distinct smoky taste.

- Provides a shelf life extension without refrigeration if properly stored.

- **Considerations**
  - Hot smoking imparts a cooked texture, while cold smoking preserves the raw texture.
  - Requires specialized equipment and proper storage to prevent contamination.

3. **Freezing**
   - **Description**: Freezing preserves fish by lowering the temperature to below 32°F (0°C), which halts bacterial growth and slows down enzymatic processes that can lead to spoilage.
   - **Process**
     - Fish is cleaned, gutted, and often packaged before being frozen.
     - Quick freezing is preferred to maintain quality by forming smaller ice crystals that do less damage to the fish tissue.
   - **Purpose**: Freezing maintains the freshness of fish and can preserve it for months or even years if stored properly.
   - **Common Uses**: Widely used for fish like tuna, salmon, cod, and haddock, and in the commercial fishing industry.
   - **Advantages**
     - Maintains flavour, texture, and nutritional value.
     - Easy to store and transport.
   - **Considerations**
     - Freezer burn can occur if the fish is not properly packaged, leading to a loss of flavor and texture.
     - Requires access to a freezer, which may not be available in some regions or for long-distance transport.

4. **Canning**

- **Description**: Canning involves placing fish in a can with brine, oil, or water and then sealing the can and heating it to destroy bacteria and enzymes, effectively sterilizing the contents.
- **Process**
  - Fish is cleaned, filleted (or left whole), and packed into cans with a preservative liquid.
  - The cans are then heated to a high temperature to kill bacteria and create a vacuum seal.
- **Purpose**: Canning provides long-term preservation of fish by sterilizing the contents and creating an airtight seal that prevents contamination.
- **Common Uses**: Tuna, salmon, sardines, and mackerel are frequently canned.
- **Advantages**
  - Very long shelf life, often several years.
  - Convenient and easy to store at room temperature.
  - Does not require refrigeration.
- **Considerations**
  - Fish can lose some texture and flavour during the canning process.
  - Cans need to be checked for dents or rust, which can compromise the seal and allow spoilage.

8.8 Fish Transportation and Packaging Method

(It has been discussed earlier)

8.9 Importance of Fish Marketing

Fish marketing plays a crucial role in the fisheries sector by ensuring that fish and fish products reach consumers efficiently, profitably, and sustainably. It involves a range of activities from capturing, processing, and packaging to transportation,

distribution, and retailing. Here are several key reasons why fish marketing is important:

1. **Economic Contribution**
    - **Revenue Generation**: Fish marketing contributes significantly to the income of both small-scale and commercial fishers, processors, wholesalers, and retailers. Efficient marketing systems help maximize the value of fish by connecting producers with consumers.
    - **Job Creation**: The fish marketing sector provides employment in various stages of the supply chain, from fishing and processing to distribution and retail.
    - **Economic Stability**: In regions heavily dependent on fishing, marketing is essential to ensure that fishery-based economies remain stable and sustainable.

2. **Ensures of Efficient Distribution**
    - **Access to Markets**: Effective marketing ensures that fish and fish products reach local, national, and international markets efficiently, increasing the availability of fish to consumers. This is particularly important in regions where fresh fish is highly sought after.
    - **Reducing Wastage**: By having organized supply chains and efficient logistics, fish marketing reduces post-harvest losses and waste, ensuring that more fish are sold and consumed rather than spoiled.
    - **Retail Accessibility**: A well-developed marketing system helps fish reach consumers in diverse forms (fresh, frozen, canned, smoked), offering variety and convenience in retail stores, markets, and online platforms.

3. **Supports Sustainability and Fisheries Management**
    - **Sustainable Fisheries**: Marketing can help promote sustainably sourced fish products, such as those certified by organizations like

the Marine Stewardship Council (MSC), helping consumers make informed choices. Sustainable practices in fishing can be supported through market demand for responsible products.

- **Encourages Responsible Fishing**: When fishers are assured that their catch can be sold profitably, they may be more inclined to adhere to regulations regarding quotas, fishing seasons, and protected species.
- **Improving Fisheries Management**: Effective marketing can provide valuable feedback to policymakers and stakeholders, helping to track fish demand trends and supporting better fisheries management.

4. Increases Consumer Awareness

- **Promoting Healthy Eating**: Fish is a valuable source of protein, omega-3 fatty acids, and other nutrients. Marketing can help educate consumers about the health benefits of consuming fish and encourage better eating habits.
- **Highlighting Fish Varieties**: Fish marketing helps introduce consumers to different species of fish that may not be familiar, broadening their dietary options and diversifying demand.
- **Promoting Processed Products**: Fish marketing allows the promotion of processed fish products (like canned fish, fish fillets, and frozen fish), offering consumer's convenient and affordable options.

5. Increases Fish Value

- **Product Differentiation**: Marketing can enhance the value of fish products by promoting their quality, freshness, and unique characteristics, allowing for price differentiation. For instance, sustainably sourced or premium-quality fish can be marketed at higher prices.
- **Value-Added Products**: Fish marketing encourages the development of value-added products such as fish fillets, smoked fish, and fish-based ready-to-eat meals, increasing the profitability of the sector.

- **Branding**: Marketing creates opportunities for branding, where specific types of fish or fish products are associated with particular regions, enhancing their appeal and reputation.

6. **Facilitates Export and International Trade**
   - **Global Market Access**: Effective marketing systems enable fish products to be exported to international markets, opening up new revenue streams and diversifying the customer base. Countries with strong fish marketing strategies can tap into global demand, particularly for high-demand fish species like salmon, tuna, and shrimp.
   - **Adhering to International Standards**: Marketing also involves ensuring that fish products meet international standards and certifications for quality, hygiene, and sustainability, which are essential for successful export.

7. **Promotes Fair Trade and Equity**
   - **Empowering Small-Scale Producers**: Proper marketing mechanisms, such as cooperatives or direct-to-consumer models, can help small-scale fishers and processors gain access to markets and achieve fair prices for their products, improving their livelihoods.
   - **Improving Rural Economies**: In many developing countries, fishing communities are often in rural areas. Fish marketing systems provide these communities with access to broader markets, raising their standard of living and reducing rural poverty.

8. **Enhances Traceability and Food Safety**
   - **Ensuring Quality Control**: Proper marketing involves maintaining the quality and safety of fish products. This includes proper packaging, storage, and transportation that meet hygiene standards to reduce the risk of contamination and spoilage.
   - **Consumer Confidence**: Through proper fish marketing and

certification, consumers can have confidence that the fish they purchase is safe, traceable, and meets food safety regulations.

- **Combatting Illegal, Unreported, and Unregulated (IUU) Fishing**: Marketing can help trace the origin of fish products, reducing the chances of illegally caught fish entering the market. Consumers are increasingly concerned with ethical sourcing, and transparent marketing can address these concerns.

9. Supports Technological Innovation

- **Adoption of New Technologies**: The growth of fish marketing can drive the adoption of new technologies in fishing, packaging, and transportation. For example, innovations in cold chain logistics, packaging materials, and e-commerce platforms improve the efficiency and sustainability of fish marketing.
- **Market Research**: Marketing involves analyzing consumer preferences, emerging trends, and market demands, helping the industry innovate and adapt to changing needs (e.g., the rise in demand for plant-based fish alternatives or aquaculture products).

10. Cultural and Social Importance

- **Promoting Cultural Foods**: Fish is a significant part of the diet in many cultures. Through marketing, traditional fish dishes and products can be promoted to preserve cultural practices and support local food systems.
- **Connecting Consumers with Fisheries**: Fish marketing helps bridge the gap between consumers and the producers (fishers and aquaculture farmers), raising awareness of the challenges and opportunities in the fish industry and fostering a connection between communities and their local resources.

Exercise

Choose the correct answer from the given alternatives.

1. The best time to harvest fish is usually .....

   a. During early morning or late evening

   b. In the middle of the day

   c. Anytime during the rainy season

   d. During extreme heat

2. At what stage fish are typically harvested for maximum profit in aquaculture?

   a. Fry stage b. Fingerling stage

   c. Marketable size d. Breeding stage

3. Which of the following nets is used for collecting fry from ponds or tanks?

   a. Gill net b. Cast net

   c. Drag net d. Fry net

4. A drag net is best suited for harvesting fish from.....

   a. Deep waters b. Shallow ponds or tanks

   c. Rapid rivers d. Ocean waters

5. What is the primary function of a gill net?

   a. Trap fish by their gills b. Catch fish using bait

   c. Drag fish to the shore d. Scoop fry from shallow water

6. Fish nets should be dried after use to.....

   a. Reduce wear and tear

   b. Prevent microbial growth and rotting

   c. Improve flexibility

   d. Increase fish-catching efficiency

7. Rust on fishing hooks can be prevented by.....

a. Storing them in water

b. Applying oil or grease

c. Wrapping them in plastic sheets

d. Leaving them exposed to air

8. What is the major advantage of using nets over traditional fishing methods?

a. Requires less labor

b. Selective harvesting of fish sizes

c. High efficiency and catch volume

d. Inexpensive equipment

9. Which harvesting method is most eco-friendly in natural water bodies?

a. Gill nets b. Trawling

c. Cast nets d. Explosives

10. The main purpose of using ice during fish transport is to.....

a. Increase fish weight

b. Improve flavor

c. Reduce spoilage by slowing bacterial growth

d. Make the fish look fresh

11. What is the recommended fish-to-ice ratio for preservation during transport?

a. 1:1 b. 2:1

c. 1:2 d. 3:1

12. Which material is commonly used for fish packaging during transport?

a. Plastic containers and ice boxes b. Wooden crates without ice

c. Paper bags d. Metal boxes

13. Vacuum packaging of fish is primarily done to.....

a. Reduce weight for transport

b. Eliminate air and slow down spoilage

c. Add flavor to the fish

d. Make packaging more attractive

14. Salting as a fish preservation method works by.....

a. Freezing bacteria

b. Lowering water activity and inhibiting bacterial growth

c. Killing bacteria with high temperatures

d. Coating fish with a protective layer

15. Which fish preservation method involves removing moisture using smoke?

a. Freezing

b. Salting

c. Smoking

d. Canning

16. Canning preserves fish by.....

a. Freezing them in cans

b. Cooking and sealing them in airtight containers

c. Applying salt before storing in cans

d. Using chemical preservatives in cans

17. Live fish are commonly transported using.....

a. Aerated tanks or oxygen bags

b. Freezers with ice

c. Dry wooden boxes

d. Paper bags with ice cubes

18. What is an essential consideration during fish transportation?

a. Use of preservatives

b. Maintenance of oxygen levels and temperature

c. Increasing water turbulence

d. Reducing ice usage

19. Fish marketing is important because.....

a. It maximizes profit for fish farmers and distributors

b. Reduces fish demand

c. Increases fishing effort

d. Prevents fish from being consumed locally

20. Which factor plays a significant role in fish marketing?

a. Market location, quality control, and pricing

b. Reducing fish variety

c. Using advanced fishing techniques

d. Avoiding local markets

Write short answer to the following questions.

1. Write short notes on:

a. Stage and time of harvesting of fish

b. Methods of harvesting.

c. Care and maintenance of fish nets

d. Use of ice for fish transport

e. Fish packaging method

2. How is fish transported? Explain in brief.

3. List out the importance of fish marketing

Write long answer to the following questions.

1. Describe the methods of fish preservation.

Unit 9

Utilization of Village Ponds in Fish Culture

9.1 Management and Utilization of Old Ponds

Fish farming is possible in the aquatic environment. A larger number of fish farming in Nepal is practiced in old and poor fish pond. Culturing the fish in the old pond does not give a satisfactory yield. Management and utilization of old fish pond helps to minimize the cost of production in one hand and increase the production in other hand. For proper management and utilization of old fish pond following points should be followed:

a) Proper Pond Preparation

— Draining and leveling of pond bottom.

— Eradication of competitors and predators by poisoning or manually.

— Check the dike leakage to prevent unnecessary loss of nutrient and water.

— Application of lime if necessary.

— Application of fertilizer to condition the soil and generate growth of natural food.

— Installation of fine meshed (6mm) screens at the gate to prevent the entry of predatory and competatory species.

— Maintenance of water depth to ensure the growth of sufficient fish food and good water quality.

c) Proper Handling of Fish Stock

— Unnecessary stress in handling is avoided to prevent mortality.

d) Proper Pond Management

— Subsequently application of fertilizers (organic and inorganic) to sustain desirable growth of natural fish food.

— Occasional water freshening to maintain good pond water.

— Applying supplemental feed if natural food is insufficient.

— Routine management as daily routine, weekly routine, monthly routine and after each cropping/ draining management is needed.

9.2 Conservation and Management of Natural Water Bodies

Water conservation encompasses the policies, strategies and activities made to manage fresh water as a sustainable resource, to protect the water environment, and to meet current and future human demand. Population, household size, and growth and affluence all affect how much water is used. Factors such as climate change have increased pressures on natural water resources especially in manufacturing and agricultural irrigation. Standing water bodies include a wide variety of aquatic habitats such as lakes, pools, ponds and tarns. They are refuges for rare protected aquatic plants and animals (amphibians, reptiles, birds, etc.) and are therefore key elements of a biotope network. At appropriate sites, they can be networked with other wetlands and with flowing waters. Standing water bodies are often drained or filled in so that they can be used for other purposes, making their conservation particularly important. Management interventions may be helpful in keeping smaller standing water bodies clear; they may also be conducive to various siltation stages and beneficial to habitats and the transformation of nutrient-rich and silted-up water bodies into near-natural ecosystems. The creation of standing water bodies (e.g. as protected areas for amphibians) is also an option, although conservation should take precedence over the creation of new small water bodies.

The goals of water conservation efforts include:

— Ensuring availability of water for future generations where the withdrawal of fresh water from an ecosystem does not exceed its

natural replacement rate.

— Energy conservation as water pumping, delivery and waste water treatment facilities consume a significant amount of energy. In some regions of the world over 15% of total electricity consumption is devoted to water management.

— Habitat conservation where minimizing human water use helps to preserve

— fresh water habitats for local wildlife and migrating waterfowl, but also water quality.

Management

The Water Resources Management Division is responsible for water resources management as per provisions of the Environmental Protection Act and the Water Resources Act. The Division has programs to protect, enhance, conserve, develop, control and effectively utilize the water resources of Nepal. About 97% of the total available water on earth is contained in ocean and hence saline in nature. Out of the balance 3% which is available as fresh water about 2% is contained in ice inaccessible region and 0.75% as ground water. Out of remaining 0.25%, only about 0.01% is available in lakes and rivers at any given time and the rest occurs as glaciers and snow. The total water contained in the atmosphere is still less and is of the order of 0.001% of the total available water. Therefore the surface water which can be readily utilized by the society is very small. Even the surface runoff that flows in the river of the world mostly goes wasted since it flows down to the ocean in absence of the proper storage for the source. It is estimated that about 96% of the total annual surface runoff goes and join the sea and is thus not to put any worthwhile use. This large scale wastage of the surface water flow is done true in Nepal because out of 225 billion cubic meter of annual surface flow, only 2% is utilized in our country and the rest drain down to Indian plain passes through the large Genetic plains of India and enters Bangladesh before it finds drain down to the Bay of Bengal and join the sea.

Management of Natural Water Resource

- Development and management of water resources shall be undertaken in a holistic, systematic manner, relying on integrated water resources management.
- Water utilization shall be sustainable to ensure conservation of the resource and protection of the environment. Each river basin system shall be managed holistically.
- Delivery of water services shall be decentralized in a manner that involves autonomous and accountable agencies (e.g., public, private, community and user-based agencies).
- Economic efficiency and social equity shall guide water resource development and management. Participation of and consultation with all the stakeholders shall constitute the basis of water sector development.
- Sharing of water resource benefits among the co-riparian countries shall be on an equitable basis for mutual benefit.
- Institutional and legal frameworks for coordination and transparency shall be an essential feature of water sector management.
- Wider adoption of the best existing technologies and practices, and rapid innovation and adaptation of both institutional arrangements and new technologies, shall be ensured.

9.3 Enclosure and Cage Culture in Natural Water Bodies

Pen Culture

A Pen is defined as "a fixed enclosure in which the bottom is the bed of the water body". Pen is to be distinguished from the Cage which in turn is defined as "an enclosure with bottom and sides of netting or bamboo etc., whether floating at the surface or totally submerged." The word 'pen' here is also used synonymous with 'enclosure' as it is used in enclosure culture.

Advantages and Disadvantages of Pen Culture

The advantages and disadvantages of pen culture are in some cases common as those for cage culture. Obviously the pens are much larger and are stationery as their walls are fixed. It also appears that in large pens the culture will be less intensive, even though small pens can vie with the cages in this respect. The taxability (or mobility) of the cage is its most definite advantage over the pen, but the later has the benefit that there can be interchange between the organisms within, with the natural bottom - at times of an inclement condition in the bottom the pen is decidedly difficult. Let us now enumerate the advantages and disadvantages of pen culture.

Advantages

i. Intensive Utilization of Space

As we have mentioned the requirement of a pen can be small (a few square metres) or large (over 100ha in the case of the largest milkfish pen), but in all cases the space given is intensively utilized. Even in the large milk fish pens utilize space intensively and their production is 4 – 10 times higher than the natural production. We have already referred to the high production (per unit area) above, that productions even in the large pens are much higher, not only because of the intense culture practices adopted, but also due to other factors such as protection from predators.

i. Safety From Predators

Within the enclosure, the predators can be excluded. Before stocking the predators will have to be removed; in the larger pens this would be more difficult, but in smaller pens this can be done as efficiently as in the cages (see also discussion following).

ii. Suitability for Culturing many Varied Species

Under artificial culture provided suitable environmental conditions are maintained, with artificial feeds, many varieties of species can be cultured as in the cage.

iii. Ease of Harvest

Even though in the large pens the harvest may not be as easy as in the cages, it would be definitely more controllable and easier than in the natural waters.

iv. The Flexibility of Size and Economy

When compared with the cage, pens can be made much larger and construction costs will be cheaper than that of the cages.

v. Availability of Natural Food and Exchange of Materials with the Bottom

Since, as pointed out earlier, the bottom of the pen is the natural bottom, unlike the cage which kept either on the bottom or floating, has always a netting/ screen separating the cage from bottom; the pen culture organisms are at an advantage that while enclosed they can procure food/exchange materials. Pen culture as cage culture is economical multiple use of same water body

Disadvantages

i. High Demand of Oxygen and Water Flow

Since the fish cultured are stocked in high density they deplete oxygen very fast and a good flow of water through the pen either by natural means or artificially by pumping is demanded for healthy and fast growing fishes.

ii. Dependence on Artificial Feed

Since high density (biomass) is to be sustained in a restricted area, for high production artificial feeding is necessary, increasing the cost of production.

iii. Food Losses

Part of the feed is likely to be lost uneaten, and drifted away in the current, but the loss here would be less than in floating cages.

iv. Pollution

Since a large biomass of fish are cultured intensively a large quantity of excrements accumulate in the area and cause a high POD - also substances such

as ammonia and other excreted materials, if not immediately removed/ recycled. They pollute the water and cause damages.

v. Rapid Spread of Diseases

For the same reason of high stocking density in an enclosed area, any disease beginning will spread very quickly and can cause immense mortality of stock and production decline.

vi. Risk of Theft

Since the fish are kept in an enclosed area, 'poaching' and thefts can take place more frequently than in natural waters, but perhaps less than those from cages.

vii. Conflict with Multiple use of Natural Waters

In locations where a pen is constructed to the requirement of higher water level for example. In a lake/reservoir, would be against the interest, for example. For irrigation water supply; enclosures can interfere with navigational routes and also with recreational activities, such as swimming, boating etc.

Types of Pen

1. Rigid pens

a. Embanked pens

b. Net enclosures

2. Flexible Pens (netting)

3. Outer barrier nets.

1. Rigid Pens

a. Embanked Pens

Intertidal enclosures such as those at Adoike in the Inland Sea in Japan and Ardtoe in Britain are the examples of rigid enclosures which have stone-pitched or concrete walls as embankments since such embankments are costly; such intertidal enclosures are not being built lately.

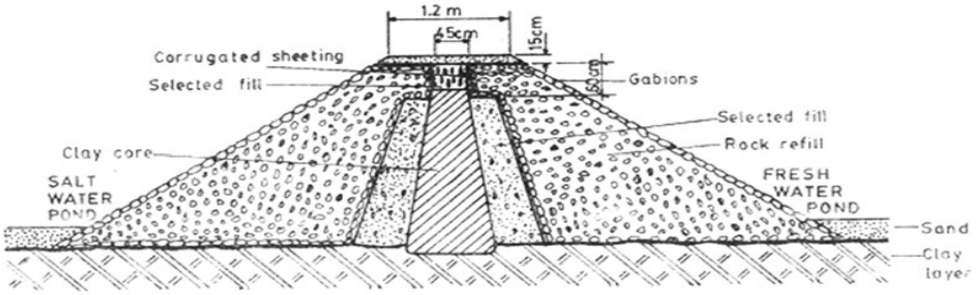
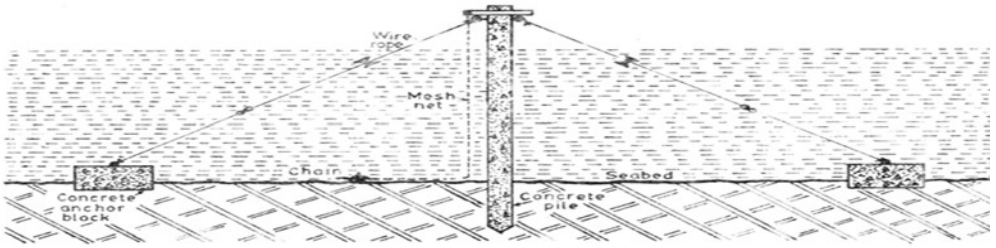


Fig : Embanked pens

b. Net Enclosures

We have already referred to the several rigid net enclosures (including barrier nets) in our review of pen culture in various parts of the world. While the gross descriptions have been given earlier we shall now refer to certain specific aspects of design and construction here. The extended length of the barrier as provided by the shape of the barrier ensures better circulation. A vinyl covered wire not (15mm square mesh) is stretched between steel piles and smaller concrete blocks on two sides of the barrier restrain the net barrier. The barrier also incorporated floating boom for passage of boats.



2. Flexible Enclosures

Most of the buoyed fish net enclosures known are bag nets with a bottom net - as per our definition this enclosure is a ‘cage’ (and not a pen/enclosure) even if the bottom net may rest on the floor. In fabricating the flexible enclosure care was taken to make use of locally available simple materials (cf. Bamboo mat replacement), even though Japanese 9.5mm (3/8") nylon net, which has antifouling properties and long life as opposed to the one-year life Philippine

nylon net, was used. Concrete block sinkers weighing 500kg were spaced 30m apart and were placed from a boat and a chain link raiser chain was provided from the sinker for attachment to the net to allow settlement in the soft sediment. The average depth of Laguna de Bay varied from 3 to 5m and therefore a 7.5m height of net was chosen to allow billowing due to water current and wave motion. In the case of the bamboo pen the fencing stretched above water surface to prevent fish from jumping, but in the present net, a 2.5m horizontal flap was provided on top with float, which effectively prevented fish jumps and also helped as a fish seal when water level rose unprecedented, for the top floats help adjust the stretching of the net into a vertical wall.

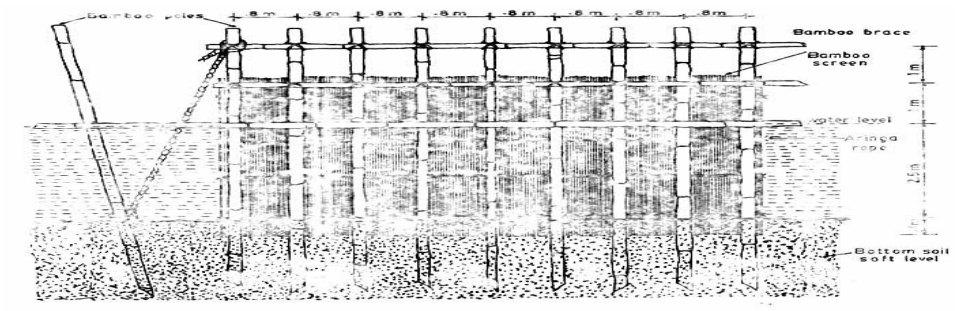


Fig.58: Flexible Enclosures

Cage Culture

Cage fish culture is a new area of fish culture in Nepal. Fishermen did not know about it although they have been using some cage-like bamboo traps for fishing. Cages for keeping common carp breeders in the Pokhara Valley lakes of Nepal was started in 1972 as the Government fish ponds near the lake suffered occasionally from water shortage. Later, a few cages introduced by the J.O.V.C. Services were used for rearing fish but remain as demonstration cum-study unit. In 1975, an Integrated Fisheries and Fish Culture Development Project in the Western Development Region of Nepal were started by the Government and UNDP/FAO. Under the project, many types of cages both locally made and imported ones have been tried in an attempt to increase the fish production from the three major lakes of Pohara Valley. The lakes lie in mid-hilly region and have

been reportedly overfished. The primary aim was to engage some 300 landless local fishermen families in fish cultivate.

Like most other types of aquaculture, cage culture began in Southeast Asia, although it is thought to be of comparatively recent origin. It seems to have developed independently in at least two countries. the oldest records of cage culture come from Kampuchea where fishermen in and around the Great Lake region would keep *Clarias spp*. catfishes and other commercial fishes in bamboo or rattan cages and baskets until ready to transport to market. In captivity, the fishes were fed kitchen scraps and were found to grow readily. This traditional method of culture has been practiced since the end of the last century, and is now widespread throughout the lower Mekong area of the country. From here it has spread in recent year to Viet Nam, Thailand and other Indo-Chinese countries.

The total natural production of fish from the lakes and rivers in the Pokhara Valley has been estimated to be around 23–25 tons per year. The catch consists of indigenous species of which mahaseer (*Tor tor*), catle (*Barbus hexagonolepis)*, asla (*Schizothorax spp.)* and baam (*Mastacembelus spp.)* are most sought after by the consumer. The bulk of the catch, however, consists of smaller species of fish which are consumed when the better quality fish are unobtainable. In recent years some stocking has been carried out in the lakes of the Pokhara Valley with common carp and Chinese carps, as well as the Indian major carp rohu (*Labeo rohita*). These have recently begun appearing in small numbers in the fish catches and have been readily accepted by the consumer.

On the basis of statistical studies the catches from the three major lakes for the period March 1977 - February 1978 have been estimated to be 7.5 t for Phewa, 5.5 t for Begnas and 3 t for Rupa. Ferro (1979b) estimates that the natural production could be raised to about 20 t in Phewa, and about 15 t each for Begnas and Rupa, through appropriate stocking and adoption of conservation measures. Ferro (1979b) also mentioned that cage fish culture could be more effective in harvesting the lakes than natural fishing. Plankton is available in the lakes and

could be utilized by plankton feeding fish while others, such as the grass carp and common carp, would depend on feed introduced into the cages.

Construction and Design of Cages

Bamboo Cages

Cages from locally available material like chicken wire mesh and split wood were tried. These were set in shallow water about 2-2.5 m deep. These did not work well because of fluctuating Lake water level even as the chicken wire mesh started rusting after 6 months only. At present, split bamboo cages with enamel painting are under study. They are of 10 m3 size (2 x 2 x 2.5 m3) and 8 m3 (2 x 2 x 2 m3) size. Durability tests of such cages with coal tar painting are being planned. The bamboo could last for about 2 years as a float as well as for framing material using knotless polyethylene net.

source: www.google.com.np/search?q=bamboo+cage Fig.59: Bamboo cage

Iron Angle and Netlon Plastic Cage

Iron angles of 13 mm or 19 mm were welded together to form a frame of 4 x 4 x 2.5 m3 and netlon plastic mesh of 10 mm or 5 mm was fixed with the nylon twines in the angle-iron frame. Four 200- liter empty oil drums were mounted in welded frames to float the cage at a depth of 2 meters making the productive volume of the cage 32 m3 or 4 x 4 x 2 m3 . The cage was divided into two compartments by a partition of netlon mesh so that fish of different sizes could be kept separately. The cages were provided with a top cover of chicken wire mesh or old nets. Walkways of woods and bamboo were made by fixing them on

the drums. The durability of such cages has been estimated to be about 10 years with minor repair and maintenance.

The advantages of cage culture of fish are as follows:

Since there is constant circulation of water through the meshes of the cages, there is relatively less accumulation of metabolic wastes, and constant renewal of oxygenated water within the cage. This enables higher stocking rates and consequently, higher production per unit volume than in ponds. The raising of fish in cages also reduces the risk of predation by carnivorous fish and other animals. The main constraint would be feed, which has to be introduced in the case of species depending on non-plank tonic food. In contrast to natural fishing, where fishermen have to depend on chance, raising fish in cages enables a predictable and more assured source of income. Better management and control of stocks is also possible.

9.4 Trout Culture and Production Technology

Rainbow trout (*Oncorhynchus mykiss*) is a cold-water carnivorous sport fish of North America, which was taken to California, Alaska, Asia and Europe

during different periods of 19th century. Among which, Japan is one of the largest producers of rainbow trout, where this species was introduced in 22 1877. Rainbow trout requires high protein feed and well oxygenated water for its cultivation. In natural habitat it feeds on aquatic insects, small crustaceans and small fish. Nevertheless, it can be cultured using artificial feed containing high animal protein. Trout can survive within a temperature range of 0-25°C. However, it grows best at the water temperature range of 10-20°C. Normally, the trout attains commercial size of 200300gm within 14 to 20 months. Its growth depends on the quality and quantity of feed, suitable temperature and dissolved oxygen concentration in the water.

Considering the suitable climatic condition and abundance of cold water, juvenile brown trout (Salmo trutta) were introduced from India for the first time during late 1969; and Rainbow trout (Oncorhynchus mykiss) from the United Kingdom in 1971. They were distributed in two places. Few hundred juveniles were kept in Godawari in a cement tank and the rest of them were transported to a newly established Trishuli Trout Hatchery (which was established in Nuwakot district on the bank of the river Trishuli). Its objective was propagation, rearing and releasing of trout into suitable hill streams to establish sport fishery for tourism development. However, mass mortality was occurred in Trishuli within the few months of their arrival. Since the Trout Hatchery was established in the king's interest, the mass mortality of trout created a big issue for the Ministry of Agriculture along with Department of Agriculture ., after a thorough investigation of all possible reasons of mortality came to a conclusion that the trout was introduced without proper preparation of physical facilities such as:

- Ponds were leaking with earthen bottom,
- Proper pellet high protein feed was not available,
- Only buffalo meat/liver was fed, and
- The water was highly silted.

The trout commission recommended that the existing facilities (ponds, water

resources, human resources, and feed) were not suitable for trout culture; and the trout farming program was dropped until rehabilitation of Trishuli Fisheries Station. Activities in Trishuli station were resumed as usual from 1974. Exotic carp were breed and distributed for pond culture and paddy cum fish culture for few years.

Present Situation

Nepal has quite appropriate for fisheries of rainbow trout fish as we have plenty of cold water and slopes. Although farmers have been attracted to it in recent times, it has not been moved ahead for lack of government investment and awareness among farmers. The Ministry of Agriculture Development had recently undertaken feasibility study of rainbow trout fish keeping in 54 districts of the country and had thought of forwarding it as a 'one village one product' scheme. Nepal Agriculture Research Council (NARC) had forwarded a programme to run 'mission rainbow trout' campaign but it has not reached to the farmers as expected.

Recently, it has been started in Sindhupalchok, Kavrepalanchok, Dolakha, Solukhumbu, Kathmandu, Lalitpur, Baglung, Rasuwa, Dhading, Makwanpur, Gorkha, Kaski, Manang, and Mustang districts commercially.

Exercise

Choose the correct answer from the given alternatives.

1. What is the primary concern in managing old ponds for aquaculture?
   a. Depth of the pond
   b. Water source availability
   c. Accumulation of organic debris and silt
   d. Aquatic vegetation diversity

2. Liming in old ponds is primarily done to.....
   a. Kill harmful microorganisms
   b. Increase oxygen levels
   c. Neutralize acidity and improve soil fertility
   d. Enhance fish growth hormones

3. The primary goal of natural water body conservation is.....
   a. Maximizing fish harvest
   b. Maintaining biodiversity and water quality
   c. Enhancing commercial fishing
   d. Building infrastructure for tourism

4. What is a key management practice to prevent eutrophication in natural water bodies?
   a. Increasing nutrient input
   b. Controlling point and non-point pollution sources
   c. Allowing free fish feeding
   d. Encouraging algal blooms

5. What is the primary advantage of cage culture in natural water bodies?
   a. Low initial investment

b. Reduction of disease transmission

c. Efficient use of natural resources for fish production

d. Complete control of water quality

6. Which of the following is NOT a recommended practice for cage culture?

a. Regular cleaning of cages

b. Overstocking for maximum yield

c. Monitoring water quality parameters

d. Providing supplementary feeding

7. Which type of water condition is most suited to trout culture?

a. Stagnant warm water b. Fast-flowing cold water

c. Polluted water bodies d. Brackish water

8. The ideal temperature range for trout culture is.....

a. 10-15°C b. 20-25°C

c. 5-10°C d. 15-20°C

9. What is the primary feed for trout in aquaculture systems?

a. Phytoplankton b. Artificial pelleted feed

c. Aquatic plants d. Zooplankton only

10. Which trout species is most commonly cultured worldwide?

a. Rainbow trout (*Oncorhynchus mykiss*)

b. Brown trout (*Salmo trutta*)

c. Brook trout (*Salvelinus fontinalis*)

d. Lake trout (*Salvelinus namaycush*)

Write short answer to the following questions.

1. Write briefly about management and utilization of old ponds.
2. How is natural water bodies managed?

3. Write short notes on enclosure and cage culture.

Write long answer to the following questions.

1. Explain in detail about rainbow trout culture and production in cold water.

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