الجمهورية الجزائرية الديمقراطية الشعبية
وزارة التعليم العالي والبحث العلمـي
جامعة الجيلالي بونعامـة خميس مليانة

كلية علوم الطبيعة والحياة وعلوم الأرض

Faculty of Nature and Life Sciences and Earth Sciences

قسم علوم البيئة والمحيط

Department of Ecology and Environment

Field of Study : Marine and Freshwater Hydrobiology

FISH FARMING COURSE

(PISCICULTURE)

Dr. DJEZZAR Miliani

Academic Year : 2025 - 2026

Contact Sheet

- Program : Marine and Inland Hydrobiology
- Specialization : Aquaculture and Fish Farming
- Level : 3rd Year Bachelor's Degree (Level L3)
- Module : Pisciculture (Fish farming)
- Credits : 4
- Weight (Coefficient) : 2
- Course Unit : Core Unit (Fundamental)
- Contact Hours : 45 hours
- Self-Study Hours : 55 hours
- Evaluation Mode : In-person Examination
- Associate Professor: Dr. DJEZZAR Miliani
- Support Modality : Online consultations — tutoring via multimedia tools
- Email : m.djezzar@univ-dbkm.dz

Course Description (Preamble)

Fish farming (pisciculture) is a key discipline within aquaculture, focusing on the understanding and mastery of fish rearing in controlled environments. This course aims to introduce students to the **fundamental principles of pisciculture** by covering diverse aspects such as the biology of farmed species, production techniques, facility management, and water quality. It also addresses the ecological and economic challenges associated with this industry.

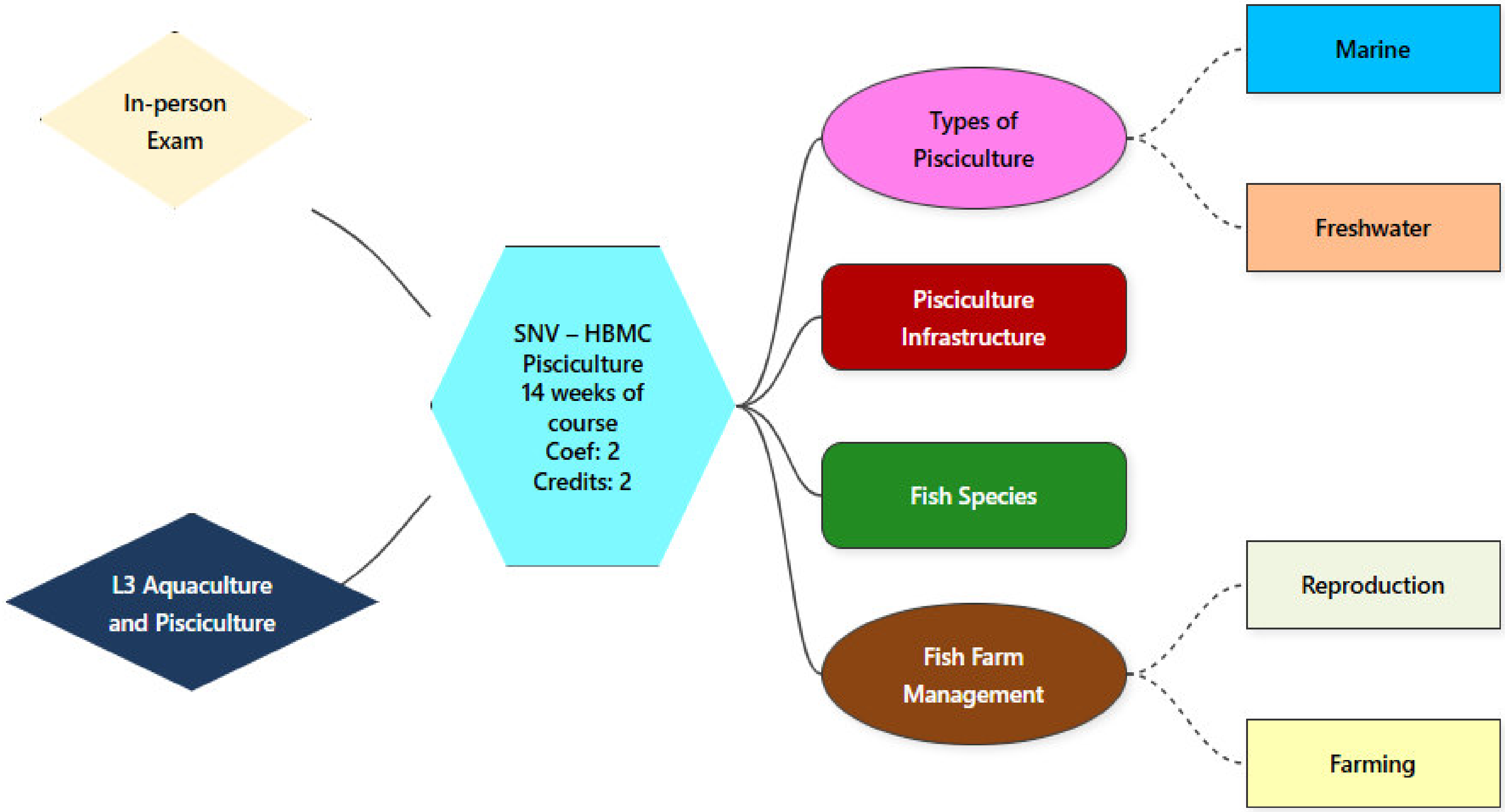
Throughout this program, students will learn to identify various **fish farming structures**, analyze fish growth parameters, and apply modern techniques to optimize yields. The course highlights the historical evolution of pisciculture, its current applications, and future prospects—particularly regarding **sustainable development** and technological innovation.

Course Objectives

This course aims to provide students with in-depth knowledge and practical skills in pisciculture, focusing on the following objectives :

- **Understand the biological and ecological foundations** of fish species reared in aquaculture.
- **Master various rearing techniques** (extensive, semi-intensive, intensive) and their application based on environmental and economic constraints.
- **Acquire fish farm management skills**, including feeding, reproduction, health monitoring, and yield optimization.
- **Analyze and interpret physicochemical water parameters**, which are essential for maintaining an optimal culture environment.
- **Evaluate the environmental impact** of fish farming and propose sustainable solutions to minimize negative effects.
- **Familiarize students with the tools and equipment** used in the management of fish farms.
- **Develop a scientific approach** to solving production-related problems through case studies and practical coursework.

CONCEPT MAP OF COURSE OBJECTIVES



Prerequisites

Before beginning this course, students are recommended to have foundational knowledge in the following areas :

- **General Biology and Aquatic Ecology:** Understanding the interactions between aquatic organisms and their environment.
- **Water Chemistry :** Knowledge of the physicochemical parameters influencing water quality (pH, dissolved oxygen, temperature, ammonia, nitrites, and nitrates).
- **Aquatic Resource Management :** Understanding the principles of sustainable management of aquatic environments and ecosystem conservation.
- **Statistics and Data Analysis:** Proficiency in interpreting fish growth and production data.

These prerequisites will enable students to more effectively engage with the advanced concepts developed throughout this course.

Table of Contents

I. Definition

Fish farming (pisciculture) is the rearing of fish in controlled environments for the purpose of food production, restocking, or ornamental use. It relies on biological and ecological techniques aimed at optimizing fish growth and survival rates while minimizing environmental impacts. It is categorized into extensive, semi-intensive, and intensive fish farming, depending on the level of human intervention and environmental control [17, 20].

II. History

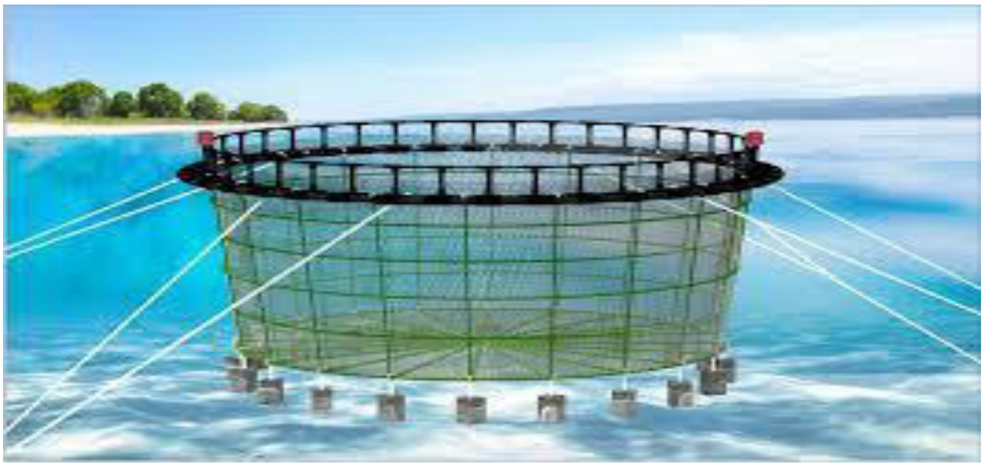
Fish farming dates back to **Antiquity**, notably in **China** (Zhou Dynasty, circa 1000 BCE), where the Chinese had already mastered carp breeding. Around 2500 BCE, the **Egyptians** reared tilapia in basins excavated near the Nile. The **Romans** also practiced pisciculture in coastal vivaria (fish ponds). Over time, techniques have evolved significantly, particularly with the development of **modern hatcheries**, the domestication of new species, and the improvement of aquaculture management systems [3,16,24].


III. Types of Fish Farming

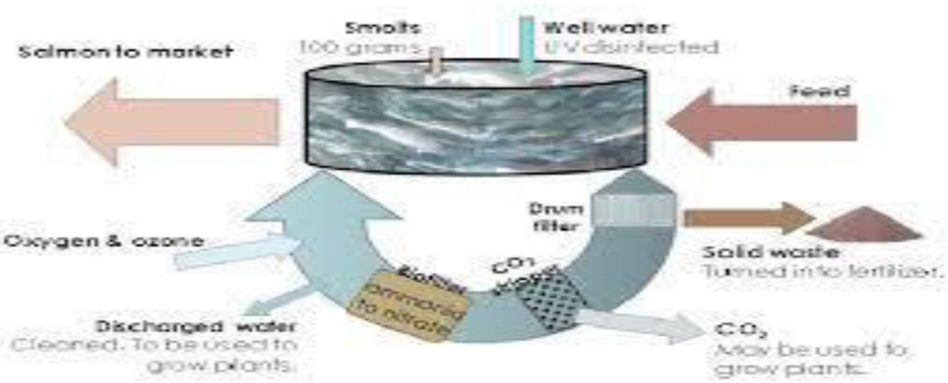
III.1 Marine Fish Farming (Mariculture)

Marine fish farming involves rearing fish in saline environments, such as the open sea, coastal lagoons, or artificial land-based tanks supplied with seawater. It includes :

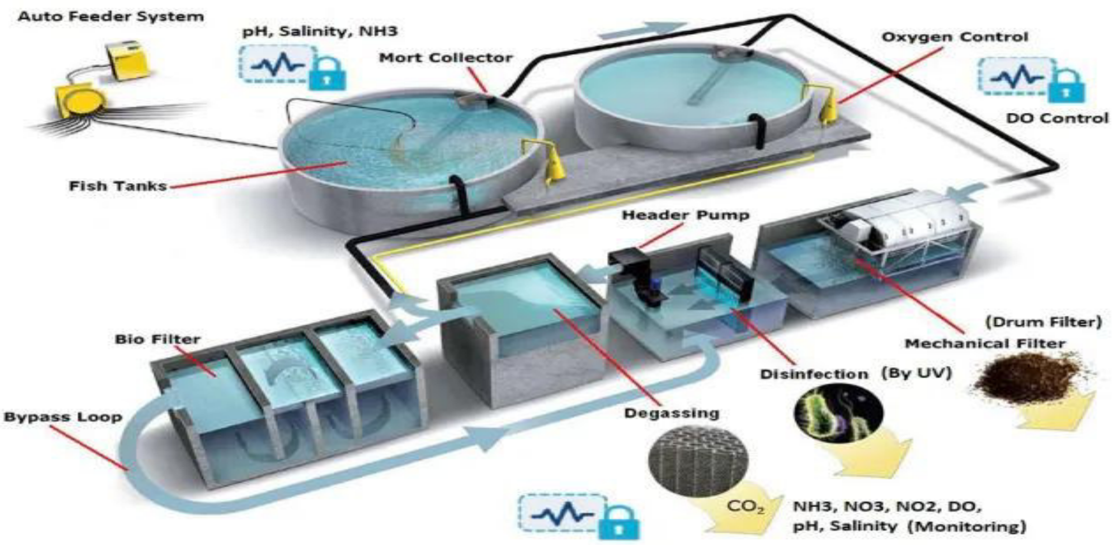
- **Floating Cage Culture :** Structures installed in the sea or lagoons that allow rearing under natural conditions [3].
- **Land-Based Tank Systems :** Artificial reservoirs filled with seawater, providing enhanced control over environmental parameters [4].
- **Recirculating Aquaculture Systems (RAS) :** Closed-loop systems where water is filtered and reused to minimize ecological impact [22].



Floating Cage Culture



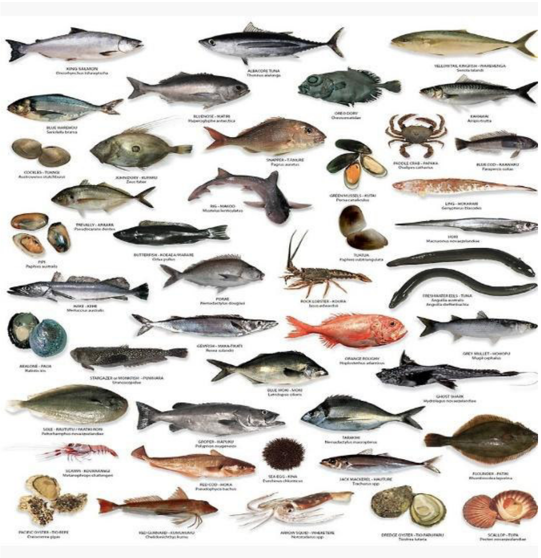
Land-Based Tank Systems



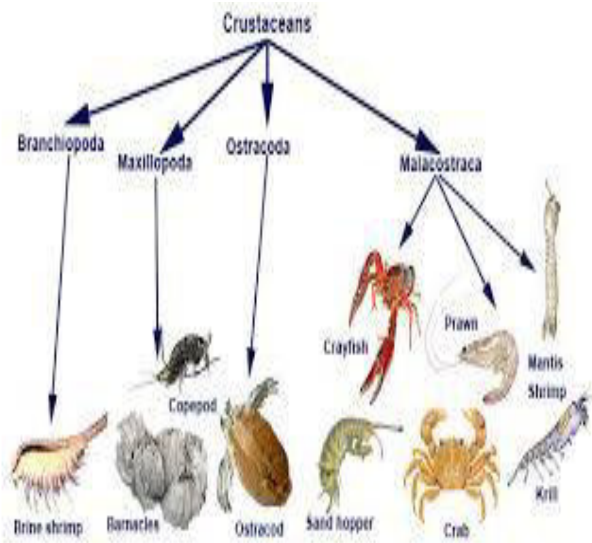
Recirculating Aquaculture Systems (RAS)

Commonly Farmed Species :

- **Fin fish:** European seabass, Gilthead seabream, Turbot, Salmon.
- **Crustaceans:** Shrimp and other marine crustaceans.
- **Mollusks:** Oysters and mussels (associated shellfish farming/conchyliculture).



Fin fish



Crustaceans

III.2 Inland Fish Farming (Freshwater Pisciculture)

Inland fish farming refers to rearing fish in freshwater environments, such as ponds, earthen or concrete tanks, and recirculating systems [8, 24, 5, 15, 22]. It is categorized as follows:

- **Extensive Fish Farming:** Utilization of natural ponds with minimal human intervention, relying primarily on natural productivity.
- **Semi-intensive Fish Farming:** Use of supplementary feed and more advanced management of water quality and fish stocks.
- **Intensive Fish Farming:** Total control over rearing conditions, often utilizing high-density tanks or closed-loop systems.

Commonly Farmed Species :

- **Carp, Tilapia, Catfish, and Trout.**
- **Sturgeon** (primarily for caviar production).
- **Catfish and Perch** for commercial aquaculture.

IV. Fish Farming Infrastructure

Fish farming infrastructure refers to the physical facilities of a fish farm, which include one or more tanks, ponds, or cages. These structures are designed to facilitate controlled fish rearing, ensuring managed and optimized production. They are adapted to various farming intensities (extensive, semi-intensive, intensive) and the specific environmental requirements of the cultured species [20].

IV.1 Inland Fish Farming Infrastructure

- **Fish Ponds :** Natural or artificial bodies of water used for extensive and semi-intensive rearing [8].
- **Concrete or Earthen Tanks :** These provide greater control over rearing conditions compared to ponds [15, 24].
- **Recirculating Aquaculture Systems (RAS) :** Used in intensive fish farming to optimize water management and limit waste discharge [22].
- **Hatcheries and Nurseries :** Specialized facilities dedicated to spawning, egg incubation, and fry rearing [6, 16].

Fish Ponds

Earthen Tanks

Recirculating Aquaculture Systems

Hatcheries and Nurseries

IV.2 Marine Fish Farming Infrastructure

- **Floating Cages :** Installed in the open sea or lagoons, allowing for rearing under natural environmental conditions [3, 20].
- **Onshore Marine Tanks :** Artificial reservoirs supplied with seawater, typically used for intensive land-based farming [16].
- **Pumping and Filtration Systems :** Essential components for maintaining optimal water quality in land-based marine systems [4, 22].
- **Marine Hatcheries and Nurseries :** Specialized structures for the reproduction and early-stage rearing of marine species [16].

Floating Cages

Onshore Marine Tanks

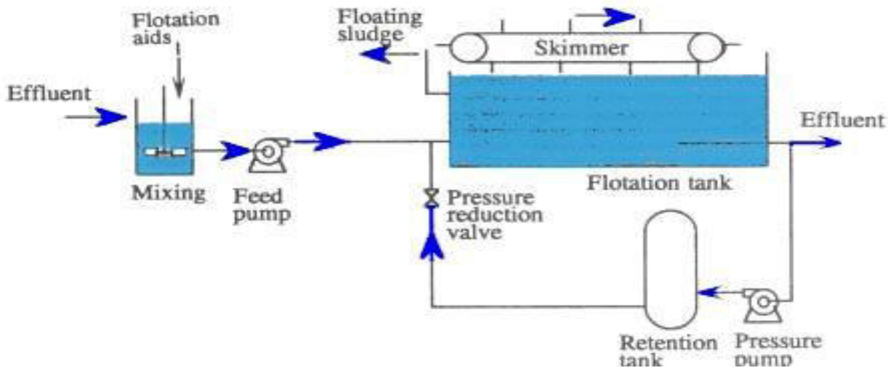
Pumping and Filtration Systems

Marine Hatcheries and Nurseries

IV.3 Equipment and Infrastructure Management

- **Aeration and Oxygenation Systems :** Devices used to maintain vital dissolved oxygen levels [10, 22].
- **Automatic Feeding Devices:** Systems designed to optimize feed delivery and reduce waste [11, 14].
- **Water Filtration and Treatment Systems :** Mechanical and biological units used to remove waste and maintain a healthy culture environment [4, 22].

Aeration and Oxygenation Systems **Automatic Feeding Devices**



Water Filtration and Treatment Systems

V. Fish Tanks and Raceways

Fish tanks are essential infrastructure for rearing fish at different stages of development. They are designed to meet the specific biological needs of the fish and ensure an optimal environment for their growth and reproduction [16].

Types of Tanks :

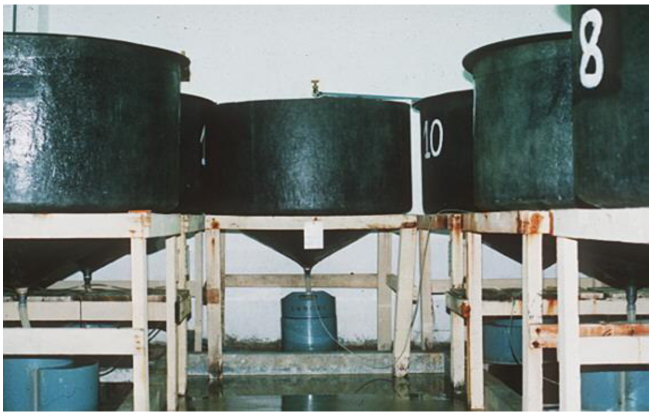
- Broodstock Tank : Dedicated to holding adult breeders, it ensures ideal conditions for maturation and spawning [6].
- Quarantine Tank : Used to isolate newly introduced or diseased fish to prevent the spread of pathogens [18].
- Holding (Stabling) Tank : Used for acclimating fish before their transfer to other units or prior to marketing.
- Spawning Tank : Designed to provide a favorable environment for spawning and fertilization [24].
- Larviculture Tank : Used for rearing larvae until they reach a stage where they can be transferred to nursery units [16].

- Nursery (Fingerling) Tank : Intended for rearing young fish before their transfer to grow-out tanks [24].
- Grow-out Tank : Used for rearing fish until they reach commercial market size, optimizing stocking density and feeding efficiency [11].

Broodstock Tank

Quarantine Tank

Holding (Stabling) Tank



Spawning Tank

Larviculture Tank

Nursery (Fingerling) Tank

Grow-out Tank

VI. Hatchery Types

Fish hatcheries are specialized facilities dedicated to the reproduction and development of fish during their earliest life stages. They optimize fertilization, egg incubation, and larval rearing before the fish are transferred to nursery tanks [6, 16, 24].

Hatchery

VI.1 Extensive Hatcheries

These hatcheries utilize natural conditions with minimal human intervention. They rely on earthen basins or ponds where reproduction occurs naturally [8, 24].

VI.2 Semi-intensive Hatcheries

These combine natural and artificial methods, incorporating water control systems and tailored feeding regimes [15, 16].

VI.3 Intensive Hatcheries

These facilities are highly controlled, featuring advanced incubation systems, automated feeding, and sophisticated filtration [16, 22].

VI.4 Hatchery Components (Vs : V. Fish Tanks and Raceways)

- **Spawning Tanks :** Designated areas for adult fish reproduction.
- **Egg Incubators :** Devices providing an optimal environment for embryonic development. They regulate temperature, oxygenation, and water flow to maximize hatching rates [16].
- **Larviculture Tanks :** Used for rearing larvae post-hatching, ensuring appropriate nutrition and growth parameter monitoring [13, 16].
- **Filtration and Oxygenation Systems :** Essential for maintaining water quality by removing waste and ensuring adequate dissolved oxygen levels [4, 10, 22].
- **Health Control Laboratories :** Facilities for disease monitoring, early pathogen detection, and the implementation of sanitary protocols.

VI.4.1 Types of Incubators

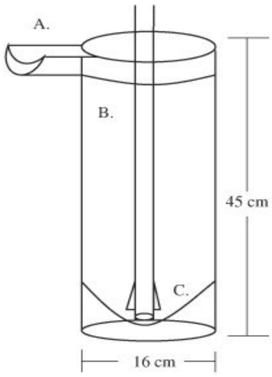
Incubators are critical hatchery components that ensure successful egg development. The choice of incubator depends on the species and culture conditions.

a) Zug-type Incubators (Zoug Jars)

- **Operating Principle :** Water flows continuously from bottom to top through vertical cylinders, maintaining gentle and uniform agitation of the eggs [16, 24].
- **Advantages :** Ensures excellent oxygenation, reduces sedimentation risk, and promotes synchronized development [16].
- **Disadvantages :** Requires a constant water flow and rigorous monitoring to prevent temperature fluctuations [4, 22].

b) McDonald-type Incubators (Bell Jars)

- **Operating Principle :** Eggs are placed in glass or plastic jars where water is injected at the base, creating a circular motion that prevents clumping [16].
- **Advantages :** Highly effective for fragile eggs requiring controlled water circulation [24].
- **Disadvantages :** High water consumption and requires regular maintenance [22].



c) Tray Incubators

- **Operating Principle :** Eggs are spread in thin layers on trays submerged in a horizontal water current, often arranged in stacks to save space [16, 24].
- **Advantages :** Easy to monitor ; ideal for species requiring minimal contact with hard surfaces, such as salmonids [16].
- **Disadvantages :** Less effective for species that require constant tumbling or agitation to prevent fungal growth or sticking [18, 4].

d) Suspended Basket Incubators

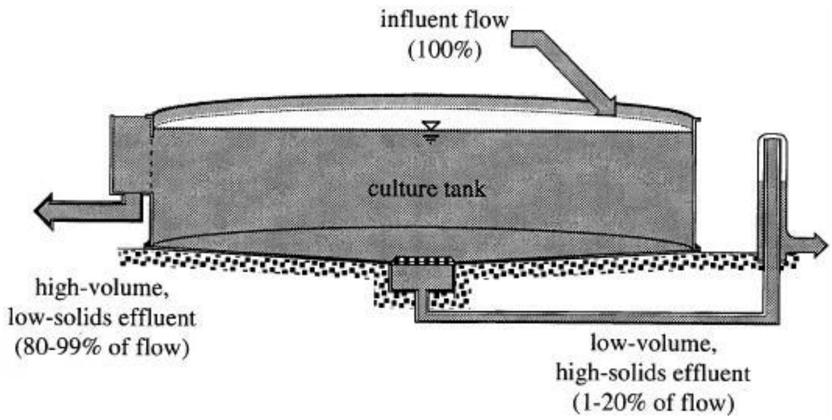
- **Operating Principle :** Perforated baskets containing eggs are suspended in a tank with a steady water current, allowing water to pass through the mesh to oxygenate the embryos [8, 24].

- **Advantages :** Easy access and inspection ; suitable for small-scale hatcheries and species with relatively large or robust eggs [8].
- **Disadvantages :** Not ideal for large-scale industrial production due to space requirements and labor intensity [24].

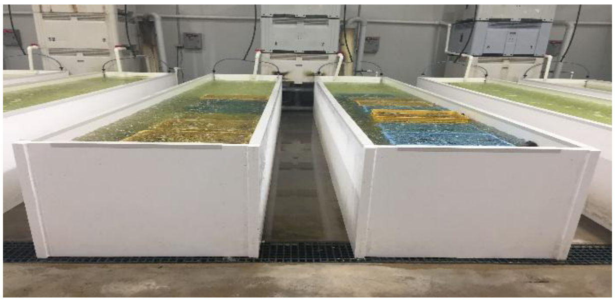
VI.4.2 Larviculture Tanks

Larviculture tanks are essential units that ensure the initial survival and growth of larvae after hatching. They must provide an optimal environment regarding water quality, oxygenation, and specific nutritional requirements [13, 16]. Types of Larviculture Tanks :

1. **Circular Tanks :**
    - Promote uniform water circulation.
    - Prevent waste accumulation (self-cleaning effect).
    - Recommended for species with active swimming behavior.



2. **Rectangular Tanks :**
    - Easy to organize and maintain.
    - Used for bulk rearing.
    - Suitable for larvae that require resting zones.



3. **Fiberglass or Plastic Tanks :**
    - Non-toxic materials and easy to disinfect.
    - Good resistance to temperature variations.
    - Lightweight and modular.

4. **Concrete Tanks :**
    - Used for large-scale operations.
    - Thermally stable but require anti-abrasive coatings.
    - Highly durable but more difficult to sterilize.

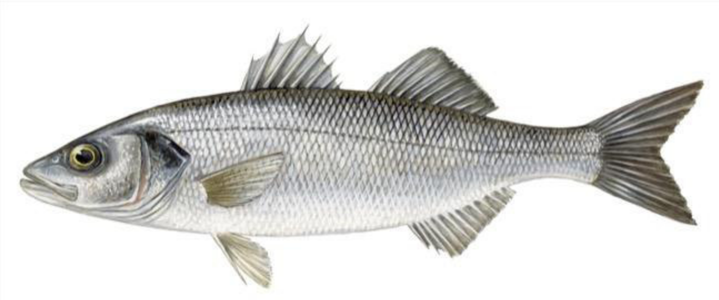
VII. Fish Species in Pisciculture

Species exploited in fish farming are classified into two broad categories: marine species and inland (freshwater) species. Each possesses specific biological and physiological characteristics that influence their rearing methods and reproduction protocols [3, 6, 11, 16, 20]. Key species include :

VII.1 Marine Species

a) European Seabass (*Dicentrarchus labrax*)

- **Description :** A large carnivorous fish, highly valued for its flavorful flesh.
- **Reproduction :** Controlled in hatcheries through hormonal induction.
- **Rearing Requirements:** Well-oxygenated saltwater; diet high in marine proteins.
- **Attributes:** High commercial demand and rapid growth rates.



b) Turbot (*Scophthalmus maximus*)

- **Description :** A fast-growing flatfish prized for its fine, delicate flesh.
- **Reproduction :** Mastery of hatchery-based breeding protocols.
- **Rearing Requirements:** Temperate, well-oxygenated water.
- **Attributes:** Very high market value.

c) Gilthead Seabream (*Sparus aurata*)

- **Description :** A euryhaline fish, highly adaptable to various farming conditions.
- **Reproduction :** Protandrous hermaphrodite ; maturation is managed under controlled conditions.
- **Rearing Requirements:** Balanced nutritional intake; suitable marine pens or tanks.
- **Attributes:** Excellent profitability and highly sought-after meat.

d) Flathead Grey Mullet (*Mugil cephalus*)

- **Description :** An omnivorous fish capable of adapting to diverse environments.
- **Reproduction :** Captive breeding techniques are well established.
- **Rearing Requirements:** High tolerance to salinity fluctuations ; requires a specific dietary formulation.
- **Attributes:** Disease resistant with low production costs.

VII.2 Freshwater Species

a) Nile Tilapia (*Oreochromis niloticus*)

- **Description :** A fast-growing omnivore widely utilized in global aquaculture.
- **Reproduction :** Spawns readily and easily in captivity.
- **Rearing Requirements:** Tolerates varied environmental conditions ; accepts both plant-based and protein-rich feeds.
- **Attributes:** Highly profitable, disease resistant, and ideal for intensive systems.

b) Mirror/Common Carp (*Cyprinus carpio*)

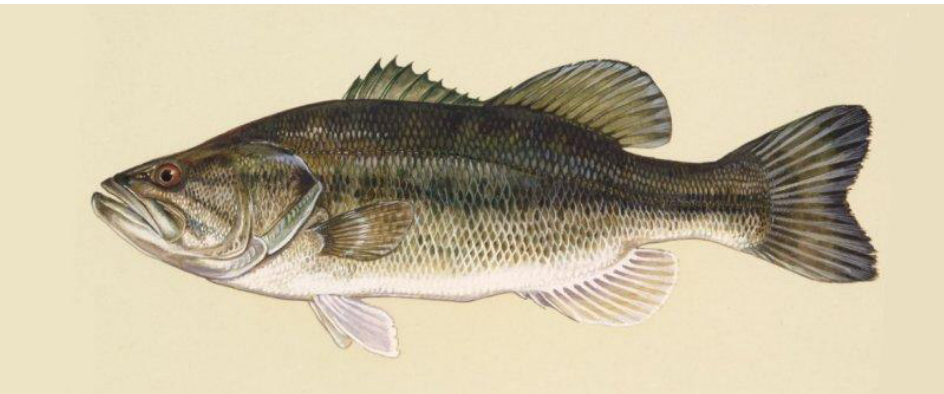
- **Description :** A robust species farmed for its rapid growth and traditional culinary value.
- **Reproduction :** Induced in hatcheries for synchronized and controlled production.
- **Rearing Requirements:** Oxygen-rich environments; diversified feeding habits.
- **Attributes:** Hardy, high yield potential; suitable for both ponds and tanks.

c) Pike-Perch/Zander (*Sander lucioperca*)

- **Description :** A freshwater predator highly esteemed in gastronomy.
- **Reproduction :** Managed in pisciculture via hormonal induction.
- **Rearing Requirements:** Clear water ; requires live prey or high-quality adapted pellets.
- **Attributes:** Fine flesh and high commercial value.

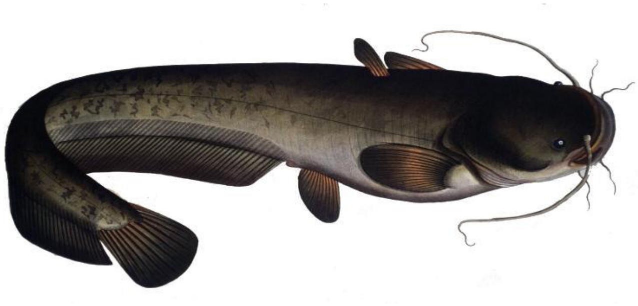
d) Largemouth Bass (*Micropterus salmoides*)

- **Description :** A carnivorous fish popular for both sport fishing and aquaculture.
- **Reproduction :** Natural spawning in prepared nesting basins.
- **Rearing Requirements:** Well-oxygenated water and a carnivorous diet.
- **Attributes:** Good adaptation to captivity with steady growth.



e) Wels Catfish (*Silurus glanis*)

- **Description :** A large-bodied fish characterized by exceptionally fast growth.
- **Reproduction :** Controlled and monitored in hatchery settings.
- **Rearing Requirements:** Large-volume tanks/basins ; high-protein diet.
- **Attributes:** High biomass production ; reared for meat and restocking programs.



VIII. Rearing Modes (Production Systems)

Fish rearing in pisciculture is classified into three primary modes : **extensive, semi-intensive, and intensive**. The choice of system depends on production goals, available resources, technological level, and environmental conditions. These systems differ mainly in stocking density, nutritional requirements, water parameter control, and capital investment [15, 20].

VIII.1 Extensive Rearing

Extensive rearing is the most natural and cost-effective method. It fundamentally relies on the natural resources of water bodies (ponds, lakes, hillside reservoirs) to sustain fish growth [1, 5, 8, 23, 24].

Key Characteristics:

- **Stocking Density :** Low (typically 1 to 3 fish/ depending on the species).
- **Feed Source :** Primarily natural (phytoplankton, zooplankton, benthic organisms).
- **Carrying Capacity :** Low, as the pond's capacity is limited by the natural productivity of the environment.
- **Human Intervention :** Minimal ; little to no artificial feeding and no mechanical aeration.
- **Advantages :** Low investment and operating costs; minimal environmental impact.
- **Disadvantages :** Slower growth rates, limited yields, and unpredictable production levels.

Suitable Species Examples :

- Common Carp (*Cyprinus carpio*)
- Tilapia (*Oreochromis spp.*)
- Flathead Grey Mullet (*Mugil cephalus*)

VIII.2 Semi-intensive Rearing

Semi-intensive rearing is a compromise between extensive and intensive systems. It involves higher human intervention, particularly regarding nutrition and water management [11, 13, 15].

Key Characteristics:

- **Stocking Density :** Moderate (5 to 10 fish/ depending on species and management).
- **Feed Source :** A combination of natural food and supplementary artificial feed.
- **Carrying Capacity :** Moderate; requires monitoring of water quality.
- **Human Intervention :** Managed feed inputs, pond fertilization, and occasional aeration or water exchange.
- **Advantages :** Higher yields than extensive systems; better production control.
- **Disadvantages :** Higher costs; requires specific infrastructure and more rigorous management.

Suitable Species Examples :

- Mirror Carp (*Cyprinus carpio*)
- Pike-Perch (*Sander lucioperca*)
- Gilthead Seabream (*Sparus aurata*)

VIII.3 Intensive Rearing

Intensive rearing relies on total environmental control and high stocking densities, requiring rigorous management of water parameters, nutrition, and fish health [2, 16, 19, 22].

Key Characteristics:

- **Stocking Density :** High to very high (exceeding 20 fish/, reaching 50 to 100 fish/ in tanks or marine cages).
- **Feed Source :** Exclusively artificial, using balanced pellets rich in proteins, lipids, and micronutrients [11, 14].

- **Carrying Capacity :** Very high ; requires continuous water renewal or filtration to prevent oxygen depletion and waste accumulation [22].
- **Human Intervention :** Permanent monitoring of water quality; use of oxygenation, filtration, and water recirculation systems (RAS).
- **Advantages :** Very high yields; year-round production potential; rapid fish growth.
- **Disadvantages :** High capital and operational expenditures; indispensable expert management ; increased disease risks [18, 21].

Suitable Species Examples :

- Atlantic Salmon (*Salmo salar*)
- Rainbow Trout (*Oncorhynchus mykiss*)
- European Seabass (*Dicentrarchus labrax*)

Conclusion

The selection of a rearing mode depends on economic objectives and available technical means. **Extensive rearing** is better suited for small-scale producers and environmentally integrated systems, whereas **semi-intensive and intensive systems** allow for optimized production to meet the growing demand for farmed fish. Rigorous management of density, biomass load, and water parameters is essential to ensure the viability and sustainability of fish farming operations [16, 20, 22].

IX. Fish Farm Management

The management of fish farms relies on the rigorous mastery of reproduction, embryonic development, larval rearing, nursery management, and the grow-out phase. Each stage requires specific conditions regarding density, water quality, and nutrition to optimize growth and survival [16, 24].

IX.1 Reproduction in Pisciculture

IX.1.1 Types of Reproduction

- **Natural Reproduction :** Fish spawn spontaneously in conditions mimicking their natural environment. Minimal human intervention is required, but success rates vary [8].
- **Semi-controlled Reproduction :** Modifying pond environments and using human intervention to stimulate spawning and optimize reproductive success [15].

- **Controlled Reproduction :** Full manipulation of the reproductive cycle, including hormonal induction, artificial insemination, and egg incubation in hatcheries [6, 16].

IX.1.2 Use of Hormonal Inducers

Hormonal induction is used to trigger maturation and spawning in captive fish [6].

- **Types of Hormones Used:**
  - Human Chorionic Gonadotropin (hCG).
  - Fish Pituitary Extracts (e.g., carp or salmon pituitary).
  - GnRH Analogues (Gonadotropin-Releasing Hormone).
  - Progestogens and estrogens for specific cases.
- **Administration Methods :**
  - Intraperitoneal or intramuscular injection.
  - Subcutaneous implants for prolonged release.

IX.2 Reproduction Techniques

IX.2.1 Stripping (Egg and Milt Collection)

- Practiced in high-value or difficult-to-spawn species such as Salmon, Trout, and Carp [16].
- Involves applying gentle pressure to the female's abdomen to expel ova.
- Milt (sperm) is collected from males for artificial fertilization [24].

IX.2.2 Fertilization

- **Dry Method :** Direct mixing of gametes (eggs and milt) in a dry container without the immediate addition of water. This prevents the micropyle (egg opening) from closing too quickly [24].
- **Wet Method :** Adding water to the mixture to activate the spermatozoa and ensure fertilization.

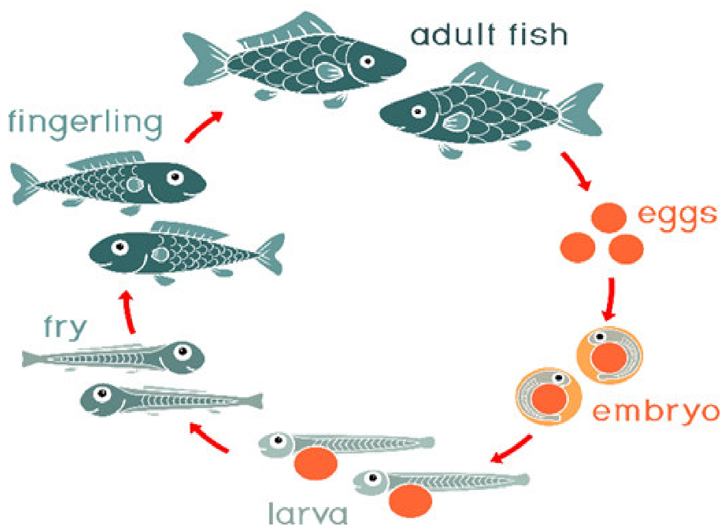
IX.2.3 Treatment of Fertilized Eggs

- **Pelagic Species (Floating Eggs) :** Incubation in open water or specialized jars with gentle circulation to keep them suspended [16].
- **Benthic Species (Adhesive Eggs) :** Fixation on artificial substrates or chemical treatment with tannin (tanninization) to remove the sticky layer, allowing for incubation in Zuger jars [24].

IX.3 Incubation and Embryogenesis

IX.3.1 Stages of Embryogenesis

1. **Cleavage (Segmentation) :** First cell divisions after fertilization.
2. **Blastula :** Formation of a hollow cellular layer (blastoderme).
3. **Gastrula :** Onset of cell differentiation and the formation of germ layers.
4. **Neurula :** Development of the neural tube, the precursor to the central nervous system.
5. **Somitogenesis :** Appearance of the first body segments (somites).
6. **Organogenesis :** Formation of vital organs, eyes, and optic vesicles.
7. **Embryonic Movement and pigmentation :** Visible movement and development of color within the egg casing.
8. **Hatching :** The embryo secretes enzymes to rupture the chorion (membrane) and release the larva**.**



IX.3.2 Incubation Parameters

Success in incubation depends on maintaining precise environmental thresholds to ensure high hatching rates and healthy larvae [7, 16, 24].

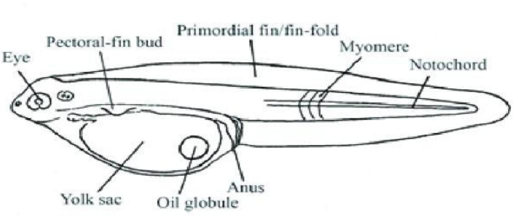
- **Optimal Temperature :** Strictly species-specific; for instance, 8–12°C for Trout, whereas Tilapia require 24–28°C [16, 24].
- **Oxygenation :** Dissolved Oxygen (DO) levels must generally be maintained above 6 mg/L to support embryonic respiration [10, 22].
- **Water Flow :** Must be carefully controlled to prevent stagnation, ensure efficient gas exchange, and remove metabolic byproducts without mechanically damaging the fragile eggs [4, 22].

IX.4 Larviculture (Larval Rearing)

This is the most critical phase in fish farming, characterized by high sensitivity to environmental changes and nutritional transitions [13, 16].

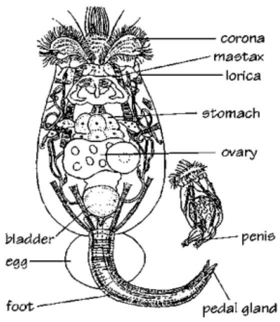
- **Stocking Density :** Very high densities are common, ranging from 50,000 to 200,000 larvae/ depending on the species and the technological level of the system [16, 22].
- **Feeding :**

  - Endogenous Feeding : Initial reliance on the yolk sac provided at birth.



  -

  - Exogenous Feeding : The transition to external food sources (live prey like Rotifers or Artemia) once the yolk sac is absorbed [13, 16].



    - Progressive transition to micro-diets and adapted pellets.
- **Water Parameters :**
  - Temperature : 22–28°C for tropical species; 10–15°C for salmonids.
  - Dissolved Oxygen: 6–8 mg/L.
  - **Photoperiod:** Adjusted to stimulate active feeding and growth.

Larviculture Tank Management Parameters

1. **Water Quality :** Maintaining physico-chemical stability is imperative for larval survival [4, 16, 22] :

   - **Temperature :** Adapted to species-specific needs [16, 24].
   - **Oxygenation :** Maintain levels **> 5 mg/L** [10, 22].
   - **pH :** Between **6.5 and 8** to avoid physiological stress [4, 22].
   - **Ammonia and Nitrites :** Must be kept at minimal levels (**Ammonia < 0.02 mg/L**) to prevent acute toxicity [4, 22].

2. **Feeding Strategy:**
   - **Live Prey :** Use of live prey (rotifers, *Artemia*) to meet the enzymatic and nutritional needs of larvae before weaning onto micro-particles [13, 16].
   - **Rationing:** Precise adjustment of rations to minimize waste and prevent water degradation [11, 14].
3. **Stocking Density :**
   Strict Control : Managed carefully (e.g., 50–100 larvae/L depending on the species) to reduce competition for food and social stress [16, 22].
4. **Hygiene :**
   - **Sanitation:** Regular cleaning (siphoning the bottom) to prevent the buildup of organic waste and bacterial proliferation [18].
   - **Filtration :** Use of high-performance mechanical and biological filtration to recycle or treat water [4, 22].

IX.5 Nursery Phase (Fingerling Production)

The nursery phase serves as the critical transition between the larval stage and the grow-out phase, focusing on stabilizing growth and ensuring high survival rates before transfer to larger production units [9, 16, 24].

- **Stocking Density :** 5,000 to 50,000 fingerlings/ depending on the species and the capacity of the aeration/filtration systems [22].

- **Nutrition :**
  - **Proteins:** High protein requirements to support rapid tissue development; **40–50%** for carnivores (e.g., Trout, Bass) and **30–40%** for omnivores (e.g., Carp, Tilapia) [11, 13].
  - **Feeding Frequency :** 6 to 8 meals/day initially to accommodate small stomach capacities and high metabolic rates, then gradually reduced as the fish grow [14, 16].

Management :
- **Water Exchange :** Regular renewal or high-rate recirculation to manage metabolic waste [4, 22].
- **Grading (Size Sorting) :** Essential procedure of sorting fish by size to prevent cannibalism (especially in Seabass and Catfish) and to ensure uniform growth within a population [16].
  - **Health Monitoring :** Frequent inspection for parasites or bacterial infections, which are common at higher densities [18, 21].

IX.6 Grow-out Phase

The grow-out phase is the final stage of the production cycle where fish are reared from the juvenile stage to commercial market size. Management at this stage focuses on maximizing biomass while maintaining health and feed efficiency [11, 20].

- **Biomass Load :**
  - 5 to 20 kg/ in standard tanks or semi-intensive ponds [15, 24].
  - Up to 50 kg/ (and sometimes higher) in RAS (Recirculating Aquaculture Systems), where oxygenation and filtration are highly optimized [22].
- **Feeding :** Rations are strictly adjusted based on the Feed Conversion Ratio (FCR). In modern, optimized systems, an FCR of 1.0–1.5 is targeted, meaning 1.0–1.5 kg of feed is required to produce 1 kg of fish weight gain [11, 14].
- **Water Parameters : * pH : 6.5–8.5.**
  - Oxygen: Maintained at > 5 mg/L to prevent stress and support growth [10].
- **Sanitary Control :** Continuous disease monitoring and rigorous waste management (removal of feces and uneaten feed) are essential to limit environmental impact and prevent outbreaks [18, 21].

Conclusion

Fish farm management relies on a rigorous understanding of the fish's life cycle. Each phase—from reproduction and incubation to the final grow-out—imposes specific requirements for density, nutrition, and water quality 16, 24. Scientific and technological monitoring, such as the use of automated sensors and balanced artificial diets, optimizes yields while ensuring fish welfare and the long-term sustainability of the aquaculture industry [20, 22].

X. Filtration and Oxygenation Systems

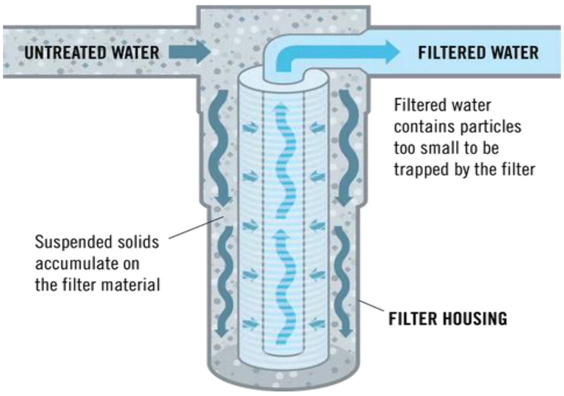
Filtration and oxygenation systems play a fundamental role in hatchery management by ensuring a healthy and optimal environment for larval development. Effective filtration removes organic waste and suspended solids, while oxygenation ensures a sufficient supply of dissolved oxygen necessary for fish survival [4, 22].

X.1 Filtration Systems

Filtration systems are classified into three main categories, each targeting different types of waste within the aquaculture environment [16, 12, 22].

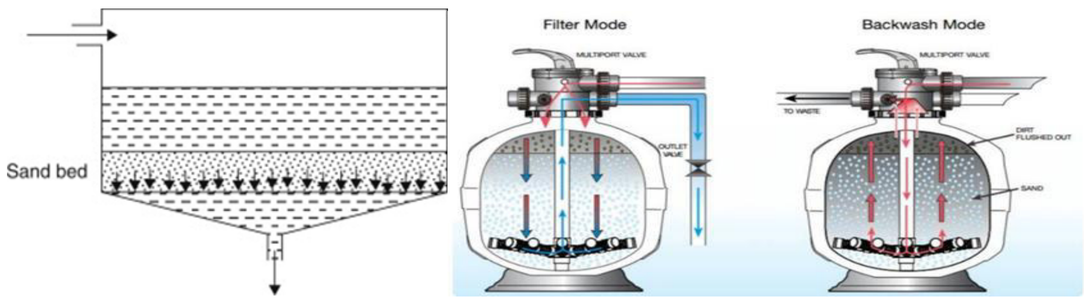
a) Mechanical Filtration

- **Principle :** Removes suspended solid particles such as uneaten feed, excrement, and organic debris [22].
- **Filter Types :**
    - **Sedimentation Filters :** Utilize gravity to allow heavy particles to settle at the bottom of a tank or basin.



    - **Screen/Sieve Filters (e.g., Drum Filters) :** Retain finer particles using rotating or stationary mesh screens.

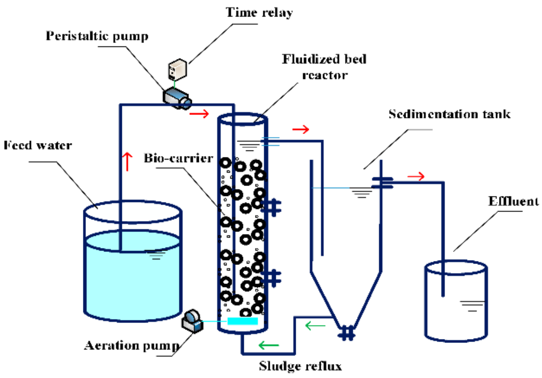
    - **Sand Filters :** Capture impurities by forcing water through a pressurized **bed of graded sand.**

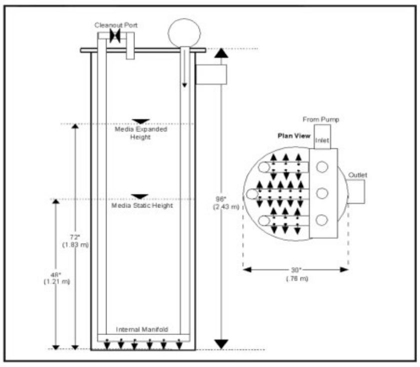


- **Advantages :** Effectively reduces Total Suspended Solids (TSS) and significantly improves water clarity.
- **Disadvantages :** Requires regular cleaning (backwashing) and maintenance to prevent clogging and anaerobic conditions.

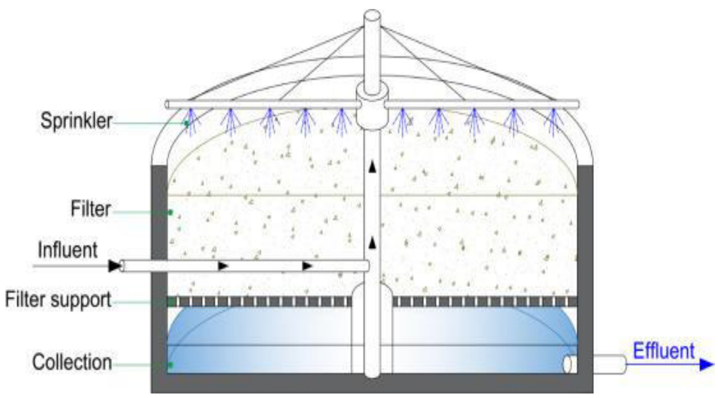
b) Biological Filtration

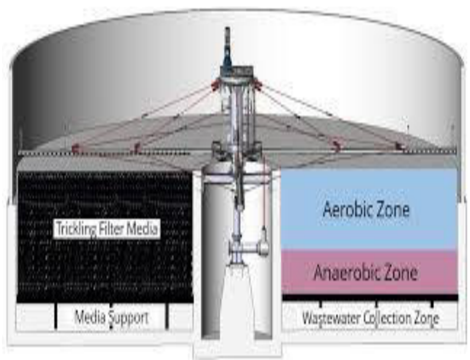
- **Principle :** Utilizes nitrifying bacteria (*Nitrosomonas* and *Nitrobacter*) to convert toxic nitrogenous waste (ammonia and nitrites) into much less toxic nitrates [4, 18].
- **Filter Types :**
  - **Fluidized Bed Filters :** Contain suspended bacterial media (such as sand or plastic beads) kept in constant motion by water or air flow.





Trickling Filters : Water trickles over a stationary high-surface-area substrate (bio-balls, stones) colonized by bacterial biofilms.

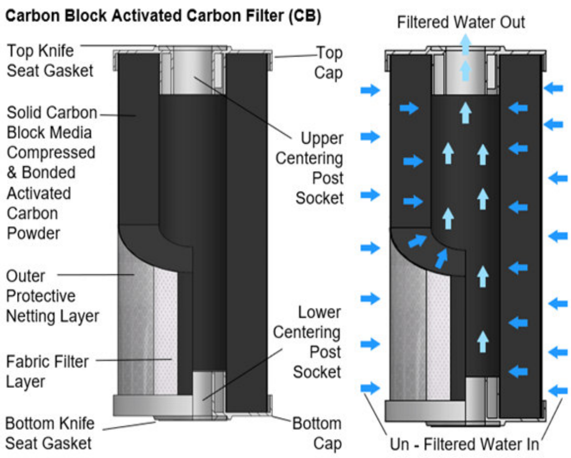




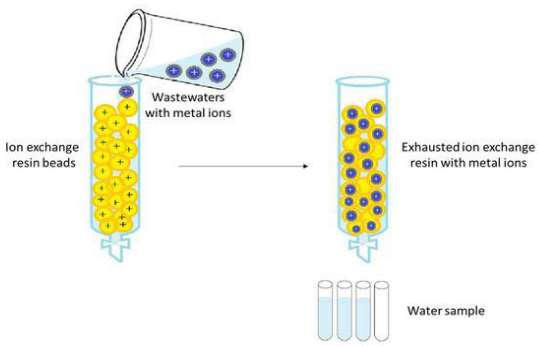
- **Advantages :** Essential for water purification by degrading dissolved chemical toxins.
- **Disadvantages :** Requires a "start-up" period (maturation) for bacterial colonization and constant monitoring of the bio-media's health to prevent "die-offs."

c) Chemical Filtration

- **Principle :** Uses adsorbent substances or chemical reactions to remove toxins and undesirable dissolved compounds that mechanical and biological filters might miss.
- **Filter Types :**
  - **Activated Carbon :** Absorbs dissolved organic and chemical pollutants, including odors and discolorations.



  - **Ion Exchange Resins:** Specifically used to regulate concentrations of minerals and heavy metals.



- **Advantages :** Highly effective at removing specific chemical contaminants and medicinal residues.
- **Disadvantages :** High operational cost; resins and carbon saturate rapidly and require frequent replacement or regeneration.

X.2 Oxygenation Systems

Dissolved oxygen (DO) is a vital element for fish larvae, as their metabolic demands are high during rapid growth phases. Several techniques are used to optimize its concentration in the water [10, 16, 22, 25] :

- **Air Diffusers:** These systems inject pressurized air through porous stones, ceramic discs, or micro-perforated pipes to create small bubbles that increase the surface area for gas exchange.
  - **Pros :** Highly effective at increasing and maintaining DO levels in small to medium-sized tanks ; helps in water circulation.
  - **Cons :** High energy consumption due to the continuous operation of air compressors or blowers; can cause gas supersaturation if not managed correctly.

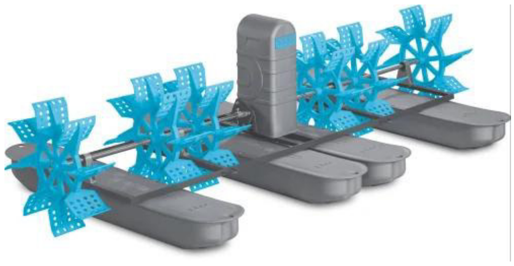
- **Cascades and Waterfalls :** Promote air-water contact through gravity-fed falling water, increasing turbulence at the surface.
  - **Pros :** Natural and cost-effective ; requires minimal mechanical parts.
  - **Cons :** Limited efficiency in high-density systems where oxygen demand exceeds atmospheric transfer rates [10, 24].

- **Pure Oxygen Injectors:** Dissolve gaseous oxygen directly into the water using specialized diffusers or oxygen cones (Speece cones).

  - **Pros :** Fast and precise oxygen delivery; allows for significantly higher stocking densities in intensive systems [16, 22].
  - **Cons :** High cost and specialized storage needs (liquid oxygen or oxygen generators).

- **Mechanical Aerators (Turbines/Paddlewheels) :** Mix air and water using rotating blades or wheels to splash the surface and facilitate gas exchange.

  - **Pros :** Excellent for large volumes of water and promoting horizontal current in ponds [8].
  - **Cons :** Noisy and energy-intensive ; can be physically harmful to delicate larvae in hatchery environments.



XI. Health Control Laboratories

Health control laboratories are essential in hatcheries to monitor water quality, ensure fish health, and prevent disease outbreaks. They optimize rearing conditions and prevent economic losses due to infections [18, 21].

XI.1 Role of Health Control Laboratories

- Monitor water physicochemical quality: Continuous assessment of pH, Dissolved Oxygen (DO), ammonia, nitrites, and nitrates [4, 22].
- Early detection of diseases: Identification of parasitic, bacterial, and viral pathogens before they reach epidemic levels [18, 21].
- Screen for contaminants : Analysis of toxic substances in water and feed sources [11].
- Optimize treatments : Development and adjustment of sanitary protocols and medical treatments [21].

XI.2 Laboratory Equipment

Hatchery labs are equipped with specialized tools for both health and environmental analysis [16, 22].

a) Water Analysis Equipment

- Multiparameter Probes : Real-time measurement of pH, DO, conductivity, and temperature [22].
- Spectrophotometer : Quantitative analysis of ammonia, nitrite, and nitrate concentrations [4].
- Optical Microscopes : Essential for the observation of external parasites (e.g., Ichthyophthirius) and pathogenic microorganisms in water or tissue smears [18].

b) Diagnostic Tools

- Rapid Diagnostic Kits : Facilitate the specific detection of common pathogens (bacteria, viruses) in the field.
- Molecular Biology (PCR) : Used to identify viral infections with high precision by detecting pathogen DNA/RNA [21].
- Bacterial Cultures : Growth and identification of pathogenic bacteria from the environment or fish tissue to determine antibiotic sensitivity [18].

XI.3 Sanitary Control Protocols

Monitoring frequencies are defined based on the sensitivity of the species and the stage of development [16, 18, 21] :

- **Daily :** Monitoring of physicochemical parameters and observation of general larval behavior and health indicators [22].

- **Weekly :** Routine microscopic observation of water samples and fish swabs to detect subclinical parasite loads [18].
- **Monthly :** Comprehensive screening for specific pathogens and adjustment of long-term sanitary protocols based on trends.

Conclusion : Proper health monitoring reduces mortality risks and enhances the profitability of fish production by guaranteeing optimal developmental conditions.

Bibliography

1) Boyd, C.E., 2015. Water quality. Springer.

2) Hamid, S.N.I.N., Abdullah, M.F., Zakaria, Z., Yusof, S.J.H.M., Abdullah, R., 2016. Formulation of fish feed with optimum protein-bound lysine for African Catfish (Clarias gariepinus) fingerlings. Procedia Eng. 148, 361–369.

3) Bostock, J., McAndrew, B., Richards, R., Jauncey, K., Telfer, T., Lorenzen, K., Little, D., Ross, L., Handisyde, N., Gatward, I., 2010. Aquaculture : global status and trends. Philos. Trans. R. Soc. B Biol. Sci. 365, 2897–2912.

4) Tacon, A.G.J., Metian, M., McNevin, A.A., 2022. Future feeds: suggested guidelines for sustainable development. Rev. Fish. Sci. Aquac. 30, 135–142.

5) Demeke, A., Tassew, A., 2016. A review on water quality and its impact on fish health. Int. J. fauna Biol. Stud. 3, 21–31.

6) Pavlov, D., Kjorsvik, E., Refsti, T., Andersen, O., 2004. Brood stock and egg production. Cult. Cold-water Mar. fish. Blackwell Publ. London 129–203.

7) Sankhla, M.S., Kumar, R., Shefali, 2020. New and advanced technologies in aquaculture to support environmentally sustainable development, in : Microbial Biotechnology: Basic Research and Applications. Springer, pp. 249–263.

8) Gopalakrishnan, V., Coche, A.G., 1994. Handbook on small-scale freshwater fish farming. Collect. FAO Form.

9) Colt, J., 2006. Water quality requirements for reuse systems. Aquac. Eng. 34, 143–156.

10) Colt, J., Watten, B., 1988. Applications of pure oxygen in fish culture. Aquac. Eng. 7, 397–441.

11) De Silva, S.S., Anderson, T.A., 1994. Fish nutrition in aquaculture. Springer Science & Business Media.

12) Yohana, M.A., Ray, G.W., Yang, Q., Tan, B., Chi, S., Asase, A., Shiyu, K., Derrick, A., 2023. A review on the use of Azolla meal as a feed ingredient in aquatic animals' diets. Aquac. Res. 2023, 2633412.

13) Halver, J.E., 2002. Fish Nutrition : 3'rd Ed–Academic Press. New York.

14) Jean, G., Kaushik, S., Bergot, P., 1999. Nutrition et alimentation des poissons et crustacés. Editions Quae.

15) Wheaton, F., 2002. Recirculating aquaculture systems: an overview of waste management, in: Proceedings of the 4th International Conference on Recirculating Aquaculture, Roanoke.

16) Moretti, M., Pedini Fernandez-Criado, M., Cittolin, G., Guidastri, R., 1999. Manual on hatchery production of seabass and gilthead seabream-Volume 1.

17) Naylor, R.L., Goldburg, R.J., Primavera, J.H., Kautsky, N., Beveridge, M.C.M., Clay, J., Folke, C., Lubchenco, J., Mooney, H., Troell, M., 2000. Effect of aquaculture on world fish supplies. Nature 405, 1017–1024.

18) Noga, E.J., 2010. Fish disease: diagnosis and treatment. John Wiley & Sons.

19) Roberts, R.J., 2012. Fish pathology 4th ed. A John Wiley Sons, Ltd., Publ.

20) Ross, L.G., Telfer, T.C., Falconer, L., Soto, D., Aguilar-Manjarrez, J., Asmah, R., Bermúdez, J., Beveridge, M.C.M., Byron, C.J., Clément, A., 2013. Carrying capacities and site selection within the ecosystem approach to aquaculture. Site Sel. Carr. Capacit. Inl. Coast. Aquac. 19.

21) Austin, B., Newaj-Fyzul, A., 2017. Diagnosis and control of diseases of fish and shellfish. Wiley Online Library.

23) Woo, P.T.K., Bruno, D.W., 2011. Vol. 3 : Viral, bacterial and fungal infections. Wallingford : CABI.

24) Woynarovich, A., Hoitsy, G., Moth-Poulsen, T., 2011. Small-scale rainbow trout farming. FAO Fish. Aquac. Tech. Pap.

25) Djezzar, M., Mortillaro, J.-M., Doumandji, S.E., Meziane, T., 2021. Links between introduced fish and zooplanktonic and zoobenthic food sources in the food webs of two reservoirs of a semi-arid zone in Algeria. African J Aquat Sci. 46(1):33–44.