AQUAFOCUS

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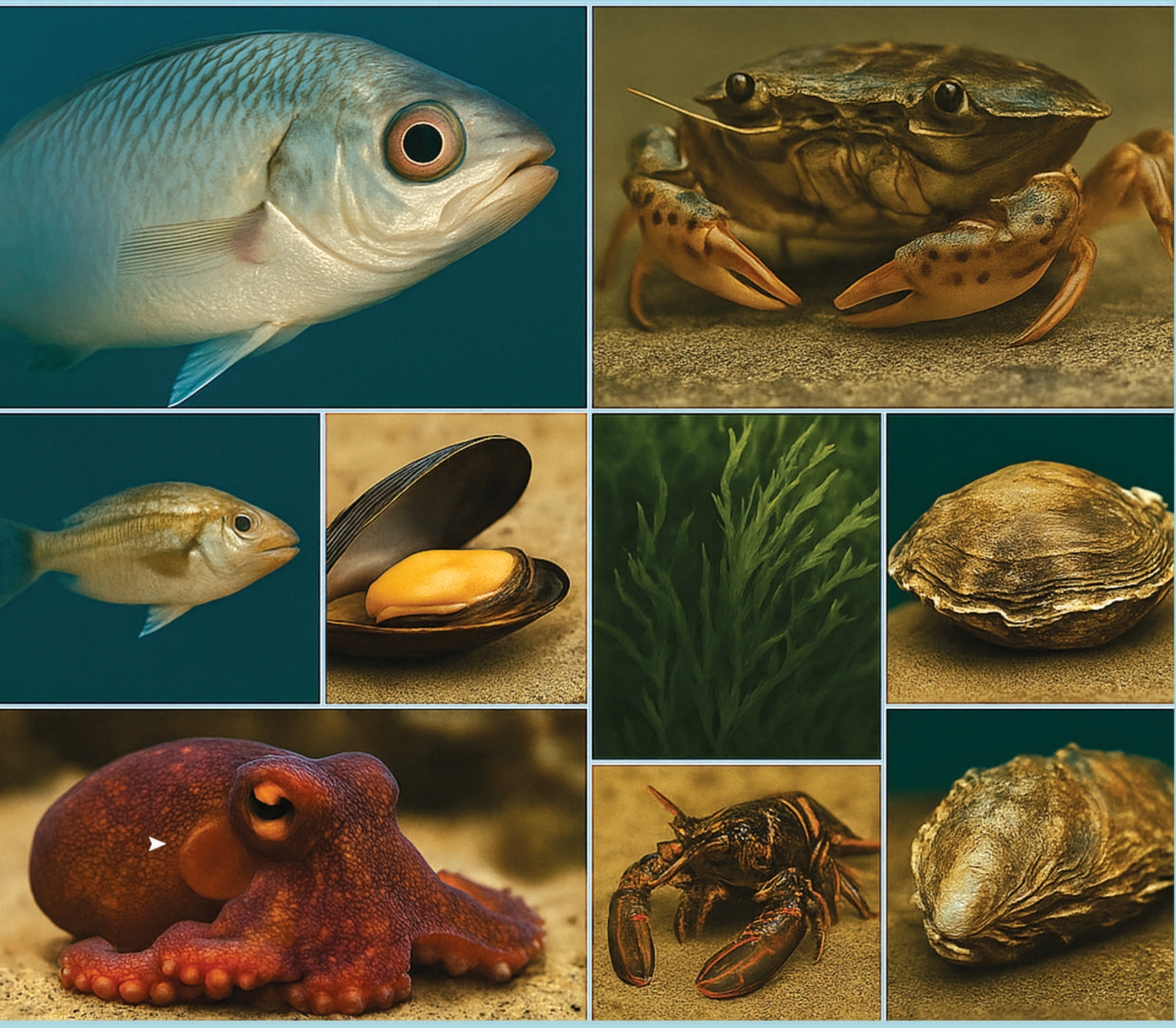

HIGHLIGHTS

- AI and IoT making farms efficient and eco-friendly
- Bacteriophage therapy replacing antibiotics
- Seaweed Farming Boosting marine life
- Marine biopolymers transforming medicine
- Aquasilviculture combining aquaculture
- IFT Expo 2025


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AQUAFOCUS

Dedicated to Aquaculture Research & Development

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EDITOR'S LETTER

Dear Readers,

Welcome to this new transformative edition of AQUAFOCUS, where innovation meets ecological consciousness in the vast realm of aquaculture. This issue brings into focus the convergence of scientific progress, grassroots ingenuity, and sustainable strategies shaping the future of our aquatic resources.

As aquaculture grapples with rising global demand, the industry is undergoing a revolution from what we feed our fish to how we integrate nature into our farming systems. Smart technologies like AI-driven water quality monitors and IoT-enabled feed systems are redefining how farms operate, minimizing waste while maximizing yield. Equally compelling is the resurgence of bacteriophage therapy, a nature-powered alternative to antibiotics in aquaculture health management.

We turn our lens to seaweed aquaculture, a silent climate warrior that not only supports marine biodiversity but also absorbs carbon and purifies our oceans. Institutions like ICAR-CMFRI and CSIR-CSMCRI are driving its growth, opening new economic frontiers for coastal communities.

Another highlight in this issue is the expanding role of aquasilviculture, a practice that gracefully fuses aquaculture with mangrove conservation. Through integrated pond systems and community-led resource management, this approach not only restores fragile coastal ecosystems but also supports resilient rural livelihoods. You'll also find an in-depth look at rotifer enrichment, a vital yet often underappreciated component of successful fish larviculture. From microalgae to commercial emulsions, the science of boosting live feed nutrition is taking larval survival rates to new heights.

In our special pharma-science feature, we explore the cutting-edge roles of chitin and chitosan, marine biopolymers transforming wound healing, tissue engineering, and drug delivery. Their journey from shrimp shells to hospital shelves is nothing short of remarkable.

Finally, we confront the heart of sustainable aquaculture: feed innovation. Insect protein, algae, microbial meals, and upcycled agri-waste are no longer future possibilities they are today's solutions. These ingredients are helping us feed fish without depleting the oceans, all while nurturing gut health, improving immunity, and closing the nutrient loop.

Each story in this issue is a testament to what's possible when science, policy, and community move in harmony. Together, we can build an aquaculture sector that nourishes both people and the planet.

With optimism and gratitude,

Dr. Jesu Arockia Raj. A
Editor-in-Chief
AQUAFOCUS

PhytoGrow

PREMIX POWDER - GUT HEALTH - AQUA FEED SUPPLEMENT

COMPOSITION PER 1 KG
Cassia cinnamon powder 175 g
Garlic extract powder 50 g
Chicory extract powder 100 g
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Calcium propionate 50 g
Bentonite up to 1 kg

GUARANTEED ANALYSIS PER KG
Cinnamaldehyde≥ 5.00g/Kg, calcium propionate≥ 35.0g/Kg, thymol≥ 35.0g/Kg

INDICATIONS
Natural growth promoter and gut health enhancer for all species and ages.

DIRECTIONS FOR USE
Mix homogeneously with feed at 0.6-5 kg/ton of complete feed. Recommended doses: Broilers: 0.6-1 kg/ ton of complete feed. Layers and breeders: 1-2 kg/ ton of complete feed. Ruminants: 1-3 kg/ ton of complete feed. Shrimp and fish: 2-5 kg/ton.
PhytoGrow does not contain antibiotics.

STORAGE AND HANDLING
Store well closed in a cool and dry place. Do not eat, drink or smoke while handling.
Avoid any contact with the product.

Net weight: 1 Kg Batch and manufacturing date: See the top of the bag.
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Rotifer Enrichment Diets for Marine Finfish Larviculture

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Abstract

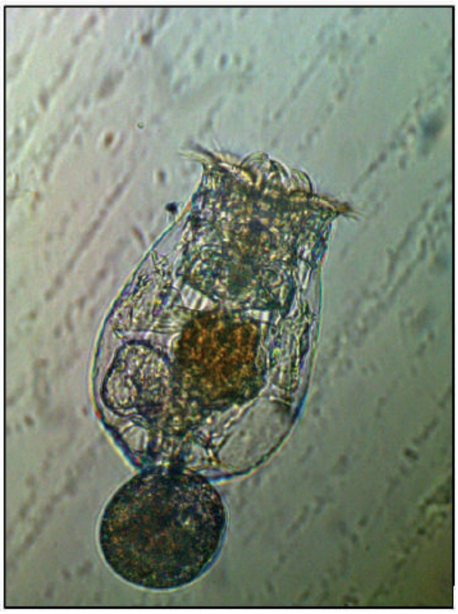
Successful raising of marine fish larvae in aquaculture is strongly dependent on the availability of appropriate and adequate live feed. Rotifers, a common first feed for many marine fish larvae, often lack essential nutrients vital for the optimal growth and survival of fish larvae. However, through enrichment techniques, rotifers can be fortified with essential nutrients, enhancing their nutritional profile and subsequently improving the growth and survival rates of marine fish larvae. This article focuses on the nutrient-rich diets available to enrich rotifers and boost the growth and survival of marine fish larvae.

Keywords: Rotifers, Bio-enrichment, Mariculture, Larval Rearing, Nutritional Benefits

Introduction

Rotifers are microscopic aquatic creatures that play an important role in the early feeding stages of marine fish larvae due to their small size and nutritional composition. Rotifers, on the other hand, are naturally deficient in key nutrients such as omega-3 fatty acids, vitamins, and minerals, all of which are required for fish larval growth. They demonstrate exceptional filter-feeding behaviour, which is critical for their survival. This feeding method uses specialised structures, such as the corona or ciliated feeding apparatus, to generate water currents that draw in suspended particles. The corona, which resembles a rotating wheel or a vortex generator, drives water and particles into the mouth, where food is gathered and taken in. Rotifers feed on a wide variety of microorganisms, including algae, bacteria, and debris, and filter them out of the surrounding water column. This filter-feeding behaviour allows them to eat a variety of foods and survive in nutrient-rich surroundings.

Bioencapsulation, also known as bio-enrichment, is the act of increasing the nutritional status of live food organisms by feeding or incorporating various types of nutrients into them. It entails improving the nutritional value of live-feed organisms through dietary management. Several bio-enrichment approaches have been developed to provide rotifers with vital nutrients. These methods include feeding rotifers nutrient-dense foods, including microalgae, yeast, and commercial emulsions containing essential fatty acids and vitamins. Rotifer bio-enrichment has a major impact on marine fish larval growth. They offer important fatty acids such as EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid), which are required for the development of larval nervous systems and overall health. Furthermore, enriched rotifers are high in vitamins and minerals, which promote healthy growth, development, and immunological function in fish larvae. Studies have demonstrated that larvae fed enriched rotifers have better growth metrics, such as body length, weight, and survival rates, than those fed non-enriched rotifers.



Rotifer (*Brachionus plicatilis*)

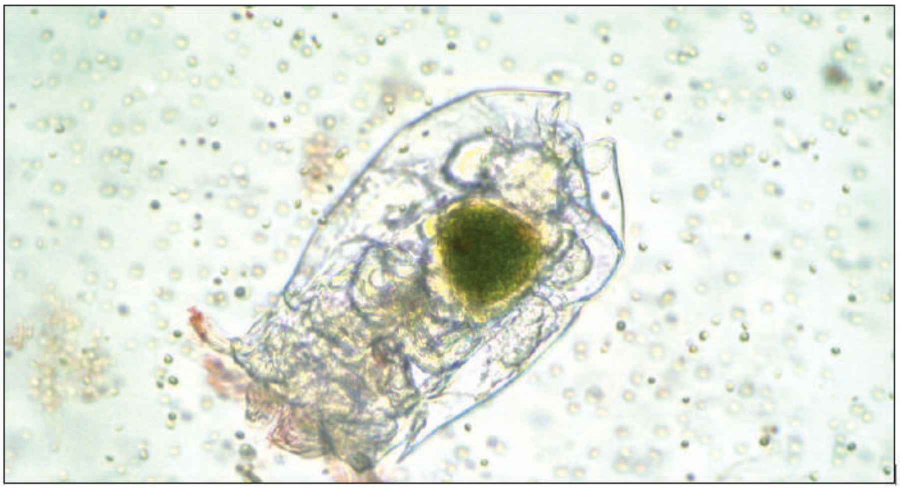
Diets for rotifer enrichment

1) Yeast

Yeast is a rich source of protein required for the growth and development of rotifers. *Saccharomyces cerevisiae*, also known as brewer's yeast, is frequently used as rotifer enrichment diets due to its high nutritional value and availability. However, there are some limitations to this enrichment process, such as lack of certain essential nutrients, quality variation, excessive fouling, and microbial growth.

2) Microalgae

Microalgae play an important part in rotifer enrichment by delivering key nutrients such as omega-3 fatty acids, vitamins, and minerals required for the growth and development of marine fish larvae. Several microalgae species are widely used for rotifer enrichment in aquaculture due to their nutritional profiles and compatibility for larval fish diets. Here are some of the most often utilised microalgae for rotifer enrichment.



Rotifer enriched with microalgae

a) Nannochloropsis sp.: Nannochloropsis is a species of microalgae renowned for its high lipid content, notably omega-3 fatty acids like EPA. It is commonly employed in rotifer enrichment diets.

b) Tetraselmis sp.: Tetraselmis is a green microalga that is extensively used in aquaculture due to its high protein, vitamin, and carotenoid content. It serves as an excellent feed for rotifers.

c) Isochrysis sp. (T-ISO): Isochrysis is a genus of microalgae recognised for its high concentration of important fatty acids, particularly DHA, vitamins, and sterols. The Isochrysis T-ISO strain is frequently used in rotifer enrichment diets due to its balanced nutritional composition.

d) Chaetoceros sp.: Chaetoceros is a genus of diatom microalgae that is widely utilised as live feed in aquaculture as it is nutrient-packed and easy to culture.

e) Thalassiosira sp.: Thalassiosira is another genus of diatom microalgae that is commonly employed in aquaculture due to its high nutritional value and appropriateness as rotifer feed.

f) Phaeodactylum tricornutum: Phaeodactylum is a diatom microalgae that contains high levels of EPA and other nutrients.

g) Skeletonema sp.: Skeletonema is a diatom microalgae that has become popular in aquaculture due to its nutritional content and suitability for feeding rotifers.

h) Schizochytrium sp.: Schizochytrium is a marine microalgae that is often utilised in rotifer enrichment for marine fish larviculture due to its high DHA content.

These microalgae species were chosen based on their nutritional value, availability, and suitability for rotifer enrichment diets in aquaculture. Aquaculturists frequently use a variety of microalgae species to offer a balanced and comprehensive diet for rotifers, resulting in optimal growth and nutritional quality for marine fish larvae.

3) Commercial Emulsions

Commercial emulsions designed explicitly for rotifer enrichment are commonly utilised in aquaculture. These emulsions contain essential fatty acids (EPA and DHA), vitamins, pigments, and other nutrients that support larval fish growth and development.

4) Microbial Products

Rotifers' nutritional quality can be improved using microbial products such as probiotics and enzymatic hydrolysates. These products provide readily available nutrients, bioactive peptides, and immunostimulants that are advantageous to larval fish nutrition.

5) Microencapsulated Diets

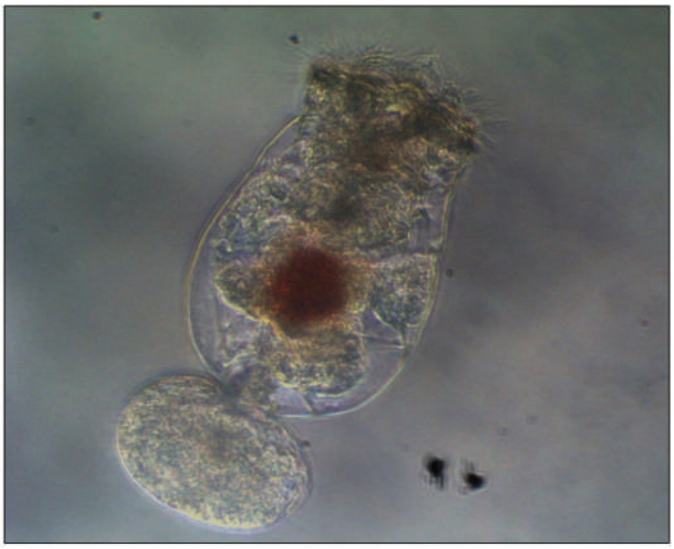
Microencapsulated meals are made up of microscopic particles that include a concentrated blend of nutrients enclosed in a lipid matrix. These diets enable controlled nutrient release, ensuring the long-term enrichment of rotifers.

6) Other Natural Supplements

In addition to the aforementioned feeds, other natural supplements such as fish oil, fish hydrolysates, and egg yolk are utilised to enrich rotifers with critical nutrients, further boosting their nutritional value for larval fish.

Aquaculturists carefully select and blend feeds depending on the nutritional requirements of both rotifers and target fish species in order to optimise the enrichment process and ensure the successful growth and development of marine fish larvae in aquaculture setups.

Commercial products for rotifer enrichment



Rotifer enriched with astaxanthin pigment

Several commercial items are routinely used in aquaculture to enrich rotifers in order to increase their nutritional value for optimal larval fish growth. These products are designed to supply important nutrients such as omega-3 fatty acids, vitamins, minerals, and pigments that marine fish larvae require for optimal health and vitality. Here are some of the well-known commercial items used for rotifer enrichment:

Selco is a well-known brand that offers a variety of products, including a combination of highly unsaturated fatty acids (HUFA), vitamins, and other elements required for fish larval growth. It is often used as a feed supplement for rotifers.

Red Pepper is a complete enrichment product for rotifers that is high in essential fatty acids while also containing well-balanced critical nutrients that are typically absent in yeast-based diets or lipid emulsions. It also contains important vitamins and chelated trace minerals, which influence immunity and collagen tissue growth.

LARVIVA Multigain is a live-feed enrichment diet with all of the nutrients needed by marine fish larvae. It contains the ideal amount and ratio of Omega-3 and -6 fatty acids, as well as a high concentration of vitamins, minerals, immunostimulants, and phospholipids.

Instant Algae provides a variety of microalgae concentrates and enrichment solutions aimed at increasing the nutritional content of live feeds, including rotifers.

RotiGrow Plus and RotiGreen contain microalgae concentrates and other nutritional supplements intended to improve the nutritional value of rotifers and other live feeds for marine fish larvae.

Algamac is a microalgae-based product that enriches rotifers with essential fatty acids, specifically EPA and DHA. It comprises a concentrated blend of microalgal species renowned for their excellent nutritional content and bioavailability.

Many more commercial products are available in the market, and these are supplied by INVE, Belgium, Bern Aqua, Belgium, BioMar, Denmark, Reed Mariculture, California, Aquafauna Bio-Marine, California, Algagen, Florida, Proviron, Belgium, Reefphyto, UK, Easy Reefs, Spain, Necton, Portugal, Shenzhen Qianhai Xiaozao Technology, China, etc. These commercial products offer aquaculturists simple and effective ways to enrich rotifers with critical nutrients, thereby promoting the successful growth and development of marine fish larvae in aquaculture systems.

Challenges and Future Directions

Despite the obvious advantages of bio-enrichment, some problems remain, including cost-effectiveness, scalability, and developing suitable enrichment procedures for various fish species. Future research should concentrate on improving bio-enrichment processes, investigating alternate cost-effective nutrient sources, determining the nutrient transmission rate, and assessing the long-term implications in marine fish larviculture.

Conclusion

Bio-enrichment of rotifers represents a potential approach for improving the growth and survival of marine fish larvae in aquaculture facilities. By fortifying rotifers with essential nutrients, aquaculturists can provide larvae with a nutritionally balanced diet, leading to improved growth rates, survival rates, and overall larval quality. Bio-enrichment strategies require ongoing study and innovation to advance sustainable practices in marine fish larviculture and meet the world's growing demand for seafood.

Cresco

Live Goods

CRESCO Objectives

CRESCO aims to cultivate and produce huge quantitative of Algae for Aquaculture Industry for use as Feed and Nutrition agent It aims for Mass production of Spirulina and value added products with an initial Target of 1Ton per month. Gradually it aims to develop large scale Algae ponds and be one of the largest producer of Spirulina – both for domestic consumption and also for International exports.

CRESCO and MICROALGAE Production

Cresco aims to produce large quantities of Algae and Microalgae. This would encompass production of economically important algal species like *Spirulina sp, Chlorella sp, Dunaliella sp, Hematococcus sp, Nanochloropsis sp, Diatoms, etc.* These are highly useful in the Aquaculture industry as Fish Nutrition.

CRESCO ALGAE FORT

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Aquasilviculture: A Sustainable Approach to Integrated Coastal Resource Management

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Abstract

Aquasilviculture is an integrated coastal resource management system that combines aquaculture with mangrove conservation or reforestation. This nature-based solution promotes environmental sustainability, economic viability, and social equity in coastal communities. In response to the harmful effects of conventional aquaculture, especially the large-scale clearing of mangroves, aquasilviculture offers a balanced approach that supports both ecological restoration and food production. This review explores the principles, benefits, challenges, pond construction methods, and future prospects of aquasilviculture as a sustainable livelihood strategy and an ecosystem-based adaptation tool.

Introduction

Aquasilviculture is an ecologically sustainable farming practice that integrates aquaculture with the conservation and rehabilitation of mangrove forests. This approach was developed in response to the environmental degradation caused by intensive aquaculture, particularly the widespread clearing of mangroves. It aims to balance economic livelihood with ecosystem preservation. By cultivating aquatic species such as shrimp, fish, or crabs alongside the protection or replanting of mangrove trees, aquasilviculture provides dual benefits: supporting the economic needs of coastal communities while restoring essential coastal habitats. This method enhances biodiversity and water quality, and it strengthens natural defenses against coastal erosion and the impacts of climate change. As a nature-based solution, aquasilviculture is crucial for achieving long-term environmental sustainability and food security in coastal regions.

Principles of Aquasilviculture

Aquasilviculture is founded on the principle of harmonious coexistence between aquaculture and mangrove ecosystems, aiming for ecological balance, economic sustainability, and social equity. This approach typically allocates 60–70% of the farming area to mangrove conservation or reforestation, while the remaining 30–40% is designated for aquaculture ponds. This spatial arrangement facilitates natural tidal exchange and nutrient cycling, reducing the need for artificial inputs such as pumps or chemical treatments. By preserving mangrove cover, the system enhances biodiversity, improves water quality, and provides natural protection against coastal erosion and extreme weather events. Moreover, community participation, the use of native species, and eco-friendly farming practices are central to aquasilviculture, ensuring that both environmental and livelihood needs are met sustainably and
inclusively.

Pond Construction and Layout

The construction and layout of ponds in aquasilviculture systems are meticulously planned to support aquaculture while conserving mangroves. Site selection focuses on low-lying coastal or estuarine areas that naturally experience tidal influences and have the potential for mangrove growth. Typically, the layout follows a 60:40 or 70:30 ratio, Ponds are constructed as shallow earthen basins, generally 0.8 to 1.5 meters deep, featuring well-compacted dikes and integrated water control structures, such as sluice gates, to manage tidal water exchange.

Internal canals and buffer zones are included to ensure effective drainage and promote mangrove growth around the ponds. Mangrove trees are planted along pond embankments and in intertidal zones to stabilize the soil and enhance ecological functions. This integrated design fosters sustainable water management, minimizes environmental impact, and creates a balanced ecosystem that benefits both aquatic and terrestrial productivity.

Species Cultured and Mangrove Compatibility

Aquasilviculture supports a variety of aquatic species that thrive in brackish water and coexist harmoniously with mangrove ecosystems. Commonly cultured species include shrimp *(Penaeus monodon and P. vannamei)*, mud crabs (*Scylla serrata)*, milkfish *(Chanos chanos)*, and tilapia (*Oreochromis spp.)*. These species can grow effectively in low-input systems that utilize natural food sources and experience minimal environmental stress, benefiting from the shelter, organic matter, and improved water quality provided by nearby mangroves.

Penaeus vannamei

Penaeus monodon

Chanos chanos

Oreochromis spp.

Scylla serrata

Mangrove species such as *Rhizophora mucronata, Avicennia marina*, and *Sonneratia alba* are often integrated into aquasilviculture systems due to their robust root structures, high salinity tolerance, and ecological significance. Their presence not only stabilizes pond embankments but also enhances biodiversity and nutrient cycling. This synergy between aquatic and mangrove species ensures the resilience and productivity of the system, making aquasilviculture an ecologically sustainable and economically viable method of coastal aquafarming.

Avicennia marina

Rhizophora mucronata

Sonneratia alba

Benefits of Aquasilviculture

Aquasilviculture offers numerous environmental, economic, and social benefits, making it a sustainable alternative to traditional coastal aquaculture. Environmentally, it supports the restoration and conservation of mangrove forests, which act as natural water filters, carbon sinks, and protective barriers against storms and coastal erosion. By maintaining ecological balance, this system enhances biodiversity and improves water quality, reducing reliance on chemical inputs.

Economically, aquasilviculture provides diverse income opportunities for coastal communities through the cultivation of fish, shrimp, crabs, and mangrove-based products such as honey, fuelwood, and handicrafts. It also lowers operational costs by utilizing natural ecosystem services like tidal water exchange and organic waste recycling.

Socially, this approach empowers local communities by encouraging their active participation in resource management and conservation initiatives. It enhances food security, creates rural employment, and promotes knowledge sharing, all of which align with the broader goals of sustainable development and climate change adaptation.

Challenges and Limitations

Despite its sustainability benefits, aquasilviculture faces several challenges that impede its widespread adoption. One key limitation is its lower productivity compared to intensive aquaculture systems, as the emphasis on ecological balance restricts stocking density and feed input. Additionally, land tenure issues and policy conflicts can arise, particularly in areas where mangroves are protected or ownership rights are ambiguous, creating barriers to long-term investment and management.

Farmers may lack the technical knowledge and training needed to effectively manage integrated systems, especially regarding water quality, species compatibility, and mangrove maintenance. Furthermore, the initial costs and labor required for mangrove planting and infrastructure development may deter smallholders. Regular monitoring and enforcement of sustainable practices are also challenging in community-based settings without adequate support. Addressing these limitations requires strong institutional support, community engagement, access to technical guidance, and policies that promote conservation-oriented aquaculture practices.

Global and Regional Applications

Aquasilviculture has been successfully implemented in various countries, particularly in tropical and subtropical coastal regions where mangroves and aquaculture coexist. In the Philippines, the National Aquasilviculture Program (NAP) has been instrumental in integrating fish and shrimp farming with mangrove reforestation, involving coastal communities in both livelihood development and environmental rehabilitation. Similarly, Vietnam and Indonesia have adopted silvofisheries models within their mangrove-shrimp farming systems, aided by government policies and support from international organizations to combat mangrove loss and promote sustainable aquaculture.

In Bangladesh, integrated mangrove-aquaculture practices have demonstrated potential in enhancing resilience to climate change and improving rural incomes. These regional initiatives illustrate the adaptability of aquasilviculture across different ecological and socioeconomic contexts, providing valuable lessons for scaling up the approach globally. Through community participation, institutional support, and knowledge sharing, aquasilviculture is increasingly recognized as a viable solution for sustainable coastal resource management.

Future Prospects

The future of aquasilviculture looks promising as the world increasingly embraces nature-based solutions to address climate change, biodiversity loss, and food security. With growing awareness of the ecological and economic benefits of mangroves, aquasilviculture offers a scalable approach to sustainable coastal development. Innovations in low-impact aquaculture practices, enhanced mangrove restoration techniques, and digital monitoring tools can improve the efficiency and appeal of these systems.

Furthermore, the rising demand for eco-certified seafood and blue carbon credits creates new economic incentives for communities and investors to adopt integrated approaches. Policymakers are also recognizing the importance of aquasilviculture in national climate adaptation and coastal protection strategies. By fostering community engagement, providing technical support, and integrating effective policies, aquasilviculture has the potential to transform degraded coastlines into productive, resilient ecosystems that support livelihoods and long-term environmental health.

Conclusion

Aquasilviculture is a sustainable and holistic approach to coastal resource management that combines aquaculture with mangrove conservation. It addresses the urgent need to balance environmental preservation with economic development, offering a viable solution to the ecological degradation caused by intensive aquaculture practices.

By prioritizing biodiversity, natural water management, and community involvement, aquasilviculture enhances the resilience of coastal ecosystems while supporting local livelihoods. Although it faces challenges such as lower yields and technical limitations, the long-term environmental, social, and economic benefits make it an appealing model for sustainable development. With increased support from governments, researchers, and international agencies, aquasilviculture has the potential to become a cornerstone of climate-resilient coastal farming and a blueprint for integrated natural resource management worldwide.

Insects, Algae, and Beyond: The New Ingredients Powering Aquafeeds

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A Blue Revolution Needs a Feed Revolution

As global demand for seafood rises, aquaculture must scale sustainably. However, the over-reliance on fishmeal and fish oil is creating ecological strain. Innovators are turning to unconventional yet sustainable ingredients from insects to algae and fermented proteins to revolutionize fish and shrimp feed.

1. Insects: The High-Protein Powerhouse

Insects particularly black soldier fly (BSF) larvae have emerged as one of the most promising sustainable protein sources in aquafeeds. These tiny organisms thrive on organic waste, converting it into nutrient-dense biomass in a matter of days. With a crude protein content of 40–60% and rich in essential amino acids, fats, and micronutrients, BSF meal is an effective substitute for traditional fishmeal.

Nutritional Highlights:

- High protein and fat content
- Rich in lauric acid (antimicrobial properties)
- Excellent amino acid profile for finfish and shrimp

Environmental Benefits:

- Grown on food and agricultural waste
- Requires far less land and water than soy or fishmeal
- Supports circular bioeconomy and waste valorization

Numerous studies have shown that BSF larvae meal can replace up to 50% of fishmeal in tilapia, catfish, and shrimp diets without compromising growth, feed conversion ratio (FCR), or health.

2. Algae and Seaweed: Ocean's Functional Feed

From microscopic microalgae to macro-scale seaweeds, marine flora is redefining the nutritional foundation of modern aquafeeds. These oceanic ingredients are rich in omega-3 fatty acids (DHA, EPA), antioxidants, vitamins, and bioactive compounds that support fish health, growth, and stress resistance.

Nutritional Highlights:

- Microalgae like Schizochytrium and Chlorella are rich in DHA and essential amino acids
- Seaweeds such as Ulva, Gracilaria, and Sargassum provide minerals, polysaccharides, and immunity-boosting compounds
- Improve pigmentation, gut health, and reproductive performance

Environmental Benefits:

- Grown without freshwater, fertilizers, or land
- Sequester carbon and improve coastal water quality
- Ideal for integration with mariculture and coastal SHG enterprises

Algal oils are now commercially replacing fish oil in salmon and trout diets with no adverse impact on growth or taste. Red and green seaweed extracts have shown antibacterial and immunostimulant effects in shrimp and carp culture.

3. Fermented Proteins: Single-Cell Innovations

As aquaculture seeks stable, scalable protein alternatives, single-cell proteins (SCPs) produced through fermentation of bacteria, yeasts, fungi, and algae are emerging as game-changers. These proteins are grown using industrial fermentation technology, often utilizing methane, ethanol, or food processing waste as feedstock.

Nutritional Highlights:

- Crude protein content between 60–75%
- Rich in nucleotides, B-complex vitamins, and functional compounds
- Highly digestible with low anti-nutritional factors.

Environmental Benefits:

• Utilizes waste carbon gases or agro-industrial residues
• Requires no arable land or freshwater
• Produces consistent quality protein all year round
Studies on species like barramundi, tilapia, and shrimp show that SCPs such as those from Methylococcus capsulatus, Corynebacterium glutamicum, or Candida

Picture 1: Showing black soldier fly larvae, spirulina, fermenters, and seaweeds on racks

utilis can replace up to 80% of fishmeal without affecting performance. They also improve gut microbiota and reduce nitrogen waste.

4. Agri-Food Waste: From Trash to Feed

In the quest for sustainable aquafeeds, agri-food waste once seen as valueless is now being upcycled into high-nutrition, low-cost feed ingredients. From fruit pomace and vegetable peels to spent grain and bakery waste, these byproducts are being fermented, dried, or pelletized to support fish and shrimp growth.

Nutritional Highlights:

• Rich in dietary fiber, residual carbohydrates, and moderate protein
• Valuable micronutrients from peels and pulp (e.g., potassium, polyphenols)
• Can serve as prebiotics to support gut health

Circular Economy Benefits:

• Reduces landfill and greenhouse gas emissions
• Creates value from perishable food chain losses
• Empowers coastal communities with micro-feed units

5. Functional Additives from Nature

As antibiotic resistance and disease outbreaks challenge aquaculture, the spotlight is shifting to natural functional additives that not only support fish growth but also enhance immunity, gut health, and resilience to stress. These ingredients, derived from plants, microbes, and marine sources, are being blended into modern aquafeeds as natural immunostimulants, probiotics, and alternatives to antibiotics.

Key Categories of Functional Additives:

1. β-glucans (from yeast/mushrooms)
• Activate non-specific immunity in shrimp and fish
• Reduce mortality under Vibrio and Aeromonas challenges
2. Phytogenic extracts (garlic, neem, turmeric, moringa)
• Antibacterial, antifungal, antioxidant properties
• Improve digestion and FCR
3. Probiotics and prebiotics (e.g., Bacillus subtilis, inulin)
• Balance gut microbiota
• Improve nutrient uptake and reduce ammonia stress
4. Phage-based biocontrol
• Target specific fish pathogens like Vibrio harveyi without harming beneficial bacteria
• Scalable for hatchery and pond use

Sustainability Angle:

• Reduces reliance on chemicals and antibiotics
• Environmentally safe, residue-free, and export-friendly
• Enables organic aquaculture certification for high-value markets

Conclusion: A Feed System Fit for the Future

As aquaculture feeds billions, future feeds must be sustainable and responsible. Insect meal, algae, SCPs, and food-waste proteins are driving the transformation of aquafeeds into climate-smart solutions for global food security.

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A Short Review on Ectoparasite Removal from Fish - Current Methods, Emerging Technologies and Control Strategies

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1. Introduction

The global aquaculture industry has expanded rapidly over the past few decades, contributing significantly to food security and livelihoods. However, with intensification and high stocking densities, disease outbreaks have become more frequent and severe. Fish infected with ectoparasites may exhibit visible lesions on their body surface and abnormal behaviours. Among these, ectoparasites are of particular concern as they cause direct damage to fish skin, fins, and gills, resulting in secondary infections, stress, reduced growth rates, and high mortality (Roberts, 2012). Examination of mucilage samples from the gills, skin, fins, and tails under a microscope can confirm the presence of ectoparasites. Common ectoparasites include *Ichthyophthirius multifiliis, Trichodina spp., Dactylogyrus, Gyrodactylus, Lernaea, Argulus, and Caligus*. Figure 1 shows the ectoparasites of fish. Ectoparasite control is vital not only for fish welfare but also for environmental sustainability and economic viability. Thus, this review explores a broad range of existing and emerging strategies to combat ectoparasitic infections in aquaculture.

2. Common Ectoparasites and Their Impacts

Ectoparasites vary in their morphology, host specificity, and pathogenic potential. Protozoans such as Ichthyophthirius multifiliis are common in freshwater fish, attaching to the skin and gills and causing respiratory distress (Matthews, 2005). Trichodina spp. are ciliated protozoans that can damage fish epithelium and facilitate bacterial co-infections. Monogeneans such as Dactylogyrus and Gyrodactylus affect gill and body surfaces, leading to hyperplasia and impaired oxygen uptake. Crustacean ectoparasites like Argulus (fish lice), Lernaea (anchor worm), and Caligus (sea lice) are particularly problematic in large-scale aquaculture operations. Figure 2 shows mechanism of ectoparasite affect fishes to cause infections. The ectoparasites feed on host tissue and blood, causing inflammation and secondary bacterial and fungal infections (Noga, 2010).

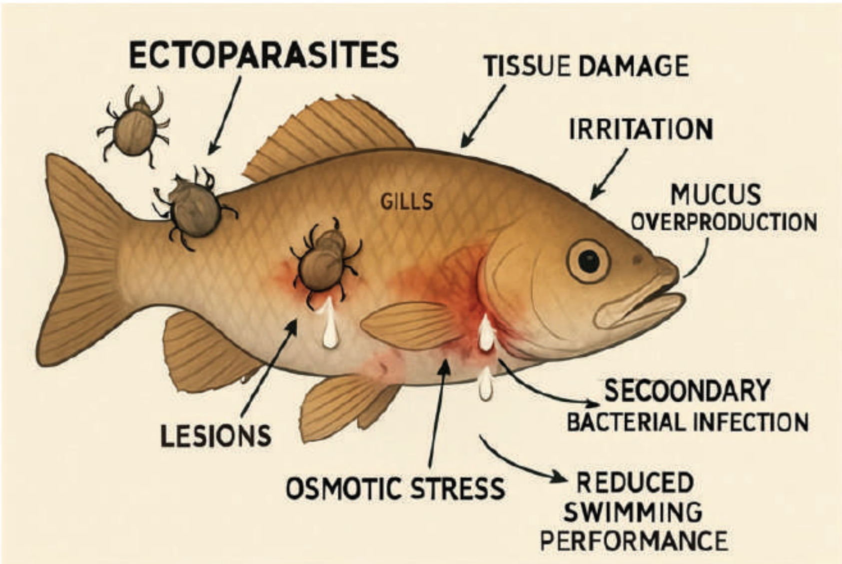

Figure 2: The mechanism of ectoparasite affect fishes to cause infections

3. Chemotherapeutic Treatments

Chemotherapy remains the primary line of defense against ectoparasites due to its immediate and observable effectiveness. Formalin, copper sulfate, potassium permanganate, and hydrogen peroxide are among the most commonly used chemicals. These agents function by disrupting parasite membranes or interfering with respiration and reproduction. For instance, formalin is effective against protozoans and monogeneans, but its carcinogenic nature and environmental persistence have raised concerns (Noga, 2010). Similarly, copper sulfate is widely used but can accumulate in sediments and become toxic to non-target organisms. Potassium permanganate (KMnO4), a strong oxidizing compound, is effective against a broad range of external parasites including Gyrodactylus, Dactylogyrus, Trichodina, and Ichthyobodo species. It acts by oxidizing the cellular structures of parasites and organic debris on fish surfaces and gills, improving respiration and reducing microbial load. Prolonged and frequent use of these chemicals has led to reduced efficacy and the emergence of resistant parasite strains. (Sommerville, 2012).

4. Biological Control Measures

The use of cleaner fish in marine aquaculture has garnered significant attention due to its potential to mitigate parasitic infestations, particularly sea lice, which pose substantial challenges to sustainable fish farming. Brooker et al., (2018) highlight that the domestication and application of cleaner fish species, such as wrasse, are progressing rapidly. The ecological and genetic considerations associated with cleaner fish translocation are critical, given that the reliance on wild-caught specimens may threaten local biodiversity and population stability. This concern is compounded by the fact that the high demand for cleaner fish in aquaculture has led to extensive wild harvesting, which may not be sustainable in the long term.

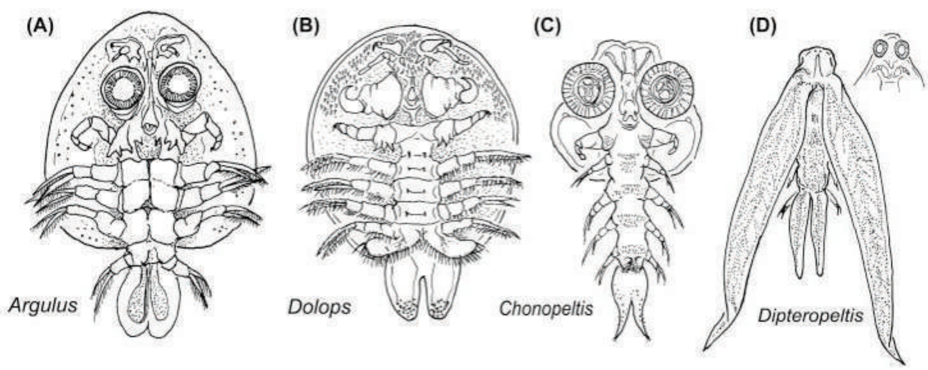

Figure 1: Ectoparasites of Fish (Courtesy: Eduardo Suárez-Morales - ScienceDirect)

5. Phytotherapy Remedies

Phytotherapy the use of plant-based compounds for disease prevention and treatment has gained significant traction in aquaculture as a safe and eco-friendly method for controlling ectoparasites. Various medicinal plants and herbal extracts exhibit antiparasitic, immunostimulant, and anti-inflammatory properties, making them valuable in integrated ectoparasite management strategies. For example, neem (Azadirachta indica) has shown efficacy against Argulus and Lernaea, while garlic (Allium sativum) acts against protozoan infections by altering osmoregulation in parasites (Sivaram et al., 2004). The safety profile of plant-based remedies, such as those derived from seeds of Cucurbita maxima and Carica papaya, has been demonstrated in controlling monogenean parasites, further supporting their application in aquaculture (Ankit sharma et al 2025).

6. Challenges in Vaccine Development

The development of vaccines targeting ectoparasite removal in fish faces numerous challenges. One significant obstacle is the complex immune response elicited by ectoparasites such as Argulus siamensis. Kar et al. 2015 demonstrated that infection with A. siamensis induces transcriptional changes in immunoglobulin isotypes in rohu, indicating an active but potentially insufficient immune response. Experimental vaccines for Ichthyophthirius multifiliis have employed immobilization antigens (i-antigens) to stimulate protective antibody responses (Clark & Dickerson, 1997). Despite initial success in lab trials, field-level efficacy has been inconsistent. The lack of commercial vaccines for ectoparasites indicates the need for further research in antigen selection, adjuvants, and delivery systems.

7. Emerging technologies

7.1 Neonicotinoids

A method for removing ectoparasites from a fish in water may comprise administering to the fish a neonicotinoid such as imidacloprid to remove the ectoparasites from the fish and exchanging the water comprising the neonicotinoid and the removed ectoparasites with replacement water, thereby separating the removed ectoparasites and the fish. The method may comprise the further step of preventing release of the removed ectoparasites into the environment, for example by passing sample of the water comprising the removed ectoparasite through a mesh filter (Marshall et al., 2017).

7.2 Electrolytic Ozone Water

The innovative method for removing ectoparasites from breeding fish using an electrolysis type ozone generating device. This device generates ozone water by electrolyzing raw material water, which is then stored in a tank. Breeding fish are placed in this electrolytic ozone water, effectively expelling the ectoparasites. This method offers a novel approach to managing ectoparasite infestations in aquaculture, enhancing fish health and potentially improving breeding outcomes (Osako et al., 2011).

7.3 Mechanical and Physical Removal

Mechanical and physical methods provide immediate and non-chemical means of ectoparasite removal, particularly useful during severe infestations. Techniques such as freshwater or saltwater baths are commonly employed to dislodge external parasites like Argulus, Lernaea, and Ichthyophthirius multifiliis. Freshwater bathing is especially effective in marine fish, as osmotic shock causes the detachment of ectoparasites from the skin and gills (Noga, 2010). Mechanical filtration systems in recirculating aquaculture setups also help by removing free-living larval stages before they can reinfect hosts.

8. Environmental Management

Environmental management is the first line of defense against ectoparasitic outbreaks in aquaculture. Optimal water quality specifically parameters like temperature, dissolved oxygen, pH, ammonia, and turbidity plays a crucial role in suppressing ectoparasite proliferation and enhancing fish immunity. Poor water conditions are known to stress fish, compromising their epithelial barriers and making them more susceptible to ectoparasitic attachment and invasion (Martins et al., 2011). Overstocking, another critical factor, increases host density, which can accelerate the spread and severity of parasite infestations, particularly for directly transmitting species like Gyrodactylus and Ichthyophthirius (Costello, 2006). Implementing proper stocking densities, regular water exchange disrupts the favourable for parasite reproduction.

9. Integrated Strategies in Ectoparasite Control in Aquaculture

9.1 Expanded on Host-Parasite Interaction Dynamics

Understanding the host-parasite relationship is critical for designing effective control strategies. Ectoparasites interact with fish through complex immunological, behavioural, and physiological pathways. These parasites exploit mucosal surfaces such as the skin and gills, often initiating localized immune suppression to evade host defenses. Environmental stress, nutritional deficiency, and compromised immunity often exacerbate parasitic outbreaks (Buchmann & Lindenstrom, 2002). Studying these dynamics allows the identification of immune markers and targets for vaccine or feed-based interventions.

9.2 Role of Functional Feeds

Functional feeds enriched with probiotics, prebiotics, and immunostimulants have shown promise in reducing ectoparasite infestations indirectly by boosting innate immune responses. These diets enhance mucosal and systemic immunity, reduce oxidative stress, and often possess direct antiparasitic properties. Additives like β-glucans, mannan oligosaccharides, nucleotides, and herbal extracts (e.g., neem, garlic, turmeric) stimulate innate defenses that reduce parasite establishment and burden (Dawood et al., 2020).

9.3 Life Cycle Disruption Strategies

Targeting specific stages of parasite life cycles offers a precise and environmentally sound approach to ectoparasite control. Many ectoparasites have free-living infective stages (e.g., theronts of Ichthyophthirius, oncomiracidia of monogeneans), which are vulnerable to physical, chemical, or biological disruption. Strategies such as UV sterilization in recirculating aquaculture systems (RAS), periodic drying of ponds, and stocking of biological control agents like copepod predators or prawns reduce infective-stage survival. Salt baths and temperature shocks are also used to break parasite transmission cycles.

9.4 Breeding for Genetic Resistance

Selective breeding for parasite-resistant fish strains is a long-term and cost-effective solution to ectoparasite control. Certain breeds or strains show enhanced resistance due to stronger mucosal immunity, epithelial resilience, or lower susceptibility to parasite attachment. For example, some strains of Atlantic salmon have demonstrated natural resistance to sea lice (Lepeophtheirus salmonis), while resistant Nile tilapia strains have shown reduced infestations by Gyrodactylus spp (Houston et al., 2008).

10. Conclusion

Ectoparasite infestations remain a persistent challenge in aquaculture, significantly impacting fish health, productivity, and farmer livelihoods. While conventional chemotherapeutic methods have provided short-term relief, they often come with environmental risks, residue concerns, and the threat of resistance development. In response, a range of sustainable, eco-friendly alternatives has emerged. Biological control methods including the use of cleaner organisms, probiotics and functional feeds offer promising non-chemical options. Phytotherapy remedies further enhance fish resilience with natural bioactive compounds. Novel approaches such as selective breeding for genetic resistance represent the future of integrated ectoparasite control. Moreover, understanding host–parasite dynamics, disrupting parasite life cycles are critical for effective long-term management.

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Zero-Waste Aquaculture: Is It Achievable?

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Introduction

Aquaculture has become the fastest-growing food production sector in the world, playing a pivotal role in food security, nutrition, and economic development. However, its rapid expansion has also triggered environmental concerns uneaten feed, fish excreta, chemical residues, and plastic waste contribute to pollution, resource inefficiencies, and ecological degradation. As the world inches towards circular economy principles and regenerative systems, the idea of zero-waste aquaculture has emerged not just as a futuristic dream, but a strategic imperative. But is it truly achievable?

This article delves into the feasibility of zero-waste aquaculture, the technologies driving this shift, the real-world examples paving the path, and the roadblocks that must be addressed to make it a mainstream reality.

What Is Zero-Waste Aquaculture?

Zero-waste aquaculture is a holistic approach that minimizes or eliminates waste generation throughout the production cycle from hatchery to harvest to processing. It aligns with the principles of sustainable development, resource recovery, and environmental stewardship. In essence, zero-waste aquaculture aims to:

• Utilize every input resource (feed, water, energy) efficiently.
• Recycle by-products (fish waste, sludge, offcuts).
• Eliminate reliance on synthetic chemicals.
• Prevent contamination of surrounding ecosystems.
• Generate value from what would traditionally be considered "waste."

This model mimics nature's closed-loop cycles, where nothing is discarded and every output becomes an input for another process. But to transition from traditional systems to such circular models requires innovation, integration, and investment.

Why Do We Need Zero-Waste Aquaculture?

The case for zero-waste aquaculture is rooted in four interconnected global challenges:

1. Environmental Degradation

Intensive aquaculture systems often discharge nutrient-rich waste into nearby waters, causing eutrophication, harmful algal blooms, and loss of biodiversity. Plastic netting, packaging, and feed bags contribute to marine litter. By achieving zero-waste, these impacts can be substantially reduced or eliminated.

2. Resource Scarcity

Aquaculture relies heavily on fishmeal, fish oil, freshwater, and land. As these resources become scarcer and more expensive, maximizing their utility becomes economically and ecologically crucial.

3. Climate Change

Aquaculture has a carbon and nitrogen footprint linked to feed production, energy use, and waste emissions. Zero-waste models that incorporate renewable energy, resource recycling, and efficient systems can contribute to decarbonizing the sector.

4. Consumer and Regulatory Pressure

Today's consumers and regulators increasingly demand transparency, sustainability, and traceability. Zero-waste branding can enhance market access, reputation, and profitability while complying with evolving environmental standards.

Innovative Technologies and Approaches Driving the Shift

1. Integrated Multi-Trophic Aquaculture (IMTA)

IMTA combines different species from various trophic levels such as fish, shellfish, and seaweed in a single system. The waste from one species (e.g., fish faeces) becomes nutrients for others (e.g., seaweed). This not only reduces pollution but also diversifies income sources.

2. Recirculating Aquaculture Systems (RAS)

RAS minimizes water use by continuously filtering and reusing water within a closed-loop system. Solid waste and sludge can be captured and repurposed into fertilizers or biogas.

3. Aquaponics

Combining aquaculture with hydroponics, aquaponics systems use fish waste to fertilize plants, while plants purify the water for fish. These systems are ideal for urban farming and local food production with minimal waste.

4. Black Soldier Fly (BSF) and Insect-Based Feed

Food waste and fish processing waste can be used to rear BSF larvae, which in turn are processed into protein-rich feed ingredients. This closes the loop on organic waste and reduces dependency on wild-caught fishmeal.

5. Seaweed and Microalgae

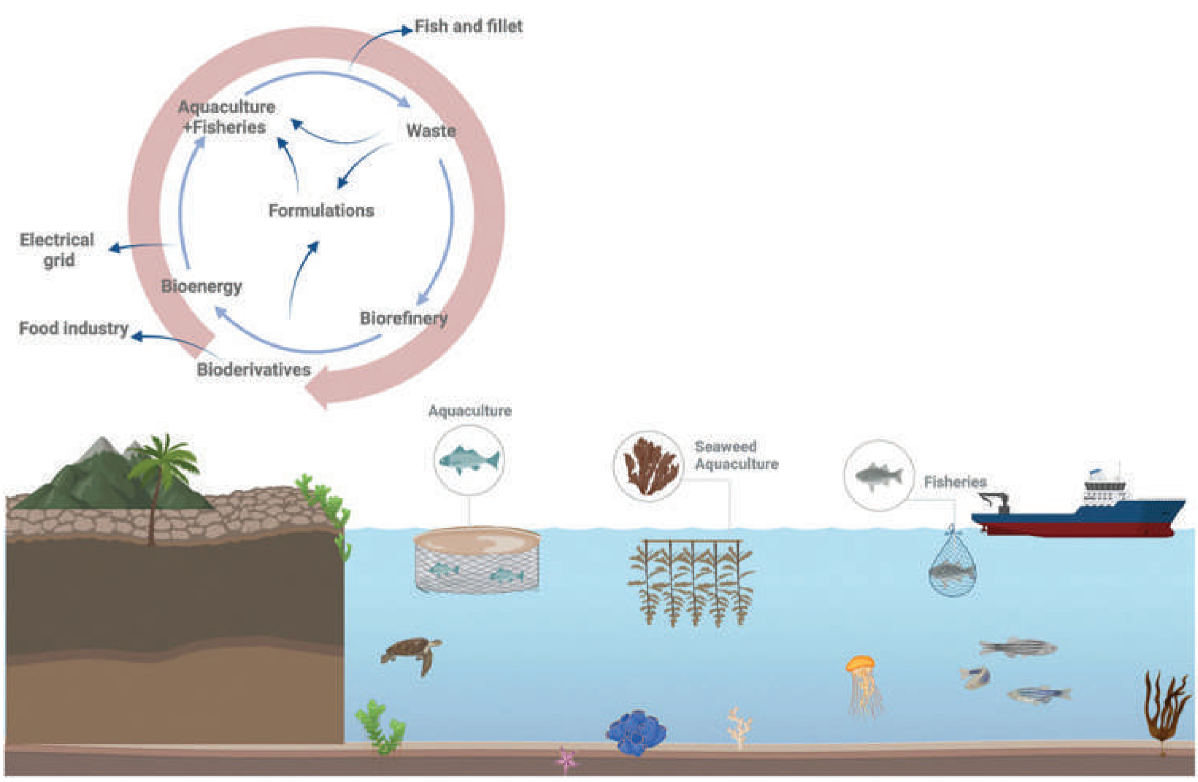

Figure 1: Aquaculture waste utilization

Biorefineries

Seaweed and microalgae not only absorb excess nutrients and CO_2 from aquaculture systems, but their biomass can be processed into feed, fertilizer, bioplastics, cosmetics, and biofuel ensuring total biomass utilization.

The Challenges to Achieving Zero-Waste

While the technologies are promising, there are still practical, economic, and systemic barriers:

1. Capital and Operational Costs

Many zero-waste systems like RAS or IMTA require significant investment in infrastructure, monitoring, and expertise. For small-scale farmers, this cost can be prohibitive without subsidies or shared facilities.

2. Regulatory Gaps

In many countries, there is no clear legal or policy framework to support circular aquaculture practices. Waste reuse (especially from animal sources) can face legal restrictions or lack of standards.

3. Lack of Awareness and Training

Farmers, particularly in low-income regions, may not be aware of zero-waste technologies or how to implement them effectively. Capacity building is essential for knowledge transfer and adoption.

4. Fragmented Supply Chains

To enable full waste utilization (e.g., fish waste into fertilizer), strong partnerships across aquaculture, agriculture, waste management, and biotech sectors are needed. Currently, many such integrations are siloed or absent.

Pathways to a Zero-Waste Future

Achieving zero-waste aquaculture is not a binary outcome. It's a continuum of progress. Here are key steps to move the sector in that direction:

1. Policy Support and Incentives

Governments must enact supportive policies, including subsidies for green infrastructure, tax incentives for waste valorization, and penalties for pollution. Public-private partnerships can fast-track innovation.

2. Localized Circular Models

Designing locally adapted systems such as integrating seaweed farming with coastal shrimp ponds or connecting fish farms with composting units can maximize resource efficiency and community benefit.

3. Tech-Enabled Monitoring

AI, IoT sensors, and blockchain can monitor water quality, feed conversion, and waste metrics in real time, allowing for data-driven decisions that reduce waste generation at source.

4. R&D and Pilot Demonstrations

Universities, startups, and R&D centres should be supported to develop and demonstrate scalable, replicable models of zero-waste aquaculture, with knowledge shared openly.

Conclusion

Zero-waste aquaculture may seem ambitious, but it is not out of reach. It represents a necessary evolution in how we produce aquatic food in the face of mounting environmental, economic, and ethical pressures. By harnessing the power of biology, technology, and systems thinking, waste can be transformed from a liability into an asset.

Achieving this vision will require more than isolated innovations; it calls for ecosystem collaboration, inclusive policies, and a shift in mindset from extraction to regeneration, from linearity to circularity. With collective will, the blue revolution can become truly green.

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Challenges and Solutions in Shrimp Aquaculture: Advances in Microbial Identification

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Introduction

Shrimp aquaculture in India has long been considered a high-risk, high-reward industry. However, in recent years, this notion has lost its relevance as farmers face mounting challenges in both production and sales. Rising raw material prices, coupled with declining exports due to intense international competition, high production costs, anti-dumping duties, export taxes, stringent regulations, and the absence of a robust local market and supply chain infrastructure, have created a crisis for the shrimp aquaculture market in India.

On the production front, farmers are battling persistent growth and disease issues. The repeated use of the same soil and water, unpredictable weather fluctuations driven by climate change, the shrimp's primitive immune system, and the mismatch between brooder genetics and the evolving environment are key factors contributing to the recurring failure of shrimp cultures in India. When these failures occur, farmers often attribute the problems to either brooder genetics or poor seed quality from hatcheries.

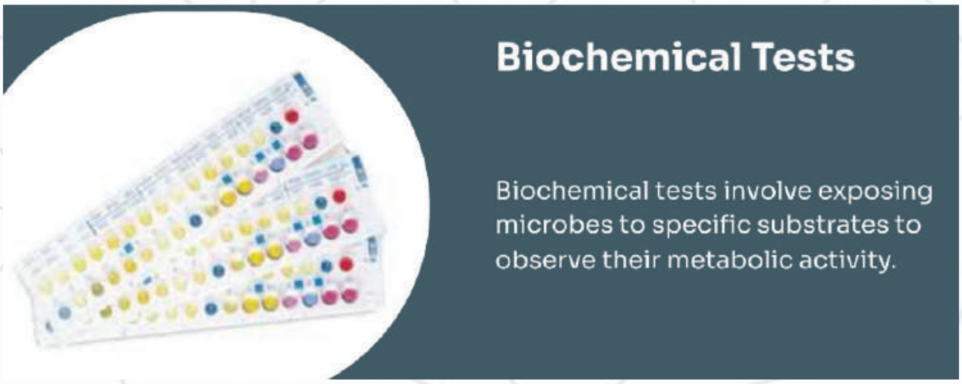
Hatcheries, the starting point of Indian aquaculture, manage the entire cycle from brooder importation to rearing. However, they face the same disease challenges as farmers. Despite adhering to strict Standard Operating Procedures (SOPs) and maintaining advanced infrastructure, hatcheries are struggling as pathogens become increasingly resilient, particularly in a fluctuating environment. Compounding the issue, shrimp lack a mature immune system, making it essential to identify pathogens and adapt SOPs for sustainable hatchery production. For the past decade, Zoea 2 syndrome has been a significant challenge in hatcheries, but more recently, the M3-PL problem has emerged with a similar impact, causing substantial survival losses or stalled conversion at the M3-PL stage, much like Zoea 2 syndrome. Both forms of pathogenicity have led to significant financial losses for hatcheries. Identifying pathogens is, therefore, the critical first step toward understanding their impact and revising SOPs—the only path forward for sustainable hatchery production. This approach also applies to farming.

Microbial Identification: Evolving Techniques

Historically, identifying microbes was a complex and time-consuming task, requiring numerous tests, staining procedures, a well-equipped laboratory, and skilled technical personnel. The process often took days of experimentation to reach a definitive conclusion. Thanks to recent technological advancements, microbial identification has become more efficient. Today, biochemical tests and staining can be conducted using strip methods or automated systems, significantly reducing the time and effort required. In this article, we explore several microbial identification systems and understand the knowledge on antibiotic resistance/sensitivity that can be effectively utilized in aquaculture to address the growing challenge of disease management.

Conventional Biochemical Tests

Conventional biochemical tests involve labour-intensive procedures, including multiple staining techniques and slow-paced experiments. These methods require various chemicals and a proper laboratory setup to ensure accurate execution. Typically, these procedures can take between 24 to 48 hours to complete.



The primary advantage of these tests is that they do not require costly equipment. In recent years, semi-automated strips, such as the API (Analytical Profile Index) system, have become available in the market. While these strips allow for quicker experiments, they do not support an electronic database for storing results, and their cost can be relatively high. Consequently, many laboratories now prefer fully automated systems for faster, electronically recorded results over conventional biochemical tests.

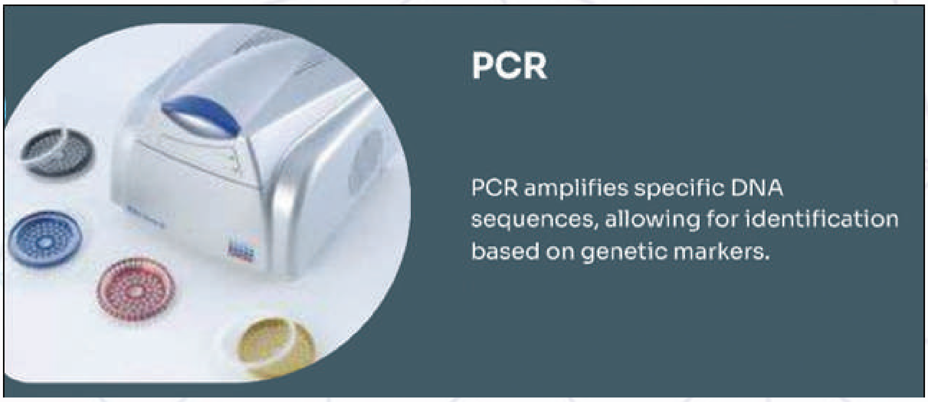
VITEK 2 Compact (BioMerieux)

In many hospitals and clinical laboratories, fully automated phenotypic identification systems like the VITEK 2 Compact (BioMerieux), BD Phoenix System (Becton Dickinson), and MicroScan System (Thermo Fisher Scientific) are widely used. These automated machines can perform up to 64 biochemical tests simultaneously, enabling rapid microbial identification in a short time. In aquaculture, the adoption of such automated systems allows for quick pathogen identification, facilitating prompt precautionary measures to mitigate the damage caused by pathogens. For instance, a study identified pathogens such as Vibrio alginolyticus and *V. harveyi* in market shrimp samples using conventional biochemical tests, VITEK 2, and MALDI-TOF MS (Sanhoury, et al., 2016). Similarly, a survey of Chinese snails in a seafood market using VITEK 2 identified all pathogenic isolates as *V. parahaemolyticus* (Song, et al., 2020). In practice, shrimp pathogens such as *Vibrio spp., Aeromonas, Photobacterium, and Streptococcus* can be isolated using specific media and subjected to VITEK 2 for rapid identification (Sanhoury, et al., 2016).

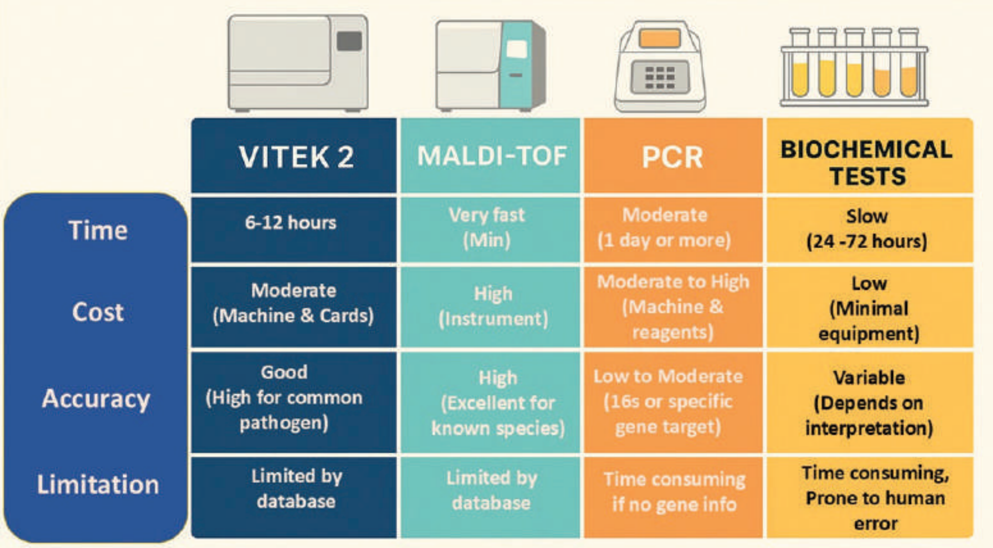
The VITEK 2 system includes a comprehensive biochemical dataset for common bacteria, allowing for easy identification. However, it has limitations, as it may struggle to identify rare or new species. Misidentifications have also been reported in some cases. For example, *V. cholerae* was misidentified as another species (Saini, et al., 2012), and *Aeromonas veronii* clinical strains were misidentified as *V. alginolyticus* (Park, et al., 2003). Therefore, unusual shrimp isolates or unexpected biochemical profiles should be rechecked using more advanced methods like PCR, MALDI-TOF MS, or sequencing. Additionally, the VITEK 2 system's database must be regularly updated with new or rare bacterial biochemical profiles to improve its microbial identification capabilities.

PCR Identification

Polymerase Chain Reaction (PCR) is a molecular-based technique that offers significant advantages for gene- or species-specific identification of known



bacterial targets. If the target gene for a particular bacterial species is known, PCR enables rapid identification—within a few hours. This method is particularly effective for identifying closely related species with high accuracy, provided prior information about the target conserved gene is available. For example, genes such as dnaJ (species-specific) and toxR (virulence gene) are commonly used to identify Vibrio alginolyticus in shrimp isolates (Sanhoury, et al., 2016). Without prior gene information, identification often relies on 16S rRNA or other marker gene assays combined with sequencing, which can be time-consuming. However, when prior gene information is available, species-specific marker genes can be designed, allowing for easy detection of the pathogen either from an isolated culture or directly from the sample.



	VITEK 2	MALDI-TOF	PCR	BIOCHEMICAL TESTS
Time	6-12 hours	Very fast (Min)	Moderate (1 day or more)	Slow (24 -72 hours)
Cost	Moderate (Machine & Cards)	High (Instrument)	Moderate to High (Machine & reagents)	Low (Minimal equipment)
Accuracy	Good (High for common pathogen)	High (Excellent for known species)	Low to Moderate (16s or specific gene target)	Variable (Depends on interpretation)
Limitation	Limited by database	Limited by database	Time consuming if no gene info	Time consuming, Prone to human error

MALDI-TOF MS

Matrix-Assisted Laser Desorption Ionization–Time-of-Flight Mass Spectrometry (MALDI-TOF MS) is an-

other powerful technique for bacterial identification, relying on protein fingerprint sequences. Similar to the VITEK 2 system, MALDI-TOF MS requires a pure bacterial culture for sample processing. This method offers faster identification and higher accuracy compared to VITEK 2 (Guo, et al., 2014). When a pure culture is available, MALDI-TOF MS can identify bacteria in just a few minutes, with a high accuracy rate if the system's database is comprehensive. Additionally, the per-sample cost for testing is lower compared to other methods. However, the main drawback is the high cost of the instrument itself, which is significantly more expensive than other systems. The species-level error rate for broad clinical samples using MALDI-TOF MS is approximately 5.6%, compared to 6.2% for VITEK 2 (Guo, et al., 2014). MALDI-TOF MS excels at distinguishing Vibrio species accurately; for instance, one study reported 100% accuracy in detecting V. cholerae and 99% accuracy for V. parahaemolyticus (Banerjee, et al., 2025).

Comparison of Microbial Identification Systems

To provide a clearer understanding of the strengths and limitations of the microbial identification systems discussed, the following chart compares Conventional Biochemical Tests, VITEK 2 Compact, PCR, and MALDI-TOF MS based on key factors such as speed, accuracy, cost, and limitations.

A Case Study: Applying Advanced Techniques in Aquaculture

We, Amazing Biotech Pvt. Ltd., technical team focuses on assaying bacteria for their probiotic potential and bioremediation capabilities. We operate three service-based laboratories dedicated to supporting shrimp culture for the benefit of farmers. In both hatcheries and farms, diseases remain a major challenge, often leading to significant economic losses.

Therefore, the rapid identification of pathogenic microbes is critical for determining the causative agent and developing effective remedies or SOPs to ensure sustainable aquaculture.

Traditionally, our labs relied on conventional biochemical assays to identify both probiotic and pathogenic strains. Recently, we partnered with Dr. Seghal Kiran from Pondicherry University and began using the advanced VITEK 2 Compact system for faster identification. This system has enabled us to obtain rapid results, allowing us to respond to issues promptly. By identifying the pathogen, we can develop targeted probiotic solutions or establish improved SOPs, benefiting both hatcheries and farms.

Often, when a problem arises in a farm or hatchery, the immediate response is to harvest or drain the tank without understanding the root cause. A new culture may then be started without revising the SOP, leaving the issue unaddressed. If the pathogen persists or the same flawed protocol is followed, the problem is likely to recur, potentially leading to further economic losses. Identifying the causative agent is, therefore, essential to prevent such setbacks.

Recently, several hatcheries along the Chennai-Pondicherry and Ulavupadu coasts have faced significant M3-PL problems. We collected samples from some of these hatcheries and processed them using the VITEK 2 Compact system and PCR methods. For further analysis, we sent the samples for sequencing. Through these techniques, we successfully identified the causative agent and recommended improved SOPs for the hatcheries. Moreover, once we obtained prior gene information about the causative agent, a simple PCR test allowed us to detect and quantify the pathogen, enabling early implementation of precautionary protocols. This approach significantly reduced economic losses. The same methods can be applied to farms as well.

Conclusion

Incorporating advanced automated techniques in aquaculture is crucial for farmers to reduce disease prevalence. Adopting improved Standard Operating Procedures (SOPs) provides a strategic advantage in combating proliferating virulent pathogens and addressing climate change challenges. In this article, we explore various microbial identification systems and their applications. A case study demonstrates how VITEK 2 and PCR techniques helped revise SOPs in hatcheries. Increased adoption of these techniques can empower farmers to overcome diseases and achieve sustainable aquaculture.

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6th India International Seaweed Expo & Summit 2025

A Milestone in India's Blue Economy

The **6th India International Seaweed Expo & Summit 2025**, jointly organized by the **Indian Chamber of Commerce (ICC)** and the **National Institute of Ocean Technology (NIOT), Ministry of Earth Sciences (MOES)**, was successfully held on **January 29–30, 2025**, at NIOT, Chennai. This significant event served as a platform to showcase the latest innovations, technological advancements, and sustainable solutions in India's growing seaweed industry.

The summit brought together leading scientists, policymakers, entrepreneurs, and seaweed farmers from across the country. The event was honoured to have **Prof. Balaji Ramakrishnan, Director of NIOT**, deliver the keynote address, where he highlighted the critical role of **NIOT and MOES in promoting offshore seaweed farming** through technological and infrastructural support. His remarks underlined the government's commitment to fostering a sustainable **blue economy** in India.

A key highlight of the summit was the participation of **seaweed cultivating farmers from Tamil Nadu**, who shared their on-ground experiences and insights into the challenges and opportunities in the industry. Their engagement enriched discussions on **scaling up cultivation, improving yield efficiency, and exploring market linkages** for seaweed-based products.

The expo featured a display of cutting-edge **seaweed processing technologies, sustainable harvesting techniques, and innovations in bioproducts** such as biofertilizers, nutraceuticals, and biodegradable packaging. It also served as a networking hub for **businesses, research institutions, and investors**, fostering collaborations that could drive the industry's growth.

The **Foundation for Aquaculture Innovations and Technology Transfer (FAITT)** was honored to be the **Media Partner** for the event, ensuring wider dissemination of the summit's discussions and outcomes.

With India's coastal regions holding immense potential for **seaweed farming as a sustainable and eco-friendly industry**, the **6th India International Seaweed Expo & Summit 2025** marked a crucial step toward harnessing this opportunity. The event successfully laid the groundwork for **future advancements, knowledge sharing, and a robust seaweed-based economy in India**.

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