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Nanobubble Technology in Aquaculture

44th Edition

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Shrimp farmers seek restriction on SPF broodstock import from South East Asia

Nanobubble technology has promising development and application prospectus in the fields of aquaculture and fisheries.

Dear Readers,

The March 2026 issue of Aqua International is in your hands. In the news section, you may find news about....

Shrimp farmers seek restriction on SPF broodstock import from South East Asia. Shrimp farmers are apprehensive about unknown pathogens in the broodstock in South East Asian countries. Almost all shrimp farmers in Andhra Pradesh have been urging the Central government to continue the existing restrictions on the import of specific pathogen-free (SPF) broodstock from South East Asian countries. They have expressed concerns over lack of screening equipment in India to detect serious shrimp diseases. Almost all shrimp farmers in Andhra Pradesh have been urging the Central government to continue the existing restrictions on the import of specific pathogen-free broodstock from South East Asian countries. They have expressed concerns over lack of screening equipment in India to detect serious shrimp diseases. Currently, the SPF broodstock is being imported primarily from Hawaii Islands in the United States of America, and occasionally Ecuador in Latin America and Madagascar in southeastern coast of Africa. The imported SPF broodstock goes through the stringent disease screening protocols at Aquatic Quarantine Facility (AQF) in Chennai to ensure the absence of several listed pathogens. Since 2013, Indian government had imposed restriction on the import of SPF broodstock from Southeast Asian countries including Thailand, China, Vietnam, and Malaysia due to the outbreak of early mortality syndrome (EMS) and acute hepato pancreatic necrosis syndrome (AHPNS). As the Centre is now likely to review it, the shrimp farmers in Andhra Pradesh have raised their voices against this. "Today, more than 70% of India's shrimp production comes from A.P. Thousands of farmers in coastal A.P. are directly dependant on shrimp farming, while lakhs of people such as ice-suppliers, feed dealers, transport workers and labourers are indirectly surviving on this. The entire economy of the State would get impacted if any new disease enters the country," Mr. Gopinadh claimed.

NMFS grants Certification to India The U.S. National Marine Fisheries Service (NMFS) recently granted India certification under the Marine Mammal Protection Act, allowing India's seafood exports to the United States to continue uninterrupted beyond December 31, 2025. This approval confirms that India's fishing practices meet U.S. standards for protecting marine mammals, giving Indian exporters a significant advantage over key competitors. Meanwhile, some fisheries from China, Mexico, and Ecuador were denied similar certifications, facing restrictions on certain seafood shipments to the U.S. This finding permits India's seafood exports to continue, a major relief for the Indian seafood industry, which sent over one-third of its $7.39 billion in seafood exports to the U.S. in fiscal year 2025.

Tariff reduction cheers shrimp sector, but search for newer markets will continue - The shrimp ecosystem is elated as US President Donald Trump announced a reduction of tariffs to 18 per cent recently. The sector, which reeled under severe stress over the last few months, is relieved. "The business will be back on track soon. We are happy. The system can easily absorb it [18 percent tariff]," Ravi Kumar Yellanki, Managing Director of Vaisakhi Bio-Marine Resources and President of the All India Shrimp Hatcheries Association. The sector, however, seems to have learned key lessons. Overly dependent on the US market for decades, it has begun to look at alternative export markets, including Australia and the recently opened EU market. Asked whether the

Contd on next page

NRS GROUP

Our Mission

Aqua International will strive to be the reliable source of information to aquaculture industry in India.

AI will give its opinion and suggest the industry what is needed in the interest of the stakeholders of the industry.

AI will strive to be The Forum to the Stakeholders of the industry for development and self-regulation.

AI will recognize the efforts and contribution of individuals, institutions and organizations for the development of aquaculture industry in the country through annual Awards presentation.

AI will strive to maintain quality and standards at all times.

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sector will switch back to the US, the easier market, or will continue to explore the alternatives, he said it will continue to focus on the old and newer markets. While welcoming the move that will pull them out of a deep financial crisis, farmers are, however, upset about a decision by feed manufacturing companies to increase the feed prices by ₱4 a kg.

Translucent Post Larvae Disease – a deadly Vibrio infection affecting farmed shrimp Molecular testing is essential for accurate identification of the specific cause combined with stringent biosecurity measures. **Understanding *Vibrio* infections in shrimp production** Infections associated with Vibrio species pose significant challenges in commercial shrimp operations. If unmanaged, these bacteria can establish populations in water, sediment, or biofilms within farm systems, leading to infections and high mortality rates. In shrimp hatcheries, Vibrio species can infiltrate or proliferate through multiple routes. These include introduction via broodstock, infected shrimp nauplii, contamination through water sources, and transmission from microalgae, live feeds, or water and air pipelines. Moreover, they can be transported on personnel equipment, on skin, or dispersed through aerosols (Shinn et al., subm.).

With the mechanism of absorbing food in water environment, tilapia has been dubbed the "BIO-WATER FILTER". Therefore, this fish is used to drop in the sedimentation pond, filter to get clean water to pump into the shrimp farming tank. Tilapia can live in both fresh, brackish and saltwater environments. Their main food is plants including filamentous algae, unicellular algae, algae, organic humus and some small animals. A special feature of this fish is the gland that secrete much MUCUS TO CATCH SUSPENDED PARTICLES IN THE WATER, forming a sticky lump full of algae, zooplankton, organic food as food. With the mechanism of absorbing food in water environment, tilapia has been dubbed the "BIOLOGICAL WATER FILTER". Based on this feature, scientists have invented measures to drop tilapia in settling ponds for shrimp farming, also known as green shrimp farming.

In the Articles section, **Carp Seed Production 2.0: Revamping Hatcheries to Sustain India's Global Leadership** authored by M. Subashini, A. Akask Arul, G.K. Raswin and S. Felix "Carp Seed Production 2.0" shall aim to modernize carp hatcheries to sustain India's leadership in global carp production. Strengthening selective breeding of Catla catla, Labeo rohita and Cirrhinus mrigala is key to improving growth, survival, and disease resistance. Pooling elite brooders and establishing regional brood banks will ensure uniform supply of quality seed nationwide. Scientific hatchery management, health screening, and seed certification can greatly enhance farmer confidence and productivity. A coordinated national seed network can transform carp aquaculture into a more resilient and high-quality production system. India continues to be the world's largest producer of carp seed and carp-based aquaculture products. However, emerging challenges related to seed quality, genetic deterioration, seasonal shortages, and uneven regional supply necessitate a strategic revision of carp seed production systems. This article examines small and medium-scale low-input carp hatchery models, emerging advanced production systems such as ponds, cages and biofloc, and the urgent need to revamp departmental hatcheries. The economic viability of different models and future directions required to sustain India's leadership in carp aquaculture are discussed. With increasing intensification of aquaculture, climate variability and growing farmer awareness, it is timely to revisit and modernize carp seed production strategies to ensure India retains its status as the world's largest carp-producing nation.

Another article titled, **Bioremediation in wastewater aquaculture**, authored by Vipendra Singh, Chonyo Shinglai, Ganapathi Naik M discussed that Bioremediation is the biological process of decontamination of pollutants in the environment. Bioremediation is the process of using bacteria, algae, fungi and yeast to remove contaminated materials from the environment. Phytoremediation is an emerging bioremediation approach that uses plants and their roots to treat contaminated soil and water. The use of bioremediation results in a lower accumulation of slime or organic matter in the pond bottom, better penetration of oxygen into the sediment and a generally better environment for the farmed stock. Industrial activities have been impacting the environment such as air contaminated soil and wastewater (Naswir et al., 2019). Thus, in recent decades, there has been global increase in environmental pollution as a result of increasing population, rapid industrialization, increased anthropogenic activities and unregulated and unsafe agricultural activities, all of which have resulted in the accumulation of hazardous waste in the environment including plastic, agricultural, domestic, rubber, metallic and industrial wastes.

Another article titled, **Nanobubble Technology in Aquaculture,** authored by M Vivek Kumar, Abhishek Kumar, Pankaj Kumar, Dr. Abhiman, Sushmita Rani discussed that in recent microbubbles and nanobubbles technologies have drawn great attention due to their wide applications in many fields of science including fisheries and aquaculture. Nanobubble technology has promising development and application prospectus in the fields of aquaculture and fisheries. This articles discusses about the nanobubble technology, its principle and its application in fisheries and aquaculture in details. The ever-growing demand for fisheries had led the aquaculture industry to seek novel approaches for more sustainable practices. Fish is important source of high protein and omega-3 still hunger is worldwide socioeconomic problem that has been faced even today with technological advances, however unsustainable practices and shocks threaten this potential, which is worsened by limited research on technologies such as nanobubble. One of the main objectives of United Nation 2030 sustainable development agenda is to act with strategies that can contribute to eradicating the effects of this problem with negative consequences to worldwide. The sustaining increase in aquaculture has been positively influenced by technological developments where there is pressing needs to find appropriate solution to meet growing world population that is expected to reach approximately 10 billion by 2050. Nanobubbles technology is one such a technology which is used aquaculture industry for various application.

Readers are invited to send their views and comments on the news, special feature and articles published in the magazine which would be published under "Readers Column". Time to time, we shall try to update you on various aspects of Aquaculture sector. Keep reading the magazine Aqua International regularly and update yourself. Wish you all fruitful results in your efforts.

M.A.Nazeer
Editor & Publisher
Aqua International

Shrimp farmers seek restriction on SPF broodstock import from South East Asia

Shrimp farmers are apprehensive about unknown pathogens in the broodstock in South East Asian countries

D. Gopinath, President, Prakasam District Prawn Farmers Association addressing the meet while other members occupy the dias at Ongole recently

Almost all shrimp farmers in Andhra Pradesh have been urging the Central government to continue the existing resitrictions on the import of specific pathogen-free (SPF) broodstock from South East Asian countries. They have expressed concerns over lack of screening equipment in India to detect serious shrimp diseases.

Almost all shrimp farmers in Andhra Pradesh have been urging the Central government to continue the existing resitrictions on the import of specific pathogen-free (SPF) broodstock from South East Asian countries. They have expressed concerns over lack of screening equipment in India to detect serious shrimp diseases.

Currently, the SPF broodstock is being imported primarily from Hawaii Islands in the United States of America, and occasionally Ecuador in Latin America and Madagascar in southeastern coast of Africa. The imported SPF broodstock goes through the stringent disease screening protocols at Aquatic Quarantine Facility (AQF) in Chennai to ensure the absence of several listed pathogens.

Since 2013, Indian government had imposed restriction on the import of SPF broodstock from Southeast Asian countries including Thailand, China, Vietnam, and Malaysia due to the outbreak of early mortality syndrome (EMS) and acute hepato pancreatic necrosis syndrome (AHPNS). As the Centre is now likely to review it, the shrimp farmers in A.P. have raised their voices against this

Prakasam District Prawn Farmers Association president D. Gopinadh said: "The existing restriction on shrimp imports from EMS-affected countries had saved Indian farmers. Through the members of Prawn Farmers Federation of India (PFFI), we came to know that the Ministry of Fisheries, Animal Husbandry and Dairying (FAHD) would be allowing the imports from South East Asia."

He wrote a letter to the FAHD Minister requesting to protect the shrimp farming sector by not opening any new import route. "Indian testing systems can check only known diseases. Nobody can predict the new diseases. By the time a test is developed, the farmers would suffer the losses. We have already seen such damage in case of the EHP (Enterocytozoon hepatopenaei)," he said.

"Today, more than 70% of India's shrimp production comes from A.P. Thousands of farmers in coastal A.P. are directly dependant on shrimp farming, while lakhs of people such as ice-suppliers, feed dealers, transport workers and labourers are indirectly surviving on this. The entire economy of the State would get impacted if any new disease enters the country," Mr. Gopinadh claimed.

Speaking to The Hindu, B. Madhusudana Rao, principal scientist at the Indian Council of Agricultural Research–Central Institute of Fisheries Technology (ICAR-CIFT), Visakhapatnam Research Centre, trashed their concerns. He said that the AQF in Chennai is fully equipped to detect all kinds of the diseases.

The ICAR-Central Institute of Brackishwater Aquaculture (CIBA) is also involved in testing the brooders. "It is only a myth that there is no proper screening equipment in India. Apart from the State Fisheries department, nine organisations are working under the Central government to look after the shrimp ecosystem," Prakasam district Joint Director of Fisheries Ch. Srinivasa Rao said.

Ongole: The Prakasam district Prawn Farmers Association demanded the Andhra Pradesh state government to immediately intervene and help them by convincing the Union government to extend the ban on the import of mother prawns into the country.

The association president, Duggineni Gopinath, explained that at the association meeting held here on Tuesday, the members expressed concern about the scheduled meeting by ministry officials in Delhi on January 22 to make a decision on the direct import of mother prawns and prawns at the PPL stage. He explained that some hatcheries in the country want to import prawn mothers from Southeast Asian countries and have successfully scheduled a meeting with the officials. He said that the prawn farmers in the country suffered huge losses during the importation of mother prawns from Vietnam, Thailand, and neighbouring countries between 1990 and 2010 due to various dis-eases, including EHP, EMS, and whitegut. Following a massive outcry from farmers, the Union government imposed a ban on the import of prawn and shrimp mothers.

Devi Aqua Feeds launches its Devi Grande & Devi Prime feeds in Gujarat Market

Yarlagadda Surya Rao, extreme right, discussing a point with the participants at Surat on 9 February 2026

Surat: Devi Aqua Feeds Pvt Ltd, a group company of Devi Fisheries Limited, launched its shrimp feed for Monodon and Vannamei species in the Gujarat market under brands Devi Grande and Devi Prime at a launching function held at Hotel Marriott, Surat, Gujarat, on 9 February 2026. Having established an impressive track record of success in the states of Andhra Pradesh and Orissa since 2019, this expansion marks a significant milestone for Devi Fisheries, said Mr Yarlagadda Surya Rao, Managing Director, Devi Fisheries Ltd.

The company had a great interaction with the farmers and dealers in Gujarat along with Mr Yarlagadda Surya Rao, Mr Yarlagadda Surendra, Mr Chitturi Indraneel, Mr U. Manavendra Rao and Mr D. Ramaraj of Unibio. Formulator, Mr Piet Jozef M, Mr G.V. Babu, GM Marketing, Mr G. Sridhar, DGM, Marketing and Mr Sk Shabaaz Ahamed, Manager-Operations also spoke on the occasion giving details of Devi Aqua Feeds and its products.

G.V. Babu, GM, Marketing; Piet Jozef M, Formulator; G. Sridhar, DGM, Marketing and Sk Shabaaz Ahamed, Manager – Operations of Devi Fisheries Ltd during the launch programme at Surat

Yarlagadda Surya Rao, MD, Devi Fisheries Ltd with the participant farmers and dealers at Surat

Y. Surya Rao receiving ASC Certificate from Dr Jagdheesh Manian, Director, Bureau Veritas India Pvt Ltd

ASC Certification, a rare achievement

Devi Fisheries Limited - Feed Division received Aquaculture Stewardship Council (ASC) Certification from Bureau Veritas for achieving quality standards of the feed. With the ASC Certification, the company will be eligible to export its feed products to Europe also. This significant accomplishment was marked by a formal presentation, where Dr Jagdheesh Manian, Director of Certification, SAR, Bureau Veritas India Pvt Ltd bestowed the certification upon Devi Fisheries Managing Director, Mr Yarlagadda Surya Rao. According to the company, in India, Devi Fisheries Ltd – Feeds Division is the first company to receive ASC Certification from Bureau Veritas.

Sk Shabaaz Ahamed welcoming

Piet Jozef M, Formulator addressing

U Manavendra Rao, Unibio

D. Ramaraj

Yarlagadda Surendra, Director, Devi Fisheries Ltd

Expanding production facilities

Devi Fisheries is supplying 30,000 tonnes of Vannamei and Monodon shrimp feed annually in India with over 40 dealers. The company has its sales and technical services network in the country. Its production facilities are located at Peddapuram, near Kakinada, Andhra Pradesh. Presently with two lines the company has production capacity of 47,000 metric tonnes annually. With the ongoing expansion of production in progress with another two lines Devi Fisheries will be able to produce another 47,000 tonnes of feed by August 2026.

MPEDA-NaCSA organizes Training for shrimp farmers at Purba Medinipur

The 2-days Training Programme on 'Standard Operating Procedure for NaCSA Cluster of Excellence' was organized at farmers' field (pond site) by National Centre for Sustainable Aquaculture (NaCSA) under MPEDA, Ministry of Commerce and Industry, Govt of India at Vill. Uttar Panichiari, near Nachinda, Contai-3 Community Development Block, Dist. Purba Medinipur, West Bengal during 6 and 7 February, 2026. On the 2 day, News communicator Subrato Ghosh gave an extended farmer-oriented lucid audio-visual Presentation on 'Health and disease management in shrimp *Litopenaeus vannamei* farming – protocols for sudden outbreaks'.

A Training session in progress

Sri Ghosh discussed in detail in Bengali language with the shrimp farmers belonging to the progressive Cluster namely 'Uttar Panichiari Narayan Aqua Welfare Society' about Better Management Practices and disease management in shrimp farms; biosecurity measures which must be strictly adopted; that the 4 components namely pathogen, host, unhealthy environment and 'triggering factors' or 'stressors' lead to shrimp disease in farm ponds; that low Dissolved Oxygen, low water exchange, high stocking density or 'crowding', high water temperature, excessive turbid water, overpassing pond's carrying capacity are other factors facilitating disease condition; status of shrimp farming and production in West Bengal *wrt* Purba Medinipur; area under culture in brackishwater Blocks of this district; enteric and systemic pathogens; SPF shrimp seeds (PL) for stocking; ways of entry and spread of pathogen in *L. vannamei* farms; life cycle and pathogenicity (infection) process of the fungal microsporidian parasite *Enterocytozoon hepatopenaei* (EHP, an emerging pathogen) in shrimp ponds, how it infects hepatopancreas; features of other important disease-causing micro-organisms, *viz*. IHHNV (Infectious Hypodermal and Haematopoietic Necrosis Virus), IMNV (Infectious Myonecrosis Virus), HPV (Hepatopancreatic Parvo-like Virus), *Vibrio* sp causing Vibriosis and AHPND (Acute Hepatopancreatic Necrosis Disease); green and yellow colonies of *Vibrio* sp; Running Mortality Syndrome (very much evident in Contai-3 Block); White Faecal Syndrome; Black Gill Disease; symptoms of infection caused by major shrimp pathogens and EHP; that WFS has 100% correlation with EHP, and also with enteric *Vibrio* sp; method of killing EHP spores in pond bottom soil; red gut disease-like condition; correct application of commercial water and gut probiotics in shrimp ponds; use of immunostimulants and Minerals (micronutrients) in shrimp ponds; composition and correct use of probiotic bacteria; use of sucrose to facilitate growth of good yellow colonies of *Vibrio* sp.

Subrato Ghosh making Presentation

Towards the end, Sri Ghosh discussed with participating shrimp farmers (who have dewatered their ponds and doing pond preparation as in 1st week of February to begin new crop in new season) about developmental schemes in brackishwater aquaculture under PMMSY (Banga Matsya Yojona) implemented in Purba Medinipur district, its subsidy component (financial support), procedure of application, etc; importance of registration and certification of all shrimp farms under Coastal Aquaculture Authority, features of CAA Act, 2005; application of organic juice in ponds and its components (indigenous prebiotic formulation); antibiotic-free shrimp farming; important management steps in shrimp culture, pond preparation, stocking and post-stocking management practices; dosages of application of all necessary inputs in every 1000sq. mt of *L. vannamei* culture pond; different types of high-valued processed and frozen shrimp products produced in processing plants meant for export; domestic market of *L. vannamei* in West Bengal. He gave photocopy of his published article in Bengali on Biosecurity measures to be adopted in shrimp farms to prevent occurrence of diseases to Group Leader of this Cluster. Sri Dhirit Ekka, Deputy Director, *MPEDA* Regional Division, *Kolkata;* Ms. D. Khonglam, Chief Executive Officer, NaCSA, MPEDA; Sri Ravi Goda, Regional Coordinating Officer, NaCSA and other officials were present in this programme and interacted with participants.

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* STORAGE:

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* DIRECTION OF USE:

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- Decompose pond bottom
- Inhibit the growth of *Vibrio* spp.
- Purification of water quality

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7 days before stocking	800 g - 1,000 g	1,200 - 1,500 g	1,200 - 1,500 g
Day of stocking	300 g - 500 g	800 g - 1,000 g	800 g - 1,000 g
Every 7 - 10 days after stocking	300 g - 500 g	800 g - 1,000 g	3 - 5 days / use 1,000g - 2,000g

****Dosages can be adjusted according to the water conditions and practices.*

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NMFS grants Certification to India

The U.S. National Marine Fisheries Service (NMFS) recently granted India certification under the Marine Mammal Protection Act, allowing India's seafood exports to the United States to continue uninterrupted beyond December 31, 2025. This approval confirms that India's fishing practices meet U.S. standards for protecting marine mammals, giving Indian exporters a significant advantage over key competitors. Meanwhile, some fisheries from China, Mexico, and Ecuador were denied similar certifications, facing restrictions on certain seafood shipments to the U.S.

Details of the U.S. ruling

India's approval: Following an extensive review, the NMFS granted India a "comparability finding," a required certification under the Marine Mammal Protection Act (MMPA). This finding permits India's seafood exports to continue, a major relief for the Indian seafood industry, which sent over one-third of its $7.39 billion in seafood exports to the U.S. in fiscal year 2025.

Competitor restrictions: For certain fisheries in China, Mexico, and Ecuador, the NMFS denied comparability findings, meaning they will face restrictions on exporting certain seafood products to the U.S. starting in 2026.

Reason for bans: The MMPA requires nations to demonstrate that their fisheries' practices do not harm marine mammals at a rate exceeding U.S. standards. The denial of certification for some fisheries in rival nations indicates they failed to meet these requirements. Previous restrictions on these countries have been linked to issues such as forced labor and bycatch, or the unintended catching of non-target species.

Impact on India: Though India still faces challenges, such as a high U.S. tariff on shrimp, the new ruling removes a potential non-tariff barrier and offers a major competitive opportunity. Industry leaders see this as a significant step forward, though the tariff issue remains a concern.

Additional factors for rival countries

China: U.S. actions against China's seafood industry have also involved concerns over forced labor. Legislation, such as the proposed "Ban C-FOOD Act," has been introduced to prohibit all Chinese seafood imports until human rights and labor concerns are resolved.

Mexico: Specific restrictions on Mexican seafood have been in place for years due to the use of gillnets in the upper Gulf of California, which poses a threat to the endangered vaquita porpoise. The U.S. prohibits the import of shrimp and certain fish species caught with these gillnets.

Ecuador: While recently denied the MMPA certification for certain fisheries, Ecuador has faced ongoing challenges regarding its seafood exports to the U.S. This includes anti-dumping duties imposed on shrimp exports and past import refusals due to detected antibiotic residues. In 2023, the U.S. Food and Drug Administration (FDA) did sign a partnership with Ecuador to enhance the safety of shrimp imports, but this appears to be a separate issue from the MMPA certification.

Tariff reduction cheers shrimp sector, but search for newer markets will continue

KV Kurmanath
Vishwanath Kulkarni
Hyderabad / Bengaluru

The shrimp ecosystem is elated as US President Don-ald Trump announced a re-duction of tariffs to 18 per cent on Monday evening. The sector, which reeled un-der severe stress over the last few months, is relieved.

"The business will be back on track soon. We are happy. The system can easily absorb it [18 per cent tariff]," Ravi Kumar Yellanki, Managing Director of Vaisakhi Bio-Marine and Vaisakhi Bio-Re-sources and President of the All India Shrimp Hatchery Association (AISHA), told businessline.

KEY LESSONS

The sector, however, seems to have learned key lessons. Overly dependent on the US market for decades, it has begun to look at alternative ex-port markets, including Aus-tralia and the recently opened EU market.

Asked whether the sector will switch back to the US, the easier market, or will continue to explore the alternatives, he said it will continue to focus on the old and newer markets.

While welcoming the move that will pull them out of a deep financial crisis, farmers are, however, upset about a decision by feed manufacturing companies to increase the feed prices by ₹4 a kg with immediate effect.

"The price hike news comes the same day we heard about the reduction in tariffs by the US. We are both happy and sad," Gopinadh, who is also the General Secretary of the district Prawn Farmers Association, told businessline.

Feed costs occupy a major portion of the cost of shrimp production. "Over 60 per cent of the total spending by us will go into the feed. If a kilogram of prawns is sold at 250, about 160-70 will go into buying feed," he said. The farmers are expecting an additional burden of ₹8-10 a kg due to the hike in MRP.

A few feed companies wrote to dealers and retailers on February 2 informing them about the price increase.

"We are increasing the prices in the wake of a sharp rise in raw material over the last six months," a top feed company said in the letter.

'DOUBLE WIN'

Rajamanohar Somasundaram, Founder & CEO, Aquaconnect, said the US tariff reduction is a significant tailwind and a double win for the industry, especially when paired with the recent EU Free Trade Agreement.

"It moves us decisively from recovery mode to actively reengaging with the US market at a greater scale. At the same time, we must not lose momentum on market diversification, including a focus on promoting domestic consumption," he said.

Divya Kumar Gulati, Chairman, CLFMA of India, said the tariff reduction materially improves price competitiveness against key rivals, including Vietnam and Indonesia, in the US market.

Correction

In February 2026 issue of Aqua International on Page 25, 4th column, first and second line, it was printed as "Out of 11 tonnes of fish production per year in the country, in Odisha, Balasore is the only district to have reached the 1 lakh tonnes production mark, and, out of it, 75,000 tonnes is shrimp production". The figures mentioned are not correct and we regret for it.

It may please be read as below:

Fish production:
India: 17.5 million tonnes in 2023 - 2024; 10.5 million tonnes fresh water aquaculture and 0.9 million tonnes brackishwater aquaculture.

Odisha: 11.12 lakh tonnes in 2024.

Balasore: 1 lakh tonnes fish and shrimp production in 2024; from it shrimp production was 75,000 tonnes.

West Bengal: 22.02 lakh tonnes in 2023 - 2024 (annual); 20.13 lakh tonnes Inland fish and 1.9 lakh tonnes Marine fish.

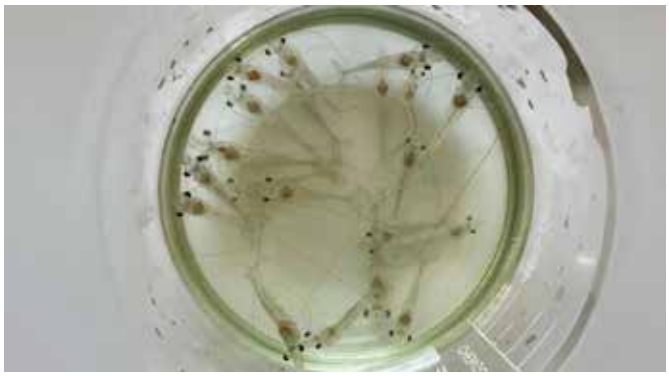
Shrimp production in West Bengal: 70,366 tonnes in 2024.

- Editor

Translucent Post Larvae Disease – a deadly Vibrio infection affecting farmed shrimp

Molecular testing is essential for accurate identification of the specific cause combined with stringent biosecurity measures

By Andrew Shinn, Ratchakorn Wongwaradechkul, Jorge Piazza, Bruno Decock, Thomas Raynaud, Alfredo Medina and Emmy LÃ©ger



TPD infected post larvae at stages 2-4 show empty gut and a colourless, translucent hepatopancreas. Mortality occurs typically within a few hours of infection.

Understanding *Vibrio* infections in shrimp production
Infections associated with Vibrio species pose significant challenges in commercial shrimp operations. If unmanaged, these bacteria can establish populations in water, sediment, or biofilms within farm systems, leading to infections and high mortality rates.

In shrimp hatcheries, Vibrio species can infiltrate or proliferate through multiple routes. These include introduction via broodstock, infected shrimp nauplii, contamination through water sources, and transmission from microalgae, live feeds, or water and air pipelines. Moreover, they can be transported on personnel equipment, on skin, or dispersed through aerosols (Shinn et al., subm.).

What is Translucent Post Larvae Disease?
Translucent Post Larvae Disease (TPD), also known as Highly Lethal Vibrio Disease (HLVD), is a severe condition that has impacted shrimp post larvae production in China and Vietnam since 2020.

The disease is primarily caused by a strain of Vibrio parahaemolyticus, though a Baishivirus has also been implicated in some cases. The V. parahaemolyticus strain associated with TPD produces a toxin that disrupts the hepatopancreas, affecting nutrition and leading to rapid mortality, especially in smaller shrimp.

Visually, affected post larvae (PL), particularly at stages 2-4, exhibit distinct symptoms such as an empty gut and a colourless, translucent hepatopancreas, leading to diminished activity and sluggish movements. Mortality occurs rapidly, typically within a few hours of infection, with rates reaching as high as 80-100% within 24-48 hours, often occurring 3-5 days post-stocking.

Since other pathogens can cause similar visual symptoms in shrimp, accurate diagnosis requires proper testing rather than relying solely on the visible symptoms.

TPD infected post larvae at stages 2-4 show empty gut and a colourless, translucent hepatopancreas. Mortality occurs typically within a few hours of infection. Photo credit: Xu Tao

The role of *Vibrio parahaemolyticus* in TPD
Most cases of TPD are caused by V. parahaemolyticus strains that carry an aerolysin gene, which produces a toxin leading to cellular damage in the hepatopancreas and resulting in death. Another shrimp disease, acute hepatopancreatic necrosis disease (AHPND), is also caused by V. parahaemolyticus, but these strains carry a different toxin gene. Although both toxin genes cause similar damage to the hepatopancreas and lead to comparable outcomes, molecular testing is essential for accurate identification of the specific cause.

How to test for TPD and AHPND
Visual inspections alone are insufficient for diagnosing TPD or AHPND. Accurate diagnosis requires laboratory testing. To do this, collect a targeted sample of PL (i.e., those exhibiting pale and moribund characteristics, approximately 30-50 individuals). Rinse the PL with sterile distilled water

and then fix them in 95-99% molecular-grade ethanol.

Laboratory tests can then identify the different toxin producing genes produced by Vibrio species. Simultaneously, request that the samples are tested for the presence of plasmid genes pirAB producing the toxins responsible for AHPND, utilising the AP4 nested PCR method developed by Dangtip et al. (2015) and for TPD using primers for the ldh gene, which produces the thermolabile hemolysin toxin (Vicente et al., 2020; Zou et al., 2020). If both tests are negative, request that samples are tested for the Baishivirus, using primers as specified by Xu et al. (2023).

Parallel assessment of microbiology results is essential. If all three PCR test results are negative, then look to other potential bacterial pathogens that might result in PL that are translucent in appearance.

Why test

Regular testing is crucial for identifying early-stage infections and preventing their establishment and spread. It raises awareness of the local risks of infection. Testing can offer valuable insights into disease dynamics and potential introduction routes. It facilitates timely interventions and enables the revision of biosecurity protocols to reduce the likelihood of future introductions and outbreaks, thereby minimising economic losses.

***Vibrios* pose a serious threat to shrimp production, but strict biosecurity measures and regular surveillance can effectively manage these risks.**

Managing TPD outbreaks

If TPD is detected, take immediate action:

- **Isolate** infected shrimp and quarantine the affected areas.
- **Conduct** tests to confirm the disease.
- **Assess** the risk to other shrimp batches and the overall farm operations.
- **Cull** infected stock to prevent further spread.
- **Strengthen** biosecurity measures, including monitoring visitors and disinfecting equipment and water systems.
- **Increase** surveillance to monitor the situation and prevent future outbreaks.

Other *Vibrio* infections affecting shrimp

Besides TPD, other Vibrio infections can also cause shrimp to appear translucent. For example, some strains of V. parahaemolyticus carrying a different toxin gene are responsible for AHPND, also known as early mortality syndrome, which can result in sudden and severe mortality. Additionally, other Vibrio species, such as *V. alginolyticus* and *V. harveyi,* can cause systemic infections leading to septic hepatopancreatic necrosis (SHPN).

Need for *Vibrio* vigilance and tight biosecurity

The rapid and severe onset of Vibrio-induced mortalities in penaeid shrimp hatcheries, transitioning from a state of apparent health to moribundity and death within mere hours, underscores the critical need for stringent biosecurity measures and vigilant surveillance protocols.

Recognising the risks associated with Vibrio infections is paramount from a biosecurity standpoint, necessitating proactive measures to prevent and mitigate potential outbreaks. Establishing robust control and management procedures are essential to effectively manage these risks. Surveillance emerges as a crucial practice for early detection and containment of infections, ensuring swift intervention when necessary.

Best practices for biosecurity in shrimp hatcheries:

1. Disinfect water and equipment using ozone, UV light, or hypochlorite.
2. Conduct comprehensive and regular cleaning of the entire production system, including pipework, air lines, and air delivery systems, to remove biofilms and surfaces where Vibrio can establish.
3. Use separate, biosecure water systems to minimise contamination risks.
4. Add probiotics to the water to enhance shrimp health and reduce harmful bacteria. Isolate broodstock in clean conditions and provide biosecure diets to maintain their health.

Managing *Vibrio* at every stage of shrimp production

- *Vibrio* infections can occur at any stage of shrimp farming, from broodstock to grow-out ponds.
- Implementing proper disinfection, maintaining strict hygiene, and adding probiotics to feed and water are essential for reducing infection risks.
- Hatcheries: Ensure biosecure water systems and conduct regular facility cleanings.
- Live feeds: Source live feeds from biosecure providers to prevent introducing *Vibrio*.
- Pond preparation: Disinfect ponds, use clean water, and avoid transferring contaminated water.
- Grow-out ponds: Monitor stocking densities and manage wastes effectively to minimise the risk of *Vibrio* outbreaks.

Remember!

Vibrio bacteria pose a serious threat to shrimp production, but strict biosecurity measures and regular surveillance can effectively manage these risks. Early detection is crucial for minimising the impact of *Vibrio*-related diseases, improving shrimp survival, and ensuring the sustainability of shrimp farming operations. Isolate broodstock in clean conditions and provide biosecure diets to maintain their health.

References are available on request. The article was published in issue November/December 2024 AQUA Culture Asia Pacific

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- Alfredo Medina is Global Technical Expert Shrimp Hatchery
- Emmy LÃ©ger is Customer Success Director.

US Senators introduce India Shrimp Tariff Act to protect Louisiana's shrimp and catfish industries against cheap import

Synopsis
Senators Bill Cassidy and Cindy Hyde-Smith have introduced the India Shrimp Tariff Act to safeguard Louisiana's shrimp and catfish industries from inexpensive Indian imports. The bill aims to establish fair competition, shielding Louisiana's seafood sector and related employment. Cassidy also secured a commitment to support Louisiana shrimp producers and oppose unfair trade practices.

US Senators Bill Cassidy, and Cindy Hyde-Smith introduced the India Shrimp Tariff Act to protect Louisiana's shrimp and catfish industries against India's supply of cheap shrimp and produce into US markets. "People come from all over to try Louisiana gumbo, jambalaya, and shrimp and grits. That's because our shrimpers and catfish farmers meet high standards," said Dr. Cassidy.

The senators said that the bill creates a level playing field and protects the Louisiana seafood and the jobs associated with it, adding that Indian shrimp was "dumped" on the US market with minimal regulation.

"By leveling the playing field, this bill protects Louisiana seafood and the jobs that depend on it. For too long Indian shrimp has been dumped on the U.S. market with minimal penalty or regulation, which has come at the expense of domestic shrimpers, processors, restaurants, and consumers. Senator Cassidy's common-sense legislation will help put our domestic industry on a more level playing field, and I will work with him to move this hill forward for the benefit of Gulf Coast shrimpers everyone who enjoy domestic shrimp," said Senator Hyde-Smith.

During a US Senate Finance Committee hearing last week, Cassidy secured a commitment from President Donald Trump's Deputy Under Secretary of the Treasury nominee Jonathan Greenstein to support Louisiana shrimp producers and oppose "unfair" trade practices "hurting the state's seafood industry."

In February, Cassidy and a group of Republican colleagues introduced the Prioritizing Offensive Agricultural Disputes and Enforcement Act to protect the Louisiana rice industry against dumping of cheap produce into U.S. markers from India and China.

ET Online Last Updated: Sep 20, 2025, 05:52:00 PM IST

Xuse Tilapia to Filter Water for Shrimp Ponds

With the mechanism of absorbing food in water environment, tilapia has been dubbed the "BIO-WATER FILTER". Therefore, this fish is used to drop in the sedimentation pond, filter to get clean water to pump into the shrimp farming tank.

Tilapia can live in both fresh, brackish and saltwater environments.

Their main food is plants including filamentous algae, unicellular algae, algae, organic humus and some small animals. A special feature of this fish is the gland that secrete much MUCUS TO CATCH SUSPENDED PARTICLES IN THE WATER, forming a sticky lump full of algae, zooplankton, organic food ... as food.

With the mechanism of absorbing food in water environment, tilapia has been dubbed the "BIOLOGICAL WATER FILTER".

Based on this feature, scientists have invented measures to drop tilapia in settling ponds for shrimp farming, also known as green shrimp farming.

This approach helps to save costs while creating a clean source of water for aquaculture

Specifically, the shrimp farming sites will be designed according to the circulation model including: shrimp ponds, ponds containing wastewater and settling ponds.

Water pumped directly from natural sources such as ponds, lakes, rivers ... will be stored in settling ponds.

Here, people conducted tilapia in about a month. During this time, the fish are not fed, instead, they will use the food source of dead shrimp, fish, dead aquatic animals and algae in the water.

THIS HELPS STABILISE THE WATER ENVIRONMENT, LIMITING THE SPREAD OF DISEASE-CAUSING ORGANISMS FROM OUTSIDE.

Jayamangala Kasulu opens Prudhvi Aqua Feeds & Needs; Rahitya Enterprises at Vinukonda

Prudhvi is the Dealer for MARRVA, L. vannamei Feed of Fedora Sea Foods

Naram Prasad, General Manager, Fedora Sea Foods inaugurating Prudhvi Aqua Feeds & Needs on 25 February 2026 at Vinukonda

Vinukonda: Mr Jayamangala Kasulu, a 30 acres shrimp farmer in Vinukonda, Palnadu District, Andhra Pradesh, started dealership business and the inaugural ceremony of the outlets titled Prudhvi Aqua Feeds & Needs and Rahitya Enterprises was held on 25 February 2026. Mr Naram Prasad, General Manager, Fedora Feeds inaugurated the outlets.

Jayamangala Kasulu

While Prudhvi Aqua Feeds & Needs is an exclusive dealer of Fedora Sea Foods Pvt Ltd for MARRVA, L. vannamei Feed, Rahitya Enterprises deals with supply of healthcare products of different companies.

Participants at the launch function of Prudhvi Aqua Feeds & Needs

Fedora Sea Foods is manufacturing MARRVA, L. vannamei feed in collaboration with PING TAI Enterprise Co Ltd, Taiwan.

Fedora Sea Foods executives Dr P. Harinath Reddy, Regional Manager, Ramesh, ASM, Rammohan, TSE, Peddiraju, TSE and Dilip Kumar, Senior TSO were present on the occasion.

On this occasion, Prudhvi Aqua Feeds & Needs management expressed its gratitude to Mr M. Dileep Kumar, COO, Fedora Sea Foods, Mr Anjireddy, Zonal Manager and other management team members of Fedora Sea Foods for their continuous support and guidance in expanding services to the farming community.

A View Prudhvi Aqua Feeds & Needs outlet

Naram Parasad and Dr Harinath Reddy during Prudhvi outlet launch meet at Vinukonda

Contd. from page 22

The filtered water is pumped into shrimp ponds. During the culture process, people supplement the water from the settling pond to the pond once a week.

When the water in the shrimp pond shows signs of discoloration, the farmer proceeds to pump water into the waste pond.

Here, the water is partly sediment and then flows to the pond to drop tilapia. Just like that, water is circulated and reused, limiting the release to the environment.

TILAPIA farming in sedimentation ponds has appeared since 2010.

This method helps to improve the pond environment and minimize disease. ; help shrimp grow and develop stably.

In addition, tilapia after raising for a while can be harvested, helping people increase their income. Thus, the tilapia farming model in the sedimentation pond not only helps to increase shrimp productivity but also brings double economic benefits for farmers.

Mayank becomes a Man

Surat: Dr Manoj Sharma, a prominent shrimp farmer & promoter of Mayank Aquaculture Pvt Ltd, Surat, Gujarat and Member of Governing Body of National Fisheries Development Board (NFDB), celebrated the marriage of his son Mr Mayank Sharma with Ms Devarshi, on 3 February 2026 at Vedik Resort, Sahol, Surat, Gujarat.

Mayank Sharma is a young, forward-thinking aquaculture entrepreneur committed to transforming shrimp farming through innovation, sustainability, and scientific excellence. He holds a Master's degree in Biotechnology, Bioprocessing, and Business Management from the United Kingdom, combining global understanding with strong practical expertise. At Mayank Aquaculture Pvt. Ltd. (MAPL), he leads research and business operations, focusing on farmer-centric solutions, microbial technologies, and sustainable farming models.

He also heads the VIVALINE division, developing science-backed aquatic healthcare products that enhance pond performance and environmental resilience. As partner of Zhingalala, a "pond-to-plate" initiative promoting domestic shrimp consumption.

Devarshi holds dual Master's degrees in Biotechnology — one from India and another from Germany, with specialization in Microbiology. With strong laboratory foundation, including research involving human cell lines, she brings a research-driven approach and aims to catalyze scientific innovation within the company.

The couple looks forward to building a future grounded in shared values, scientific excellence, and continued contribution to aquaculture sector.

Family members, aquaculture stakeholders and friends blessed the couple at a function held in Vedik Resort, Sahol, Surat.

Wedding Celebration: *Mayank and Devarshi during wedding reception with parents Mrs & Dr Manoj Sharma and other family members on 3 February 2026 at Surat, Gujarat*

Mayank and Devarshi

Vijayawada, Andhra Pradesh to host India International Aquaculture Expo 2026 on April 16-17-18

Aqua International will present Excellence Awards to individuals, institutions and companies who have excelled their performance and also contributed to the development of aquaculture sector

Vijayawada: A 3-days Exhibition on aquaculture titled India International Aquaculture Expo 2026 will be held at SS Convention, Labbipet, & 18 April 2026. During the Expo, there will be "Panel Discussion and Experts - Farmers Interaction Meet" with the theme: Tap the Potential to take Andhra Pradesh and the India's Aquaculture to the next level.

The main objective of the Expo is to bring awareness among aquaculture farmers and other stakeholders on various products,

Advantages of Farmers' Participation in the Expo

Farmers can directly meet and talk to the companies, who exhibit their products & services in the stalls and know about the products and their usefulness in shrimp and fish culture.

Companies (Exhibitors) can meet farmer-customers and get their feedback on their products and performance as well as services. This will enable the companies / manufacturers to know farmers' feed back and suggestions to further improve the quality of their products and services.

Every product displayed in Aquaculture Expo and every word spoken in the inaugural session and during the technical interaction are meant for farmers and the culture.

Farmers can also interact with experts on various aspects and get solutions for various problems in Aquaculture. We are creating a ***Lounge for Experts - Farmers Interaction*** during the exhibition time in the venue.

This Expo is also a very good opportunity to the enterprising people who would like to take up Aquaculture as a profession.

Exhibition Timings: 10:00 AM to 6:00 PM on April 16 - 17 - 18
Inaugural Session : 10.30 AM on April 16

Experts - Farmers Interaction Lounge open during the Expo timings in the venue

For Stalls booking and information, please contact:

NRS Events, Aqua International
BG-4, Venkataramana Apts.,
11-4-634, A.C. Guards, Near IT Towers,
Hyderabad - 500 004, Telangana, India.
Tel: 040 - 2330 3989, M: 96666 89554
E-mail: iiae.nrs@gmail.com

Stalls Booking in progress
Rush to Reserve your choice of Stalls

technology, and services available to get better productivity in aquaculture. The Expo is a wonderful opportunity to aquaculture farmers and other stakeholders to update their knowledge on various aspects in aquaculture, informed Mr M.A. Nazeer, Chief Executive of the Expo and Editor, Aqua International. The event is also an opportunity for buyers and sellers as well in the sector, he added.

Companies dealing with manufacture and supply of products and services related to aquaculture sector will display their products and services in the Exhibition. Organizations with research and development on aquaculture would also take part in it. The expo is being organised by Aqua International.

In Andhra Pradesh, instead of organising many Exhibitions in different places like Nellore, Bhimavaram, Amalapuram, Kakinada etc, we want to organise and develop one big & potential Expo on Aquaculture sector at Vijayawada, the aquaculture hub of India, and it is centrally located in A.P. with required facilities. Hence, India International Aquaculture Expo 2026 is coming up on 16-17-18 April 2026 at Vijayawada, Andhra Pradesh. We want to develop it as an All India and international level event. It would be a good platform for farmers and other stakeholders of aquaculture sector to meet, exchange ideas, update knowledge and develop business opportunities.

I to present Excellence Awards

On this occasion, Aqua International will present Excellence Awards to the individuals, institutions and companies on aquaculture sector who have excelled their performance and also contributed to the development of aquaculture sector.

FORM IV

Statement about ownership and other particulars about newspaper, Aqua International, to be published in the first issue every year after the last day of February.

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6.	Names and addresses of individuals who own the newspaper and partners or shareholders holding more than one percent of the total capital.	: M.A. Nazeer Indian BG-4, Venkataramana Apartment 11-4-634, A.C. Guards, Near IT Towers, Hyderabad – 500 004, Telangana.

I, M.A. Nazeer, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Date: 1.3.2026

Sd/-
Signature of Publisher

44th Edition

India International Aquaculture Expo 2026

IIAE

Exhibition & Excellence Awards

Aqua International Excellence Awards 2026

For Excellence & Contribution to Aquaculture sector

16-17-18 April 2026

SS Convention, M.G. Road,
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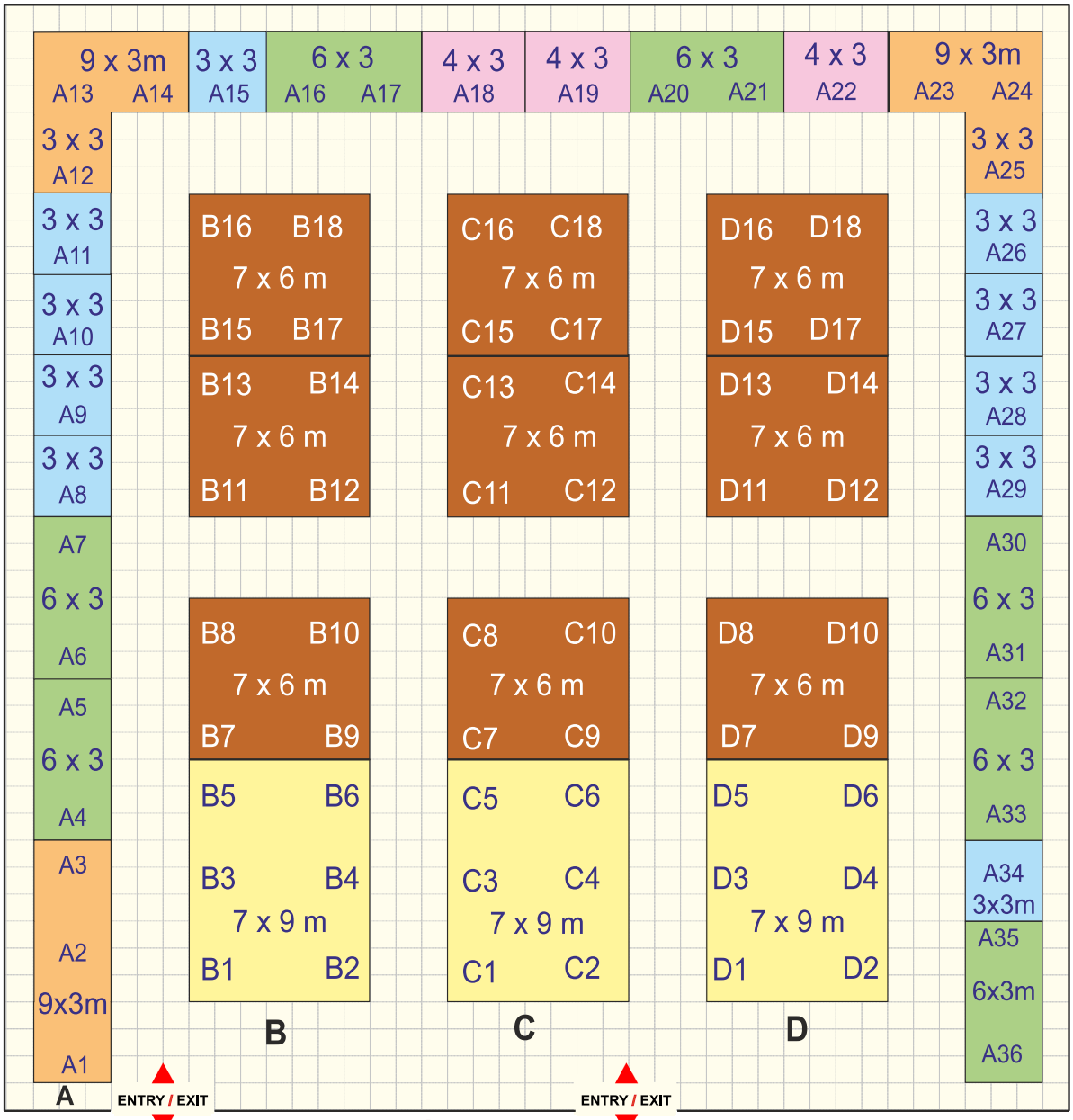

LAYOUT OF STALLS

For Stalls Booking, Contact:

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Carp Seed Production 2.0: Revamping Hatcheries to Sustain India's Global Leadership

M. Subashini, A. Akask Arul, G.K. Raswin and S. Felix
St. Devasahayam Institute of Fisheries Science & Technology, Amanattantheri, Enayam Post. KK Dist – 629 193.

Highlights:

"Carp Seed Production 2.0" shall aim to modernize carp hatcheries to sustain India's leadership in global carp production.

Strengthening selective breeding of Catla catla, Labeo rohita and Cirrhinus mrigala is key to improving growth, survival, and disease resistance.

Pooling elite brooders and **establishing regional brood banks** will ensure uniform supply of quality seed nationwide.

Scientific hatchery management, health screening, and seed certification can greatly enhance farmer confidence and productivity.

A coordinated national seed network can transform carp aquaculture into a more resilient and high-quality production system.

Abstract

India continues to be the world's largest producer of carp seed and carp-based aquaculture products. However, emerging challenges related to seed quality, genetic deterioration, seasonal shortages, and uneven regional supply necessitate a strategic revision of carp seed production systems. This article examines small and medium-scale low-input carp hatchery models, emerging advanced production systems such as ponds, cages and biofloc, and the urgent need to revamp departmental hatcheries. The economic viability of different models and future directions required to sustain India's leadership in carp aquaculture are discussed.

Introduction

Carps, particularly Indian Major Carps (Catla catla, Labeo rohita and Cirrhinus mrigala), form the backbone of freshwater aquaculture in India and contribute significantly to food security, rural employment and farmer livelihoods. Tamil Nadu, along with several other states, has played a major role in carp seed production through a network of government and private hatcheries. Historically, emphasis was placed on maximizing seed output to meet increasing farming demand. While this approach succeeded in expanding carp culture, the present scenario calls for a shift in focus towards the production of genetically sound, healthy and uniform-quality seed produced through sustainable and economically viable systems. With increasing intensification of aquaculture, climate variability and growing farmer awareness, it is timely to revisit and modernize carp seed production strategies to ensure India retains its status as the world's largest carp-producing nation.

Carp breeding protocol at a Hatchery facility at Tamil Nadu

Present Challenges in Carp Seed Production

Despite large-scale production capacity, several challenges continue to affect carp seed quality and availability across the country. Repeated use of limited broodstock populations has resulted in inbreeding and genetic deterioration in many hatcheries. Inadequate broodstock nutrition and poor conditioning practices adversely affect fecundity, fertilization and hatchability. Biosecurity measures and health screening protocols are often insufficient, increasing the risk of disease transmission from hatcheries to grow-out farms. Seed production remains highly seasonal, leading to shortages during critical stocking periods in certain regions. In addition, ageing infrastructure and limited technical upgrading in many departmental hatcheries further constrain both quality and quantity of seed production. These factors collectively reduce farmer confidence and overall farm productivity.

Table 1 presents the general characteristics of small and medium-scale carp hatcheries in terms of investment, production capacity and market orientation.

Parameter	Small-Scale Hatchery	Medium-Scale Hatchery
Initial investment (₹ lakh)	5–8	8–15
Area requirement (ha)	0.5–1.0	1.0–2.0
Annual spawn production (million)	30–60	80–150
Production focus	Local demand	District / regional demand
Technology level	Conventional, low-input	Semi-intensive, improved
Suitability	Small&marginal farmers	Entrepreneurs / cooperatives

Selection of fish breeders at a carp hatchery

Role of Small and Medium-Scale Hatcheries in Local Seed Supply

Small and medium-scale carp hatcheries continue to serve as the backbone of local and regional seed supply systems. Their proximity to farming areas reduces transportation time, stress and mortality of seed, while also ensuring timely availability during the breeding season. Such hatcheries typically operate using Chinese circular hatchery systems or eco-hatchery designs, rely on locally available broodstock with periodic rotation, and employ low-energy water management practices. When supported by basic broodstock management, live feed enrichment and simple water quality monitoring, these decentralized hatcheries are capable of producing high-quality spawn and fry with relatively low capital investment. They are particularly well suited for meeting the seed requirements of small and marginal farmers.

Advanced Models for Enhancing Carp Seed Production

In order to overcome limitations associated with conventional systems and to ensure reliability of seed supply, several advanced production models are being increasingly adopted. Improved pond-based hatchery systems focus on scientific broodstock conditioning, controlled fertilization and enhanced aeration, resulting in improved fecundity and larval survival. Cage-based broodstock management in reservoirs and large irrigation tanks allows better control over brood health and gonadal development while reducing land dependency. Biofloc-based nursery and seed rearing systems provide a controlled environment that improves survival rates, accelerates growth and produces uniform fingerlings with reduced water exchange and improved biosecurity. Partial recirculating aquaculture systems and indoor nurseries further support year-round seed availability and are particularly suitable for hatchery-linked fingerling production units.

Revamping Departmental Hatcheries: A Strategic Necessity

Departmental hatcheries have a crucial role to play in ensuring seed quality, genetic conservation and technology dissemination. These hatcheries must be transformed from routine production centres into centres of excellence focusing on broodstock improvement, quality assurance and capacity building. Revamping efforts should include rejuvenation of broodstock through the introduction of genetically diverse and improved lines, modernization of infrastructure such as incubators,

Hapas type systems used for spawn collection

aeration systems and water treatment units, and adoption of standardized operating procedures for breeding and larval rearing. Regular training and skill upgradation of technical staff, along with strong linkages with private hatcheries and farmer producer organizations, will significantly enhance the impact of these institutions

Economic Viability of Carp Hatchery Systems

Economic sustainability remains a key determinant for the adoption and long-term success of carp hatchery enterprises. A medium-scale carp hatchery typically requires an initial investment ranging from ₹8 to 15 lakh, with annual operational costs of ₹4 to 6 lakh. Such units are capable of producing 80 to 150 million spawn annually, generating gross returns of ₹10 to 18 lakh per year. Net profits generally range between ₹4 and 8 lakh, with benefit–cost ratios of 1.8 to 2.5. Integration of advanced nursery systems such as biofloc or partial RAS can further enhance profitability by improving survival rates, reducing production risks and enabling premium pricing for quality seed. Table 2 provides indicative economic parameters for a medium-scale carp hatchery.

Way Forward

To sustain and strengthen India's global leadership in carp aquaculture, the emphasis must clearly shift from quantity-oriented seed production to quality-driven, technology-supported and economically viable systems. Tamil Nadu, with its strong institutional framework, skilled manpower and progressive farming community, is well positioned to lead this transformation. A balanced approach that strengthens small and medium-scale hatcheries, promotes adoption of advanced production models and revitalizes departmental hatcheries will ensure consistent availability of high-quality carp seed. Such an approach will enhance farmer profitability, improve farm productivity and support the long-term sustainability of freshwater aquaculture in India.

Typical Chinese Carp hatchery model system

Table 2 Indicative Economics of a Medium-Scale Carp Hatchery

Economic parameter	Value
Initial capital investment	₹8–15 lakh
Annual operational cost	₹4–6 lakh
Annual spawn output	80–150 million
Gross annual income	₹10–18 lakh
Net annual profit	₹4–8 lakh
Benefit–Cost ratio	1.8–2.5
Payback period	2–3 years

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Bioremediation in wastewater aquaculture

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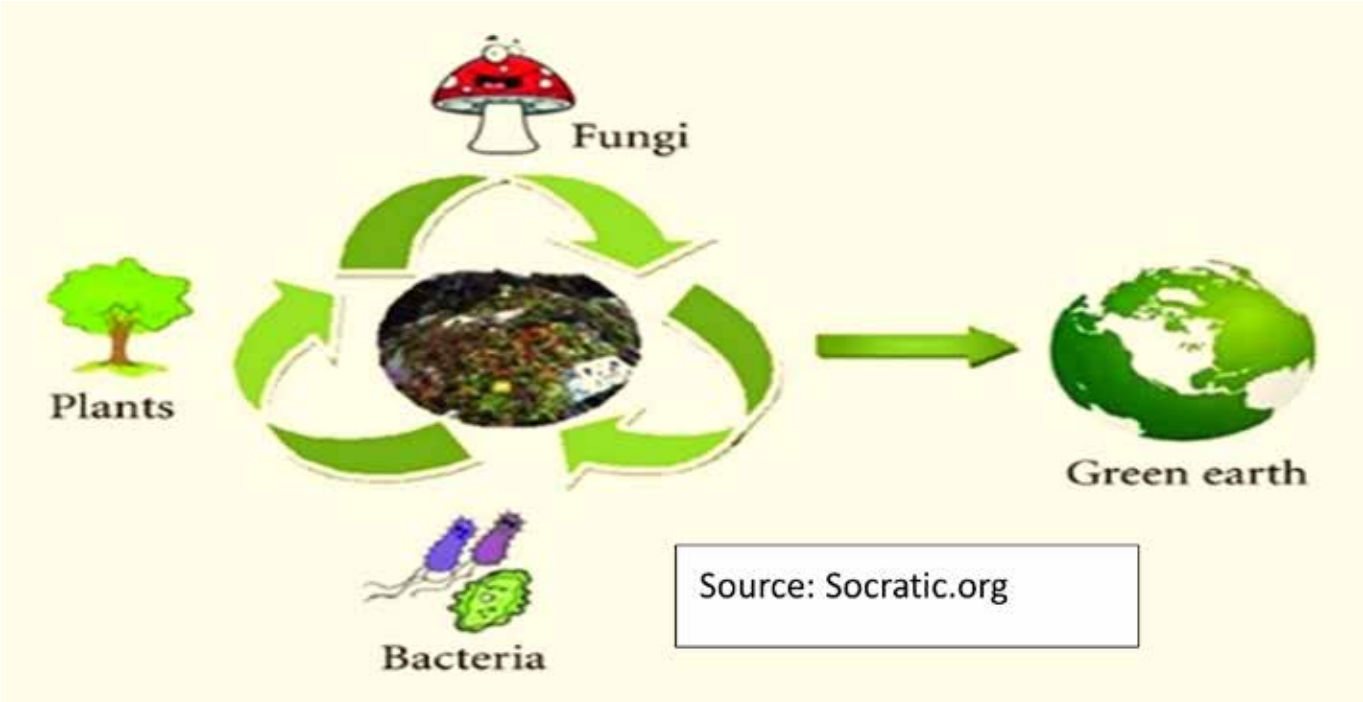
Introduction

Industrial activities have been impacting the environment such as air contaminated soil and wastewater (Naswir *et al*., 2019). Thus, in recent decades, there has been global increase in environmental pollution as a result of increasing population, rapid industrialization, increased anthropogenic activities and unregulated and unsafe agricultural activities, all of which have resulted in the accumulation of hazardous waste in the environment including plastic, agricultural, domestic, rubber, metallic and industrial wastes. These effects will have detrimental consequences for human health, plant, animal and environmental deterioration. In 1950, plastic production was around 2 million tons and it was expanded to 368 million tons in 2019. Plastic consumption has thus increased about 180 times from 1950 to 2018. An estimated 400.3 million tons of plastic will be produced globally in 2022 and by 2050, which is further expected to increase by 2 billion tons by 2050 (Pilapitiya and Ratnayake, 2024). The plastic particles < 5 mm in size are known as microplastics (MP). The size range of plankton, fish larvae, meso and meiobenthos—the developmental stages of several invertebrates and fish is comparable to that of MP (Dey *et al*., 2023).

Bioremediation is defined as the process whereby organic wastes are biologically degraded under controlled conditions. Bioremediation is the biological process of decontamination of pollutants in the environment (Goltapeh *et al*., 2013). The setting can be aquatic, terrestrial, or a combination of the two. Bioremediation also involves cleaning up the contaminants in the environment microorganisms' capacity to by diverse exploiting metabolic diminish the pollutants (Megharaj *et al*., 2011). Bioremediation is a high-value, low-cost technology for addressing environmental degradation. The widespread use of genetically-modified microorganisms that can also help to eliminate petroleum, naphthalene, toluene, benzene and other xenobiotic chemicals is now being studied (Singh *et al*., 2022). Biodegradation is a catabolic process that breaks down plastics using microbes or enzymes over some time. The type of microorganisms has a significant impact on the rate and degree of



Identity of the bioremediator	Source	Used on	Method of application	References
Gram-Positive Bacteria				
Bacillus sp	Commercial product	Channel catfish	Spread in pond water.	Queiroz and Boyd, 1998
Bacillus sp.	Commercial product	*Brachionus plicatilis*	Mixed with water.	Hirata *et al*., 1998
Gram-Negative Bacteria				
Aeromonas media	Unknown	Crassostrea gigas	Mixed with water.	Gibson *et al*., 1998
Pseudomonas fluorescence	*Onchorhynchus* mykiss	*Onchorhynchus* mykiss	Mixed with water to 105 or 106 cells ml-1	Gram *et al*., 2001
Pseudomonas sp	*Onchorhynchs* mykiss	*Onchorhynchus* mykiss	Mixed in water.	Spanggaard *et al*., 2001

plastic biodegradation (Shilpa *et al*., 2024). Fungi start colonizing the plastic surface resulting in multiple new species (Sangale *et al*., 2019). Fungi accelerate the activity of metabolic intermediates and their rapid breakdown.

Highlight Point

- Bioremediation is the biological process of decontamination of pollutants in the environment
- Bioremediation is the process of using bacteria, algae, fungi and yeast to remove contaminated materials from the environment.
- Phytoremediation is an emerging bioremediation approach that uses plants and their roots to treat contaminated soil and water.
- The use of bioremediation results in a lower accumulation of slime or organic matter in the pond bottom, better penetration of oxygen into the sediment and a generally better environment for the farmed stock.

Principles of bioremediation

In bioremediation, living organisms such as microorganisms (bacteria, fungi and algae) or plants are used to degrade and detoxify the hazardous pollutants present in the environment and convert them into CO_2, H_2O, microbial biomass and metabolite. It uses naturally occurring bacteria and fungi or plants to degrade or detoxify substances hazardous to human health and/or the environment. The microorganisms may be indigenous to a contaminated area or they may be isolated from elsewhere and brought to the contaminated site (Okonko et al., 2007). It's the process of converting harmful organic pollutants like carbon dioxide and water into non-toxic or naturally-occurring inorganic compounds that are suitable for aquatic life, plants, animals, and people to utilize.

Microorganisms used in bioremediation

Biological equilibrium is maintained in part by the contribution of microorganisms to nutritional chains. Bioremediation is the process of using bacteria, algae, fungi and yeast to remove contaminated materials from the environment (Saxena *et al*., 2020). Microbes use the hazardous contaminant as their energy and carbon source in either aerobic and anaerobic conditions and thus via metabolic activity can degrade or convert the pollutant to less or nontoxic metabolites (Tiwari and Singh, 2014).

Types of bio-remediation

The bioremediation process is broadly categorized into *ex situ* bioremediation and *in situ* bioremediation based on the origin, transportation and removal of pollutants from contaminated sites.

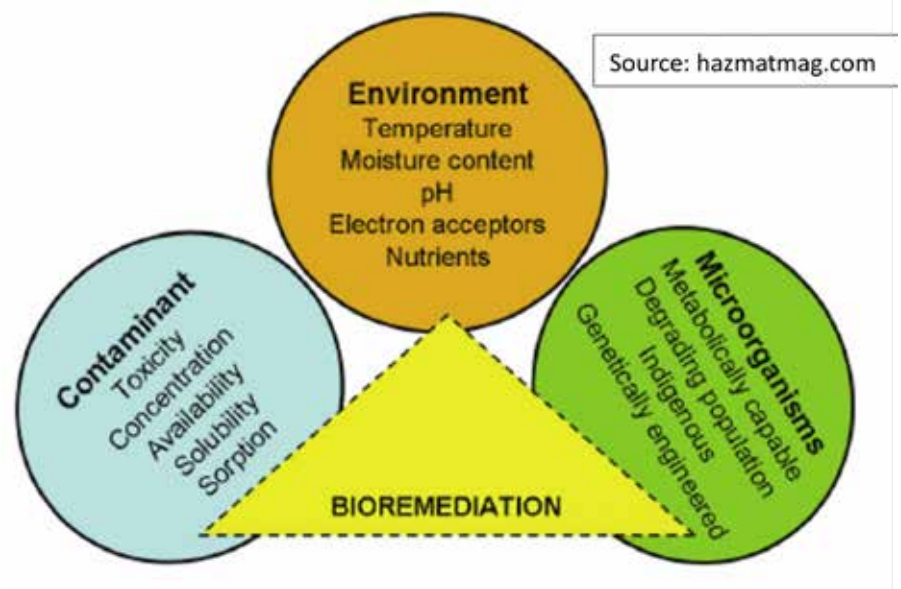
In-situ bioremediation

In -situ techniques are defined as those that are applied to soil and groundwater at the site with least amount of disruption. These techniques are generally the most desirable options due to lower cost and fewer disturbances, since they provide the treatment in place avoiding excavation and transport of contaminants. The depth of soil that can be successfully treated limits the extent of treatment. In many soils, effective oxygen diffusion for desirable rates of bioremediation extend to a range of only a few cm to about 30 cm into the soil, although depths of 60 cm and greater have been effectively treated in some cases (Boopathy. 2000).

Bioaugmentation

A collection of native bacteria, microbes from other sites, or genetically engineered microbes are added to the polluted site to speed up the breakdown process (Sharma, 2012). Adding native or exogenous microorganisms to the contaminated locations is a common step in bioremediation (Anjaneyulu *et al*., 2005). Two factors limit the use of added microbial cultures in a land treatment unit:

1) Non indigenous cultures rarely



compete well enough with an indigenous population to grow and maintain useful population levels.

2) Most soils with long-term exposure to biodegradable waste have indigenous microorganisms that are effective degrades if the land treatment unit is well managed.

Bio-stimulation

This approach of *in situ* bioremediation promotes the growth of indigenous microbial populations in contaminated soil or groundwater in order to effectively remove contaminants. This is an effective approach for treating hydrocarbons and metal-contaminated environments (Kao *et al*., 2008).

Bioventing

In the bioventing bioremediation approach, air (oxygen) and nutrients are given in a controlled manner through wells to the polluted soil stimulating micro bioactivity for the degradation process (Atlas and Philp, 2005). By using modest air flow rates, bioventing reduces volatilization and the release of pollutants into the environment while supplying just the right quantity of oxygen for biodegradation. It works for simple hydrocarbons and can be used where the contamination is deep under the surface (Pamela *et al*., 2010).

Ex situ bioremediation

Ex-situ procedures are used on the site's soil and groundwater that have been removed by pumping (water) or excavation (soil). Using these methods, contaminated soil is excavated or removed from the earth (Paniagua-Michel. 2003). The *ex-situ* bioremediation techniques are further classified into different categories such as land farming, composting, bio piling, bioreactors and biofilters based on the pollutant types, depth and degree of pollution, treatment cost and the geographical and geological features of the polluted site (Atlas and Philp, 2005).

Land farming

Land farming is a simple technique in which contaminated soil is excavated and spread over a prepared bed and periodically tilled until pollutants are degraded. The objective is to promote the aerobic breakdown of pollutants by native biodegradative bacteria. During land farming, tillage provides irrigation, nutrients and aeration to increase microbial activity (Volpe *et al*., 2012). It is seen that the land farming can be done only for the treatment of 10 -35 cm of surface soil (Kumar *et al*., 2018).

Bio-slurping

Soil vapour extraction (SVE), bioventing and vacuum-assisted pumping are employed to reach soil and groundwater levels for restoration, together with a direct oxygen supply and promotion of pollutant biodegradation (Anekwe *et al*., 2021). This approach can be used to recover unsaturated and saturated zones as well as light non-aqueous phase liquids (LNAPLs). This technology can be used to remediate soils contaminated with flammable and moderately-flammable organic substances. This method uses soil moisture to lower air permeability and oxygen transfer rate, which in turn lowers microbial activity. By promoting soil gas movement, this vapour extraction enhances aerobic biodegradation and aeration.

Phytoremediation

Phytoremediation is a bioremediation process that uses various types of plants to remove, transfer, stabilize and/or destroy contaminants in the soil and ground water. Phytoremediation is an emerging bioremediation approach that uses plants and their roots to treat contaminated soil and water. The majority of the research investigations have indicated that, at the contaminated site, the pollutant removal mechanism by plants involves the uptake of pollutants by a passive process, translocation of the pollutant from root to shoot by xylem flow and accumulation in the shoot (Miguel *et al*., 2013). Numerous plants (over 300) are better candidates for phytoremediation because they ideally absorb Cu, Zn, and Ni. Heavy metal bioavailability is decreased and off-site transfer is avoided through phytostabilization, also known as *in situ* inactivation or immobilization. Metals are absorbed and restored in the roots of the plant.

Factors affecting bioremediation

The overall result of a biodegradation process depends on microbial biomass and its diversity, microbial metabolism and enzymatic activity (bioactivity and bio chemistry), the physicochemical characteristics of substrates/contaminants (structure and concentration), energy sources (electron donors) and environmental parameters (pH, temperature, moisture present, carbon and energy sources and availability of electron acceptors). The interaction of the pollutant, nutrients, microbes and environment affect the bioavailability

Bacillus sp.	Mineralization and breakage of proteins.
Nitrosomonas sp.	Oxidation of ammonia.
Nitrobacter sp	Oxidation of nitrites.
Aerobacter sp.	Reduction of organic matter.
Cellulomonas sp.	Breakage of plant material.

(Akpor et al., 2010)

and bio degradability of pollutants and the physiological requirements for the degradation process, thus helping to assess the efficacy of the bioremediation process (Kumar *et al.*, 2018).

Bioremediation of aquaculture waste waters

Aquaculture has been the fastest growing sector over the last few decades with the average annual growth rate of more than 8% (Mirzoyan *et al.*, 2012). Its integrated agricultural practices and traditional polyculture, which maximize the use of farm resources including farm wastes, made it an environmentally sound practice at one point. Currently, aquaculture uses bioremediation, which involves adding microorganisms or enzymes to the ponds to improve the water quality. The use of bioremediators results in a lower accumulation of slime or organic matter in the pond bottom, better penetration of oxygen into the sediment and a generally better environment for the farmed stock. A successful bioremediation involves:

1. Optimizing nitrification rates to keep low ammonia ion concentration.
2. Optimizing denitrification rates to eliminate excess nitrogen from ponds as nitrogen gas.

Bioremediation of nitrogenous compounds

Nitrogen applications in excess of pond assimilatory capacity can lead to deterioration of water quality through the accumulation of nitrogenous compounds (e.g., ammonia and nitrite) with toxicity to fish and shrimp. Fish excretion and sediment flux from the mineralization of organic matter and molecular diffusion from reduced sediment are the main sources of ammonia, however air deposition and cyanobacterial nitrogen fixation are also occasionally significant (Ayyappan and Mishra, 2003).

The most practical technique for eliminating ammonia from closed aquaculture systems is bacteriological nitrification, which is often accomplished by establishing a bio-filter made of sand and gravel that allows water to pass through. The nitrite oxidizers belong to three genera: *Nitrobacter, Nitrococcus* and *Nitrospira,* while the ammonia oxidizers are classified under five genera: *Nitrosomonas, Nitrosovibrio, Nitrosococcus, Nitrolobus and Nitrospira*. Additionally, certain heterotrophic nitrifiers only generate trace amounts of nitrite and nitrate and frequently use organic nitrogen sources instead of nitrite or ammonia. In addition to producing nitrate, nitrification slightly raises the pH to an acidic range, which makes soluble components more readily available (Ayyappan and Mishra, 2003).

Probiotics in aquaculture bioremediation

Applying probiotics and/or enzymes to ponds is the most recent attempt to improve water quality in aquaculture. This involves manipulating pond microbes to increase the mineralization of organic matter and remove unwanted waste chemicals (Akpor *et al.*, 2010).

Micro algae in industrial waste water treatment

The types of microorganisms used to treat industrial wastewaters vary greatly, as do the wastewaters themselves. An effective method of preserving biomass during WWT is biomass immobilization (Nicolella et al., 2000) and microalgae immobilization in polymeric material such as carrageenan, chitosan, or alginate has been reported by various authors (Chevalier and De la Nou¨ e, 1985; Lau et al., 1995 and Robinson et al., 1998).

Application of bioremediation in environmental management

A report of Mesa et al. (2015) studied enhanced heavy metal removal by Spartina maritima from the metal-contaminated estuaries which were bioaugmented with indigenous rhizobacteria and the results were increased plant biomass and heavy metal uptake and removal. A study by Kao et al. (2008) has shown a 70% reduction in BTEX contaminants from contaminated groundwater using the bio -sparging bioremediation technique. Treatment of contaminated soil using the bio pile technique after the pre-treatment of contaminated soil resulted in a 71% TPH reduction over the 50-day experiment period (Dias et al., 2015).

Various research studies related to heavy metal bioremediation have reported 19% to 65% removal of As, Cu, Pb, and Zn, 99.3% removal of heavy metals (Fe, Zn, Cd, Cu, B, and Cr), 50% to100% removal of Pb, 25% to 60% removal of Ni, and 20% to 70% removal of silver nanoparticles using bioaugmented rhizoaccumulation, rhizofilteration, and phytoaccumulation methods of phytoremediation (Elias et al., 2014; Mesa et al., 2015). A report of Bhattacharya et al. (2015) has shown 62% to 69% removal of saturated and aromatic hydrocarbons from an oil-contaminated site using a stir-tank bioreactor system and similarly Xu et al. (2015) reported that the 48% to 98% reduction of naphthalene from coal gasification wastewater in a membrane bioreactor system.

Advantages and disadvantages of bioremediation

Bioremediation is a natural process and is therefore perceived by the public as an acceptable waste

treatment process for contaminated water. The residues for the treatment are usually harmless products and include carbon dioxide, water and cell biomass. Bioremediation can prove less expensive than other technologies that are used for clean-up of hazardous waste.

Disadvantages

Bioremediation is limited to those compounds that are biodegradable. Not all compounds are susceptible to rapid and complete degradation. There are some concerns that the products of biodegradation may be more persistent or toxic than the parent compound.

- Future aspects of the bioremediation technique
- Integration of nanotechnology with bioremediation (e.g., nanoparticle-enhanced microbial activity for heavy metal removal (Paul et al., 2005).
- Development of specialized microbial consortia (e.g., nitrifying and denitrifying bacteria) to efficiently remove ammonia, nitrites and organic waste from aquaculture effluents.
- Use of constructed wetlands with aquatic plants (e.g., duckweed, water hyacinth etc.) to absorb excess nutrients and heavy metals.
- Aquaponics systems combining fish farming with hydroponic plant growth for a closed-loop, zero-discharge approach.
- Genetically-engineered plants can be able to bioremediate specific pollutants through discovered metabolic processes, enzymes, genes, or operons (Prasad et al., 2018).
- GMOs can clean up a wide range of waste effluents and polluted land (Kumar et al., 2020)

Conclusion

Bioremediation is a more sustainable, cost-effective and environmentally benign alternative to standard physical/chemical remediation procedures. Depending on the site, both in situ and ex situ bioremediation approaches have been shown to be effective in treating contaminated areas. The choice of bioremediation is determined by geological features (soil type & contamination depth), location and technology performance. Advances in biotechnology, molecular biology and bioinformatics show enormous potential for enhancing bioremediation techniques and applications.

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Nanobubble Technology in Aquaculture

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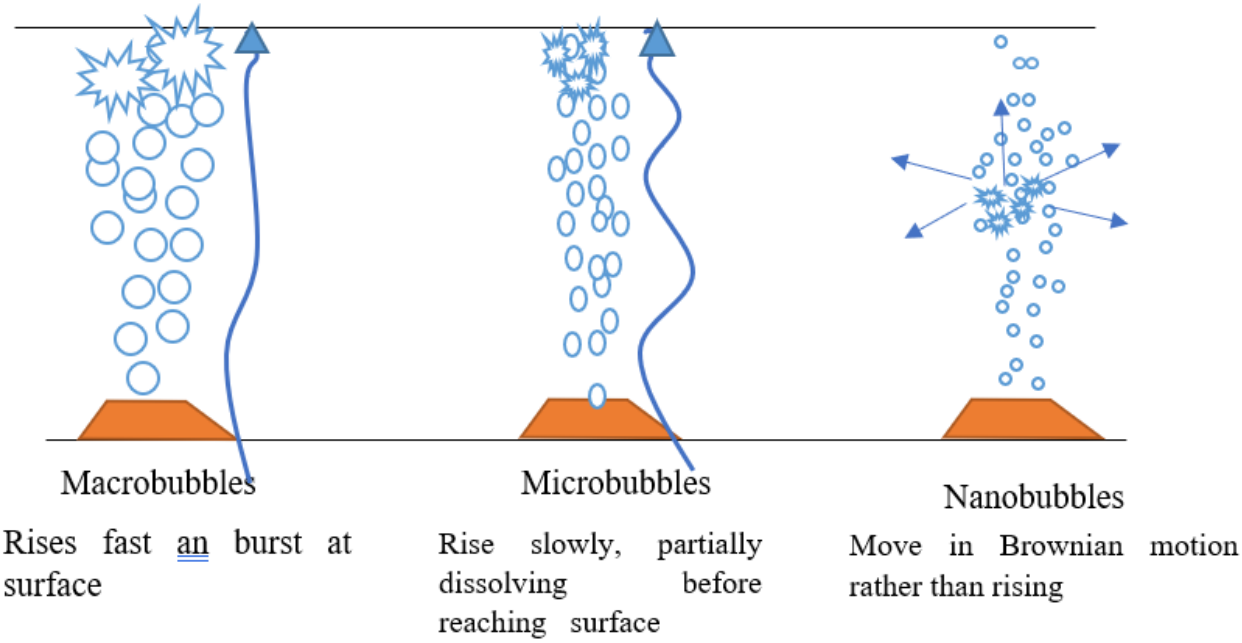


Abstract: In recent microbubbles and nanobubbles technologies have drawn great attention due to their wide applications in many fields of science including fisheries and aquaculture. Nanobubble technology has promising development and application prospectus in the fields of aquaculture and fisheries. This articles discusses about the nanobubble technology its principle and its application in fisheries and aquaculture in details.

Keywords: - Nanobubble, Microbubble, Aeration, Dissolved oxygen

Introduction

The ever-growing demand for fisheries had led the aquaculture industry to seek novel approaches for more sustainable practices. Fish is important source of high protein and omega-3 still hunger is worldwide socioeconomic problem that has been faced even today with technological advances, however unsustainable practices and shocks threaten this potential, which is worsened by limited research on technologies such as nanobubble. One of the main objectives of United Nation 2030 sustainable development agenda is to act with strategies that can contribute to eradicating the effects of this problem with negative consequences to worldwide. The sustaining increase in aquaculture has been positively influenced by technological developments where there is pressing needs to find appropriate solution to meet growing world population that is expected to reach approximately 10 billion by 2050. Nanobubbles technology is one such a technology which is used aquaculture industry for various application. Nanobubble are gas filled pockets suspended as sphere-like cavities or attached to surface with diameters less than one micro meter (<1 µm). Compared to microbubbles nanobubble`s have demonstrated unique characteristics such as long residence time in water, higher gas mass transfer efficiency, and hydroxyl radical production. Nanobubbles are spherical bundles with a diameter of less than 1 micrometer that can be found at the solid-liquid interface or scattered in a liquid medium. According to their morphologies and their locations, they can be divided into surface nanobubbles (solid-liquid interface nanobubbles) and bulk nanobubbles. Nanobubbles are gaseous domains with a radius of tens to hundreds of nanometers that are too small to be seen with the naked eye or conventional microscopes.

Nanobubble technology has been used in a variety of industries, including biomedical engineering, agriculture, and a wide range of industrial applications. Due to its small size, they can also be

used in fewer intrusions surgical procedures. Considering the size of the nanobubbles, the nanobubbles can be categorized into two types' namely micro nanobubbles and macro nanobubbles. The bubbles with diameter less than 1 µm are called as nanobubbles and the bubble diameter between 1µm to 100µm is called as micro bubbles and the diameter bigger than 100µm are called as macro bubbles.

Principle of Nanobubble

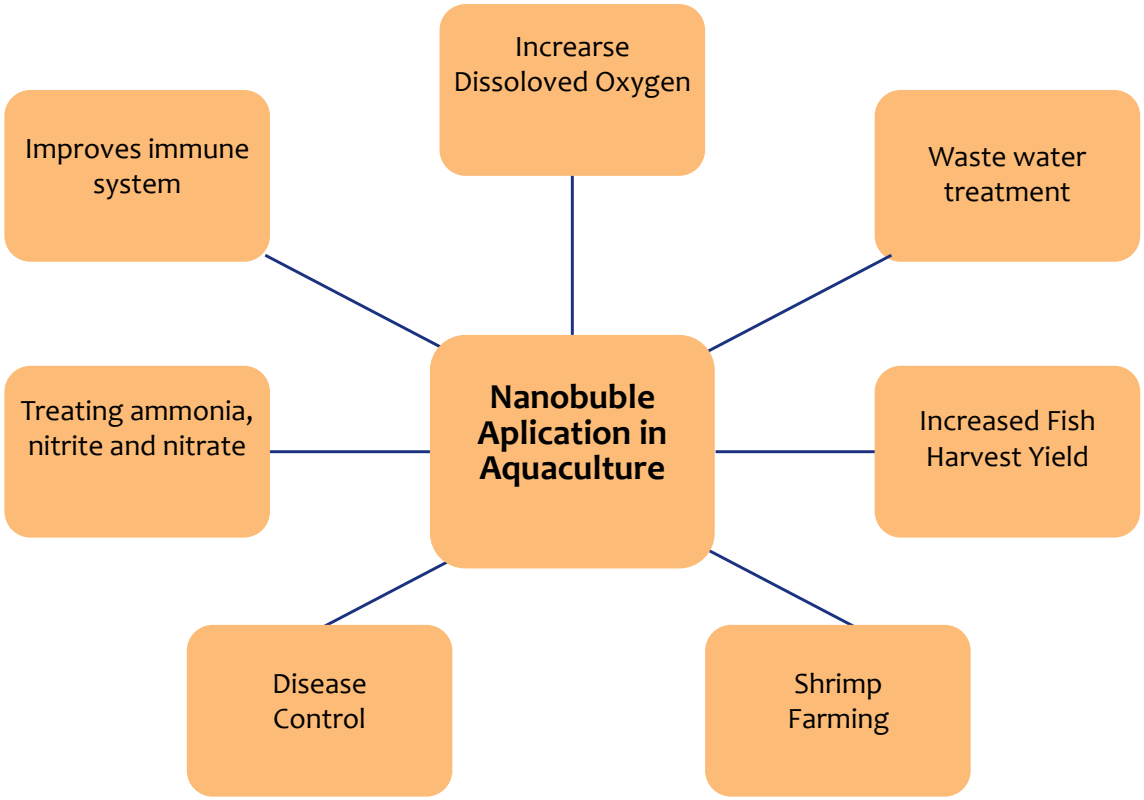
The nanobubble technology works on principle of using ultra tiny gas bubble (under 200 nm) that remains suspended in liquid for the long time because of some unique properties, due these properties their principle includes include enhanced gas-to-liquid transfer, a high surface area to volume ratio and unique surface charges which enables them to aerate water, attract and break down impurities and improves process efficiency. The diagram below depict the different types of bubbles and how they behave inside the water. The Macrobubbles rises fastly towards surface and burst at surface whereas nanobubbles rises very slowly and its movement is very random in all direction that is why it has highest retention time in water.

Applications of Nanobubble

There are many applications of nanobubbles in aquaculture and also in other industry.

a) Nanobubbles for efficient oxygen supply: - There are numerous examples how aeration can promote aquatic animal health and growth but delivery of oxygen in the form of nanobubbles are scarce. The studies on nanobubbles assisted fish and shrimp farming have utilized a wide range of aquaculture system from small plastic bags to large tanks in which the nanobubble system was installed with different exposure time. The species reared as well as the criteria for assessing the effects of nanobubbles on aquaculture production, also differed among the studies. Studies use metrics such as animal weight gain (kg), differential size measurements (m), total tank harvest (kg), productivity per unit surface area (kg/m^2), specific growth rate, higher survival rate, lower oxygen consumption. The studies varied in the gaseous content of the Nanobubble (e.g., air or oxygen), concentration, and bubble size distribution, which could have a significant impact on treatment efficacy.

b) Effects of nanobubbles on increasing fish harvest yield: - Dissolved oxygen is a very important and critical variable in pond aquaculture, as higher yields require an increase in the amount of feed supplied, leading to a high risk of oxygen depletion consumed by aerobic metabolism. Air and oxygen nanobubble can significantly increase the dissolved oxygen of the water. Studies suggest that dissolved oxygen concentration was significantly higher than the control demonstrating the role of nanobubble in gradual infusion of oxygen into water. Studies on nanobubble have suggested that there was 127% increase in final weight of sweetfish and 37% higher in case of rainbow trout as compared to control.



c) Effect of nanobubble on increasing shrimp farming: - In shrimp farming also oxygen is very important and low DO levels can have restricted growth and a high risk of mortality. Nanobubbles technology could offer opportunities in this sector. Various studies have shown that use of nanobubble technology in the culture of *Penaeus vannamei* or white leg shrimp increase in the total yield. Total harvest and productivity, while disease free water exposed to nanobubble improved survival rate and this resulted in an increase in total weight.

d) Nanobubbles for aquaculture wastewater treatment: - The generation of the aquaculture waste water due to rapid development of aquaculture industry has led to environmental concerns. Aquaculture farm effluents can contain large amount of total nitrogen and phosphorus suspended solids, dissolved organic matter, and pharmaceuticals, which are negatively affect the environment if not treated properly prior to discharge. Intensive cultivation aquaculture system are even more challenging due to high density of organisms and thus, the larger waste production footprint. Animal metabolic products can be removed by microbial communities in biofilters and microbial communities in the discharge areas.

e) Nanobubble for treating ammonia, nitrite and nitrate: - The excessive presence of these harmful substance in aquaculture unit hinder aquaculture production. Ammonia poising is one of the main causes of mortality in aquaculture species. Ammonia toxicity decreases survival, inhibits growth, and causes various physiological dysfunctions. Therefore, keeping nitrogen species at low level is vital for aquatic life, efficient nitrification and denitrification processes are essential in aquaculture systems. Ammonia oxidation in the nitrification process requires the activity of nitrifying bacteria molecular oxygen for nitrogen oxidation pathways and respiration. Air and pure oxygen nanobubble to remove ammonia from a RAS for catfish larvae hatchery. Experiments showed that air and oxygen nanobubble removed 62-67 5 and 70-83 % of ammonia in 45 min, respectively, while the aquaculture effluent showed 40 % ammonia reduction with oxygen nanobubble. Study suggested that ammonia was effectively due to higher DO availability and formation of ROS after bubble collapse.

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THE SKY LINE

Considering only the growth rate gives you a wrong image: survival is as much a key to success.

The Blue Genetics Sky Line delivers a consistent growth rate with an over 90% survival rate at the final harvest in extensive tests we have done in India.

	Blue Genetics Sky Line	Other brands
Stocking Density	25-30 units per sq m	35-40 units per sq m
DOC	110 days	110 days
Final count	40 units per kg / 25 g	40 units per kg / 25 g
Survival rate	90%	60%
Final Density	23 to 27 units per sq m	21 to 24 units per sq m
Final weight per sq m	0.65 kg	0.55 kg
Final Weight per Hectare	6.5 tons	5.5 tons

THE CUSTOMER'S VIEWPOINT

Extensive customer tests by Indian farmers indicate that the Sky Line's growth is very competitive while delivering an exceptional survival rate, resulting in higher profits:

Farmers can stock at a lower density while obtaining better result than other brands:

- Lower density stocking means less PL cost (lower upfront investment).
- Lower density stocking means less food cost (lower maintenance cost).
- Lower density stocking means less animal stress during growth improving health conditions (better health conditions).

Conclusion : Less expenses, more tons per hectare, better profitability.

BLUE GENETICS
Caring for life

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