English Monthly from Hyderabad, India

Aqua International

Estd. 1993

Health • Nutrition • Technology • Management

December 2024

Annual Subscription: ₹800 Foreign USD 100

Inside...

As aquaculture continues to grow, its success will depend on balancing production needs...

Celebrating Aquaculture's Role in Food Security

Technological Innovations for Fish Biodiversity Conservation

Ms Atashi Maity – A successful woman Mud Crab fattener of WB

Best Management Practices in Shrimp Farming

Aqua International

English Monthly Magazine
(Established in May 1993)

Volume 32 Number 8 December 2024

Editor & Publisher
M. A. Nazeer

Editorial & Business Office:
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Annual Subscription
India : Rs. 800
Foreign Countries : US $ 100
or its equivalent.

Aqua International will be sent to the subscribers in India by Book Post and to the foreign subscribers by AirMail.

Edited, printed, published and owned by M. A. Nazeer and published from BG-4, Venkataramana Apts., 11-4-634, A.C.Guards, Hyderabad - 500 004, India. Printed at Srinivasa Lithographics.
Registered with Registrar of Newspapers for India with Regn. No. 52899/93. Postal Regn. No. L II/ RNP/HD/1068/2021-2023.

NRS PUBLICATIONS
www.aquainternational.in

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Subscriptions for Aqua International, English monthly, should be sent to:
The Circulation Department, Aqua International, BG-4, Venkataramana Apartments, 11-4-634, A.C.Guards, Near Income Tax Towers, Hyderabad - 500 004, India. Email: info@aquainternational.in

As aquaculture continues to grow, its success will depend on balancing production needs with environmental preservation and equitable distribution

By focusing on critical areas such as seed selection, pond preparation, feed management and biosecurity, shrimp farmers can significantly reduce risks related to disease outbreaks and environmental degradation. Regular monitoring and adaptation of these practices ensure optimal growth conditions and enhance the overall health of shrimp populations. Ultimately, adopting BMPs not only boosts profitability but also contributes to the long-term viability of the shrimp farming industry and the preservation of aquatic ecosystems.

Dear Readers,

The December 2024 issue of Aqua International is in your hands. In the news section, you may find news about....

Mr Ramakanth Akula, CEO, The Water Base Ltd, explicated well about the World Fisheries Day, celebrated annually on November 21, and highlighted the critical importance of aquatic ecosystems in supporting global livelihoods, food supply and sustainability. As natural fish catches dwindle due to overfishing and environmental degradation, aquaculture has emerged as a beacon of hope in meeting the ever-growing demand for seafood. Its unique ability to supply high-quality, lean protein on a sustainable basis positions it as an indispensable player in ensuring global food security.

In recent years, aquaculture has outpaced wild-capture fisheries in its contribution to global seafood production, now accounting for more than 50% of all seafood consumed across India. This rapid growth is largely attributed to advancements in technology, improved management practices and a growing understanding of sustainable farming methods.

By meeting the increasing demand for seafood, aquaculture ensures that protein-rich diets remain accessible even in regions where natural catches are no longer sufficient. The shrimps are the best form of Lean and High nutrient foods. The shrimps are low in saturated fat yet rich in essential fatty acids, making it a heart-healthy choice. One of aquaculture's most significant contributions to food security lies in its ability to produce sustainable protein.

The World Fisheries week serves as a reminder of our collective responsibility to protect and sustainably manage aquatic resources. As aquaculture continues to grow, its success will depend on balancing production needs with environmental preservation and equitable distribution. This includes investing in innovative technologies, promoting sustainable certification standards, and raising awareness about the importance of seafood in a balanced diet.

Dr Ghosh mentioned that India has achieved 1st position in world in inland aquaculture production and 5th in marine capture fisheries; that Indian fisheries and aquaculture sector plays an important role in our aim to achieve Vikshit Bharat by year 2047. India's present annual fishery and aquaculture production of 17.3 to 17.5 million tonnes should be increased to 40 million tonnes that we have to achieve in 2047. Our present annual freshwater aquaculture production (biggest contributor in production) of 10.5 million tonnes should be increased to 25 million tonnes by 2047, aquaculture production should be increased from present annual 0.9 million tonnes to 3.0 million tonnes in 2047. Total

Contd on next page

NRS GROUP
Aqua International

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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inland aquaculture production to be increased to 28 million tonnes in year 2047. In Indian marine capture fisheries, we can increase production to 5.3 million tonnes (which is maximum potential) in 2047 from presently annual 4.0 million tonnes, and inland capture fisheries production can be increased to 2.7 million tonnes in 2047 from presently annual 1.8 million tonnes. Total capture fisheries production to be increased to 8.0 million tonnes in year 2047.

New Executive Committee was elected for Aqua Professionals Welfare Association with Mr Tetali Srinivas as the President, Mr Vijaya Satish Kumar Bodapati as the General Secretary and Mr Venkata Subrahmanyam Palasala as the Treasurer on 8 November 2024. The founder President Mr Amaraneni Srinivas took the initiative for the formation of the new committee with the kind of experience and the organisational backup Mr T. Srinivas has got, he is expected to take APWA to reach new heights serving the professionals in the industry.

Ms Atashi Maity, the 38 year old home maker in village Char Kendiyamari in Purba Medinipur district, West Bengal, has adopted the improved and advanced 'box crab fattening' technology and became successful. She earned reputation by dint of her hard work, will power and other good qualities, and her success story may be seen in this issue.

In the Articles section, **AI-driven Aquaculture,** authored by Suvetha. V and S. Felix stated that aquaculture has become one of the fastest-growing sectors (8%) in the food production industry. However, its growth is hampered by challenges such as disease outbreaks, inefficient feeding practices, and environmental degradation. The shift towards intelligent fish farming through the application of AI technologies presents a transformative opportunity for the aquaculture industry. By enhancing growth monitoring and health management, AI can help address critical challenges such as sustainability, efficiency, and labour shortages. As the technology continues to evolve, its integration into aquaculture practices will likely play a pivotal role in meeting the growing global demand for aquatic products while ensuring environmental stewardship. AI has the potential to revolutionize aquaculture by improving the efficiency of growth and health monitoring, optimizing resource use, and minimizing environmental impact. While challenges remain in terms of cost, data availability, and ethical considerations, the integration of AI-driven technologies into fish farming practices will likely become more prevalent as the industry continues to grow.

Another Article titled **Best Management Practices in Shrimp Farming,** authored by M. Petchimuthu, G. Ferolin Jessina, and S.J. Abisha Juliet Mary, discussed that fish and shellfish are produced through aquaculture, primarily for human consumption. This practice requires continuous interaction with the environment, as it is carried out in ponds, cages, or open water bodies. When aquaculture is conducted in a way that is both socially and environmentally responsible, it can be a sustainable activity. Sustainable aquaculture systems work in harmony with the environment and other organisms, use renewable resources whenever possible, provide animals with conditions that closely resemble their natural habitats, and consider the human and social context of the area.the implementation of Best Management Practices (BMPs) in shrimp farming is vital for achieving sustainable aquaculture that balances productivity with environmental and social responsibility. By focusing on critical areas such as seed selection, pond preparation, feed management and biosecurity, shrimp farmers can significantly reduce risks related to disease outbreaks and environmental degradation. Regular monitoring and adaptation of these practices ensure optimal growth conditions and enhance the overall health of shrimp populations. Ultimately, adopting BMPs not only boosts profitability but also contributes to the long-term viability of the shrimp farming industry and the preservation of aquatic ecosystems.

Another Article titled **Indigenous Technological Knowledge and Practices in Traditional Fish Catching in Shallow Freshwater Bodies in West Bengal,** authored by Subrato Ghosh, discussed that the knowledge of elderly villagers on small-scale freshwater fishing and their cultural heritage is precious. Different kinds of indigenous devices and traps of different shape and size are traditionally employed since long for fishing in less-deep freshwater bodies in different villages of West Bengal. The methods of fish catching may be regarded as 'village science' or 'rural technology', which are cost-saving, cost-effective and fruitful. Nevertheless, region-specific fishing devices needs to be thoroughly documented. This precious ITK possessed by villagers in West Bengal and other eastern and north-eastern states of India in the fields of inland fishery and aquaculture needs further investigation and documentation.

Another Article **Pulicat Lake's Aquatic Ecosystem under Siege: The Charru Mussel Invasion,** authored by J. Magimai John Jose, S. Selvaraj and R. Jeya Shakhila, discussed that Pulicat Lake, the second largest brackish water lagoon in India, is located along the southeast coast between Andhra Pradesh and Tamil Nadu. Geographically the lake is situated in between 13 24'-13 43' N latitude and 80 03'- 80 18' E longitudes. Originally covering 461 km^2 with an average depth of 1.5 meters, it has now reduced to 350 km^2 with a depth of less than one meter due to siltation. Addressing this complex issue requires both immediate and long-term action. Immediate measures should include ongoing monitoring, physical removal efforts, and strategies to prevent further spread. Long-term efforts must explore biological and chemical control options, restore affected habitats, and raise public awareness about the impacts of invasive species.

Another Article, **Plant-based meat: An approach to cut down the Environmental Footprints,** authored by Kurapati Nagendrasai, and Chundru Sri Sai Venkat Stated that in recent years, there has been a significant shift in the way people think about food, particularly when it comes to meat consumption. There is widespread worry about red meat's consequences on human health and climate change. Plant-based meat substitutes, designed to emulate the sensory experience and nutritional value of red meat, have lately entered the consumer market. Plant-based meats are advertised as having environmental and human health advantages, to appeal to a wide range of consumers. As technology advances and consumer preferences evolve, we can expect to see even more diverse and compelling plant-based options that cater to a wide range of tastes and dietary preferences. Future studies should consider calls for collaboration, particularly among stakeholders of the food supply chain (i.e., industries and food services) and the scientific community (i.e., nutritionists and dietitians, food technologists, and consumer scientists), to facilitate the transition toward healthier and more sustainable plant-based protein sources.

M.A.Nazeer
Editor & Publisher
Aqua International

Uni-President

AQUACULTURE PROBIOTICS EXPERT

Nu Ri
NET 200 g **BSL**

Probiotics for water treatment

1. WATER QUALITY CONDITIONING

Best choice of *Bacillus* spp. that rapidly decompose uneaten feed, feces and other organic substances in pond water, keeps water quality optimal

2. HIGH ACTIVITY OF SPORES

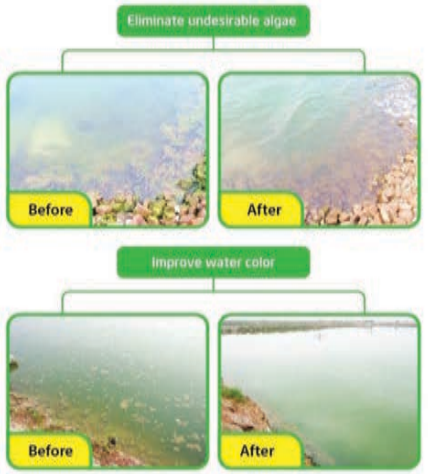
No cultivation is needed. Easily adapt to the changes of surroundings and grow fast in freshwater or seawater culture farming, even under low oxygen environment

3. DECREASE AMMONIA CONTENT

Prevent the accumulation of toxic substances such as NH_3, NO_2, etc.

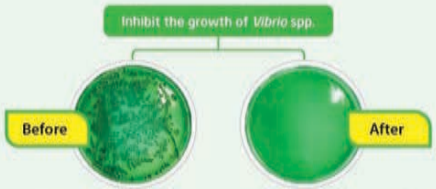
4. IMPROVE WATER COLOR

Improve water color regulate the algae and bacteria balance in water, turning your pond from green to clear



5. ESTABLISH BALANCED POND BACTERIA SYSTEM

Compete nutrition with vibrio and inhibit them to grow. Provide nutrition for probiotics in the pond, to establish a well-balanced farming system.



6. INCREASE AQUACULTURE PRODUCTION

Good quality of water prevents fish/prawn infections, making high profit of production

* COMPOSITION:

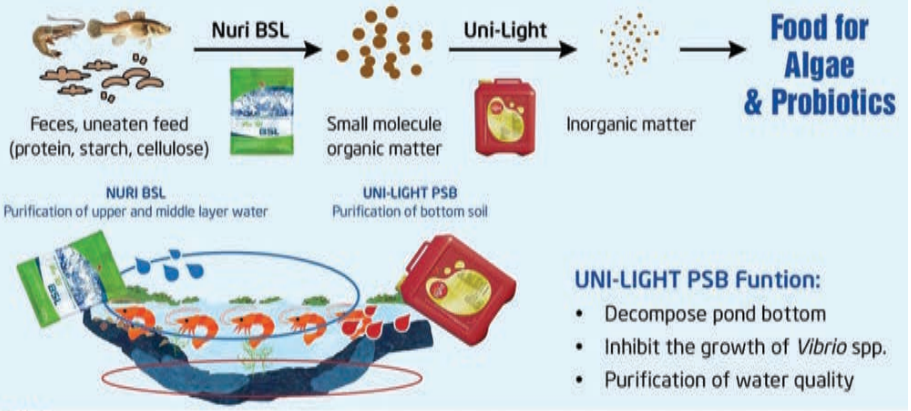
Bacillus spp. > 1x 10^{11} cfu/kg	15%
(Bacillus subtilis, Bacillus amyloliquefaciens, Bacillus licheniformis)	
Carrier (rice bran, corn gluten)	75%
Moisture	10%

* STORAGE:

Keep at dry, well-ventilated condition. Avoid direct sunlight exposure and use as soon as possible once opened for best quality.

* DIRECTION OF USE:

No cultivation is needed. Apply Nuri BSL with water-soluble bag near to the working water wheel or pour into the pond evenly. Recommend apply Uni-Light PSB together with Nuri-BSL on sunny day to achieve a clear pond more efficiently.



UNI-LIGHT PSB Funtion:

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

BSL Dosage:

/10,000 m³ Quantity	10 - 30 pl/m² tiger prawn or < 80 pl/m² Vannamei	For >30 pl/m² tiger prawn or > 80 pl/m² Vannamei	For > 150 pl/m² Vannamei
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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Celebrating Aquaculture's Role in Food Security

World Fisheries Day, celebrated annually on November 21, highlights the critical importance of aquatic ecosystems in supporting global livelihoods, food supply, and sustainability. As natural fish catches dwindle due to overfishing and environmental degradation, aquaculture has emerged as a beacon of hope in meeting the ever-growing demand for seafood. Its unique ability to supply high-quality, lean protein on a sustainable basis positions it as an indispensable player in ensuring global food security.

Seafood is an exceptional source of lean, nutrient-dense protein. Unlike other animal proteins, seafood especially farmed fish and shrimp provides essential amino acids, omega-3 fatty acids, and micronutrients like selenium, iodine and zinc in a form that is easily digestible and widely consumed. As the global population rises beyond 8 billion, the demand for such high-quality protein is skyrocketing, and aquaculture has proven its capacity to bridge the supply gap.

In recent years, aquaculture has outpaced wild-capture fisheries in its contribution to global seafood production, now accounting for more than 50% of all seafood consumed across India. This rapid growth is largely attributed to advancements in technology, improved management practices, and a growing understanding of sustainable farming methods.

Ramakanth Akula, CEO, The Water Base Ltd

For species like shrimp, salmon, tilapia and catfish, aquaculture systems have enabled scalable, predictable production cycles while reducing pressure on overexploited wild fish stocks. By meeting the increasing demand for seafood, aquaculture ensures that protein-rich diets remain accessible even in regions where natural catches are no longer sufficient.

The shrimps are the best form of Lean and high nutrient foods. The shrimps are low in saturated fat yet rich in essential fatty acids, making it a heart-healthy choice. Its high bioavailability of nutrients makes it a superior protein source compared to plant-based or heavily processed alternatives.

The Seafood forms a crucial part of the diet in many coastal and island nations, where it often constitutes the primary protein source. As aquaculture expands, even landlocked regions gain access to this vital nutrition through improved supply chains.

The Comparison to terrestrial livestock farming, aquaculture typically requires less land, water, and feed to produce equivalent amounts of protein. This makes it a more resource-efficient option in addressing global protein demands.

One of aquaculture's most significant contributions to food security lies in its ability to produce sustainable protein. Modern aquaculture practices focus on minimizing environmental impact while maximizing yield.

As seafood consumption grows globally, aquaculture has become a major contributor to international trade. Farmed shrimp, for instance, is one of the most traded seafood products worldwide with exporters like India, Vietnam and Ecuador playing a leading role. This global trade not only strengthens economies but also ensures that seafood remains a viable protein option in regions where local production is limited.

The World Fisheries week serves as a reminder of our collective responsibility to protect and sustainably manage aquatic resources. As aquaculture continues to grow, its success will depend on balancing production needs with environmental preservation and equitable distribution. This includes investing in innovative technologies, promoting sustainable certification standards, and raising awareness about the importance of seafood in a balanced diet.

CMFRI develops captive breeding tech for high-value marine ornamental fishes

The aquarium business is set to get a major boost with ICAR-Central Marine Fisheries Research Institute developing captive breeding technologies of two high-value marine ornamental fishes -- Azure damsel and Ornate goby.

This is expected to open up prospects for aquarium enterprises and marine ornamental fish aquaculture in the country, B Santhosh, Head of the Vizhinjam Regional Centre of CMFRI, said. The high demand and market value of these fishes, coupled with the relatively low cost of production, make it an attractive venture for aspiring entrepreneurs.

The high demand and market value of the ornamental fishes, coupled with the relatively low cost of production, make it an attractive venture for aspiring entrepreneurs

PROFITABLE VENTURE

The economic feasibility study proved that a medium-scale seed production unit with an annual production of 24,000 juveniles would fetch an annual income of around 12 lakh. Both species are de sirable with their beauty, brant colours, and captivating aquarium behaviour.

Azure damsel is a vibrant reef-associated fish with bright blue and yellow col- ours. Its market value is around Rs 350 per fish in India and $15-$25 internationally.

Ornate goby, a favourite in marine aquariums, is admired for its striking colours, intricate patterns and curious behaviour. Its pectoral fins, marked with five vertical rows of white dots, add to its charm. This hardy species also helps maintain tank cleanliness by sifting sand.

A marketable-sized (5-8 cm) fish costs around 250 in India while online retail trade price in international markets is $15-$30.

Santhosh said the development would unfold new avenues for sustainable production of these fish, reducing pressure on wild populations and contributing to the conservation of delicate coral reef ecosystems.

Telangana Celebrates Fish Festival

The high demand and market value of the ornamental fishes, coupled with the relatively low cost of production, make it an attractive venture for aspiring entrepreneurs

Hyderabad: Fish fry, prawn wings, Apollo fish along with a variety of fish dishes at 20 stalls enticed the mouths of food lovers. Telangana, on the occasion of World Fisheries Day, Speaker Mr Gaddam Prasad Kumar recently inaugurated the fish festival organized by the Federation of Fisheries Cooperative Societies at the HMDA ground next to the IMAX. The government made arrangements for marketing by providing all kinds of facilities to the fishermen.

Later, National President of All India Fishermen's Congress Armstrong Fernando, MP Anil Kumar Yadav, MLA Danam Nagender, Chairman of Fisheries Corporation Mettu Saikumar etc. Speaker awarded awards to fishermen and officers for their service. Fish festival continued till November 24. Congress senior leader, former MP V. Hanmantha Rao, Corporator Vijaya Reddy, chairmen of various departments, Telangana Ganga Tepotsava Committee Chairman Mahender Babu and others participated in this program.

ICFA appoints Former Union Minister Suresh Prabhu as its new Chairman

New Delhi, Nov 12, 2024: The Indian Chamber of Food and Agriculture (ICFA) has appointed former Union Minister Suresh Prabhu as the new Chairman. Mr Prabhu a board member of the World Agriculture Forum (WAF) and former Union Minister of Commerce & Industry and other portfolios in his name have been nominated as chairman by the newly constituted 24 members of the ICFA Board. Mr Prabhu brings decades of experience in public service and a growth-oriented vision for ICFA.

India's first Agri Exports Policy was launched under Mr Prabhu's leadership in 2018, which resulted in unprecedented growth of agri exports from 15 million MT in 2018 to 38 million MT in 2022. His commitment to working collaboratively with stakeholders across the agricultural value chain to create a more resilient food system in India would go a long way to building a robust ecosystem for all stakeholders especially farmers.

His extensive experience in the global arena, having served on several UN bodies, and as India's Sherpa for G-7 and G-20 countries, Prabhu is set to lead ICFA in its mission to promote agro trade, technology and investments in agriculture by expanding ICFA's global presence through collaborations and partnerships, said the outgoing chairman, Dr M.J. Khan.

Speaking on the occasion, Shri Suresh Prabhu said, I am honoured to take on the role of Chairman of the Indian Chamber of Food and Agriculture. I believe that by harnessing innovation, collaborating across stakeholders, and focusing on policies that benefit both farmers and the entire food and agriculture value chain we can transform India into a global leader in agriculture and food security. I look forward to working with all stakeholders to realise this vision.

Mr Prabhu added that his greater focus would be reaching out and partnering with farmers' organisations by expanding the ICFA network of State and District Agriculture Councils.

In addition, the new leadership team at ICFA also features Dr Tarun Shridhar (Former Union Secretary) as DG, Dr Ashok Dalwai (Chairman, PM Task Force on DFI) as Co - chair, Dr Meenesh Shah (Chairman, NDDB) and Mr Simon Wiebusch (MD, Bayer Crop Science), as Vice Chairs who will help the organisation navigate new heights.

ICFA, through its network of working groups, councils, and strategic collaborations, is committed to positioning India's agriculture sector at the forefront of global food security and sustainability initiatives," said Dr Ashok Dalwai, Co-Chair, ICFA Board, adding that the Chamber's vision aligns with Shri Prabhu's focus on making Indian agriculture globally competitive and capable of producing high-quality food products for both domestic and international markets.

The Indian Chamber of Food and Agriculture looks forward to Suresh Prabhu's leadership and expertise as it continues to champion the interests of the agricultural sector and contribute significantly to India's economic growth and food security.

About Indian Chamber of Food and Agriculture

The Indian Chamber of Food and Agriculture is the apex body in India, working on business, policy and development agendas and serving as a global platform for trade facilitation, partnerships, technology and agribusiness services.

In a short period of more than seven years, the Chamber has signed MoUs with the ICAR, APEDA, NRDC, RAKEZ Group, ASYAD Group, University of California, University of Maryland, Michigan State University, Iowa State University, Western Australia University, German Agribusiness Alliance, Borlaug Institute for South Asia, African Asian Rural Development Organization, NASSCOM, Sociedad Rural Argentina (SRA), FAMATO, CCI Pau Béarn, IFPRI, etc. Through international partnerships, ICFA envisions mobilising technologies and investments that will catalyse agribusiness and agri-startups. Read More – www.icfa.org.in

Salem Microbes – Tech Talk on latest Tools in Vibrio Mitigation

Salem: Salem Microbes Pvt Ltd conducted various technical meetings and technical seminars in Kaikalaru, Bhimavaram and Ganapavaram in October 2024, coinciding with the launch of their new technology innovation **V PHAGES GROWOUT,** the latest tool of bacteriophages consortia for combating vibrio infections in Shrimps. It was attended by various dealers and farmers and was well appreciated.

This product gives solution for the present day problem of White Gut Disease, White Fecal Disease and Running Mortality Syndrome which are all caused by aggravated vibrio infection. V Phages Growout primarily targets different vibrio species and helps the infected shrimps to recover fast and save that crop.

Dr D.Ramesh Kumar, CEO, Salem Microbes Pvt Ltd, who gave the product details, also shared his various experiences as to how this product has saved several ponds from collapse and helped farmers to have a better harvest. *Dr D.Vijay Anand, Director, Salem Microbes Pvt Ltd* was also present on the occasion .

Dr D. Ramesh Kumar, MD & CEO, Salem Microbes Pvt Ltd gave the speech on "LATEST TOOLS IN VIBRIO MITIGATION"

Dr D. Ramesh Kumar, MD & CEO, Salem Microbes spoke on "LATEST TOOLS IN VIBRIO MITIGATION".

Kaikiluru: Konda Reddy, Technician, Progressive Shrimp farms, Mudinepalli, Eluru, shared his experience in Solving white gut infection with V Phages Growout.

Kaikaluru: Satyanarayana Raju, Partner, SSR Aqua Farms, Bantumilli, Bhimavaram and Venkatasai Aqua Needs, Kakinada shared his success story and was the lead farmer to launch V PHAGES GROWOUT in the meet.

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Achitha Ravindra, Nagasai traders and farmer, shared his success story.

Prasad Pindi, farmer, shared his success story.

Gassen Plus

Bon Ammonia and obnoxious Gasses

Shrimp / Fish performs all their body functions and growth in water. Good quality water and proper D.O. levels determines the success or failure. Good quality water, optimum D.O. level is of prime importance for health and growth of Shrimp / Fish.

Irregular water exchange, excess and leftout feed, dead algae, fecal matter, increases the organic load at the pond bottom. Accumulation of such waste absorbs available oxygen, creating anaerobic condition which leads to pollution of pond bottom. Polluted pond bottom and unhealthy environmental conditions triggers the release of toxic gasses like Ammonia, H_2S, Methane, etc, The toxicity of Ammonia, Hydrogen Sulphide, Methane attributed mainly due to unionized form. As the concentration in water increases, ammonia excretion by aquatic organism diminishes and the level of ammonia in blood and in other tissues increases. Ammonia increases oxygen consumption by tissues, damage gills and reduces the ability of blood to transport oxygen, and increases the disease susceptibility. To eliminate / overcome the above problems 'GASSEN PLUS' Yucca Schidigera, it contains Steroidal"Saponin" which help to reduce ammonia and other noxious gasses such as H_2S, Methane, etc., Microbial enzyme "Urease' Production inhibited by Saponin which leads to an increases D.O. and reduction of BODand COD levels.

Bacterial strains such as Bacillus Subtilis, Nitrobactor, Nitrasomonas, rapidly converts ammonia into Nitrates, Nitrites and finally non-toxic Nitrogen. Hydrogen Sulphide converts into Sulphates, Sulphites and finally non-toxic Sulphur, Methane into Non-toxic carbon. This conversion reduces the obnoxious gasses in the pond bottom. Reduction of this gasses improve the D.O. level in the water and bottom.

COMPOSITION:
YUCCA SCHIDIGERA
ALOEVERA
BACILLUS SUBTILIS
BACILLUS POLYMIXA
BACILLUS LICHENIFORMIS
NITRASOMONAS
NITROBACTOR
STABILIZERS

DOSAGE : 1 Kg per Acre or consult your Aqua Technician For Specific Usage & Dosage

PRESENTATION: 500 gms &1 kg

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Ravada Ram Mohan Rao, MD, Sri Vijaya Kiran Biotech introduces the product by sharing his customers feedback.

Tech Talk 1, Kaikaluru: Yedukondal Rao, Veera Siva Chandu Traders, Kaikaluru in discussion with CEO, Dr D. Ramesh Kumar.

Kanaka Raju, Kaligotla - Kiran, Ravada Ram Mohan Rao, Dr Ramesh Kumar, CEO, Ramesh Varma, MD and Ramakrishna Varma of Ravindra Commercial Corporation, Tirumani Tataji, RSM in the meeting.

Dr D. Ramesh Kumar interacting on a point with Venkatapathy Raju and others.

A participant with the product V PHAGES GROWOUT on its launch.

Ravada Ram Mohan Rao, MD, Sri Vijaya Kiran Biotech introduces the product by sharing his customers feedback.

Srinivasa Raju, MD, NSR Hatcheries and Vasista Marines Group graced the meeting.

Dignitaries with the product V PHAGES GROWOUT on its launch.

Farmers Gathering.

Dr D. Ramesh Kumar making a presentation

A view of farmers gathering.

Corporate

Salem Microbes Products on Display in the meeting.

D. Vijayanand, Director, Salem Microbes Pvt Ltd, with his Sales & Technical team members, Yatam Siva Naga Murali , Technical Manager, Tirumani-Tataji, Regional Sales Manager and Dhanunjaya, Marketing Executive.

Ms Atashi Maity – A successful woman Mud Crab fattener of West Bengal

Kolkata: In a developing country like India, as we understand, practice of inland aquaculture in improved and scientific methods contribute to integrated rural development in five significant ways – causing protein-rich food production, eradicating malnutrition-related health disorders, income and employment generation in rural and sub-urban areas, aqua-entrepreneurship development, export earnings. The fifth segment is mostly applicable to brackishwater aquaculture scenario in districts located in coastal India in coastal states. Trade in aquaculture products, as like the high-valued mud crab *Scylla olivacea*, plays an important role as generator of export revenue - where lies opportunity for export and foreign exchange earnings. In terms of aquaculture species diversification and system diversification, mud crab aquaculture, with reference to its fattening method, has shown a new way since last 10 to 15 years that holds potential.

Good quality fattened *S. olivacea* of above 180-200gm in weight and further bigger ones are produced by fish farmers in coastal districts Purba Medinipur, North 24 Parganas and South 24 Parganas in West Bengal. These are exported in live condition to USA, European Union, UAE, Middle-East and South-East Asian countries, where there is consistent market and consumer demand. In terms of production of marketable-sized Indian

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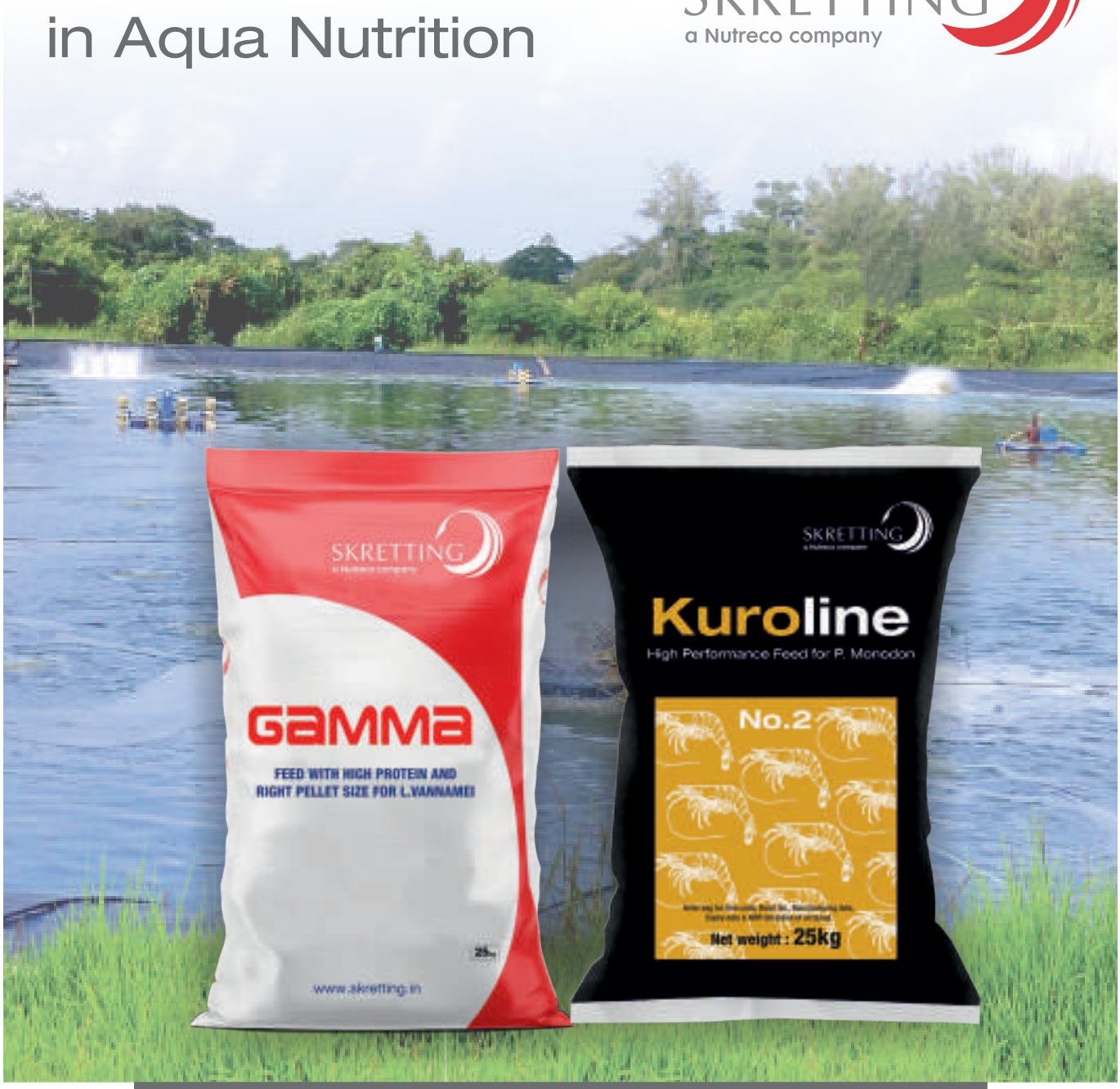

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major carps, shrimp *Litopenaeus vannamei* and mud crab, Purba Medinipur is leading district in West Bengal in overall yearly inland aquaculture production. Mud crab fattening, both in small open pond condition or 'earthen chambers' and in boxes arranged in bigger ponds, has become more popular than its grow-out farming from crablet stage. Export trade of fattened live mud crabs from three districts is undertaken by exporters in Baghajatin area in south-east Kolkata city. Presence of quite a few reputed live mud crab exporters, big export companies, agencies, traders and suppliers have encouraged production of fattened mud crabs in West Bengal.

On the bank of Haldi river in Purba Medinipur, the village Char Kendiyamari is located, under jurisdiction of Kendiyamari-Jalpai Gram Panchayat, Nandigram-1 CD Block, P.O. Kendiyamari, Nandigram Police Station. Ms. Atashi Maity's home and adjoining mud crab fattening ponds are here, near to Kendiyamari canal. Ms. Maity, aged 38, is a village homemaker and progressive mud crab fattener and, since year 2017, she has adopted the improved and advanced 'box crab fattening' technology. She has been doing it actively in medium- to large-scale in her two perennial ponds 28 decimal and 18 decimal in effective water area, brackish in nature. She earned reputation by dint of her hard work, will power and other good qualities. She stocks soft-shelled females with infirm outer covering

Mud crab fattener, Ms Atashi Maity

and under-developed ovary, and males (somewhat lean) that have to be fed and grown to fill their new shells with meat after moulting, individually in each box.

At Ms Maity's farm, one will find many durable, perforated and submerged-type mud crab fattening boxes of two different size, properly positioned on floating rafts made of parallel long PVC pipes as set-up in two clean ponds. News communicator Subrato Ghosh visited Ms Atashi Maity's *S. olivacea* farm on 27/10/2024 morning to learn from her and gain practical knowledge, who was kind enough to speak about her activity in detail. It is a profitable vocation. She possess considerable expertise, getting very good harvest as expected at end of each mud crab fattening period, which are supplied to export companies and wholesalers at Baghajatin. She expressed that she has learnt management practices step by step, handling of boxes and other particulars from her husband Mr Sambhu Maity, who is a well-known and experienced mud crab farmer (precisely fattener, following this improved technology) in Purba Medinipur District and *L. vannamei* farmer. Ms Maity got help from Fishery Extension Officer, Nandigram-1 CD Block, learnt about Government assistance and benefit-oriented developmental schemes of West Bengal Fisheries Department; her success captured attention of Block-level administration. Ms Atashi Maity's noteworthy achievement as well as success story is a lesson and inspiration to traditional small-scale fishermen, shrimp farmers, both men and women rural SC youths in Char Kendiyamari and nearby villages who may think about adopting mud crab fattening as means of self-employment and income generation.

Mr Ghosh and Ms Maity near second crab pond

New EC elected for APWA with Tetali Srinivas as the President

Bhimavaram: The new Executive Committee was elected for Aqua Professionals Welfare Association (APWA) with Mr Tetali Srinivas as the President, Mr Vijaya Satish Kumar Bodapati as the

General Secretary and Mr Venkata Subrahmanyam Palasala as the Treasurer on

8 November 2024. The founder President Mr Amaraneni Srinivas took the initiative for the formation of the new committee. APWA was formed 12 years back. Srinivas assured to take out his time to establish APWA at district and state level.

On the occasion, the new President Mr Tetali

APWA New Team: Srinivas Tetali, President (Centre), Vijaya Satish Kumar Bodapati, General Secretary and Venkata Subrahmanyam Palasala, Treasurer, Aqua Professionals Welfare Association addressing the participants after getting elected as new office barrers on 8 November 2024.

Srinivas thanked the old executive committee members and said that he along with other members of the committee will strengthen APWA by inducting more members in the organization while continuing the programs being carried out by the Association.

General Secretary Mr Vijaya Satish Kumar Bodapati said that programmes are being designed for the welfare of

Mr T. Srinivas

APWA members. Treasurer Mr Venkata Subrahmanyam Palasala said that he will put efforts to strengthen APWA financially.

Founder office barrers of the association Mr Amaraneni Srinivas, Mr Rayaprolu Srinivas and

Mr S. Rajaramam were thanked for the services rendered to APWA.

With the kind of experience and the organisational backup Mr T. Srinivas has got, he is expected to take APWA to a greater heights.

New team with the founders of APWA Amaraneni Srinivas and S. Rajaramam.

Newly elected president Srinivas Tetali being honoured.

APWA members during an occasion.

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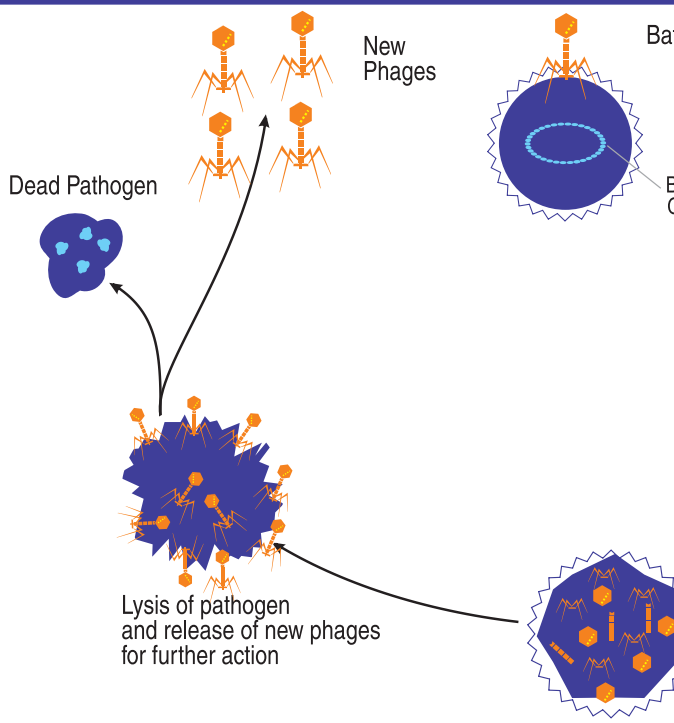

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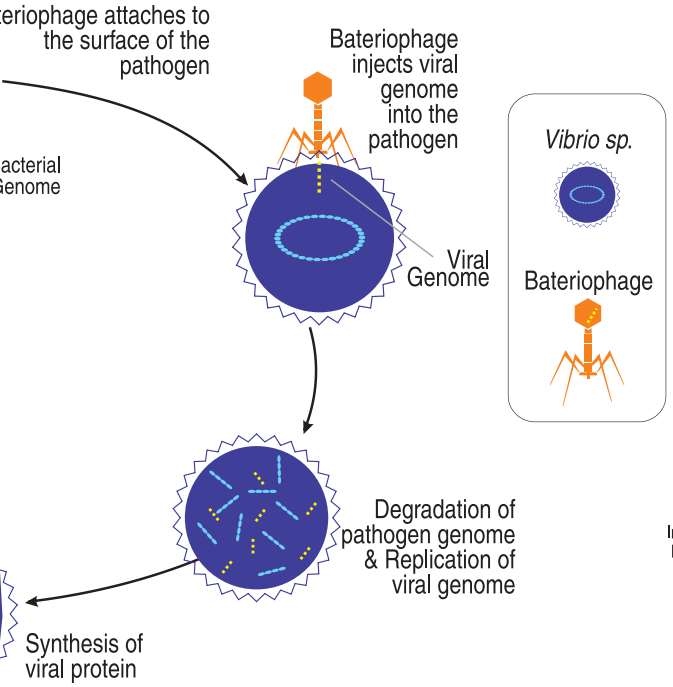

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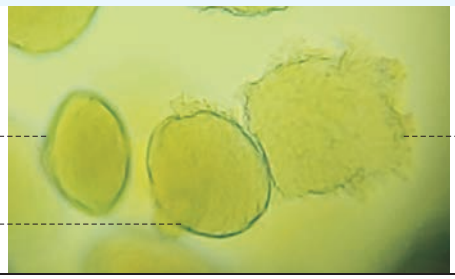
Stages of *Vibrio sp.* colonies infected with Bacteriophages & Progressive Lysis observed on an Agar plate, under Stereo Microscope

Colony 1 in Stage 1: Intact Colony may be infected or yet to get infected.

Colony 2 in Stage 2: Phage infected Colony showing Partial lysis.



Colony 3 in Stage 3: Phage infected Colony Completely lysed, cell contents with multiplied phages spreads out in search of their host.

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A Catch of Reliability: Protection from Oxidation with Precision

Lipid oxidation in fish meal is a major quality and safety issue resulting in loss of nutrients affecting the aquatic animals. The health and performance of fish and shrimp are also negatively affected by poor dietary lipid quality. So, selecting the right antioxidants is critical to ensure fish meal stability, transportation, shipping and storage safety. Camlin Fine Sciences Ltd (CFS), one of the leading manufacturers of antioxidants, specializes in providing shelf-life solutions for varied industries including the fish meal industry.

1. **How oxidation affects the quality and shelf-life of fish meal and the industry economically ?**
   Commercial fish meal is primarily used in aquaculture feeds. It is typically made from fish or fish parts that are not directly used for human consumption. It is also nutrient-dense source of protein, oils and fats, minerals and vitamins.

   Lipid oxidation is a significant challenge in fish meal production, primarily due to the presence of unsaturated fatty acids. When these fatty acids react with oxygen, they lead to rancid flavors, off odours, and a reduction in nutritional quality. This not only impacts the marketability of the fish meal but also risks failing to meet export standards, resulting in substantial economic losses.

   Moreover, oxidation can cause spontaneous heating during storage and transportation, posing safety hazards. Therefore, effectively controlling oxidation is essential for preserving the quality and economic viability of fish meal.

2. **Could you elaborate on how Camlin Fine Sciences (CFS) has developed its expertise in antioxidants for the fish meal industry ?**
   Camlin Fine Sciences (CFS) is the world's leading fully integrated manufacturer of antioxidants. Our focus on efficient manufacturing processes, quality and economies of scale enables us to build strong partnerships and cultivate customer loyalty. A fully integrated setup in traditional or synthetic (sold under the brand name "Xtendra") as well as natural antioxidants like rosemary extract, mix tocopherols and other natural blends (marketed as, "NaSure") gives our customers assurance of quality product, consistent supply, availability, and complete traceability. Our extensive research and development efforts have enabled us to offer antioxidant blends that extend the shelf life of fish meal and fish oil, addressing critical concerns such as lipid oxidation.

Xtendra AccuSystem

Our innovative automated dosing system, Xtendra Accusystem, further empowers our customers in effective application of antioxidants, enhanced precision and reinforces our leadership in the antioxidant space.

3. **How is CFS addressing specific oxidation challenges of the fish meal industry ?**
   Our Xtendra product line offers a synergistic blend of traditional antioxidants like BHA and BHT, designed to tackle oxidation at various stages. Our brands like Xtendra 510, 918A, and 920 are formulated with specific combinations of antioxidants to address the unique challenges faced by the fish meal industry, such as varying storage conditions and the different types of unsaturated fatty acids in the meal. These solutions have been proven to effectively delay oxidation, maintain nutritional value, and extend shelf life, giving our customers a competitive edge.

"CFS plays a vital role in supporting the sustainable growth of the fish meal industry by providing comprehensive solutions for feed protection while ensuring compliance with regulatory requirements."

- Dr Chandrakant Ghotekar Vice President, Animal Nutrition, Camlin Fine Sciences Limited, India.

4. **Are there proven methodologies to measure fish meal oxidation ?**
CFS' Customer Service and Applications Laboratory in India conducts extensive scientific studies using advanced methodologies like Rancimat and Oxypres to measure the oxidative stability of fish meal. These techniques help us generate valuable technical data, which we share with our customers to help them better understand the oxidation process and make informed decisions regarding antioxidant dosage and application. By offering this data, we provide a comprehensive service that ensures the most effective protection for their products.

5. **Can you explain a little more about the precision of Xtendra Accusystem ?**
In the fish meal industry, the correct dosage is critical for maximizing the shelf life and preventing over- or under-application, both of which can have negative consequences. The Xtendra Accusystem is designed to minimize manual errors ensuring consistency and accuracy. It optimizes the antioxidant treatment while reducing waste and operational costs for our customers. This technology helps protect the quality of the meal during storage and transportation.

6. **How do synergistic blends of antioxidants for fish meal storage score over traditional solutions ?**
Synergistic blends of antioxidants like BHA and BHT provide multiple layers of protection against oxidation. Unlike traditional solutions, which might target a specific stage of oxidation, our blends offer comprehensive protection that covers various stages, from initial lipid oxidation to the formation of secondary oxidation products. This makes them particularly effective in the fish meal industry, where oxidative challenges are complex and multifaceted. These blends also help extend shelf life more efficiently than individual antioxidants used in isolation.

7. **Can CFS provide insights on the appropriate antioxidant dosage for various conditions ?**
There is a need for customized solutions based on the specific conditions faced by each customer, whether it's storage, shipping, or transportation. Additionally, our Xtendra Accusystem plays a vital role in ensuring that the correct antioxidant dosage is applied with precision. Our technical team too works closely with customers to understand their operational needs and provides guidelines for dosage based on the type of meal, the environmental conditions, and the expected duration of storage.

8. **With the rise of fish meal exports from India, how can CFS support the industry's growth ?**
Our goal is to be reliable partner in supporting the sustainable growth of the fish meal industry by providing comprehensive solutions for feed protection while ensur ing compliance with regulatory requirements. CFS's antioxidant solutions help the Indian fish meal industry meet the stringent quality standards required by international markets. By extending shelf life and preventing oxidation, we ensure that Indian fish meal remains fresh, nutritious, and export-ready. Our Xtendra and NaSure line of comprehensive solutions offer a superior, provenproduct with added precision of antioxidant application, ensuring that our customers can consistently deliver high-quality products to global markets. In this way, CFS supports the growth of the industry and helps it capitalize on the rising export opportunities.

9. **CFS has invested heavily in research, innovation, and customer support. How does the CFS team engage with customers in the fish meal industry ?**
We take a collaborative approach with our customers, working closely with them to understand their unique challenges and requirements. Our technical team provides on-site support, helping to optimize antioxidant usage and dosage. We also educate customers about the importance of antioxidants and proper storage practices. This level of service ensures that our solutions are tailored to each customer's specific needs, helping them achieve the best possible results with a reliable partner.

10. **What future trends might influence the fish meal industry, and how is CFS positioning itself to meet the changing demands in India and beyond ?**

We expect to see continued growth in the fish meal industry, driven by rising demand for high-quality feed ingredients in the aquaculture sector. There will be increasing pressure to meet international quality standards and extend shelf life, especially as export opportunities expand. CFS is well-positioned to address these evolving needs through our research and product innovation. We will continue to focus on offering tailored, proven shelf-life solutions, alongside providing technical support and automated systems that optimize the entire production and storage process. Our commitment to innovation will help the industry meet future challenges and maintain a competitive edge.

Technological Innovations for Fish Biodiversity Conservation in connection with National Seminar at Kishanganj Fisheries College

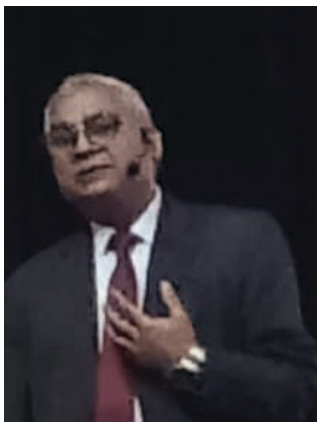
The National Seminar on 'Advances in Environment Management for Sustainable Fisheries and Livestock Production' (AEMS - 2024) was organized by Department of Aquatic Environment Management, College of Fisheries, Kishanganj, Bihar affiliated to Bihar Animal Sciences University during 18 and 19 November 2024. In the two-days programme, there were five technical sessions: Eco-friendly Sustainable Fish and Livestock Production (Technical Session-I); Environmental Biotechnology in Fisheries & Veterinary Science

Dr Mahua Saha making Presentation

(Technical Session-II); One Health for Ecosystem Wealth (Technical Session-III); Technological Innovations for Biodiversity Conservation (Technical Session-IV); Climate Change in Fisheries and Livestock System (Technical Session-V).

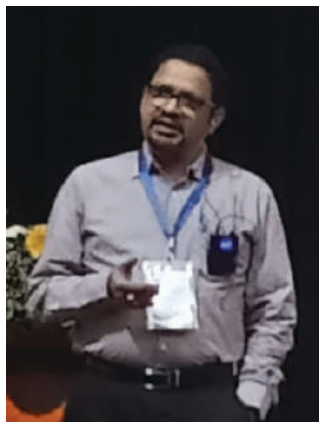
Banner of National Seminar at main entrance

On the second day, Technical Sessions IV and V were held parallelly. Technical Session-IV was held at the main Auditorium Hall in Fisheries College campus. News communicator Subrato Ghosh listened to all presentations in the Technical Session-IV, titled 'Technological Innovations for Biodiversity Conservation'. Dr P. K. Pandey, Director, ICAR - Directorate of Coldwater Fisheries Research, Bhimtal and Former Dean, College of Fisheries, Lembucherra, Tripura gave the Keynote address on topic 'Fish genetic resource of north - east India'. Dr Pandey said that detailed study is needed on this subject matter and this genetic resource to be explored and trapped for its economic value. He spoke about three biodiversity hotspots in India for conservation priorities at North - East India, Himalayan and Western Ghats with respect to the first one; World Bank Technical Paper on freshwater biodiversity



Dr P. K. Pandey making Presentation

in Asia with respect to fish; reason for high biodiversity in north-east India (mountain torrents, lakes, rivers, processes like tectonic activity, plate collision); different river systems in north-east India belonging to different tectonic plates;



Dr S. K. Rout making Presentation

six important drainages making biodiversity very strong here (Brahmaputra, Teesta, Kaladan, Barak-Surma, Karnaphuli, Chindwin).

Dr P. K. Pandey informed only 11% and 8% of river stretch in lotic and lentic habitats respectively are used for aquaculture; described features of high, middle and low altitude water bodies in north-east (diversity in substratum, torrential flow, etc) and the inhabiting fish fauna therein, which comprise 402 - 422 fish species; typical body structures of hill fish species, how they maintain against and adjust to torrential water flow; that 85% fishes having ornamental value exported from India every year is from north-east India; endemic fishes of north-east India of which we can develop breeding and culture technology. Dr Pandey described different hill fish species of interest. Among the threatened ones, 1% are critically-endangered (in Manipur, Mizoram region), 3% endangered, 10% vulnerable, etc.

We should think about how to conserve them, each species has its own importance. Dr Pandey spoke about major threats

to fish biodiversity here (river flow modification and construction of hydro-electricity projects, invasive species, habitat degradation, pollution, over-exploitation like community fishing by tribal Manipuris which is destructive method - fishes killed irrespective of age and size), that each fish species in nature should be given a chance to breed at least once in its lifetime so that proper recruitment happens. *Oncorhynchus mykiss* is invasive fish in wild freshwaters, *Osteobrama belangiri* is almost extinct, *Pethia manipurensis* is endangered because of invasive fishes. Population growth leads to scientific and technological advancements like dynamiting, damming which are threat to fish diversity. Environmental Impact Assessment of dams should be conducted in pre and post construction periods to safeguard fish diversity here. Total 130 numbers of new fish species described in India in the last 20 years, exploration is needed to be done, status of fishes in Himalayan region and north-east should be assessed. Species discovery is yet to be completed, so conservation is a must. As conservation recommendations, Dr Pandey spoke about prevention of mass exploitation during fish breeding season; local community to be awarded about impact of their activities; co-management of natural water bodies is important; the core idea is sustainable utilization of fish resource for human benefit; mesh size regulation and closed fishing season; diversification

Dr S. Ghosh, ADG Marine Fisheries felicitated at Conference Hall of Fisheries College

of aquaculture through locally-available fish species – small indigenous fishes, food fishes and ornamental fishes with study on their biology, breeding, etc; protocols of introduction of invasive fishes in north-east water bodies.

First Lead Lecture in this session was given by Dr S. K. Rout, Professor & Head, Aquatic Environment Management Department, West Bengal University of Animal and Fishery Sciences, Kolkata on topic '*Technological Innovations for Biodiversity Conservation*'. Dr Rout gave detailed explanation on biodiversity, said that we do not have sufficient data for quite a number of fish species and so these are classified as 'Data deficient' in status, more study required. Biodiversity plays vital role in assessing ecosystem health, it is critical environmental issue. He spoke on need of innovative technologies for fish biodiversity conservation; community engagement and education; artificial intelligence, remote sensing, genetic technologies; role of technology in conservation; monitoring, data analysis and enforcement, species distribution model, population viability analysis, climate change impact prediction; invasive species detection, ecological modelling for biodiversity conservation for understanding complex environmental interactions; other application of artificial intelligence like modelling ecosystem services and environmental impact, big data processing and analysis. We have to educate people, which is Citizen Science Project.

Dr Rout explained remote sensing for habitat monitoring (satellite imagery, LiDAR technology, hyperspectral imaging); spoke on some important biodiversity conservation strategies / studies, techniques applied and data sources; biodiversity mapping, modelling, assessment; artificial intelligence for species identification (in age recognition, acoustic monitoring, predictive modelling); drones and autonomous vehicles for wildlife tracking, aerial survey, anti-poaching patrols, habitat mapping; block-chain and distributed ledgers for anti-poaching efforts. We should reward local communities for conservation efforts.

Dr Rout spoke about importance of environmental education programme and indigenous community-led conservation; genetic technologies for conservation like gene editing, biodiversity conservation in aquatic ecosystem; acoustic monitoring of marine life (soundscape with software, capture, sound analysis, population insights); that environmental DNA analysis can identify and track elusive species without direct observation, can reveal changes in species abundance; remote sensing and satellite imagery (expansive coverage, spatial modelling); mentioned names of satellites used in remote sensing in Indian fisheries; artificial intelligence and machine learning (the wings include automated monitoring, intelligent decision support, predictive modelling). He explained protocol and procedure of environmental DNA sampling; autonomous underwater vehicles for seafloor exploration, integrated data collection, aerial monitoring; marine protected area management and GIS tools, block-chain for sustainable fisheries and exploitation, sensor networks and real time data; crowdsourcing and citizen science platform & initiatives. According to Dr Rout, technological innovations are increasingly integral to conserving biodiversity in new ways. These enable researchers to gather precise data on species populations, track habitat changes.

Second Lead Lecture in the session was given by Dr Mahua Saha, Principal

Scientist, Chemical Oceanography Division, CSIR - National Institute of Oceanography, Goa, on topic 'Plastic Litter and Marine Microplastics; Impact and Governance to the Indian Ocean Ecosystem'. Microplastics are emerging contaminants in aquatic ecosystem. Dr Saha gave description of plastics in our day to day life in 21st century, its consequences; spoke about improper management and dumping of used plastic products; story and journey of plastics since year 1830; production of plastics; global map of mismanaged plastic waste (with India in 12th position); countries responsible for plastic pollution; overall lifecycle of plastics in the environment; chemical, photo and microbial degradation of plastics in ocean; generation of microplastics; classification of microplastics, its sources and fate; transfer of plastic-associated toxins to human *via* food chain; that microplastics is a good vector of certain pathogens; its bioaccumulation and biomagnification processes; standardized method for identification and characterization of microplastics in complex environmental matrices using micro FTIR.

Dr Saha also spoke on microplastic pellets observed along Goa coast and beaches, its accumulation with respect to different seasons; microplastic study in stretches of Ganga and Yamuna rivers at Patna, Agra, Kanpur, Allahabad; microplastics (as religious materials) retrieved from banks of these rivers; identification of polymers in micro FTIR;

Dr S. Ghosh, ADG (Marine Fisheries), ICAR is felicitated after Dr P. V. Dehadrai Memorial Lecture

understanding sources and pathways of microplastics by studying polymers; how microplastics affect seafood, its environmental impact; microplastics observed in studied pelagic and benthic organisms (gut of finfishes like mullets and full tissue of shellfishes like mussels and clams), that five different types of polymers could be identified; study on microplastics at CSIR-NIO since 2015 in coastal and marine environments; assessment of micro and macroplastics along west coast of India – their abundance, distribution, polymer-type and toxicity. Similar pattern of microplastics observed in pelagic fishes and water, and in benthic fishes and sediments. Microplastics cause metabolic disorder, endocrine disruption, affects reproductive health in human and aquatic organisms.

Dr Saha emphasized on how we can contribute to reduction in use of plastics, how to stop plastic pollution in the ocean, means to tackle plastic crisis, our behavioural changes in this regard and our role for improvement of marine fishery industry. We should stop plastic generation in land.

Keynote address and two Lead Lectures were followed by Oral Presentations by teachers of Kishanganj Fisheries College, Scientists and others in Technical Session IV. Thereafter, Late Dr P. V. Dehadrai Memorial Lecture was given by Dr S. Ghosh, Assistant Director General (Marine Fisheries), ICAR, New Delhi on topic 'Expanding Indian Mariculture: striving for Harnessing the Potential'. Dr Ghosh mentioned that India has achieved 1st position in world in inland aquaculture production and 5th in marine capture fisheries; that Indian fisheries and aquaculture sector plays an important role in our aim to achieve Vikshit Bharat by year 2047. India' s present annual fishery and aquaculture production of 17.3 to 17.5 million tonnes should be increased to 40 million tonnes that we have to achieve in 2047. Our present annual freshwater aquaculture production (biggest contributor in production) of 10.5 million tonnes should be increased to 25 million tonnes by 2047, Magnitude of shrimp in Indian economy is noteworthy and important contributor to value, annual brackishwater aquaculture production should be increased from present annual 0.9 million tonnes to 3.0 million tonnes in 2047. Total inland aquaculture production to be increased to 28 million tonnes in year 2047. In Indian marine capture fisheries, we can increase production to 5.3 million tonnes (which is maximum potential) in 2047 from presently annual 4.0 million tonnes, and inland capture fisheries production can be increased to 2.7 million tonnes in 2047 from presently annual 1.8 million tonnes. Total capture fisheries production to be increased to 8.0 million tonnes in year 2047.

Dr Ghosh explained the parameters and indicators of increasing fish production and for prioritizing marine species in Indian mariculture, that 3.0 to 4.0 million tonnes contribution need to come from Indian mariculture in year 2047; seed production capacity developed for mariculture; isolation and mass production for calanoid copepods as live feed for growing larvae and fry of cultivable marine finfishes; prospects of seaweed mariculture, culture of clams, pearl oysters, edible oysters; hybrid marine ornamental fishes produced having vibrant & attractive colour; finfish cage culture in open sea and in coastal ponds; seaweed *Kappaphycus* sp farming with groupers and separately with cobia as Integrated Multi-trophic Aquaculture.

Dr Ghosh further informed that eleven nutraceutical products have been developed from seaweeds in India, nine of them been commercialized. Mariculture technology can meet the demand-supply gap of fishes,

National Seminar at Kishanganj Fisheries College

India shares 8% of global fish production. Cobia, pompano, seabass, snappers, groupers, sea breams, pomfret are high-valued farmed marine finfishes in India – which are excellent opportunity of increasing production through mariculture. In marine spatial planning, potential cage farming sites along the Indian coastline have been identified and mapped, fish production potential in each cage and in cages that can be installed in every 1 hectare area have been estimated.

Dr Ghosh informed about seed production of important marine finfish species (cobia, silver pompano and Indian pompano, grouper, sea bream) achieved successfully in India during 2010 to 2017 and importance of these fishes. Other marine food fishes that could be bred include *Lutjanus* sp, *Acanthopagrus* sp, *Pomadasys* sp, *Lethrinus* sp, *Siganus* sp. In Indian marine finfish cage aquaculture, he further mentioned about stocking density, culture period and weight at harvest individually of cobia, silver pompano & Indian pompano, grouper, sea bream. As way forward, Dr Ghosh spoke about preparedness for emerging diseases and parasites in mariculture finfishes and shellfishes, requirement of fish seed and cost-effective supplementary fish feed, about installation of large volume fish cages in offshore marine waters (if possible), incorporation of precision farming and artificial intelligence technologies in Indian mariculture.

After Dr Ghosh's presentation at main Auditorium Hall, the event 'Best Indian Scientist Award Presentations' was held at Mahananda Conference Hall of Kishanganj Fisheries College. Learned Scientists and Assistant Professors made audio-visual presentations on newer avenues in different disciplines of fishery and aquaculture for the Dr V. G. Jhingran Gold Medal in two different age groups. Late Dr V. R. P. Sinha Memorial Lecture was given by Dr Dilip Kumar, Former Director-cum-Vice-Chancellor, ICAR - Central Institute of Fisheries Education (Deemed University), Mumbai on 'Aquaculture for sustainable development: tribute to Dr V. R. P. Sinha' on the first day. It was altogether a very enriching, enlightening and informative two-days national seminar.

Animal Husbandry and Aquaculture for Sustainable Livestock and Fish Production and Women Empowerment

Kolkata: The 3rd International Conference on 'Climate-Smart Nutri - Sensitive Integrated Farming System for Gender-equitable Sustainable Agriculture: Prospects and Challenges (ICNSFS-2024)' was jointly organized in Hybrid Mode by Pragati International Scientific Research Foundation, Meerut and ICAR-Central Institute for Women in Agriculture (CIWA), Bhubaneswar in collaboration with Research Association for Gender in Agriculture, Bhubaneswar on 6 to 8 November 2024 at ICAR-CIWA, Bhubaneswar. The Technical Session VII Theme VIII-a and Technical Session IX Theme VIII-b were held on second day 7 November 2024 on topic titled 'Animal Husbandry and Aquaculture for Sustainable Livestock and Fish Production and Women Empowerment', Part-I and Part-II respectively. Sub-themes of these two sessions included Climate Resilient Integrated Livestock and Aquaculture Production Systems; Technological innovations in sustainable livestock and fish management; Value chain management in livestock and fish production systems; Livestock and aquaculture health prospects & challenges; Dairy technologies for the production of quality and affordable products.

In addition to other informative and enlightening presentations on recent advancements in disciplines like Livestock, Veterinary Science, Animal Husbandry and Dairy by Scientists and researchers in these two sessions, there were two Presentations on Fishery and Aquaculture.

Dr Ananya Jaitly from International Institute of Veterinary Education and Research, Rohtak spoke on 'Animal husbandry and Aquaculture for sustainable livestock and fish production' and Dr B. Shanthi, Principal Scientist, Social Science Division, ICAR-Central Institute of Brackishwater Aquaculture, Chennai spoke on 'Community aquafarming among coastal and tribal women and their success stories'.

Dr Jaitly spoke about climate-resilient aquaculture production system; approaches for climate-resilient livestock farming (improved animal housing, feeding management, heat

Conference Banner at Technology Unit, ICAR-CIWA

ameliorative measures); explained integrated farming system in detail; main and secondary linkages in livestock-fish integration; importance and need of inculcation of integrated crop-livestock systems (ecological / environmental benefits, social acceptance, economic profitability, improved soil fertility, increased biomass availability); the process in which livestock and fish improve sustainability of farming systems; different approaches under integrated livestock farming system; primary methods for integrating rice and fish farming (concurrent system, side by side system, rotational system), that crop-livestock-fishery farming system bring increased yields, income and levels of nutrition. She gave descriptive account about crop, livestock, poultry and fishery farming system; crop, livestock, fishery, biogas / vermicomposting system; benefits of Azolla sp farming, its production as livestock feed; aquaponics – integrated aquaculture and hydroponics system; structure of biofloc-based fish farming system, where controlled aquatic environment in indoors is created for beneficial bacteria, algae and fungi – which convert uneaten fish feed and fish excreta into protein-rich food for growing fish.

Dr Jaitly mentioned that climate-resilient livestock integrated farming offers a sustainable approach to addressing the challenged posed by climate change in agriculture. It improves soil fertility and water management, enhances food security and farm profitability, making it ecologically and economically viable. It is well-suited to rural communities. As climate change continues to impact agricultural systems, adopting climate-resilient integrated farming practices will be crucial for ensuring sustainable food production and long-term well-being of farming communities.

Dr Shanthi gave an account of some technologies transferred to women. Communities' involvement inhabiting coastal areas and engaged in aquaculture at small-scale is important for augmenting fish production improving social equity. It in turn will uplift their family nutrition, social and economic conditions. Dr Shanthi conducted studies at Tiruvallur, Kanchipuram, Tuticorin, Nagapattinam and Chengalpattu districts in Tamil Nadu, worked with successful coastal and tribal women in fishery and aquaculture. She emphasized on the fact that resource-poor coastal families need appropriate livelihoods, and adoption of scientific aqua-farming through technology dissemination will lead to sustainable livelihoods. She spoke about technologies (and how these proved useful) like edible crab farming in boxes; methods and significance of crab fattening and crab farming in tide-fed ponds; crab farming in pen enclosures and boxes; crab fattening in pens; Asian seabass farming in hapa enclosures in open backwaters involving women SHGs; seabass farming in cages in village; shrimp processing as small-scale business; brackishwater ornamental fish spotted scat farming in tanks; seed (fry) production of pearl spot in homestead backyard rearing units.

In the end, Dr Shanthi mentioned the names and noteworthy works of prominent women farmers having expertise in finfish, ornamental fish, crab and shrimp aquaculture, and the technology 'Development of value-added fish food dishes and fish food products (fish pickle, fish papad, fish curry, fish fry, crab soup)' for women SHG beneficiaries. News communicator Subrato Ghosh listened to all Presentations in these two Technical Sessions attentively.

International Conference at ICAR-CIWA

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Best Management Practices in Shrimp Farming

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Introduction: Fish and shellfish are produced through aquaculture, primarily for human consumption. This practice requires continuous interaction with the environment, as it is carried out in ponds, cages, or open water bodies. When aquaculture is conducted in a way that is both socially and environmentally responsible, it can be a sustainable activity. Sustainable aquaculture systems work in harmony with the environment and other organisms, use renewable resources whenever possible, provide animals with conditions that closely resemble their natural habitats, and consider the human and social context of the area. Sustainability can be achieved through the use of Best Management Practices (BMPs), which include legal compliance, social responsibility, careful site selection, and proper farm construction. Additionally, BMPs involve effective farm management, from pond preparation to harvest and post-harvest processes. By adopting BMPs, aquaculture can achieve better production, higher productivity, and profitability, while also fulfilling environmental and social responsibilities.

Guidelines for Better Management Practices in Shrimp Farming: The growing demand for shrimp products is driving higher stocking densities and increased chemical use in the aquaculture industry. If this trend continues, aquaculture could become unsustainable. Best Management Practices (BMPs) offer the only viable solution to these challenges. BMPs are a set of guidelines developed through risk factor studies, in collaboration with practitioners and relevant stakeholders, to address current issues in the industry. While production needs to increase to meet demand, sustainability must remain a priority. For farmers to adopt and implement BMPs, these practices should be simple, science-based, cost-effective, and appropriate to their specific context.

Pond preparation methods: Following best management practices for pond preparation creates a cleaner environment for shrimp farming by using scientific methods to minimize the risk of diseases and other outbreaks. The following steps should be followed when preparing ponds:

- Maintain a minimum water level of 1.4 meters to ensure proper water holding capacity.
- Disinfect the pond before stocking with a strong disinfectant to reduce microbial load.
- Manage sludge build up, especially when the gap between two cultures is short. Sludge, a mix of organic and inorganic materials, can lead to algal blooms and pathogen growth.
- Apply a potent probiotic before and after stocking to control harmful bacteria and support shrimp health.
- Ensure mineral balance in the pond to meet the shrimp's mineral requirements.

Water quality: Water quality is the most crucial factor for achieving a successful shrimp crop, as the entire farming process relies on it. To maintain optimal water quality, the following practices should be adopted:

- Maintain a reservoir for proper water treatment.
- Use double-layered 60 mesh filters to block unwanted carriers, with an 80 mesh filter below the inlet.
- Treat water with high-quality bleaching powder (35% or 70%) and avoid using pesticides or insecticides.
- Use triple salt compounds, such as AquaCare 3D, to prevent pathogens in the water.
- Apply fermented juices with yeast to support healthy plankton bloom, along with high-quality probiotics like AquaCare Control.
- Chain dragging is recommended if a healthy plankton bloom does not develop.
- Use quality minerals, such as AquaCare Mineral Balance, to maintain ionic balance in the water, focusing on calcium, magnesium, and potassium levels.

Removal of organic waste from pond bottom: Organic matter in ponds releases toxic gases like ammonia and hydrogen sulfide, which can stress or kill shrimp. This waste typically forms a black layer on the pond floor, especially in feeding areas, corners, trenches, and the center. Aerators should be checked for this black layer when wet. To remove organic

matter, the following methods can be applied:

- Use probiotics like *Nitrosomonas* and *Nitrobacter* along with photosynthetic bacteria like *Rhodococcus* and *Rhodobacter* to eliminate nitrates and hydrogen sulfides.
- Drying and ploughing the pond helps oxidize organic matter and reduce sludge build up.
- Plough the soil to release toxic gases and remove gastropods and other unwanted debris.
- Apply high-quality neem cake, around 40 kg per acre, to eliminate unwanted species.

Fertilization of the pond: Fertilizing the pond helps balance its mineral content, enhances its carrying capacity, and improves soil fertility. This can be achieved through the following practices

- Maintain an organic matter content of at least 1.5% by applying 500 kg to 1,000 kg of vermicomposting or 80 kg of potassium humate per acre.
- Use high-quality lime to maintain the soil's optimal pH level.
- Apply 6 kg of chelated zinc per acre for nutrient enrichment.

Biosecurity: Biosecurity in shrimp farming is essential for maintaining a disease-free environment and involves several critical practices, including stocking disease-free seed, preparing the pond, screening water, preventing the entry of disease carriers, and ensuring personal hygiene and sanitation. Key measures include:

- To control burrowing carriers like crabs, use crab fencing made of high-quality nylon and LDPE materials.
- Install bird fencing with red and blue-colored threads to deter birds and prevent contamination from droppings.
- Keep the farming area clean and maintain sanitizing dips at all entry and exit points.
- Regularly clean farm equipment and utensils with potassium permanganate or hypochlorite solutions to prevent cross-contamination.
- Ensure farm workers maintain proper personal hygiene.

Seed selection & stocking methods: Seed selection is one of the most crucial factors for the success of the entire shrimp crop. The following practices should be followed:

- Choose seed from a CAA-certified hatchery with SPF (Specific Pathogen Free) bloodstock that has been PCR tested.
- Before selecting the seed, check the pond water conditions, especially salinity, and conduct a stress test in the hatchery using your pond's water inputs.
- Avoid using wild, contaminated, or unhealthy seed.
- Ensure seed is packed with adequate aeration and a sufficient amount of artemia for longer transport durations.
- Select shrimp post-larvae (PL) of a good size, ideally between PL 15 to 20.
- Stock the seed during early mornings or late evenings for best results.
- Follow an acclimatization process before stocking to reduce stress on the seed.

Feed management: Effective feed management is crucial for successful shrimp farming, accounting for 50-60% of total operational costs. Key practices include:

- Penaeus monodon requires higher levels of protein, omega-3, phospholipids, and phosphorus. Use high-quality feed like Kuroline, which is specifically formulated to meet the nutritional needs of this species.
- Ensure that feed is used within 120 days from its date of manufacture.
- Follow a feed chart based on the shrimp's body size and weight to prevent wastage.
- Monitor feeding by using check trays, and reduce feed accordingly.
- Reduce feeding during rainy and cloudy weather, during plankton crashes, in high temperatures, and in low dissolved oxygen (DO) conditions.
- Decrease feeding during pre-molting stages.
- Regularly monitor ammonia and nitrate levels in the water.
- Conduct weekly sampling to assess shrimp growth, survival rates, and feed conversion ratio (FCR).
- Avoid overfeeding, as it can deteriorate pond water quality.
- Store feed in clean, well-ventilated areas away from direct sunlight. Keep it on pallets in a rodent-free environment.

Disease management: Monitor shrimp health daily using feed check trays. If feed consumption is low for three to four consecutive days, it may indicate health issues. Assess the general health and growth of shrimp using a cast net weekly, sampling early in the morning or late in the evening at various locations. Key practices include:

- Regularly check bacterial loads and water quality parameters.
- Identify any fouling or deformities in the shrimp.
- Ensure that the gut is 80% filled with feed.
- Observe for antenna cuts and check the color of the hepatopancreas.
- In case of virus outbreaks, use effective sanitizers and regularly apply high-quality probiotics.
- Prevent cross-contamination by maintaining strict hygiene protocols.
- Dead or affected shrimp should be buried away from the pond area.
- Avoid transferring equipment from affected ponds to unaffected ones.

Post - Harvest and Harvest methods: Harvest methods are crucial for ensuring the freshness and quality of shrimp. Key practices include:

- Exchange 30% of the water one

week before harvesting.

- Apply soil probiotics to prevent gill infections.
- Use oxidizers like hydrogen peroxide or potassium permanganate to prevent black discoloration.
- Avoid harvesting during the molting period.
- Do not feed shrimp for at least six hours before harvesting.
- Complete the harvesting process in the morning to minimize discoloration.
- After harvesting, apply lime and bleach in the harvesting area to prevent cross-contamination.
- Use high-quality ice for packing the shrimp.

Conclusion: In conclusion, the implementation of Best Management Practices (BMPs) in shrimp farming is vital for achieving sustainable aquaculture that balances productivity with environmental and social responsibility. By focusing on critical areas such as seed selection, pond preparation, feed management, and biosecurity, shrimp farmers can significantly reduce risks related to disease outbreaks and environmental degradation. Regular monitoring and adaptation of these practices ensure optimal growth conditions and enhance the overall health of shrimp populations. Ultimately, adopting BMPs not only boosts profitability but also contributes to the long-term viability of the shrimp farming industry and the preservation of aquatic ecosystems. As the demand for shrimp continues to rise, it is imperative for farmers to embrace these practices to promote a resilient and responsible aquaculture sector that benefits both producers and consumers alike

AI-driven Aquaculture

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Abstract
Aquaculture has become one of the fastest-growing sectors (8%) in the food production industry. However, its growth is hampered by challenges such as disease outbreaks, inefficient feeding practices, and environmental degradation. Recent advancements in artificial intelligence (AI) and machine learning (ML) offer transformative solutions for improving fish growth and health monitoring. This article reviews current AI applications in aquaculture, discussing innovations in fish behavior tracking, automated feeding, water quality monitoring and disease detection. It also highlights challenges and the potential future of AI-driven aquaculture.

Introduction
Aquaculture, as the name implies, is farming fish and other aquatic organisms and has become a critical pillar in global food production. As wild fish stocks face increasing pressure from overfishing, climate change, and environmental degradation, aquaculture has stepped in to meet the growing seafood demand. The significance of this shift became clear in 2022, when aquaculture production surpassed capture fisheries for the first time, producing over 50% of all aquatic animals destined for human consumption. That year, total global fish production reached 184.6 million metric tons, driven by substantial gains in fish farming (FAO, 2022a). By 2023, global fish production had increased to 186.6 million metric tons, with aquaculture contributing 96 million metric tons, more than capture fisheries production 90.6 million metric tons. This upward trend is largely fueled by the continued focus to expansion and intensification of aquaculture. This historic shift signals a new era where aquaculture plays an increasingly dominant role in addressing global food security and sustainability challenges (FAO, 2022b; Mair et al., 2023).

To sustain this growth, farmers must ensure optimal conditions for fish health and growth while minimizing environmental impacts. Traditionally, fish farming techniques are labor-intensive, prone to human error and the manpower was insufficient for managing large-scale operations. The integration of AI technologies can revolutionize aquaculture, providing precision in fish growth and health monitoring while improving sustainability. These advancements in aquaculture industry are critical to ensure that aquaculture can meet the increasing global demand for fish. Though, focus should be given to

minimize its environmental impacts and promoting sustainable practices. Artificial Intelligence (AI) integrated farming is revolutionizing the aquaculture industry by enhancing feeding and growth management for fish. This transformation is critical as it addresses several challenges in traditional fish farming, including labour shortages, high feed costs, inefficient feeding practices, and environmental sustainability. This article discusses the key ways AI contributes to optimizing feeding and growth management in aquaculture.

Artificial Intelligence

Artificial Intelligence, often referred to as AI, nothing but the computer systems capable of performing varying range of tasks that usually require human intelligence. AI systems use algorithms and models to simulate cognitive functions, enabling machines to learn from data and improve their performance over time. Common applications of AI include speech recognition, image analysis, autonomous vehicles, and decision-making in industries like healthcare, finance, and agriculture(West and Allen, 2018).

What is Smart/Intelligent Fish Farming?

Smart or intelligent fish farming involves the use of advanced technologies, particularly AI and Internet of Things (IoT), to enhance the efficiency and sustainability of aquaculture (C. Wang et al., 2021). This approach uses sensors, AI-driven data analysis, and automated systems to monitor fish health, optimize feeding schedules, track environmental conditions (e.g., water quality), and predict potential risks such as disease outbreaks. Intelligent fish farming aims to increase productivity while minimizing environmental impact and resource consumption.

Applications of AI in Aquaculture

The 4 key applications of AI in fish farming, further specific applications of AI in predicting and preventing fish diseases, optimized feeding regimes, enhanced growth management, and sustainable practices are as follows.

A. The Role of AI in Intelligent Fish Farming

AI technologies are being leveraged to create intelligent fish farms that optimize various aspects of aquaculture management.

i. Data-Driven Decision Making

AI facilitates the collection and analysis of vast amounts of data from various sources, including environmental sensors and monitoring systems (Ubina et al., 2023). This data-driven approach allows for precise control over critical factors such as water quality, feeding schedules, and fish health monitoring. For instance, machine learning algorithms can analyze historical data to predict optimal feeding times and quantities, thereby minimizing waste and maximizing growth rates (C. Wang et al., 2021).

ii. Water Quality Monitoring

Water quality is critical for fish survival and growth. Parameters such as pH, dissolved oxygen, temperature, and ammonia levels must be continuously monitored. AI and the Internet of Things (IoT) can automate water quality management by utilizing sensors connected to AI-driven monitoring systems (Lee et al., 2000). These systems predict when water quality parameters are likely to deviate from optimal ranges, triggering corrective actions such as aeration or water exchange. For example, if sensors detect a drop in oxygen levels, automated systems can adjust aeration or feeding practices to mitigate stress on fish populations. Predictive analytics, leveraging historical data, can also forecast harmful algal blooms or changes in water chemistry (G. Wang et al., 2021).

iii. Behavior Analysis and Biomass Estimation

Advanced machine vision technologies can be employed to monitor fish behavior and estimate biomass accurately. This capability is crucial for assessing the health and growth of fish stocks, ensuring that feeding and harvesting practices are aligned with actual needs rather than estimates (Gonçalves et al., 2022; Sadoul et al., 2014).

iv. Automation of Feeding and Harvesting

Intelligent feeding systems utilize AI to optimize feed distribution based on real-time data about fish behavior and environmental conditions. This not only improves feed efficiency but also reduces the environmental impact associated with overfeeding. Additionally, automated harvesting technologies can streamline operations, reducing the need for manual labor and enhancing overall productivity (Ubina et al., 2023).

B. Predicting and preventing fish diseases in aquaculture

Disease outbreaks are a major challenge in aquaculture, often leading to significant losses. AI can play a pivotal role in early disease detection, diagnosis and prediction, the likelihood of disease outbreaks.

i. Early Disease Detection

AI-powered systems can analyze fish behavior, feeding patterns, and external appearance to detect early signs of disease. Advanced techniques like deep learning and convolutional neural networks can classify abnormal conditions with high accuracy. For example, one study achieved 98.94% accuracy in detecting three types of disease in cage-cultured grouper (J. C. Chen et al., 2022).

ii. Predictive Disease Modeling

AI algorithms can process large datasets on past disease outbreaks, environmental conditions, and fish health records. By identifying patterns and correlations, these models can predict the likelihood and spread of future disease events. This enables proactive prevention measures and targeted treatment (Mandal and Ghosh, 2023).

iii. Automated Disease Diagnosis

AI-based image analysis techniques can be used to detect and automatically diagnose diseases based on external signs of disease, such as lesions or abnormal coloration, through high-resolution underwater cameras. By combining this with water quality data and fish behavior analysis, the accuracy of

disease identification is significantly improved (Darapaneni et al., 2022)..

iv. Personalized Health Management
AI facilitates the development of tailored health plans for individual fish farm or populations. By analysing each farm's unique conditions, AI can optimize feed formulations, vaccination strategies, and treatment protocols to boost immunity and prevent disease (Li et al., 2022). While challenges remain around cost and data availability, the potential of AI in aquatic disease prevention is substantial. As the technology continues to advance, AI-powered systems will play an increasingly important role in ensuring the health and sustainability of fish farms worldwide.

C. Optimized Feeding Regimes
i. Smart Feeding Systems
Feeding represents one of the largest costs in aquaculture, and overfeeding can lead to waste and water pollution. AI-driven feeding systems, equipped with machine learning algorithms, optimize feeding schedules by analysing fish size, activity, and environmental conditions in real-time. AI-based acoustic sensors can detect when fish are actively feeding and adjust feed delivery accordingly, reducing waste (Ramesh et al., 2021). AI technologies, such as computer vision, enable the monitoring of fish behaviour in real-time. Advanced imaging techniques can track fish movements and feeding responses, allowing farmers to optimize feed distribution and timing based on actual fish behaviour rather than assumptions (F. Chen et al., 2022).

ii. Optimal feeding and enhanced Feed Conversion Rates
AI systems utilize machine learning algorithms to analyse vast datasets, including historical feeding patterns, fish growth rates, and environmental conditions. By processing this data, AI can predict the optimal feeding schedules and quantities tailored to specific fish species and growth stages. This precision reduces feed waste and lowers operational costs, as feed accounts for a significant portion of aquaculture expenses, often ranging from 40% to 50% of total production costs (Pradhan, 2023). By optimizing feeding strategies and ensuring that fish receive the right nutrients at the right times, AI improves feed conversion rates. Higher feed conversion efficiency means that more of the feed provided is utilized for growth rather than wasted, which is critical for sustainable aquaculture practices (F. Chen et al., 2022).

D. Enhanced Growth Management
i. Personalized Nutrition Plans
AI facilitates the development of personalized nutrition plans by analysing the nutritional needs of individual fish based on their growth rates and health status (Mandal and Ghosh, 2023). This approach ensures that each fish receives the appropriate nutrients, promoting optimal growth while minimizing waste. By assessing various feed ingredients' nutritional value and environmental impact, AI helps in sourcing responsible feed, further enhancing sustainability in aquaculture practices.

ii. Predictive Growth Modelling
AI can also create predictive models to forecast fish growth under varying environmental conditions. By integrating data on water quality, temperature, and fish health, these models provide insights into how different factors affect growth rates (Mandal and Ghosh, 2023). This information allows farmers to make informed decisions about management practices, such as adjusting feeding strategies or modifying environmental conditions to enhance growth.

E. Sustainable Practices
i. Waste Reduction and Environmental Impact
AI's ability to optimize feeding and growth management directly contributes to reducing environmental impacts. By minimizing feed waste and ensuring that fish receive only what they need, AI helps decrease nutrient runoff into surrounding waters, which can lead to harmful algal blooms and other ecological issues. Moreover, AI systems can monitor water quality parameters, ensuring a healthier environment for fish and reducing the reliance on chemicals (Mustapha et al., 2021).

ii. Automation and Labor Efficiency
The integration of AI in aquaculture also leads to greater automation in feeding processes (Pradhan, 2023). Automated feeding systems powered by AI can adjust feed delivery in real-time based on fish behavior and environmental conditions, reducing the need for manual labor. This shift not only enhances operational efficiency but also addresses the labor shortages currently faced in the aquaculture sector.

Challenges and Limitations

a. The effectiveness of AI systems depends heavily on the availability of high-quality data. In many aquaculture operations, especially small-scale farms, data collection systems may be inadequate. The lack of standardized data formats and the presence of noisy, incomplete datasets can hinder AI model training.

b. Many aquaculture operations still rely on traditional methods. Integrating AI technologies into these systems requires significant investment and training. Implementing AI technologies requires significant investment in hardware, such as underwater cameras, sensors, and computing infrastructure. For small and medium-sized enterprises, the high cost of these technologies may be a barrier to adoption.

c. The use of AI in aquaculture raises concerns regarding data privacy, especially when dealing with integrated systems that share information across platforms. Moreover, the over-reliance on AI systems without proper oversight may lead to ethical issues, such as animal welfare considerations being overlooked in favor of optimizing production.

d. Different regions may have varying regulations regarding the use of AI in agriculture, necessitating

careful navigation of compliance requirements.

Future Directions

The future of AI in aquaculture looks promising, with continued advancements in machine learning algorithms and IoT technologies. The development of AI-powered aquaculture systems that are more accessible and affordable will be critical for widespread adoption. Moreover, integrating AI with other technologies, such as blockchain, could improve transparency and traceability in the supply chain, enhancing consumer trust in aquaculture products.

Conclusion

The shift towards intelligent fish farming through the application of AI technologies presents a transformative opportunity for the aquaculture industry. By enhancing growth monitoring and health management, AI can help address critical challenges such as sustainability, efficiency, and labor shortages. As the technology continues to evolve, its integration into aquaculture practices will likely play a pivotal role in meeting the growing global demand for aquatic products while ensuring environmental stewardship. AI has the potential to revolutionize aquaculture by improving the efficiency of growth and health monitoring, optimizing resource use, and minimizing environmental impact. While challenges remain in terms of cost, data availability, and ethical considerations, the integration of AI-driven technologies into fish farming practices will likely become more prevalent as the industry continues to grow.

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Indigenous Technological Knowledge and practices in traditional fish catching in shallow freshwater bodies in West Bengal

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Abstract

The knowledge of elderly villagers on small-scale freshwater fishing and their cultural heritage is precious. Different kinds of indigenous devices and traps of different shape and size are traditionally employed since long for fishing in less-deep freshwater bodies in different villages of West Bengal. It is the indigenous way of small-scale fishing by elderly villagers. In this field study, an attempt was made to document and compile baseline information on some important indigenous fishing devices, their specifications, mode of operation in feebly-flowing or stagnant shallow freshwater bodies after on-site discussion with elderly villagers and small-scale traditional fishermen in some villages of Purba Medinipur and South 24 Parganas districts of West Bengal.

Nutritious naturally-occurring small freshwater fishes

Fish and fisheries have been playing an important role in addressing food, nutritional and livelihood security of the poor in developing countries. Fisheries and inland aquaculture sector usually makes a valuable contribution to economic and social development of rural areas. Freshwater fishes are rich source of high quality animal protein and other essential nutrients needed for healthy living of school going children, pregnant mothers, elderly family members and is necessary in our daily diet. Nutritious small-sized and medium-sized fishes are captured from natural open water bodies by professional fishermen and also by villagers whose livelihood associated activities are largely centred around agriculture. These naturally-occurring self-recruiting fishes can alleviate malnutrition-related health disorders among poor rural households and fulfill the requirements of essential nutrients in body, if eaten on a regular basis. Some high-valued economically-important fishes like Indian major carps and air-breathing catfishes are cultured in well-maintained farm ponds to meet consumer demand.

Aatol or Chero

Application of ITK in making and operating fish catching devices

The 'precious' wisdom and indigenous practice of small-scale freshwater fishing employing traditional knowledge-based fish catching devices and concerned Indigenous

Bana or aara (traditional pen-type) made of split bamboo

Bitti

Technological Knowledge (ITK) in rural West Bengal are less known to us. Fishing devices and traps, varying in shape-size and mode of operation, are used by agriculture-dependant men and women in shallow wetlands, inundated river banks, water-logged paddy fields and other still freshwater bodies during monsoon and post-monsoon months. This low-cost but effective technology and practice was passed down from predecessors to generation after generation to posterity; targeting small-sized, naturally-occurring freshwater fishes and shellfishes. Some woven structures made of only closely-placed split bamboo sticks, while others of split bamboo and fine-meshed net. ITK has been applied to develop unique fish catching devices using locally-available construction materials. Less-economic but important fishes and shrimps caught, the 'poor man's protein source', are got back from the devices and traps live without any damage - are caught in small amounts, cooked at village homes and eaten, mainly meant for household consumption, aiding in rural family nutrition. Most of these are locally-built by elderly villagers with less-expensive materials.

In villages, freshwater bodies like shallow wetlands or beels,

Cast net in pond

Big triangular net

inundated river banks, water-logged paddy fields, canals and other still freshwater bodies of low water depth are a repository of edible small-sized freshwater fishes, prawn, riverine shrimp and crabs during monsoon and post monsoon months, that reproduce on their own. They have applied their Indigenous Technological Knowledge (ITK) and indigenous knowledge system, skill

Cast net in river

and ingenuity to make and operate these devices. They possess a treasure of ITK, tricks of catching fish from low-lying areas. Traditional fishing methods and management practices, called as 'fisher's knowledge', has a prominent role in optimum and sustainable exploitation of such edible bioresources from nature. Scheduled Caste, Scheduled

Chhankni jaal - close view

Tribe and backward rural population (many in BPL category) make different fishing gears using natural construction materials and operate those for some additional income by selling fish in nearby markets, or family fish consumption at home for daily nutrition.

Features of some indigenous fish catching devices and traps

1) Mughri - 1

It is a V-shaped structure, machine made (woven), fine-meshed white net and split bamboo used to make Mughri. Once fishes enter, it cannot come out. When laid in proper position in shallow water bodies, three-fourth of its height remains under water and one-fourth above water surface. More amount of small-sized fishes and shrimps caught during full moon and new moon days. It is placed in stagnant water above

Chhankni jaal - woman on right side

knee-height depth in late evening on sides of inundated agricultural fields besides river, remains undisturbed, taken up in next morning. Riverine adult small-sized shrimps, sub-adults of giant freshwater prawn and fishes (*Glossogobius* sp, *Pseudapocryptes* sp, *Xenentodon* sp, small *Puntius* sp, *Liza* sp) are caught in Mughri. Small riverine crabs caught 1.5-2.0kg in amount every night in one Mughri, when high tide water inundates low-lying river banks. When used in small wetlands and ponds, *Mastacembelus* sp, *Colisa* sp, pond-dwelling small crabs, very small-sized freshwater prawns and others are caught (which are self-recruiting species).

2) Mughri - 2

It is made up of entirely split bamboo canes. Thin sticks of raw bamboo or split bamboo slats form a screen,

Torodung

no netting material. It is operated in feebly flowing narrow canals and stagnant shallow water bodies. Its shelf life is three years, costlier than split bamboo and white net built Mughri. Its height is 2 feet. When height of water in canals is more, then one such Mughri is placed above the other. More amount of small-sized fish and crabs caught during monsoon months, also during full moon and new moon days. Mughri is placed at low water depth in canals before high tide sets in. It is taken up (along with the caught fishes inside) in the period between high tide and low tide, fishes are taken out - again the empty Mughri is placed at that position till completion of low tide. Every time 500-4000gm fish and shrimp are caught in one Mughri, less amount during event of low tide.

3) Large triangular net

The front horizontal portion of the net is 5-6 feet in length, no use of bamboo in this portion, thus can be folded. Two raw bamboo used each 6-8 feet in length, made to laid across and form X-shape towards the bottom. Two bamboo tied together and along with the attached net, it forms a triangular structure. It is used in inundated river banks during high tide in monsoon and post monsoon months, riverine shrimps mainly

Split bamboo Ghuni

Split bamboo Mughri

caught. It is pushed forward when in operation. Total 12-20 nos of small sized riverine shrimps caught in this net per 50 mt distance. It is operated at waist height water depth. Hand woven net, home-made by elderly experienced village men and women using soft threads. Its mesh size may be very small to small (little bigger) according to desired and targeted

Net and split-bamboo Mughri

naturally-occurring riverine shrimp species. About 1.5-2.0kg fishes and shrimps are caught in each large triangular net in every 30mins-3 hour period. The two species of riverine shrimps mainly caught are *Metapenaeus monoceros* and *Metapenaeus brevicornis* - maximum size is 4.0-4.5 inch, locally sold @ Rs 350-400 per kg and smaller ones 1.5-2.0 inch in size, sold @ Rs 250-300 per kg.

Small-sized Ghuni

4) Chhankni jaal

It is circular-shaped in opening and somewhat conical towards bottom, net material tied to main frame. The rim 3 feet in diameter, mesh size of net is 6-8mm. It is hand-made, operated in stagnant water bodies in between knee and waist height depth. Split bamboo 1.0.-1.5 inch in width is curved and main frame is made.

5) Ghuni

The structure is built using bamboo split and chopped into sticks. Two longitudinal narrow openings exist in front wall of Ghuni for fishes to enter unknowingly. Thin cane sticks laterally placed beside one another, inter-weaved with thread. It is rectangular parallelepiped (box) cage like structure. Normal size: 3 feet x 2

Kolee jaal for giant freshwater prawn seed

feet x 2 feet or 2.0-2.5 feet x 1.5 feet x 1.5 feet. One-fourth of the upper flat portion can be manually opened and closed for taking out the trapped fishes, prawn and shrimps inside. Ghuni is placed for whole day across feebly flowing water in canals, creeks, towards banks of rivers underneath water upon bottom soil.

6) Kolee jaal for giant prawn seed collection

Three bamboo tied together to form a triangular frame to which a fine meshed net is attached. Bamboos used are 4-5 feet in length. It is pushed in front below water through water column along banks of rivers and canals. It is machine made structure, fine-meshed mosquito net material used, and operated only during night hours to catch seeds (post larvae 10-24mm) of giant freshwater prawn from marginal areas of rivers.

Khaloi - hanging from left shoulder

7) Khaloi
It is made up of fine bamboo sticks, round-shaped bamboo basket (chhubri). Its open mouth is 5-6 inch in diameter, middle region spacious 8 inch in diameter. Live fishes kept inside cannot jump and come out. Trapped fishes, prawns, shrimps in Chhankni jaal and large triangular net are periodically taken out and kept temporarily in Khaloi, kept and carried in hanging condition from shoulder of women by means of thread.

8) Brackishwater crab traps in Indian Sundarbans region
The main opening is 1.5 feet in diameter, another entry point for crabs inside is 5.0-5.5 inch in diameter. Strong and durable nylon threads used to make such traps, which is hand-made. Mesh size of crab trap is 1 inch. Baits (small pieces of raw fish, snail or mussel meat) are used inside the trap, and operated in shallow brackishwater creeks, placed upon bottom soil to catch mud crabs of genus *Scylla* sp.

Ghuni - back side

9) Aatol
Sturdy raw bamboo are split longitudinally into four strips to make Aatol. Its length is 3-4 feet, height 3.0-3.5 feet, hand-made structure where nylon thread (main net material) is used. The main split bamboo built frame is also hand-made. It is used in large and less-deep brackishwater fish farming water bodies, ponds, small wetlands; kept upon bottom soil. Adult and marketable-sized farmed prawns, shrimps, brackishwater finfishes enter in Aatol and are caught. Mesh size of net material is 1 inch. Two narrow longitudinal V-shaped inlets or openings exist, like Ghuni.

Device for catching tiger shrimp seed

10) Bitti
The trapped fishes and shrimps from Mughri, Aatol and Ghuni are taken out and kept in such structure. Its upper opening is circular (1.5 feet diameter) but base is squarish. It is 2 feet in height. Thin cane sticks are interwoven using nylon thread to make Bitti.

11) Chinese net or Dip net
Naturally-occurring small and medium-sized freshwater fishes are caught from beels and floodplain wetlands using Chinese net. Main net is 5 feet x 5 feet, soft net material used, curved at corners to form a holding. Two long stretches of split bamboo, each 10-12 feet in length are used, each curved to connect each of the two opposite corners of squarish net. Four corners of net are fastened to two flexible crossed bamboo frames. A lifting pole is attached at the centre of the crossed bamboo frames. Home-made fish feed is given in the centre of net, fishes move into the dipped part of net. It is operated in marginal areas of the still water bodies. Net is dipped and kept underwater for 15-20mins every time and lifted up to get the fishes.

Dip net or Chinese net

Crab trap of Sundarbans region

12) Torodung and other fishing gears
Torodung is a fishing device mainly used by tribal population to catch fish in nearby shallow water bodies. It is made up of split bamboo, 40-55cm in length and 30-40cm in open mouth diameter. A circular net is home made for catching 15-25 mm *Mystus gulio* seeds from waterlogged paddy fields for farming in ponds. The Khyapla jaal or cast net is thrown over water surface, having 15-30mm mesh size and bottom diameter 5-6 mt, which is operated from shore in beels and rivers. A simple device is used by women for catching seeds of economically-important cultivable shrimp *Penaeus monodon* (20-24mm) from rivers for supplying to farmers, which is dragged from behind through water column.

Fishes and shellfishes caught in indigenous fishing devices
Important species of freshwater fishes caught in small to medium

Crab trap - another view

amounts in the indigenous fishing devices almost throughout the year are *Pseudapocryptes lanceolatus, Glossogobius giuris, Xenentodon cancila, Anabas testudineus, Puntius ticto, Mastacembelus pancalus, Colisa fasciatus, Puntius sophore, Puntius ticto, Channa, punctatus, Channa striatus.* Important species of freshwater shellfishes caught in the indigenous fishing devices are *Macrobrachium rosenbergii* juvenile, *Varuna litterata, Macrobrachium lamarrei, Macrobrachium malcolmsonii, Sartoriana spinigera.* In addition to these shellfishes, there are two small-sized riverine shrimps of *Metapenaeus* genus (mentioned earlier).

Chhankni jaal in operation

End note

The methods of fish catching may be regarded as 'village science' or 'rural technology', which are cost-saving, cost-effective and fruitful. The indigenous small-scale fishing devices used are very good instances of the applied (practical) side of inherited traditional knowledge of elderly villagers, accumulated over generations. But the indigenous knowledge system is a 'dying discipline' - their acceptance and use are becoming less and less as days progress due to changing livelihood pattern of new generations in villages in modern day times, availability of improved techniques. Use of small-scale fishing devices and traps are becoming less also due to less abundance and diminishing stock of naturally-occurring freshwater fishes, prawns, shrimps and crabs, declining trend of fish biodiversity, shrinking open freshwater resource (rivers, canals, beels, *i.e.*, floodplain wetlands) and water quality deterioration. Nevertheless, region-specific fishing devices needs to be thoroughly documented. This precious ITK possessed by villagers in West Bengal and other eastern and north-eastern states of India in the fields of inland fishery and aquaculture needs further investigation and documentation.

For further reading

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Trap for finfish seeds in waterlogged rice fields

Plant-based Meat:
An approach to cut down the Environmental Footprints

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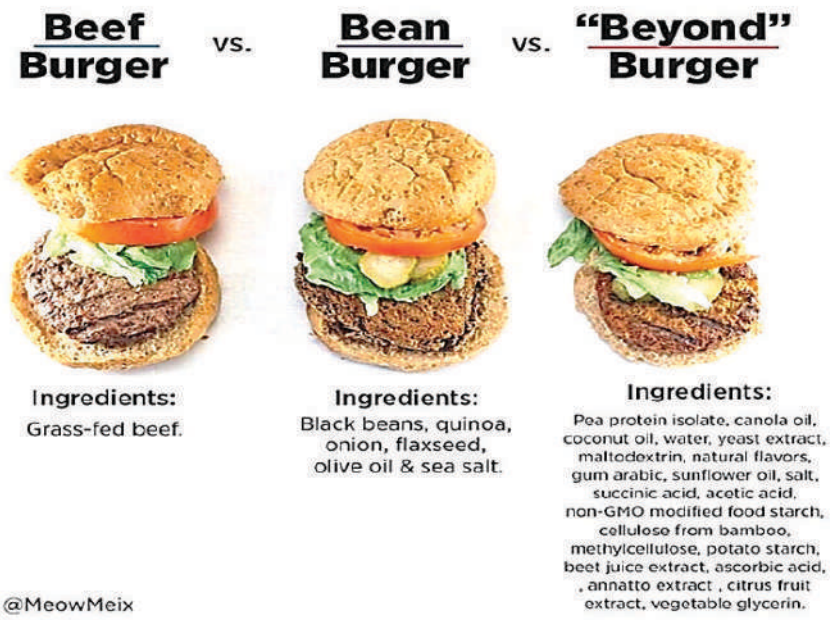
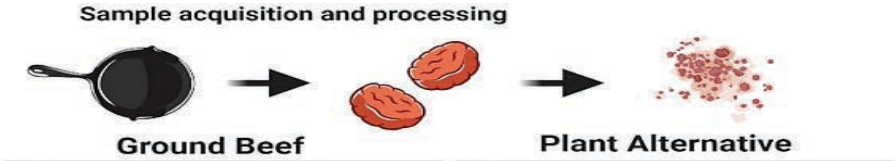
Introduction

In recent years, there has been a significant shift in the way people think about food, particularly when it comes to meat consumption. There is widespread worry about red meat's consequences on human health and climate change. Plant-based meat substitutes, designed to emulate the sensory experience and nutritional value of red meat, have lately entered the consumer market. Plant-based meats are advertised as having environmental and human health advantages, to appeal to a wide range of consumers. Meat production is criticized for overusing water resources, degrading landscapes, and emitting greenhouse gases; nevertheless, depending on production techniques, plant-based meat substitutes may have reduced environmental footprints. According to life-cycle assessments, the innovative plant-based meat alternatives have an environmental footprint that is smaller than that of feedlot-finished cattle but greater than that of beef produced on well-managed pastures. With concerns about sustainability, animal welfare and personal health on the rise, many individuals are turning to plant-based alternatives as a viable solution. One of the most notable innovations in this space is plant-based meat, which has gained immense popularity and recognition globally.

Plant-based meat, also known as alternative meat or meat analogues, refers to products that imitate the flavour, texture and features of conventional red meat but are entirely developed from plants. These are manufactured using ingredients like soya bean, wheat, pea protein, mushrooms and other plant-based components. Through advanced food processing techniques and the use of natural flavouring agents and additives, manufacturers can create products that closely resemble animal meat in terms of taste and texture.

Novel plant-based meat alternatives such as the Impossible™ Burger and Beyond Burger® are becoming widely popular among consumers and have attracted significant financial investments, media coverage, and research attention. Their success has led other food manufacturing companies to make their product versions. The plant-based meat market is growing rapidly and is expected to be worth more than $30 billion by 2026 (Statista, 2020). Meat alternatives, formulated to mimic the taste and sensory experience of red meat, are marketed for their ecological and health benefits compared to red meat. While ingredients vary amongst plant-based meat products, the new generation of alternatives is formulated specifically to mimic the sensory experience and macronutrient content of meat by using plant proteins (e.g., soy, pea, potato, rice, wheat, and / or mycoprotein), fats (e.g., canola, coconut, soybean, and / or sunflower oil), and other novel ingredients (e.g., soy-leghemoglobin, red-coloured vegetable extracts, and / or flavouring agents). Additionally,





Ground Beef

Nutrition Facts

Serving size	(113g)
Amount Per Serving	
Calories	**220**
	% Daily Value*
Total Fat 14g	18%
Saturated Fat 5g	25%
Trans Fat 0g	
Cholesterol 60mg	20%
Sodium 70mg	3%
Total Carbohydrate 0g	0%
Dietary Fiber 0g	0%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 23g	46%
Vitamin D 0.1mcg	0%
Calcium 12mg	0%
Iron 2mg	10%
Potassium 289mg	6%
Thiamin 0.05mg	4%
Riboflavin 0.2mg	15%
Niacin 4.8mg	30%
Vitamin B6 0.4mg	25%
Folate 6mcg	2%
Vitamin B12 2mcg	80%
Phosphorus 175mg	15%
Zinc 4.6mg	40%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Plant Alternative

Nutrition Facts

Serving size	(113g)
Amount Per Serving	
Calories	**250**
	% Daily Value*
Total Fat 14g	18%
Saturated Fat 8g	40%
Trans Fat 0g	
Cholesterol 0mg	0%
Sodium 370mg	16%
Total Carbohydrate 9g	3%
Dietary Fiber 3g	11%
Total Sugars 0g	
Includes 0g Added Sugars	0%
Protein 19g	38%
Vitamin D 0mcg	0%
Calcium 180mg	15%
Iron 4.2mg	25%
Potassium 610mg	15%
Thiamin 28.2mg	2350%
Riboflavin 0.4mg	30%
Niacin 4.8mg	30%
Vitamin B6 0.4mg	25%
Folate 115mcg	30%
Vitamin B12 3mcg	120%
Phosphorus 180mg	15%
Zinc 5.5mg	50%

*The % Daily Value (DV) tells you how much a nutrient in a serving of food contributes to a daily diet. 2,000 calories a day is used for general nutrition advice.

Figure 1: Plant-based meat mimics the nutritional profile of meats (Curtain & Grafenauer, 2019)

various vitamins and minerals that are naturally found in meat (e.g., zinc, iron, and B vitamins) are increasingly added to plant-based meats (Curtain & Grafenauer, 2019). By doing so, novel plant-based meat alternatives can closely mimic the Nutrition Facts panels of meat (Figure 1).

Plant-based meats may also reduce apprehensions regarding the effects of red meat on human health and climate change, and fit with recommendations for dietary transitions toward reduced meat consumption and increased plant-based diets, particularly in Western civilization (Godfray et al., 2018; Graça et al., 2019). Moreover, the novel meat alternatives are particularly targeted at flexitarians - omnivores who are looking to eat less animal foods. Given the close resemblance of novel plant-based meat alternatives to meat, we will discuss the nutritional and ecological impacts of eating plant-based meat alternatives vs. animal meats, while also providing a broader discussion of the ecological and health effects of replacing animal foods with plant foods.

Rise of Plant-based Meat Companies

Several companies have emerged as leaders in the plant-based meat industry, driving innovation and expanding product offerings. Beyond Meat and Impossible Foods are two prominent examples, known for their realistic plant-based burgers and other meat alternatives. These companies have successfully captured consumers' attention worldwide and have partnerships with major food chains and retailers to make plant-based options more accessible.

Ecological impacts of plant-based meat vs. Meat consumption

The plant vs. meat controversy takes on other dimensions when assessing environmental degradation and climate change, both of which adversely affect human health and are crucial considerations when making recommendations on diets for livestock and humans. Meeting requirements of nutrients with plant foods (e.g., folate, manganese, thiamine, copper, and β-carotene) may come at a lower environmental footprint (i.e., less greenhouse gas emissions) than when these nutrients are met with animal foods (Eshel et al., 2019).Moreover, when footprints—land use for production and as greenhouse gas emissions (GHGE)—are calculated to consider amino acid content and nutrient density (e.g., iron, vitamin B_{12}, zinc, retinol, and amino acids), the footprint of animal foods may be more similar to plant foods (Drewnowski et al., 2015; Tessari et al., 2016) because animal foods can more readily meet our needs for these specific nutrients.

The lower carbon footprint of plant-based meat alternatives is touted as the main reason for choosing plant alternatives over beef. Recent life-cycle analysis (LCA) of the Beyond Burger® and the Impossible™ Burger demonstrates a smaller carbon footprint (+3.2 and 3.5 kg CO_2-eq emissions/kg product, respectively) compared to US beef finished on total-mixed rations in feedlots (Heller and Keoleian, 2018; Quantis International, 2019a), which ranges from +10.2 to +48.5 kg CO_2-eq emissions/kg product, this depends on the model used, the geographical location where the cattle are raised, and the inclusion of GHGE potential of retail, distribution, restaurant or at-home use, and end-of-life stages (Heller and Keoleian, 2018; Stanley et al., 2018; AsemHiablie et al., 2019; Rotz et al., 2019).

Plant-based Meat vs Environmental Impact

One of the most compelling reasons for the growing popularity of plant-based meat is its positive impact on the environment. The production of traditional meat, particularly beef, is associated with significant greenhouse gas emissions, deforestation, and water usage. In contrast, plant-based meats have a vastly lower environmental footprint. Studies have shown that producing plant-based burgers results in significantly lower greenhouse gas emissions and requires far less land and water compared to beef burgers.

Plant-based Meat vs Health Benefits

Beyond its environmental advantages, plant-based meat offers numerous health benefits. These products are typically lower in saturated fats and cholesterol compared to traditional meats, making them a heart-healthy choice for individuals concerned about cardiovascular health. Plant-based meats are also free from antibiotics,

hormones, and other additives commonly found in animal-derived products, offering a cleaner and more natural option for consumers.

Plant-based Meat vs Culinary Versatility
One of the most exciting aspects of plant-based meat is its culinary versatility. These products can be used in a wide range of recipes and cuisines, allowing home cooks and chefs to get creative in the kitchen. From plant-based burgers and tacos to stir-fries and pasta dishes, the possibilities are endless. Plant-based meats can also be grilled, roasted, sautéed, or fried, providing a satisfying and flavorful experience for those craving the taste of meat without environmental or ethical concerns.

Plant-based Meat vs Animal Welfare
Another key advantage of plant-based meat is its positive impact on animal welfare. The production of traditional meat often involves intensive farming practices that can lead to animal suffering. By opting for plant-based alternatives, consumers can contribute to reducing the demand for animal products and promote more ethical food choices.

Benefits of Plant-based Meat
Environmental Sustainability- One of the primary reasons for the growing popularity of plant-based meat is its environmental benefits. Traditional meat production is associated with high levels of greenhouse gas emissions, land use, and water consumption. Plant-based meat, on the other hand, has a significantly lower environmental footprint, making it a more sustainable choice for environmentally conscious consumers.

Animal Welfare- Another key advantage of plant-based meat is its positive impact on animal welfare. The production of traditional meat often involves intensive farming practices that can lead to animal suffering. By opting for plant-based alternatives, consumers can contribute to reducing the demand for animal products and promote more ethical food choices.

Health Considerations- Plant-based meat offers several health benefits compared to traditional meat. It is typically lower in saturated fat and cholesterol, making it a heart-healthy option for individuals looking to improve their diet. Plant-based meats are also free from antibiotics and hormones commonly found in animal products, offering a cleaner and more natural alternative.

Diverse Options- Plant-based meat products come in a wide range of varieties, including burgers, sausages, chicken nuggets, and more. This diversity allows consumers to enjoy their favourite meat-based dishes while opting for a plant-based alternative, making it easier to transition to a more plant-centric diet.

Future of Plant-based Meat
As consumer awareness and demand for sustainable food options continue to grow, the plant-based meat industry is poised for further expansion and innovation. Major food companies, restaurants, and retailers are increasingly offering plant-based options on their menus and shelves, reflecting a shift towards more plant-centric diets. Advancements in food science and technology are also driving improvements in plant-based meat products, enhancing their taste, texture, and nutritional profile. From startups to established brands, there is a collective effort to make plant-based meats more accessible, affordable, and appealing to a broad audience.

Challenges and Future Outlook
While the plant-based meat sector continues to grow, it faces certain challenges, including taste and texture consistency, price competitiveness, and consumer acceptance among traditional meat eaters. However, ongoing research and development efforts are addressing these challenges, leading to continuous improvements in plant-based meat products.

The future outlook for plant-based meat is promising, with projections indicating sustained growth and increasing market share. As awareness of environmental and health issues continues to grow, more consumers are likely to embrace plant-based alternatives as part of their regular diet, driving further innovation and market expansion.

Conclusion
Plant-based meat represents a revolutionary shift in the way we approach food production and consumption. With its numerous benefits, including environmental sustainability, animal welfare, and health considerations, plant-based meat is poised to play a significant role in shaping the future of food. As technology advances and consumer preferences evolve, we can expect to see even more diverse and compelling plant-based options that cater to a wide range of tastes and dietary preferences. Future studies should consider calls for collaboration, particularly among stakeholders of the food supply chain (i.e., industries and food services) and the scientific community (i.e., nutritionists and dietitians, food technologists, and consumer scientists) to facilitate the transition toward healthier and more sustainable plant-based protein sources.

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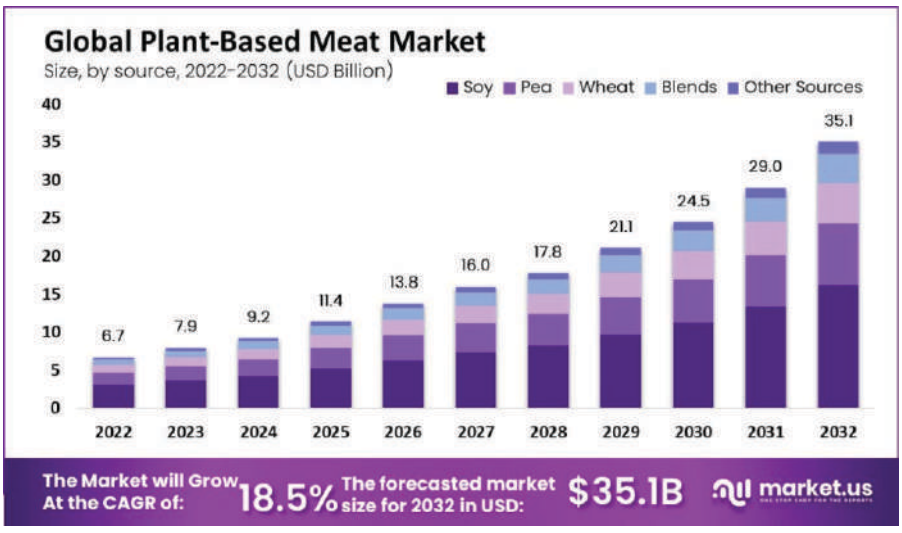

Pulicat Lake's Aquatic Ecosystem under Siege:

The Charru Mussel Invasion

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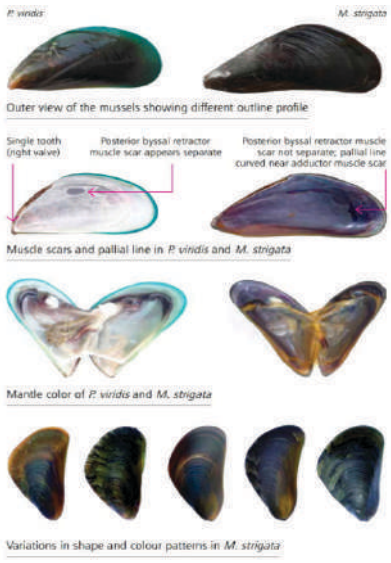
Introduction to Pulicat Lake's Ecosystem:

Pulicat Lake, the second largest brackish water lagoon in India, is located along the southeast coast between Andhra Pradesh and Tamil Nadu.Geographically the lake is situated in between 13 24'-13 43' N latitude and 80 03'- 80 18' E longitudes.Originally covering 461 km² with an average depth of 1.5 meters, it has now reduced to 350 km² with a depth of less than one meter due to siltation. The lake spans the Nellore district of Andhra Pradesh and Thiruvallur district of Tamil Nadu, connecting to the Bay of Bengal near Pulicat village. Its drainage area is 4,400 km², yielding about 1,100 tonnes annually. The lake receives water from three monsoonal rivulets—Swarnamukhi, Kalangi, and Arni—and is intersected by the Buckingham Canal at its southern end. It also features several mud-flats and large islands, including Sriharikota, Venaadu, and Irukkam. It is an ecologically rich area, home to diverse species such as migratory birds, fish, and mangroves, which support both biodiversity and local livelihoods through fishing and shrimp farming. The lake also holds cultural importance for local communities. However, it faces environmental challenges like pollution, habitat degradation, and the impacts of climate change.

Understanding the Charru Mussel (Mytella strigata):

The Charru mussel *Mytella strigata* (previously known as *M. charruana*) is native to South America and has become invasive in many parts of the world. Is a small, fast-reproducing bivalve that has become an invasive species in regions like Pulicat Lake? Thriving in brackish waters, this mussel can tolerate a wide range of salinity levels, allowing it to spread rapidly.In spat stage *M. strigata* can be confused with the spat of the green mussel, *Perna viridis* Shell of *M. strigata* is dark brown to black in colour,The beak of *P. viridis* is more pointed as compared to that of *M. strigata*.Identity of *M. strigata* can also be confirmed using molecular techniques.. However, it can be distinguished from the green mussel visually based on the following characters.. Typically measuring 2 to 3 centimeters, the mussel reproduces quickly by releasing large numbers of gametes, resulting in significant



population growth. Its larvae are free-swimming, enabling wide dispersal before settling on surfaces such as rocks or piers. Its invasive traits—such as high tolerance to environmental conditions, fast colonization, and competitive dominance over native species—make it a serious ecological threat

The Spread of Charru Mussels in Pulicat Lake:
The spread of the Charru mussel (*Mytella strigata*) in Pulicat Lake has been rapid and concerning, driven by the mussel's adaptability to the lake's brackish waters and favorable environmental conditions. Likely introduced through ballast water or aquaculture practices, the mussel quickly colonized large areas of the lake, displacing native species. Key factors contributing to its spread include its high reproductive rate, which allows it to release vast numbers of larvae dispersed by water currents, and its wide tolerance for varying salinity and temperature levels. The absence of natural predators in Pulicat Lake further enables the mussel to proliferate unchecked. Forming dense clusters on rocks, poles, cages, and man-made structures, the Charru mussel outcompetes native mollusks and other aquatic organisms for space and food, significantly altering the lake's ecosystem. Its filter-feeding behavior affects water quality and nutrient cycles, while the decline of native species threatens local fisheries and the livelihoods of fishing communities. As the Charru mussel continues to expand, it poses serious ecological and economic challenges, underscoring the need for urgent management efforts.

Ecological Impacts of the Invasion:
The invasion of the Charru mussel (*Mytella strigata*) in Pulicat Lake has caused significant ecological disruptions, threatening the balance of the lake's ecosystem. One of the primary impacts is the displacement of native species, particularly mollusks, which are outcompeted for space and food. The Charru mussel forms dense colonies on rocks, poles,cages, and submerged structures, limiting habitats for native organisms and reducing biodiversity. This competition also affects the broader food web, as species reliant on native mollusks, such as fish and birds, face declining populations due to reduced prey availability. Additionally, the Charru mussel's filter-feeding behavior alters water quality and nutrient cycles by removing large amounts of phytoplankton, potentially disrupting oxygen levels and overall ecosystem health. These dense colonies also degrade habitats by covering surfaces and damaging vegetation like mangroves, further impairing the ecosystem's ability to support diverse life forms. The decline of native species and changes in water quality indirectly affect fish populations, exacerbating the ecological imbalance. Without intervention, these widespread impacts could have long-lasting consequences for Pulicat Lake's biodiversity and ecological integrity.

Alterations in Water Quality and Habitat Structure:
As filter feeders, Charru mussels consume large amounts of phytoplankton, disrupting nutrient cycles and potentially reducing dissolved oxygen levels, which can lead to localized hypoxia and harm aquatic organisms. Their feeding also increases water clarity by removing suspended particles, but this can reduce food supply for small organisms and filter-feeding fish, disrupting the food chain. Moreover, clearer water allows deeper sunlight penetration, altering aquatic plant growth and sometimes promoting algal blooms. In terms of habitat structure, the mussels form dense colonies on rocks, mangroves, and submerged surfaces, creating barriers that limit space and movement for native species, a phenomenon known as biofouling. This biofouling not only affects natural habitats but also damages man-made structures like piers and boats, causing economic losses. The invasion has also harmed critical ecosystems such as mangrove forests and seagrass beds, smothering their growth and reducing their ability to support marine life. Overall, the Charru mussel has caused widespread changes in water quality and habitat structure, threatening the lake's biodiversity and ecological balance.

Economic and Social Consequences:
The lake's fisheries have been particularly affected, with native fish and shellfish populations declining as the mussels outcompete them for resources. This has led to reduced catches, financial strain, and uncertainty for fishermen. Aquaculture operations, especially shrimp farming, have also suffered due to the mussels' fouling of ponds and equipment, increasing maintenance costs and decreasing yields. Additionally, the mussels cause damage to infrastructure like piers, boats, and water intake systems, leading to costly repairs and operational disruptions. The resulting economic hardships impact families' ability to meet basic needs and disrupt traditional practices and cultural rituals associated with the lake. In response, communities have had to adapt by seeking alternative livelihoods and raising awareness about the issue, underscoring the urgent need for effective management strategies to support affected populations and mitigate the invasion's effects.

Response and Mitigation Efforts:
Addressing the Charru mussel (*Mytella strigata*) invasion in Pulicat Lake involves a range of immediate and long-term strategies. Initially, monitoring and assessment are crucial to track the spread and impact of the mussels, followed by physical removal efforts to manage localized infestations. Preventing further spread involves cleaning and decontaminating equipment and regulating ballast water management. Long-term mitigation includes exploring biological control methods, such as introducing natural predators or pathogens, and employing chemical treatments, while ensuring minimal environmental harm. Habitat restoration efforts, like replanting mangroves and seagrass beds, aim to recover affected ecosystems. Public awareness and education campaigns are essential for promoting best practices and

engaging local communities in management efforts. Ongoing collaborative research and strengthening policies related to ballast water and invasive species control are vital for developing effective strategies and preventing future invasions. Together, these efforts are crucial for managing the Charru mussel invasion and safeguarding Pulicat Lake's ecological health.

Challenges in Managing the Invasive Species:

The mussel's rapid reproduction and wide tolerance range complicate control efforts, as it quickly repopulates and thrives in various conditions. The lack of natural predators in its new environment exacerbates the problem. Ecologically, the mussel disrupts water quality and habitat structure, which adds complexity to management efforts and can lead to further habitat damage if not carefully balanced. Operationally, managing the invasion is resource-intensive, requiring substantial funding, equipment, and manpower, which strains available resources. Effective coordination among stakeholders, including government agencies, scientists, and local communities, is crucial but often challenging. The socio-economic impact on local communities, particularly in fishing and aquaculture industries, complicates efforts to secure support for management measures. Additionally, raising public awareness and achieving compliance with best practices can be difficult. Regulatory challenges include inadequate policies and the need for adaptive management strategies that can be slow to implement. Addressing these multifaceted challenges requires a coordinated and resourceful approach to effectively mitigate the impacts and control the spread of the Charru mussel.

Conclusion and Call to Action:

The invasion of the Charru mussel (Mytella strigata) in Pulicat Lake poses a severe threat to the lake's ecological health, economic stability, and social well-being. The rapid spread of this invasive species has disrupted native biodiversity, altered water quality and habitat structure, and imposed significant financial burdens on local communities. Addressing this complex issue requires both immediate and long-term action. Immediate measures should include ongoing monitoring, physical removal efforts, and strategies to prevent further spread. Long-term efforts must explore biological and chemical control options, restore affected habitats, and raise public awareness about the impacts of invasive species. Effective management will rely on collaboration among government agencies, scientists, local communities, and other stakeholders, alongside strengthening policies and regulations related to invasive species and ballast water control. Increased investment in research and development is crucial for finding innovative solutions, and public engagement is essential for fostering community support and promoting best practices. The time to act is now; by working together and adopting a proactive approach, we can mitigate the impacts of the Charru mussel invasion and restore the health and resilience of Pulicat Lake's ecosystem, securing its future for both the environment and the communities that depend on it.

Date of Publishing:
7 December 2024

RNI Regn. No.: 52899/93
Postal Regn. No.: HD/1068/2024-2026

Date of Posting:
8th, 9th December 2024

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