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THE NEOTIA UNIVERSITY
ज्ञानम् आत्म प्रदीपाय
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MATSYA JAGAT

Vol. 1, Issues 4 Dec., 2023

- Division of Fisheries Science
The Neotia University
Sarisha, Diamond Harbour

Content

Forewords

Dear Readers,

It is with great pleasure that I welcome you to the 4rth issue of our E-Magazine **"Matsya Jagat"**. As we navigate the dynamic currents of the aquatic world, our commitment to delivering insightful content remains steadfast.

In this issue, we strive to bring you forward-thinking perspectives that shed light on the evolving landscape of fisheries. Dedicated team of writers and experts of the Division of Fisheries Science have delved into a myriad of topics, from sustainable practices to cutting-edge technologies, all aimed at fostering a harmonious relationship between humanity and the oceans.

One of the focal points of this edition is the exploration of innovative approaches to fisheries management. As our planet faces unprecedented challenges, the need for adaptive strategies is more apparent than ever.

I would like to take this opportunity to express my gratitude to Prof. (Dr.) H Shivananda Murthy (Chair Professor, Division of Fisheries Science, TNU) for this thoughtful initiative. I take this opportunity to extend my best wishes to all readers.

Dr. Biswajit Ghosh
Vice Chancellor
The Neotia University

The Editor-in-Chief Message

Welcome, avid readers and enthusiasts of aquatic wonders, to the 4rth issue of E-Magazine **"Matsya Jagat"**. In the following pages, we immerse ourselves in the dynamic and ever-evolving world of fisheries, where the ebb and flow of life beneath the water's surface intertwines with the tapestry of human existence.

Our contributors (Professors) of the Division of Fisheries Science to passionate anglers, offer a diverse array of insights, research findings, and stories that illuminate the multifaceted nature of fisheries. From the sustainable practices that safeguard our oceans for future generations to the cultural significance of fishing traditions

In this issue, we delve into the latest advancements in fisheries science, examining how technology, conservation efforts, and responsible management practices are shaping the future of our aquatic resources. Yet, we also honor the timeless art of angling, recognizing the profound connection between humans and the aquatic creatures that grace our rivers, lakes, and oceans.

Thank you for joining us on this exploration of the watery realms. May Matsya Jagat serve as a beacon for understanding, appreciation, and sustainable stewardship of the fisheries that enrich our lives.

I would like to place on record my appreciation for the consistent efforts put in by the editorial team towards making of this magazine.

Prof (Dr.) H Shivananda Murthy
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From the
Editorial Desk

Dr. Vikas Pathak

Editor- Matsya Jagat,
Assistant professor and Head

Dear Fisheries Enthusiasts,

As we dive into another captivating issue of Fisheries Magazine, I am thrilled to welcome you to an edition that promises to be both insightful and thought-provoking. Our dedicated team of contributors has worked tirelessly to bring you a diverse range of activity of the division, recent news of fisheries, articles, students corner, and perspectives.

In this issue, we explore the latest advancements in sustainable aquaculture practices, shedding light on innovative technologies and strategies that are shaping the future of the industry. Our commitment to environmental conservation and responsible fishing practices remains unwavering.

As we navigate the challenges and opportunities within the fisheries sector, our magazine continues to be a platform for sharing knowledge, fostering dialogue, and inspiring positive change.

Thank you for your continued support and enthusiasm for Fisheries Magazine Matsya Jagat. We hope this issue sparks new ideas, encourages collaboration, and contributes to the ongoing dialogue that shapes the future of fisheries.

Wishing you an enjoyable and enlightening read.

Best Regards,

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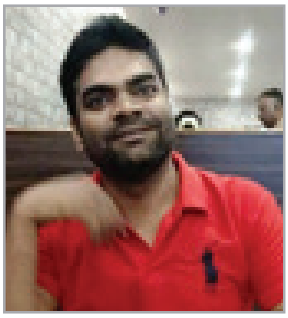
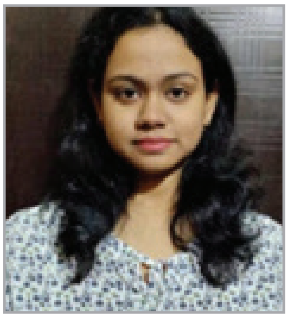
Editorial Members





Dr. Neeraj Pathak

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Dr. Neeraj Pathak is an Assistant Professor and Faculty Head for the Division of Fisheries Science, as well as in charge-head of Fish Processing Technology and Fisheries Engineering Department at The Neotia University. He is also serving as Academic Coordinator of the Division. He received his doctorate in the subject of Fish Quality Assurance and Management. He has teaching experience of seven years of various organizations throughout India. He has received several national and international Awards. His areas of interest in the research include Fish Processing Technology, Seafood Thermal Processing (Developed a pasteurization technique for soft shell blue swimming crabmeat in Ph.D. research work), and Emerging Fish Quality and Safety (Including value chain analysis for crabmeat, Seafood authentication, Traceability, Exposure of Nanoscience Technology of Scanned Electron microscopy and Transition Electron Microscopy for the crabmeat, Exposed to handle all quality analysis advanced instrument Viz. ICPMS, GCMS, SEM, TEM, LCMS, TPA).

Ms. Camelia Chattopadhyay

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She holds a master degree (M.F.Sc) in Fisheries Extension from ICAR-CIFE, Mumbai. She has different training experiences regarding fish culture and value-added fish products from several reputed fisheries institutes. She has participated as Event Manager/Media Crew in ICAR NAHEP sponsored Skill Development Programme on Communicating Science. She has completed one month internship in ‘Video Editing’ from ‘Bangla Time’, Kolkata. She has participated in All India Agri Uni Fest in the event group dance at Shree Venkateshwara Veterinary University (SVVU), Tirupati. Her directed and edited tribal short film ‘Dream Never Lies’ has been awarded in International Micro Film Festival, Kolkata in January, 2022. She has published research paper in popular journals.

Editorial Members

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Dr. Bardhan's research focuses on antibiotic resistance, with a particular emphasis on florfenicol. He has made significant contributions to the field, publishing and co-authoring approximately 13 papers, book chapters and popular articles in renowned national and international journals. Notably, he worked as a young professional II for 6 months under the national project 'All India Network Project on Fish Health. He has organized several fish farmers training program.. he actively serves as a reviewer for several esteemed international journals. He is a life member of the Healthcare and Biological Sciences Research Association (HBSRA) and holds recognized memberships with prestigious organizations. He has received research grant project proposal in TNU, reflecting his dedication to innovative research.

Dr. Suman Karmakar
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Dr. Suman Karmakar is an Assistant Professor in the Fishery Science Division at The Neotia University. He has received Masters degree and Doctor of Philosophy award in the subject of Aquatic Environment Management. He was participated different types of National and International Symposium. He is expert in the field of Aquatic Toxicology and Aquatic Ecology and Biodiversity. He was published a number of research article in National and International Journals.

Editorial
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Mr. Khemraj Bunkar is an Assistant Professor in the Department of Fisheries Economics. The Neotia University, Sarisha, West Bengal, India. He received his Master's degree in the subject of Fisheries Economics from the ICAR- Central Institute of Fisheries Education, Mumbai. In addition, He qualified for the ICAR - National Eligibility Test (ICAR-NET) in the subject of Agriculture Economics. His areas of interest in the research include fish supply chain analysis, value chain analysis, and economics of reservoir fisheries & fish markets. He has published a number of research articles, book chapters, books, and popular articles in peer-reviewed national and international journals, magazines, and publishers.

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Dr. Mudasir is an Assistant Professor in the Division of Fisheries Sciences at The Neotia University. With a strong background in Fish Genetics and Biotechnology, his research focuses on fish nutritional genomics and proteomics, plant-based alternatives for antibiotics, and the development of climate-resilient aquaculture systems through genome editing and nutritional intervention. Dr. Hakim completed his Ph.D. in Animal Biotechnology from Faculty of Veterinary Sciences & Animal Husbandry SKUAST-K, where he worked on identifying novel bioactive compounds for growth and immune response in Rainbow trout aquaculture. He has published numerous research articles, collaborated with prestigious research institutes both in India and abroad, and received awards and scholarships for his contributions to the field. Previously he did his MFSc (Fish Biotechnology) from CoF Ratnagiri DBSKKV Maharashtra. He graduated in Fisheries Sciences from Faculty of Fisheries SKUAST-K.

Editorial Members

Dr. Pankaj Gargotra

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Dr. Pankaj Gargotra joined the faculty on July 7th, 2023, and has been employed as an assistant professor in aquaculture at the Fisheries Division of The Neotia University. He has done his doctorate in Aquaculture from Fisheries College and Research Institute, Toothukudi (Tamil Nadu Dr. J Jayalalithaa University, Nagapattinam). For his doctorate, he received a Senior Research Fellowship from ICAR. For the first time ever in captivity, he successfully reproduced an Indian Spiny Loach during his doctoral studies. Dr. Pankaj Gargotra received his master's degree in aquaculture from the Kerala University of Fisheries and Ocean Studies, Kochi. During his master's program, he worked on replacing soy meal with guar meal and investigated its impact on the development and survival of Cyprinus carpio fry. Dr. Pankaj Gargotra graduated from the Faculty of Fisheries, Rangil, SKUAST-K. Additionally, he has 1.6 years of work experience from the ICAR-DCFR, where he made a substantial contribution to the first successful breeding of the key coldwater fish species Barilius vagra.

Ms. Aditi Rambhau Banasure

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Ms. Aditi Rambhau Banasure is working as an Assistant Professor. She completed her graduation (B.F.Sc.) from the College of Fishery Science, Nagpur, and post-graduation (M.F.Sc.) from the College of Fisheries, Shirgaon, Ratnagiri, Maharashtra under the Fisheries Engineering and Technology department. She has research experience on study and designing traditional freshwater fish traps in Ratnagiri district, Maharashtra, India in the Department of Fisheries Engineering and Technology. She has published research papers, articles, and abstracts. Also, she has presented at international conferences and attended training, skill development programs, and workshops.

Activities
of the Division of Fisheries Science

Routine random sampling of fish ponds involving B.F.Sc. Students. Sampling is done to know the performance (growth and overall health) of fish species under culture.

Newly inaugurated unit of Integrated (Duck cum fish farming) under the Division of Fisheries Science


Newly inaugurated unit of Ornamental Fish Production under the Divison of Fisheries Science





Different activities under skill development program

Entrepreneurship skill development programme successfully completed under students ready programme of the final-year B.F.Sc students.

Water quality testing at the fish pond

Water quality testing at the duck cum fish pond

Students signalizing water quality parameters in the laboratory

Out of campus activity

Visited NBFGR, Lucknow during All India Study Tour Program

Visited NFDB - Eastern Regional Centre/ Department of Fisheries, Bhubaneshwar, Orissa

Visited ICAR-DCFR Nainital, Uttarakhand during All India Study Tour program


Student activities during Rural Fisheries Work Experience (RFWE)

Industrial and Academic collaboration of the Division of Fisheries Science

MoU between The Neotia University and ICAR-CIFRI

The Division of Fisheries Sciences has recently signed MoU with another premier Central Government Institute, namely, ICAR- Central Inland Fisheries Research Institute, Barrackpore, West Bengal. In fact, it was the 1st Fisheries Institute in the Country established by the pre - independent India. It has all the infrastructure and state of art research facilities. We have signed MoU with this Institute recently, which will pave the way for collaboration in Education, Research and Extension Education, particularly students internships, inplant training, exchange of students and faculty visits and research collaboration.

Earlier MoUs were signed with another ICAR- Central Institute for Freshwater Aquaculture, Bhubaneswar; Bangladesh Agriculture University, Sylhet; M/s Anmol feeds Pvt Ltd and several other Corporate and Industries related to Fisheries

MoU between The Neotia University and Bangladesh Agricultural University

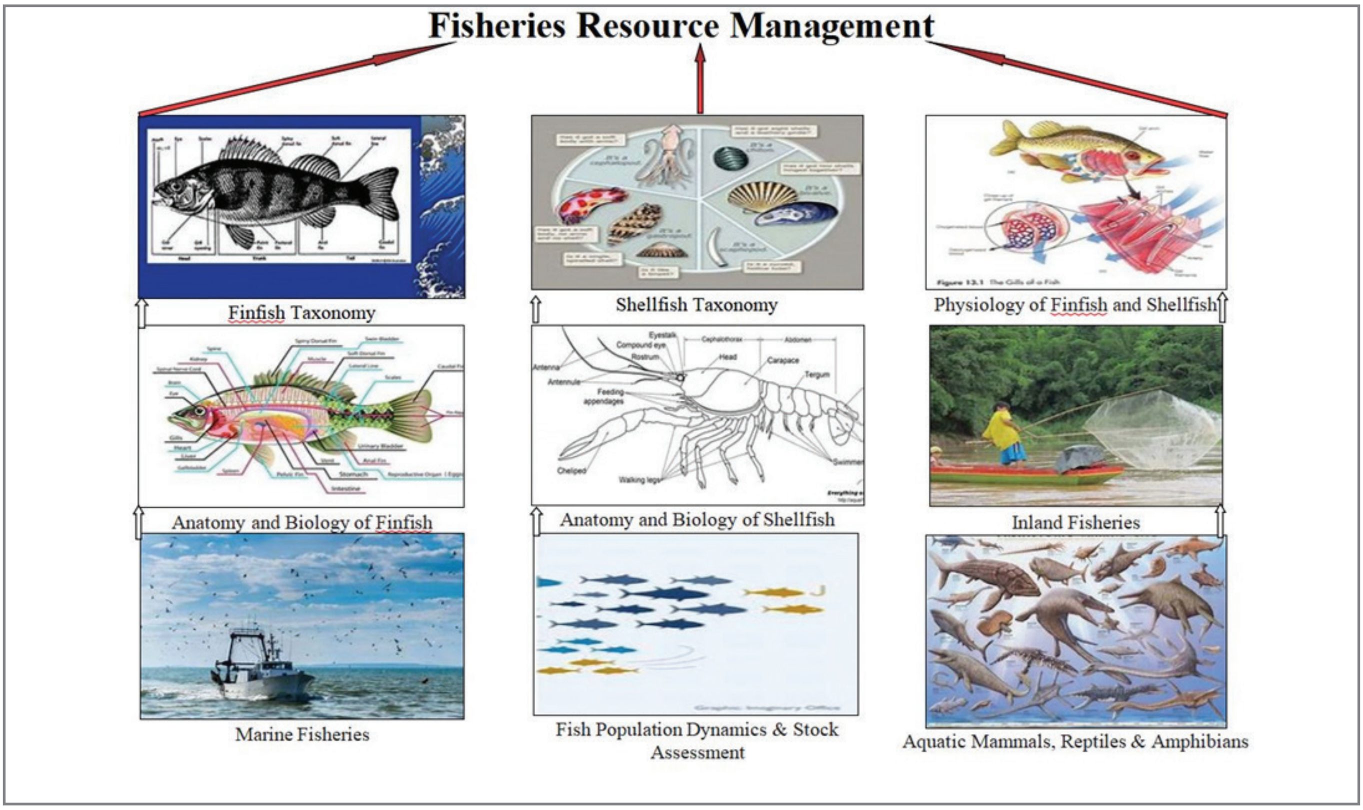
MoU between The Neotia University and Krishna Agritech Industries

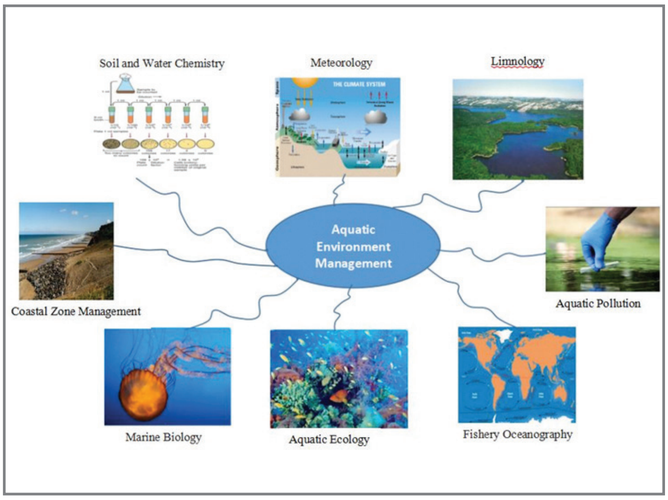
MoU between The Neotia University and Aqua Doctor Solutions

MoU between The Neotia University and NDM Seafood processor and Exporter

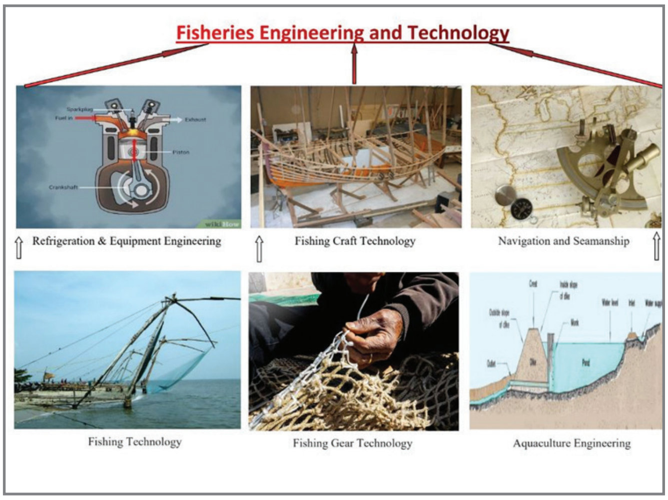
MoU between The Neotia University and Anmol Feeds Pvt. Ltd.

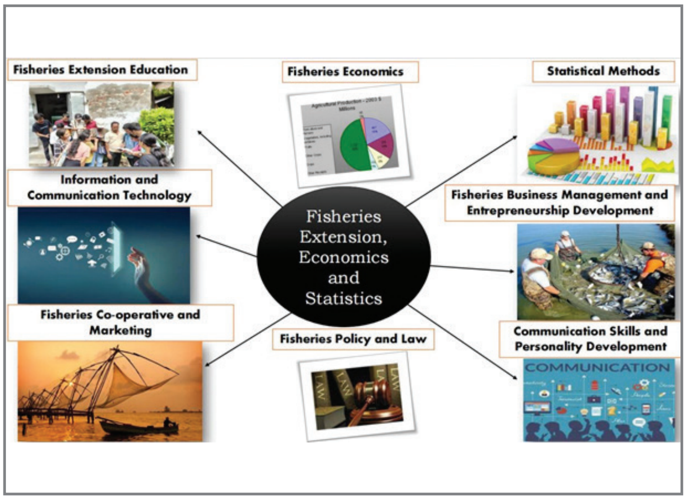
B.F.Sc. Courses

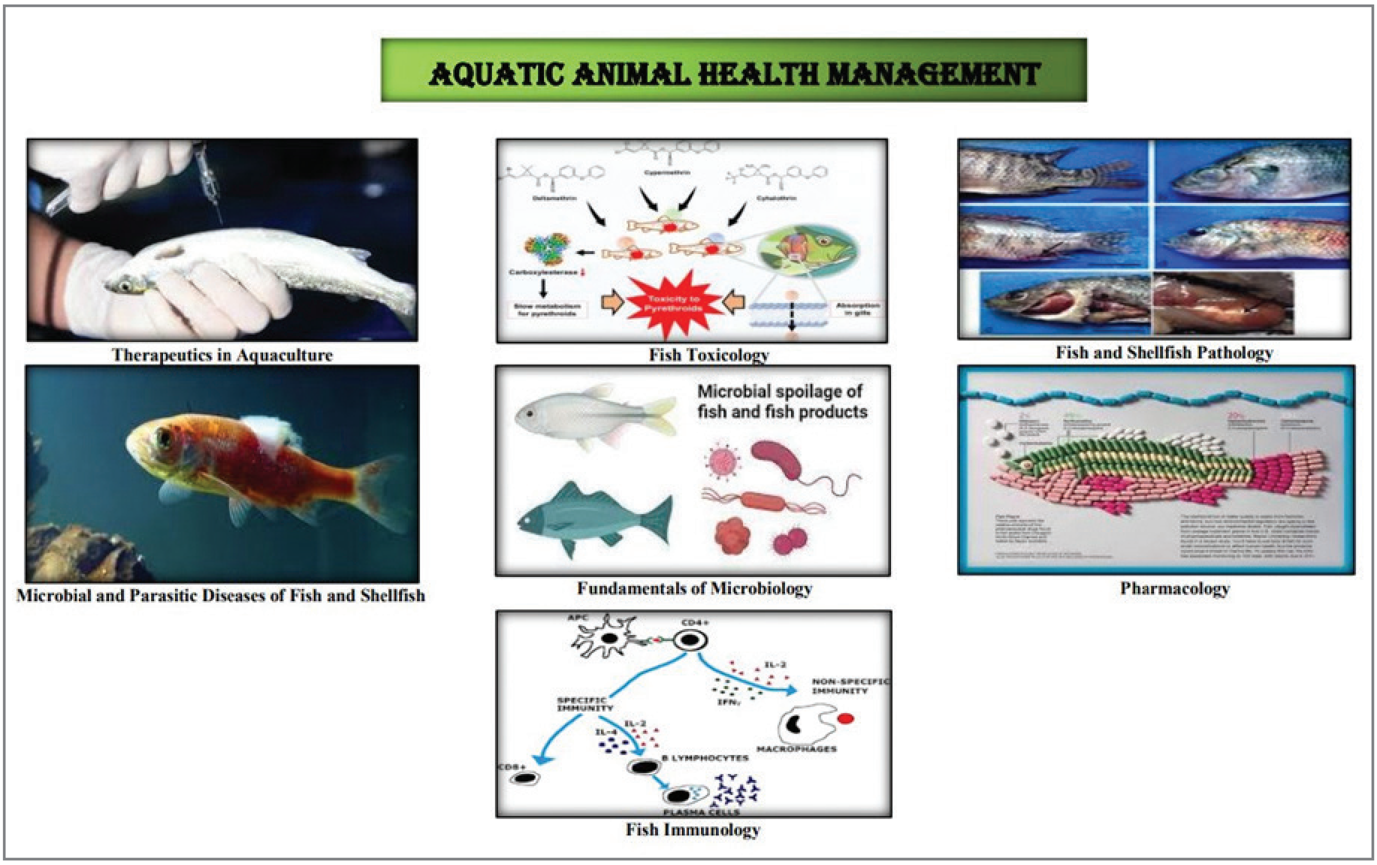



Soil and Water Chemistry
Meteorology
Limnology
Aquatic Environment Management
Coastal Zone Management
Aquatic Pollution
Marine Biology
Aquatic Ecology
Fishery Oceanography


FISH PROCESSING TECHNOLOGY
Fish in Nutrition
Food Chemistry
Freezing Technology
Fish Canning Technology
Fish Packaging Technology
Fish By-products and Waste Utilization
Microbial spoilage of fish and fish products
Fish Products and Value Addition
Microbiology of Fish and Fishery Products
Quality Assurance of Fish and Fishery Products


Fisheries Engineering and Technology
Refrigeration & Equipment Engineering
Fishing Craft Technology
Navigation and Seamanship
Fishing Technology
Fishing Gear Technology
Aquaculture Engineering


Fisheries Extension Education
Fisheries Economics
Statistical Methods
Information and Communication Technology
Fisheries Extension, Economics and Statistics
Fisheries Business Management and Entrepreneurship Development
Fisheries Co-operative and Marketing
Fisheries Policy and Law
Communication Skills and Personality Development
COMMUNICATION


AQUATIC ANIMAL HEALTH MANAGEMENT
Therapeutics in Aquaculture
Fish Toxicology
Fish and Shellfish Pathology
Microbial spoilage of fish and fish products
Microbial and Parasitic Diseases of Fish and Shellfish
Fundamentals of Microbiology
Pharmacology
APC
CD4+
IL-2
NON-SPECIFIC IMMUNITY
SPECIFIC IMMUNITY
IFN
IL-4
MACROPHAGES
B LYMPHOCYTES
CD8+
PLASMA CELLS
Fish Immunology

Students Corner

1. Which of the following Fishes found in association with Bombay duck & Non-penaeid prawns.
   A) Ribbon Fish **B) Golden Anchovy** C) Whaite Bait D) Unicorn Cod.

2. Green eye chlorophthalmus spp. Were predominant in depth zone of...................................
   A) **200-400mt** **B) 400-600mt** C) 600-800mt

3. Among perches, which species contributing highest production.
   A) Rock Cod B) Snappers C) Pig Face Breams **D) Thread Fin Breams**

4. SILO fish feed is prepared from
   A) Tuna Waste B) Shrimp Waste C) Cephalopod Waste D) Sardine Waste.

5. Rich resources of Windowpane oyster found in...................................
   A) A.P. (Kakinada) B) Goa C) Gujarat

6. Which of the following tuna species are oceanic in nature.
   A) Yellow Fin Tuna B) Skipjack Tuna C) Big Eye Tuna **D) all**

7. Tuna is not exploited from which coast of India.
   A) W.B. B) Orissa C) Karnataka D) Goa

8. Major catch of large pelagics contributed in which gear
   A) Hook & Line B) Gill Nets C) Trawl Net **D) Both A & B**

9. Major gear for exploitation of oceanic tuna.
   A) Hook & Line B) Long Line C) Purse Seine D) Drift Gill Net

10. Major gear for exploitation of cobia.
    A) Trawl Net **B) Gill Net** C) Hook & Line D) Dol Net

11. Major gear for exploitation of barracuda
    A) Trawl Net B) Hook & Line C) Gill Net D) Dol Net

12. Which of the following reef fish species endangered species.
    A) Cheilinus undulates B) Sigunus canaliculatus C) Chaetodon collare
    D) Chlorus sordidus

13. A bottom set gill net which targeted lobsters in Gulf of mannar region
    A) Singhivalai B) Nanduvalai C) Thiruvalai D) Dhonivalai

14. A bottom set gill net which targeted crabs in Gulf of mannar region
    A) Nanduvalai B) Thalumadi C) Thiruvalai D) Dhonivalai

15. The central part of rampani net is called as
    A) Bunt B) Bay **C) Chikarbale** D) Allibale

Students Corner

16. Side portion of Rampani net is called as

    A) Allibale B) Chikarbale C) Bunt D) Lint

17. In Gujarat and Maharashtra net used exclusively for polynemid fishery

    A) Waghrajal B) Tramel Net C) Dol Net D) Trawl Net

18. In Maharashtra juvenile of polynemids called as

    A) Chalna B) Dara C) Karkara D) Dam

19. Nuchal spine is an important character in

    A) Polynemids B) Silver Biddies C) Tiger Perch D) All

20. Which of the following flat fish species forming an independent and full pledged commercial fishery

    A) Psettodes erumei B) Cynoglosius arel **C) C. macrostomus** D) C. dubius

21. Marine cat fishes are

    A) Predatory B) Carnivorous C) Scavengers **D) All**

22. In southern ratnagiri coast a net exclusively used to capture cat fish called

    A) Jot B) Paneli C) Maribale D) Odam

23. A fishery whose catches are consumed by fisher folks and their relatives only

    A) Artisanal Fishery **B) Subsistence Fishery** C) Commercialized Fishery
    D) Sub-commercialized Fishery

24. How many species of lesser sardines contribute to the pelagic fishery of Indian coast

    A) 14 B) 16 **C) 12** D) 8

25. Which of the following gear is used to capture mackerel

    A) Shore Seine B) Boat Seine C) Gillnet **D) all**

26. Leather jackets belongs to family

    A) Carangidae B) Serranidue C) Letherinidae D) Belonidae

27. How many species of carangids occurring along the Indian coast

    A) 46 **B) 56** C) 66 D) 76

28. Which of the following is not a targeted fishery

    A) Ribbon Fishes **B) Bill Fishes** C) Lobsters D) Tuna

29. Flying fish fishery at Coramandel coast mainly supported by

    A) Hirundichthys Coramandelesis B) Parexocoetu Sbrachypterus
    C) Exocoetus Volitans D) All

30. Satellite obtained the parameters

    A) SST & Chlorophylla **B) SST & Salinity** C) Chlorophylla & Salinity D) O_2, Salinity & SST

Logo of different council/institute

Sr. No.	Logo	Name of the Institute and city of headquarter as per the logo	Established (year)
1.	भाकृअनुप ICAR		
2.	CSIR-INDIA		
3.	सी एम एफ आर आइ CMFRI		
4.	CIFRI		
5.	सी.आई.एफ.टी		
6.	CENTRAL INSTITUTE OF FISHERIES EDUCATION		
7.	NBFGR		
8.	CIFA		
9.	CIBA		
10.	Directorate of Coldwater Fisheries Research		
11.	COCHIN		

Logo of different council/institute

Sr. No.	Logo	Name of the Institute and city of headquarter as per the logo	Established (year)
12.	CENTRAL INSTITUTE OF FISHERIES NAUTICAL & ENGINEERING TRAINING		
13.	THE MARINE PRODUCTS EXPORT DEVELOPMENT AUTHORITY - INDIA -		
14.	NFDB		
15.	NIO		
16.	NATIONAL INSTITUTE OF OCEAN TECHNOLOGY NIOT · CHENNAI ·		
17.	NABARD		
18.	KVAFSU COLLEGE OF FISHERIES, MANGALORE		
19.	MANAGE मैनेज		
20.	NOAA NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION U.S. DEPARTMENT OF COMMERCE		
21.	NCAOR · GOA ·		

Fisheries News

1. Central Marine Fisheries Research Institute's research on coral reefs garners national recognition (TOI: 06 Nov 2023)

The research on coral reefs being carried out by the ICAR Central Marine Fisheries Research Institute (CMFRI) has garnered national recognition, with Alvin Anto, a young professional at the institute, securing the prestigious Hasmukh Shah Memorial Award for Ecological Studies for the year 2023 in the research category. Anto has been recognised for his extensive research on the resilience of the coral reefs in the Lakshadweep Islands, highlighting the increasing threats these critical ecosystems face from climate change and other human-induced factors. The Hasmukh Shah Memorial Award, instituted by the Gujarat Ecology Society (GES) and funded by the Kachnar Trust, aims to honour and reward individuals who have made significant contributions through research, development, or implementation of innovative environmental, technical, or social solutions that address and mitigate pressing sustainability or societal issues

Coral reef and fish diversity

Fisheries News

2. Centre giving thrust to fisheries sector: Minister (TOI: 17 Oct 2023)

Fish exports and shrimp production and exports have doubled in the country in the last nine years, which shows that the central government is giving more thrust to this sector, said Union minister for fisheries, animal husbandry and dairying, Parshottam Rupala. The minister was speaking after inaugurating an international conclave on "Mainstreaming Climate Change into International Fisheries Governance and Strengthening of Fisheries Management Measures in the Indo-Pacific Region" in Chennai. The fish production in the country was only 95.79 lakh tonne during 2013-14, which rose to 131.37 lakh tonne in 2022-23. The annual shrimp production was 3.22 lakh tonne in the 2013-14 period, which touched 11.84 lakh tonne in 2022-23. Similarly, annual shrimp exports earned a revenue of Rs 19,368 crore in 2013-14, whereas now in the 2022-23 period, it fetched Rs 43,135 crore from the exports.

Fishing vessels of the India

Fisheries News

3. Extreme plankton bloom creates marine 'dead zone' off eastern Thailand (TOI: 4 Oct 2023)

An unusually dense plankton bloom off the eastern coast of Thailand is creating an aquatic "dead zone", threatening the livelihood of local fishermen who farm mussels in the waters. Marine scientists say some areas in the Gulf of Thailand have more than 10 times the normal amount of plankton, turning the water a bright green and killing off marine life. Plankton blooms happen one or two times a year and typically last two to three days, experts say. They can produce toxins that harm the environment, or they can kill off marine life by depleting the oxygen in the water and blocking sunlight. Chonburi's coasts are famous for their mussel farms, and more than 80% of the almost 300 plots in the area has been affected. The cause of the intense plankton bloom remains unclear, scientists believe pollution and the intense heat caused by climate change are to blame. "El Niño causes drought and higher sea temperatures," said Tanuspong. "Everything will get worse if we don't adjust how we manage resources, water waste and how we live." Earlier this year, a plankton bloom caused thousands of dead fish to wash up along a stretch of beach in Thailand. Worldwide, marine heatwaves have become a growing concern this year, with thousands of dead fish washing up on beaches in Texas

Coral reef and fish diversity

Fisheries News

4. Odisha urges DRDO to restrict missile testing during nesting season of turtles (The economic time: 09 Dec 2023)

The state government urged the DRDO to restrict missile testing off the Odisha coast in February and March -- the mass nesting season of the endangered olive ridley sea turtles. "It is an annual practice to request the DRDO to restrict testings during this time as these locations are close to the famed Gahirmath sanctuary, which is considered the cradle of olive ridley turtles," the senior official of the state Forest Department said. At a meeting chaired by Chief Secretary JK Jena on Dember 7, it was also decided to request the DRDO to appoint a nodal officer who will coordinate with the Fisheries Department for protecting the turtles. Lakhs of olive ridley turtles visit the state's coast every year for mating and laying eggs. While mating starts in January, the mass nesting begins in February at Gahirmath beach in Kendrapara district, Rushikulya beach in Ganjam and the confluence of the Devi river and Bay of Bengal in Puri district. These turtles are sensitive and it is feared that missile testings might have an adverse impact on their mating and mass nesting, the official said. During the last season, a record 6.56 lakh turtles had laid eggs at the Rushikulya rookery and 5.12 lakh turtles turned up for mass nesting at the Gahirmatha beach.

Sea turtle

Matsya Jagat. Oceanic acidification. Vol 1 Issue 4, Oct-Dec 2023, pp 25-27

Ārticle

Oceanic Acidification

Camelia Chattopadhyay

Division of Fisheries Science, The Neotia University, WB

Introduction

An acidic environment in the context of marine ecosystems typically refers to oceanic acidification, which is the ongoing decrease in the pH of Earth's oceans caused by the uptake of carbon dioxide (CO_2) from the atmosphere. Oceanic acidification refers to the ongoing decrease in the pH of Earth's oceans due to the absorption of carbon dioxide (CO_2) from the atmosphere. This process leads to an increase in the concentration of hydrogen ions (H^+) in the water, making it more acidic. The primary driver of ocean acidification is the excessive release of CO_2 into the atmosphere through human activities, mainly the burning of fossil fuels and deforestation.

Origin

When we burn fossil fuels like coal, oil, and natural gas for energy, we release large amounts of CO_2 into the atmosphere. While a significant portion of this CO_2 remains in the atmosphere, a considerable portion is absorbed by the oceans. When CO_2 dissolves in seawater, it reacts with water to form carbonic acid (H_2CO_3), which then dissociates into bicarbonate ions (HCO_3^-) and hydrogen ions (H^+). The increased concentration of hydrogen ions in the water decreases the pH of the ocean, making it more acidic. This process disrupts the delicate balance of ocean chemistry.

The chemistry of oceanic acidification:

It revolves around the interaction of carbon dioxide with seawater, which leads to the formation of carbonic acid. Here's a breakdown of the key chemical reactions involved:

- **Dissolution of CO_2 in Seawater:**

  When CO_2 from the atmosphere comes into contact with the surface of the ocean, it can dissolve in seawater. This dissolution is a physical process and doesn't involve chemical reactions. The dissolved CO_2 can exist in different forms, including molecular CO_2 ($CO_2(aq)$), bicarbonate ions (HCO_3^-), and carbonate ions (CO_3^{2-}).

- **Formation of Carbonic Acid:**

  Once dissolved CO_2 interacts with water molecules, it undergoes a series of chemical reactions to form carbonic acid (H_2CO_3): $CO_2(aq) + H_2O \rightleftharpoons H_2CO_3$

- **Equilibrium with Bicarbonate and Carbonate Ions:**

  Carbonic acid can further dissociate into bicarbonate ions and hydrogen ions: $H_2CO_3 \rightleftharpoons HCO_3^- + H^+$. In turn, bicarbonate ions can also dissociate into carbonate ions and additional hydrogen ions: $HCO_3^- \rightleftharpoons CO_3^{2-} + H^+$

These reactions collectively represent the equilibria between CO_2, carbonic acid, bicarbonate ions, and carbonate ions in seawater. As more CO_2 is absorbed from the atmosphere, the equilibrium shifts towards the production of more carbonic acid, bicarbonate ions, and hydrogen ions. This increase in hydrogen ions leads to a decrease in pH, making the seawater more acidic.

Significant impacts on marine ecosystems

Calcifying Organisms: Many marine organisms, such as corals, mollusks (including clams, oysters, and snails), and some types of plankton, rely on calcium carbonate to build their shells and skeletons. In an acidic environment, the availability of carbonate ions (a key component of calcium carbonate) decreases. This makes it harder for these organisms to build and maintain their calcium carbonate structures, leading to weaker shells, slower growth rates, and increased vulnerability to predation.

Coral Reefs: Coral reefs are particularly susceptible to ocean acidification. Corals build their skeletons from calcium carbonate, and when the ocean becomes more acidic, their ability to form these skeletons is impaired. This can result in slower coral growth, reduced reef structure integrity, and increased susceptibility to other stressors like rising sea temperatures and pollution.

Food Web Disruption: Ocean acidification can disrupt marine food webs. Many small marine organisms, such as plankton, are at the base of these food webs. If these organisms are affected by acidification, it can have cascading effects on the entire ecosystem. For example, reduced plankton populations can impact the fish that rely on them for food, which in turn affects the animals that prey on those fish.

Economic Impact: Ocean acidification can have significant economic implications. Fisheries that rely on shellfish, like oysters and clams, can be seriously affected. These shellfish are not only ecologically important but also economically valuable. Reduced growth and survival rates due to ocean acidification can lead to decreased yields and financial losses for shellfish farmers and fishing industries.

Biodiversity Loss: The overall biodiversity of marine ecosystems can be threatened by ocean acidification. Organisms that are more resilient to changing pH levels may outcompete more sensitive species, leading to shifts in the composition of marine communities. This can result in a loss of biodiversity and reduced ecosystem stability.

Ecosystem Services: Marine ecosystems provide various ecosystem services, such as carbon sequestration, nutrient cycling, and coastal protection. Ocean acidification could potentially disrupt these services, with broader implications for global climate regulation and the health of coastal areas.

Shell Formation and Growth: Many shell-forming organisms, such as oysters, mussels, and certain types of shrimp, rely on calcium carbonate to build their shells and skeletons. As the ocean becomes more acidic, the availability of carbonate ions decreases, making it harder for these organisms to build and maintain their shells. This can lead to weaker shells, slower growth rates, and increased susceptibility to predation and disease.

Fish Behavior and Physiology: Oceanic acidification can also affect the behavior and physiology of fish species. Some research suggests that elevated CO2 levels in the water can lead to changes in fish behavior, including altered predator-prey interactions, impaired sensory perception, and disrupted schooling behavior. Additionally, certain fish species may experience negative effects on their growth and development in more acidic conditions.

Relationship between climate change and ocean acidification

Climate change and ocean acidification are interconnected environmental issues, both driven by the increase in atmospheric carbon dioxide (CO2) concentrations primarily resulting from human activities such as the burning of fossil fuels and deforestation. Here's an overview of the relationship between climate change and ocean acidification:

CO2 Emissions: Human activities release substantial amounts of CO2 into the atmosphere. A significant portion of this CO2 is absorbed by the oceans, where it contributes to ocean acidification.

Warmer Ocean Temperatures: The excess heat trapped by greenhouse gases also leads to warmer ocean temperatures. Warmer waters can affect the rate of chemical reactions, including those driving ocean acidification.

Synergistic Effects: Both climate change and ocean acidification have negative impacts on marine ecosystems. Coral reefs, for example, are vulnerable to both higher temperatures (coral bleaching) and increased acidity (coral calcification reduction). These stressors can interact, making it even more challenging for marine organisms to survive and adapt.

Mitigation strategies: Ocean acidification is a complex issue primarily driven by the absorption of carbon dioxide (CO2) by the world's oceans, leading to a decrease in pH levels. To address and mitigate ocean acidification, it is crucial to focus on reducing carbon dioxide emissions and implementing strategies to protect marine ecosystems. Here are some key steps that can be taken:

1. Reduce Carbon Emissions:

- Transition to renewable energy sources: Promote and invest in renewable energy options such as solar, wind, and hydroelectric power to decrease reliance on fossil fuels.
- Energy efficiency: Implement energy-efficient technologies and practices in industries, transportation, and households to reduce overall carbon emissions.

2. **Reforestation and Conservation:**
    - Trees and plants absorb CO_2, so supporting reforestation and conservation efforts can help sequester carbon from the atmosphere.

3. **Sustainable Practices:**
    - Adopt sustainable agricultural practices that reduce carbon emissions and runoff into the oceans.
    - Implement sustainable fishing practices to maintain the health of marine ecosystems.

4. **Ocean Conservation and Restoration:**
    - Establish and expand marine protected areas to safeguard vulnerable ecosystems.
    - Support efforts to restore damaged marine habitats, such as coral reefs and seagrasses, which play a crucial role in buffering against acidification.

5. **International Cooperation:**
    - Encourage international cooperation to address the global nature of carbon emissions and ocean acidification. Agreements and initiatives that promote carbon reduction and conservation on a global scale are essential.

6. **Public Awareness and Education:**
    - Increase public awareness about the impacts of carbon emissions on the oceans and the importance of preserving marine ecosystems.
    - Support educational programs that promote environmental stewardship and sustainable practices.

7. **Research and Monitoring:**
    - Invest in research to better understand the specific impacts of ocean acidification and identify innovative solutions.
    - Establish monitoring programs to track changes in ocean acidity and assess the effectiveness of mitigation efforts.

8. **Policy and Legislation:**
    - Advocate for and implement policies that regulate carbon emissions and support sustainable practices.
    - Support international agreements and conventions aimed at mitigating climate change and protecting the oceans.

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Matsya Jagat. Prebiotics: enhancing aquaculture efficiency and sustainability. Vol 1 Issue 4, Oct-Dec 2023, pp 28-30

Prebiotics: Enhancing aquaculture efficiency and sustainability

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Introduction

Efficiency in aquaculture production is a paramount objective, often achieved through intensification. However, this intensification can render cultured organisms more susceptible to diseases due to deteriorating water quality and heightened stress. Bacterial infections frequently afflict these organisms, particularly when their immune systems are compromised by stress. Antibiotics, a common remedy, have faced criticism for their potential to foster antibiotic-resistant bacteria, disrupt environmental microbial ecosystems and exhibit limited efficacy in some cases. Furthermore, some antibiotics may suppress the immune system, rendering cultured organisms more vulnerable to viral or parasitic infections (Akhter et al., 2015). Concerns over antibiotic use have led to bans and stringent regulations in various regions, prompting the exploration of alternative disease control strategies. Recent research has focused on dietary supplementation as a promising avenue to bolster the health and disease resistance of cultured organisms. These supplements encompass immunonutrients and immunostimulants, differing in their modes of action. Immunonutrients support the immune system by providing substrates or energy sources, while immunostimulants enhance immunity through signals to the neuro-immuno-endocrine system or cell signaling pathways (Akhter et al., 2015). Among immunostimulants, prebiotics stand out for their numerous benefits in terrestrial and aquatic animals. Prebiotics are non-digestible food components that enhance host health by stimulating the growth and activity of beneficial gut bacteria (Gatlin et al., 2006).

Probiotics and immunostimulants in aquaculture

In aquaculture, immunostimulants derived from natural microbes or their products, such as lipopolysaccharides and β-glucans, activate the immune systems of aquatic animals. β-glucans, in particular, show promise for enhancing health and disease resistance when administered orally, though optimal protocols need refinement. Probiotics, like *Bacillus, Lactobacillus* spp., and others, enhance intestinal microbial balance, boosting disease resistance and immunity in aquatic organisms (Akhter et al., 2015). Challenges include cost, biological evaluations, impacts on microbial biodiversity, and

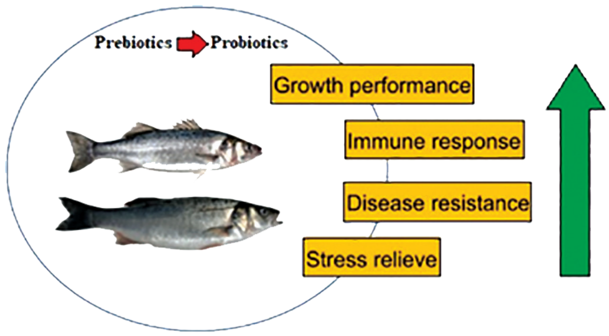


Fig. 1. An overview of the potential advantages a prebiotics has in aquaculture

constraints in dietary use, like heat susceptibility during processing. Prebiotics support probiotics (collectively known as synbiotics) and their gaining of importance has been relatively recent.

Exploring prebiotics in aquaculture: Potential benefits and challenges

Prebiotics have played a crucial role in semi-intensive and intensive aquaculture over the past few years. Its applications are quite a few **(Fig. 1).** In the pioneering in vitro prebiotic trial involving fish conducted by Burr et al. (2009), a fructooligosaccharide (FOS) concentration of 0.375% was found to have a significant impact on the microbial population within the gastrointestinal tract of red drum *Sciaenops ocellatus.* In light of the constraints associated with probiotic application in aquaculture and the documented positive effects of live microbes on growth and disease resistance in aquatic species, there is a growing interest in evaluating prebiotics. Commonly recognized and commercially available aquacultural prebiotics include FOS, transgalactooligosaccharide (TOS) and inulin (Ringø et al., 2010). These prebiotics have been shown to stimulate health-promoting bacteria, such as *Lactobacillus* and *Bifidobacter* spp., while concurrently limiting potentially pathogenic bacteria like *Salmonella, Listeria* and *Escherichia coli* (Ringø et al., 2010). The microbiota influenced by prebiotics plays integral roles in various processes, including growth, digestion, immunity and disease resistance. Although the application of prebiotics in aquaculture has been relatively limited thus far, it holds significant potential. However, effective implementation in aquatic organisms will require a better understanding and characterization of their microbial communities.

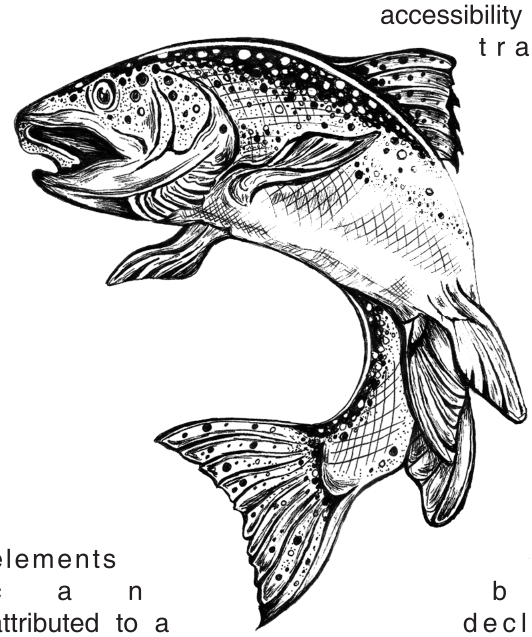
Exploring prebiotics in fish nutrition: Limited research yet promising outcomes

The current landscape of research on prebiotics in fish nutrition remains relatively underexplored, particularly in comparison to the more established domain of probiotics. Nevertheless, recent preliminary studies have initiated exploration into this promising field. A significant advantage that prebiotics hold over probiotics is their natural origin as integral feed ingredients, potentially alleviating regulatory constraints associated with dietary supplementation (Ringø et al., 2010). One noteworthy commercial prebiotic, GroBiotic-A®, a composite of partially autolyzed yeast, dairy component constituents and dried fermentation products, has exhibited promise in bolstering the resistance of diverse fish species, including hybrid striped bass, rainbow trout and golden shiner against a spectrum of bacterial pathogens (Carbone and Faggio, 2016). Dietary supplementation with GroBiotic-A® has also showcased improved survival rates in *Litopenaeus vannamei* cultured under low-salinity conditions (2 ppt), with analogous enhancements observed in freshwater challenges (Ringø et al., 2010).

Nevertheless, the precise mechanistic underpinnings responsible for the heightened survival under low-salinity conditions remain enigmatic. Recent investigations involving *Litopenaeus vannamei* have provided indications that dietary FOS can augment hemocyte respiratory burst, a metric of nonspecific immunity, albeit without live disease challenges. Furthermore, a study conducted with *Psetta maxima* larvae unveiled that dietary supplementation of 2% inulin led to substantial alterations in gastrointestinal microflora, notably elevating Bacillus spp. to 14% while concurrently diminishing Vibrio spp (Carbone and Faggio, 2016). In addition, turbot larvae fed 2% oligofructose demonstrated markedly superior growth rates in comparison to those fed 2% inulin, 2% lactosucrose or 2% cellulose. Furthermore, studies with GroBiotic-A, mannanoligosaccharides (MOS), galactooligosaccharides (GOS) and FOS showed superior protein and organic matter digestibility in shrimps and turbots (Ringø et al., 2010). Prebiotics like transoligosaccharides (TOS) have also demonstrated the capacity to modulate the fermentation products within the gastrointestinal tract and increase the concentrations of volatile fatty acids (VFAs), specifically propionate and butyrate (Carbone and Faggio, 2016).

Enhanced nutrient uptake and trace element bioavailability through prebiotic inclusion

The incorporation of prebiotics into dietary regimes has demonstrated notable advantages, encompassing heightened glucose absorption and enhanced trace element. The improved accessibility of trace



elements can be attributed to a decline in the pH levels within the intestinal tract, stemming from increased concentrations of VFAs. Furthermore, an osmotic effect, characterized by proton exchange and a potential reduction in proteins like calcium-binding protein, may contribute to the heightened availability of trace elements within the small intestine (Ringø et al., 2010).

Conclusion

In the realm of aquaculture, we have delved into the intricate world of prebiotics, shedding light on their potential to revolutionize nutrition and health management for aquatic species. Yet, as we navigate the uncharted waters of aquatic prebiotics, we are also met with the alluring promise of synbiotics. Remarkably, synbiotics remain a relatively unexplored concept in aquaculture, with no known evaluations conducted in aquatic species to date. As we conclude this chapter on prebiotics, we stand at the precipice of a new era in aquaculture nutrition. To harness the full potential of prebiotics and the intriguing possibilities offered by them, we call for a concerted effort in conducting in-depth research. This endeavor will pave the way for a comprehensive understanding of how prebiotics can shape the microbial ecology of the gastrointestinal tract in aquatic animals. Armed with this knowledge, we can forge efficient management strategies to manipulate GI tract microflora, ultimately enhancing the production and well-being of aquatic species in the dynamic world of aquaculture. The future holds great promise, and it beckons us to explore, innovate, and optimize the nutrition and health management of aquatic organisms in this ever-evolving field.

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Matsya Jagat. Black soldier fly larvae meal as an alternative to fish meal in aquafeed. Vol 1 Issue 4, Oct-Dec 2023, pp 31-32

Black Soldier Fly Larvae Meal as an Alternative to Fish Meal in Aquafeed

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Introduction

India is the third largest fish-producing country in the world, with 8 per cent input to the total global fish production. India stood second in global aquaculture production (FAO, 2022). In the year 2021-22, the total fish production of India is 16.24 MMT, encompassing marine fish production of 4.12 MMT and 12.12 MMT from the aquaculture sector. The availability of inert compound feeds is essential for more than 60% of global scientific aquaculture practices. Fishmeal is the ideal source of animal protein for aquafeed due to its exceptional nutritional qualities, which include a well-balanced amino acid profile, highly digested protein, and palatability due to wise use and lack of proper supply, escalating the price of fish meal, which put economic pressure on the aquaculture practices in present circumstances. Therefore, relying excessively on fish meal for feed composition would not be a sustainable strategy. Therefore, researchers and feed manufacturers have been exploring substitute protein components to replace fish meal in aquafeed. Aquafeed's manufacturing costs are anticipated to decrease with the partial or complete replacement of fish meal with less expensive, protein-rich animal or plant sources. One potential source of animal protein that can be used in aquafeed is insect meal. There is no shortage of insects because they comprise the largest species in the environment. Among the insect meal, the Black Soldier Fly's (*Hermitia illucens*) (BSF) larvae meal has drawn more attention due to its nutritional efficiency. Its protein content ranges from 42 to 60 %, and it is easy to produce on a large scale. Hence, the Black Soldier Fly's larvae meal may be a promising next-generation protein ingredient.

The Nutritional Profile of Black Soldier Fly's Larvae

Black soldier fly larvae have a crude protein content of 42.1%, while the defatted ones have a crude protein content of 56.9%, comparable to soybean meal and slightly less than fish meal. The amino acid profile of the black soldier fly larvae is superior to that of soybean meal. However, before processing, the oil needs to be eliminated from the biomass of black soldier fly larvae. Their nutritional value peaks at the pupal stage, when they are particularly rich in ash, calcium, and phosphorus. They can be stored for many weeks at room temperature, but their maximum shelf life is between 10 and 16°C (50 and 60°F). Bioactive compounds such as lauric acid, chitin, and antimicrobial peptides are also available in BSF. These bioactive compounds have been demonstrated to alter the gut host microbiota, enhancing general health in farm animals by enhancing gut health and maintaining the intestinal mucosal barrier.

Life Cycle of Black Soldier Fly

The adult female of Hermetia illucens, commonly known as the black soldier fly, typically lays anywhere from 206 to 639 eggs during a single reproductive cycle. These eggs are naturally placed on surfaces near decaying organic matter like manure or compost. Within a span of 3 to 4 days, these eggs hatch into larvae. Upon hatching, the newly emerged larvae are minuscule, measuring only 1 millimeter in length and weighing approximately 0.1 grams. As they progress through the larval stage, they can grow up to 25 millimeters in length and reach a weight of around 0.22 grams. The duration of their larval growth varies, lasting anywhere from 18 to 36 days, contingent on factors such as the quality of the available food substrate and the prevailing temperature. Following the larval stage, there is a transitional pre-pupal phase which spans up to seven days. Subsequently, the pupal stage, where they transform into pupae, typically lasts for a period of 1 to 2 weeks. In terms of adult longevity, when provided with a suitable diet of water and sugar in captivity or nectar in their natural habitat, black soldier fly adults can have a lifespan ranging from 47 to 73 days.

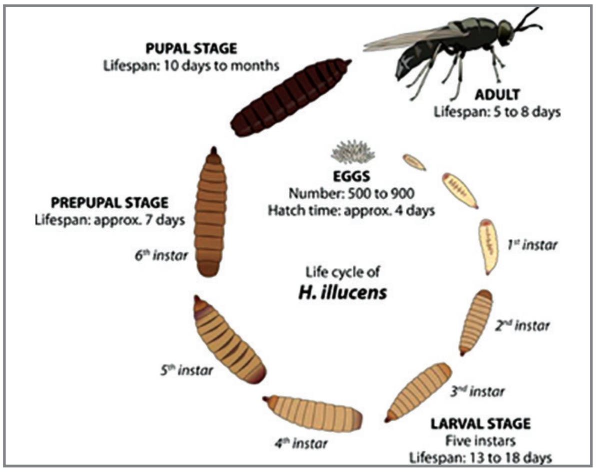

Figure: Complete life cycle of Hermetia illucens

Black Soldier Fly's Larvae as a Feed

The harvested pupae and pre-pupae are fed to poultry, fish and pigs. The use of black soldier fly larvae in the EU as aquaculture feed has been authorized. The diets of turbot, rainbow trout, Jian carp, Pacific white shrimp, and Atlantic salmon demonstrate the potential utility of BSF as a substitute for fish meal. Li et al. (2017) reported that Jian carp juveniles (*Cyprinus carpio* var. *jian*) exhibit satisfactory development, carcass composition, antioxidant enzyme activities, and digestive enzyme activities when given defatted black soldier fly larvae meal up to 50% of fish meal in their diet. Juvenile Japanese seabass (*Lateolabrax japonicus*) demonstrated improved immunological response, good growth performance, and intestinal antioxidant activity when fed 64% defatted black soldier fly larvae meal instead of fish meal. Moreover, replacing fish meal with insect meal did not affect the growth parameters or the whole body composition of Atlantic salmon as well as maintained the sensory qualities of the salmon fillet (Belghit et al., 2019).

Additionally, black soldier fly larvae meal can be utilized for the culture of ornamental fish, particularly guppy fish (*Poecilia reticulata*), where it can substitute fish meal by up to 25-50% (Sanjaya et al., 2020). As well as fin fish, black soldier fly larvae meal has a beneficial effect on shellfish, especially the pacific white shrimp species (*Litopenaeus vannamei*), which gains good weight, grows at a specific rate, and converts food into an amount that replaces fish meal in the diet by less than 25% (Cummins et al., 2017).

Conclusion

Black soldier fly larvae meal offers a protein-rich alternative for aquafeed, serving as a viable replacement for fish meal. With the increasing fish meal demand and cost, exploring alternative protein sources becomes crucial. Notably, black soldier fly larvae are highly efficient feed ingredients for ornamental and food fish. Numerous studies have been conducted, and their collective findings support the conclusion that black soldier fly larvae meal can effectively substitute for fish meal in fish feed without any detrimental impact on fish health or quality.

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Matsya Jagat. Exploring current trends in fish biotechnology: a comprehensive overview.
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Exploring Current Trends in Fish Biotechnology: A Comprehensive Overview

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Fish biotechnology, a rapidly evolving field, is at the forefront of scientific advancements, contributing to both aquaculture and fisheries management. This article provides a brief overview of the hottest topics in fish biotechnology, highlighting key areas of research that promise to shape the future of the industry.

1. Genomic Editing in Aquaculture:

Recent breakthroughs in CRISPR-Cas9 and other genomic editing tools have revolutionized the field of fish biotechnology. Researchers are employing these techniques to enhance desirable traits in fish species, such as disease resistance, growth rates, and nutritional content. The ethical considerations and regulatory frameworks surrounding genomic editing in aquaculture are also significant areas of discussion.

2. Functional Genomics and Transcriptomics:

Advancements in high-throughput sequencing technologies have propelled functional genomics and transcriptomics research in fish. Studying gene expression patterns under different environmental conditions, stressors, or during specific developmental stages provides valuable insights into the molecular mechanisms governing fish physiology. This knowledge aids in developing targeted interventions for disease management and optimizing aquaculture practices.

3. Microbiome Studies in Aquatic Environments:

Understanding the role of the fish microbiome in health, disease resistance, and overall performance is gaining prominence. Researchers are employing metagenomics to characterize the microbial communities associated with different fish species and their environments. Manipulating the fish microbiome holds potential for improving disease resilience and enhancing nutrient utilization.

4. Biotechnological Approaches for Disease Management:

Fish diseases pose significant challenges to aquaculture. Biotechnological strategies, including the development of vaccines, antiviral agents, and disease-resistant strains through selective breeding or genetic modification, are actively researched. This area holds promise for mitigating economic losses and ensuring the long-term sustainability of aquaculture operations.

Conclusion

Fish biotechnology continues to push the boundaries of scientific understanding and technological innovation. From precision genome editing to unraveling the mysteries of the fish microbiome, researchers are actively engaged in addressing key challenges facing the aquaculture industry. The dynamic nature of this field ensures that ongoing research will bring about transformative changes in the sustainable management and production of fish resources.

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Matsya Jagat. An overview of the Indian Fisheries industry. Vol 1 Issue 4, Oct-Dec 2023, pp 34-35

An Overview of the Indian Fisheries Industry

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India is bestowed with an extensive coastline spanning over 8,118 kilometers, a continental shelf of 0.53 million km2, an exclusive economic zone of 2.02 million km2, 29,000 kilometers of rivers, 0.3 million hectares of estuaries, 0.19 million hectares of backwater and lagoons, 3.15 million hectares of reservoirs, 0.2 million hectares of floodplain wetlands, and 0.72 million hectares of upland lakes, constituting significant fisheries resources. This diverse ecological milieu is integral to India's rich and varied fisheries industry, which plays a pivotal role in the nation's economic and nutritional security. The Indian fisheries sector encompasses various activities, including marine and inland fishing, aquaculture, and processing. This article presents a scientific overview of the Indian fisheries industry, delving into its importance, salient characteristics, challenges, and prospective avenues.

Significance of the Fisheries Industry in India:

- ***Economic Contribution:*** India ranks as the world's third-largest fish producer and the second-largest in aquaculture. The fisheries sector substantially contributes to India's economy, yielding 16.24 million tonnes of fish in 2021-22 (4.12 million tons from marine and 12.12 million tons from the inland sector). With a fisheries export value of Rs. 57,586 crore, the sector constitutes 6.72% of the agricultural Gross Value Added (GVA) and 1.1% of the Indian economy during 2021-22, fostering employment opportunities and economic growth, especially in coastal and rural regions.
- ***Nutritional Security:*** In 2021-22, India contributed 8% to global fish production, showcasing an annual growth rate of 10.34%. Fish, a staple food in many Indian regions, provides essential proteins, vitamins, and minerals. Despite this, per capita fish consumption in India is notably lower (6.13 kg) compared to countries like Iceland (90.59 kg) and the Maldives (83.09 kg). The fisheries industry plays a crucial role in addressing nutritional security and combating protein deficiencies in the country.
- ***Fishermen Population:*** The Indian fisheries sector sustains a significant role in the national economy by providing livelihoods to approximately 1.36 billion fishermen.

Key Features of the Indian Fisheries Industry:

- ***Diversity of Resources:*** India's fisheries sector boasts a diverse range of marine and inland water resources, encompassing both capture fisheries and aquaculture, which involve the controlled farming of fish in various environments.
- ***Coastal and Inland Fisheries:*** While the coastal regions support a thriving marine fisheries industry, inland fisheries significantly contribute through the utilization of rivers, lakes, and reservoirs.
- ***Aquaculture Growth:*** Recent years have witnessed a discernible shift towards aquaculture to meet escalating fish demand. The cultivation of species such as shrimp, prawns, and various fish varieties has gained prominence.

Fisheries Institute:

Fisheries institutes are essential as they play a pivotal role in conducting research and development, providing training and capacity building, offering policy support, contributing to the conservation of biodiversity, and managing the sustainability of the fisheries sector. Here are the names of some prominent fisheries institutes with their year of establishment:

- ICAR - Central Marine Fisheries Research Institute (ICAR-CMFRI), Kochi, Kerala, 1947
- ICAR - Central Inland Fisheries Research Institute (ICAR-CIFRI), Barrackpore, West Bengal, 1947.
- ICAR - Central Institute of Fisheries Education (ICAR-CIFE), Mumbai, Maharashtra, 1961.
- ICAR - National Bureau of Fish Genetic Resources (ICAR- NBFGR), Lucknow, Uttar Pradesh, 1983.
- ICAR - Central Institute of Freshwater Aquaculture (ICAR-CIFA), Bhubaneshwar, Odisha 1987.
- ICAR - Central Institute of Brackishwater Aquaculture (ICAR- CIBA), Chennai, Tamil Nadu, 1987.

Challenges Facing the Industry:

Recent breakthroughs in CRISPR-Cas9 and other genomic editing tools have revolutionized the field of fish biotechnology. Researchers are employing these techniques to enhance desirable traits in fish species, such as disease resistance, growth rates, and nutritional content. The ethical considerations and regulatory frameworks surrounding genomic editing in aquaculture are also significant areas of discussion.

- ***Overfishing and Depleting Resources:*** Overfishing in specific regions poses a threat to marine biodiversity, resulting in the depletion of fish stocks. Sustainable fishing practices are imperative to ensure the industry's long-term viability.
- ***Infrastructure and Technology:*** Outdated infrastructure and the need for technological advancements pose challenges to the fisheries industry. Modernizing fishing techniques, storage facilities, and processing methods are essential for enhancing productivity and quality.
- ***Environmental Concerns:*** Pollution, climate change, and habitat destruction present significant challenges. Sustainable and environmentally friendly practices are vital for preserving marine ecosystems.

Future Prospects and Initiatives:

- ***Government Initiatives:*** The Government of India has implemented various schemes under the Blue Revolution program, such as the Pradhan Mantri Matsya Sampada Yojana 2020, to promote sustainable fisheries, provide financial support to fishermen, and enhance infrastructure. These efforts aim to address challenges and boost industry growth.
- ***Technology Adoption:*** OEmbracing modern technology, including satellite-based navigation systems, advanced fishing gear, Remotely Operated Vehicles (ROVs), Robotic cages for fish farming, Recirculatory Aquaculture System (RAS), Integrated multi-trophic aquaculture (IMTA), Composite and Integrated Fish Farming, and efficient processing techniques can enhance the efficiency and sustainability of the fisheries sector.

3. International Collaboration:

Collaborating with international organizations and adopting best practices from successful fisheries models worldwide can contribute to the development of a robust and sustainable fisheries industry in India.

Conclusion

India's vast aquatic resources, comprising an extensive maritime boundary and diverse ecosystems, underpin a crucial fisheries industry vital for the nation's economic and nutritional security. The sector's significant contributions, from being the world's third-largest fish producer to addressing nutritional deficiencies, highlight its pivotal role. Despite challenges such as overfishing and outdated infrastructure, the industry's adaptability is evident in the growing prominence of aquaculture. Fisheries institutes and government initiatives underscore the commitment to sustainability and technological advancements. Collaborative efforts and innovative approaches position India's fisheries sector for a resilient and prosperous future, ensuring sustainable development, economic growth, and environmental preservation.

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Application of Digital Twins in aquaculture

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Introduction

Aquaculture is the fastest food-growing agriculture sector in the world with an estimated global fish production of 214 million tonnes in 2020. Countries like China and India are among the top producers and the majority of the production has been reported from the developing countries. Reports of wild fish stock depletion are increasing daily (FAO, 2020). Aquaculture has undoubtedly increased the amount of fish produced for human consumption, but the sustainability of this use of natural resources is a matter of concern. Globally, it is now widely acknowledged that new technical advancements are required to increase fish production more sustainably to fulfill the increasing food demands of the planet's population (FAO, 2020).

Sustainable farming, Industry 4.0, and Industry 5.0 are thought to be the main driving forces behind the expansion of manufacturing of environmentally friendly technologies (Lima et al., 2022). Although many technical innovations have been effectively used to increase the profit from aquaculture practices, additional more sound-oriented technologies still need to be developed. Aquaculture practices are now being revolutionized by lowering the cost of monitoring equipment and boosting computing power to maximize farm yields. The main goals of all fish farms, including the reduction of operating costs, the maximization of profits, the improvement of fish quality, and the optimization of harvest efficiency, have been successfully attained through technological innovation. Farms in remote locations may now easily acquire and analyze information thanks to the Internet of Things (IoT), which consists of sensors, wireless transceivers, and connections. Using real-time sensor monitoring capabilities, it enables the operator to manage and keep an eye on the farm's conditions.

The digital twin is a digital representation of real-world practices that provides technical control of tasks like as component integration, testing, simulation, monitoring, and routine maintenance. The digital twin is an effective instrument for integrating many cultural elements, their real-time monitoring, and their practice management in aquaculture with the ultimate goal of profit maximization. In 2010, NASA was the first to employ this technique. Digital twins can be categorized into three main groups: digital twin prototypes (DTP), which include designing, analyzing, and processing real-time physical processes; digital twin instances (DTI), which include individual part components linked to their physical conditions; and digital twin aggregates (DTA), which combine the information generated by DTIs and use it for additional purposes.

The primary purpose of this cutting-edge technology is to keep an eye on farms, which provide significant difficulty due to varying environmental conditions. The main characteristic of digital twins is connectivity, which facilitates the movement of information from one phase to another for processing, its digital counterpart, and other requirements. It is now easier and faster to access ground data thanks to the development of increasingly sophisticated sensors. These sensors have enabled access to the hard and distant circumstances, as well as the interpretation of changes and monitoring necessary for culture optimization.

The improvement of the global food chain, the reduction of farm waste, and increased productivity are a few of the advantages of AI-based digital technologies and have a substantial impact on aquaculture operations. To fulfill the expanding demands of the fish food industry, large-scale adoption of digital twins requires a coordinated and all-encompassing strategy from academia, business, government, and society. Each of these plays a crucial part in educating employees, evaluating technology, giving funding, and promoting disruption through aquaculture accelerator programs. The uses, innovations, components, and future requirements of digital twins in fish farming will all be covered in this article.

Digital twin in fisheries and aquaculture:

It is widely acknowledged that aquaculture is essential for meeting the expanding population's food demands, which may be achieved by producing and controlling aquaculture-fed species at optimal levels, as noted by FAO in recent studies. Aquaculture's early phases of development placed a lot of emphasis on manually increasing pond output. We are in the process of fine-tuning a high-tech culture system due to the rise in demand for aquaculture goods. Additionally, the growth of aquaculture is hampered by the lack of readily accessible, inexpensive manpower for the deep sea culture systems' routine maintenance and monitoring. To increase aquaculture profit, a culture system based on AI must be implemented. The production of aquaculture is expected to move towards intelligent farming in the future. The major advantages of AI-based farming are;

a. Regular monitoring of the culture practices.

b. Disease diagnosis at early stages.

c. Record data about different life stages such as larvae, reproduction, etc.

d. Enable us to monitor cage fouling and cage damage even at higher water depths.

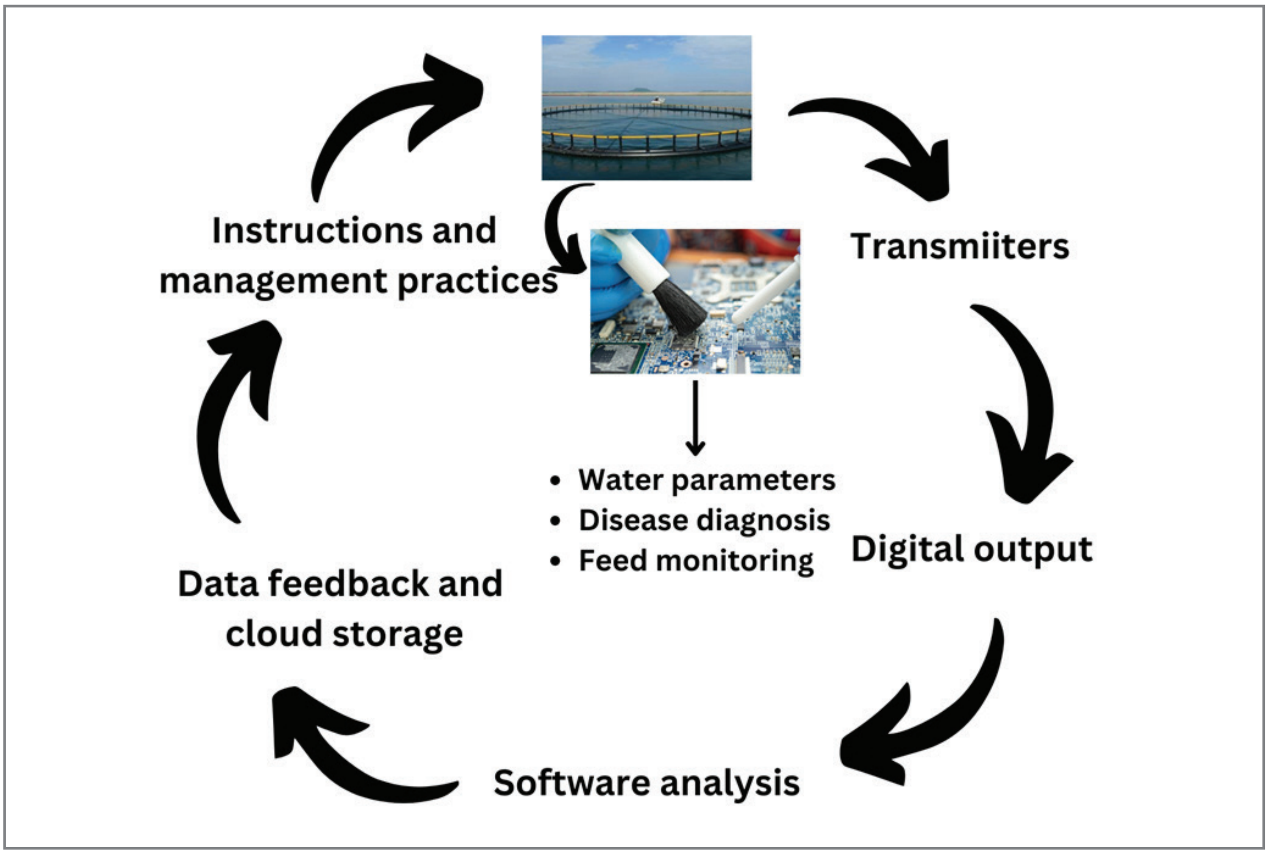

Figure 1 Diagrammatic representation of different components of the digital twin in aquaculture

To accomplish optimized aquaculture practices based on the usage of AI and understanding the data produced by it, digital aquaculture adheres to the idea of Industry 4.0 technologies. The owner or manager of the farm can quickly evaluate enormous amounts of data and models with the use of AI-based technology. Additionally, it enables quick action to be taken to prevent aquaculture losses due to adverse weather conditions. Digital technologies, including different equipment like cameras, sensors, Internet of Things (IoT), cloud storage, software, digital output devices, etc., are used to gather and process agricultural data into a comparable form. The ideal sensor should be capable of measuring the essential data with more accuracy, be able to endure significant systemic variations, have a longer shelf life, and not damage the cultured species.

The next step in the framework of the digital twin is the use of AI-based feedback and data analysis capacity of the automated system that can process the data collected from the sensors. The next important part in digital farming is IoT that made a close loop by connecting different sensors with appropriate transmitters and their connectivity for gathering and exchanging real time base data to the farm operator. The efficiency of IoT lies on the decision making and data collecting capabilities of the sensors. Also the data collected by different sensor needs to be properly analysed and interpret for transferring the numerical based data into digital based that can be done with the help of various software. During the recent few years, agriculture and aquaculture based food producing sectors have noticed rapis integration of digital twins.

The need of digital twins can be better explained based on an example. Let us assume that a farmer practices deep sea cage culture for high value species. For the maximum benefit from the farm, the farmers needs to deploy planety of manpower, designated as feed operator, data analyser, harvesting operator, general farm manager, etc. But when digital twin came into play it excludes the need of all the manpower by simply deploying sensor based feed dispenser, water quality monitoring system, health diagnosis system and also to interpret various other farm related data and efficiently control the healthy conditions of the farms. Also, the time consuming data collection by labour and its traditional way of storing in the form of writing down on lengthy notes could be excluded using cloud storage and different software. Thus AI based technologies, not only reduced the cost of fish production, but also manage the farm in less time. Planetary Digital Twins explores closed-loop feedback and control as key features to build a global-scale virtual replica of physical facilities [3, 4, 15].

Conclusion

With the increased pressure on the wild stock, world organization like FAO has clearly mentioned looking for sustainable production of fish for human consumption. In this regard, with the growing demand for fish and fish by-products, the urgent need for sound husbandry culture practices with the integration of AI-based technologies is the need of the hour. As we have discussed earlier, AI-based fish farming is helpful in many ways, such as effective time management, sound husbandry practices, profit optimization, reducing labor costs, etc. Thus, various organizations such as academics, industries, and political organizations, should take necessary collaborative steps for the effective development of smart technology-based fish farming practices.

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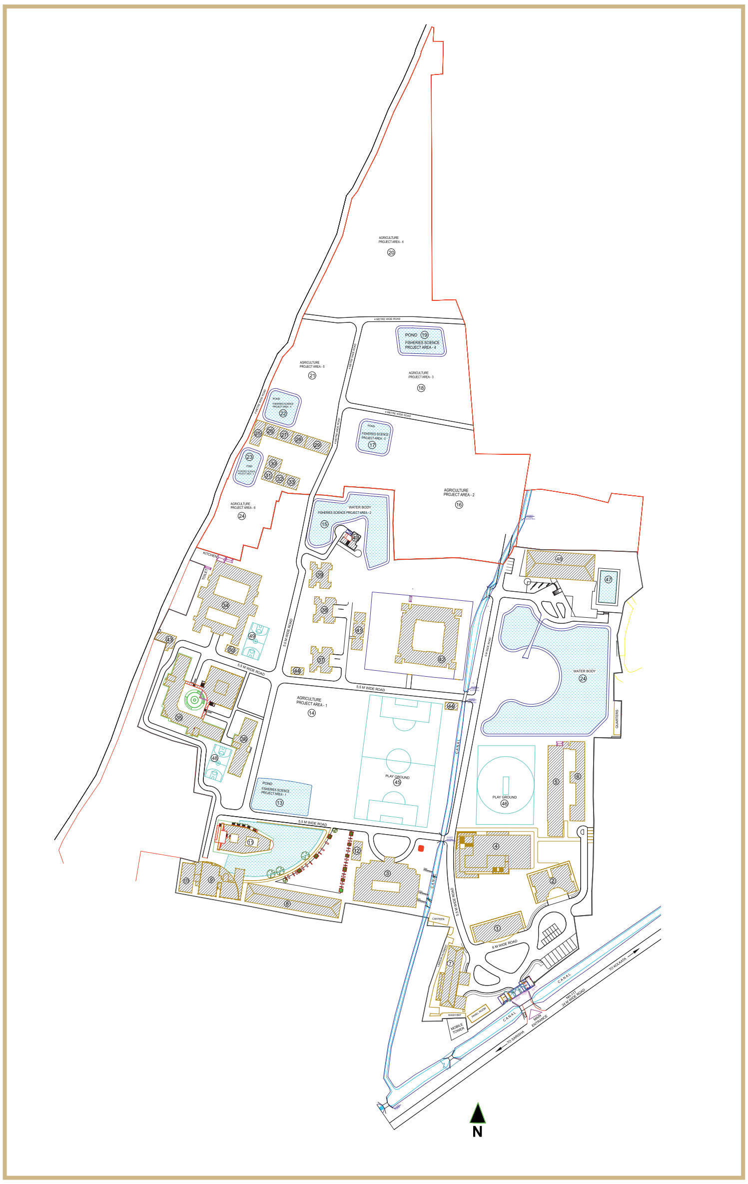


LEGEND- BUILDING

A. ADMINISTRATIVE BLOCK

1. ADMINISTRATIVE BUILDING (G + V)

B. ACADEMICS BLOCK

2. SCHOLASTIC BUILDING - 1 (G + III)
3. SCHOLASTIC BUILDING - 2 (G + II)
4. SCHOLASTIC BUILDING - 3 (G + III)
5. SCHOLASTIC BUILDING - 4 (G + III)
6. SCHOLASTIC BUILDING - 5 (G + III)
7. WORKSHOP BUILDING
8. NEW WORKSHOP BUILDING
9. NEW PHARMACY BUILDING (G + III)
10. PHARMACY BUILDING (G + III)
11. SHIP IN CAMPUS (G + III)

C. AGRICULTURE & FISHERY SCIENCE BLOCK

12. POLY HOUSE & NET HOUSE
13. FISHERY SCIENCE PROJECT AREA - 1
14. AGRICULTURE PROJECT AREA - 1
15. FISHERY SCIENCE PROJECT AREA - 2
16. AGRICULTURE PROJECT AREA - 2
17. FISHERY SCIENCE PROJECT AREA - 3
18. AGRICULTURE PROJECT AREA - 3
19. FISHERY SCIENCE PROJECT AREA - 4
20. AGRICULTURE PROJECT AREA - 4
21. AGRICULTURE PROJECT AREA - 5
22. FISHERY SCIENCE PROJECT AREA - 5
23. FISHERY SCIENCE PROJECT AREA - 6
24. AGRICULTURE PROJECT AREA - 6
25. MUSHROOM UNIT
26. FIELD LAB
27. STORE HOUSE
28. SERICULTURE UNIT
29. THRESHING FLOOR
30. BIO GAS PLANT
31. CATTLE SHED
32. VERMI COMPOST PIT
33. BIO FERTILIZER PLANT

D. RESIDENTIAL BLOCK

34. BOY'S HOSTEL - 1 & 2 (G + III)
35. BOY'S HOSTEL - 1 & 2 (G + III)
36. BOY'S HOSTEL - 1 & 2 (G + III)
37. OLD STAFF QUARTERS (G + III)
38. NEW STAFF QUARTERS (G + III)
39. NEW STAFF QUARTERS (G + III)
40. DIRECTOR'S RESIDENCE (G + I)
41. OLD STAFF QUARTERS (G + III)
42. GIRL'S HOSTEL - 3 (G + II)

E. UTILITY & SERVICES BLOCK

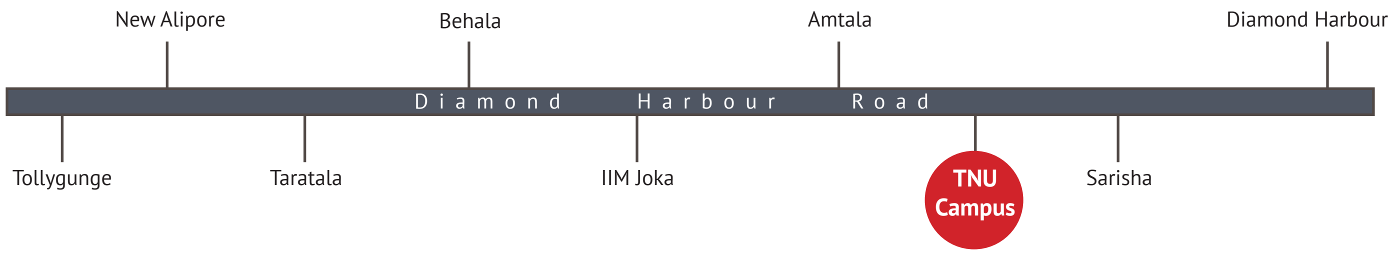
43. ELECTRICAL ROOM
44. PUMP ROOM

F. RECREATIONAL BLOCK

45. FOOTBALL GROUND
46. CRICKET GROUND
47. SWIMMING POOL
48. MULTI PURPOSE HALL
49. BASKETBALL COURT (3 NOS.)

G. HEALTH BLOCK

50. MEDICAL UNIT



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