FAO Reference Centre

Terminal report (October 2022- February 2026)

Title of FAO Reference Centre: FAO Reference Centre for Antimicrobial Resistance (AMR) & Aquaculture Biosecurity (AB)

Name of the institution: Nitte University (NU)

Country: India

Date of report: 28 February 2026

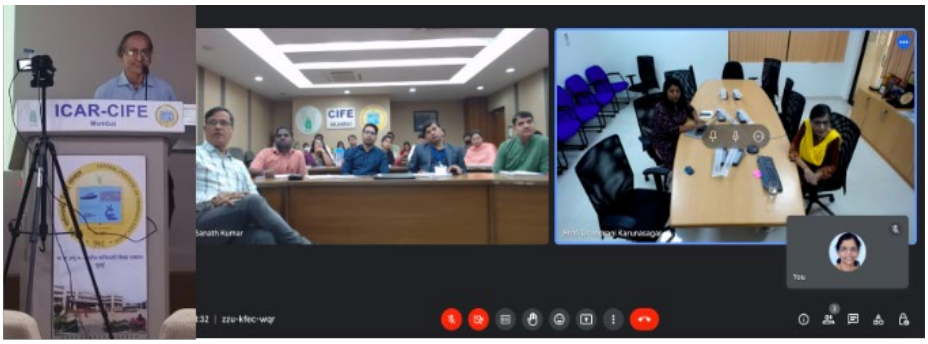
Name of the Institute's Responsible Officer: Prof. Dr Indrani Karunasagar **E-mail: indrani.karunasagar@nitte.edu.in**		
Name of the Reporting Officer: Prof. Dr Iddya Karunasagar **E-mail: iddya.karunasagar@nitte.edu.in**		
Years of the Designation:	**From**	**To**
	October 2022	**February 2026**
Website: https://nufaocen.in		
If this report is published on your website, please provide the link: https://nufaocen.in		

Activities supporting raising awareness on AMR

1. **Interactive session on World Food Day 2022 Theme: "Leave no one behind"**

An interactive discussion session on the theme of World Food Day 2022 was held at the Centre for Science Education and Research (NUCSER) on 18 October 2022, with food industry representatives and other stakeholders. World Food Day marks the foundation of the Food and Agriculture Organisation of the United Nations, and the theme of 2022 World Food Day was “Leave no one behind” in the march towards better food production, better nutrition, better environment, and better life. The event was organized in partnership with Kanara Chamber of Commerce and Industry (KCCI), Confederation of Indian Industry (CII), FSSAI, MSME Development and Facilitation Office (DFO), South Regional Office of International Federation of Inventors’ Association (IFIA), and partner institutions. The discussion was around four major themes: (a) Technological needs of food industries, (b) Food processing machinery, (c) Food safety, quality, and AMR, (d) Regulation and compliance, including minimisation of use of antibiotics.

2. **Training program on Antimicrobial resistance in food fish: Challenges and mitigation**



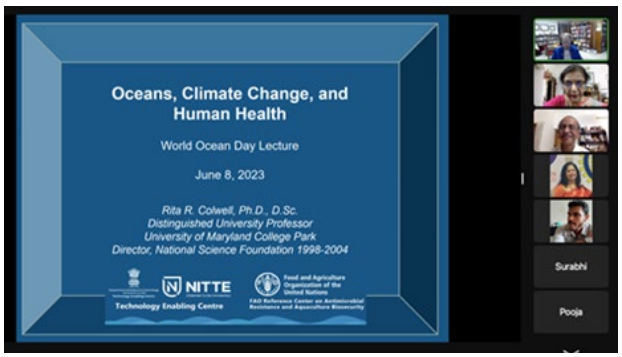
Dr. Sanath Kumar and Dr. BB Nayak, Central Institute of Fisheries Education, ICAR. Mumbai conducted a training program from 9 – 29 January 2023 on “Antimicrobial resistance in Food Fish: Challenges and Mitigation. Dr. Iddya Karunasagar and Dr. Indrani Karunasagar were

resource persons. Dr. Iddya Karunasagar delivered a talk titled “Antimicrobial resistance and food safety,” and Dr. Indrani Karunasagar spoke on “Zoonoses and public health.”

3. **Celebrating World Food Safety Day on the theme: Food standards save lives with a Workshop on “Understanding food safety standards”**

The FAO Reference Centre in collaboration with the Confederation of Indian Industries (CII), Kanara Chamber of Commerce and Industries (KCCI) and Food Safety and Standards Authority of India (FSSAI) organized a Workshop on “Understanding food safety standards” at Ocean Pearl Hotel, Mangalore on 07 June 2023, to create awareness about food safety standards and improve the understanding about these in the industry, on the occasion of World Food Safety Day with the theme “Food standards save lives”. Dr. M.S. Moodithaya, Vice Chancellor of Nitte University, highlighted in his talk the impact of food processing and our eating habits on food safety. Mr. Ananthesh Prabhu, Vice President, KCCI, indicated that the workshop meets the request from food industries in the region. Dr. Divya Suresh from FSSAI spoke about the need to raise awareness of food safety standards and the processes required to meet them. Dr. Iddya Karunasagar spoke about Codex Alimentarius Commission standards for aquaculture and fisheries, and the practices needed, such as Good Aquaculture Practices, Good Hygienic Practices, and the Code of Practice for fish and fishery products, that can enable aquaculture value chain actors to produce safe fish and fishery products.

4. **Webinar on World Ocean Day: Oceans, Climate Change, and Public Health**



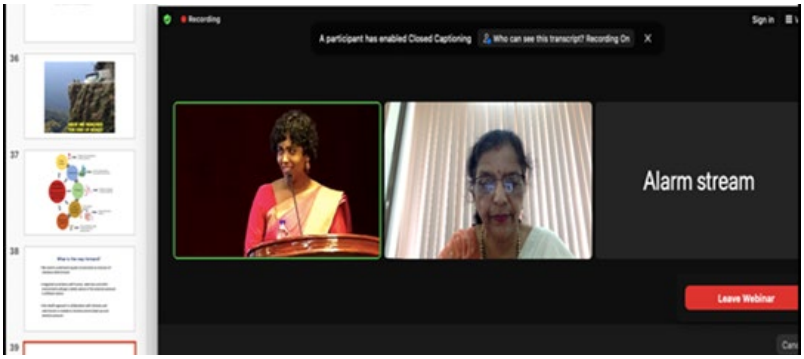
The Centre organized a webinar on “Ocean, Climate Change and Public Health” as a part of the Ocean Day celebration on 8 June 2023. Prof. Dr. Rita R Colwell, Former Director of the National Science Foundation and distinguished University Professor at the University of Maryland, USA, delivered the guest lecture. The objective of the webinar was to raise

awareness of the ocean's crucial role and how climate change impacts the microbiome in human health and disease. Students and faculty had the opportunity to gain new insights into recent advancements in predictive microbiology related to the burning issue of climate change.

5. **World Food Day 2023 Workshop on the theme "Water is life, water is food, leave no one behind.**

The Centre organized "World Food Day 2023" on 27 October 2023 with the theme "Water is life, water is food, leave no one behind". The event was a combination of food day theme-related talks, food fest, and various competitions for students, trying to actively enroll and bring experts under a common roof in the field, students, staff, and stakeholders. Water Conservation journalist, Mr. Shri Padre, Rtd Principal Scientist CFTRI, Mysore, Dr. Annu Appaiah, Rtd Senior Fishery Officer, FAO, and advisor research and patents, Dr. Iddya Karunasagar, and Dr. Indrani Karunasagar delivered the keynote lectures. Dr. Smitha Hegde welcomed the audience, and Dr. Iddya Karunasagar introduced the keynote speakers.

6. **Guest Lecture on One Health Approach to AMR at ALARM-2023**



Amitha Legion for Antimicrobial Resistance (ALARM) of Amritha Vidyapeetha organised a Hybrid Workshop on Antimicrobial Resistance on 17-18 November 2023. Dr. Indrani Karunasagar was an invited speaker. She explained the complexities involved in understanding antimicrobial resistance in the aquatic environment and how aquaculture is

impacted by the AMR that has emerged in other sectors like human health, animal health and agriculture.

7. **Scientific Session on "Preventive Healthcare in Aquaculture – Significance and Strategies"**

Dr Iddya Karunasagar chaired a scientific session on "Preventive Healthcare in Aquaculture – Significance and Strategies" organized by the Kerala University of Fisheries and Ocean Sciences (KUFOS), Kochi, 12–14 January 2024. The session brought together eminent speakers from Indonesia, Germany, and India to foster international knowledge exchange on disease prevention, biosecurity, and sustainable aquaculture practices. Key outcomes included strengthened global collaborations, identification of strategic approaches to reduce disease outbreaks through preventive healthcare measures, and enhanced awareness of how to improve productivity and sustainability in aquaculture systems. The deliberations contributed to promoting science-based health management practices for resilient and responsible aquaculture development.

8. **International Conference on "Environmental Mutagenesis – Impact on Biodiversity and Human Health"**

Dr. Iddya Karunasagar delivered a talk on "Antimicrobial Resistance in the Aquatic Environment" at the International Conference on "Environmental Mutagenesis – Impact on Biodiversity and Human Health", held at the Central University of Kerala, Kasaragod, 31 January 2024. The presentation highlighted the growing impact of antimicrobial resistance (AMR) on aquatic ecosystems, biodiversity, and public health, emphasizing the need for integrated mitigation strategies. The event facilitated meaningful scientific exchange with

experts from Malaysia, Singapore, the United Kingdom, and Germany, strengthening international academic collaboration.

9. **National Technology Day 2024: Agri-Food Technology Exposition and Panel Discussion**

The centre, in association with an ICAR–Directorate of Cashew Research, organized a National Technology Day Agri-Food Technology Exposition and Panel Discussion, on 11 May 2024. Dr. Dinakara Adiga, Director, ICAR-DCR, was the Chief Guest, and Prof. M.S. Moodithaya, Vice Chancellor, Nitte (DU), presided over the event. The program highlighted the importance of stakeholder collaboration, entrepreneurship, market potential of regional cash crops, and technology-driven development in strengthening the agri-food sector for participants from agri-food entrepreneurs, industry members, scientists, faculty, and students.

10. World Food Safety Day–2024 Outreach Programme

The centre, in association with the Department of Public Health, KSHEMA, Nitte (DU), organized a World Food Safety Day outreach programme at St. Aloysius College Higher Primary School, Mangaluru, on 7 June 2024. The event engaged around 370 students (Grades 5–7) and 25 teachers through educational sessions and an interactive quiz competition. Speakers highlighted the significance of food safety and the global importance of World Food Safety Day in preventing and managing foodborne risks. The quiz, comprising

multiple thematic rounds on food hygiene, nutrition, and food processing, encouraged active student participation and teamwork, with prizes awarded to the top teams. The programme effectively promoted awareness of safe and nutritious food practices among school students.

11. Interactive session related to World Food Day–2024 Theme: Right to Food for a Better Life and a Better Future.

The Centre celebrated World Food Day–2024 on 16 October 2024 at NUCSER, based on the theme “Right to Food for a Better Life and a Better Future.” Dr. Vinod Kumar M.G., Radboud University Medical Centre, The Netherlands, was the Chief Guest. Dr. Iddya Karunasagar delivered a lecture on “One Health for Better Food, Better Life and Better Future,” highlighting global food security challenges, FAO initiatives, and the importance of adhering to international standards such as Codex, WOAH, and SPS/TBT agreements. Dr. Indrani Karunasagar spoke on “Right to Quality Food and Water,” addressing food safety hazards and the need for strict regulatory compliance. The event, attended by around 120 faculty members and students, promoted awareness on food safety, nutrition, and sustainable food systems.

12. Highlighting Phage Research - convener of Phage session at VIROCON 2024

Dr Indrani Karunasagar, Vice President (Veterinary and Aquatic Virology) and executive committee member, Indian Virological Society convened a session on phage research at VIROCON-2024 held at Defense Research and Development Organization, Gwalior during 11-13, November 2024. She chaired the session and also delivered a keynote address on “Application of phages in food and water safety in One Health context”. The session included invited speakers from clinical, veterinary, aquatic and environmental sectors.

13. **Keynote Lectures at Global Conference on Infection Prevention, Control and Antimicrobial Stewardship (G-SPARC 2024)**

The Infection Control Academy of India (IFCAI), in association with Pragyaan Sustainable Health Outcomes Foundation (PRASHO), organized the Global Conference on Infection Prevention, Control and Antimicrobial Stewardship (G-SPARC 2024) at Hyderabad from 3–5 October 2024. Dr. Iddya Karunasagar and Dr. Indrani Karunasagar were invited as lead speakers and session moderators. Dr. Iddya Karunasagar delivered a lecture on "Antimicrobial Resistance, One Health and Assessment of Food Safety Risk," while Dr. Indrani Karunasagar spoke on "Antimicrobial Resistance and One Health: Implications and Mitigation Strategies in Aquaculture." The conference was attended by over 1000 scientists, professionals, and students from medical, veterinary, and environmental sectors, fostering interdisciplinary dialogue on AMR and One Health approaches.

14. **One Health Webinar on "Foodborne Disease Surveillance"**

Dr. Iddya Karunasagar was the guest speaker at the One Health Webinar organized jointly by the Indian Council of Medical Research (ICMR) and the Centers for Disease Control (CDC), USA, on Foodborne Disease surveillance on 27 November 2024. Dr Carmen Savelli from World Health Organization and Dr Heather Carleton from CDC were the other speakers.

Dr Iddya Karunasagar highlighted the resources available from FAO/WHO on foodborne disease surveillance including the use of whole genome sequences of pathogens.

15. Distinguished Lecture under One Health

The centre organized a lecture by Dr. M Suresh, Associate Dean for Research and Graduate Education and John Butler Professor of Comparative and Mucosal Immunology at the University of Wisconsin School of Veterinary Medicine, USA. Dr. Suresh spoke on “Tenets of T Cell Immunity to Respiratory Viral Pathogens”. The distinguished lecture was held on 27 February 2025. This event was organized as part of the ‘One-Health Lecture series. The speaker provided insights into vaccine-induced multifaceted mucosal T-cell immunity with implications for the development of vaccines against respiratory pathogens, including the influenza virus and SARS-CoV-2, using a combination adjuvant strategy to elicit CD8 and CD4 T-cell responses. The relation between immune response and protection against infection and disease was also explained. Most often, immune response is measured in terms of antibody titers, but the need to understand T-cell response, which is important in overcoming intracellular pathogens like viruses, was highlighted. The lecture focused on providing fundamental insights into T-cell-based vaccine-induced protective immunity against respiratory viruses.

16. National Conference on “Antimicrobial resistance: Strategies for prevention and alternatives”

The National Conference on “Antimicrobial Resistance: Strategies for Prevention and Alternatives” at KSTA Auditorium, Bangalore, on 14-16 May 2025, was inaugurated by Dr. Iddya Karunasagar, Shri N.S. Bosaraju, the Hon’ble Minister for Science and Technology, Government of Karnataka, and Dr. Raghavendra Bhatta, Deputy Director General, Indian Council of Agricultural Research. The conference was organized by Karnataka Science and Technology Academy (KSTA) and was addressed by delegates from the WHO and leaders from various national organizations. Dr. Indrani Karunasagar delivered a keynote lecture on “Phage therapy for the mitigation of antimicrobial resistance”, emphasizing the potential of bacteriophages as highly specific and effective agents against multidrug-resistant bacteria. It discussed the mechanisms by which phages infect and lyse bacterial cells, offering a targeted approach that does not disrupt beneficial microbiota. The talk also addressed current challenges, including regulatory frameworks, phage characterization, and large-scale production.

17. Organizer of Scientific Sessions – 12th Symposium on Diseases in Asian Aquaculture

12th Symposium on Diseases in Asian Aquaculture on “Transformative Innovations Shaping the Future of Aquatic Animal Health Management” organized by the Indian Council of Agricultural Research-Central Brackish Water Aquaculture, was held in Chennai on 23-26 September 2025. Dr. Iddya Karunasagar delivered a keynote lecture on “Antimicrobial Resistance and Aquatic Animal Health” and chaired the session on “One Health and Aquatic Biosecurity”. Dr. Indrani Karunasagar chaired the session on “Finfish Health” and served as a Jury Member for the Best Oral Presentation and Best Poster awards.

18. World Antimicrobial Awareness Week (WAAW): "Advancing Aquatic Health – Addressing AMR in Global Aquaculture"

The 2025 World AMR Awareness Week event was hosted by the Mississippi State University through the FAO Reference Centre on AMR and Aquaculture Biosecurity, in collaboration with global partners on 17 November 2025. The Centre played a significant role as one of the FAO Reference Centers on AMR and Aquaculture Biosecurity, contributing actively to the global dialogue on antimicrobial resistance in aquaculture.

19. Workshop on One Health: Together for a Safer Future

The centre organized the workshop titled "One Health: Together for a Safer Future," held on 24 November 2025, emphasized the interconnectedness of human, animal, and environmental health. The programme highlighted collaborative strategies to prevent zoonotic diseases, strengthen antimicrobial resistance surveillance, and promote interdisciplinary research. Experts and participants engaged in discussions to foster integrated approaches that ensure a safer, healthier future for all.

20. Virocon-2025: Annual international conference organized by the Indian Virological Society (IVS)

"VIROCON 2025" with the theme "Changing Landscapes in Human, Animal and Plant Viruses: Bridging Basic Science, Innovation and Public Health". The conference was jointly organized by the Indian Virological Society (IVS) and ICMR-National Institute of Virology (ICMR-NIV), Pune, Maharashtra along with NIV Research Foundation, from 8-10 December 2025. Dr. Indrani Karunasagar was invited to chair the scientific session on "Development of countermeasures". The session emphasized the development of effective countermeasures against emerging and re-emerging viral diseases, highlighting the importance of integrated surveillance, translational research, and strong laboratory networks in strengthening public health preparedness.

21. **International Conference on "Blue Horizon 2025: Rethinking Fisheries for a Sustainable Future"**

The International Conference on "Blue Horizon 2025: Rethinking Fisheries for a Sustainable Future", held on 17–18 December 2025, brought together leading scientists, researchers, and industry experts to deliberate on emerging challenges and innovations in fisheries, aquaculture, aquatic animal health, and sustainable resource management. The conference featured plenary sessions, keynote addresses, technical presentations, and panel discussions structured across four thematic areas: Aquaculture & Animal Health, Aquatic Environment & Conservation of Fishery Resources, Fish Harvest Technology & Engineering, and Fisheries Extension & Economics. The inaugural plenary address by Dr. Indrani Karunasagar set the tone for the conference, stressing the need to realign fisheries and aquaculture with sustainability, biosecurity, and global health priorities in the face of emerging aquatic animal diseases. She highlighted the growing challenges posed by climate change, globalization, and intensive farming, emphasizing a One-Health approach, cautioning against antimicrobial misuse, and advocating science-based alternatives and advanced molecular surveillance tools. Her address concluded with a strong call for capacity building, interdisciplinary collaboration, and responsible innovation to ensure a resilient and sustainable future for fisheries and aquaculture.

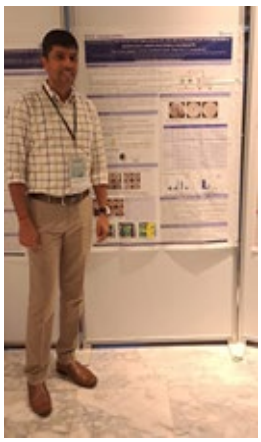
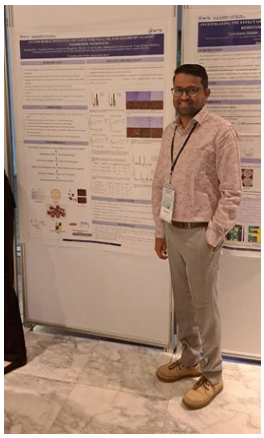
22. **Capacity building programme on "Towards Sustainable & Resilient Global Ecosystem: A One Health Approach"**

Dr Indrani Karunasagar was invited as guest of Honour for The Capacity Building Programme titled "Towards Sustainable and Resilient Global Ecosystem: A One Health Approach" was organized by NITTE–GOK Centre of Excellence (NITTE-GOK COE) C on 29–30 January 2026. The programme focused on strengthening interdisciplinary understanding of the One Health approach by integrating human, animal, and environmental health perspectives for sustainable ecosystem management. Experts from diverse fields delivered lectures and interactive sessions addressing emerging global challenges, ecosystem resilience, and the role of science and policy in promoting sustainability. The programme provided participants with practical insights into collaborative approaches for managing health risks and

environmental threats. The event served as an important platform for capacity building and knowledge exchange among students, researchers, and professionals working in the area of One Health.

23. National conference on AMR One Health (OH)




Dr. Indrani Karunasagar and Prof. Dr. Iddya Karunasagar were invited to participate in the AMR One Health (OH) Conference held in Thailand from 2–4 February 2026. The conference focused on antimicrobial resistance (AMR) within the One Health framework, bringing together global experts to discuss integrated approaches to human, animal, and environmental health.

They were accompanied by other staff members including Dr. Krishna Kumar, Associate Professor, Dr. Akhila D. S., Associate Professor, Deekshit, Associate Professor, Dr. Praveen Rai, Associate Professor, and Dr. Prithvisagar, Project Associate. The delegation actively engaged in scientific discussions, knowledge exchange sessions, and collaborative networking with international researchers. Their participation highlighted the continued commitment of the institute to addressing global AMR challenges through interdisciplinary research and collaboration.

Support for Developing the Capacity of Surveillance of AMR, AMU and Residues

1. **Workshop on "Emergence and Spread of Antimicrobial Resistance in Aquaculture"**

Dr. Iddya Karunasagar delivered a special lecture on "Overview of AMR in aquaculture and mitigation measures" at the national webinar on "Emergence and spread of antimicrobial resistance in aquaculture" organised by the Tamil Nadu Jayalalitha Fisheries University (TNJFU) on 16 November 2022. Dr. Karunasagar explained sources of AMR in aquatic environments and risk management methods that can be applied to minimise them.

2. **One Health workshop on "Environment, Fisheries and Aquatic Security".**

Dr. Iddya Karunasagar co-presented with Dr. David Werner-Jeffreys, CEFAS, UK, a keynote lecture on "Keeping fish healthy" at the Indo-UK One-Health workshop on "Environment, Fisheries and Aquatic Security" organized at Kochi on 20-21, February 2023. In his address, he talked about the emergence of new diseases, pathogen evolution through horizontal gene exchange, zoonotic pathogens in aquaculture systems, challenges in disease diagnosis and management in aquatic systems, and new approaches needed.

3. **Expert lectures on "Import Risk Analysis for aquaculture products".**

Dr. Iddya Karunasagar delivered an expert lecture on the topic 'Import risk analysis' at a conference on 28 February 2023, organized by the Central Institute of Brackishwater Aquaculture (CIBA) of the Indian Council of Agricultural Research (ICAR). The lecture covered the World Organisation of Animal Health (OIE) Import Risk Analysis Protocol. Dr. Karunasagar's lecture covered disease surveillance in aquaculture and minimisation of use of

antimicrobials in line with WOAH guidance on prudent and responsible use of antimicrobials in aquaculture.

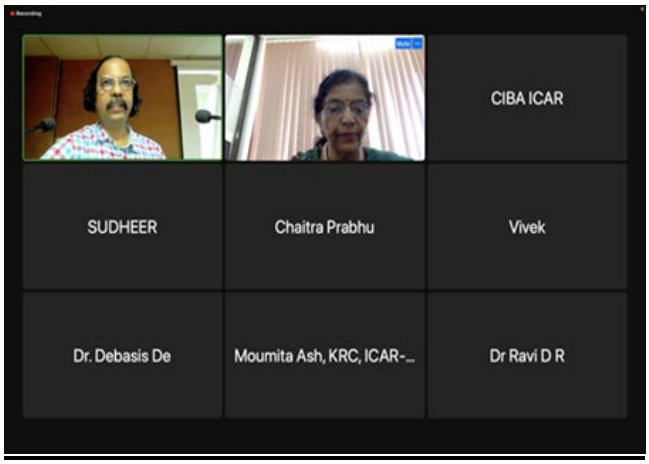
4. **Expert lectures on "Aquatic animal health management and biosecurity, and understanding of antimicrobial resistance in aquaculture"**

Dr. Iddya Karunasagar served as the resource person and delivered an online talk titled "Aquatic animal health management and biosecurity, and **u**nderstanding anti-microbial use and antimicrobial resistance in aquaculture in One Health framework," organized by FAO Regional Committee on Fisheries (RECOFI), Jeddah, Kingdom of Saudi Arabia, during 10-13 July, 2023. He highlighted that the aquatic environment receives antimicrobial residues and antimicrobial resistance determinants from the human, livestock, poultry, and agricultural sectors through wastewater, sewage, stormwater, sludge, flooding, and other sources. Hence, aquaculture would be impacted by antimicrobial use in all sectors. The workshop was informed of the importance of studying antimicrobial use (AMU) and antimicrobial resistance (AMR) within a one health framework, recognizing the interconnections among humans, animals, plants, and their shared environment. He further noted that AMU AMR surveillance should be carried out in accordance with guidelines from international agencies such as FAO, WOAH, and the Codex Alimentarius Commission, and that risk analysis, as outlined in these guidelines, could help prioritize AMU and AMR surveillance.

5. **Hands-on training in Microbial Genomics and Metagenomics**

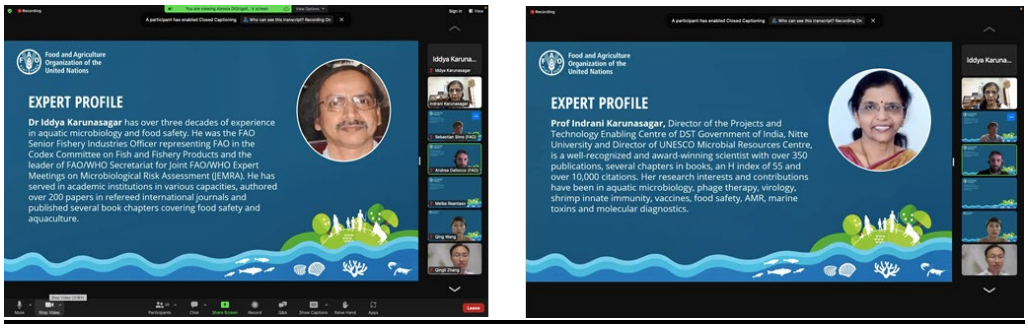
The centre organised a five-day training program on "Microbial Genomics and Metagenomics" with focus on AMR and Virulence gene analysis in association with Biokart India Pvt Ltd. from 17 to 21 July 2023. The resource persons were Mr. Vikram S, CEO, Biokart India Pvt. Ltd., Ms. Helga Jenifer, Senior Bioinformatician, Biokart India Pvt. Ltd, Dr. Krishna Kumar B, Asst. Professor, NUCSER, Dr. Deekshit, Asst. Professor, NUCSER, Dr. Praveen Rai, Asst. Professor, NUCSER and Mr. Prithvisagar KS, Research Associate, NUCSER.

6. Delivered a Talk on Environmental Dissemination of AMR through Wastewater



Dr. Indrani Karunasagar delivered a talk on "Dissemination of AMR in the environment through wastewater," organized by CIBA on 22 November 2023 on the occasion of World AMR Awareness Week (WAAW). This talk highlighted the role of wastewater in the spread of antimicrobial resistance and emphasized the need for effective environmental management strategies to mitigate AMR transmission.

7. Webinar on "Avoiding AMR together: Ensuring healthy and safe aquatic foods"



FAO, along with four reference centres, organized a webinar "Avoiding AMR together: Ensuring healthy and safe Aquatic foods" in connection with the antibiotic awareness week, on 27 November 2023. Dr. Iddya Karunasagar delivered an expert lecture on "Aquatic organisms of zoonotic concern," and Dr. Indrani Karunasagar spoke on "AMR and One Health".

8. **Third International Conference on Aquatic Animal Epidemiology (Aqua Epi III)**

Dr. Iddya Karunasagar was the Guest of Honour at the inauguration of the Third International Conference on Aquatic Animal Epidemiology (Aqua Epi III) at the National Bureau of Fish Genetic Resources, Lucknow, on 29 Nov 2023. The other guests included Dr. Kenton Morgan from the UK and Dr. Edgar Brun from Norway. Dr. Iddya Karunasagar also chaired scientific sessions at this International Conference.

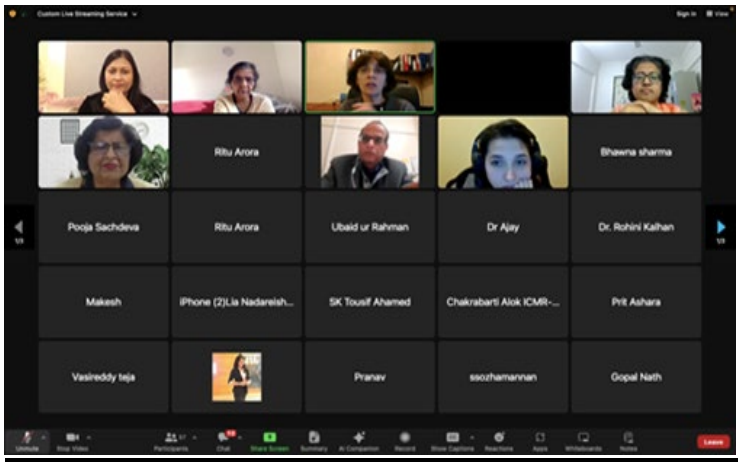
9. **Virocon-2023: Annual international conference organized by ICAR-National Research Centre for Banana and the Indian Virological Society (IVS)**

Dr. Iddya Karunasagar and Dr. Indrani Karunasagar delivered a lead talk and chaired a session under the theme - “Phages and Phage Therapy as alternatives to antibiotics” in VIROCON-2023, jointly organized by ICAR-National Research Centre for Banana, Tiruchirappalli, and the Indian Virological Society (IVS) at, Tiruchirappalli during 01-03 December 2023.

10. Indo-Norway Workshop on “Aquatic Animal Health Management”

The Centre organized an Indo-Norway workshop on “Aquatic Animal Health Management” on 05 December 2023. This workshop discussed joint projects between Nitte University and Nord University, Bodo, Norway, focusing on technologies such as vaccine development and delivery in aquaculture, as well as bacteriophage therapy as an alternative to antibiotics.

11. Webinar on Georgia’s Experience and Perspectives on Phage Therapy



Dr. Indrani Karunasagar contributed to the webinar on Georgia’s experience and perspectives on phage therapy, organized by the Phage Society on 22 December 2023. Dr. Mzia Kutateladze, Director of George Eliava Institute, Tbilisi, Georgia, was the resource person. The webinar focused on bacteriophages as alternatives to antibiotics in various sectors.

12. Expert lecture on “Startup and funding ecosystem in Agri-food sector”

The Center, along with the Institution Innovation Council, organized an expert lecture on “Startup and Funding Ecosystem in the Agri-Food Sector” on 6 February 2024 at the University

Auditorium, Paneer Campus. Mr Arvind Modi, Partner at Sathguru Catalysers, shared insights on grants, equity, debt, venture capital, angel investors, startup funding, and practical tips for founders on execution, cost management, and team building. The session concluded with a Q&A and vote of thanks by Dr Praveen Kumar Shetty.

13. 13th Indian Fisheries and Aquaculture Forum (IFAF)

Dr. Iddya Karunasagar served as Chair of the session “Frontiers in Fish Health Management” at the 13th Indian Fisheries and Aquaculture Forum (IFAF), held from 23–25 February 2024 at the Biswa Bangla Convention Center, Kolkata. He also participated as a Panelist in the “13th IFAF Student Interface Meet,” where he shared insights on technology development and startup opportunities in the aquaculture and fisheries sector. His deliberations emphasized the importance of skill development, innovation, and entrepreneurship promotion within Fisheries Universities. The engagement contributed to strengthening industry–academia collaboration and fostering a robust innovation ecosystem in fisheries and aquaculture.

14. Key Elements for the Success of the Food Industry: Regulatory, Technological, and Funding Ecosystem

The Centre, in association with KCCI, organized a session on “Key Elements for the Success of the Food Industry Regulatory, Technological and Funding Ecosystem” on 28 February 2024. The event brought together entrepreneurs, start-ups, students, investors, and industry

stakeholders. Dr. Sanu Jacob, Director, FSSAI, highlighted regulatory compliance, digital licensing systems, and food safety responsibilities under the Food Safety and Standards Act. Dr. K. Narayanan discussed technological advancement, mechanization, and venture capital opportunities in the food sector. The session concluded with a panel discussion moderated by Dr. Iddya Karunasagar, strengthening collaboration among regulators, academia, and industry to support a robust food industry ecosystem.

15. Invited Lecture at Symposium on "Food Safety and Health"

Dr. Iddya Karunasagar delivered an invited lecture at the Symposium on "Food Safety and Health," organized by the Department of Food Technology, Royal Global University, Guwahati, Assam, on 16 September 2024. He addressed international food safety regulations and standards developed by the Codex Alimentarius Commission, the joint FAO/WHO standard-setting body, and explained the relevance of the WTO Sanitary and Phytosanitary (SPS) Agreement. He highlighted the scientific basis of standard development through risk assessments conducted by JEMRA and elaborated on the risk analysis framework encompassing risk assessment, risk management, and risk communication. The symposium also featured a lecture by Dr. Sabu Thomas on microbiome research and health, and was coordinated by Dr. Pranita Das, Head of the Department of Food Technology.

16. Regional Workshop on Antimicrobial Use and Antimicrobial Resistance in Aquaculture (Asia–Pacific)

Dr. Iddya Karunasagar was invited by WOAH to deliver three lectures at the Regional Workshop on AMU/AMR in Aquaculture for the Asia–Pacific region, held from 30 October–1 November 2024 in Singapore and hosted by NParks. He spoke on antimicrobial stewardship, AMU/AMR in the shrimp industry, and alternatives to antibiotics in aquaculture.

The workshop was attended by around 50 experts from Asia–Pacific countries and WOAH offices, strengthening regional efforts to combat AMR in aquaculture.

17. International Workshop on “Utilising Microbiome and Genomic Resources to Mitigate Antimicrobial Resistance in Aquaculture in One Health Context”

FAO Reference Centre Nitte commemorated antibiotic awareness week by hosting an International hands-on workshop on "Utilising microbiome and genomic resources for understanding and mitigating antimicrobial resistance in aquaculture in One Health context," in accordance with the FAO Reference Centre's terms of reference on 18-22 Nov 2024. The workshop was organized in collaboration with the Indian Council of Agricultural Research, New Delhi, supported by UNESCO, Centre for Environment, Fisheries and Aquaculture Sciences, UK, National Fisheries Development Board (NFDB) and Marine Products Export Development Authority (MPEDA). Dr M.S. Moodithaya, the Vice Chancellor, Nitte DU presided the inaugural function. Dr J.K. Jena, Deputy Director General, ICAR was the Chief Guest and Dr Eduardo Leano, Director General of the Network of Aquaculture Centers in Asia Pacific (NACA) based in Thailand was the Guest of Honour. Other Guests of Honour included Dr. Karthikeyan, Director, MPEDA and Dr. Robin Paul, FAO India. FAO Headquarters in Rome was represented by Dr Melba Reantaso and FAO Reference Center in UK was represented by Dr Athina Papadopoulou and the US Reference Center was represented by Dr Hossam Abdelhamed from Mississippi State University, USA. The Workshop included resource persons from Italy, Norway, Philippines, and Sweden. Delegates from Bangladesh, Cambodia, Ethiopia, Nepal, Malaysia, Saudi Arabia, Sri Lanka, Tanzania, Thailand, Uzbekistan, Zambia and India attended this workshop.

After inauguration, Day-1 had lectures from FAO, WHO, ICAR, National One Health Institute, MPEDA, FAO Reference Centers in UK and US and country presentations to share experiences in mitigation of AMR. The Day-2 of the workshop included lectures from various resource persons on adopting standardized methods for antimicrobial susceptibility testing and wet lab experiments on antimicrobial susceptibility testing. Prof. Dr Iddya Karunasagar presented on issues in phenotypic testing for AMR, Dr Athina Papadopoulou, CEFAS gave a lecture on generating data for epidemiological cut-off points. The talk on phenotypic testing for AMR in aquaculture associated bacteria in the EU was delivered by Dr Manfrin Amedeo. Dr Luana Cortinovis, IZSVe presented on quality control in AMR testing laboratory and instructions on practical phenotypic testing for AMR. Mechanisms of AMR in aquatic bacteria in the USA was dealt by Dr Hossam Abdelhamed, MSU. Dr Gaurav Rathore, ICAR-NBFGR presented on Indian network for fisheries and animal antibiotic resistance via virtual mode. Dr Gunnar Kahlmeter, EUCAST Development Laboratory explained about MIC distributions and ECOFFs and their correlation between “wild-type organisms" as determined with phenotypic and genotypic methods via online presentation. Laboratory sessions were mentored by Dr Luana Cortinovis, Dr Amadeo Manfrin, Dr Athina Papadopoulou, Dr Deekshit, Dr Biswajit Maiti, Dr Praveen Rai, Dr Juliet Mohanraj (Nitte DU).




The Day-3 of the workshop included lecture series related to sequencing and bioinformatics sessions with the aim of training participants of different countries about the implementation of standardized methods for detecting antimicrobial resistance and to promote prudent and responsible use of antimicrobials in One Health. Lecture on introduction to Next Generation Sequencing (NGS) and sequence analysis was handled by Dr Praveen Rai and Dr Prithvisagar KS, Nitte DU. Dr Deekshit, Nitte DU explained about the sample preparation

required prior to sequencing. Ms. Divya Shetty, Zelle Biotechnology Pvt Ltd, gave an overview of Oxford Nanopore Sequencing Technology, followed by a demonstration of Oxford Nanopore Library Preparation, sequencing, and sequence retrieval post-run. The Day-4 and Day-5 of the workshops focused on Bioinformatics sessions which were handled by Dr Krishna Kumar B, Dr Prithvisagar KS, Dr Deekshit, Dr Praveen Rai Nitte DU, and Mr Ashwin, Biokart India Pvt Ltd. Hands on session included microbial whole genome sequence analysis, microbiome analysis including raw data QC, trimming & quality filter, assembly of the raw reads, annotations and AMR, virulence and mobile genetic element identification and analysis.

The participants also had the opportunity to visit various research facilities at NUCSER. The Mentimeter quiz sessions were conducted between sessions to assess knowledge gain on the topics covered in the workshop. The Workshop was a huge success, with active participation from 48 faculty members from 22 different Countries.

18. International Symposium on Aquaculture Medicine and Aquatic Animal Health Management (AQUAMAP)

Dr. Iddya Karunasagar and Dr. Indrani Karunasagar delivered keynote lectures at the International Symposium on “Aquaculture Medicine and Aquatic Animal Health Management” (AQUAMAP), organized by Cochin University of Science and Technology, Kochi, 16-18 January 2025. Dr. Iddya Karunasagar enlightened the audience on the recent developments in disease diagnosis and the field-level application of diagnostics. He also served as moderator for the Panel discussion on “Cell line development”. Dr. Indrani Karunasagar moderated the session on “Sustainable aquaculture production systems in practice” and delivered a lead lecture on the topic “Vaccination and immune stimulation as two facets of preventive healthcare and drug delivery systems in the aquaculture industry”.

19. Training on Bacterial Whole Genome Sequencing and Metagenomic Analysis

The centre organized a two-day hands-on training workshop on bacterial whole-genome sequencing and metagenomic analysis from 26- 27 March 2025. The training was organized for scientists from the Central Marine Fisheries Research Institute (CMFRI) in Cochin to strengthen their bioinformatics capabilities. Participants were introduced to advanced tools and pipelines for genome assembly, annotation, and comparative genomic analysis. The workshop also covered metagenomic data processing, microbial diversity analysis, and interpretation of high-throughput sequencing results. The programme enhanced the participants’ practical skills in applying bioinformatics approaches to aquatic and marine microbial research.

20. Development of Farm-Level Early Warning System for Aquatic Animal Disease

The programme on “Development of Farm-Level Early Warning System for Aquatic Animal Disease” focused on formulating guidelines and developing a roadmap to strengthen aquatic animal health surveillance. Organized from 3–5 November 2025 by Yellow Sea Fisheries Research Institute (YSFRI) and 7-9 November 2025 by Pearl River Fisheries Research Institute (PRFRI), and the Food and Agriculture Organization (FAO) in collaboration with the Chinese Academy of Fishery Sciences (CAFS), the initiative aimed to enhance preparedness at the farm level. Experts deliberated on risk assessment models, disease reporting frameworks, and rapid response strategies for emerging aquatic diseases. The roadmap emphasized the integration of field diagnostics, data-sharing platforms, and the capacity building of farmers and extension personnel. The programme laid a strategic foundation for improving biosecurity, minimizing disease outbreaks, and safeguarding aquaculture productivity.

21. Validation Workshop on the “Technical Roadmap for the Early Warning System (EWS) for Aquatic Diseases”

The Aquatic Disease Early Warning System (EWS) Validation Workshop was held from 9–11 December 2025 in Rome, Italy. Organized by the Food and Agriculture Organization (FAO), the workshop focused on validating the effectiveness and reliability of the EWS framework for aquatic diseases. Experts reviewed data models, surveillance mechanisms, and implementation strategies to strengthen early detection and rapid response systems in aquatic animal health management.

22. Workshop on "Genomic Technologies in Antimicrobial Resistance (AMR) Research"

The Centre organized a three-day capacity building programme titled "Genomic Technologies in Antimicrobial Resistance (AMR) Research" from 21–23 January 2026. The programme focused on introducing participants to modern genomic approaches for studying antimicrobial resistance, including whole-genome sequencing, data analysis, and the interpretation of AMR-related genetic information. The training aimed to strengthen technical skills and enhance research capacity among participants working in the field of microbiology and antimicrobial resistance.

23. Training programme on "Integrated Food Safety Management Regulatory Compliance Training: HACCP Training & ISO 22000 Internal Audit"

The Department of Food Safety & Nutrition at the Nitte University Centre for Science Education & Research (NUCSER), under Nitte (Deemed to be University), organized the inaugural programme of HACCP Training & ISO 22000 Internal Audit on 25 February 2026. Dr. Iddya Karunasagar was invited as the Chief Guest. The training initiative aimed to strengthen knowledge and implementation of HACCP principles and ISO 22000 internal auditing practices in food safety management systems.

24. Assisted in developing Extramural/Intramural research projects

a. **Elucidation of platelet activation and NLRP-3 inflammasome response in platelets during invasive *Vibrio vulnificus* infection to understand its potential role in the immunopathogenesis (PI: Dr Krishna Kumar B):** This project investigates platelet activation and NLRP-3 inflammasome signaling during invasive *Vibrio vulnificus* infection. By elucidating platelet-driven inflammatory responses, the study aims to clarify their role in immunopathogenesis and identify potential therapeutic targets to reduce disease severity and improve clinical outcomes

b. **Climate change and AMR - understanding the potential of oceans to act as a carbon sink (PI: Dr Arvind Singh):** This activity involved masters and doctoral students of Nitte

University and the students of National Physical Laboratory (NPL), Ahmedabad hosted by Nitte University. The project focused on improving ocean alkalinity. Oceans can absorb large amounts of carbon dioxide from the atmosphere. Improving ocean alkalinity increases seawater's capacity to store CO_2 safely as dissolved bicarbonate, reducing acidification while enhancing long-term carbon sequestration, offering a promising, nature-based approach to help mitigate climate change alongside emissions reductions. The outcomes of the project are important for maintaining the water quality of the aquatic environment since water alkalinity is an important parameter of water quality in aquaculture.

c. **Development and characterization of a novel three-dimensional biofilm of *Pseudomonas aeruginosa* for the assessment of the mechanism of nonmucoid to mucoid strain conversion, virulence, antibiotic resistance and macrophage immune response (PI: Dr Sudarshan Kini):** This project focuses on developing and characterizing a novel three-dimensional biofilm model of *Pseudomonas aeruginosa* to study the conversion from nonmucoid to mucoid strains. It evaluates associated changes in virulence, antibiotic resistance, and macrophage immune responses. The model aims to better replicate in vivo conditions, providing insights into pathogenic mechanisms and supporting the development of improved therapeutic strategies against chronic infections.

d. **Effect of *in-vitro* gut conditions on antibiotic resistance pattern in gut pathogens (PI: Dr Deekshit):** This project examines how simulated in-vitro gut conditions influence antibiotic resistance patterns in gut pathogens. By mimicking key intestinal factors such as pH, bile salts, and microbial interactions, the study evaluates changes in bacterial susceptibility and resistance mechanisms. The findings aim to improve understanding of gut-driven resistance development and support strategies to optimize antibiotic use and combat antimicrobial resistance.

e. **Development and standardization of monoclonal antibody based immunochromatographic (lateral flow) technology for the rapid detection of enteric viruses (Noro and Hepatitis A) from aquatic food: Protecting food chain and public health. (PI: Dr Krishna Kumar B):** This project aims to develop and standardize sensitive monoclonal antibody-based lateral flow assays for rapid detection of Norovirus and Hepatitis A in food samples. The user friendly, field deployable technology facilitates early identification of viral contamination, supports routine food safety monitoring, reduces outbreak risks, and strengthens public health protection across the food supply chain.

f. **CEFAS - Contract for services of whole genome sequencing of *Streptococcus agalactiae* serotypes in Indian aquatic systems, under the Ocean Country Partnership Programme (OCPP). (PI: Dr Akhila D S):** This project involves whole genome sequencing

and molecular characterization of *Streptococcus agalactiae* serotypes from Indian aquatic systems under the Ocean Country Partnership Programme (OCPP). It aims to generate genomic data to understand strain diversity, virulence factors, antimicrobial resistance profiles, and transmission pathways. The findings will strengthen epidemiological surveillance, support evidence-based disease management strategies, and enhance aquatic animal health and biosecurity.

g. **Investigating the role of Low calcium response H (LCRH) in secretion of *Vibrio parahaemolyticus* Type III Secretion System (T3SS) proteins (PI: Dr Krishna Kumar B):** Focusing on the molecular mechanisms of virulence, this study investigates the role of Low Calcium Response H (LCRH) in the secretion of Type III Secretion System (T3SS) proteins in *Vibrio parahaemolyticus*. It seeks to clarify how LCRH regulates T3SS expression and protein export, providing insights into pathogenicity and supporting the development of targeted control strategies.

h. **Enhancing the lytic activity of *Bdellovibrio* by optimizing the media conditions (PI: Dr Divyashree M):** Targeting improved biological control strategies, this study seeks to enhance the lytic performance of *Bdellovibrio* by optimizing culture media and growth conditions. It examines the effects of nutrient composition, pH, temperature, and incubation parameters on predatory activity, with the aim of maximizing antibacterial efficacy and supporting sustainable alternatives to antibiotics in aquaculture and environmental systems.

25. Advisory support to Student Research Projects

a. **Isolation and characterization of vibriosis and vibriophages (International visiting student from Ghent University):** This project focuses on isolating and characterizing vibriosis-causing bacteria and their corresponding vibriophages. It aims to understand pathogen–phage interactions and evaluate phages as potential biocontrol agents for managing *Vibrio* infections in aquatic environments and aquaculture systems.

b. **Antimicrobial activity of bacteria associated with mangrove sediments:** This study comprised bacterial isolates from mangrove sediments of Dakshin Kannada. PCR amplification of biosynthetic gene clusters, such as nonribosomal peptide synthetases (NRPSs) and polyketide synthases (PKSs), associated with antimicrobial compound production was performed. Bioinformatics analysis using BLAST confirmed that these isolates belong to the *Pseudomonas* and *Exiguobacterium* species. Phylogenetic trees constructed revealed evolutionary relationships among strains. Mangrove sediments harbor diverse bacteria with antimicrobial potential and valuable biosynthetic capacity, positioning them as promising sources of new bioactive metabolites and antibiotics.

c. **Nanoparticle assemblies as mimics to inhibit host-viral interactions (White Spot Syndrome Virus of Shrimps):** This study focuses on developing self-assembled DNA-mediated sulfonated gold nanostructures as inhibitors of viral infections by targeting host-viral interactions. The research synthesized higher-order multivalent gold nanostructures by conjugating nucleic acids to dibenzocyclooctyne (DBCO) via copper-free strain-induced click chemistry, enabling precise self-assembly via DNA hybridization. These nanostructures present optimized multivalent ligand arrangements that mimic viral binding surfaces, thereby blocking viral attachment and invasion. This approach demonstrates a promising platform for designing advanced antiviral materials that interfere with host-viral adhesion mechanisms.

d. **Detection of plasmid-mediated quinolone resistance genes in gut pathogens:** This project focuses on detecting plasmid-mediated quinolone resistance (PMQR) genes in gut pathogens to understand their prevalence and their role in the spread of antimicrobial resistance. Using molecular techniques, the study identifies key resistance determinants and their genetic mobility, providing insights into horizontal gene transfer within the gut microbiome. The outcomes aim to support surveillance efforts and guide strategies to curb the emergence of quinolone resistance.

e. **Evaluation of biofilm formation of fish pathogen for oral vaccination of fish:** This project involves cloning and sequencing the outer membrane protein–encoding gene of *Edwardsiella* to characterize its genetic structure and potential role in pathogenicity. The study aims to provide molecular insights into virulence-associated surface proteins, supporting improved understanding of host–pathogen interactions and contributing to the development of diagnostic markers or vaccine candidates.

f. **Cloning and sequencing of the outer membrane protein-encoding gene of *Edwardsiella***: This project involves cloning and sequencing the outer membrane protein–encoding gene of *Edwardsiella* to characterize its genetic structure and potential role in pathogenicity. The study aims to provide molecular insights into virulence-associated surface proteins, supporting improved understanding of host–pathogen interactions and contributing to the development of diagnostic markers or vaccine candidates.

g. **Understanding the function of the *Vibrio parahaemolyticus* secretion system-induced infection using a mouse model:** This project investigates how secretion system–mediated mechanisms drive infection in *Vibrio parahaemolyticus* using a mouse model. By analyzing host responses, bacterial virulence, and tissue pathology, the study aims to elucidate key molecular pathways involved in disease progression. The findings will enhance understanding of pathogen–host interactions and support the development of targeted therapeutic strategies to control invasive infections.

h. **Bacteriophages and their products for controlling the biofilms of drug-resistant *Klebsiella pneumoniae*:** This project explores bacteriophages and their derived products to disrupt biofilms formed by drug-resistant *Klebsiella pneumoniae*. It evaluates anti-biofilm efficacy and mechanisms of action, aiming to develop alternative therapeutic strategies to combat persistent, antibiotic-resistant infections.

i. **Unravelling the role of T3SS translocon-chaperone complex of pathogenic *Vibrio parahaemolyticus* in toxin delivery to host cells:** This project investigates how the T3SS translocon–chaperone complex in pathogenic *Vibrio parahaemolyticus* mediates toxin delivery into host cells. The study aims to clarify molecular mechanisms of virulence, advancing understanding of host–pathogen interactions and supporting development of targeted therapeutic interventions.

j. **Assessment of microplastic and toxicity profiling in zebrafish:** This project evaluates microplastic exposure and associated toxicity in zebrafish by assessing accumulation, physiological stress, and molecular responses. The study aims to understand the ecological and health impacts of microplastics, providing evidence to support environmental risk assessment and pollution mitigation strategies.

k. **Investigating the bioactivity of marine macroalgae extract:** This project investigates the bioactivity of marine macroalgae extracts by evaluating their antimicrobial, antioxidant, and cytotoxic properties. The study aims to identify promising natural compounds and assess their potential applications in pharmaceuticals, nutraceuticals, and biotechnology.

l. **Characterization of bacteriocin produced by probiotic bacteria for application against bacterial fish pathogens (International visiting student from Ghent University):** This project characterizes bacteriocins produced by probiotic bacteria and evaluates their activity against bacterial fish pathogens. The study aims to develop eco-friendly antimicrobial alternatives for aquaculture, supporting disease control while reducing reliance on conventional antibiotics.

m. **Isolation and characterization of local and novel bacteriophages against *Aeromonas hydrophilia* in juvenile Nile tilapia:** This project isolates and characterizes local and novel bacteriophages targeting *Aeromonas hydrophila* in juvenile Nile tilapia. It evaluates phage efficacy, host specificity, and therapeutic potential, aiming to develop sustainable, antibiotic-free strategies for controlling aeromoniasis in aquaculture.

n. ***Streptococcus agalactiae* infections in tilapia: Isolation and characterization of *Streptococcus agalactiae* phages (International visiting student from Ghent University):** This study addresses Streptococcus agalactiae infections in tilapia through the isolation and

comprehensive characterization of bacteriophages specific to the pathogen. It evaluates phage diversity, host specificity, lytic activity, stability, and therapeutic potential under laboratory conditions. The research aims to develop phage-based biocontrol strategies as sustainable alternatives to antibiotics, thereby reducing antimicrobial resistance risks and improving health management practices in aquaculture systems.

o. **Cloning and sequencing of bacteriocin mersacidin from *Bacillus subtilis*:** This study focuses on the cloning and sequencing of the bacteriocin mersacidin from Bacillus subtilis. It aims to characterize the genetic determinants responsible for its production and assess its antimicrobial potential. The work supports the development of novel antimicrobial agents as alternatives to conventional antibiotics for controlling resistant bacterial pathogens.

p. **Immune response evaluation of outer membrane protein-based vaccine against *Edwardsiella tarda* in zebrafish:** This study evaluates the immune response elicited by an outer membrane protein-based vaccine against Edwardsiella tarda in zebrafish. It assesses humoral and cellular immune parameters, protective efficacy, and survival following challenges. The findings aim to support the development of effective vaccination strategies for controlling edwardsiellosis in aquaculture.

q. **Detection of *Salmonella* from unprocessed foods and poultry farms using conventional Polymerase chain reaction:** This study focuses on the detection of Salmonella in unprocessed food samples and poultry farm environments using conventional Polymerase Chain Reaction (PCR). It involves sample collection, bacterial isolation, DNA extraction, and amplification of specific target genes for accurate identification. The approach enhances sensitivity and specificity compared to traditional culture methods, enabling rapid confirmation of contamination. The findings contribute to improved surveillance, early outbreak detection, and strengthened biosecurity and food safety measures in the poultry production chain.

r. **Assessing the Biodegradability of polymers by microbes in Marine mesocosm:** This study evaluates the biodegradability of polymers by marine microbes using controlled mesocosm systems that simulate natural marine environments. It examines microbial colonization, biofilm formation, polymer degradation rates, and changes in physicochemical properties over time. The research aims to understand microbial-driven breakdown pathways and environmental factors influencing degradation, contributing to sustainable material design and mitigation of marine plastic pollution.

s. **Cloning and sequencing of subtilosin bacteriocin from *Bacillus subtilis*:** This study focuses on the cloning and sequencing of the subtilosin bacteriocin gene from *Bacillus subtilis*. It aims to identify and characterize the genetic elements involved in its biosynthesis, regulation, and antimicrobial activity. Molecular analysis will confirm gene integrity and

sequence variations, while comparative studies will assess its potential against pathogenic bacteria. The findings support the development of novel, naturally derived antimicrobial agents as alternatives to conventional antibiotics.

t. **Detection of *Salmonella* typhi from unprocessed foods and poultry samples using polymerase spiral reaction assay:** This study focuses on the detection of *Salmonella* typhi in unprocessed food items and poultry samples using the Polymerase Spiral Reaction (PSR) assay. The method involves rapid DNA amplification under isothermal conditions, enabling sensitive and specific identification of the pathogen without sophisticated equipment. The approach aims to provide a quick, cost-effective diagnostic tool for routine surveillance, early contamination detection, and improved food safety management in poultry production systems.

u. **Investigating the antioxidant activity of bioactive compounds from the selected Brown algae:** This study investigates the antioxidant potential of bioactive compounds extracted from selected brown algae. It involves solvent extraction, phytochemical profiling, and evaluation of antioxidant activity using established in vitro assays such as DPPH, ABTS, and FRAP. The research aims to identify potent natural antioxidants, understand their functional properties, and explore their potential applications in nutraceutical, pharmaceutical, and food industries.

v. **Decoding drug resistance in *Streptococcus agalactiae* isolated from aquatic environments:** This study isolated and identified *S. agalactiae* from hospital environments and aquatic environments using standard microbiological and molecular methods. Antibiotic susceptibility testing revealed resistance to streptomycin, amikacin, and methicillin, aligning with known resistance patterns in *S. agalactiae*. The findings highlight the genetic basis of antimicrobial resistance and emphasize the public health risks linked to resistant strains in aquaculture settings. The study stresses the need for continuous surveillance and tailored antimicrobial stewardship programmes to mitigate the emergence of resistant strains.

w. **CRISPR typing of *Streptococcus agalactiae* isolated from aquatic environments:** Using bioinformatic resources such as CRISPR Cas Finder and CRISPR Cas Typer, we identified and characterized the CRISPR-Cas systems of *Streptococcus agalactiae* isolates. All strains possessed a type II-A CRISPR-Cas system, with short spacer arrays and three principal types of direct repeats. RNA structure prediction revealed that the repeats adopted stable hairpin structures, suggesting they are functionally relevant. The study observed high spacer sharing among aquatic isolates, indicating restricted phage exposure. This project produced India's first curated CRISPR dataset for aquatic GBS and identified several novel spacer sequences. Our study helps close the knowledge gap in Indian GBS data and lays the foundation for enhanced disease surveillance, outbreak management, and prevention.

x. **Genomic characterization of *Streptococcus agalactiae* isolated from Indian aquatic systems:** This study conducted whole-genome sequencing and comparative genomic analysis of *Streptococcus agalactiae* isolates from Indian aquatic and human clinical sources to understand genetic diversity, antimicrobial resistance (AMR), virulence, and zoonotic potential. Molecular typing revealed distinct host-associated lineages and evolutionary links, including the CC7 clonal complex, which is found across environments, suggesting potential cross-species transmission. Clinical isolates showed AMR for tetracycline, aminoglycosides, and macrolides, whereas aquatic isolates generally lacked these resistance genes. This emphasizes the need for integrated "One Health" surveillance to monitor and control the health and economic impacts of GBS across humans, animals, and the environment.

26. Supported internship training programs undertaken by post-graduate students

a. **Extraction of Polysaccharides from Red Seaweeds:** The training was undertaken at the Central Marine Fisheries Research Institute, Kochi, where students received hands-on training in various extraction methods, including Solvent extraction, aqueous extraction, Thin-Layer chromatography, ion-exchange chromatography, and spectrophotometric quantification.

b. **Bioprospecting techniques of biomolecules and instrumentation:** Hands-on training at Central Marine Fisheries Research Institute, Kochi on use of various techniques and instruments in screening and identification of biomolecules from various marine resources.

c. **Production of seaweed-based products as additives and supplements in agriculture, animal husbandry and food industries:** The training program conducted at AquAgri processing Pvt Ltd included techniques for extraction of chitosan from shrimp wastes, fucoidan from brown algae, cellulose from red algae, and fermentation of red algae using bacterial and fungal strains for extraction of proteins and lipids.

d. **Bacteriophage Based Biocontrol Agent for The Management of Aeromonas hydrophila Infections in Ornamental Fish:** The training was undertaken at Aquatic Biosystems, Mangalore and Mangalore Biotech Laboratory, Mangalore. The training mainly focused on Four bacteriophages (P11, P21, P31, and P43) against *Aeromonas hydrophila* were isolated as potential alternatives to antibiotics in aquaculture. Training was also gained in host range analysis and lytic activity assessment. Exposure was obtained to MOI optimization, stability studies, and genomic and morphological characterization.

e. **Metagenomics analysis using Bioinformatic tools:** Hands-on training at Biokart India Pvt.Ltd. Bengaluru on the use of various Bioinformatic tools such as Galaxy Server, Illumina sequence Data , FASTQ , Kraken2 , BIOM-format , MEGAHIT for the Metagenomic Analysis.

f. **Vaccination of Gold fish via different routes:** Supported internship for a student at College of Fisheries, Kishanganj, Bihar to get training in vaccination of gold fish via different routes, under the guidance of Dr. Abhiman, Assistant Professor, Department of Aquaculture.

Support for Strengthening Governance Related to AMU, AMR, and Aquaculture Biosecurity

1. **Workshop On "Official control protocol and strategic framework for the development of the fisheries and aquaculture value chain" in Cambodia**

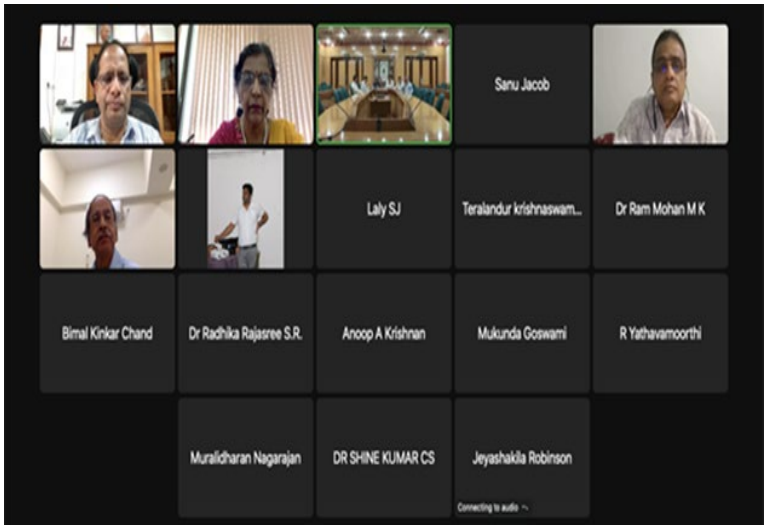
Dr. Iddya Karunasagar was invited as an International expert to a validation workshop on the official control protocol and strategic framework for the development of the fisheries and aquaculture value chain in Cambodia, organized by the United Nations Industrial Development Organization on 21 November 2022 in Phnom Penh, Cambodia. Dr. Iddya Karunasagar also provided training on Hazard Analysis Critical Control Point (HACCP) for Cambodian Government officials and industry representatives on 23-25 November 2022, at Siem Reap, Cambodia.

2. **Electronic Expert Group (EEG) meeting of the nominated members of the World Organization for Animal Health (WOAH) to develop guidelines for monitoring AMU in aquaculture**

Dr Indrani Karunasagar, a nominated member of an Electronic Expert Group (EEG) of the World Organisation for Animal Health (WOAH) participated in an online meeting from 02-05

May 2023 to collaboratively develop standardized guidelines for monitoring antimicrobial use (AMU) in aquaculture, supporting global surveillance, responsible antibiotic practices, and improved aquatic animal health. The EEG developed guidelines for field-level monitoring of AMU in aquaculture.

3. Webinar on Food Safety Strategies for the Indian Fisheries Sector



Dr Iddya Karunasagar and Dr Indrani Karunasagar delivered expert talks at the webinar on "Food Safety Strategies for the Indian fisheries sector" organized by National Academy of Agricultural Sciences and Indian Council for Agricultural Research on 17 May, 2023. The lectures highlighted best practices for hygienic handling, antimicrobial stewardship, quality assurance, and regulatory compliance. It aimed to strengthen capacity across the value chain, ensuring safer seafood, improved market access, and sustainable growth of India's fisheries industry. This webinar has resulted in the Food Safety Strategy Policy Paper (Policy Paper No. 125: https://naas.org.in/Policy%20Papers/Policy%20125.pdf).

4. G20 technical meeting on "One-Health opportunities and challenges"

Dr. Iddya Karunasagar was an invited speaker at the G20 Technical meeting on "One-Health Opportunities and challenges" held at Bangalore and organized by the Indian Council of Agricultural Research (ICAR) during 29-31 August 2023 at Bangalore. The meeting was attended by delegates from the US, Canada, the UK, Italy, Saudi Arabia, Oman, Spain, and others. Dr. Iddya Karunasagar spoke on aquaculture food safety in the One Health context. He highlighted the importance of biotoxins in fish and fishery products, as well as some recently identified zoonotic pathogens transmitted through them.

5. **Supporting implementation of international practices in the import of seafood in Indonesia**

Dr. Iddya Karunasagar conducted a training programme on best international practices in the import of seafood in Jakarta, Indonesia, from 18-22 September, 2023. This programme was supported by the Trade Facilitation Office Canada, through a multi-donor funding alliance. This training focused on the World Organization of Animal Health (WOAH) Aquatic Animal Health Code standards on import risk analysis, health certification of aquatic animals, and their impact on international trade. The use of the WOAH Manual of Diagnostic tests for Animals for testing and certification was also discussed. The capacity-building programme follows the earlier support provided on good importing practices and risk categorization based on pathogens affecting aquatic animal health.

6. **XVI Agriculture Science Congress with the theme "Aquaculture and fisheries-based Transformation of food systems**

Dr. Iddya Karunasagar chaired a session on "Genetics, Health and Nutrition" under the theme "Aquaculture and Fisheries-based Transformation of food systems" at the XVI Agriculture Science Congress, organized by the National Academy of Agricultural Sciences at Kochi, 10-13 October 2023. Scientists from Norway and different parts of India delivered keynote lecture, lead lecture and oral presentation in this session which resulted in a policy paper.

7. **Technical Support for Strengthening Import Control of Aquaculture Inputs in Cambodia**

Dr. Iddya Karunasagar was in Phnom Penh, Cambodia, from 16-26 October 2023 to support the Fisheries Administration of Cambodia in implementing international best practices for the import control of aquaculture inputs. This activity was under a UNIDO project in Cambodia. Since Cambodian aquaculture depends to a large extent on imports of inputs such as broodstock, fish seeds, fish feed, and even market-ready fish, it is important that import control activities comply with the recommendations of the World Organization for Animal Health (WOAH) Aquatic Animal Health Code. Dr. Iddya Karunasagar met with senior officers of the General Directorate of Customs and Excise and explained the risk-based approach in import control.

8. **FAO Reference Centre Coordination Meeting on Annual Action Plan and Activities**

Meeting of the FAO reference centres in the US, China and India held on 18 October 2023 to discuss the action plan and activities for the forthcoming year.

9. Capacity Building Workshop on “Aquatic Animal Health and Food Safety” in Malaysia

Under a project supported by the United Nations International Trade Centre (ITC), Dr. Iddya Karunasagar conducted a series of three capacity-building training workshops in Malaysia during November 2023. The first workshop, held from 6–8 November in Penang, focused on training participants in conducting import risk analysis in accordance with the World Organisation for Animal Health (WOAH) Aquatic Animal Health Code, strengthening the technical capacity of officers involved in aquatic animal health management and trade. The second workshop, conducted from 9–11 November in Penang, provided specialized training to officers of the Department of Fisheries, Malaysia on aquatic animal disease surveillance, including approaches for monitoring, reporting, and improving early detection systems. The third workshop, held from 13–17 November in Kota Kinabalu, Sabah, focused on the implementation of Hazard Analysis Critical Control Point (HACCP) systems in fish processing, with emphasis on practical aspects of food safety management. This workshop primarily targeted fisheries officers and aimed to enhance their capacity to ensure safe and quality fishery products for domestic consumption and international trade.

10. Capacity Building Programme on HACCP Application in Fish Processing

Dr. Iddya Karunasagar delivered training on the application of Hazard Analysis Critical Control Point (HACCP) in fish processing in Phnom Penh, Cambodia, 12-14 December 2023, under the EU-funded CAPFISH CAPTURE project implemented by UNIDO. Dr. Lahsen Ababouch,

former Director of the FAO Fisheries Division, was another resource person. This programme was intended as training for trainers, and 26 officers from the Fisheries Administration of Cambodia had been trained earlier as auditors for Quality Seal, Cambodia. The programme included practical sessions in which participants went through the steps of HACCP implementation across various fish processing industries.

11. FAO expert meeting on Antimicrobial Use surveillance

The centre hosted the FAO Expert meeting on the application of the 12-point checklist for antimicrobial use (AMU) surveillance in aquaculture. The meeting held on the Zoom platform on 13 December 2023, was attended by experts from Brazil, the United States, Germany, Ireland, the United Kingdom, the Network of Aquaculture Centers in Asia Pacific (NACA), China, and the FAO Headquarters in Rome. Dr. Iddya Karunasagar coordinated the meeting. The meeting outlined the modifications needed in this 12-point checklist to adapt it for AMU surveillance. During the meeting, each checklist item was discussed. Members highlighted the complexities involved in AMR surveillance, and the consensus was it would be good to develop a checklist first for AMU surveillance.

12. Discussion on setting guidelines for monitoring antimicrobial use in aquaculture

Dr. Indrani Karunasagar participated in a discussion on developing guidelines for monitoring antimicrobial use at the field and farm levels during the WOAH meeting on 18 December 2023.

13. National Seminar on Seafood Safety and International Trade

Dr. Iddya Karunasagar delivered an invited talk on “Seafood Safety and International Trade A Regulatory Perspective” at the DBT-sponsored National Seminar on Seafood Safety On 04 January 2024. The presentation provided comprehensive insights into regulatory frameworks, compliance requirements, and international standards governing seafood trade. The session enhanced awareness on food safety and quality assurance among stakeholders from ICAR institutes, universities, and the fish processing industry. It also strengthened linkages between research institutions and the seafood sector, contributing to improved export readiness and national capacity building in seafood safety management.

14. International Scientific Advisory Board Meeting on Food Safety Risk Assessment

Dr. Iddya Karunasagar was invited by the Government of the Kingdom of Saudi Arabia to serve as a Member of the International Scientific Advisory Board on Food Safety Risk Assessment. He attended the Advisory Board meeting held from 13–15 February in Riyadh, Saudi Arabia, where he provided expert inputs on food safety risk assessment processes undertaken by Joint FAO/WHO bodies and the application of scientific advice by the Codex

Alimentarius Commission. On this occasion, he delivered two invited talks: (a) “Food Safety Considerations in Aquaculture Products” and (b) “Antimicrobial Resistance in Aquaculture.” His participation strengthened international collaboration in food safety governance and contributed to evidence-based risk assessment and standard setting initiatives.

15. **Global Reference Centre Meeting on Progressive Management Pathway for Aquaculture Biosecurity**

Dr. Iddya Karunasagar and Dr. Indrani Karunasagar participated in the Global Reference Centre Meeting on the Progressive Management Pathway (PMP) for Aquaculture Biosecurity – Updates and Roll-out Monitoring, held at Qingdao, China From 13–15 May 2024. The meeting was jointly organized by FAO and the Chinese Academy of Fisheries Sciences and chaired by Dr. J.K. Jena, Deputy Director General, ICAR. The deliberations focused on strengthening aquaculture biosecurity frameworks, monitoring implementation strategies, and enhancing international collaboration for effective disease prevention and sustainable aquaculture development.

16. **Strategy Development Workshop on Strengthening Seafood Import Control and Inspection Systems in Indonesia**

Dr. Iddya Karunasagar was invited by the Trade Facilitation Office, Canada, to support the project “Enhancing Risk Management of Seafood Import Control and Inspection System of Indonesia” at a Strategy Development Workshop held from 5–7 August 2024. He provided expert inputs on international best practices in import control risk assessment and highlighted relevant guidelines from the World Organization for Animal Health (WOAH), Codex

Alimentarius Commission, and Joint FAO/WHO standards. Based on earlier advisory inputs, the Ministry of Fisheries had introduced new regulations to strengthen risk management protocols. During the workshop, Indonesian quarantine officials shared lessons learned from the project, international study tours, and audit visits. Dr. Karunasagar further advised on strategic actions required to enhance and sustain improvements in Indonesia's seafood import control system.

17. **WHO Expert Group Consultation on Risk-Benefit Analysis of Food Substitutes**

Dr. Iddya Karunasagar was nominated by the World Health Organisation (WHO) to be an expert committee member of Risk Benefit Assessment Group (RBAG) working on optimal intake of animal – source foods. The Expert committee meeting was held in Porto, Portugal during 11-15 November, 2024. The RBAG discussed microbiological and chemical hazards associated with various foods and considerations for the possibility of replacement of red meat with other healthier foods.

18. **International Scientific Advisory Board Meeting of the Saudi Food and Drug Authority**

Dr Iddya Karunasagar, as a Member of the International Scientific Advisory Board of the Saudi Food and Drug Authority attended the second meeting of the Board at Riyadh on 19-20

February 2025. Dr Karunasagar provided advice on issues related to microbiological risk assessment for various food commodities and the measures that need to be adopted following any food safety emergencies Dr Karunasagar had several one-to-one meetings with SFDA officers to address the queries they had on microbiological issues.

19. **Microbiome Conclave and Ideathon 2025**

Dr Iddya Karunasagar delivered an invited lecture on “Regulations related to Microbiomes and Probiotics” at Microbiome Conclave and Ideathon 2025 organized by the Center for Excellence in Microbiome and Kerala Startup Mission in Cochin on 5 March 2025. The conclave was attended by several Startups and Academic Institutions from Kerala and other States. The Startups evinced keen interest in understanding the regulatory landscape for the application of microbiomes in various sectors.

20. **Participation in the World Society for Virology Conference 2025**

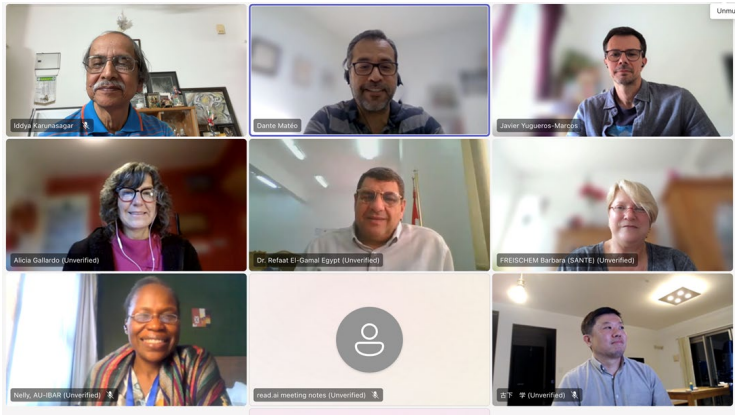
Dr. Indrani Karunasagar and Dr. Iddya Karunasagar were invited to participate in the 3rd International Conference of the World Society for Virology (WSV 2025) held from 6–8 May 2025 in Kuala Lumpur, Malaysia. The international conference brought together virologists and researchers from several countries to discuss advances in virology covering human, animal, plant, and environmental viruses within a One Health framework. The conference provided an important platform for exchange of knowledge on emerging viral diseases and interdisciplinary approaches relevant to aquaculture and public health.

21. **The 3rd Global Food Regulators Summit 2025**

Dr. Iddya Karunasagar, Dr. Sanu Jacob, Director, National Food Laboratory, Chennai and Dr. Indrani Karunasagar attended the GFRS 2025, organized by the Food Safety and Standards Authority of India **(**FSSAI) under the Ministry of Health & Family Welfare, held on 26-27 September 2025 at the Bharat Mandapam, New Delhi, focusing on "Evolving Food Systems, Yatha Annam Tatha Manah". More than 70 country representatives and various international organizations participated in the summit to discuss updating and harmonizing global food safety standards, risk assessment, technological innovations, integrating traditional food practices, and balancing

food safety with traceability, nutrition, and health goals. The summit reinforced India's role as a hub for global food safety regulations and innovation.

22. WOAH Ad Hoc Group on the Revision of Chapter of Aquatic Animal Health Code



The World Organisation for Animal Health invited Dr. Iddya Karunasagar to participate in the first WOAH Ad hoc Group meeting for the revision of Chapter of the Aquatic Animal Health Code. The Ad hoc Group was constituted to review and update international standards to ensure scientific accuracy and global relevance. This engagement further strengthened collaborative efforts aimed at improving aquatic animal health management worldwide.

23. International Conference Participation – World Aquaculture Society India 2025

Dr. Indrani Karunasagar and Prof. Iddya Karunasagar were invited to participate in World Aquaculture India 2025, held from 10–13 November 2025 in Hyderabad, India. The international conference brought together scientists, industry experts, and policymakers from across the Asia-Pacific region and other parts of the world to discuss recent developments and challenges in sustainable aquaculture, including aquatic animal health and antimicrobial resistance.

24. World Seafood Congress 2026

World Seafood Congress 2026 was held from 9–11 February 2026 at the Chennai Trade Centre, bringing together global leaders, policymakers, researchers, and industry stakeholders from across the seafood sector. Organized by the International Association of Fish Inspectors in collaboration with the MPEDA (Marine Products Export Development Authority), the congress focused on the theme “Sustainable Solutions for Inclusive Growth - Building a Safer, Fair and Resilient Global Seafood Trade.” The event featured panel discussions, technical sessions, and networking forums aimed at strengthening international cooperation and promoting responsible fisheries and aquaculture practices. Dr Iddya Karunasagar was invited to the congress in recognition of his distinguished contributions to seafood safety, quality assurance, and global trade standards.

Promote Good Aquaculture Practices and Prudent Use of Antimicrobials

1. **Virtual webinar on preventing antimicrobial resistance on the occasion of World Antibiotic Awareness Week 2022**

Dr. Indrani Karunasagar delivered an expert lecture on Preventing Antimicrobial Resistance Together- Go blue for AMR on 30 November 2022, as part of a virtual webinar on preventing Antimicrobial resistance, in support of the World Antibiotic Awareness Week (WAAW) 2022.

2. **Official Launch of FAO Reference Centres on Antimicrobial Resistance and Aquaculture Biosecurity**

The official launch of FAO Reference Centers for Antimicrobial Resistance and Aquatic Biosecurity took place on 26 June 2023 at the FAO Headquarters, Rome.The program was webcast in six UN languages (Arabic, Chinese, English, French, Russian, and Spanish). The Keynote speech on behalf of Nitte management was delivered by Pro Chancellor Mr. Vishal Hegde (online). The Indian Ambassador to Italy, along with Ambassadors from China and the US, attended the launch.

3. Training on Disease management in ornamental fishes in Malaysia

Dr. Iddya Karunasagar represented the FAO Reference Center on Antimicrobial Resistance and Aquaculture Biosecurity and served as resource person, along with Dr. Sylvie Coulon of the EU, for training on disease management in ornamental fish in Malaysia (Putrajeya,18-28 July, 2023) and on Codex Code of Practice for fishery products in Tawau, Sabah (July 31-Aug 4, 2023). Dr. Iddya Karunasagar provided lectures on the Codex standard, the Code of Practice, and the World Organization for Animal Health (WOAH) guidelines for aquaculture disease surveillance and import risk analysis. The training in Tawau, Sabah, focused on Codex Code Practice for fish and fishery products as a basic requirement for implementing Hazard Analysis Critical Control Point-based food safety management.

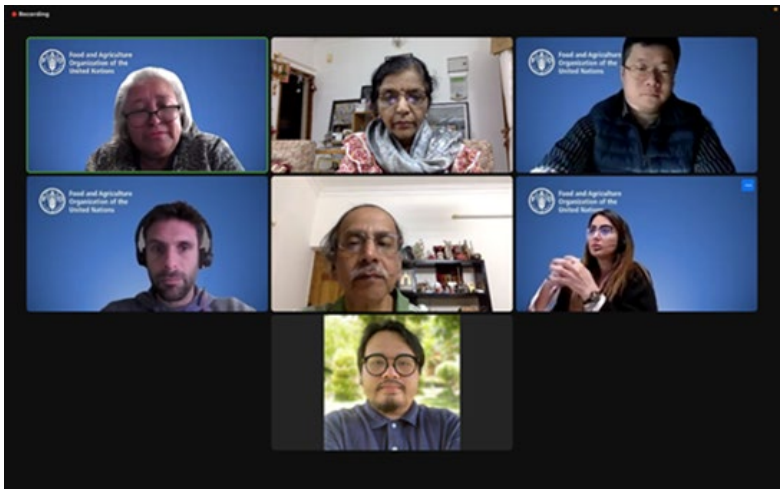
4. Hands-on Training Program on "Molecular techniques for fish and shrimp diseases: Disease surveillance protocols"

Dr. Indrani Karunasagar was invited as the chief guest for the Hands-on Training Program on "Molecular techniques for fish and shrimp diseases" under the aegis of the National Surveillance Program for Aquatic Animal Diseases (NSPAAD), conducted at CIBA on 9 August 2023.

5. Motivational talk on Food Safety Standards during the Silver Jubilee Year Celebration of Central Agricultural University, Tripura

Dr. Iddya Karunasagar was invited by the Central Agricultural University, College of Fisheries, Lembucherra, Tripura, to deliver the Silver Jubilee Lecture on 26 September 2023. Dr. Iddya Karunasagar discussed international food safety standards set by the Codex Alimentarius Commission and the scientific advice provided by the Joint FAO/WHO Expert Meeting on Microbiological Risk Assessment. He highlighted emerging zoonotic pathogens in the aquatic environment.

6. Expert Consultation on Risk Profiling of *Vibrio parahaemolyticus*



Dr. Indrani Karunasagar and Dr. Iddya Karunasagar participated in an FAO Zoom consultation meeting on 22 January 2024 , contributing expert inputs toward the development of a risk profile for *Vibrio parahaemolyticus*. Their deliberations supported the formation and guidance of an international expert team for risk assessment and strengthened collaboration with FAO on global seafood safety and risk analysis initiatives. The engagement advanced evidence-based risk management strategies and reinforced international efforts to enhance seafood safety standards.

7. Presentation on AMU/AMR Surveillance

Dr. Iddya Karunasagar and Dr. Indrani Karunasagar presented the work on AMU/AMR surveillance and related activities undertaken by the FAO Reference Centre on AMR and Aquatic Biosecurity at Nitte University during the Meeting of FAO Reference Centres held at Qingdao, China from May 16–18 2024. The presentation highlighted surveillance initiatives, research progress, and collaborative efforts aimed at strengthening antimicrobial resistance monitoring and promoting responsible antimicrobial use in aquaculture at the global level.

8. Participation in WOAH Global Expert Group Meeting on Antimicrobial Use Guidelines in Aquaculture

Dr. Indrani Karunasagar was nominated to the Global Expert Electronic Group for the development of guidelines on antimicrobial use in aquaculture in March 2023. She participated in the physical meeting of the expert group held at the World Organization for Animal Health (WOAH), Paris, from June 11–14 2024, where the draft guidelines were discussed in detail by international experts. Her contribution supported the development of science-based global guidelines to promote responsible antimicrobial use and mitigate antimicrobial resistance in aquaculture.

9. Fish-Vet + Dialogue II:One Health, Biosecurity, and Aquatic Organism Health

Dr. Iddya Karunasagar and Dr. Indrani Karunasagar were invited to participate in the FAO Expert Meeting on “Fish-Vet + Dialogue II: One Health and Biosecurity” and the International Conference on “Aquatic Organism Health – To Vaccinate or Not to Vaccinate,” held at FAO Headquarters, Rome, Italy, from June 18–20 2024. Dr. Iddya Karunasagar delivered a talk on “Foodborne AMR – Optimizing Genomic Resources for Mitigation of AMR,” while Dr. Indrani Karunasagar moderated Session 1 on One Health, AMR, zoonosis, fish safety, and fish welfare, and delivered a presentation on “Oral Nano-vaccines: Emerging Technology against *Aeromonas* Infection.” The meetings were attended by representatives of the Government of India, including Dr. J.K. Jena, Deputy Director General, ICAR, and technical officers from the Ministry of Fisheries. Their participation strengthened international collaboration in aquatic animal health, biosecurity, and AMR mitigation under the One Health framework.

10. Aquatic Animal Diseases: Emerging Challenges and Preparedness

Dr. Iddya Karunasagar delivered a Lead Lecture on “Biosecurity and Aquaculture” at the Symposium on “Aquatic Animal Diseases: Emerging Challenges and Preparedness” on 13 February 2025. This Symposium was part of the 14th Aquaculture and Fisheries Forum organized by the Asian Fisheries Society and the Indian Council of Agricultural Research at the National Agricultural Science Complex, Delhi, held on 12-15 February 2025.

11. One-day workshop on Food Safety: Science in Action

The Centre organized a one-day workshop on the occasion of celebrating World Safety Day 2025 on 10 June 2025. The theme for the Food safety day 2025 was "Food Safety: Science in Action". Dr Iddya Karunasagar, delivered a talk on the scientific basis for international food safety standards. He explained the scientific risk assessment reports produced by the Joint FAO/WHO Expert Committees, the Joint Expert Committee on Food Additives (JECFA), the Joint Expert Meeting on Microbiological Risk Assessment (JEMRA), and the Joint Meeting on Pesticide Residues (JMPR). These risk assessments form the basis of science-based food safety standards set by the Codex Alimentarius Commission. He also explained about microbiological sampling plans and compliance testing. Dr. S B Barbuddhe, Director, ICAR-National Meat Research Institute, Hyderabad, enlightened the gathering on the present contours and future scope for advancement in food safety. He highlighted the importance of *Listeria monocytogenes* as a foodborne pathogen and the repository and culture collection of foodborne pathogens being maintained at ICAR-NMRI. He also explained the problems with food authenticity and the technology used to detect mislabeled food. Dr. Indrani Karunasagar addressed the attendees about the safety of water in food production and processing. She explained the need for fit-for-purpose water to be made available to primary producers, such as agricultural fields, fishing boats, and fish landing centers. She explained harmful algal blooms and the toxins they produce, which may impact food safety. Her presentation included concepts of food adulteration and food contamination, and ways to minimize or mitigate them.

12. Managing Emerging Environmental Contaminants in Aquaculture and Fisheries

The National Academy of Agricultural Sciences organized a scientific programme on 18 July 2025 titled "Managing Emerging Environmental Contaminants in Aquaculture and Fisheries". The session focused on understanding how environmental contaminants contribute to the emergence and spread of new pathogens in aquaculture systems, the role of pollutants such as heavy metals, antimicrobial residues, and industrial effluents in altering aquatic ecosystems and weakening host immunity. The deliberations emphasized the link between environmental

stressors and increased disease outbreaks in fish and shellfish populations. The programme highlighted the need for integrated monitoring, sustainable management practices, and policy interventions to safeguard aquatic animal health and food security.

13. Marine Nutraceuticals for Boosting the Bio-Economy of India

The programme titled “Marine Nutraceuticals for Boosting Bio-Economy of India” focused on exploring the immense nutraceutical potential of carotenoid pigments derived from marine algae as an emerging frontier in dietary supplements. Organized by the National Academy of Agricultural Sciences on 18 July 2025, the event highlighted the growing significance of marine bioresources in strengthening bio-economy of India. The programme me emphasized the health-promoting properties of marine carotenoids, including their antioxidant and therapeutic benefits. Experts deliberated on sustainable harvesting, value addition, and commercialization strategies to translate research into market-ready products. The programme me underscored the need for interdisciplinary collaboration to harness marine nutraceuticals for economic growth and public health advancement in India.

14. Workshop on One Health: Together for a Safer Future

The Centre organized a workshop titled “One Health: Together for a Safer Future” on 24 November 2025, as part of World Antibiotic Awareness Week 2025. The workshop was conducted in collaboration with K S Hegde Medical Academy (KSHEMA), Nitte University Centre for Science Education and Research (NUCSER), and Nitte Institute of Allied Health Sciences (NIAHS), and brought together experts to discuss interdisciplinary approaches to health under the One Health framework. Eminent speakers addressed topics including vector-borne diseases, zoonotic viral diseases, antimicrobial resistance in tertiary care hospitals, food safety, and water safety. Dr. Iddya Karunasagar delivered a lecture on “One Health and Food Safety,” while Dr. Indrani Karunasagar spoke on “Water Safety and One Health,” highlighting the importance of integrated approaches to combat antimicrobial resistance and emerging health challenges.

15. AquaSolve 2026: Transforming Research with Real-World Needs

Dr Indrani Karunasagar was invited as an evaluator for a programme organized by NITTE–GOK Centre of Excellence. The programme was conducted on 16 January 2026 and focused on promoting industry-driven research in aquaculture and fisheries. The event highlighted the importance of addressing real-world challenges through scientific innovation and strengthening collaboration between academia and industry. Technical sessions covered topics such as aquaculture and ornamental fisheries, hatchery technologies and fish feed production, fish processing and entrepreneurship, and marine fisheries policy and regulations.

Experts from industry, academia, and government organizations participated as speakers and panel members, providing practical insights and facilitating knowledge exchange among participants.

16. One-Day National Conference on Smart Biomaterials and Next-Generation Drug Delivery Platforms

The NGSM Institute of Pharmaceutical Sciences (NGSMIPS), Mangalore, under Nitte (Deemed to be University), organized a One-Day National Conference on Smart Biomaterials and Next-Generation Drug Delivery Platforms on 20 February 2026. Dr Indrani was invited as the Chief guest and Guest of honour.

17. Workshop on "Translating Biology to Industry: A Hands-On Training on Bioprocess Technologies

The Departments of Bio & Nano Technology and Food Safety and Nutrition, NUCSER organized a three-day Industry-Academia workshop on "Translating Biology to Industry: A Hands-On Training on Bioprocess Technologies" on 20 February 2026. Dr. Indrani Karunasagar was invited to deliver a talk on "Industrial Applications of Bioprocessing: Harnessing the Power of Living Systems to Transform Modern Manufacturing." Her address highlighted the transformative role of living systems in advancing sustainable and innovative manufacturing practices. The workshop aimed to bridge academic research and industrial applications through practical exposure to bioprocess technologies.

List of Publications

1. Anees M, Deekshit VK, Shetty AV. In-vitro effectiveness of essential oils against isolated *Klebsiella pneumoniae* and *Acinetobacter baumannii*: A narrative review. Biomedicine: 2022 Dec; 42(6): 1128-1137. doi.org/10.51248/.v42i6.1977
2. Pinto DS, Prithvisagar KS, Rohit A, Karunasagar I, Karunasagar I, Kumar BK. Genome analysis of clinical isolates of *Campylobacter fetus* subspecies fetus MMM01 from India reveals genetic determinants of pathogenesis and adaptation. Acta Microbiologica et Immunologica Hungarica. 2022 Dec;69(4):332-44. doi: 10.1556/030.2022.01900
3. Poojari K, Akhila DS, Raj JM, Santhosh KS, Kenjar A, Ashwath P. Biocontrol of *Escherichia coli* and *Salmonella* in poultry meat using phage cocktail. Iranian Journal of Veterinary Research. 2022;23(3):270–274. doi: 10.22099/IJVR.2022.41490.6030
4. Dubey S, Anger-Wick E, Kumar J, Karunasagar I, Karunasagar I, Peng B, Evensen Ø, Sørum H, Munang'andu HM. *Aeromonas* species isolated from aquatic organisms, insects, chicken, and humans in India show similar antimicrobial resistance profiles. Frontiers in Microbiology.2022 Dec;13 : 1008870. doi: 10.3389/fmicb.2022.1008870
5. Kotian A, Aditya V, Sheikh J, Saikrishnan S, Rai P, Chakraborty A, Karunasagar I, Deekshit VK. Effect of NaCl, high iron, iron chelator and antibiotics on growth, virulence gene expression and drug susceptibility in non-typhoidal *Salmonella*: an in vitro fitness study. Archives of Microbiology. 2022 Nov ; 204(11):667. doi: 10.1007/s00203-022-03278-x.
6. Rai P, Shetty SS, Prabell S, Kuntar A, Pinto D, Kumar BK, Divyashree M, Raj JR, Premanath R, Deekshit VK, Karunasagar I. Characterisation of broad-spectrum phiKZ like jumbo phage and its utilisation in controlling multidrug-resistant *Pseudomonas aeruginosa* isolates. Microbial Pathogenesis. 2022 Nov 1;172:105767. doi: 10.1016/j.micpath.2022.105767
7. Deekshit VK, Srikumar S. 'To be, or not to be'—The dilemma of 'silent'antimicrobial resistance genes in bacteria. Journal of Applied Microbiology. 2022 Nov;133(5):2902-2914. doi.Org /10. 1111 / jam.15738
8. Akshay SD, Anupama KP, Deekshit VK, Rohit A, Maiti B. Effect of sub-minimum inhibitory concentration of ceftriaxone on the expression of outer membrane proteins in *Salmonella enterica* serovar Typhi. World Journal of Microbiology and Biotechnology.2022 Nov;38(11): 190. doi.org/10.1007/s11274-022-03383-5
9. Premanath R, James JP, Karunasagar I, Vaňková E, Scholtz V. Tropical plant products as biopreservatives and their application in food safety. Food Control. 2022 Nov; 141(109185). doi.org/10.1016/j.foodcont.2022.109185
10. Gollapalli P, Selvan GT, Santoshkumar HS, Ballamoole KK. Functional insights of antibiotic resistance mechanism in *Helicobacter pylori*: Driven by gene interaction network

and centrality-based nodes essentiality analysis. Microbial Pathogenesis. 2022 Oct ;171:105737. doi.org/ 10.1016 / j.micpath 2022.105737

11. Aditya V, Kotian A, Sanil A, Thaseena PM, Karunasagar I, Deekshit VK. Survival and Virulence Potential of Drug-Resistant *E. coli* in Simulated Gut Conditions and Antibiotic Challenge. International Journal of Environmental Research and Public Health.2022 Oct ;19(19): 12805 ; doi.org/10.3390/ijerph191912805
12. Somanath Disha, Undiganalu Gangadharappa Yathisha, Mave Harshitha, Biswajit Maiti (2023) In silico evaluation of outer membrane protein S2 as a suitable vaccine candidate against *Edwardsiella tarda* infection of fish. North American Journal of Aquaculture https://doi.org/10.1002/naaq.10322
13. Raj JR, Dinesh A, Vittal R, Rohit A. Prophage and Plasmid-Mediated Beta-Lactamases in Multidrug-Resistant Extraintestinal *Escherichia coli*. Journal of Health and Allied Sciences NU. 2023 Aug 24. https://doi.org /10.1055/s-0043-1772707
14. Nayak, A., Harshitha, M., Dubey, S., Munang'andu, H.M., Chakraborty, A., Karunasagar, I., Maiti, B. Evaluation of probiotic efficacy of Bacillus subtilis RODK28110C3 against 1 pathogenic *Aeromonas hydrophila* and *Edwardsiella tarda* using in vitro studies 2 and in vivo gnotobiotic zebrafish gut model system. Probiotics and Antimicrobial Proteins. http://doi/10.1007/s12602-023-10127-w.
15. Shetty S, Kenjar A, Raj JM, Akhila DS, Karunasagar I, Vittal R. Prevalence and characterization of *Legionella pneumophila* and related species from water-based recreational sites. Journal of health and allied sciences NU. 2023 . http://dx.doi.org/10.1055/s-0043-1770070.
16. Akshatha K, Aditya V, Sheikh J, Saikrishnan S, Rai P, Chakraborty A, Karunasagar I, Deekshit VK. Survival, virulence gene expression and difference in the drug susceptibility of non-typhoidal *Salmonella* in gut physiological conditions. World Journal of Microbiology and Biotechnology. 2023. https://doi.org/10.21203/rs.3.rs-479102/v1.
17. Ashwath Nayak, Harshitha Mave, Somanath Disha, Saurabh Dubey, Hetron Mweemba Munang'andu, Øystein Evensen, Indrani Karunasagar, Anirban Chakraborty, Biswajit Maiti. In vitro determination of probiotic efficacy of Bacillus subtilis 1 TLDK301120C24 isolated from tilapia against warm water fish pathogens and in vivo validation using gnotobiotic zebrafish model. Microbial Pathogenesis .2023 Dec; 185:106429. https://doi.org/10.1016/j.micpath.2023
18. Sadanand Dangari Akshay, Vijaya Kumar Deekshit, Juliet Mohan Raj, Biswajit Maiti . Outer Membrane Proteins and Efflux Pumps Mediated Multi-Drug Resistance in *Salmonella*: Rising Threat to Antimicrobial Therapy. ACS Infectious Diseases 2023 Nov; 9 (11): 2072-2092. https://doi.org/ 10.1021/acsinfecdis.3c00408
19. Mohan M, Gaonkar AA, Nanjappa DP, Krithika K, Vittal R, Chakraborty A, Chakraborty G. Screening for microplastics in drinking water and its toxicity profiling in zebrafish.

Chemosphere. 2023 Nov; 341:139882. https://doi.org/10.1016/j.chemosphere.2023.139882

20. Nayak S, Aanice D, Andria D, Pai A, Maiti B. Polymerase chain reaction-based typing methods and protein profiling analysis of *Acinetobacter baumannii* isolated from environmental and clinical sources from South India. Canadian Journal of Microbiology. 2023 Nov; 69(11):449-462. https://doi.org/ 10.1139/cjm-2023-0010.
21. Mave Harshitha, Ashwath Nayak, Somnath Disha, Uchangi Satyaprasad Akshath, Saurabh Dubey, Hetron Mweemba Munang'andu, Anirban Chakraborty, Indrani Karunasagar , Biswajit Maiti. Nanovaccines to combat *Aeromonas hydrophila* infections in warm water aquaculture: Opportunities and challenges. Vaccines. 2023 Oct; 11(10):1555. https://doi.org/10.3390/ vaccines 11101555
22. Karunasagar I. Bacterial pathogens associated with aquaculture products. InZoonoses: Infections Affecting Humans and Animals 2023 Oct 10 (pp. 231-265). Cham: Springer International Publishing.
23. Kushalan S, Kashyap A, Morajkar S, Hegde S. Geospatial distribution of fluoride and iron in natural water sources in Mangalore city. Journal of Health and Allied Sciences NU. 2023 Oct; 13(4):525–534. http://dx.doi.org/10.1055/s-0042-1760322.
24. Suresh S, Saldanha J, Bhaskar Shetty A, Premanath R, Akhila DS, Mohan Raj JR. Comparison of Antibiofilm Activity of *Pseudomonas aeruginosa* Phages on Isolates from Wounds of Diabetic and Non-Diabetic Patients. Microorganisms. 2023 Sep 4;11(9):2230.
25. Bondad-Reantaso MG, MacKinnon B, Karunasagar I, Fridman S, Alday-Sanz V, Brun E, Le Groumellec M, Li A, Surachetpong W, Karunasagar I, Hao B. Review of alternatives to antibiotic use in aquaculture. Reviews in Aquaculture. 2023 Sept;15(4): 1421-1451. https:// doi.org/10.1111/ raq.12786

26. Daoud Z. Indrani Karunasagar. Global dissemination and evolution of epidemic multidrug-resistant gram-negative bacterial pathogens: Surveillance, diagnosis, and treatment. Frontiers in Microbiology.July 2023; 13:1028288. https://doi.org/10.3389/fmicb.2022.983963
27. Prakash Shetty V, Akshay S D, Rai P, Deekshit VK. Integrons as the potential targets for combating multidrug resistance in Enterobacteriaceae using CRISPR- Cas9

technique. Journal of Applied Microbiology.2023 July: 134(7):1-7. https://doi.org/10.1093/jambio/lxad137.

28. Prithvisagar KS, Gollapalli P, D'Souza C, Rai P, Karunasagar I, Karunasagar I, Kumar BK. Genome analysis of clinical genotype *Vibrio vulnificus* isolated from seafood in Mangaluru Coast, India provides insights into its pathogenicity. Veterinary Quarterly. 2023 Aug;43(1):1-17.https://doi.org/10.1080/01652176.2023.2240389
29. Theresse LT, Rohit A, Aditya V, Kotian A, Karunasagar I, Deekshit VK. Detection of novel gyrB mutation in fluoroquinolone-resistant *Salmonella* and *Escherichia coli* using PCR-RFLP. Journal of Allied Health Science NU. 2023 July;13(03): 337-342. https://doi.org/ 10.1055/s-0042-1755597.
30. Banu S, Alva S, Prabhu PJ, Krishnan S, Mani MK. Detection of non-ribosomal and polyketide biosynthetic genes in bacteria from green mud crab *Scylla serrata* gut microbiome and their antagonistic activities. Fish and Shellfish Immunology Reports. 2023 June; 5:100104. https://doi.org/10.1016/j.fsirep.2023.100104
31. Ashwath P, Deekshit VK, Rohit A, Rai P, Aditya V, Babu N, Karunasagar I, Dharnappa Sannejal A. Sequence-specific gene silencing of acrA in the multi-drug efflux system AcrAB induces sensitivity in drug-resistant *Klebsiella pneumoniae*. Molecular Biotechnology. 2023 June; 65(6):953-960. https://doi.org/10.1007/s12033-022-00585-y
32. Hebbar CS, Kenjar AR, Raj JM, Karunasagar I, Vittal R. Isolation of Bacterial Pathogens Associated with Commercially Available Spices in Mangaluru City, India. Journal of pure and applied microbiology. 2023 May; 17(2):993-999. https://doi.org/10.22207/JPAM.17.2.28
33. Bhat I, Jose NM, Mamatha BS. Oxidative stability of lutein on exposure to varied extrinsic factors. Journal of Food Science and Technology. 2023. April; 60(4): 987–995. .https://doi.org/ 10.1007/s13197-022-05430-3
34. Jathanna NN, Krishnamurthy GK, Paithankar JG, Hegde S, Goveas LC, Ravindranath BS, Gowdru M. Phyto-bacterial biosorption of basic fuchsine: A self-sustainable approach towards biomitigation of contaminant of emerging concern. Journal of Environmental Chemical Engineering. 2023 April; 11(2):109330. https://doi.org/10.1016/j.jece.2023.109330
35. Akshay SD, Nayak S, Deekshit VK, Rohit A, Maiti B. Differential expression of outer membrane proteins and quinolone resistance determining region mutations can lead to ciprofloxacin resistance in *Salmonella Typhi*. Archives of Microbiology. 2023 March 24; 205(4):136 https://doi.org/10.1007/s 00203-023-03485-0.
36. Prithvisagar KS, Kodama T, Rai P, Deekshit VK, Karunasagar I, Karunasagar I, Ballamoole KK. Non-clinical isolates of *Vibrio parahaemolyticus* harbouring traits of potential pathogenicity and fitness: A molecular analysis. Microbial Pathogenesis. 2023 March; 178:106069. https://doi.org/ 10.1016/j.micpath.2023.106069.

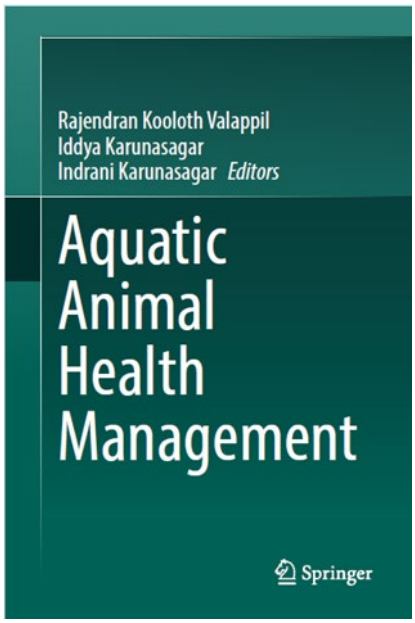
37. Nayak S, Do Carmo Lobo N, Anupama KP, Nayak A, Akshay SD, Maiti B. Evaluation of loop-mediated isothermal amplification assay for visual detection of *Acinetobacter baumannii* directly from soil and water sample from Mangalore. Letters in Applied Microbiology. 2023 March; 76(3): ovad028. https://doi.org/10.1093/lambio/ovad028.
38. Suresh S, Naik A, Premanath R. Glucose-induced enhanced virulence in strains of multidrug-resistant *Pseudomonas aeruginosa* isolated from diabetic patients. Current Microbiology. 2023 Mar; 80(3):100. https://doi.org/10.1007/s00284-023-03200-8
39. Caputo A, Bondad-Reantaso MG, Karunasagar I, Hao B, Gaunt P, Verner-Jeffreys D, Fridman S, Dorado-Garcia A. Antimicrobial resistance in aquaculture: A global analysis of literature and national action plans. Reviews in Aquaculture. 2023 Mar;15(2):568-78.
40. Haenen OL, Dong HT, Hoai TD, Crumlish M, Karunasagar I, Barkham T, Chen SL, Zadoks R, Kiermeier A, Wang B, Gamarro EG. Bacterial diseases of tilapia, their zoonotic potential and risk of antimicrobial resistance. Reviews in Aquaculture. 2023 Feb;15:154-85
41. Suresh MS, Rai D, Raj JM, Premanath R Divyashree M. Predatory efficacy of *Bdellovibrio stolpi*i isolated from the wastewater sources against the multidrug-resistant clinical isolates. Journal of Water and Health. 2023 Feb; 21 (2): 147–159. https://doi.org/10.2166/wh.2023.136
42. Ashwath P, Somanath D, Sannejal AD. CRISPR and Antisense RNA Technology: Exploiting Nature's Tool to Restrain Virulence in Tenacious Pathogens. Molecular Biotechnology. 2023 Jan; 65(1):17-27. https://doi,org/10.1007/s12033-022-00539-4.
43. Yathisha UG, Tanaaz M, Bhat I, Luckose F, Mamatha BS. Physicochemical properties and angiotensin-I converting enzyme inhibitory activity of lipid-free ribbon fish (Lepturacanthus savala) protein hydrolysate. Journal of Food Science and Technology. 2023 Jan; 60(1):340-52. https://doi.org/10.1007/s13197-022-05620
44. Deekshit VK, Maiti B, Kumar KB, Kotian A, Pinto G, Karunasagar I, Karunasagar I. Antimicrobial resistance in fish pathogens and alternative risk mitigation strategies. Reviews in Aquaculture. 2023 Jan; 15(1)261-273.https://doi.org/10.1111/raq.12715
45. Anshida M, Raj JM, Mamatha BS, Akhila DS, Vittal R. Incidence of Aflatoxin in ready-to-eat nuts from local food markets in Mangaluru, India. Journal Health Allied Sci. NU, 2023 Jan; 3(01): 103-106. https://doi.org/10.1055/s-0042-1748804
46. Akhila Dharnappa Sannejal, Mithoor Divyashree, Deekshit Vijaya Kumar, M. S. Nithin, and Praveen Rai. Fish Microbiome and Metagenomics, In: Microbiome of Finfish and Shellfish, November 2023. Springer, Singapore.https://doi.org/10.1007/978-981-99-0852-3_4. 978-981-99-0852-3
47. Feby Luckose, Mamatha BS, Nidhi S. Shetty and Akshath Uchangi Satyaprasad. Recent Trends in Nano Biosensors for Food Testing In Engineering Aspects of Food Quality and Safety. Springer Publisher 2023 (pp 383–409).ISBN: 978-3-031-30682-2

48. Akhila DS, Ashwath P, Manjunatha KG, Akshay SD, Rao R, Reddy D, Vittal R. Pesticide and xenobiotic metabolism in aquatic organisms. In Xenobiotics in Aquatic Animals: Reproductive and developmental impacts.2023 (pp.1:66) Spinger Publisher. ISBN: 978-981-99-1213-1
49. Mathias RC, Kushalan S, Hegde H, Jathanna NN, Hegde S. Phycoremediation: algae-based bioremediation. In: Algae Materials 2023 Jan 1 (pp. 451-469). Academic Press. ISBN: 978-981-99-1213-1
50. Priyanka A, Ramya P, Rajeshwari V, Deekshit VK, Prarthana A, Feroz AS, Akhila DS. Bacterial diseases of finfish prevalent in Cold, water fisheries and aquaculture management 2023(pp.55). CRC Press. ISBN: 9781003369905
51. Maiti B, Harshitha M, Disha S, Badekila AK, Kini S, Rai P. Nanovaccine. In. Nanotechnological Approaches to the Advancement of Innovations in Aquaculture 2023 Mar 28 (pp. 37-65). Cham: Springer International Publishing. ISBN : 9783031155192,
52. Arivarasan VK, Loganathan K, Karunasagar I, editors. Nanotechnological approaches to the advancement of innovations in aquaculture. Springer; 2023.
53. Nijil S, Bhat SG, Kedla A, Thomas MR, Kini S. A silver lining in MRSA treatment: The synergistic action of poloxamer-stabilized silver nanoparticles and methicillin against antimicrobial resistance. Microbial Pathogenesis. 2024 Dec; 197:107087. doi.org / 10. 1016 /j.micpath. 2024.107087
54. Naik A, Premanath R. Anti-quorum sensing activity of essential oils against multidrug-resistant Klebsiella pneumoniae: a novel approach to control bacterial virulence. Brazilian Journal of Microbiology. 2024 Dec;55(4):3909-3920. doi: 10.1007/s42770-024-01546-0.
55. Rai D, Sulthana F, Divyashree M. Production and Antimicrobial Activities of Pyocyanin Extracts from Pseudomonas aeruginosa. Journal of Pure & Applied Microbiology. 2024 Dec ;18(4):2371-2379. https://doi.org/10.22207/JPAM.18.4.10
56. Jogi N, Mathew A, Mamatha BS. Modification of bioactive properties in food protein hydrolysates by Alcalase and trypsin. *Journal of Health and Allied Sciences NU* 2024 Dec; 14(S 01): S26-S34. DOI: 10.1055/s-0044-1782643
57. Nayak, A., Harshitha, M., Dubey, S., Munang'andu, H.M., Chakraborty, A., Karunasagar, I., Maiti, B. Evaluation of probiotic efficacy of *Bacillus subtilis* RODK28110C3 against pathogenic *Aeromonas hydrophila* and *Edwardsiella tarda* using in vitro studies 2 and in vivo gnotobiotic zebrafish gut model system. Probiotics and Antimicrobial Proteins. 2024 Oct;16(5):1623-1637 .doi.org/10.1007/s12602-023-10127-w
58. Ajakkala PA, Nayak S, Maiti B, Rohit A, Mohan Raj JR, Karunasagar I. Phenotypic Changes in Phage Survivors of Multidrug-Resistant *Klebsiella pneumonia.* Indian Journal of Microbiology.2024 Sept;64(3):1379–1383.doi.org/10.1007/s12088-024-01217-6

59. Jogi N, Adusumilli S, Nagesh M, Yannam SK, Mamatha BS. The role of duel hydrolysis of soybean on functional properties and protein digestibility: a sustainable approach. Frontiers in Nutrition. 2024 Sept; 11:1444329. doi: 10.3389/fnut.2024.1444329
60. Yoginath Bhambure S, E Costa LI, Gatty AM, Manjunatha KG, Vittal R, Sannejal AD. Unveiling the traits of antibiotic resistance and virulence in Escherichia coli obtained from poultry waste. Brazilian Journal of Microbiology. 2024 Sep;55(3): 2997-3007.doi: 10.1007/s42770-024-01367-1
61. Akhila Dharnappa Sannejal, Radhika Suresh Jakkappagol, Kavitha Guladahalli Manjunatha, Abhirami Somasekharan, Ramith Ramu, Rajeshwari Vittal. Revealing the Antimicrobial Potential of Jackfruit Rag Extract: Profiling with Spectro analysis. African Journal of Biological Sciences. 2024 Aug ;6(14);683-712 doi.org/10.48047/AFJBS.6.14.2024.682-712
62. Miyar HK, Jathanna NN, Selvaraj R, Vinayagam R, Pugazhendhi A, Goveas LC. Multifunctional Hydrophobin-Like Protein (HFB-NJ1): A Versatile Solution for Wastewater Treatment. Environmental Research 2024 Aug; 255: 119139. doi.org/10.1016/j.envres.2024.119139
63. Muliya Sankappa N, Shivani Kallappa G, Kallihosuru Boregowda K, Mandrira Ramakrishna N, Kattapuni Suresh P, Shriraje Balakrishna D, Ballamoole KK, Thangavel S, Sahoo L, Lange MD, Deshotel MB. Novel lytic bacteriophage AhFM11 as an effective therapy against hypervirulent Aeromonas hydrophila. Scientific Reports. 2024 July 23;14(1):16882. doi.org/10.1038/s41598-024-67768-2
64. Irusan D, Akshay SD, Shetty VP, Karunasagar I, Deekshit VK, Rohit A. Analysis of MCR family of colistin resistance genes in Gram-negative isolates from a tertiary care hospital in India. Journal of Applied Microbiology. 2024 July 2;135(7): lxae172. doi.org/10.1093/jambio/lxae172
65. Raj JR, Dinesh A, Vittal R, Rohit A. Prophage and Plasmid-Mediated Beta-Lactamases in Multidrug-Resistant Extraintestinal *Escherichia coli*. Journal of Health and Allied Sciences NU. 2024 July;14(3):.42-425. doi.org /10.1055/s-0043-1772707
66. Harshitha M, D'souza R, Akshay SD, Nayak A, Disha S, Aditya V, Akshath US, Dubey S, Munang'andu HM, Chakraborty A, Karunasagar I, Maiti, B. Oral administration of recombinant outer membrane protein A-based nanovaccine affords protection against *Aeromonas hydrophila* in zebrafish. World Journal of Microbiology and Biotechnology. 2024 June;40(8):250. doi.org/10.1007/s11274-024-04059-y. I
67. Dinesha P, Udayakumar D, Shetty VP, Deekshit VK. Design, synthesis, characterization, and biological evaluation of novel pyrazine-1, 3, 4-oxadiazole/[1, 2, 4] triazolo [3, 4-b][1, 3, 4] thiadiazine hybrids as potent antimycobacterial agents. Journal of Molecular Structure. 2024 May; 1304:137657. doi.org/10.1016/j.molstruc.2024.137657

68. Dinesha P, Udayakumar D, Shetty VP, Prabhu C, Deekshit VK. Synthesis and In vitro Screening of Pyrazine-2-Carbohydrazide Derivatives as Potential Antimicrobial Agents. Journal of Computational Biophysics and Chemistry. 2024 May;23(4):541-60 doi.org/10.1142/S2737416524500042
69. Nayak S, Akshay SD, Deekshit VK, Raj JM, Maiti B. Exposure to imipenem at sub-minimum inhibitory concentration leads to altered expression of major outer membrane proteins in *Acinetobacter baumannii*. Journal of Applied Microbiology. 2024 May; 135(5): lxae105 . doi.org/10.1093/jambio/lxae105
70. Shetty S, Kenjar A, Raj JM, Akhila DS, Karunasagar I, Vittal R. Prevalence and characterization of *Legionella pneumophila* and related species from water-based recreational sites. *J*ournal of Health and Allied Sciences NU. 2024 April; 14(02): 260-266. doi.org/10.1055/s-0043-1770070
71. Jathanna NN, Krishnamurthy GK, Gowdru MS, Ravindranath BS, Shetty NG. Deciphering phyto-fungal dye concoction mitigation, degraded metabolite analysis, and assessment of ecotoxicity. Journal of Environmental Chemical Engineering. 2024 April;12(2):112171. doi.org/10.1016/j.jece.2024.112171
72. Somanath Disha, Undiganalu Gangadharappa Yathisha, Mave Harshitha, Biswajit Maiti. *In silico* evaluation of outer membrane protein S2 as a suitable vaccine candidate against *Edwardsiella tarda* infection of fish. North American Journal of Aquaculture .2024 April;86(2):193–201. doi.org/10.1002/naaq.10322
73. Bhavya JN, Anugna SS, Premanath R. Sub-inhibitory concentrations of colistin and imipenem impact the expression of biofilm-associated genes in *Acinetobacter baumannii*. Archives of Microbiology. 2024 April;206(4):169. doi/ 10.1007/s00203-024-03869-w.
74. Shetty VP, Rodrigues C, Deekshit VK. Detection of multi drug resistant integrons associated with *Acinetobacter baumannii* isolated from clinical and environmental samples. Journal of Pure and Applied Microbiology. 2024 March;18(1):605-613. doi.org/10.22207/JPAM.18.1.44
75. Akhila DS, Ashwath P, Manjunatha KG, Akshay SD, Surasani VK, Sofi FR, Saba K, Dara PK, Ozogul Y, Ozogul F. Seafood processing waste as a source of functional components: Extraction and applications for various food and non-food systems. Trends in Food Science & Technology. 2024 Jan : 104348.doi /10.1016/j.tifs.2024.104348.
76. Ashwath P, Premanath R, Vittal R, Aithal P, Shah FA, Sannejal AD. Bacterial Diseases of Finfish Prevalent in Coldwater Aquaculture. In Coldwater Fisheries and Aquaculture Management 2024 (pp. 91-145). Apple Academic Press.

77. The book *Aquatic Animal Health Management*, edited by Rajendran Kooloth Valappil, Iddya Karunasagar, and Indrani Karunasagar, is a comprehensive reference published by Springer that addresses key aspects of aquatic animal health. The editors are distinguished experts in aquaculture and aquatic animal diseases, bringing together contributions from leading researchers and practitioners in the field. The volume covers a wide range of topics including bacterial, viral, and parasitic diseases of finfish and shellfish, environmental influences on health, and advances in disease diagnosis and management. It also discusses emerging technologies in aquaculture, including genomics, nanotechnology, vaccines, probiotics, and cell line development. Additionally, the book highlights policy frameworks, surveillance programmes, and international trade issues, making it a valuable resource for researchers, policymakers, and aquaculture professionals. The book was released at the International conference on diseases in Asian Aquaculture held during organized by the Indian Council of Agricultural Research-Central Brackish Water Aquaculture, was held in Chennai on 23-26 September 2025.



78. Apurva VG, Ananya B, Nayak A, Karunasagar I, Chakraborty A, Maiti B. Aqua-derived bacteriocins: exploring their role as antibacterial agents for sustainable fish disease control. Aquaculture International. 2025 Dec;33(8):701. https:// doi.org /10.1007/s10499-025-02377-y
79. Anupriya, Kavitha, GM, Abhirami, S, Rajeshwari V, Akhila D.S Incidence and Evaluation of Extended Spectrum Beta-Lactamase in Avian Pathogenic *E. coli*" Brazilian Journal of Microbiology 2025 Dec;56(4):2921-2927. doi: 10.1007/s42770-025-01763-1.
80. Rai D, Lobo AE, Rao N. Divyashree M. Bdellovibrio bacteriovorus, a natural microbial predator in the fight against pathogens—One Health approach. International Journal of Environmental Health Research. 2025 Dec;35(12):3735-3751. doi: 10.1080/09603123.2025.2495197.
81. Iyer S, Sheshappa MB. Formulation and Characterisation of Lutein Nano-Bilosomes for Enhanced Absorption. Journal of Food Science and Technology. 2025 Dec;62(12):2381-2389. https://doi: ttp://dx. doi.org/ 10.1007 /s13 197 -024 06182-y
82. Premanath R, Gowda VR, Suresh S, Bhavya JN, Naik A. Contamination of shopping carts and baskets with ESKAPE pathogens: A study from Mangaluru, India. Food and Humanity. 2025 Dec; 5 ;100715. https:// doi.org/ 10.1016/ j. foohum.2025.100715
83. Sujana Prabell , Sarika Suresh , Ramya Premanath , Juliet Roshini Mohan Raj, Phage-Mediated Degradation of *Pseudomonas aeruginosa* Exopolysaccharides. Journal of

Health and Allied Sciences NU, 2025 Oct- Dec;15(4));470-478. https://doi:10.25259/JHS-2024-9-16-R1-(1508)

84. Ranu Y, Nayak S, Ajakkala PB, Prabhu C, DSouza C, Maiti B. Comparative analysis of *Klebsiella pneumoniae* isolates between antibiotic-resistant and antibiotic-sensitive strains using polymerase chain reaction-based genotyping and protein profiling. Journal of Microbiological Methods. 2025 Nov:238: 107265. https://doi: 10.1016 /j.mimet. 2025. 107265.
85. Sushma,, Mohanraj Roshni Juliet, Bhat Nanditha, Revanasiddappa Bistuvalli Chandrashekharappa and Sharmila Kameyanda Poonacha. In silico and in vitro Antimicrobial Assessment of *Oroxylum indicum* (L). Kurz stem bark extract against four Bacterial and Fungal Species. Research Journal of Biotechnology. 2025 Oct; 20(10):241-249. https://doi.org/10.25303/2010rjbt2410249;
86. Rwezawula P, Mwanja WW, Raj JR, Karunasagar I, Bossier P, Vanrompay D. Phenotypic and safety exploration of indigenous bacterial strains for probiotic applications in aquaculture. BMC Microbiology. 2025 Oct 2;25(1):614. https:// doi:10. 1186/s12866-025-04157-3.
87. Shetty VP, Shravya R, Rohit A, Deekshit VK. Novel Class 1 Integron in Clinical Isolates of *Burkholderia cepacia* Complex. Journal of Health and Allied Sciences NU. 2025 Oct; 15(4);542-547. https://doi:10.25259 / JHS-2024-10-4-R1-(1604)
88. Kenjar AR, Girisha BS, Jayaraman J, Deekshit VK, Raj JR, Bhat R, Karunasagar I. Resistance & virulence traits in dermatophytes isolated from Mangaluru, India. *The* Indian Journal of Medical Research. 2025 Sep 16;162(1):95. https://doi: 10.25259/IJMR_283_2025.
89. Harshitha M, D'souza DL, Rakshitha BT, Karunasagar I, Chakraborty A, Maiti B. Oral delivery of recombinant outer membrane protein 23-based nanovaccine can minimize *Aeromonas hydrophila* infection in *Oreochromis niloticus*. Microbial Pathogenesis. 2025 Sept; 206:107765. https:// doi.org /10.1016 /j.micpath. 2025. 107765
90. Naik A, Nirmala BJ, Kumar S, Srinivasa MG, BC R, Premanath R. Interference of selected essential oils in modulating quorum sensing mechanism in *Klebsiella pneumoniae*. Microbial Pathogenesis. 2025 August; 205:107679. https://doi.org /10.1016 /j.micpath.2025.107679
91. Shetty P, Bhat R, Padavu S, Rai P, Kumar BK, Shetty S. Molecular profiling of antibiotic resistance genes in acute and chronic irreversible pulpitis: A cross-sectional study. Journal of Conservative Dentistry and Endodontics. 2025 Aug ; 28(8):814-20. *DOI:* 10.4103 /JCDE. JCDE_ 311_25
92. Chakraborty S, Dinakaran I, Karunasagar A, Ahmed W, Raj JM, Karunasagar I, Vashisth M, Chauhan A. WGS of a lytic phage targeting biofilm-forming carbapenem-resistant

Klebsiella pneumoniae prevalent in a tertiary healthcare setup. Microbial Pathogenesis. 2025 August:205(107680). https:// doi.org /10.1016 /j. micpath. 2025. 107680

93. Akyeh ML, Morita M, Tandhavanant S, Kumar BK, Anh PH, Hien TT, Linh PT, Tu ND, Hien VT, Takemura T, Terashima H. Virulence Potential of Nonclinical *Vibrio parahaemolyticus* Isolates from Vietnam: Evidence for Functional T3SS2-Mediated Enterotoxicity. Microbiology and Immunology. 2025 August:69(8); 429-445. https://doi.org/10.1111/1348-0421.13229
94. Mini P, Prithvisagar KS, Karunasagar I, Karunasagar I. Assessing genetic diversity of tiger shrimp *Penaeus monodon* Fabricius, 1798 utilising microsatellite DNA markers. Indian journal of fisheries. 2025 July-sept;72(3):83-90. doi: 10.21077 /ijf.2025.72.3.164411-09
95. Adesiji YO, Deekshit VK, Odunola RA, Karunasagar I, Daodu OB, Ahmad AM. Virulence-Encoding Genes Conserved in *Salmonella* Isolated from Humans, Poultry, and Seafood. Journal of Tropical Medicine. 2025 July:1139253. https:// doi.org /10.1155 /jotm/1139253
96. Anees TM, Shetty AV, Mehandale SG, Karnaker VK, Deekshit VK. Comprehensive Analysis of Biofilm Formation in Intensive Care Unit Isolates: Biofilm-associated Genes (mrkA, fimA, bap, and ompA) of Klebsiella pneumoniae and *Acinetobacter baumannii*. Biomedical and Biotechnology Research Journal (BBRJ). 2025 Jul 1;9(3):335-44. Doi.10.4103/bbrj.bbrj_214_25
97. Satheesan N, Madhyastha H, Sakai K, Kini S. Magnetic Nanoparticle Capture and Quantum Dot Labeling for Rapid and Quantitative Detection of Methicillin-Resistant *Staphylococcus aureus*. ACS Omega. 2025 Jul 1:*10* (29), 32189-32201. DOI: 10.1021 /acsomega. 5c03973
98. Thillai BD, Aditya V, Kini S, Ballamoole KK, Deekshit VK. Synergistic effects of antibiotics and efflux pump inhibitors on multidrug-resistant Escherichia coli and Klebsiella pneumoniae. Journal of Applied Microbiology. 2025 Jul ;136 (7): lxaf169. https: //doi. Org /10. 1093 /jambio /lxaf169
99. Shetty VP, Akshay SD, Devi Thilai B, Deekshit VK. Biomedical waste management: navigating the challenges to achieve the promise of Sustainable Development Goal 3. Waste Disposal & Sustainable Energy. 2025 Jun 2025;7(2): 303-321. https:// doi.org/ 10. 1007/s42768-025-00231-8
100. Sarika Suresh, Gayathri Sathyanath, Akshatha Naik, Bhavya J. N., Ramya Premanath. Prevalence and Molecular Characterization of Carbapenem- and Colistin-Resistant Genes in Clinical Strains of *Pseudomonas aeruginosa* Isolated from Diabetic Patients. Journal of Health and Allied Sciences NU. 2025 April; 15(2):177-182. https://dx.doi.org/10.1055/s-0044-1789212
101. Nayak S, Apurva VG, Ajakkala PB, Disha S, Raj JM, Deekshit VK, Maiti B. Bacteriophage induces modifications in outer membrane protein expression and antibiotic susceptibility in *Acinetobacter baumannii*. International Journal of Biological

Macromolecules. 2025 April; 298:139589. https:// doi.org/ 10.1016/ j.ijbiomac. 2025. 139589

102. Harshitha Mave, Ruveena D'souza, Somanath Disha, Uchangi Satyaprasad Akshath, Saurabh Dubey, Hetron Mweemba Munang'andu, Anirban Chakraborty, Indrani Karunasagar, and Biswajit Maiti. (2025) Polylactic-Co-glycolic Acid Polymer-Based Nano-Encapsulation Using Recombinant Maltoporin of *Aeromonas hydrophila* as Potential Vaccine Candidate. Molecular Biotechnology.2025 Mar;67(3):1178-1187. https://doi.org/10.1007/s12033-024-01117-6

103. Prabhu C, Satyaprasad AU, Deekshit VK. Understanding Bacterial Resistance to Heavy Metals and Nanoparticles: Mechanisms, Implications, and Challenges Journal of Basic Microbiology. 2025 Feb;65(2): e2400596. https:// doi.org/ 10.1002/ jobm.202400596

104. Jogi N, Mathew A, Mamatha BS. Modification of Bioactive Properties in Food Protein Hydrolysates by Alcalase and Trypsin. Journal of Health and Allied Sciences NU. 2024 Jan;14(S 01):S26-34. DOI: 10.1055/s-0044-1782643

105. Kumar M, Ashok AK, Bhat T, Ballamoole K, Gollapalli P. Computational-driven discovery of AI-2 quorum sensing inhibitor targeting the 5′-methylthioadenosine/S-adenosylhomocysteine nucleosidase (MTAN) to combat drug-resistant *Helicobacter pylori*. *Computers in Biology and Medicine*. 2025 Jan; 184:109409. https:// doi.org /10. 1016 /j.compbiomed.2024.109409

106. George G, Stoy AC, Gopinath V, Kishore N, Baruah K, Gopalakrishnan A, Prithvisagar KS, Karunasagar I. Climate Change as Drivers of Microbial–Algal Interactions and Their Implications. In Navigating Climate Change: Impacts on Biodiversity and Ecosystem Resilience 2025 Oct 1 (pp. 61-79). Singapore: Springer Nature Singapore.

107. Chakraborty G, Mohanraj J, Mohan M, Vittal R. Loop-Mediated Isothermal Amplification Assay (LAMP) for Detection of *Staphylococcus aureus* in Meat. In Foodborne Pathogens: Loop-mediated Isothermal Amplification Protocols 2025 Jun 15 (pp. 83-90). New York, NY: Springer US. https://doi.org/10.1007/978-1-0716-4526-0_7

108. Divyashree M., Shubha JR, Exploitation of Microbes as a Means for Biofortification of Zinc in Crop Plants. In Zinc in Soil-Plant Continuum 2025 May 11 (pp. 163-179). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-96-4253-3_7

109. Divyashree M, Rai D, Neeksha, Shubha JR, Shama Prakash K. Microbes as Tools for the Amelioration of Zinc Phytotoxicity. In Zinc in Soil-Plant Continuum 2025 May 11 (pp. 277-297). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-96-4253-3_11

110. Maiti B, Ananya B, Apurva VG, Raj JM, Deekshit VK, Karunasagar I. Strategies for Control of AMR Pathogens in Shrimp Farming: One Health Approach. In Shrimp Culture Technology: Farming, Health Management and Quality Assurance 2025 Feb 4 (pp. 185-

207). Singapore: Springer Nature Singapore. https://doi.org/10.1007/978-981-97-8549-0_10

111. Praveen Rai. Akhila DS, Shruthi P, Athira AP, Prerana S, Krishna Kumar B, Karunasagar I, Recent Advances in Shrimp Disease Diagnosis. Shrimp Culture Technology: Farming, Health Management and Quality Assurance. Springer. 2025 Feb 4:155-83.

112. Karunasagar I. Issues in International Trade of Seafood. In Aquatic Animal Health Management 2025 Sep 1 (pp. 881-897). Singapore: Springer Nature Singapore.

113. Ajakkala PB, Kenjar AR, Prabell S, Bhandarkar S, Bhat S, Sannejal AD, Karunasagar A, Chauhan A, Karunasagar I, Raj JR. Updated phage banks essential to cope with pathogen evolution: Lessons from *Klebsiella pneumoniae* and their phages. Journal of Microbiology, Immunology and Infection. 2025 Aug 29:S1684-1182(25)00178-1. doi: 10.1016/j.jmii.2025.08.022. Online ahead of print

114. Shetty NS, Shubha JR, Satyaprasad AU. Quantum-Dot-Based Enzyme Biosensor for Rapid Screening of Antibiotic Susceptibility in Urine Samples. ACS omega. 2026 Jan 6.

115. Prabhakar S, Premanath R. Dynamics, ecological implications, and mitigation strategies of the ocean plastisphere. Environmental Science and Pollution Research. 2026 Jan 8:1-22.

116. Shreevani K, Narayana B, Sarojini BK, Dayananda BS, Revanasiddappa BC, Shetty VP, Deekshit VK, Jayaprakash K. Evaluation of Eudragit/Polycaprolactone/2, 3-Diphenyl-3-Hydroxyflavone Derivative Composite Electrospun Nanofibers for Sustained Drug Delivery. Journal of Applied Polymer Science. 2026 Mar 15;143(11):e70256.

117. Shetty P, Bhat R, Padavu S, Rai P, Shetty S. Profiling of microbes associated with chronic irreversible pulpitis using metagenomic next-generation sequencing. BMC Oral Health. 2026 Dec;26(1):118.

118. Rohit A, DSouza C, Prasad M, Akshay SD, Irusan D, Jenifer A, Dorairajan SK, Boahen CK, Karunasagar I, Kumar V. Age-specific predictive modelling of sepsis mortality: The diagnostic utility of CRP and serum creatinine. Respiratory Medicine. 2025 Nov 29:108530.

119. Karunasagar A, DSouza C, Pugazhenthi AA, Alli B. Systematic Review of biofilms and potential antibiofilm agents in chronic rhinosinusitis. Indian Journal of Otolaryngology and Head & Neck Surgery. 2025 Nov 17:1-8.

120. Gollapalli P, Gnanasekaran TS, Shivashankara SK, Kumar BK. Genome-scale mapping of *Serratia marcescens* core interactome to probe essential proteins and functional modules. Biologia. 2026 Jan 12;81(1):7.

121. Devi Thillai B, Kini S, Deekshit VK. Nanobiotics to tackle efflux-mediated resistance in bacterial pathogens. Critical Reviews in Microbiology. 2025 Dec 3:1-23.

122. Prabhu C, Kotian A, Aditya V, Deekshit VK. Environmental and physiological factors influencing the survival of resistant *Salmonella* under infection-related gut conditions. Clinical Microbiology Reviews. 2025 Dec 5:e00196-25.

123. Rao N, Rai D, Madival S, Mithoor D. Exploration of polyhydroxyalkanoate-producing bacteria in diverse soils with emphasis on bioremediation. International Journal of Environmental Health Research. 2025 Nov 27:1-22.

124. Vittal R, Xavier S, Mohan M, Chakraborty A, Chakraborty G. Detection and characterization of microplastics in commercial salts in India.

125. DSouza SY, Shetty VP, DSouza C, Karunasagar I, Deekshit VK. Investigation of antibiotic resistance determinants in aquatic environments. Biologia. 2026 Jan;81(1):23.

126. Swaroopa S, Kenjar A, Raj JR, Kedilaya VR, Gnanasekaran TS, Gollapalli P, Poonacha SK. Biological prospecting of endophytic fungi from the stem bark of *Oroxylum indicum* (L.) Kurz with antioxidant efficacy. Journal of Applied Pharmaceutical Science. 2025 Dec 5;16(1):232-43.

127. Swaroopa S, Raj JR, Gnanasekaran TS, Radhakrishna V, Poonacha SK. Phytochemical Profile and Antioxidant Potential of Endophytic Fungi Isolated from the Stem Bark of *Oroxylum indicum* (L.) Kurz. Journal of Health and Allied Sciences NU. 2026 Jan 6;16(1):124-31.

128. Yathisha UG, Srinivasa MG, Chandrashekara RB, Gopalakrishna BK, Gowda A, Salam AA, Sheshappa MB. Computational Studies of Fish Protein Hydrolysates as Human Angiotensin I-Converting Enzyme Inhibitors. Journal of Health and Allied Sciences NU. 2026 Jan 6;16(1):78-92.

129. Chaouhan HS, Sharma A, Siddique HR. Methods to Study DNA Damage Using Drosophila melanogaster. Genotoxicity Assessment: Methods and Protocols. 2025 Nov 23:449-74.

130. Rajeshwar BN, Kushala KB, Nithin MS, Nayak A, Chakraborty A, Abraham TJ. Bioinformatics in Aquatic Animal Health Management: Recent Advances and Applications. Bioinformatics Tools for Predictive Ecology and Fisheries. 2026 Jan 6:439-67.

List of patents published:

1. Consortium of Broad-spectrum Jumbo bacteriophages for the control of multi-drug resistant Pseudomonas aeruginosa. (Indian Patent No.: 202141044837)
2. Antisense constructed against the AcrAB efflux system to combat multidrug resistance in *Klebsiella pneumoniae.* (Indian Patent No.: 202241062642)
3. Specific primers to detect *Acinetobacter baumannii* with Loop-Mediated Isothermal Amplification Assay. (Indian Patent No.: 202241073827)
4. Detection of circulating microRNA as biomarkers in the diagnosis of leptospirosis. (Indian Patent No.: 202341027302)
5. Unique primers for the detection of Tilapia Lake Virus using reverse transcriptase polymerase spiral reaction(Indian Patent No.:202441001346)
6. Unique primer sequences for the detection of Shigella spp by loop mediated isothermal amplification (Indian Patent No.:202441001756)
7. Formulation of outer membrane protein nanovaccine medicated feed for oral vaccination in zebrafish(Indian Patent No.:202441027575)
8. Novel primers and guide RNA sequence for the detection of *Enterocytozoon hepatopenaei* (EHP) by Recombinance Polymerase amplification (RPA) -CRISPR-Cas12a based fluorescent assay(Indian Patent No.:202441097384)
9. Unique primer pairs for the rapid detection of Hepatitis B Virus (HBV) by polymerase spiral reaction (PSR) assay. (Indian Patent No. 202541068643)
10. Species specific oligonucleotide primers for molecules of *Streptococcus agalactiae.* (Indian Patent No. 202541067390)
11. Fluorescence-based nanoprobes for selective detection and quantification of methicillin-resistant *Staphylococcus aureus*. (Indian Patent No. 20254100024
12. Process for rapid detection of *Salmonella* under isothermal conditions using polymerase spiral reaction (PSR) assay (Indian Patent No: 202541120643)
13. Process for specific detection of *Klebsiella pneumoniae* under isothermal conditions using polymerase spiral reaction (PSR) assay. (Indian Patent No: 202541120644)
14. Wearable photoplethysmography (PPG) device for continuous monitoring of cardiovascular function and pulse activity. (Indian Patent No: 202541084673)
15. Species-specific oligonucleotide primers targeting the pbp gene and process for rapid molecular detection of *Vibrio vulnificus* using loop-mediated isothermal amplification(LAMP). (Indian Patent No: 202641009234)

Highlights:

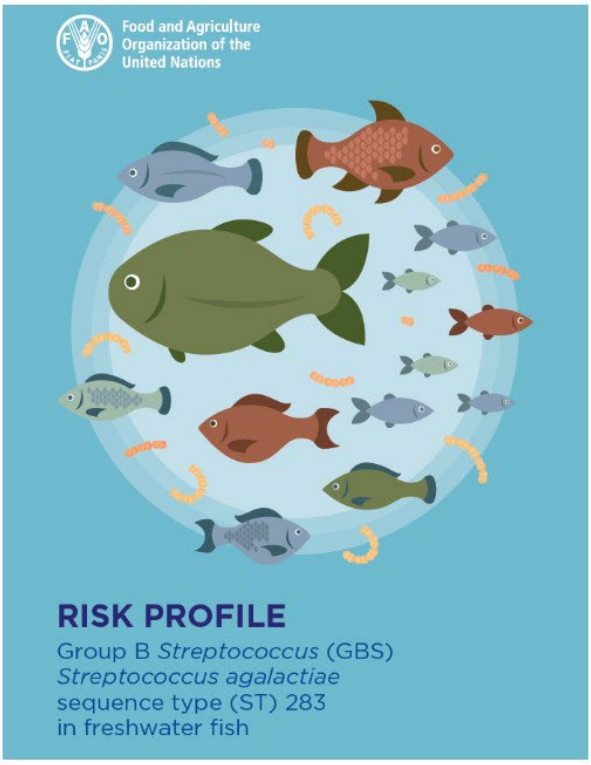
MoUs with National and International Institutions

Members of Research Advisory Committees

Dr Indrani Karunasagar and Dr Iddya Karunasagar

- Central Institute of Fisheries Education (CIFE), Mumbai
- Central Institute of Freshwater Aquaculture (CIFA), Bhubaneshwar
- Central Institute of Brackishwater Aquaculture (CIBA), Chennai
- Central Institute of Coldwater Fisheries Research Institute (CICFRI), Bhimtal
- Central Institute of Fishing Technology (CIFT), Kochi
- Food Safety & Standards Authority of India (FSSAI), New Delhi

---



LIST OF CONTRIBUTORS

Experts

Syafinaz Amin-Nordin
Professor
Department of Medical Microbiology Faculty of Medicine and Health Sciences Universiti Putra Malaysia
Selangor, Malaysia

Mohammad Noor Amal Azmai
Associate Professor
Department of Biology, Faculty of Science & Aquatic Animal Health and Therapeutics Laboratory, Institute of Bioscience Universiti Putra Malaysia
Selangor, Malaysia

Paola Andrea Barato Gomez
Scientific Director and CEO
Corporación Patología Veterinaria CORPAVET y MolecularVet SAS
Bogota, Colombia

Timothy Barkham
Associate Professor
Department of Laboratory Medicine, Tan Tock Seng Hospital
Singapore

Swaine Lin Chen
Associate Professor of Medicine, National University of Singapore, and Group Leader in Bacterial Genomics, Genome Institute of Singapore
Singapore

Alex Cook
Associate Professor
Saw Swee Hock School of Public Health
National University of Singapore
Singapore

Matteo Crotta
Research Fellow
Veterinary Epidemiology, Economics and Public Health Group (VEEPH), The Royal Veterinary College
United Kingdom of Great Britain and Northern Ireland

Mags Crumlish
Senior Lecturer in Food Security & Sustainability
Institute of Aquaculture, University of Stirling
Scotland, United Kingdom of Great Britain and Northern Ireland

Balbir BS Dhaliwal
Professor (Veterinary Public Health)
Centre for One Health, Guru Angad Dev Veterinary & Animal Sciences University
Ludhiana, Punjab, India

Fiona Harris
Associate Professor in Anthropology and Health
Nursing, Midwifery and Allied Health Professions Research Unit, University of Stirling
Scotland, United Kingdom of Great Britain and Northern Ireland

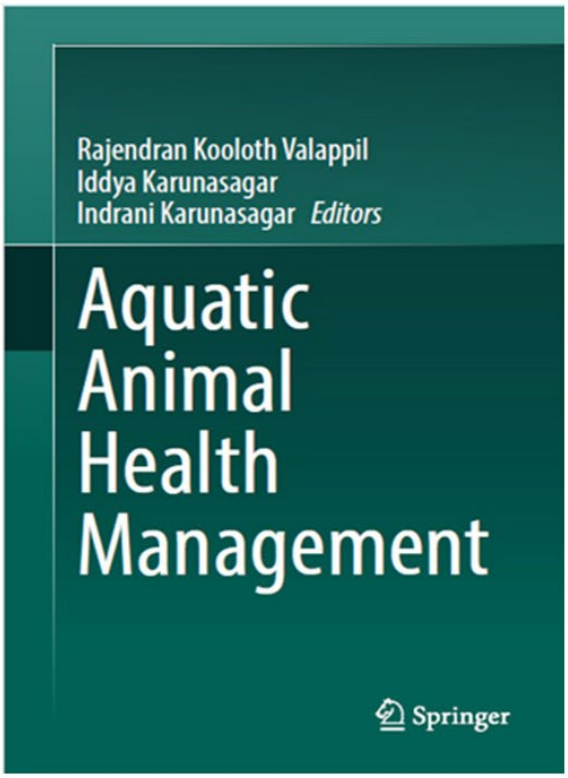
Karunasagar Iddya
Senior Director, International Relations
Nitte University, Mangalore
India

Margaret Ip
Professor
Department of Microbiology, Chinese University of Hong Kong
Hong Kong SAR, China

Pattanapon Kayansamruaj
Assistant Professor
Department of Aquaculture, Faculty of Fisheries, Kasetsart University
Bangkok, Thailand

Andreas Kiermeier
Director
Statistical Process Improvement Consulting and Training Pty Ltd
Adelaide, Australia

Theresa Lamagni
Senior Epidemiologist and Section Head
National Infection Service, Public Health England
United Kingdom of Great Britain and Northern Ireland



World Organisation of Animal Health – Guidelines for AMU in Aquaculture

EEG Paper

Relevance and Challenges Associated with Antimicrobial Use (AMU) Monitoring at Field Level in Aquaculture

Journal selected Aquaculture Reports | Journal | ScienceDirect.com by Elsevier

Citations are made with zotero in the AQUACULTURE REPORTS style https://www.sciencedirect.com/journal/aquaculture-reports

AUTHORS

Tosca Sala - EMBRC-ERIC / World Organisation for Animal Health

Dante Mateo - World Organisation for Animal Health

Javier Yugueros-Marcos, World Organisation for Animal Health

Indrani Karunasagar - FAO Reference Centre for AMR and Aquaculture Biosecurity, Nitte University, Mangalore , India

Frederik Carl Uhland, Public Health Agency of Canada

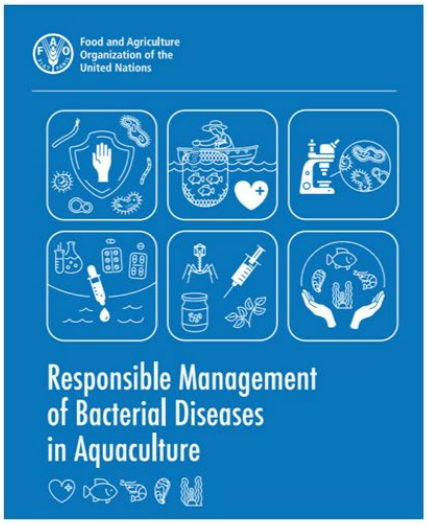
Dušan Palić, Chair for Fish Diseases and Fisheries Biology, Faculty of Veterinary Medicine Ludwig-Maximilians-Universität München, Germany; d.palic@lmu.de

Sameh Abdelazeem , WorldFish1, Central Laboratory for Aquaculture Research

Marcela Lara , Center for Antimicrobial Stewardship in Aquaculture of Chile - Salmon Council, Chile

Nelly Isyag, African Union Interafrican Bureau of Animal Resources, Nairobi, Kenya.

FAO publication - Bacterial Diseases of Fish & Shellfish



List of Contributors

Melba G. Bondad-Reantaso
Food and Agriculture Organization of the United Nations (FAO)
Rome, Italy

Susan M. Bower
Nanaimo. Canada

Duncan J. Colquhoun
Norwegian Veterinary Institute
Oslo, Norway

Diane G. Elliott
US Geological Survey
Seattle, WA, USA

Mohamed Faisal
Michigan State University
East Lansing, Michigan, USA

Sophie Fridman
Powmill, Scotland
United Kingdom

Olga Haenen
Wageningen, Netherlands

Larry Hanson
Mississippi State University
Starkville, Mississippi, USA

Indrani Karunasagar
Nitte University
Mangalore, India

Iddya Karunasagar
Nitte University
Mangalore, India

Celia Lavilla-Pitogo
Tigbauan, Iloilo
Philippines

Mark Lawrence
Mississippi State University
Starkville, Mississippi, USA

Thomas P. Loch
Michigan State University
East Lansing, Michigan, USA

Brett MacKinnon
City University of Hong Kong
Kowloon, Hong Kong

Amedeo Manfrin
Istituto Zooprofilattico Sperimentale delle Venezie
Venezia, Italy

Sharon McGladdery
St Andrews, New Brunswick
Canada

Lora Petrie-Hanson
Mississippi State University
Starkville, Mississippi, USA

J. Gustavo Ramírez-Paredes
Ridgeway Biologials, Ltd.
Compton, Berkshire, GB

Esteban Soto
University of California
David. California, USA

Rohana Subasinghe
FutureFish
Sheffield, England, United Kingdom

Snjezana Zenčić
Croatian Veterinary Institute
Zagreb, Croatia

Received: 5 December 2021 | Revised: 4 May 2022 | Accepted: 10 August 2022

DOI: 10.1111/raq.12743

REVIEW

REVIEWS in Aquaculture

Bacterial diseases of tilapia, their zoonotic potential and risk of antimicrobial resistance

Olga L. M. Haenen[1] | Ha Thanh Dong[2] | Truong Dinh Hoai[3] | Margaret Crumlish[4] | Iddya Karunasagar[5] | Timothy Barkham[6] | Swaine L. Chen[7] | Ruth Zadoks[8] | Andreas Kiermeier[9] | Bing Wang[10] | Esther Garrido Gamarro[11] | Masami Takeuchi[12] | Mohammad Noor Amal Azmai[13] | Belén Fouz[14] | Rolando Pakingking Jr.[15] | Zeng Wei Wei[16] | Melba G. Bondad-Reantaso[11]

[1]National Reference Laboratory for Fish Diseases, Wageningen Bioveterinary Research, Lelystad, The Netherlands

[2]School of Environment, Resources and Development, Asian Institute of Technology, Pathum Thani, Thailand

[3]Faculty of Fisheries, Vietnam National University of Agriculture, Hanoi, Vietnam

[4]Institute of Aquaculture, University of Stirling, Stirling, UK

[5]Technology Enabling Center, Nitte University, Mangalore, India

[6]Department of Laboratory Medicine, Tan Tock Seng Hospital, Singapore, Singapore

[7]Genome Institute of Singapore, National University of Singapore, Singapore, Singapore

[8]Sydney School of Veterinary Science and Marie Bashir Institute, University of Sydney, Sydney, Australia

[9]Statistical Process Improvement Consulting and Training Pty Ltd, Adelaide, Australia

[10]College of Agricultural Sciences and Natural Resources, University of Nebraska-Lincoln, Lincoln, Nebraska, USA

[11]Fisheries and Aquaculture Division, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

[12]Food Systems and Food Safety Division, Food and Agriculture Organisation of the United Nations (FAO), Rome, Italy

[13]Department of Biology, Faculty of Science & Aquatic Animal Health and Therapeutics Laboratory, Institute of Bioscience, Universiti Putra Malaysia, Serdang, Selangor, Malaysia

[14]Departamento de Microbiología y Ecología & Instituto en Biotecnología i Biomedicina (BIOTECMED), Universitat de València, Burjassot, Valencia, Spain

[15]Aquaculture Department, Southeast Asian Fisheries Development Center (SEAFDEC AQD), Tigbauan, Iloilo, Philippines

[16]Guangdong Provincial Key Laboratory of Animal Molecular Design and Precise Breeding, School of Life Science and Engineering, Foshan University, Foshan, People's Republic of China

Received: 22 April 2022 | Revised: 29 December 2022 | Accepted: 3 January 2023

DOI: 10.1111/raq.12786

REVIEW

REVIEWS in Aquaculture

Review of alternatives to antibiotic use in aquaculture

Melba G. Bondad-Reantaso[1] | Brett MacKinnon[2] | Iddya Karunasagar[3] | Sophie Fridman[1] | Victoria Alday-Sanz[4] | Edgar Brun[5] | Marc Le Groumellec[6] | Aihua Li[7] | Win Surachetpong[8] | Indrani Karunasagar[3] | Bin Hao[1] | Andrea Dall'Occo[1] | Ruggero Urbani[9] | Andrea Caputo[10]

[1]Fisheries and Aquaculture Division, Food and Agriculture Organization of the United Nations (FAO), Rome, Italy

[2]Jockey Club College of Veterinary Medicine and Life Sciences, City University of Hong Kong, Hong Kong SAR, China

[3]Nitte University, Medical Sciences Complex, Mangaluru, Karnataka, India

[4]National Aquaculture Group (NAQUA), Al Lith, Kingdom of Saudi Arabia

[5]Norwegian Veterinary Institute, Ås, Norway

[6]Direction of Domestication and Genetics, Pathology and Biosecurity, Aqualma/Unima Group, Majunga, Madagascar

[7]Institute of Hydrobiology, Chinese Academy of Sciences, Wuhan, China

[8]Department of Veterinary Microbiology and Immunology, Faculty of Veterinary Medicine, Kasetsart University, Bangkok, Thailand

[9]Veterinary Department Prevention, Rome, Italy

[10]ReAct - Action on Antibiotic Resistance, Uppsala University, Uppsala, Sweden

Correspondence
Melba G. Bondad-Reantaso, NFIMF: Food Safety, Nutrition and Health, Fisheries and Aquaculture Division (NFID), Food and Agriculture Organization of the United Nations (FAO), Viale delle Terme di Caracalla, 00153 Rome, Italy.
Email: melba.reantaso@fao.org

Abstract

With the rapid growth of the aquaculture production since the 1980s, there has been a concomitant increase in disease outbreaks. The injudicious and/or incorrect use of antimicrobial agents against diseases of farmed aquatic species poses a considerable threat to the development and growth of a successful and sustainable aquaculture industry. An increase in antimicrobial resistance (AMR) is an important consequence, resulting to the difficulty in treating common bacterial diseases in populations of aquatic organisms, combined with the presence of antibiotic residues in food fish and their products, leading to import refusals and negative impacts on international trade. To reduce the frequency of AMR, good aquaculture and effective biosecurity practices should include the prudent and responsible use of antibiotics and also consider the use of alternatives to antibiotics, in addition to disease prevention management. This article reviews the literature discussing the scope of the problem pertaining to antibiotic use, the emergence of AMR in aquaculture and to consider and discuss viable alternatives (e.g., vaccination, bacteriophages, quorum quenching, probiotics and prebiotics, chicken egg yolk antibody and medicinal plant derivative). We also discuss lessons learnt, from specific case studies such as the vaccination of farmed salmon in Norway and the use of 'specific pathogen-free' seed—as primary and essential part of a biosecurity strategy.

KEYWORDS

alternatives to antimicrobials, AMR, antibiotics, aquaculture, microbiome, vaccination

Received: 10 March 2022 | Revised: 13 June 2022 | Accepted: 11 July 2022
DOI: 10.1111/raq.12715

REVIEW

Reviews Aquaculture

Antimicrobial resistance in fish pathogens and alternative risk mitigation strategies

Vijaya Kumar Deekshit[1] | Biswajit Maiti[1] | Ballamoole Krishna Kumar[1] | Akshatha Kotian[1] | Gillaine Pinto[1] | Melba G. Bondad-Reantaso[2] | Iddya Karunasagar[1] | Indrani Karunasagar[1]

[1]Nitte (Deemed to be University), Nitte University Centre for Science Education and Research, Mangalore, India
[2]Fisheries and Aquaculture Division, Food and Agriculture Organization of the United Nations, Rome, Italy

Correspondence
Indrani Karunasagar, Nitte (Deemed to be University), Nitte University Centre for Science Education and Research, Paneer Campus, Deralakatte, Mangalore 575018, India.
Email: indrani.karunasagar@nitte.edu.in

Funding information
DST-SERB, DST, Grant/Award Numbers: ECR/2017/00059, INT/NOR/RCN/BIO/P-01/2018; Swedish Research Council, Grant/Award Number: VR 2016-05655

Abstract

The discovery of antimicrobial agents, particularly antibiotics, is one of the most important milestones in the history of therapeutics. Since their discovery, antibiotics have been widely used in human medicine, veterinary, agriculture and aquaculture sectors. Many of the antibiotics used in human and veterinary medicine are also being used in the aquaculture sector either for therapy or as prophylactic agents. However, there is increasing awareness and concern for the indiscriminate use of antibiotics and the consequent emergence of antimicrobial resistance in the aquaculture settings. An aquatic environment, especially if it is eutrophic, provides a suitable niche for many bacterial pathogens to survive and multiply. Although there are limited reports of large-scale outbreaks in the aquaculture sector directly caused by antibiotic resistant fish pathogens, the presence of transferable plasmids, transposons and integrons in fish pathogens such as *Aeromonas* spp., *Edwardsiella* spp. and *Vibrio* spp. is a cause of concern. Thus, the need to study the resistance determinants found in these transmissible elements to different classes of antibiotics carried by fish pathogens and, their dissemination is highly relevant.

KEYWORDS
antibiotics in aquaculture, antimicrobial agents, antimicrobial resistance, aquatic environment, bacterial pathogens, good aquaculture practices

REVIEWS IN Aquaculture

REVIEW

Potential application of bacteriocins for sustainable aquaculture

Ashwath Nayak, Indrani Karunasagar, Anirban Chakraborty, Biswajit Maiti

First published: 20 December 2021 | https://doi.org/10.1111/raq.12647 | Citations: 1

Read the full text > PDF TOOLS SHARE

Abstract

The emergence and prevalence of bacterial pathogens in freshwater aquaculture systems is a growing concern as the economic losses associated with diseases are mounting and impacting the fishery sector. One way of controlling fish mortality and morbidity is using bacteriocin-secreting probiotics, which are generally considered safe without any adverse effects that usually accompany other treatment strategies. Understanding the mode of action of bacteriocin on pathogens is vital for considering them suitable for application as a prophylactic in aquaculture. Although several measures such as antibiotic treatment, chemotherapy, vaccination, etc., are available, though not without concerns, these methods have limitations for field-level applications since they result in several adverse effects both for the animals and the aquatic environment affecting several species in the food chain. In this situation, the use of bacteriocin can be an excellent alternative to minimize the disease burden in freshwater aquaculture if delivered appropriately. Here, we provide an update on the various bacteriocins and their mode of action against important pathogens encountered in aquaculture.

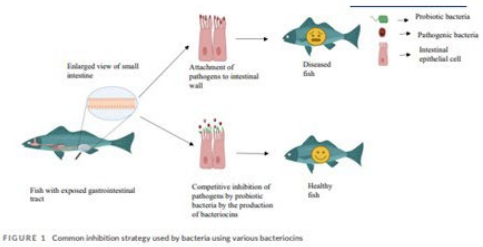
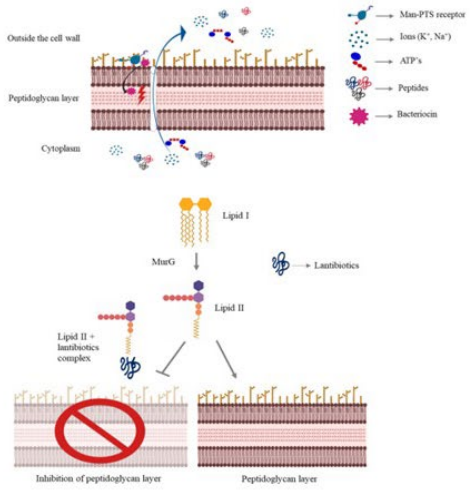
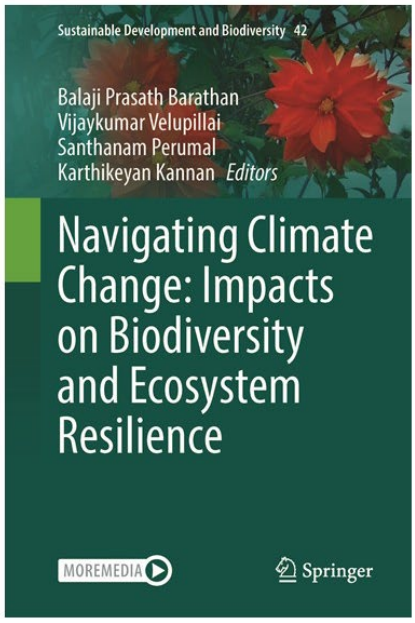


FIGURE 1 Common inhibition strategy used by bacteria using various bacteriocins





Chapter 3

Climate Change as Drivers of Microbial–Algal Interactions and Their Implications

Grinson George, Ancy C. Stoy, Vineetha Gopinath, Nanda Kishore, Kartik Baruah, Achamveetil Gopalakrishnan, Kattapuni Suresh Prithvisagar, and Indrani Karunasagar

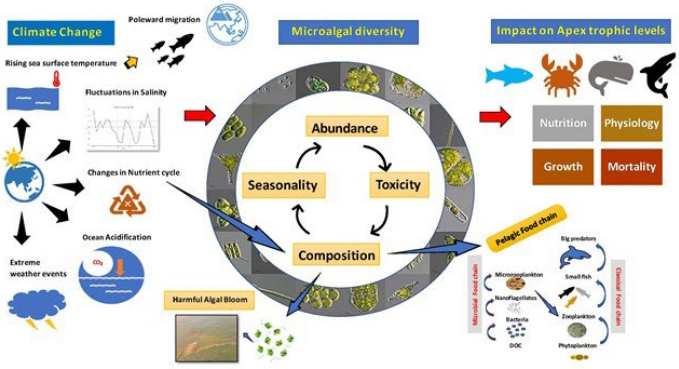
G. George · A. C. Stoy · V. Gopinath · N. Kishore · A. Gopalakrishnan
Indian Council of Agricultural Research-Central Marine Fisheries Research Institute, Kochi, India

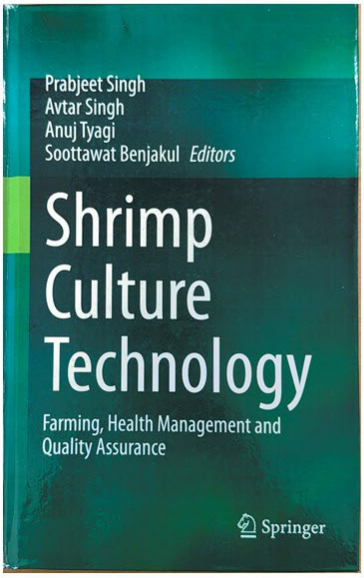
Cochin University of Science and Technology, Kochi, India

K. Baruah
Department of Applied Animal Science and Welfare, Swedish University of Agricultural Sciences, Uppsala, Sweden

K. S. Prithvisagar (✉) · I. Karunasagar (✉)
FAO Reference Centre for AMR & Aquaculture Biosecurity, DST TEC, Nitte University, Mangalore, India
e-mail: prithvi.sagar@nitte.edu.in; indrani.karunasagar@nitte.edu.in

B. P. Barathan et al. (eds.), *Navigating Climate Change: Impacts on Biodiversity and Ecosystem Resilience*, Sustainable Development and Biodiversity 42,
https://doi.org/10.1007/978-981-95-0409-1_3





Chapter 9

Recent Advances in Shrimp Disease Diagnosis

D. S. Akhila, P. Shruthi, A. P. Athira, S. Prerana, B. Krishna Kumar, Indrani Karunasagar, and Praveen Rai

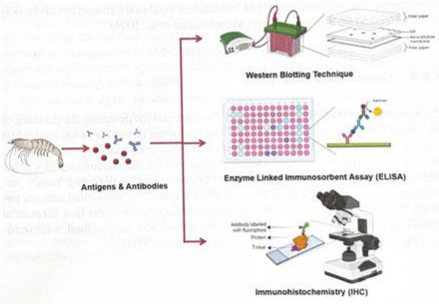
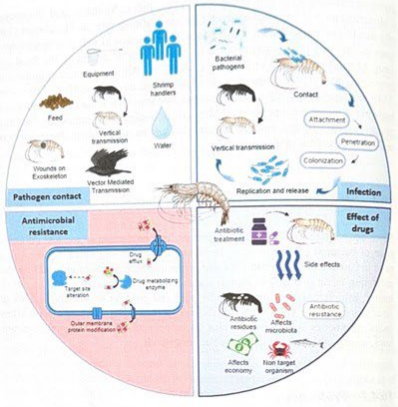


Fig. 9.2 Various immunological approaches for the diagnosis of shrimp diseases

Chapter 10

Strategies for Control of AMR Pathogens in Shrimp Farming: One Health Approach

Biswajit Maiti, Belman Ananya, Vijay Gundmi Apurva, Juliet Mohan Raj, Vijaya Kumar Deekshit, and Indrani Karunasagar



Development of Farm-Level Early Warning System for Aquatic Animal Disease organized from 3–5 November 2025 by Yellow Sea Fisheries Research Institute (YSFRI) China and 7-9 November 2025 by Pearl River Fisheries Research Institute (PRFRI) China, and the Food and Agriculture Organization (FAO)

Validation Workshop on the "Technical Roadmap for the Early Warning System (EWS) for Aquatic Diseases" held from 9–11 December 2025 in Rome, Italy. Organized by the Food and Agriculture Organization (FAO), Rome

FAO Reference Centre Collaboration NU-CEFAS

Success Story (October 2022 – February 2026)

Nitte University FAO Reference Center has been able to carry out number of activities in accordance with the terms of reference of the designation in collaboration with FAO Headquarters, other FAO Reference Centers, WHO, WOAH, UNIDO, UNESCO, International Trade Center of UN and other international organisations. This collaboration led to participation in capacity building activities in Malaysia, Indonesia, Myanmar, Cambodia and other countries. The international workshop on “Utilisation of microbiome and genomic resources in understanding and mitigation of antimicrobial resistance in one health context” in collaboration with Indian Council of Agricultural Research at Mangalore, Nov 18-22. This workshop received co-funding support from UNESCO, FAO Reference Center at CEFAS, UK, National Fisheries Development Board (NFDB). FAO Reference Center at Mississippi State University, USA contributed a resource person. The Workshop included resource persons from Italy, Norway, Philippines, and Sweden. Delegates from Bangladesh, Cambodia, Ethiopia, Nepal, Malaysia, Saudi Arabia, Sri Lanka, Tanzania, Thailand, Uzbekistan, Zambia and India attended this workshop. The FAO Reference Center contributed to development of Policy papers, collaborated with WOAH in updating chapters of Aquatic Code and collaborated with WHO in the work on medically important antimicrobials.

Supporting Faculty to the Activities of FAO Reference Centre:

- Dr Anirban Chakraborty
- Dr Biswajit Maiti
- Dr Praveen Rai
- Dr Krishna Kumar B
- Dr Deekshit
- Dr Akhila D S
- Dr Juliet Roshini Mohanraj

Supporting Technical Team:

- Dr Prithvisagar KS
- Dr Nishith
- Dr Apoorva R Kenjar
- Dr Caroline Dsouza
- Dr Akshatha K
- Dr Ashwath Nayak