FAO Reference Centre

Annual report - October 2022 - December 2023

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 **Tel.: +91 9448479750** **E-mail: indrani.karunasagar@nitte.edu.in**
Name of the Reporting Officer: Prof. Dr Iddya Karunasagar **E-mail: iddya.karunasagar@nitte.edu.in**
Website: https://nufaocen.in
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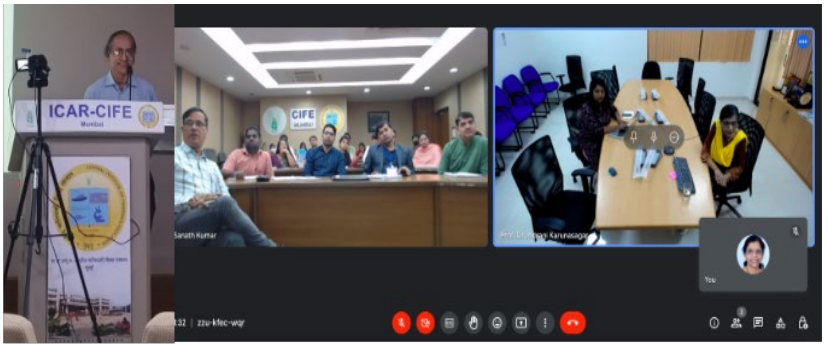
Activities supporting raising awareness on AMR

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 Nitte University Center 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 Organization 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 minimization of use of antibiotics.

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

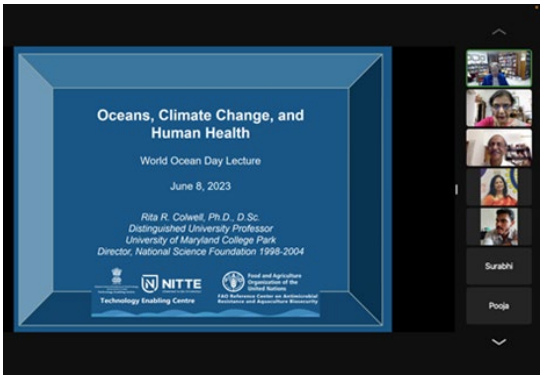


Dr. Sanath Kumar and Dr. BB Nayak, Central Institute of Fisheries Education, ICAR. Mumbai conducted a training program from 9 – 29 January 2023 on “Antimicrobial resistance in Food Fish: Challenges and Mitigation. Dr. Iddya Karunasagar and Dr. Indrani Karunasagar were resource persons. Dr. Iddya Karunasagar delivered a talk on “Antimicrobial resistance and food safety”. 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 Center 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, Nitte University, in his talk highlighted 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, 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**



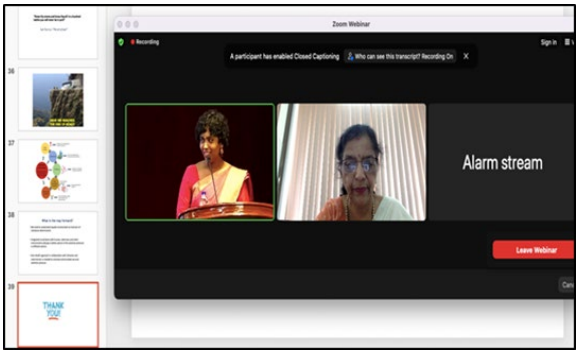
The Centre organized a webinar on "Ocean, Climate Change and Public Health" as a part of the Ocean Day celebration on 8 June 2023. Prof. Dr. Rita R Colwell, Former Director of the National Science Foundation and distinguished University Professor at the University of

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 Center 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 under a common roof expert 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.

Support for developing 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 about sources for AMR found 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".**

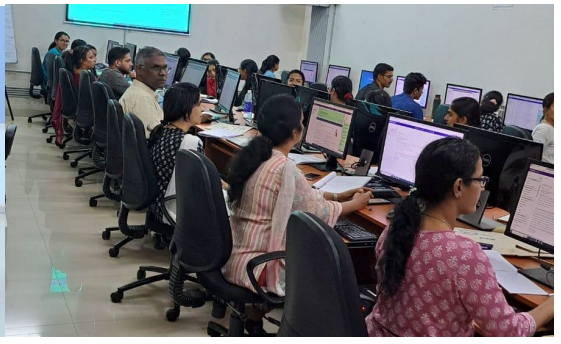
Dr. Iddya Karunasagar delivered an expert lecture on the topic 'Import risk analysis' at a conference on 28 February 2023 organized by the Central Institute of Brackishwater Aquaculture (CIBA) of the Indian Council of Agricultural Research (ICAR). The lecture covered the World Organisation of Animal Health (WOAH) 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.

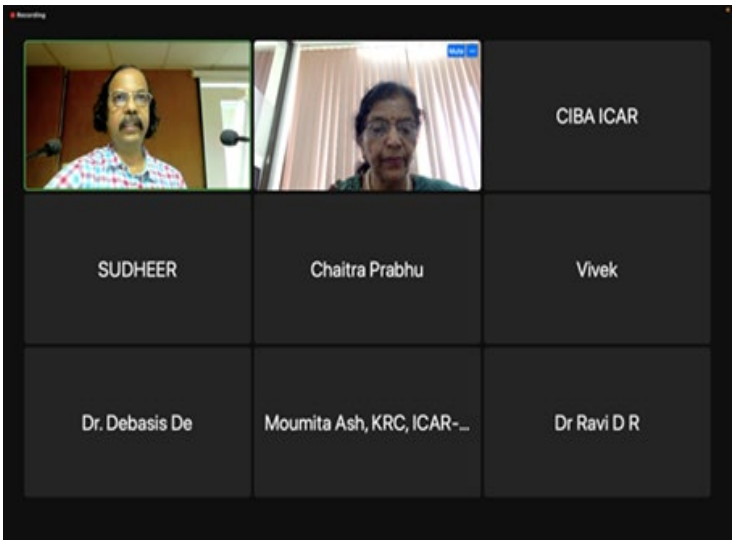
5. **Hands-on training in Microbial Genomics and Metagenomics**



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

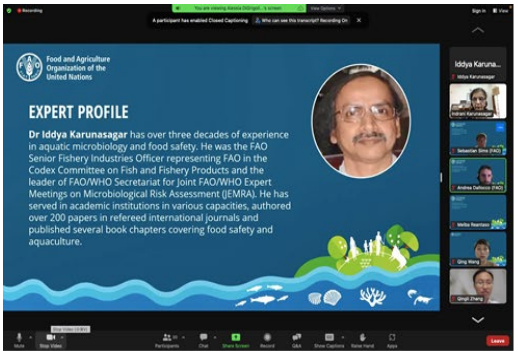
17 to 21 July 2023. The resource persons were Mr. Vikram S, CEO, Biokart India Pvt. Ltd., Ms. Helga Jenifer, Senior Bioinformatician, Biokart India Pvt. Ltd, Dr. Krishna Kumar B, Asst. Professor, NUCSER, Dr. Deekshit, Asst. Professor, NUCSER, Dr. Praveen Rai, Asst. Professor, NUCSER and Mr. Prithvisagar KS, Research Associate, NUCSER.

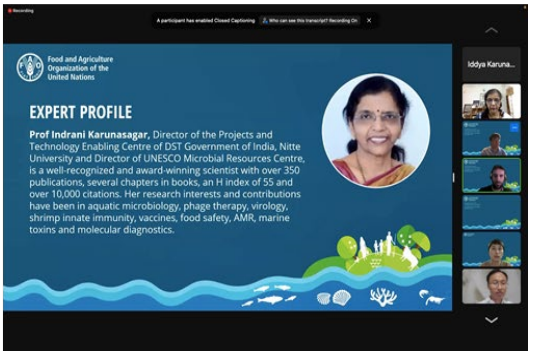
6. Delivered a Talk on Environmental Dissemination of AMR through Wastewater



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 centers, 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)**

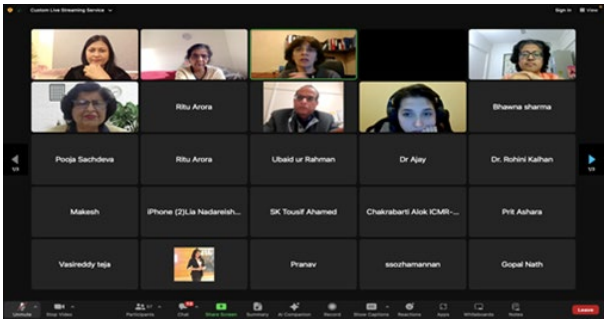
Dr. Iddya Karunasagar and Dr. Indrani Karunasagar delivered a lead talk and chaired a session under the theme - “Phages and Phage Therapy as alternatives to antibiotics” in VIROCON-2023, jointly organized by ICAR-National Research Centre for Banana, Tiruchirappalli, and the Indian Virological Society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

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 focussed on bacteriophages as alternatives to antibiotics in various sectors.

12. 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.

13. 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:** 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 hydrophila* 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.

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

A. Extraction of Polysaccharides from Red Seaweeds: The training was undertaken at Central Marine Fisheries Research Institute, Kochi, where students obtained hands-on training on various extraction methods including Solvent extraction, aqueous extraction, Thin Layer chromatography, Ion exchange chromatography and quantification by spectrophotometry.

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.

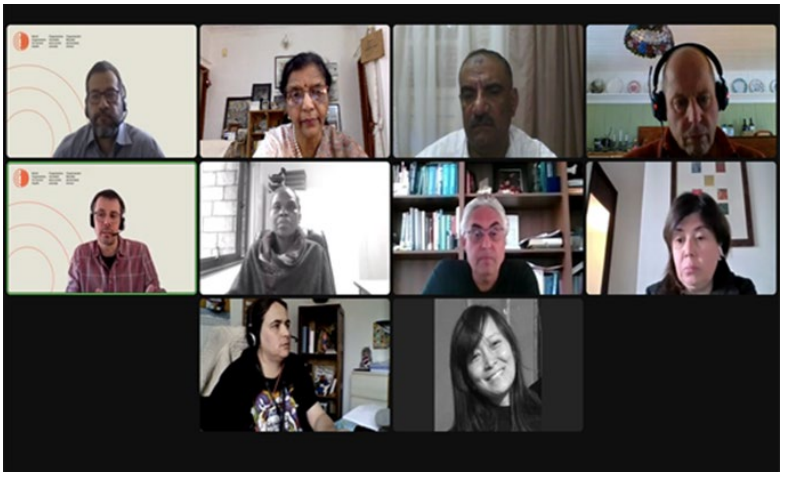
C. **Production of seaweed-based products as additives and supplements in agriculture, animal husbandry and food industries:** The training program conducted at AquAgri processing Pvt Ltd included techniques for extraction of chitosan from shrimp wastes, fucoidan from brown algae, cellulose from red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

Support strengthening governance related to AMR/AMU 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.

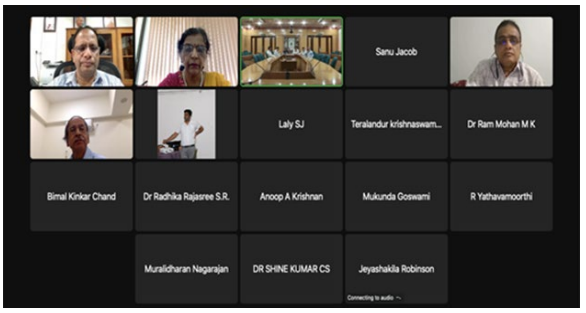
2. **Electronic Expert Group (EEG) meeting of the nominated members of the World Organization for Animal Health (WOAH) to develop guidelines for monitoring AMU in aquaculture**



Dr Indrani Karunasagar, a nominated member of an Electronic Expert Group (EEG) of the World Organization for Animal Health (WOAH) participated in online meeting during 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 best 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 centers 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 Organization 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 center 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.

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 Centre 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.

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

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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

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List of Patents

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)

Success story (October 2022 - December 2023):

The major success story for this period was the contribution of Nitte FAO Reference as the lead for FAO work on (a) Development of 10-point checklist for surveillance of antimicrobial use in aquaculture and (b) Risk profile of antimicrobial resistance in Vibrio parahaemolyticus. The FAO Reference Center, in consultation with FAO Headquarters, set up two international Expert Committees to work on these and organized two online meetings for each of the abovementioned topics. This was followed by drafting these documents. Another highlight was the participation of Dr. Iddya Karunasagar as Member of WHO Advisory Group on critically important antimicrobials in human medicine. With this membership, Nitte FAO Reference Center contributed to the development of WHO publication “Medically important antimicrobials”, which was published in 2024. Other important highlights include delivery of training workshops on aquatic animal disease surveillance and import risk analysis in Penang, Malaysia in collaboration with International Trade Center of UN and on Codex standards on antimicrobial resistance surveillance and aquaculture food safety in Phnom Penh, Cambodia in collaboration with UNIDO.