INFAAR – a research platform for accelerating laboratory-based surveillance of antimicrobial resistance in fisheries and aquaculture in India

'Antimicrobial resistance is a global threat to health, livelihoods and the achievement of the Sustainable Development Goals'. This statement by the UN the Secretary-General in May 2019 about Sustainable Development Goal (SDG) 3, viz. 'Good Health and Well-being' (https://undocs.org/en/A/73/869) was enough to raise alarm bells of a shift in human–pathogen interactions. The World Health Organization has called antimicrobial resistance (AMR) as one of the most important public health threats of the 21st century. The death of 700,000 people per annum at present is linked to AMR, which is estimated to rise to 10 million by 2050 (ref. 1). AMR is projected to cause a loss of US$ 100 trillion to the global economy by 2050 that is equivalent to a 3.5% reduction in global GDP[1]. In May 2015, the 68th World Health Assembly endorsed the Global Action Plan on AMR (https://apps.who.int/gb/ebwha/pdf_files/WHA68-REC1/A68_R1_REC1-en.pdf#page=27). India responded with a National Action Plan (NAP) on AMR, which was launched by the Ministry of Health and Family Welfare, Government of India in 2017 (https://www.ncdc.gov.in/WriteReadData/linkimages/AMR/File645.pdf).

AMR is the ability of microorganisms to resist the effects of antimicrobials. It can occur naturally, as all microbes can adapt to their surrounding environment. However, AMR is increasing by inappropriate and excessive use of antimicrobials in both human healthcare and animal sector. In 2014, India was the highest consumer of antibiotics in the human sector, followed by China and the United States, even though the per capita consumption of antibiotics in India is much lower than in many high-income countries[2]. India was the fifth largest consumer of antibiotics in food animals in 2010. Antibiotic consumption is projected to grow by 312%, making India the fourth largest consumer of antibiotics in food animals by 2030 (ref. 3). Antimicrobials are used in production practices to manage animal/fish diseases, and as growth promoters at a sub-therapeutic level. In recent decades, the intensification of animal production due to the increasing demand for animal proteins has led to increase in the use of antimicrobials. AMR makes disease treatments ineffective, increases severity of the disease, reduces productivity and leads to economic losses. In addition, more than half the amount of antimicrobials used in animals/fish is excreted as waste contaminating soil, water and the environment. This also contributes to the emergence and spread of AMR through selection pressure on microorganisms in the environment. Besides, antimicrobial usage (AMU) can lead to antimicrobial residues in the edible animal/fish products, which are a public health risk.

Currently, there are limited data available on AMR in the livestock and aquaculture sector in India. Most of them are individual studies with limited geographical coverage, samples and questionable quality. Thus, it is important to quantify the burden of AMR in food-producing animals and aquaculture through structured surveillance with pan India coverage. Implementation of the Indian Network of Fisheries and Animal Antimicrobial Resistance (INFAAR) is aimed to document AMR in different production systems, describe the spread of resistant bacterial strains and resistance genes, identify trends in resistance and generate hypotheses about sources and reservoirs of resistant bacteria through a structured national surveillance programme. The crucial data emerging at the spatial level will be input to formulate strategies and policies to prevent and reduce the spread of AMR in farmed animals and fish, and subsequently to the humans.

INFAAR is a technical programme of the Indian Council of Agricultural Research (ICAR), being executed with the cooperation of the Food and Agricultural Organization (FAO) and USAID since August 2018, largely operated at present with the internal financial resources of ICAR institutions. In this network, ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow, is the lead institution for fisheries and ICAR-Indian Veterinary Research Institute (IVRI), Bareilly, for animal science. To assure maximum national coverage, INFAAR is currently operational through 18 organizations (15 ICAR institutions and three State Agriculture Universities) in 20 centres (nine centres from fisheries and 11 from the livestock sector) spread across the country. INFAAR envisions to: (i) undertake surveillance of AMR in target microorganisms isolated from healthy farmed animals and fish/shellfish to quantify its burden, and monitor the spatial and temporal trends of AMR in India, and (ii) improve awareness and understanding of AMR among the farming community, veterinary and fish health professionals and policy-makers through effective communication, education and training to promote the judicious use of antimicrobials in farmed food animals and fish.

The priority microorganisms identified under the fisheries component of INFAAR are *Escherichia coli*, *Staphylococcus aureus*, other coagulase-negative *Staphylococcus* species (CONS) and *Aeromonas* species in farmed freshwater fish and *E. coli*, *S. aureus*, CONS and *Vibrio* species, including *Vibrio parahemolyticus* in farmed shrimps and cage-cultured marine fish. Target freshwater fish for AMR analysis are Indian major carps (catla, rohu and mrigal), and exotic pangas catfish *Pangassius hypophthalamus*. Cultured shrimps, mainly *Litopenaeus vannamei* and cage-cultured seabass are the target species for brackishwater aquaculture and mariculture respectively. Standard operating procedures for isolation, identification and antibiotic sensitivity testing (AST) of microorganisms have been developed for the fisheries sector to obtain uniform results by the partners[4]. The results are analysed using internationally accepted WHONET software. Data on AMU in fish farms are being collected through a field-based questionnaire. This would establish a link between AMU and AMR.

The three main activities of generating data on AMR include isolation, identification and AST of target organisms. Each of these is a specialized activity that requires training and guidance. In

last two years, two training programmes on AST (conducted by ICAR-IVRI and ICAR-CIFT (ICAR-Central Institute of Fisheries Technology)) and two training programmes on WHONET (conducted by ICAR-NBFGR and ICAR-IVRI) were organized by INFAAR in collaboration with FAO, India to train 53 participants on AMR-related laboratory procedures and data management. Besides, a specialized FAO–ICAR training on Assessment Tool for Laboratories and Antimicrobial Resistance Surveillance Systems was organized at ICAR-CIFT for skill upgradation of 22 scientists of INFAAR. The scientists of INFAAR have participated in the 'FAO-NACA regional consultation on AMR in aquaculture' held in Bangkok, Thailand from 4 to 7 September 2018 and an international training on 'Standardized and harmonized surveillance methods for AMR in food animals in South Asia' held at Bangkok from 28 to 31 May 2019. These have helped INFAAR in developing a skilled workforce for AMR analysis.

The issue of AMR also needs to be addressed by raising awareness amongst all stakeholders on implementing good practices to reduce the use of antimicrobials. Every year INFAAR creates awareness on 'judicious use of antibio-

tics' among the public, especially during 'World Antibiotics Awareness Week' from 18 to 24 November in different parts of the country. INFAAR has launched a dedicated website (www.infaar.icar.gov.in), which provides the latest information on AMR in the country. An Advisory Board established by the ICAR/Department of Agricultural Research and Education (DARE) is regularly guiding the functioning and activities of INFAAR.

INFAAR is working towards safe food production for human consumption without the risk of transmitting AMR to humans through the food production cycle. Safe food production without AMR risk will promote human and animal health, and a clean environment. The data generated by INFAAR will lead to the identification of strategies to prevent and reduce the development and spread of AMR in aquaculture and food animals. Successful implementation of INFAAR will be a key component NAP on AMR for the protection of human health, animal health and food safety in India.

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MEETING REPORT

Global seismology and tectonics*

A twelve-day 'International Virtual Workshop on Global Seismology and Tectonics' was organized recently to bring national and international experts together and boost the morale of the students and researchers during the COVID-19 pandemic by providing opportunities to interact with eminent scientists in the domain of seismology and tectonics.

G. Narahari Sastry (Director, CSIR-North East Institute of Science and Technology, Jorhat), who inaugurated the workshop, emphasized the impor-

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tance of computational technology in every branch of science and research. The workshop was chaired by J. R. Kayal (former Deputy Director General, Geological Survey of India, Kolkata). About 1000 participants from 30 countries registered for the event. Fifteen eminent speakers from different geoscience institutions delivered lectures and each of the lectures was attended by about 800 participants. The lectures by the keynote speakers covered all major aspects of seismology. Sixteen lectures were delivered during the workshop and are briefly highlighted here.

Andrew J. Michael (United States Geological Survey (USGS)) gave a talk on 'Why it is hard to count earthquakes: estimating catalog completeness'. He discussed that it is now much easier to

acquire earthquake event information from institutions such as the USGS or the International Seismological Centre (ISC), than in the past. While the advances are positive, it also means that researchers may not be in contact with the catalogue creators, who can advise them on its strengths and weaknesses. Over time, seismic networks have also become much better with more stations, higher quality seismometers, digital recording and improved analysis methods. However, it is important to understand how these advancements affect earthquake catalogs.

Michael also discussed 'The Poisson assumption: applications in spite of clustering'. He discussed how the Poisson probability distribution is frequently used to describe the temporal behaviour of