Antimicrobial resistance in foodborne pathogens

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Introduction

Antimicrobial resistance (AMR) is the ability of the microorganisms (bacteria, fungi, viruses and parasites) to resist the action of treatments. So, it's very difficult to treat the common infections and could, which may cause severe illnesses, chance of spreading of infections and finally lead to death. If we fail to tackle AMR as a pandemic issue, it could lead to 10 million deaths per year by 2050 and may cost $100 trillion lost from global GDP (O'Neill 2014). AMR is a major cause of death globally, with a burden likely to be higher than that of HIV or malaria. A comprehensive systematic study estimated that globally AMR was associated with 4.95 million deaths, including the direct contribution to 1.27 million deaths, in 2019 and India had one of the highest burdens of AMR and maximal resistance trends in Asia [Murray et al., 2022]. Moreover, AMR threat has long been signaled from the Recommendation-Commission on antibiotic resistance in 2013 and the O'Neil report, Global Antimicrobial Resistance and Use Surveillance System (GLASS) by WHO in 2015, Fleming Fund, 2015 and G7 Finance Ministers issued statements to support antibiotic development in 2021. But action has been episodic and uneven, resulting in global inequities in AMR. However, surveillance on AMR, diagnostics, treatment, control, vaccines and discovery of new antibiotics are extremely in slow progress. Moreover, the recent SARS-COVID-19 pandemic could have been worsened emergence of AMR due to unexpected and unpredicted prescriptions of antibiotics (Hsu, 2020).

Aquaculture farming and use of antibiotics in aquaculture

Due to consumer's food habit and awareness on health, fish and fisheries products get more attention across the globe due to nutrient contents viz., essential protein, fatty acids (PUFA), micro, and macro-nutrients. The per capita consumption of fish in the world was 9.0 kg in the year 1961, which grew to 20.5 kg in 2017 [FAO, 2018]. Because of its higher demand and exponential population growth, the intensified aquaculture farming system is blooming on every year. The intensive aquaculture often demands the use of formulated feeds, antibiotics, disinfectants, water, soil treatment compounds, algaecides, pesticides, fertilizers, probiotics, prebiotics etc., (Subasinghe et al., 2000; Bondad- Reantaso et al., 2005 and Rico et al., 2013] which could cause severe stress on fishes that lead to disease outbreak [Rottmann et al., 1992]. So, the fish farmers are often bound to use antibiotics to control the diseases. Generally, the antibiotics are administered through feed or applied directly into the aquaticulturte ponds [Heuer et al., 2009, Pham et al., 2015, Okocha et al., 2018]. Moreover, the administered antibiotics are not metabolized completely by the fishes and almost 75 % of the consumed antibiotics are excreted in to the pond through feces and directly applied antibiotics in the ponds will remain for a certain period (varied days of withdrawal period for different antibiotics). As on now, there is no defined antibiotics are produced for the control of fish diseases and often veterinary antibiotics are being used in fish farming [Chi et al., 2017].

Trends of antibiotic consumption

Global antimicrobial consumption in aquaculture in 2017 was estimated at 10,259 tons and antimicrobial consumption in aquaculture is expected to increase 33 % between 2017 and 2030 and mainly due to its expansion of aquaculture farming. The four countries with the largest share of antimicrobial consumption in 2017 were all in the Asia–Pacifc region: China (57.9 %), India (11.3 %), Indonesia (8.6 %), and Vietnam (5 %) and they represented the largest share of aquatic animal production output in 2017: China (51.2 %); India (9.9 %); Indonesia (9.8 %) and Vietnam (5.7 %) [Schar et al., 2020]. India accounts for about 3 % of the global consumption of antimicrobials in food animals [Van Boeckel et al., 2015]. By 2030, global antimicrobial use in human, terrestrial and aquatic food producing animal sectors is projected to reach 236,757 tons annually. On an equivalent biomass basis, estimated antimicrobial consumption in 2017 in aquaculture (164.8 mg kg−1) is 79 % higher than human consumption (92.2 mg kg−1) and 18 % higher than terrestrial food producing animal consumption (140 mg kg−1), which is projected to change to 80 % higher than human (91.7 mg kg−1) consumption and 18 % higher than terrestrial food producing animal consumption in 2030 [Schar et al., 2020].

Antibiotics used in Aquaculture

Globally, the most commonly used classes of antimicrobials were quinolones (27 %), tetracyclines (20 %), amphenicols (18 %), and sulfonamides (14 %) [Lulijwa Ronald et al., 2020]. Most frequently reported antibiotic compounds in Asian aquaculture production were sulphonamides: sulphadiazine, sulfamethoxine; beta-lactam: amoxicillin and florfenicol [Rico et al., 2012]. Food and Drug Administration (USFDA) has approved oxytetracycline, florfenicol, and Sulfadimethoxine/ormetoprim antibiotics for use in aquaculture [Romero et al., 2012].

Factors influencing antimicrobial resistance (AMR)

AMR is poorly understood in this aquaculture sector. Often the waterbodies/ aquaculture system may act as the source of AMR pathogen. The aquaculture system either use the natural waterbodies (rivers, lakes, streams, marine backwater and sea cage) or human made systems (fin fishes and shell fish farming). This frequently gives a chance of contracting with the AMR pathogen, antibiotic residues and AMR contributing factors such as biocides, chemical residues (Copper, Selenium, Lead etc.), heavy metal contaminations, pesticides, global warming and water quality parameters (pH, salinity, DO, ammonia, nitrate, nitrites etc.) through domestic, industrial and hospital sewage and agricultural runoff. The existing potential normal microflora of the aquatic system would acquire these ARGs and develop resistance against these pollutants and influence the transfer of ARGs between them, which lead to the accumulation of AMR pathogens [Michael et al., 2013]. Antimicrobial resistant bacteria can be transferred from food animals to humans either through direct contact with animals, contaminated foods, or indirectly through contaminated environments [Sharma et al., 2018, Argudín et al., 2017, Muloi et al., 2018]. The important listed AMR pathogens by FAO/ WHO/ OIE tripartite are ESKAPE whereas, numerous publications are pouring in the recent years with non- pathogenic bacterial species are also harboring from a few to more than 10 numbers of antimicrobial resistance genes (ARGs) and also harbor virulence and toxigenic genes. These non-pathogenic antibiotic resistant bacterial species in this aquatic system are either ignored or not monitored properly. A clear-cut understanding of the origin and environmental factors that accounts for the clinical appearance of ARGs is still lacking. Moreover, consistent study is warranted to prevent the extent of AMR amplification and its dissemination under the influence of environmental selection pressure/ factors and also to evaluate its risks (pathogenicity) to human, animal and aquatic animal health. So, spread of AMR infection has to be prevented through proper sanitation, hygiene, use of protective gears, proper disposal of waste and infection prevention measures, proper treatment of effluent from hospitals, manufacturing waste and impact of antibiotic discharges, reducing unnecessary use in aquaculture, promoting development of new rapid AMR diagnostics, promoting the development of vaccines, immune-modulators, antimicrobial peptides, digestible enzymes in feed, endolysins, hydrolases, and new drugs, enhancing the potential of existing antibiotics and finding alternatives to the antibiotics (bacteriophage therapy, pre and probiotics) and CRISPR- cas9 genome editing etc.

Regulation of antibiotics used in aquaculture

The use of antibiotics in aquaculture in India is regulated by government agencies: Coastal Aquaculture Authority of India (CAA), Marine Products Export Development Authority (MPEDA), Export Inspection Agency (EIA), Food Safety Standard Authority of India (FSSAI) and State Government. These agencies have aligned their antibiotics regulations to Maximum Residual Limits (MRLs) of the European Council (EC) and the FDA requirements, to meet export requirements. In India, government have listed antibiotic compounds as authorized and banned for use in aquaculture (CAA) and have adopted EC MRLs to meet export requirements of the importing countries.

Conclusion

It is imperative to identify and mitigate the source and spread of AMR as they are contributing to antimicrobial resistance, alterations of microbial community, health hazards to the stakeholders, food safety and quality issues and economic loss worldwide. It is well known that AMR is a one health approach. Thus, for eliminating the contamination of antibiotics and resistance genes in the aquaculture field, it is necessary to implement better management practices, effective biosecurity measures and employ other disease prevention measures instead of chemotherapy.

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