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Antibiotic Resistance in Aquaculture Environment in India

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Abstract

Recent reports pointing out that the antimicrobial use (AMU) and antimicrobial resistance (AMR) are continue to increase with the growth of population, animal, agricultural, aquaculture and environmental settings worldwide. The waterbodies are becoming a major reservoir of both AMR pathogen and antimicrobial residues since about 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water and it acts as a reservoir and vehicle for the transmission of antimicrobial resistance genes (ARGs). In addition, the aquaculture farming system receives several inputs like water, seed, feed, manure, antibiotics, probiotics; pesticides altogether contributes as AMR drivers. In order to prevent these emerging pollutants in the field of aquatic environment and fisheries, monitoring of AMR and AMU from various sources is imperative to set up regulatory standards by the authorities. For the effective surveillance programme on AMR more rapid and sensitive epidemiological techniques are required.

Keywords: Aquaculture; Fatty Acids; Food

Abbreviations: AMU: Antimicrobial Use; AMR: Antimicrobial Resistance; ARGs: Antimicrobial Resistance Genes; CAA: Coastal Aquaculture Authority of India; MPEDA: Marine Products Export Development Authority; EIA: Export Inspection Agency; FSSAI: Food Safety Standard Authority of India; MRls: Maximum Residual Limits; EC: European Council.

Introduction

Fish and fisheries products acquire more attention from the past decade due to their savor and better nutrient composition such as essential protein, fatty acids, micro, and macro-nutrients which fetched more demand in local markets and as well as in overseas. Due to its demand, dependency on the capture fisheries changed to a highly intensified aquaculture culture farming system and it contributes approximately 45% from the aquaculture fish production to the total fish production. Per capita consumption of fish in the world was 9.0 kg in the year 1961, which grew to 20.5 kg in 2017 [1]. Global fish production is growing rapidly and is become a major source of food for humans [1,2]. There is a huge diversity of farmed aquatic animal species and about 558 were commercially farmed worldwide as compared to terrestrial food animal producing species (chickens, pigs and cattle) in 2016 [1,3].

Aquaculture Farming and Use of Antibiotics in Aquaculture

Subasinghe, et al.; Bondad-Reantaso, et al. and Rico, et al. [4-6] reported that intensive aquaculture often demands the use of formulated fees, antibiotics, disinfectant's, water, soil treatment compounds, algaecides, pesticides, fertilizers, probiotics and prebiotics etc. The intensification of aquaculture farming caters to the needs but it puts huge stress on fishes that culminate in disease outbreak [7]. Often encounter with a high mortalities due to pathogen outbreak lead to lower production, so to encounter this problem fish farmers frequently use antibiotic as a prophylactic and or therapeutic purposes to control this diseases. The administration of antibiotics is being practiced either through feed or applied directly into the aquatic environment [2,8-10]. The administered antibiotics are not metabolize completely by the fishes and almost 75% of the consumed antibiotics are excreted in to the environment through feces and also antibiotics are directly dispersed in aquatic environment and it will remains for a certain period (withdrawal period for each antibiotic). Moreover, there is no defined antibiotics are produced for the control of fish diseases, often veterinary and or human antibiotics are being used as the prophylactic measures by the aquaculturist in fish farming in order to prevent mass mortalities mainly from the bacterial diseases [11] or as a growth-boosting factor [12].

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, excluding molluscs, in 2017: China (51.2%); India (9.9%); Indonesia (9.8%); and Vietnam (5.7%) [13]. India accounts for about 3% of the global consumption of antimicrobials in food animals [14]. By 2030, global antimicrobial use from 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 from 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}), shifting to 80% higher than human (91.7 mg kg^{-1}) consumption and remaining 18% higher than terrestrial food producing animal consumption projected in 2030 [13]. The recent review reported that if no action is taken to curb the AMR as a pandemic issue, it could cause the deaths of 10 million people worldwide every year by 2050, with a cumulative economic impact of around $100 trillion lost from global GDP.

Antibiotics Used in Aquaculture

Globally, the most commonly used classes of antimicrobials were, by frequency of use, quinolones (27%), tetracyclines (20%), amphenicols (18%), and sulfonamides (14%) [15]. Most frequently reported antibiotic compounds in Asian aquaculture production were sulphonamides: sulphadiazine, sulfamethoxine; beta-lactam: amoxicillin and florfenicol compared to tetracycline, quinolone and sulphonamides [16]. Food and Drug Administration (FDA) in the USA has approved oxytetracycline, florfenicol, and Sulfadimethoxine/ormetoprim antibiotics for use in aquaculture [17].

Factors Influence of Antimicrobial Resistance (AMR)

Many other external factors triggers AMR spread in the aquaculture field as it fully depends on other inputs like water source, feed, manure, disinfectant, probiotics, *etc*. Since numerous factors play a significant role in aquaculture practices for the AMR, aquaculture can itself act as a hotbed for the dissemination of AMR. Much attention is paid mainly in the human sector on the addressing the issues of AMR as compared to the agricultural, animal husbandry & aquaculture/ environment sector. Moreover AMR is poorly understood in this aquaculture sector in the emergence, reemergence and spread of AMR and collectively involved in the emergence of AMR as one health perspective. Often the waterbodies/ aquaculture system may act as the source of AMR pathogen by collecting from all possible settings and potential source for dissemination of AMR to the clinical and animal settings since its well interconnected system in India since more than 75% of the people are either directly or indirectly associating with the agricultural and animal husbandry activities. But the remaining human populations are being a chance of exposure to even hospital settings since their birth as the routine checking of the pregnant mother and advocating the vaccination schedule during the first 6 months of child birth.

The aquaculture system either use the natural waterbodies (rivers, lakes, streams, marine backwater and sea cage) and human made aquaculture farming (fin fishes and shell fish farming) are frequently getting a chance of contracting with the AMR pathogen, antibiotic residues and AMR contributing factors such as biocides, chemical residues (cu, 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. Whereby the existing potential normal microflora of the aquatic system would acquire these ARGs through HGT or vertical and development resistance against these pollutants and influence the transfer of ARGs between them which lead to the accumulation of AMR pathogens and risk to the clinical settings [18]. Antimicrobial resistant bacteria can be transferred from food animals to humans either through direct contact with animals, contaminated foods, or indirectly through contaminated environments [19-21].

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. So these non-pathogenic antibiotic resistant bacterial species in this aquatic system are either ignored or not monitored/ surveillance properly since these species could act as potential reservoir for the dissemination of AMR and may amplify AMR. However, a clear cut understanding of the origin and environmental factors that account for the clinical appearance of ARGs is still lacking. Clear understanding on the mobilization of ARGs among the potential recipient bacterial species are possible as and when encounter or admix it and this could also influenced by the above mentioned environmental factors including the selective pressure of antibiotic residues. Moreover consistent study is warranted to prevent the extent of AMR amplification and its dissemination under the influence of the environmental selection pressure/ factors and to evaluate of its risks (pathogenicity) to human, animal and aquatic animal health. So thereby **I**mprove hygiene and prevent the spread of AMR infection through 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, promote development of new rapid AMR diagnostics, promote the development of vaccines, immune-modulators, antimicrobial peptides, digestible enzymes in feed, endolysins, hydrolases, and new drugs, enhance 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 have aligned their antibiotics regulations and Maximum Residual Limits (MRLs) with the European Council (EC) and the FDA requirements, to meet export requirements. India, government authorities have listed antibiotic compounds authorized and banned for use in aquaculture (CAA) have adopted EC MRLs to meet export requirements of the importing consuming countries.

Conclusion

It is imperative to identify and mitigate the source and spread of AMR as they contributing serious antimicrobial resistance, alterations of microbial community, causes of 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 that includes connections between humans, animals, and the environment as a cause and a solution. 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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