ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 13, Issue, 03, pp. 62082-62085, March, 2023
https://doi.org/10.37118/ijdr.26350.03.2023

RESEARCH ARTICLE OPEN ACCESS

AQUACULTURE AND THE VARIOUS ASPECTS

***Dini Chandran, C. S.**

Research Scholar, Kerala University, India

Received 10th January, 2023; Received in revised form 18th February, 2023; Accepted 22nd February, 2023; Published online 28th March, 2023

Citation: ***Dini Chandran, C. S. 2023.*** "Aquaculture and the various aspects". *International Journal of Development Research*, 13, (03), 62082-62085.

INTRODUCTION

Importance of aquaculture: Aquaculture is the rearing of freshwater and saltwater populations under controlled or semi-natural conditions. It includes the business of producing aquatic animals and plants in managed, unnatural aquatic ecosystems for profit (Boyd and Schmittou, 1999). According to the Food and Agriculture Organization (FAO), aquaculture is understood to mean the farming of aquatic organisms including fish, mollusks, crustaceans and aquatic plants. Particular kinds of aquaculture include fish farming, shrimp farming, oyster farming, mariculture, alga culture such as seaweed farming and the cultivation of ornamental fish. Since in 1970s, global aquaculture production has grown rapidly and is now among the fastest growing food production sectors in many countries. Although Asia is by far the leading region contributing to about 90% aquaculture production, the importance of aquaculture is still growing and there is vast scope for its development. Despite its potential, aquaculture is an often-neglected option in agricultural development. Worldwide, millions of people suffer from protein malnutrition causing general ill health.(Olaf Muller and Michael Krawinkel.,2005) In India, fish in the diet is most important in the east and south India. Fish is a nutrient dense food. Fish gives sufficient amounts of all the essential amino acids required by the body for growth and maintenance. Fish is low in fat and high in easily digestible protein and Vitamin B-12. Some fishes are high in heart friendly cholesterol-lowering oils. It's a good source of protein - most varieties contain around 23.5% of protein, the same as meat. In 2015, fish accounted for about 17 per cent of animal protein consumed globally, and provided about 3.2 billion people with almost 20 per cent of their average per capita intake of animal protein (The state of world fisheries and aquaculture, 2020).

Common diseases affecting aquaculture: Almost all fish produced from aquaculture is mainly for human consumption. Diseases are one of the major constrains to aquaculture and the main limiting factor for economic and socio-economic developments in India and as in many other countries of the world (De Silva, S. S. 2001). It is understood that occurrence of disease is a result of the complex interaction between the host, the pathogen and the environment. Different stress factors such as non-optimal water quality, higher microbial load, poor nutritional status, high stocking density can trigger the chances of infection by opportunistic pathogens in aquatic environment (Mishra *et al*., 2017). Most bacterial, parasitic and fungal pathogens are not strictly parasitic micro-organisms. These pathogens have a high adaptability to environmental changes. If the conditions for parasitism are unsuitable, saprophytic relationship will occur. Environmental stress factors can result in increased development of fungal infections (Ana Cao *et al*., 2013). Most of the farmers are with a little knowledge of aquaculture health management and with inadequate opportunities for the improvement of disease problems. Most of them do not understand the signs of diseases. For this reason, efforts have to give not only on the occurrence of disease and pathogens but also on the awareness developmental programmes on farmer's disease awareness. Some diseases have caused serious damage, not only the livelihood of fish farmers, but also, to the future development of the industry.(Rosamond L Naylor *et al*.,2021) Many diseases affecting present day aquaculture is due to the resultant of boosting of culture practices without the basic insight of tangled balance between host, pathogen and environment.(MD. Ashihur Rahman *et al*., 2019). It is understood that occurrence of disease is a result of the complex interaction between the host, the pathogen and the environment (Ayalew Assefa and Fufa Abunna., 2018) In conclusion, rather than trying to treat every disease case, it advisable to follow a preventive approach before the event of any disease outbreaks. Besides implementation of better management practices it is relevant to prevent frequent occurrence of disease and production loss in aquaculture. It is clear that aquaculture is a huge industry operating worldwide and growing rapidly. Among these challenges, infectious diseases take the lion share causing billion dollar loss annually. Therefore, problems planning impediment and control strategy based on globally accepted principles and locally applicable strategies are to be followed. These strategies should focus on preventing the development of infection rather than treating diseased stocks.

Use of Antimicrobials in aquaculture: Antimicrobials are used globally both for humans and animals to prevent and treat contagious diseases (O'neill, 2014). Furthermore, in some countries, antimicrobials are used in animal breeding as growth promoters (Flo´rez *et al*., 2017).Low and sub therapeutic antimicrobial dosage plays a very important role in improving feeding proficiency, stimulating animal growth, disease avoidance, and control (Magouras *et al*., 2017). Overall, antibiotic use in the livestock sector is increasing and estimates of total use range from around 63,000 tons, to over 240,000 tons per year (Van Boeckel *et al*. 2015). Antimicrobials are widely employed in aquaculture industry, which mainly contribute to the rise of antimicrobial resistance, sustain potential consequences for animal, human, and ecosystem health (Daniel Schar *et al*., 2020) The faster growth of aquaculture has emerged in a series of developments harmful to the human and aquatic animal health as well as environment. Also, the exploit of wide variety human non-biodegradable antibiotics remains aquatic environment (M.G. Rasul1 and B.C. Majumdar., 2017). It directly causes development of antibiotic-resistance bacteria and transferable resistance genes can be transferred to disease-causing bacteria, resulting in antibiotic-resistant infections for humans, fish and other aquatic animal. The greater the volume of antibiotics used, the greater the risks that antibiotic-resistant populations of bacteria will induce in the contest for survival of the fittest at the bacterial level. Judicious use of antibiotics in animals is a requirement to delay the emergence of bacteria resistant to the still-working antibiotics,(Vangelis Economou and Panagiota Gousia, 2015) Furthermore, fish farmers must confirm that fish are kept in the best state of health and welfare. The invention of novel drugs or the use of alternatives to antibiotics should also be encouraged. Vast assemblage of antibiotics are applied to the aquaculture in a belief that it will enhance the production and also will improve the socio economic profile in developing countries (R.Vignesh *et al*., 2011). It is well acknowledged that the problems relating to antimicrobial use in animal food and aquaculture are of global concern. Intensive fish farming has promoted the outspread of several bacterial diseases, which in turn has led to the abundant use of antimicrobials. The high proportions of antibiotic-resistant bacteria that persevere in sediments and farm environments may provide a threat to fish farms because they can serve as sources of antibiotic-resistance genes for fish pathogens in the vicinity of the farms (Miriam Reverter *et al*., 2020). In addition to the potential effects on human health, inefficiencies in antibiotic treatment of fish illnesses lead to significant economic losses. One strategy for reducing antibiotic use in aquaculture is to execute rearing practices that minimize the level of stress on the fish and that reduce the likelihood that infections requiring antibiotic treatment will occur (Ayalew Assefa and Fufa Abunna, 2018).

Evidence of antimicrobial residues in aquaculture: Residues of antimicrobials in food have received much surveillance in recent years because of growing food safety and public health concerns (Fritz Michael Treiber and Heide Beranek-Knauer, 2021). Antimicrobial existence in foods of animal origin constitutes socioeconomic challenges in international trades in animal and animal products. The major public health significances of antimicrobial residues include the development of antimicrobial drug resistance, hypersensitivity reaction, carcinogenicity, mutagenicity, teratogenicity, bone marrow depression, and disruption of normal intestinal flora. Indiscriminate use of antimicrobials in aquaculture resulting in matter of residues in aquaculture products and associated harmful health effects in humans requires control measures to ensure consumer protection (Reuben Chukwuka Okocha1 *et al*.,2018) Ungoverned use of antibiotics in aquaculture industry for the production of farm raised fish and shrimps could pose human health and food safety concerns that remain largely nonregulated in most developing nations of the world. The presence of antibiotic residues in aquaculture products could result in the development of bacterial resistance and toxicity to consumers that can lead to morbidity and or death. Chloramphenicol residues, for example, lead to an increased risk of developing cancer and in very low concentrations may trigger aplastic anemia, a disease that causes bone marrow to stop producing red and white blood cells and is often irreversible and fatal. Other toxic effects include immunopathological effects and carcinogenicity by sulphamethazine, oxytetracycline, and furazolidone; mutagenicity and nephropathy by gentamicin; and allergy by penicillin. The presence of antibiotic residues in domestic animal products and the associated consumer's health hazards have been reported with little attention focused on the aquaculture industry.

Today antimicrobials play a major role in modern livestock production for avoidance and treatment of diseases as well as growth fostering (Feiyang Ma *et al*., 2021) The global rise in production and demand for aquaculture products has resulted in increasing vulnerability on antibiotics with resultant residues in the products produced for human consumption (Daniel Schar *et al*, 2020) Antimicrobial residues irrespective of the route or purpose of administration, antimicrobials can accumulate as residues in tissues, before they are completely metabolized or excreted from the body. The occurrence of residues in fish or other animal tissues is most likely when animals are harvested for human utilization. Consumption of such products may result in many health problems in humans (Reuben Chukwuka Okocha *et al*., 2018). The problem of antimicrobial residues in animal products is not new. However, due to the globalization of the food trade we are constantly fronting new challenges. Educational work regarding antimicrobial residues in animal products and the associated blooming of multi-resistant germs must be enhanced in developing countries (Fritz Michael Treiber and Heide Beranek Knauer, 2021). This can only be reduced through increased monitoring of the use of antibiotics in animal breeding. In any case, users must be informed about the health consequences for their customers regarding antibiotic residues in animal products and the development of multi-resistant germs. While low level residues of certain antibiotics are considered safe in some food products, residues of other antibiotics may pose inappropriate risk to public health and are therefore forbid for use in food animals (Ian Philips *et al*., 2004). Without antibiotics, food animals suffering from bacterial infectious diseases will be denied effective treatment and outbreaks of disease may not be effectively controlled or prevented within a herd.(Christy Manyi *et al*., 2018). In general, antibiotics should only be used when preferable and used in food animals; they should be under veterinary supervision. Aquaculture products should be screened for safety levels of antimicrobial residues. Efforts should also be made to reduce the use of antibiotics by implementing good animal husbandry practices.

Emergence of antibiotic resistance in aquaculture: One of the major problems to be addressed in aquaculture is the importance of antimicrobial resistance (AMR). The development of bacterial infections in cultured fishes promotes the continuous use of antibiotics in aquaculture, which results in the selection of proliferated antibiotic-resistant bacteria and increases the possibility of transfer to the whole environment through horizontal gene transfer (Preena Prasannan Geetha *et al*., 2020). Antimicrobial resistance is a growing distress among the wide infectious agents in multiple sectors. This reminds the possibility of spread of antibiotic-resistant genes from aquatic to non-aquatic environment, which could be considered seriously as it impacts global health analysis. Antimicrobial resistance is a growing menaces to global public health, and the overuse of antibiotics in animals has been identified as a major threat factor (Sammer Dhingra *et al*., 2020). With high levels of international trade and direct connectivity to the aquatic environment, shrimp aquaculture may play a role in global AMR dispersal(Kelly Thornber *et al*., 2020). As the human population increases there is an increasing dependency on aquaculture to supply a safe, reliable, and economic supply of food. Infections caused by resistant bacteria lead to up to two-fold higher rates of unfavourable outcomes compared with similar infections caused by susceptible strains.These adverse outcomes may be clinical or economic and reflect primarily the failure or delay of antibiotic treatment.(N D Friedman *et al*., 2015). This apathetic crisis is driven by the overuse of antimicrobial drugs in humans, animals, as well as the contamination of natural environments with antimicrobial residues and resistant pathogens (Christy Manyi Loh *et al*., 2018). The accelerated and semi-intensive practices are used to produce large stocks of fish, but frequent disease outbreaks occur, and the use of antimicrobials has become a traditional practice to control them (Lucia Santos and Fernando Ramos, 2018). Although most farmers in India are uneducated and cannot understand the meaning of AMR and the risks it thrives, a lot of projects have been set up by different authorities to make the farmers understand and make them antibiotic-smart. Antibiotic resistance will not be removed completely in a few months or years to come; rather we can decrease the consequences of AMR by using them judiciously and safely.

Public health implications of antimicrobials: Aquaculture has become the fastest growing sector of food production in the world. Despite the encouraging trends, several obstructions have negative impact on the growth of aquaculture.Therefore, strict measures, legislations and regulations for the use of antimicrobials in aquaculture should be developed and implemented, especially in developing countries, to avoid such negative impacts in human, fish, animals and environment (Salah Mesalhy Aly and Aqel Albutti, 2014). The intensification of aquaculture to achieve market demands could lead to an increase in infectious diseases by pathogenic bacteria. Consequently, antimicrobials act as controls for emerging infectious diseases, but their use must follow the rules and regulations of the country where the activity is performed (Louis Eduardo de Souza Gazal *et al*., 2020) Resistant bacteria from fish farming are a serious concern because they can be acquired by humans with handling or food chain, which may represent a public health problem. Excessive use of antimicrobials in aquaculture can thus potentially negatively impact animal and human health as well as the aquatic environment and should be better evaluated and regulated (Felipe C Cabello *et al*., 2013) Antibiotics have been extensively and effectively used in aquaculture due to expedite growth of aquaculture and this has resulted in the development of serious health problems in aquaculture, other animals, and human (Pathmalal M Manage, 2018)

Alternate antibiotic strategies in aquaculture: The wide and frequent use of antibiotics in aquaculture has resulted in the development and spread of antibiotic resistance. Because of the health risks associated with the use of antibiotics in animal production, there is a growing awareness that antibiotics should be used with more care. This is reflected in the recent execution of more strict regulations on the prophylactic use of antibiotics and the presence of antibiotic residues in aquaculture products.(Tom Defoirdt *et al*.,2011) The aquatic environment is more supportive to pathogenic bacteria independently of their host than the terrestrial environment and pathogens can reach high densities around the animals, which then ingest them either with the feed or when they are drinking. Culturing several species of aquatic animals in many cases suffers from highly uncertain survival rates because of bacterial diseases (Laurent Verschuere *et al*.,2000) .In addition to regulations on the use of antibiotics in aquaculture, many governments around the world have enforced Maximum Residue Levels (MRLs) for aquaculture products (Ronald Lulijwa *et al*.,2019) .One of the alternative strategies that has recently been developed to control infections caused by antibiotic-resistant bacteria is the disruption of quorum sensing, bacterial cell-to-cell communication.(Tom Defoirdt *et al*., 2007) This is in contrast to conventional antibiotics, which also affect harmless and beneficial bacteria and pose strong selective pressure in any environment. Indeed, the biocontrol agents include viruses (bacteriophages), algae or their metabolites and bacteria or their metabolites. In this respect, the alternative strategies discussed here could be the basis for a rational selection of probiotics bacteria based on different modes of action. Indeed, selection of probiotics for aquaculture so far focused mainly on the production of constraint substances in vitro (S. Mohapatra *et al*.,2012). Although most of them have been tested both in vitro and in vivo, few have been tested in 'real life' situations .Because most probably no biocontrol strategy will be successful in all cases, we think that it is important to further develop different strategies that could be combined or used in rotation in order to maximize the chance of successfully protecting the animals and to prevent resistance development.

Current perspective and future challenges in aquaculture : The results obtained by using techniques that disrupt quorum sensing systems of pathogenic bacteria indicate that it is a promising replacement for antibiotics in fighting bacterial infections (Tom Defoirdt *et al*., 2004). This new approach might also have value in aquaculture since a link between quorum sensing and virulence factor expression in several aquatic pathogens has been demonstrated. Unfortunately, data about the impact of quorum sensing on virulence (i.e. the net result of all virulence factors) of aquatic pathogens are still lacking. Hence, bacterial diseases affecting either agricultural crops, fish, or shellfish not only cause large economic losses to producers but can even create food shortages, resulting in malnutrition, or even famine, in vulnerable populations. Phages are viruses that specifically infect bacteria; they are highly host-specific and represent an environmentally-friendly alternative to antibiotics to control and kill pathogenic bacteria.

CONCLUSION

The diverse nature of aquaculture leads to the paradox that it is often proposed as a solution to global food supply issues, but may actually be a net consumer of fish and reduce the availability of fish for people (Naylor *et al*., 2000) culture where predators and competitors are controlled. Although the boom that took place in the aquaculture sector in the eighties and early nineties, crashed in the mid-nineties but still an opportunity exists for revival of the industry. What is required is the practice of responsible and technologically sound aquaculture that will be eco-friendly and sustainable. The significant growth in fisheries and aquaculture production, especially in the past two decades, has enhanced the world's capacity to consume diverse and nutritious food. Fish and fish products have a crucial role in nutrition and global food security, as they represent a valuable source of nutrients and micronutrients important for diversified and healthy diets. Moreover, in lower-income countries, the importance of fish is enhanced by the fact that it contains many of the vitamins and minerals required to address some of the most severe and widespread nutritional deficiencies. Even small quantities of fish in people's diet can have a significant positive impact on the nutritional status of poor consumers across the world. Since 1961, the annual global growth in fish consumption has been twice as high as population growth, demonstrating that the fisheries sector is crucial for a world without hunger and malnutrition (FAO, 2018). Despite the significant contributions that fisheries and aquaculture make to employment, nutrition, and trade in the developing world, they are rarely included in national development policy and donor priorities. This is largely due to problems with valuation of small-scale fisheries, as policy makers often do not have access to data which reflect the importance of fisheries and aquaculture to development. Even with improvements in regulation, however, pressures on capture fisheries will remain, due to continued population growth. Further development of sustainable aquaculture and improvements in the post-harvest sector to reduce losses could help to maintain fish supply and the contribution of fish.

REFERENCES

Anwesha Roy, Avijit Biswas, Subal Kumar Ghosh, Hauzou Kim and Sagarika Swain (2021)," Current scenario of antibiotic-resistance in Indian aquaculture ", School of Fisheries, Centurion University of Technology and Management, Odisha, India , The Pharma Innovation Journal 2021; SP-10(7): 454-461

Ayalew Assefa and Fufa Abunna Rahman (2018)," Maintenance of Fish Health in Aquaculture: Review of Epidemiological Approaches for Prevention and Control of Infectious Disease of Fish", Sekota Dryland Agricultural Research Center, Ethiopia College of Veterinary Medicine and Agriculture, Oromia,Ethiopia Veterinary Medicine International Volume 2018, Article ID 5432497, 10 pages.

Carmen Sieiro, Lara Areal-Hermida , Ángeles Pichardo-Gallard ,Trinidad de Miguel, Sandra Sánchez, Ángeles Sánchez-Pérez and Tomás G (2020),)," A Hundred Years of Bacteriophages: Can Phages Replace Antibiotics in Agriculture and Aquaculture? ", Department of Functional Biology and Health Sciences, Spain ,Sydney School of Veterinary Science, Faculty of Science, University of Sydney, Australia, Antibiotics 2020.

Daniel Schar1, EiliY. Klein , Ramanan Laxminarayan , Marius Gilbert and Thomas P.Van Boecke (2020)," Global trends in antimicrobial use in aquaculture", Spatial Epidemiology Laboratory,Belgium,Center for Disease Dynamics, Washington,USA, Institute for Environmental Decisions, Switzerland. Scientific Reports | (2020) 10:21878.

Dr. Charles M. Benbrook (2002), Antibiotic Drug Use in U.S. Aquaculture", The Northwest Science and Environmental Policy Center Sandpoint, Idaho Antibiotic Use in Aquaculture. 20

Esther Eyram Agoba, Francis Adu, Christian Agyare and Vivian Etsiapa Boamah Boecke (2017)," Antibiotic Use and Practices in Selected Fish Farms in the Ashanti Region of Ghana ", Department of Pharmaceutics, Faculty of Pharmacy and Pharmaceutical Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana J Infec Dis Treat. 2017, Vol.3 No.2:9.

Felipe C. Cabello,(2006)," Heavy use of prophylactic antibiotics in aquaculture: a growing problem for human and animal health and for the environment", Department of Microbiology and Immunology, New York Medical College, USA, Environmental Microbiology (2006) 8(7), 1137–1144

Fritz Michael Treiber and Heide Beranek-Knauer (2021), "Antimicrobial Residues in Food from Animal Origin A Review of the Literature Focusing on Products Collected in Stores and Markets Worldwide", Institute of Molecular Biosciences, University of Graz, Austria Antibiotics 2021, 10, 534.

G.K.Sivaraman V,Murugadas and M.M.Prasad (2018)," Impact of Antimicrobial resistance (AMR) in aquatic products ", Microbiology, Fermentation and Biotechnology Division, ICAR - Central Institute of Fisheries Technology, Cochin –Kerala . ICAR-CIFT, Cochin, 05-25, 2018.

Jaime Romero, Carmen Gloria Feijoó and Paola Navarrete (2012)," Antibiotics in Aquaculture – Use, Abuse and Alternatives ",Universidad de Chile, Biotechnology Laboratory, Institute for Nutrition and Food Technology (INTA) Universidad Andrés Bello, Laboratory of Developmental Biology, Santiago Chile Health and Environment in Aquaculture. 2012

Lucia Santos, Fernando Ramos (2018)," Antimicrobial resistance in aquaculture: Current knowledge and alternatives to tackle the problem ", Pharmacy Faculty, University of Coimbra, Portugal International Journal of Antimicrobial Agents 52 (2018) 135–143

Lucia Santos, Fernando Ramos (2018)" Antimicrobial resistance in aquaculture: Current knowledge and alternatives to tackle the problem ", Pharmacy Faculty, University of Coimbra, Portugal International Journal of Antimicrobial Agents 52 (2018) 135–143

M. Krishnan and Pratap S.Birthal (2002), "Aquaculture development in India: an economic overview with special reference to coastal aquaculture Central Institute of Brackish water Aquaculture", Chennai, India Aquaculture Economics and Management 6(1/2) 2002

M.G. Rasul1, B.C. Majumdar Dr. Charles M. Benbrook ,(2017)," Abuse of Antibiotics in Aquaculture and its Effects on Human, Aquatic Animal and Environment ", Department of Fisheries Technology, Bangabandhuy, Sheikh Mujibur Rahman Agricultural University, Gazipur, Bangladesh Haya: Saudi J. Life Sci.; Vol-2, Iss-3 (Apr-Jun, 2017):81-88

M.Kumaran, V.S. Chandrasekaran and N. Kalaimani (2003), "Aquaculture Extension: the neglected aspect in Aquaculture Development " Central Institute of Brackish water Aquaculture (CIBA), Santhome High Road,Chennai Fishing Chimes Vol.23 (2003).

Marta Sargenti, Silvia Bartolacci, Aurora Luciani , Katiuscia Di Biagio, Marco Baldini, Roberta Galarini, Danilo Giusepponi and Marinella Capuccella,(2020)," Investigation of the Correlation between the Use of Antibiotics in Aquaculture Systems and Their Detection in Aquatic Environments: 18.A Case Study of the Nera River Aquafarms in Italy", Experimental Zooprophylactic Institute of Umbria and Marche, Italy Sustainability 2020.

MD. Ashikur Rahman, Shirin Akter, M Mominuzzaman Khan and MD. Khalilur Rahman Fisheries Research Institute, Freshwater Station, Mymensingh, Bangladesh Department of Fisheries and Marine Bioscience, Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalgonj J. Fish. (2019) 31(2) : 253-260

MD. Ashikur Rahman,Shirin Akter,M Mominuzzaman Khan and MD.Khalilur Rahman (2019)," Relation between aquaculture with fish disease & health management: A review note ", Bangladesh Fisheries Research Institute, Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalgonj Bangladesh J. Fish. (2019) 31(2) : 253-260.

Michael Tlusty Edgerton, 2002. "The benefits and risks of aquacultural production for the aquarium trade Research Laboratory" New England Aquarium, Central Wharf, USA Aquaculture 205 (2002) 203–219.

Ole E. Heuer, Hilde Kruse, Kari Grave, P. Collignon,Iddya Karunasagar and Frederick J. Angulo (2009),),"Human Health Consequences of Use of Antimicrobial Agents in Aquaculture",Danish Zoonosis Centre, National Food Institute, Denmark; National Veterinary Institute and Department of Food Safety and Infection Biology, Norwegian School of Veterinary Science, Norway FOOD SAFETY CID 2009.

P. Jayasankar, K.N. Mohanta and S. Ferosekhan (2018),"Freshwater Aquaculture in India",ICARCentral Institute of Freshwater Aquaculture, Odisha Aquaculture in India, Pages 23-49 2018.

Pathmalal M. Manage ,(2018)," Heavy use of antibiotics in aquaculture: Emerging human and animal health problems – A review", Centre for Water Quality and Algae Research, Department of Zoology, University of Sri Jayewardenepura, Nugegoda, Sri Lanka , J. Aquatic Sci. 23(1) (2018): 13-27

Pragyan Dash, Satheesha Avunje, Ritesh S. Tandel, Sandeep K. P. and Akshaya Panigrah (2017), "Biocontrol of Luminous Vibriosis in Shrimp Aquaculture: A Review of Current Approaches and Future Perspectives", Indian Council of Agricultural Research-Directorate of Coldwater Fisheries Research (DCFR) , Bhimtal, India; Indian Council of Agricultural Research-Central Institute of Brackish water Aquaculture (CIBA), Chennai, India , Reviews in Fisheries Sciences and Aquaculture 2017.

R. Vignesha, B.S. Karthikeyanb , N. Periyasamya and K. Devanathan ,(2011)," Antibiotics in aquaculture: An overview ", Centre for Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Tamilnadu, India, Department of Bioinformatics, School of Life Sciences, Bharathidasan University, Tamilnadu, India, J Exp Biol; 1 (3): 2011

Reuben Chukwuka Okocha1, Isaac Olufemi Olatoye and Olufemi Bolarinwa Adedeji , (2018)," Food safety impacts of antimicrobial use and their residues in aquaculture ", Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Nigeria,Public Health Reviews (2018) 39:21.

Roslina Kamaruddin and Amir Hussin Baharuddin (2015), "The importance of good aquaculture practices in improving fish farmer's income" A case of Malaysia, Department of Economics and Agribusiness, Article in *International Journal of Social Economics* December 2015.

Sudipto Sarkar and Bimal Chandra Mal 2005. "The Status of Aquaculture in India: Development, Adoption and Constraints" Agricultural Engineering Today, Vol. 29 (5-6): 46-52, 2005

****