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# Antimicrobial Resistance in Aquaculture: A Looming Global Crisis

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Bacterial diseases greatly affect aquaculture and thus impact the health of fish and the economies involved. Farmers have been using antibiotics in aquaculture to prevent and cure bacterial diseases for several decades. The extensive use of antibiotics in aquaculture has led to an alarming rise in antimicrobial resistance (AMR). AMR is a global problem because the resistant bacteria could spread into humans and the environment, thus creating critical public health and ecological challenges. The resistance mechanisms include enzymatic inactivation, efflux pumps, and biofilm formation. Treatment becomes increasingly difficult. Antibiotics enter aquaculture systems through contaminated feed, water, and agricultural runoff, thus worsening the problem. AMR decreases the effectiveness of antibiotics in treatment and impacts food safety and environmental sustainability. To overcome these challenges, there is a need for stricter antibiotic regulations, better biosecurity, and the development of alternative treatments, such as vaccines and phytotherapy. The article discusses the mechanisms of resistance, pathways of contamination, and potential mitigation strategies to promote sustainable aquaculture practices.

**Keywords:** Bacteria, Aquaculture, Antibiotic, Antimicrobial resistance, Biosecurity

## Introduction

Bacterial diseases significantly threaten fish health in aquaculture, with common pathogens like *Vibrio*, *Aeromonas*, *Pseudomonas*, and *Flavobacterium* causing lethal infections. These bacteria can cause substantial death rates, particularly in intensive farming situations. Antibiotics are now widely used in therapeutic and prophylactic efforts to control diseases and prevent outbreaks. However, the widespread and improper use of antibiotics in aquaculture has resulted in the emergence of antimicrobial resistance (AMR) (Preena *et al*., 2020). The inappropriate use of antimicrobials in aquaculture raises serious concerns, as a link has been established between antimicrobial use in food-producing animals and the emergence of resistant bacteria that can be transmitted to humans (Santos *et al*., 2018). Antimicrobial resistance arises when bacteria, viruses, fungi, or parasites develop mechanisms to resist the actions of medications that were previously effective in treating infections caused by these pathogens (Uddin *et al*., 2021). Antimicrobial resistance is increasingly regarded as a severe concern in the European Union (EU) and worldwide. According to the World Health Organisation (WHO), AMR has already reached alarming levels in several regions of the world (WHO, 2014). Resistant bacteria cause infections that are more difficult to treat, necessitating less available, more expensive, and typically more toxic treatments.

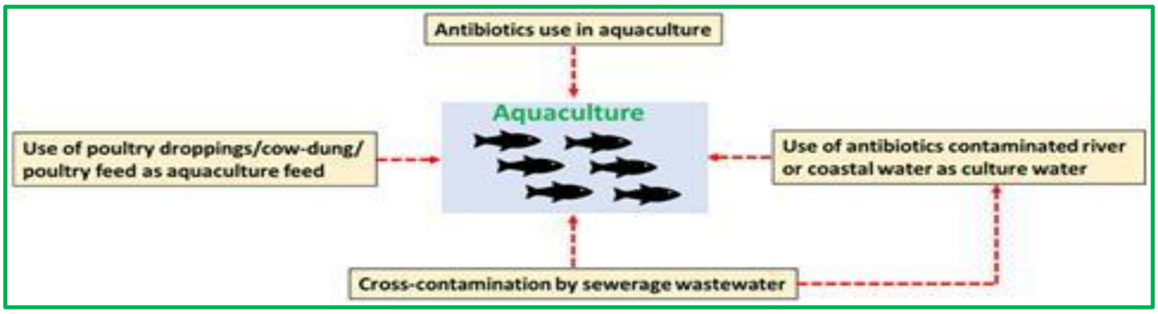
## Mechanism of antibiotic resistance

- **Enzymatic inactivation:** Bacteria release enzymes, such as β-lactamases, that degrade antibiotics, making them ineffective. This is a frequent route for resistance to β-lactam antibiotics such as penicillin and cephalosporins (Duijkeren *et al*., 2018).

- **Efflux pumps:** Bacteria employ efflux pumps to expel antibiotics from their cells, decreasing the intracellular concentration of the drug. This method is found in numerous bacterial species, including *Pseudomonas aeruginosa* (Duijkeren *et al*., 2018).
- **Decreased permeability:** Changes in the bacterial cell membrane or outer membrane proteins can limit antibiotic uptake, making the drug less effective. This is a common resistance mechanism found in Gram-negative bacteria (Ghai *et al*., 2018).
- **Target modification:** The binding affinity and efficacy of antibiotics can be decreased by bacteria that modify the target sites, such as DNA gyrase, ribosomes, or penicillin-binding proteins (PBPs). Resistance to fluoroquinolones, macrolides, and β-lactams is an example of this mechanism (Munita *et al*., 2016).
- **Biofilm formation:** In order to protect themselves against antibiotics, bacteria create barriers called biofilms. Antibiotic penetration is restricted by biofilms, making bacterial eradication challenging (Duijkeren *et al*., 2018).
- **Alteration of metabolic pathways:** Bacteria can use different metabolic pathways to survive instead of the ones that drugs target. According to Kumar *et al*. (2013), this mechanism is observed in resistance to trimethoprim and sulfonamides.

## Pathways of antibiotic contamination in aquaculture

- **Use of antibiotics as prophylaxis and therapeutics in fish farms:** Metabolic waste and unfed feed containing antibiotics contaminate water and sediment with antibiotics.
- **Use of antibiotics-contaminated river or coastal water as culture water:** Introducing water already contaminated with antibiotics into aquaculture systems.
- **Use of poultry droppings, cow dung, or poultry feed as aquaculture feed:** Introducing residual antibiotics from animal waste or feed into aquaculture environments.
- **Cross-contamination by sewage wastewater:** Wastewater carrying antibiotics entering aquaculture systems, leading to contamination.




**(Source- Hossain *et al*., 2022)**

## Risks due to antibiotic abuse

- **Development of resistant bacteria:** Frequent and improper antibiotic use leads to antibiotic-resistant bacteria in aquaculture environments (Hossain *et al*., 2022).
- **Transfer of resistance genes:** Resistant bacteria can transfer their resistance genes to other microbes in the environment through horizontal gene transfer (Von Wintersdorff *et al*., 2016).
- **Reduced treatment effectiveness:** Antibiotics may become ineffective against bacterial diseases, leading to higher fish mortality rates (Santos and Ramos, 2018).
- **Food safety concerns:** Residual antibiotics and resistant bacteria in fish products can pose health risks to consumers (Alderman *et al*., 1998).
- **Contamination of surrounding areas:** Antibiotic residues and resistant bacteria can spread to nearby natural water bodies, affecting wild aquatic organisms (Lupo *et al*., 2012).

## Mitigation Strategies

To minimize these risks, aquaculture practices should emphasize:

- Strict regulation of antibiotic use.
- Enhanced biosecurity and hygiene practices.
- Development of alternative treatments like phytotherapy, antimicrobial peptides, vaccines, and immunostimulants.
- Ongoing research to monitor and address resistance trends.

## Conclusion

Antimicrobial resistance poses a significant threat to aquaculture and public health, driven by the overuse and misuse of antibiotics in fish farming. Resistant bacteria compromise the effectiveness of treatments, increase fish mortality, and pose risks to food safety and the environment. Understanding the mechanisms of resistance and the pathways of antibiotic contamination is crucial for addressing this growing problem. Effective mitigation strategies, including stricter regulations, improved biosecurity measures, and alternative treatments, can help ensure the sustainability of aquaculture practices while protecting public health and aquatic ecosystems. Immediate action and ongoing research are essential to curb the escalating threat of AMR in aquaculture and beyond.

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