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Dispersal of Antibiotic Resistant Bacteria into Aquatic Environment - An Overview

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Abstract

Antibiotic resistance is a major public health concern and this phenomenon has been continuously increasing in environmental settings. Aquatic environments, which are often affected by anthropogenic activities, provide a favourable environment for the horizontal exchange of mobile genetic elements encoding antibiotic resistance. In this article, we are emphasizing on the emergence and spread of antibiotic resistance in and through the aquatic environment. The knowledge of sources and mechanisms of antibiotic resistance will be essential for developing effective strategies for reducing the impact of antibiotic-resistant bacteria on the public health.

Keywords: Antibiotic resistance; Aquatic environment; Public health

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Introduction

Aquatic environments have great ecological and economic importance. Unfortunately, they are polluted by a large number of anthropogenic activities, worldwide. Urban, industrial, medical and farming activities are responsible for the discharge of pollutants into these systems. Hospital-wastes, biocides, fertilizers, sludge, organic compounds, heavy metals and other sources of wastewater are released into the water bodies often without appropriate treatment [1,2]. Such activities lead to eutrophication, hypoxia, toxicity, bioaccumulation, and dissemination of pathogens. Water helps these pollutants to spread across long distances. Thus, thinly populated areas where human activities are less intense are also affected by these disturbances [3,4]. In this article, we are emphasizing on the emergence and spread of antibiotic resistance in and through the aquatic environment.

Emergence of antibiotic-resistant bacteria

The use of antibiotics in an alarming rate and irrational manner has led to the emergence of resistance in bacterial strains. The foremost reason for the emergence and spread of antibiotic resistant bacteria (ARB) is due to the heavy and irrational use of antibiotics in last four decades, across the globe [5-7]. Antibiotic resistance was reported after few years of its introduction and now the problem has reached to all parts of the world. Improper use of antibiotics, premature discontinuation of antibiotic therapies, self-medication and intake of antibiotics when they are not prescribed (e.g. in viral infections) promotes the development of resistance [6-8]. The poor sanitation and unscientific modes of waste disposal leads to spread of these pathogens, especially in developing and underdeveloped countries, where the hygiene standards are low. It has been confirmed by World Health Organization and by several other surveillance reports that antibacterial resistance is a rapidly growing threat to public health [6,7,9].

Mechanism of development of antibiotic resistance in bacteria

A bacterium undergoes massive selection pressure due to the excessive use of antibiotics on it. The genetically adopted bacterium continues to reproduce and survive in presence of antibiotic and transfers resistance to its following generations. The antibiotic slowly becomes ineffective towards these resistant bacteria [10]. There are specific targeted molecular structures in the bacterial cell, which are attacked by the antibiotics. In case of spontaneous mutation, the antibiotic fails to locate these targets, hence the bacterium develops resistance. Further, the antibiotic gets thrown out of the bacteria cell in a process called efflux mechanism. Hence, the antibiotic loses its potentiality. Other processes such as horizontal transfer of resistance genes from one bacterium to other in nature are a common mechanism of transferring antibiotic resistant genes (ARG) [11]. Accumulation of free DNA containing resistant genes into the bacterial genome can also take place in the natural environment. Short fragmented DNA plasmids can also be transferred from cell to cell. Bacteriophage (bacterial virus) also acts as vectors in transferring resistant genes. Thus, the spread of resistant bacteria can further spread the resistant gene to other bacteria rapidly in nature [1,2,12].

Role of aquatic ecosystem in spread of ARB and risk factors

The aquatic ecosystem plays a major role in the contamination and spread of ARB and ARG. Water acts as the most important mode for bacterial propagation and distribution of antibiotic resistance between man and environment. For the evolution antibacterial resistance, urban water system, animal husbandry operations and pharmaceutical industry effluents are considered as the major hotspots [1,2,4,13]. The process of controlled and engineered water cycle which is operated in a local environment otherwise known as ‘urban cycle' is performed in two stages. Firstly, the abstraction of surface water and groundwater for consumption and secondly, the treatment and disinfection of sewage before it's discharged into the environment. This serves as a path for the transfer of antibiotic resistance from the environment to human and back to the environment, as a large number of resistant bacteria enter the sewage through faeces, which is further carried into water bodies. Resistant bacteria and other pathogens in wastewater remain in close contact with sewage sludge bacteria and other microorganisms during biological treatment at wastewater treatment plants, where the horizontal transfer resistant genes takes place [14]. Therefore, wastewater treatment plant becomes a hub of gene transfer and evolution of ARB. Resistant bacteria can also reach the groundwater in an agricultural field due to manure spreading and animal grazing. New forms of resistance can be acquired by the bacterial strains in these environments. Pathogens that last longer and are dispersed in the environment causes greater hazard than those which can also be transmitted from one person to another. The spread of these resistant bacteria in the environment initiates poses a serious threat to the public health [14,15].

Role of biocides in evolution of ARB

Along with antibiotics, disinfectants, heavy metals and biocides even at low concentration plays an important role in the development of resistant bacteria. The sublethal concentration of herbicides increases the expression of efflux pumps in certain bacteria and accelerates the elimination of toxic substance. By this mechanism, the induction of higher levels of antibiotics resistance of bacteria can take place. Therefore, control measures must be taken in the release of such substances into the environment [3].

Control measures

It is always advisable to treat the heavily contaminated wastewater (e.g. hospital wastes, industrial wastes, etc) separately, where municipal or other downstream waste management is not mixed. Scientific disposal methods should be followed for effective and complete removal of microorganisms and other contamination [16]. The industry and health care centres must review is water treatment policy and should try actively to avoid resistance factor to come in contact with humans and animals. Measures must be taken to avoid contamination of supply water which is used for household and recreational purposes. In order to control the growth and spread of resistance, it would be advisable to build barriers and protection wherever possible by maintaining proper hygiene, clean environmental conditions and elimination of pathogen concern. The combination of measures such as ozonation or activated carbon treatment in combination with Ultra-filtration can reduce micro pollutants along with bacterial cell counts [17,18]. Research is still under process to select the most suitable method for elimination of ARBs and ARGs. In many developed countries, there are microbiological safety regulations and monitoring programs which constantly evaluate the risks from the antibiotic-resistant pathogen in the environment [6,7]. In other developing countries, initial steps are being taken for the improvements in waste disposal, sanitation process and scientific treatment of wastewater [17,18].

Conclusion

Preventive measures must be taken to reduce the spread of antibiotic resistance, by reducing water pollution and by judicious use of antibiotics. Several approaches have been implemented, worldwide to reduce the spread of ARB in aquatic ecosystems. Risks to human well-being and animals brought by pollution of natural habitats are likely to be among the most convincing arguments for the preservation of Earth's ecosystems. Therefore, it is important to increase the awareness of antibiotic resistance by disseminating this information throughout the world.

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Conflict of Interests

The authors declare that there have no conflicts of interest.

References

1 Andremont A, Walsh TR (2015) The role of sanitation in the development and spread of antimicrobial resistance. AMR Control, pp: 68-73.

2 Chen Z, Yu D, He S, Ye H, Zhang L, et al. (2017) Prevalence of antibiotic-resistant *Escherichia coli* in drinking water sources in Hangzhou city. Fron Microbiol 16: 1133.

3 Marti E, Variatza E, Balcazar JL (2014) The role of aquatic ecosystems as reservoirs of antibiotic resistance. Water Sci Technol 22: 36-41.

4 Suzuki S, Pruden A, Virta M, Zhang T (2017) Editorial: Antibiotic resistance in aquatic systems. Front Microbiol 8: 14.

5 Rath S, Padhy RN (2014) Prevalence of community and hospital-acquired multidrug-resistant *Klebsiella oxytoca* and *Klebsiella pneumoniae* in an Indian tertiary care hospital. J Infec Publ Health 7: 496-507.

6 Shah AS, Karuranratne A, Sakhaya G, Barreto I, Khare S, et al. (2017) Strengthening laboratory surveillance of antimicrobial resistance in South East Asia. BMJ 358: j3474.

7 Kinh NV, Wertheim HFL, Thwaites GE, Khue LN, Thai CH, et al. (2017) Developing an antimicrobial resistance reference laboratory and surveillance programme in Vietnam. Lancet Global Health 5: e1186-e1187.

8 Rath S, Dubey D, Sahu MC, Padhy RN (2014) Surveillance of ESBL producing multidrug resistant *Escherichia coli* in a teaching hospital in India. Asian Pacif J Trop Dis 4: 140-149.

9 Rath S, Padhy RN (2015) Prevalence of fluoroquinolone resistance in *Escherichia coli* in an Indian teaching hospital and adjoining communities. J Taibah Univ Med Sci 10: 504-508.

10 Thomas CM, Nielsen KM (2005) Mechanisms of, and barriers to, horizontal gene transfer between bacteria. Nat Rev Microbiol 3: 711-721.

11 Blair JMA, Webber MA, Baylay AJ, Ogbolu DA, Piddock LJ (2015) Molecular mechanisms of antibiotic resistance. Nat Rev Microbiol 13: 42-51.

12 Munita JM, Arias CA (2016) Mechanisms of antibiotic resistance. Microbiol Spectr 4.

13 Biyela PT, Lin J, Bezuidenhout CC (2004) The role of aquatic ecosystems as reservoirs of antibiotic resistant bacteria and antibiotic resistance genes. Water Sci Technol 50: 45-50.

14 Bouki C, Venieri D, Diamadopoulos E (2013) Detection and the fate of antibiotic-resistant bacteria in wastewater treatment plants: a review. Ecotoxicol Environ Saf 91: 1-9.

15 Karkman A, Do TT, Walsh F, Virta MPJ (2017) Antibiotic-resistance genes in wastewater. Trends Microbiol.

16 Port JA, Cullen AC, Wallace JC, Smith MN, Faustman EM (2014) Metagenomic frameworks for monitoring antibiotic resistance in aquatic environments. Environ Health Perspect 122: 222-228.

17 Zhuang Y, Ren H, Geng J, Zhang Y, Zhang Y, et al. (2015) Inactivation of antibiotic-resistance genes in municipal wastewater by chlorination, ultraviolet, and ozonation disinfection. Environ Sci Pollut Res Int 22: 7037-7044.

18 Li N, Shen GP, Lu YZ, Zeng RJ, Yu HQ (2017) Removal of antibiotic resistance genes from wastewater treatment plant effluent by coagulation. Water Res 111: 2014-212.