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Review

Antibiotics in the aquatic environment of Vietnam: Sources, concentrations, risk and control strategy

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HIGHLIGHTS

- Review of all sources of antibiotics discharged to the aquatic environment in Vietnam.
- Both input and output (residues in the environment) of each source were reviewed.
- Pharmaceutical manufacturing could be an important source of antibiotics in open waters.
- Lack of wastewater treatment system in Vietnam may increase the emergence antibiotic resistance.
- Government should pay more attention to controlling discharges of antibiotics to the environment.

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ABSTRACT

The presence of antibiotics in the aquatic environment is a serious concern because it may lead to the emergence of antibiotic resistance, thus lowering the therapeutic effect of antibiotics. In Vietnam, the problem is aggravated by the irrational use of antibiotics in different sectors of agriculture and human health service. Moreover, the residues of antibiotics in the aquatic environment can be spread widely due to the lack of proper wastewater treatment systems. In this paper, we aim to comprehensively review all relevant sources that discharge antibiotics to the aquatic environment in Vietnam. Apart from the common source of antibiotics from aquaculture, other activities that release considerable amounts of antibiotics into water environment are also included. Environmental concentrations of antibiotics related to those sources are studied to demonstrate their contributions to the presence of antibiotics in the aquatic environment in Vietnam. As antibiotic-contained water may be used as water supply for irrigation and even human consumption in rural areas, the essence of wastewater treatment is highlighted. Finally, we also discuss the new National Action plan from the Ministry of Health for controlling the issue of antibiotic resistance in Vietnam.

Contents

List of abbreviation: AZI, azithromycin; CEF, ceftazidime; CLA, clarithromycin; CIP, ciprofloxacin; DOX, Doxycycline; ENR, enrofloxacin; ERY, erythromycin; LIN, lincomycin; LOM, lomefloxacin; NOR, norfloxacin; OFX, ofloxacin; OTC, oxytetracycline; ROXI, roxithromycin; SDX, sulfadimethoxine; SDZ, sulfadiazine; SMR, sulfamerazine; SMT, sulfamethazine; SMX, sulfamethoxazole; SMZ, sulfamethizole; SND, sulfanilamide; SPI, spiramycin; SPY, sulfapyridine; STZ, sulfathiazole; TC, tetracycline; TRI, trimethoprim.

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1. Introduction

Antibiotics are effective medication for the treatment of infectious diseases in human and animals. Additionally, antibiotics can also be used as preventative medicine and more and more commonly as growth promoters in farming and husbandry (McEwen and Fedorka-Cray, 2002; Van Boeckel et al., 2015). The production and use of antibiotics for human and animals have resulted in significant reduction of mortality and morbidity rates, which were once inflicted by common infectious diseases. But the mass production and consumption of antibiotics also led to the situation that antibiotics are now ubiquitous in the environment (Kümmerer, 2009a). Antibiotics have been detected in aquatic environments such as lakes, rivers, water reservoirs, wastewater influents and effluents, groundwater and even drinking water even though drinking water was treated (Kolpin et al., 2004; Valcárcel et al., 2013; Sui et al., 2015). The most remarkable potential consequence of environmental antibiotics is the emergence of antibiotic resistance even at low antibiotic concentration (Kümmerer, 2009b; Gullberg et al., 2011). Therefore, antibiotics are considered emerging environmental pollutants of substantial consequence (Sui et al., 2015).

Antibiotics in environmental water originated from various sources: municipal (hospital and municipal sewage including a large part from household use and disposal) (Bound and Voulvoulis, 2005; Tong et al., 2011), agriculture (aquaculture, husbandry) (Hirsch et al., 1999; Lin et al., 2008), and pharmaceutical industry (Phillips et al., 2010). The degree of contribution of each source is different from country to country. For example, the veterinary contribution in Germany was minor while human contribution is a major source (Hirsch et al., 1999). Meanwhile in Taiwan, husbandries, hospitals and pharmaceutical manufacturers were the dominant sources of antibiotics in comparison to aquaculture and effluent of sewage treatment plants (Lin et al., 2008).

Vietnam's economy has been growing and so as the production and consumption of antibiotics, for both humans and livestock (Sy et al., 2017). Consequently, more antibiotic residues are expected to be discharged into the environment. However, information on the profile of antibiotics in aquatic environment on Vietnam was limited although the number of antibiotic groups and the quantity of antibiotics are considerably larger than other neighboring countries, including Indonesia and China (Andrieu et al., 2015). There are previous reviews on antibiotics in aquatic environment in Vietnam (Thuy et al., 2011; Sebesvari et al., 2012; Suzuki and Hoa, 2012; Thuy and Nguyen, 2013). However, they were focused mainly on the antibiotics discharged from aquaculture practice and did not look into the input side of the industries. Hence it does not provide enough information to understand all the potential sources of antibiotic contamination in aquatic environment in Vietnam. Apart from aquaculture, there are consumptions and discharges of antibiotics from other farming sectors (Dang et al., 2011; Kim et al., 2013), hospitals (Duong et al., 2008; Lien et al., 2016) and pharmaceutical manufacturer industry (Cardoso et al., 2014; Larsson, 2014; Binh et al., 2017) that could contribute substantially to the load of antibiotics measured in the aquatic environment of Vietnam (see Fig. 1) but so far they were not discussed in details in previous reviews.

This review thus aims to provide a more comprehensive picture on the introduction of antibiotics in environmental waters in Vietnam from different sources (aquaculture, husbandry, hospital, and pharmaceutical manufacturer industry) in order to understand the profile of antibiotics in the aquatic environment and to provide the basis for any policy to control the antibiotic pollution in Vietnam.

2. Search approach

The relevant publications for this comprehensive review were collected by searching in the Web of Science database for published papers in all years using following key words: “antibiotic”, “water”, and “Vietnam”. The outcome was then screened using the title. This screening resulted in 34 peer-reviewed publications in English. Additionally, we also searched for relevant documents in Vietnamese including Government reports and guidelines on the topic of antibiotic residues and resistance. The documents in Vietnamese are the basis for our discussion on control strategy in Vietnam.

Our review covered 6 classes of antibiotics including beta-lactams, sulfonamides, macrolides, cyclines, lincosamides, quinolones with all potential sources, the first comprehensive review of this kind for Vietnam. A summary of the antibiotics found in the