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Antibiotic residues from aquaculture farms and their ecological risks in Southeast Asia: a case study from Malaysia

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ABSTRACT

Background and Objectives: One major source of antibiotic contamination in the sea is from aquaculture. We monitored the concentration of commonly used antibiotic classes and antibiotic resistance genes (*tet*(M), *sul1, sul2* and *sul3*) in aquaculture farms in Peninsular Malaysia.
Methods: Antibiotic residues and resistance genes were quantified using high-performance liquid chromatography and real-time PCR respectively. Risk quotients in European technical guidance document on risk assessment was used to assess the potential environmental risk.
Results: We detected 23 antibiotics with tetracyclines, sulfonamides and quinolones were the most frequently detected classes, indicating a wide distribution of antibiotics in Malaysian aquaculture farms. The dendrogram and heatmap revealed three groups of antibiotic concentration patterns but with no differences in the types of antibiotics usage among aquaculture farms. The ARGs (10^{-3} copies/16S) were detected in >90% of the sites except for *sul3*. Ciprofloxacin, enrofloxacin, norfloxacin and lincomycin posed risks to cyanobacteria and algae in Kelantan, Perak and Pahang.
Conclusion: Relative to Asian aquaculture farms, the residues detected here were at low or moderate levels except for quinolones. This study will be useful to develop effective management of aquaculture wastewater in order to mitigate antibiotic pollution and transmission of ARGs to humans through the food chain.

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Introduction

Aquaculture plays an important role as a main source of animal protein in global diets (FAO 2016; Mohd et al. 2017; Department of Fisheries (DOF) 2019). In order to meet the demand of the world's growing population and to achieve sustainable food production and security, aquaculture production will have to be increased by an additional 46.4 million metric tons by 2030 (World Bank 2013). Asia is referred to as "home of aquaculture," accounting for about 89% of global production in 2016 (FAO 2020). In terms of aquaculture production, Malaysia is ranked 15th in the world and 6th in Asia with an estimated production of 427,022.66 metric tonnes worth USD 731.81 million (FAO 2016; Dermawan 2019). In many Southeast Asia countries, aquaculture production has contributed significantly to their national economies [Gross Domestic Product (GDP), 0.2-5% increase]. Therefore, aquaculture industry has been recognized as a potential pillar to strengthen economic growth (Lundgren et al. 2006; SEAFDEC 2017).

However, one of the major threats to the aquaculture industry worldwide is bacterial infection. More than USD 6 billion per annum is lost from the aquaculture industry due to disease (Stentiford et al. 2017). Both extensive and intensive aquaculture farming have greatly enhanced the transmission opportunities for waterborne pathogens that can spread at faster rates compared with terrestrial systems (McCallum, Harvell, and Dobson 2003). For example, *Vibrio parahaemolyticus*, the causative agent of acute hepatopancreatic necrosis disease (AHPND) and formerly known as early mortality syndrome (EMS) causes devastating losses that reached billions of dollars annually since its first outbreak in Southern China in 2009 (Lightner et al. 2012a, 2012b; Tran et al. 2013). This disease is rapidly spreading and has affected several countries in Southeast Asia consecutively, e.g., Vietnam in the year 2010, Malaysia (2011), Thailand (2012), Philippines (2013), and has even spread to the Americas e.g., Mexico in 2013 (Tran et al. 2013; Nunan et al. 2014; De La Peña et al. 2015).

In order to treat and prevent bacterial diseases in aquaculture, antibiotics are commonly used as therapeutic and/or prophylactic agents. Tetracyclines, sulfonamides, oxolinic acid and erythromycin are commonly

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This article has been corrected with minor changes. These changes do not impact the academic content of the article.
Supplemental data for this article can be accessed here.