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Antibiotics in water and sediments of rivers and coastal area of Zhuhai City, Pearl River estuary, south China

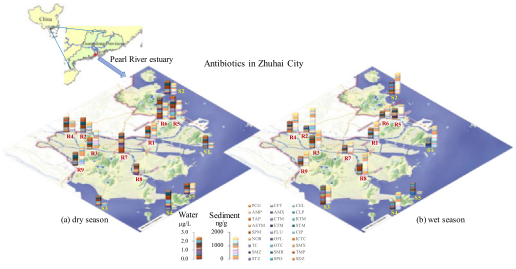
Si Li [a,b], Wanzi Shi [c], Huimin Li [a], Nan Xu [c], Ruijie Zhang [a], Xuejiao Chen [c], Weiling Sun [a,c,*], Donghui Wen [a], Shanliang He [d], Jianguo Pan [d], Zhidong He [d], Yingying Fan [d]

[a] College of Environmental Sciences and Engineering, Peking University, The Key Laboratory of Water and Sediment Sciences, Ministry of Education, Beijing 100871, China
[b] Xiamen Urban Water Environmental Eco-Planning and Remediation Engineering Research Center, Xiamen 361021, China
[c] Shenzhen Key Laboratory for Heavy Metal Pollution Control and Reutilization, School of Environment and Energy, Peking University Shenzhen Graduate School, Shenzhen 518055, China
[d] Zhuhai Environmental Protection Monitoring Station, Zhuhai 519000, Guangdong, China

HIGHLIGHTS

- 27 antibiotics were monitored in water and sediments from Zhuhai City.
- Quinolones and aminoglycosides were dominant antibiotics in water and sediments.
- Antibiotics levels in river water were significantly higher in dry season.
- Higher concentrations of antibiotics in coastal sediments were found in wet season.
- Anhydroerythromycin and clarithromycin posed the main ecological risk.

GRAPHICAL ABSTRACT



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ABSTRACT

The occurrence, spatiotemporal distribution and ecological risks of 27 antibiotics in water and sediments from rivers and coastal area of Zhuhai, Pearl River estuary, south China were investigated. Higher concentrations of antibiotics were found in river water in dry season than those in wet season ($p < 0.01$), especially for quinolones (QNs) (6.36–463 ng/L) and aminoglycosides (AGs) (94.9–458 ng/L). In coastal water samples, the concentrations of antibiotics were up to 419 ng/L and 357 ng/L in dry season and wet season, respectively. Higher concentrations of antibiotics in coastal sediment samples were observed in wet season compared with those in dry season ($p < 0.01$). This may be ascribed to the greater discharge of antibiotics from mariculture and surface sediment flushing in wet season, leading to the accumulation of polluted sediments in the estuary. Redundancy analysis showed that the concentrations of antibiotics in water were correlated with biological/chemical oxygen demand, ammonia nitrogen, and/or total nitrogen (TN). In addition, sediment organic matter (SOC) and TN strongly affected the distribution of antibiotics in sediments. Ecological risk assessment based on risk quotients (RQs) indicated that most antibiotics in water samples posed insignificant risk to fish and green algae, and insignificant to medium risk to daphnid.

1. Introduction

In the past several decades, antibiotics have received increasing attention worldwide due to their widespread occurrence in the environment (Kümmerer, 2009; Li et al., 2018) and their potential harmful

* Corresponding author at: College of Environmental Sciences and Engineering, Peking University, The Key Laboratory of Water and Sediment Sciences, Ministry of Education, Beijing 100871, China.
E-mail address: wlsun@pku.edu.cn (W. Sun).

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effects on ecosystem and human health (Ding et al., 2017; Li et al., 2018). Antibiotics have been extensively used to prevent and treat bacterial infections in human and animals, and/or as growth promoters in animal agriculture and aquaculture industry (Kümmerer, 2009; Zhang et al., 2015). Approximately 10%–90% of the administered antibiotics may be excreted as unchanged active compounds (Kümmerer, 2009), and then enter into receiving surface and coastal waters, sediments, and soils (Li et al., 2018; Zhou et al., 2011). The accumulation of the antibiotic residues in the environment can cause direct toxicity to plants (Brain et al., 2004) and animals (Kim et al., 2007). More importantly, the widespread occurrence of antibiotics threatens the aquatic ecosystem and human health due to the potential dissemination of antibiotic resistance (Sharma et al., 2016).

China is the largest producer and consumer of antibiotics in the world (Zhang et al., 2015), with annual production of 248 million kg and usage of 162 million kg in 2013 (Zhang et al., 2015). Therefore, the emission, presence, and potential risks of antibiotics in China raised serious concern. Extensive studies have been done recently to investigate the occurrence of antibiotics in different environmental compartments across China, including wastewater (Chang et al., 2010; Liu et al., 2009), surface water (Cheng et al., 2014; Li et al., 2014; Luo et al., 2011), groundwater (Hu et al., 2010), coastal water (Chen et al., 2015; Na et al., 2013), and sediments (Liang et al., 2013a; Xu et al., 2014), with concentrations mostly at ng/L level in waters and ng/g level in sediments (Bu et al., 2013; Li et al., 2018).

The Pearl River Delta (PRD) is one of the most economically developed regions in China and it showed the highest emission density of antibiotics (79.3–109 kg/km^2·year) among the 58 river basins in China (Zhang et al., 2015). PRD is also one of the most developed aquaculture regions in China (Chen et al., 2017; He et al., 2012). The aquaculture production in Guangdong Province located in the Pearl River basin reached an output of 6.68 billion kg/year (Liu et al., 2017). As a result, numerous antibiotics such as sulfonamides (SAs), quinolones (QNs), tetracyclines (TCs), macrolides (MLs), and amphenicols (APs) have been detected in water and sediment samples from the mainstream and tributaries of Pearl River (Xu et al., 2007; Yang et al., 2010; Yang et al., 2013; Zhang et al., 2012), Pearl River estuary (Liang et al., 2013a; Xu et al., 2013), and mariculture sites in PRD (Chen et al., 2017; He et al., 2012).

Zhuhai City is one of the earliest four Special Economic Zones in China, which located at the southwest bank of the Pearl River estuary in Guangdong Province facing the South China Sea (Fig. 1). This city covers a land area of 1732 km^2 and a sea area of 6135 km^2, with >1.67 million residents. The pig population was 0.82 million, while the total production from freshwater aquaculture and mariculture in Zhuhai City reached 205.6 million kg and 80.9 million kg, respectively, in 2016 (Report, 2016). The extensive and abnormal use of antibiotics in animal agriculture and fish farming in Zhuhai City greatly increases the antibiotic burden in the surface and coastal waters and sediments (Chen et al., 2017; Zhang et al., 2015). However, concentration profiles and distribution patterns of antibiotics in water and sediments of rivers and coastal area across Zhuhai City is still unknown.

This study focused on the occurrence, spatiotemporal variation, distribution, and ecological hazards of antibiotics in water and sediments from the rivers and coastal area of Zhuhai City, Pearl River estuary, south China. In total, 27 widely used antibiotics from seven groups including SAs, QNs, TCs, MLs, APs, β-lactams (β-Ls), and aminoglycosides

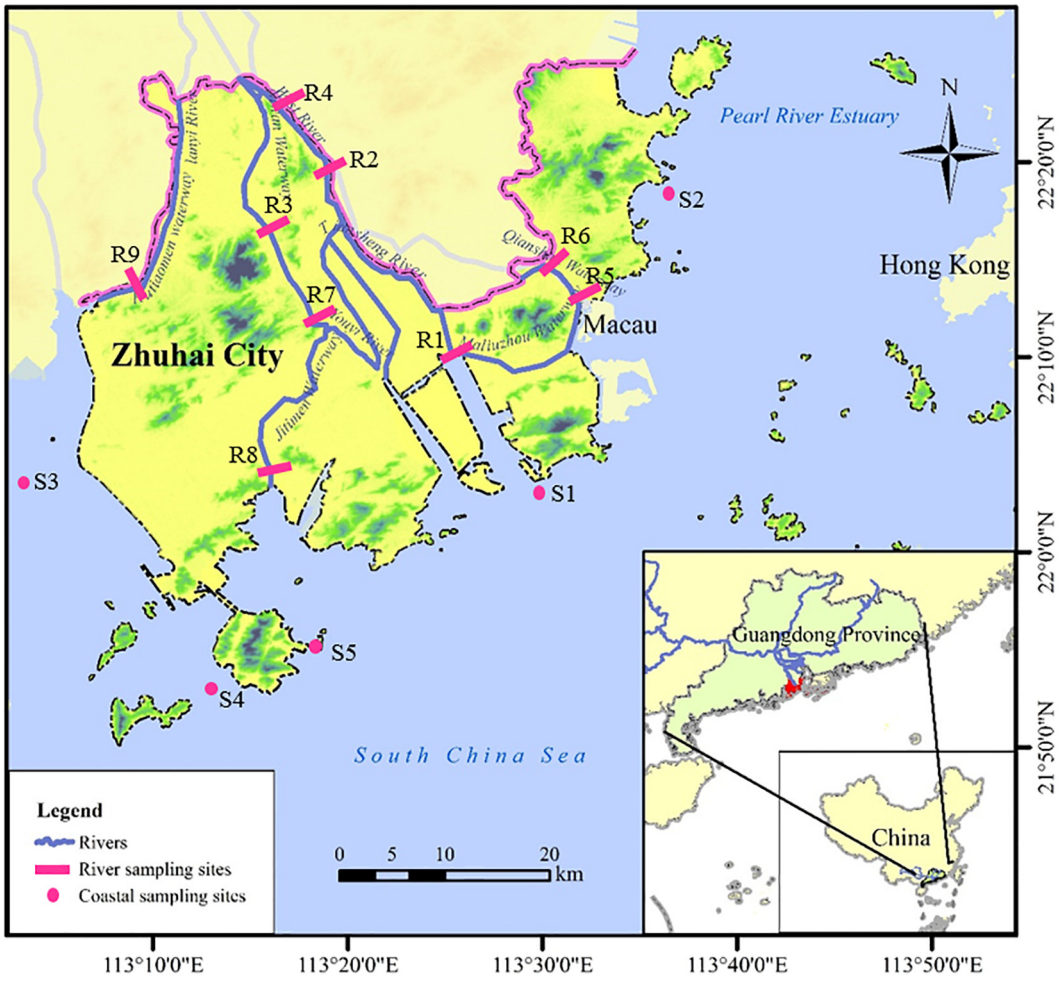

Fig. 1. Location of sampling sites in rivers and coastal area of Zhuhai City.