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Baseline

Spatial and seasonal characteristics of dissolved heavy metals in the east and west Guangdong coastal waters, South China

Ling Zhang^a, Zhen Shi^b, JingPing Zhang^a, Zhijian Jiang^a, Fei Wang^c, Xiaoping Huang^{a,*}^a CAS Key Laboratory of Tropical Marine Bio-resources and Ecology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China^b State Key Laboratory of Tropical Oceanography, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China^c State Key laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China

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ABSTRACT

Heavy metal concentrations and physicochemical parameters in seawater were measured in Guangdong coastal waters, South China. Results showed that the concentrations and distribution of heavy metals varied spatially and seasonally. Generally, heavy metal concentrations in the east regions were higher than in the west. Concentrations of Pb, Zn, Cd and Cr in wet seasons were generally higher than in dry seasons owing to the seasonal differences of the river discharge, rainfall and seawater intrusion. Principal component (PC) analysis showed that PC1, PC2 and PC3 in the east were correlated to Pb + Cr + Zn + Cd, As + Cd and Cu, respectively, and they were correlated to Pb + Cr, Zn + Cu + Cd and As + Cu, respectively, in the west. That was maybe due to the differences of local heavy metal sources. The anthropogenic activities contributed more to the main sources of heavy metals, and contamination factors indicated that Zn and Pb pollution was serious in study area.

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Escalating human populations and economic development have significantly contributed to the current worldwide deterioration in water quality, including accumulation of heavy metals in the aquatic environment (Pertsemli and Voutsas, 2007; Krishna et al., 2009; Li and Zhang, 2010; Varol, 2013). Heavy metals are non-biodegradable, tending to rapidly accumulate in the environment and are able to reach toxic levels in short period, but, their removal is rather difficult and sometimes impossible. Nowadays, heavy metals originating from human activities are frequently detected in sediments and water column (Sun et al., 2010; Huang et al., 2012). In the aquatic environments, heavy metals are derived from a variety of natural and anthropogenic sources, such as atmospheric deposition, geologic weathering, agricultural activities, residential and industrial products (Soriano et al., 2012; Wang et al., 2012a; Li et al., 2013). Anthropogenic activities, particularly electroplating, mining and mineral processing etc. have been greatly influencing the local and global geochemical cycles of heavy metals (Jiann and Wen, 2009; Dou et al., 2013), which has attracted more and more public concerns in recent decades (Beltrame et al., 2009; Varol, 2011; Gao and Li, 2012).

With rapid urbanization and industrialization, coastal areas in China are now facing great challenges in regard to heavy metal contamination (Ip et al., 2007; Sun et al., 2009; Wang et al., 2012a). Guangdong Province (GD) is adjacent to the South China Sea with the longest coastline of 3.37×10^6 m in China, which displays from north-east to south-west and there are more than ten important industrial cities along the coastline. As one of the most developed industrial areas in China and the manufacturing base in the world, GD coastal regions have been exposed for several decades to a high human pressure as a result of high population and industrial densities and intensive agricultural activities. Large amounts of pollutants (nutrients, toxic metals and persistent organic pollutants) have been discharged into the coastal waters (Zhang et al., 2009; Yin et al., 2011; Wang et al., 2012a,b; Qiao et al., 2013). In combination with the long residence time of these pollutants, they present a preoccupying threat to the coastal ecosystem. Among the various contaminants, heavy metals are of particular concern due to their environmental persistence, biogeochemical recycling and ecological risks. The Pearl River Estuary (PRE) was the largest estuary in GD with abundant studies (Ip et al., 2007; Chen et al., 2012; Zhang et al., 2013). There were also some other researches in coastal waters in GD (Zhang et al., 2011; Wang et al., 2013; Xu et al., 2014). However, previous studies mainly focused on the sediments, or the work was carried out in limited waters. That was to say, the research work about dissolved

* Corresponding author.

E-mail address: xphuag@scsio.ac.cn (X. Huang).

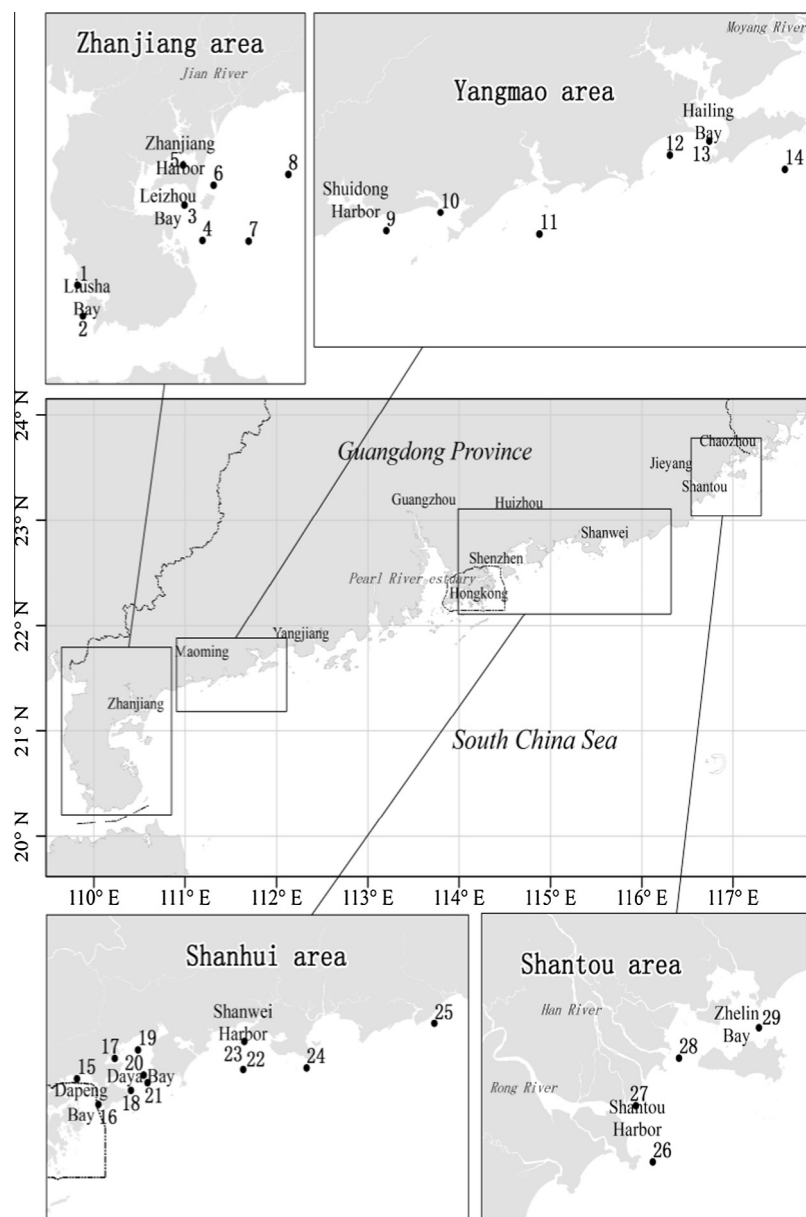


Fig. 1. Map showing the Guangdong coastal regions and the study areas with sampling sites.

heavy metals were still very scarce in the east and west GD coastal regions, which are significant as the important supporting-area to the Pearl River Delta. More importantly, with the call for sustainable development and marine environmental conservation, it is of great significance in the present day to speed up the comprehensive understanding of the whole coastal regions in GD. Therefore, an integrated research about the heavy metals in this area would be a reference and the base for further study. For this purpose, in this work, 29 sites were selected and 108 surface seawater samples were collected in four seasons during 2006–2007 in GD coastal waters (divided into the east and west regions excluding the PRE). At the same time, dissolved heavy metal concentrations (Cu, Pb, Zn, Cr, Cd and As) and the physicochemical parameters in seawater were measured. The objectives of this study are (1) to investigate the spatial and seasonal variations of dissolved heavy metal distribution in the east and west GD coastal waters; (2) to discuss the possible sources of heavy metals and to assess the metal contamination in seawater. To our knowledge, there was no integrated research like our study about the dissolved

heavy metals in GD coastal waters. This research will help to establish the scientific data set for the study of the ecological and environmental quality in this significant subtropical coastal area.

In this work, the study area is mainly divided into four parts from the east to the west along the GD coastline, including Shantou area, Shanhui area (the East GD coastal waters), Yangmao area and Zhanjiang area (the West GD coastal waters, Fig. 1). The seawater samples in the east were mainly collected in Zhelin Bay, Shantou Harbor, Shanwei Harbor, Daya Bay, Dapeng Bay and their adjacent waters. The samples in the west were collected from Hailing Bay, Shuidong Harbor, Zhanjiang Harbor, Leizhou Harbor, Lusha Bay and their adjacent waters. Sampling was carried out in spring (April), summer (July), autumn (November) and winter (December). Water samples were collected using a 5-L Niskin bottles from 0.5 m below the surface at each site. 100 ml seawater for total organic carbon (TOC) analysis was transferred to a glass bottle previously washed with HNO_3 . The water samples for metal and nutrient determination were filtered immediately through 0.45 μm pore glass fiber filter (GF/F, Whatman),

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