Marine Pollution Bulletin 117 (2017) 499–506

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Baseline

Assessment of nutrient and heavy metal contamination in the seawater and sediment of Yalujiang Estuary

Hongjun Li [a], Lin Lin [b], Sheng Ye [a], Hongbo Li [a], Jingfeng Fan [a,*]

[a] Marine Ecology Department, National Marine Environmental Monitoring Center, Dalian 116023, China
[b] Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

ARTICLE INFO

Article history:
Received 9 November 2016
Received in revised form 21 January 2017
Accepted 27 January 2017
Available online 6 February 2017

Keywords:
Yalujiang Estuary
Nutrient
Heavy metal
Seawater
Sediment

ABSTRACT

Yalujiang River is a famous border river between China and North Korea. In this study, 22 sample sites (seawater and sediments) were investigated to determine the concentrations of nutrients (dissolved inorganic nitrogen and soluble reactive phosphorus) and trace elements (Hg, As, Pb, Cu, Cd, Cr, and Zn) during the flood season (August). Generally, the concentration of nutrients were higher in the entrance of the estuary than that in the downstream region and the trophic index ranged from moderate to high production, indicating a potential eutrophication risk. With the exception of Cd, the mean concentrations of most metals attained the first level of seawater quality. Sediment pollution assessment was undertaken using contamination factor (*CF*) and geoaccumulation index (I_{geo}). The *CF* values of the seven trace elements were in the following order: Cd > Hg > Pb > As > Cu > Zn > Cr. Both *CF* and I_{geo} values indicated the elevated Cd and Hg concentrations in the region. Cluster analysis indicated that the sources of Cu, Cd, Cr, and Zn were mainly derived from copper mine and coastal industrial effluents, whereas Pb, Hg, and As were mainly from vehicle emissions and oil combustion. This study could provide a basis for the sustainable management of the marine ecosystem in this region.

As the confluence area of land runoff and seawater, an estuary transports terrestrial matter to the sea. With the rapid economic development of coastal, estuaries receive substantial amounts of anthropogenic inputs from both point and non-point upstream sources of pollution from industrialization and urbanization activities, and ecological problems have become severe as a result. Consequently, the estuarine ecosystem is one of the most heavily used and globally threatened natural systems (Lotze et al., 2006; Liu et al., 2016a, b). Estuaries often act as nurseries to numerous forms of aquatic life; thus, estuaries are important to aquaculture and fisheries. The intertidal areas of estuaries attract a variety of birds, and these zones are often globally important sites for migratory species. Thus, assessing the contamination in estuaries and its biological influence is crucial.

Heavy metal pollution in the marine environment has received global attention because of the ubiquity, difficult degradation, and easy accumulation of heavy metal pollutants. In estuarine and coastal regions, sediments have been regarded as both carriers and sinks of various contaminants originating from industrial and agricultural processes (Gan et al., 2013; Yang et al., 2012), As a result, sediment contamination is recognized as a major source of marine ecosystem health stress (Chapman and Wang, 2001). Sediments release more heavy metals into the seawater when local environmental conditions (e.g., salinity, pH, and redox potential) change (Valdés et al., 2005; Hill et al., 2013). Consequently, the transfer of metals from sediment to water columns and the subsequent bioaccumulation along the food chain are detrimental to the marine environment and public health (Pan and Wang, 2012; Zhang et al., 2012).

Yalujiang Estuary is located in the Northern Yellow Sea, Liaoning Province, China. This estuary is known for being the boundary river between China and North Korea. Yalujiang River originates from Tianchi Lake in Changbaishan Mountain and flows a distance of approximately 790 km from northeast to southwest through Jilin Province and Liaoning Province. This river supplies the most important sources of drinking water for the surrounding cities. With the rapid urbanization and industrialization in recent years, Yalujiang River suffers from industrial, agricultural, and domestic pollution, which results in potential ecological risks (Gao et al., 2008). Some industrial enterprises (e.g., automobile, papermaking, printing, and textile) are concentrated in the cities of Dandong and Donggang. Substantial amounts of industrial effluents have been taken to the sea by the river, particularly during the flood season. The average water discharge is 3.02×10^8 m^3/a, of which 70%–80% occurs during the flood season. However, only few pollution investigations have been conducted in Yalujiang Estuary (Wu et al., 2003; Gao et al., 2008; Cheng et al., 2011); as a result, the understanding of the influence of human activities on the marine ecosystem in this region is limited. In the current study, the spatial distribution of heavy metals during the flood season in Yalujiang Estuary is determined, and the

* Corresponding author.
E-mail address: jffan@nmemc.org.cn (J. Fan).

http://dx.doi.org/10.1016/j.marpolbul.2017.01.069
0025-326X/

sources of these pollutants are identified to provide basic information for future pollution monitoring and environmental management.

Seawater and sediment samples for metal analysis were collected from 22 sites in Yalujiang Estuary during the flood season (August 2016) (Fig. 1). The surface seawater samples were collected from 0.5 m below the surface at each site with 5 L Niskin bottles. The surface sediment samples (top 5 cm of the surface) were obtained using a van Veen collector (0.05 m^2). The bulk sediment samples were divided into three subsamples for the determinations of trace metals, total organic carbon (TOC), and grain size. The seawater salinity and temperature were measured in situ with a multiparameter sensor (YSI6600), and the pH values were determined with a pH meter. The seawater for dissolved oxygen (DO) analysis was collected with a tube reaching the bottom of the bottle until the water overflowed. Suspended particulate material samples were filtered through pre-weighted Whatman GF/F fiber filters (25 mm). The samples for metal determination were immediately filtered through Whatman GF/F fiber filters (0.45 mm), acidified with 10% HNO_3, placed in an icebox, and then transported to the laboratory.

The concentrations of NO_3, NO_2, NH_4, and PO_4 in seawater were determined following to the methods described by Grasshoff et al. (1983). DO was determined using the Winkler titration method. Chlorophyll-*a* (Chl*a*) was determined by filtering 100–200 mL of seawater through a GF/F fiber filter with a cascading filtering device under a low vacuum pressure. After extraction with 90% acetone, Chl*a* was determined using a Turner Designs fluorometer (TD Trilogy). The concentrations of the dissolved heavy metals were determined by inductively coupled plasma mass spectrometry (ICP-MS, Thermo X series) for Cd, Pb, Zn, Cu, and Cr, whereas the contents of Hg and As were determined using an atomic fluorescence spectrometer (AFS-920).

The grain sizes of the sediment samples were determined using a Mastersizer 2000 laser particle size analyzer (Malvern, UK). The samples were divided into four fractions according to particle size: clay (<2 μM), silt (2–40 μM), fine sand (40–200 μM), and coarse sand

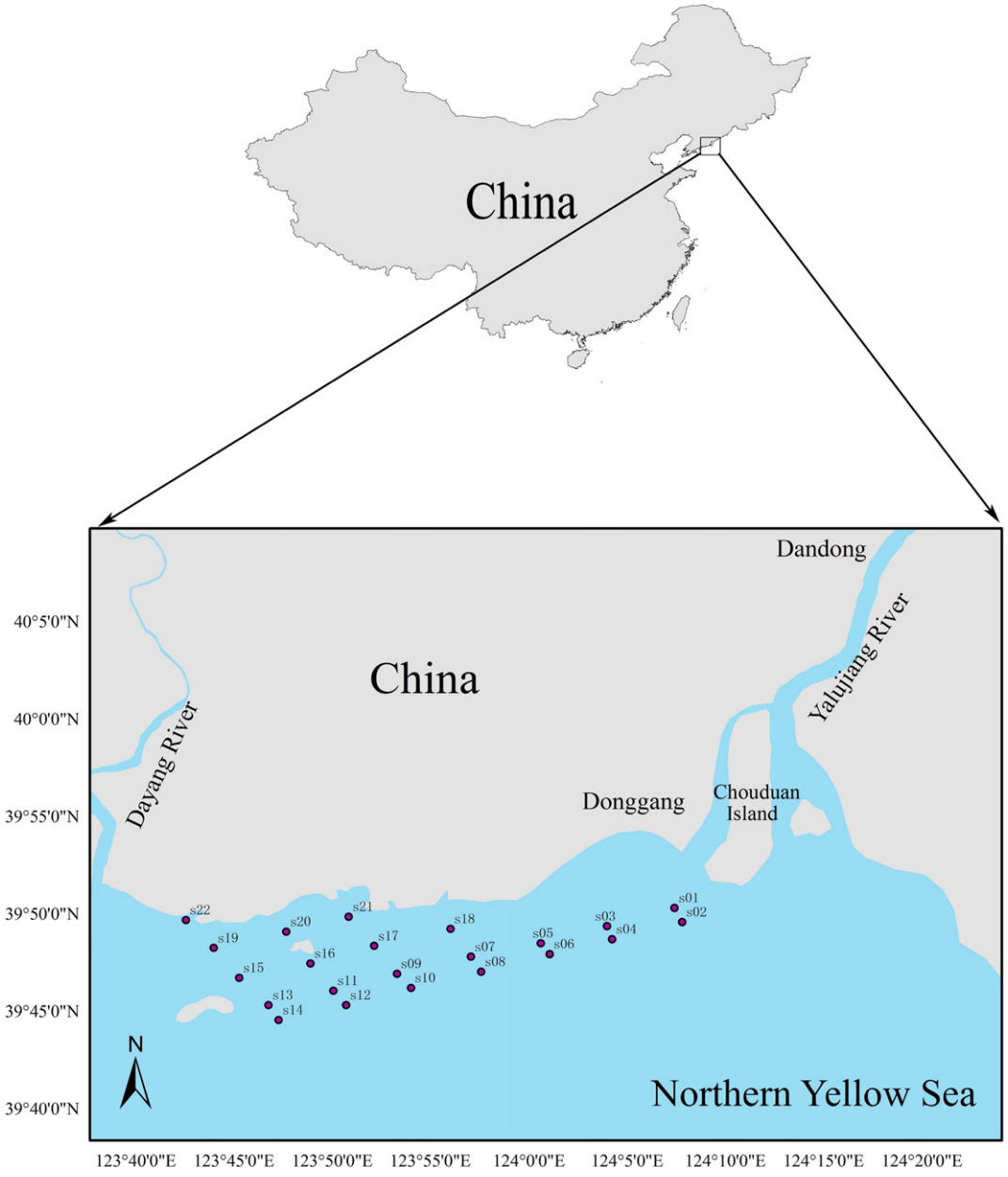

Fig. 1. Location map of sample sites in Yalujiang Estuary.