



Baseline

Heavy metal pollution and Pb isotopic tracing in the intertidal surface sediments of Quanzhou Bay, southeast coast of China



Ruilian Yu ^{a,*}, Weifang Zhang ^a, Gongren Hu ^{a,b}, Chengqi Lin ^a, Qiuli Yang ^a

^a Department of Environmental Science and Engineering, Huaqiao University, Xiamen, China

^b State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang, china

ARTICLE INFO

Article history:

Received 9 October 2015

Received in revised form 27 January 2016

Accepted 28 January 2016

Available online 2 February 2016

Keywords:

Heavy metal

Surface sediment

Pollution evaluation

Pb isotopic tracing

Quanzhou Bay

ABSTRACT

Concentrations of 16 heavy metals and Pb isotopic ratios in the intertidal surface sediments of Quanzhou Bay were determined to study the pollution level of heavy metals and the sources of Pb. The results showed that most concentrations of Cd, Sn, Mn, Cu, Zn, Cr, Pb, Hg, Ni, Co, Cs, Fe and V were higher than the background values, while most concentrations of Ti, Sb and Sr were lower than the background values. The mean concentrations of Cu, Zn, Pb, Cr and Cd exceeded the first-grade criteria of Chinese marine sediment quality. The geo-accumulation indexes revealed that the sediments had been polluted by some heavy metals. The results of Pb isotopic tracing indicated that the total Pb in the sediments were mainly from parent material, industrial emission and vehicle exhaust with the mean contributions of 38.2%, 51.3% and 10.5%, respectively, calculated by a three-end-member model of Pb isotopic ratios.

© 2016 Elsevier Ltd. All rights reserved.

With the rapid economic development and population growth, a large amount of industrial, agricultural wastewater and sewage has been discharged into various water bodies such as lakes, rivers and oceans, resulting in deterioration of the water environment (Mulligan et al., 2001). Among the substantial pollutants, heavy metals have been paid much attention due to their toxicity, non-biodegradation, persistence and bioaccumulation. Most heavy metals will rapidly deposit into sediment after being discharged into a body of water, and may release again to the water owing to the variation of environmental conditions such as the physical, chemical, biological processes and human activities (Beck et al., 2013). Therefore, sediment is the sink and the second source of heavy metals in water body. Pollution of heavy metals in sediment is a great risk for human health and has increasingly received public attention (Li et al., 2012).

It is essential to determine the source of pollution for investigating and mitigating the pollution. Isotopic measurement is superior to using pollutant concentration alone in tracing pollutant sources because isotope ratios are significantly more sensitive tracers than elemental concentrations (Aggarwal et al., 2008; Cheng and Hu, 2010). The analysis of Pb isotopic ratios has been proved a powerful tool for identifying Pb pollution sources and assessing the relative contributions (Balcaen et al., 2010; Chiaradia et al., 1997; Michael et al., 2008). There are four naturally stable isotopes of Pb: ²⁰⁴Pb, ²⁰⁶Pb, ²⁰⁷Pb and ²⁰⁸Pb. Among them, ²⁰⁴Pb is the only non-radiogenic with a constant abundance, while the other three isotopes are derived from the

radioactive decay of ²³⁸U to ²⁰⁶Pb (decay half-time of the parent isotope $t_{1/2} = 4.468 \times 10^9$ years), ²³⁵U to ²⁰⁷Pb ($t_{1/2} = 0.704 \times 10^9$ years) and ²³²Th to ²⁰⁸Pb ($t_{1/2} = 1.401 \times 10^{10}$ years) (Álvarez-Iglesias et al., 2012; Cheng and Hu, 2010; Larsen et al., 2012; Townsend and Seen, 2012). Pb isotopic fractionation does not occur in industrial and environmental processes, in other words, industrial and environmental processes hardly change the isotopic composition of Pb after it is released into the environment from the original ore (Cheng and Hu, 2010). Materials from different sources possess different radiogenic Pb isotopes, hence the radiogenic Pb isotope ratios can be used as a fingerprint to trace the different sources of Pb in the given environment (Ip et al., 2007; Li et al., 2012; Sun et al., 2011).

As the famous starting place of the Maritime Silk Road in ancient China, Quanzhou Bay is located in the southeast of Fujian province and to the west of Taiwan Straits. It is a semi-enclosed bay with its mouth opening towards the Taiwan Straits, with a greatest water depth of 25 m, a mouth width of 8.9 km, a total area of 136.42 km² and an intertidal area of 89.80 km² (Yu et al., 2008). The bay is adjacent to some intensely industrialized cities such as Quanzhou city, Jinjiang city, Shishi city and Hui'an county. There are two considerable rivers entering into the bay, namely Jinjiang River and Luoyang River. The intertidal zone of Quanzhou Bay has been polluted by heavy metals due to the rapid development of industry, agriculture, mining and aquatic breeding in the surrounding regions (Yu et al., 2008). In recent years, there have been several studies on heavy metal pollution in the sediments of Quanzhou Bay. These previous studies mainly focused on the distribution, pollution assessment and chemical speciation of heavy metals in sediments (Hu et al., 2013; Li et al., 2010; Yu et al.,

* Corresponding author.

2008, 2010). However, the source analysis of heavy metals in the sediments of Quanzhou Bay has seldom been reported to date. How to identify the sources of pollutants is an important issue in controlling the environment pollution. The aims of this study were to investigate the level of 16 heavy metals (Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Cd, Pb, Fe, Cs, Sb, Sn, Sr and Hg) in the intertidal surface sediments of Quanzhou Bay, to evaluate the pollution degree of heavy metals using geo-accumulation index method, and to discuss Pb sources based on the Pb isotopic tracing technology.

In December 2011, 41 surface sediments (0–5 cm) were collected in the intertidal zone of Quanzhou Bay (Fig. 1). The sampled sediments were stored in clean sealed plastic bags and kept frozen at $-20\text{ }^{\circ}\text{C}$ prior to pretreatment. In the laboratory, the sediment samples were defrosted and air-dried in a clean environment. When the sediments were semi-dry, a clean glass bottle was used to crush the sediments. Then, the sediment samples were put into an oven and dried at $35 \pm 2\text{ }^{\circ}\text{C}$ to a constant weight. The dry sediment samples were ground with an agate pestle and mortar, then sieved with a $63\text{ }\mu\text{m}$ nylon sieve. The samples under the sieve ($<63\text{ }\mu\text{m}$) were kept in sealed plastic vessels at $4\text{ }^{\circ}\text{C}$ for further analysis (Horowitz and Elrick, 1987).

For each sediment sample, 0.1000 g dry sediment was put into a 50-mL Teflon vessel with 6 mL HNO_3 , 2 mL HCl, 2 mL H_2O_2 , and 1 mL HF, digested at $180\text{ }^{\circ}\text{C}$ in a closed system for 12 h. After digestion, the completely dissolved sample was diluted with deionized water to 100 mL for further analysis. For each batch of digestion procedure, a reagent blank and a sediment reference material, GBW07314, issued by the State Oceanographic Administration of China, were processed with the same digestion procedure.

Concentrations of Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Cd, Pb, Fe, Cs, Sb, Sn and Sr in the digestion solutions were determined by inductively coupled plasma-mass spectrometry (ICP-MS) (ELAN9000, Perkin-Elmer, USA) with the detection limits of $0.001\text{--}0.098\text{ }\mu\text{g L}^{-1}$, while Hg was determined with an automatic mercury analyzer RA-3 (NIC, Japan) with the detection limit of $0.009\text{ }\mu\text{g L}^{-1}$. Background correction and matrix interference were monitored throughout the analyses. All the solutions were analyzed in triplicates. The analytical precisions were better than 10%. The analytical results of the measured metals showed a good agreement between the reference and the analytical values for the reference material GBW07314 with the recovery range of 87%–106%.

The analysis of Pb isotopic composition was conducted in the clean laboratory of Beijing Research Institute of Uranium Geology. Sample preparation including sample digestion, separation and purification was processed according to the analytical procedures of Chinese geological mineral industry standard DZ/T 0184.12-1997. Pb isotopic composition was determined by thermal ionization mass spectrometry (VG354, VG Instruments, UK). The reference material (NBS981, National Bureau of Standards, USA) was used for the quality control in the analysis process of Pb isotopic ratios. The $^{208}\text{Pb}/^{206}\text{Pb}$, $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{207}\text{Pb}/^{204}\text{Pb}$ of the reference material NBS981 were 2.1681 ± 0.0008 , 0.91462 ± 0.00037 and 15.4910 ± 0.0064 , respectively. In this study, 28 sediment samples were measured for Pb isotopic ratios with the relative standard deviations of less than 0.05%. The Pb isotopic compositions of local potential-source samples including parent materials, industrial emissions (industrial sludge in this study), coal and vehicle exhaust were cited from Hu et al. (2013).

Guaranteed reagents were used in the concentration determination of heavy metals, and MOS reagents were used in the analysis of Pb isotopic ratios. Normal precautions for the analyses were observed throughout. Double deionized water from a MILLI-Q system was used for preparing the solutions and dilutions. All the glassware and the Teflon vessels used in the study were previously soaked overnight with 20% HNO_3 and then rinsed thoroughly with deionized water. The data were processed using Excel 2007 and Origin 8.0 software packages. ArcGIS 10.2 was used to draw the map of sampling sites.

As shown in Table 1, the concentrations of heavy metals in the intertidal surface sediments of Quanzhou Bay were different at distinct sampling sites that might be attributed to the possible pollution source inputs. The concentration ranges of Ti, V, Cr, Mn, Co, Ni, Cu, Zn, Cd, Pb, Fe, Cs, Sb, Sn, Sr and Hg were 2005–4860, 62.96–100.80, 52.76–165.9, 697–1857, 9.44–15.04, 16.22–45.72, 24.82–160.6, 120.4–324.5, 0.280–1.155, 37.03–93.19, 33,200–42,561, 5.81–9.82, 0.308–1.930, 7.39–25.91, 30.76–185.2 and $0.107\text{--}0.350\text{ mg kg}^{-1}$, respectively, with the mean concentrations of 3431, 83.75, 84.72, 1295, 11.93, 26.77, 60.81, 186.7, 0.639, 66.98, 38,455, 7.37, 0.886, 12.59, 88.53 and 0.107 mg kg^{-1} , respectively. It should be noted that 100% samples for Cr, Mn, Cu, Zn, Cd, Sn and Hg, 97.6% samples for Co, Pb and Fe, 95.1% samples for Ni, 85.4% samples for Cs, 73.2% samples for V, 31.7% samples for Sb, 12.2% samples for Ti and 2.4% samples for Sr exceeded the background values. The mean concentrations of Cd, Sn, Mn, Cu, Zn, Cr, Pb, Hg, Ni, Co, Cs, Fe

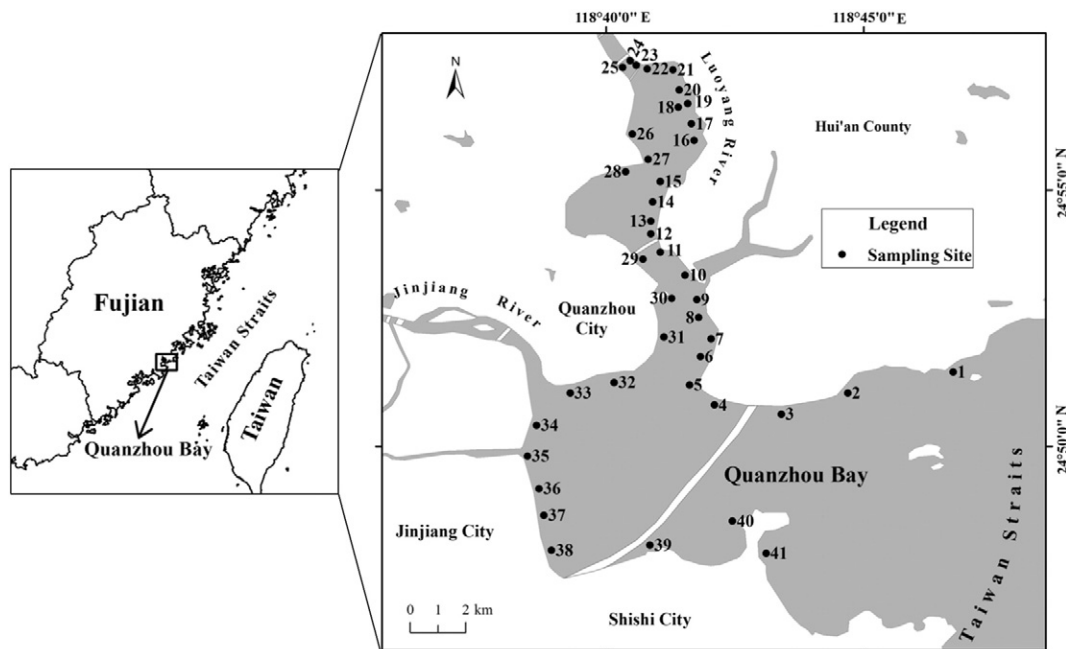


Fig. 1. Map of sampling sites.

Download English Version:

<https://daneshyari.com/en/article/4476558>

Download Persian Version:

<https://daneshyari.com/article/4476558>

[Daneshyari.com](https://daneshyari.com)