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Baseline

Intensive anthropogenic activities had affected Daya Bay in South China Sea since the 1980s: Evidence from heavy metal contaminations

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ABSTRACT

Sediment geochemical characteristics were analyzed to assess how anthropogenic activities affected the Daya Bay, a subtropics bay adjacent to the most economically developed region of China. Vertical profiles of heavy metal contents and their enrichment factors indicated the development of Daya Bay environment in the past 100 years basically experienced three stages, which were closely consistent with the economic development. Before 1980s, the concentration of heavy metals was basically at the background level. Contamination of metals, particularly for Cr, Ni, Cu, Zn, Cd, and Pb, generally began in mid-1980s and became serious in 2000s. However, after late-2000s, the sediment quality had been radically improved. Heavy metals in nearshore sediment of Daya Bay were all closely related with import of anthropogenic and/or terrestrial material, whereas those in offshore were likely to be related with joint influence from the anthropogenic activities and the natural processes.

With rapid development of industrialization and urbanization since the Chinese economic reform, a series of environmental changes, such as water pollution, eutrophication, ecological function degradation, and ecosystem unbalance have gradually emerged in the coastal sea. Significantly, heavy metals have become an important environmental hazard for invertebrates, fish, and human, because they are continuously to be discharged into estuarine and coastal area through rivers runoff and land-based point sources. Some regions in nearshore estuaries, bays, and shallows of China are suffering from various degrees of environmental risks from heavy metal contamination (Dai et al., 2007; Fang et al., 2016; Gao et al., 2014; Hu et al., 2015; Wang et al., 2010; Wang et al., 2016, 2017). Daya Bay is one of the largest bay in northeastern Southern China Sea (SCS) (113°30′-114°50′ E, 23°31′-24°50′ N). It is not only a multi-type ecosystem that has coral reefs, mangroves and rock reefs, but a good place for the reproducing and culturing of fish, shrimp, crabs and shellfish (Y.S. Wang et al., 2008). Before, 1980s, there was just few residents settled around Daya Bay and its vicinity, and factory was also quite scarce there. However, rapid expansion of aquacultural, industrial and agricultural activities have occurred around this region since late-1970s and early-1980s, following with thriving developments of tourism and construction of harbors. What's more, two nuclear power stations, the Daya Bay nuclear power station and the Lingao nuclear power station, which came into operation in 1994 and 2002 respectively, are situated at its western coast.

Due to the persistent toxic and long-term accumulation effects, heavy metal pollution status and their potential ecological effect in Daya Bay are highly concerned by researchers. In general, hydrologic conditions and anthropogenic inputs were jointly responsible for the contents of heavy metals in surface sediment of its coastal regions (Yu et al., 2015). And most heavy metals in surface sediment of Daya Bay generally had no risk or low risk, because of their high percentages in residual fraction, except Cd and Pb (Gao et al., 2010). Nevertheless, contamination of particular metals, such as Mn, and Zn, has occurred locally over the past 30 years in Daya Bay, basing on their records in corals (Chen et al., 2010). Although geochemical characters of heavy metal in sediment of Daya Bay had been studied in recent two decades, the research was basically confined to the overall pollutant level and/or the speciation characters of sediment in surface. The understanding about heavy metals in a long period is quite limited (Du et al., 2008). What's more, heavy metals in marine sediment could serve as a reliable record of environmental changes and anthropogenic activities (Yu et al., 2015). In this article, the biogeochemical status and sediment history of eight heavy metals, including Vanadium (V), Chromium (Cr), Manganese (Mn), Nickel (Ni), Cupper (Cu), Zinc (Zn), Cadmium (Cd),

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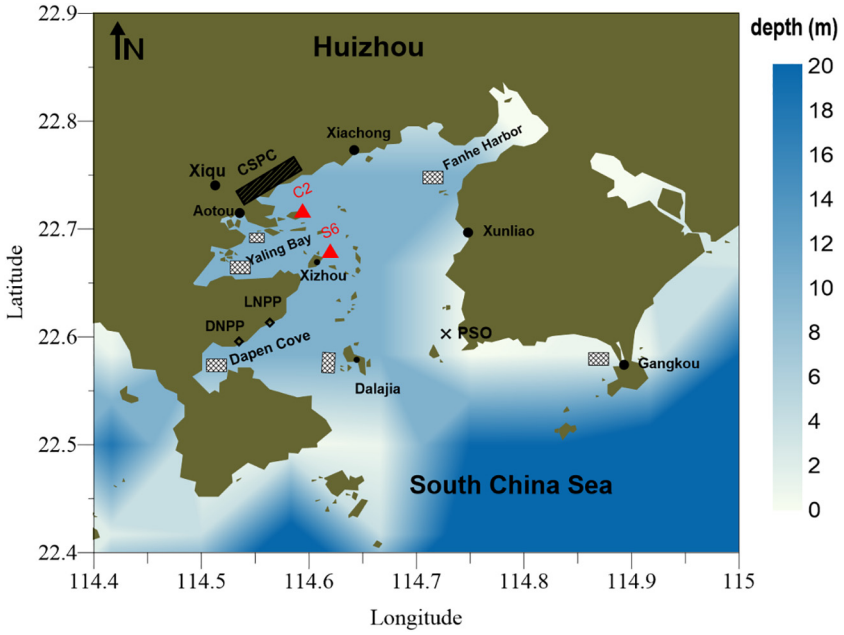

Fig. 1. Geographical conditions and administrative division of Daya Bay. Core sediment was collected at station C2 and S6. The black rectangle stands for the industry park of China National Offshore Oil Corporation and Shell petrochemical company limited (CSPC), and the black cross stands for the Petrochemical Sewage Outlet (PSO) of CSPC. Gray dashed rectangles stands for the aquaculture regions. DNPP and LNPP are the abbreviation of Daya Bay Nuclear Power Plant and Lingao Nuclear Power Plant.

Table 1
Certified values of the certified reference materials (GBW07429 and GBW07309) and the relevant measured values in this study.

μg/g	GBW07429		GBW07309	
	Certified	Determined	Certified	Determined
V	119 ± 3	119	97 ± 6	98
Cr	87 ± 4	81.5	85 ± 7	80.4
Mn	963 ± 20	837	620 ± 20	570
Ni	41 ± 1	42	32 ± 2	33
Cu	37 ± 2	33	32 ± 2	31
Zn	94 ± 4	93	78 ± 4	77
Pb	38 ± 2	38	23 ± 3	23

and Lead (Pb) in two sediment cores of Daya Bay were present. Together with ^{210}Pb chronology information, total organic carbon (TOC) contents, δ^{13}C results, and metal enrichment factor (EF), we tried to obtain the historical variation trends of these heavy metals during the last 100 years, and distinguished their various sources, assessed their environmental risks, and discussed the potential influence of anthropogenic activities on Daya Bay's ecological environment.

The sediment sample was collected at the end of July 2015 by a gravity corer in the station of C2 and S6 (Fig. 1). The C2 station was located in the northwestern of Daya Bay with water depth of 4.4 m, and adjacent to the coastal of Huizhou-Daya Bay Economic and Technological Development Zone. The S6 station was located in the central part of the bay with water depth 8.7 m. It was close to the aquaculture region of the bay. So, the two sampling station generally could represented the most obviously anthropogenic influenced region of Daya Bay.

Once the core sediment was sampled we immediately subsectioned it in intervals of 1–2 cm with careful and all samples were stored in dark

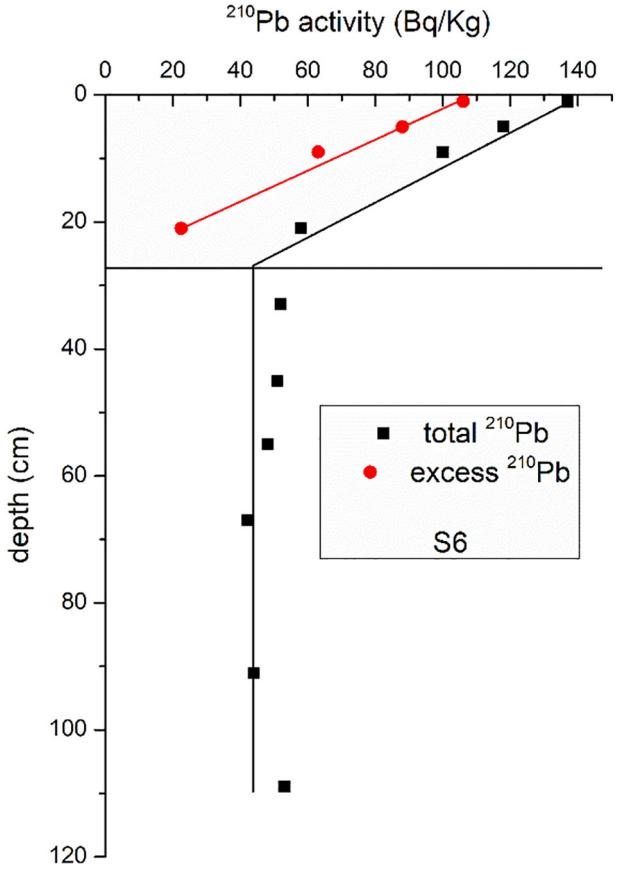

Fig. 2. Depth profiles of ^{210}Pb activity in the sediment core of S6.