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Seasonal bioconcentration of heavy metals in *Onchidium struma* (Gastropoda: Pulmonata) from Chongming Island, the Yangtze Estuary, China

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Abstract

The seasonal concentration changes of selected heavy metal Cd, Cr, Cu, Fe, Mn, Pb, and Zn in five tissues of marine gastropod *Onchidium struma* were studied in the Chongming Island, the Yangtze Estuary in April 2007, July 2006, September 2006, and November 2006, respectively. The results demonstrated that the bioconcentration factor of Cu (biomass/water) in all selected tissues was about 10^4 magnitudes, Fe and Cd were 10^3, Zn was 10^2, and Mn, Pb, and Cr were 10^1. Hepatopancreas was proven to be the dominant storage tissue of Cr, Cu, Mn, and Zn, whereas Fe and Pb were mainly stored in muscle and digenetic gland, and Cd was stored in vitelline gland and albumen gland. Additionally, it was found that Cu, Fe, Mn, and Zn were concentrated significantly by *O. struma* (whole-body) in summer or autumn, and Cd, Cr, and Pb increased slightly in spring and winter. Furthermore, the bioconcentration of Cr was nearly 2-fold higher and Zn was 1.6-fold higher in the water compared with the Water Quality Standard for Fisheries. With view of excessive amount of Pb, Cd, and Cu according to seafood standard, the consumption of *O. struma* might have the risk of health hazard.

Key words: *Onchidium struma*; heavy metal; bioconcentration; the Yangtze Estuary

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Introduction

Anthropogenic pollutants have contaminated many ecosystems, such as sea, estuaries, and rivers (Campbell and Evans, 1991; Blais and Kalff, 1993). Heavy metals are now recognized to be among the most relevant contaminants in the marine environment and their concentrations are elevating in some coastal waters (Ober *et al*., 1987; Schuhmacher *et al*., 1990; García *et al*., 2001). Since aquatic organisms living in polluted ecosystems often bioconcentrate metals into their tissues, it has been argued widely that these organisms can be used as biomonitors indicating the bioavailability of contaminants and the degree of pollution (Luten *et al*., 1986; López-Artiguez *et al*., 1989; Peerzada and Kozlik, 1992; Schuhmacher, 1996). With a wide geographical distribution, high abundance in the benthic environment, selective absorption of certain ions and sedentary nature, mollusks are considered suitable as biomonitors (Sawidis *et al*., 1995; Blackmore, 1999; Blackmore and Wang, 2003). Mollusks, therefore, are used in monitoring heavy metals and other pollutants in the estuarine waters and other marine environments (Bryan *et al*., 1980, 1985; Sally and Bobby, 1996).

Onchidium (Gastropoda: Pulmonata) is one of the most widespread mollusks across semitropical coast, especially throughout the Indo-Pacific estuaries. Previous studies on *Onchidium* have been mostly focused on hormonal control (Hanumante *et al*., 1979; Deshpande *et al*., 1980), metabolism regulation (Hanumante and Deshpande, 1980; Chew *et al*., 1999), and reproductive physiology (Deshpande and Nagabhushanam, 1983). As for *Onchidium struma*, reports have been mainly targeted on its ecological habit (Huang *et al*., 2004), embryonic and larval development (Wang *et al*., 2005), as well as reproductive system and gonadal development (Wang *et al*., 2006). However, few studies report the bioconcentration of heavy metals in *Onchidium* (*Onchidium struma*) and their toxic effects. Marine gastropod *O. struma*, used in this study, was collected from Chongming Island. And the selected sampling site is located in the northern branch of the Yangtze Estuary, which is potentially new water resource for the regions nearby especially for Shanghai. So the bioconcentration of heavy metals in this area is of great importance to its water quality as well as to the exploitation and development in those regions nearby (Lim *et al*., 1996). Furthermore, it was found that the abundance of *O. struma* in this area was higher than other areas in the Chongming Island. Additionally, *O. struma* is being consumed by local people and potentially cultured in a large-scale in this area (Huang *et al*., 2004). Moreover, it feeds on the humus of sediments in the estuary where various pollutants are enriched heavily.

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Hence, the consumption of *O. struma* probably constitutes a health hazard. Levels of heavy metals in the water and sediments as well as bioconcentration in *O. struma* from the Chongming Island are of profound interest not only because they can be used to document those geographic areas where metal pollution might be problematic, but also because they may transfer potential health hazards to consumers.

Numerous surveys for metal concentrations in the Yangtze Estuary have been undertaken in recent years (Zhang, 1999; Lin *et al.*, 2002; Feng *et al.*, 2004; Qiao *et al.*, 2007; Quan *et al.*, 2007). It should be taken into account that differences in the size, age, genetic difference, gonadal maturation, individual variability in metal uptake, induction of metal-binding proteins, sampling season and so on. These factors may also influence the results (Lytle and Lytle, 1990; Páez-Osuna and Marmolejo-Rivas, 1990). Therefore, differences coming from metal category (essential or non-essential), seasonal physicochemical conditions (water temperature, pH, salinity, and dissolved oxygen), species speciality (hibernation), individual parameters (body weight and length), population density, and tissue-specificity were taken into consideration in this study. Furthermore, by detecting the metal concentrations (Cd, Cr, Cu, Fe, Mn, Pb, and Zn) in the water, sediments and tissues of *O. struma* seasonally, this study will provide basic information on heavy metal bioavailability in the marine water, sediments and mollusk within selected territory to evaluate metal pollution and ecosystem quality together with providing references for the large-scale culture of *O. struma* in this area.

1 Materials and methods

1.1 Sample collection

Marine gastropod *O. struma* was collected from Beibao Harbor (Station O, Fig. 1) of Chongming Island,

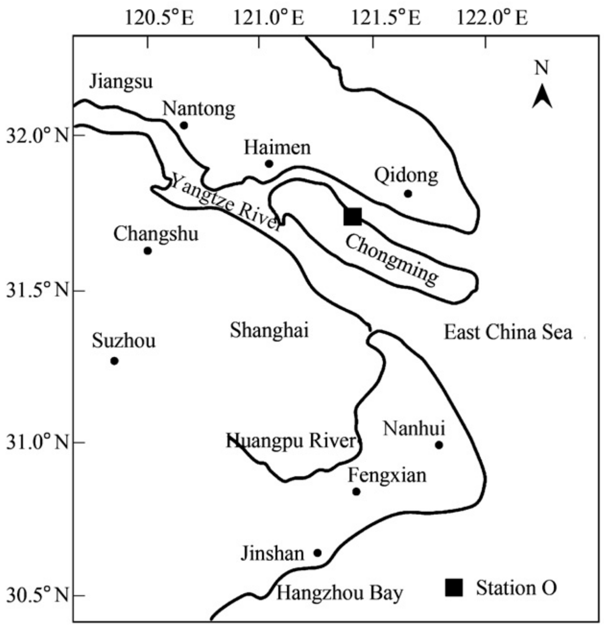

Fig. 1 Sampling location at Station O.

Shanghai, China (31°38′12.7″N, 121°41′03.4″E) in July 2006, September 2006, November 2006, and April 2007, respectively. Approximately 100 marine gastropods were collected from three sites (located in upper, middle, and low tidal flat respectively) in Station O and placed in polyethylene plastic barrels, ten of them were randomly selected at each site, dissected into hepatopancreas, muscle, albumen gland, vitelline gland and digenetic gland, and then kept frozen at –80°C after measuring the weight and length. Samples of water and sediments were also collected in the same time.

1.2 Sample treatment and analysis

Water and tissue treatment were carried out according to Water Quality-Determination of Selenium-Graphite Furnace Atomic Absorption Spectrometric Method (GB/T15505-1995), while sediment treatment was carried out according to Determination of Iron, Magnesium and Manganese in Foods (GB/T5009-1990). To determine the concentrations of heavy metals in the water, each 100 mL of water sample was acid-digested with 10 mL of 65% HNO_3 (analytical-reagent grade) and evaporated until the total volume reached to approximately 1 mL. Then the mixture was digested using 5 mL of diluted HNO_3 (1:49, *V/V*) for 12 h at room temperature. Five tissues including hepatopancreas, muscle, albumen gland, vitelline gland and digenetic gland of *O. struma* were analyzed to determine the concentrations of selected heavy metals. Tissular samples (1 g, wet weight) were heated at 100°C for 1.5 h to evaporate most water and improve the efficiency of the following steps (Tilstone and Macnair, 1997). Then all the samples were subjected to the carbolite at 700°C for 4 h until into ashes. The samples were then treated with 2 mL additional 65% HNO_3, digested for 12 h at room temperature. Approximately 1 g sediment (dry weight) was subjected to the carbolite at 700°C for 4 h into ashes. Charred sediment was treated with 5 mL mixed acid of HNO_3 and $HClO_4$ (analytical-reagent grade) with the ratio of 4:1 (*V/V*) and heated until completely bright. The dealt samples including water, tissues, and sediments were filtrated through microporus membrane of 220 nm in diameter and adjusted to 10 mL with Millipore ultrapure water.

Millipore ultrapure water was used as control for each method mentioned above. To avoid metal contamination, all glassware were cleaned with HNO_3 and rinsed with ultrapure water. The concentrations of heavy metals (Cd, Cr, Cu, Fe, Mn, Pb, and Zn) in the treated samples including water, sediments, tissues and control groups were determined in triplicate respectively by IRIS Intrepid II XSP Spectrometer (ICP, Thermo Electron Corporation, USA). Unit for metal concentrations in the water is expressed as μg/L. The data of organism are defined as μg/g wet weight while those of sediments described as μg/g dry weight.

1.3 Statistical analysis

Statistical analysis was performed with SPSS v.11.0 software (SPSS Inc., Illinois, USA). One-way ANOVA of variance with the 95% confidence interval followed