Coastal Marine Science 32(1): 127–130, 2008

Organotin Levels in Coastal Areas in Vietnam

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Received 16 March 2008; Accepted 7 May 2008

Abstract — The present status of levels of butyltin (BT) and phenyltin (PT) compounds in clam and sediment in Vietnam are overviewed. The levels of TBT in clams and sediments were within limits reported from other countries. Further, the TBT level in clams was lower than the tolerable average residue level (TARL) estimated based on tolerable daily intake (TDI). Trace amounts of PTs were also found in both clam and sediment samples. Of total BTs, TBT was the dominant species in clams from almost sites reported. The ratios of TBT in sediment tended to be higher among BT compounds. In spatial distribution, TPT showed a pattern similar to TBT, suggesting the use of TPT as an antifouling paint.

Key words: organotin compounds, TBT, TPT, clam, sediment, Vietnam

Introduction

The use of TBT as an antifouling agent has been regulated in several countries between 1980 and 1990. For example, in Hong Kong, a valid permit is required for the use and importation of all antifoulants containing TBT. In Japan, TBT is banned for all vessels. However, the use of TBT is still permitted in many Asian countries. Thus, several instances of OT contamination have been reported in various Asian countries. High concentrations of TBT in sediments, seawater, and biological samples have been detected in Malaysia (Tong et al. 1996), Thailand (Kan-Atireklap et al. 1997), Taiwan (Hung et al. 1998), and Korea (Shim et al. 1999). BTs were also detected in fish tissues and foodstuffs from several Asian and Oceanian countries (Kannan et al. 1995). Further examples of imposex have been found in three gastropods, *Thais kieneri*, *T. savignyi*, and *Vasum turbinellus*, in coastal areas of Ambon Island, Indonesia (Evans et al. 1995), in three species of *Thais* from Singapore (Tan 1997), and in *T. clavigera* from oyster marine culture areas in Taiwan (Hung et al. 2001). Further, higher OT levels have also been detected in Hong Kong and Japan, despite its regulation (Ko et al. 1995, Harino et al. 1998). These reports indicate widespread BTs contamination in Asian coastal areas.

Vietnam has a long coastline of 3,200 km between 8°34′N and 21°33′N, which contains about 125 large and small beaches (Fig. 1). Vietnam is composed of three parts, northern, central and southern Vietnam. Vietnam's ongoing economic liberalization has seen the rapid development of industry, and vigorous international trade, imposing a potential risk for OT contamination, which in turn could exert stress on the aquatic environment (Kannan et al. 1997). However in this area, a few studies have been conducted to determine the contamination level of OTs (Sudaryanto et al. 2000, 2002, Midorikawa et al. 2004a, b, Nhan et al. 2005). Therefore, it is important to assess the current status of OTs contamination

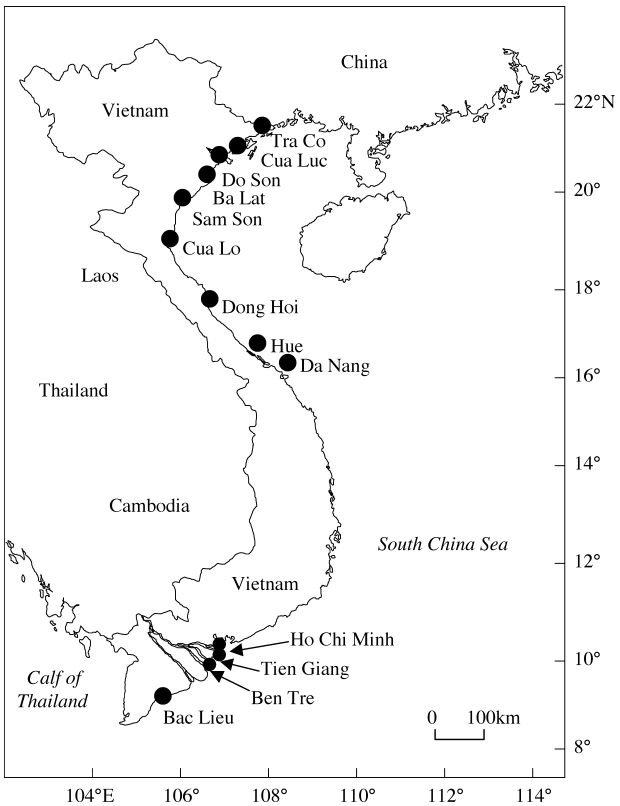

Fig. 1. Sampling sites of sediment and clam from coastal areas in Vietnam (Midorikawa et al. 2004a, b).

in Vietnam. In the paper, BT and PT in sediments and in clams (*Meretrix* spp.) from coastal areas in Vietnam were discussed to understand the present status for those chemicals.

Distribution of OTs in clams

Butyltin compounds were widely distributed along the Vietnamese coast (Fig. 2) (Midorikawa et al. 2004a, b). Concentrations of MBT, DBT, and TBT in clam *Meretrix* spp. were in the range of 0.1 to 44, 0.3 to 10, and 0.4 to 56 ng g^{-1} wet wt., respectively (Midorikawa et al. 2004a, b). Total butyltin (∑BTs) concentrations were in the range of 2.1–63 ng g^{-1} wet wt., these were much lower in clams from southern Vietnam at 2.9–17 ng g^{-1} wet wt. Sampling points in all 4 sites in southern Vietnam are around coastal aquaculture areas. No or slight input of TBT from aquaculture net might be supposed. The highest concentration of TBT was found in Cua Luc and the value was 47 ng g^{-1} wet wt. In all the other sites of Vietnam, concentrations of TBT were in the range of 0.41–6.8 ng g^{-1} wet wt. As to composition of butytin compounds, the highest ratio of MBT among butyltin derivatives was found in clams from Som Son, Dong Hoi, Da Nang, Tien Giang and Bac Lieu, while TBT was the highest ratio in the other sites. The ratio of TBT in clams from Cua Luc where the highest concentration was observed. Cua Luc is an industrial area with a big international trading port. Many vessels including large-hulled vessels from various countries therefore moor there. These findings suggest that a major source of TBT in Cua Luc was due to the antifouling paint leaching from these vessels. Concentrations of MBT were higher in Dong Hoi (29 ng g^{-1} wet wt.) and Da Nang (28 ng g^{-1} wet wt.), which are fishing port and international trading port area, respectively. In both Dong Hoi and Da Nang, the ratio of MBT was predominant among butyltin compounds.

Phenyltin compounds were also widely distributed in Vietnamese coast (Midorikawa et al. 2004a). Concentrations of MPT, DPT, and TPT in clams from all sampling sites were in the range of 0.2 to 11, <0.1 to 0.7, and <0.1 to 3.1 ng g^{-1} wet wt, respectively. Spatial of phenyltin compounds was similar to those of butyltin compounds. TPT level was the highest in Cua Luc. Higher level and higher ratio of MPT were found in Dong Hoi and Da Nang. This might suggest that the coastal marine environment in Dong Hoi and Da Nang had been contaminated by much TBT in the past. Phenyltin concentrations in most of the sampling sites were close to the detection limit. It is well known that TPT is more stable than TBT in biological samples (Fent and Hunn 1991). Nevertheless, the levels of TBT in clams were also higher than TPT levels, suggesting a greater TBT input to the aquatic environment in comparison with TPT.

Distribution of OTs in sediments

The highest levels of TBT in sediments from north and central Vietnam occurred at Hue (28 ng g^{-1} dry wt) (Midorikawa et al. 2004a) (Fig. 3). Hue is a trading port, in which many small vessels moor. Furthermore, this sampling site is in a zone of poor flushing. Subsequently, the concentrations of TBT in sediment were also high in Cua Luc (15 ng g^{-1} dry wt), despite good tidal flushing water. Cua Luc is an industrial area with a large international trading port, and provides mooring for many large foreign vessels. TBT were also high in Sam Son (6.3 ng g^{-1} dry wt) and Tra Co (5.5 ng g^{-1} dry wt), which are fishing ports in the zone of poor flush-

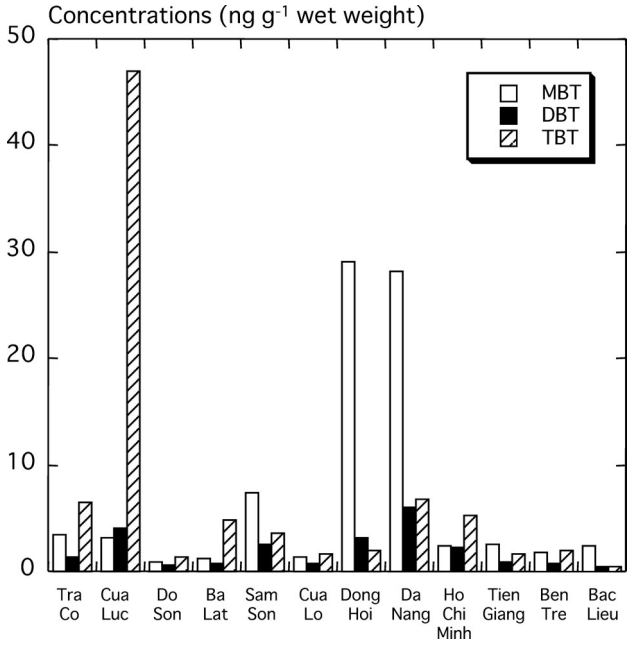

Fig. 2. Concentrations of butyltin compounds in clam samples *Meretrix* spp. from Vietnam (Midorikawa et al. 2004a, b).

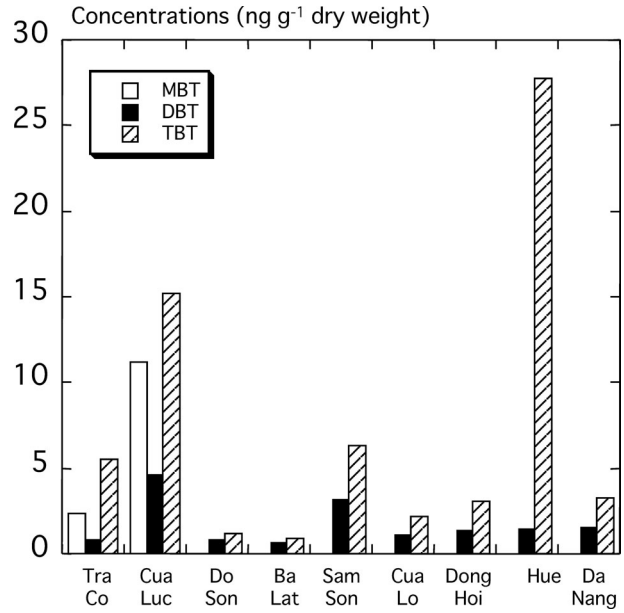

Fig. 3. Concentrations of butyltin compounds in sediments from Vietnam (Midorikawa et al. 2004a).

ing. Nhan et al. (2005) also reported that the concentrations of MBT, DBT and TBT in sediments from the seven sampling sites in Hai Phong, Da Nang and Ho Chi Minh cities ranged from 3.95 to 29.7 ng g^{-1} dry wt, from 8.13 to 42.7 ng g^{-1} dry wt, and from 8.25 to 50.5 ng g^{-1} dry wt respectively. The total concentrations of all BTs (∑BTs) in sediments from areas where shipyards or vessel repair facilities are located were always higher than those from the other facilities. Half-lives of TBT in sediment have been reported to be 4-5 months (Maguire and Tkacz 1985). Dowson et al. (1993) have reported that the half-lives of TBT ranged from 360–775 days in surface sediments. Furthermore, it has been reported that if TBT-based paint chip are present in sediment, these chips degrade more slowly than TBT adsorbed by sediment particles (Stang et al. 1992). Thus, since OT compounds are less likely to degrade in sediments, the sediments themselves may display a history of OT contamination in aquatic environments. The higher concentrations of TBT in sediment from fishing ports and trading ports such as Hue and Cua Luc indicate a continuous input of OTs in these areas. The concentrations of TPT as well as TBT were also high in sediment from Hue (0.36 ng g^{-1} dry wt), followed by Cua Luc (0.14 ng g^{-1} dry wt) and Sam Son (0.15 ng g^{-1} dry wt).

Higher percentages of TBT were observed (Midorikawa et al. 2004a), showing continuous input of TBT in these areas. Of the total PTs, MPT, which is a degradation product of TPT, was the predominant PT species at all sites.

TBT levels with TARL

The clam (*Meretrix* spp.) is an important food source in the Vietnamese diet. Therefore, the presence of BT in clams may pose a health risk to humans. A tolerable daily intake (TDI) of TBT was derived to be 0.25 μg/kg body weight/day for TBTO by Penninks, (1993), this value is generally accepted and referred to the previous studies (Kannan and Falandysz 1997, Robinson et al. 1999, Belfroid et al. 2000). Belfroid et al. (2000) calculated tolerable average residue levels (TARL) from TDI based on the formula as described below.

$$\text{TARL} = (\text{TDI} \times 60\ \text{kg body weight}) / (\text{average daily seafood consumption})$$

Average daily seafood consumption in Vietnam was 34.5 g/day (Belfroid et al. 2000). Based on the data, the TARL for seafood in Vietnam was calculated to be 435 ng g^{-1} wet weight as TBTO, and 87 ng g^{-1} wet weight as Sn for an average person weighing 60 kg. The TBT levels in bivalves samples collected from Vietnam (0.37–56 ng g^{-1} wet wt were lower than the TARL.

Conclusion

The levels of OTs in Vietnam were within the range of those found worldwide. Spatial distribution of OTs revealed highest concentrations at sites where large vessels were moored or where tidal exchange was poor. In Vietnam, the construction of large harbors is planned in the near future. Greater industrial activity and related international shipping might be expected to lead to be increased TBT pollution, although the use of TBT-based antifouling paint has been banned since 2008. The clam *Meretrix* spp. is important source of food in the Vietnamese diet. Continuous monitoring is therefore necessary in order to ensure the safety of food and to protect the marine environment.

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