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Technical note

Butyltin in ballast water of merchant ships

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Abstract

The time series of analyzed values indicated that concentration of butyltin (BT) compounds in ballast water varied widely depending on the tanks, depths, and dates of sampling, ranging 4–93 ng l^{-1} during 7-day voyage. Variations in concentrations of BT in the two ballast tanks corresponded well with the level of BT contamination in different pumping sites of ballast waters. Concentrations of BT species detected in ballast water were rather consistent with those found in port waters and sediment of Taiwan and Japan. This study suggested that the problems concerning BT contamination were neither static nor localized.

Keywords: Ballast water; Butyltin compounds; Tributyltin; Ships; TBT; Marine coating

1. Introduction

A common and necessary practice for marine vessels is to pump substantial amount of water into the specifically designed ballast tanks to maintain structural integrity and adjust draft to enhance maneuverability and propulsion efficiency. A large containership, for example, may carry as much as 15,000 tons of ballast water (Talley, 2005).

It has been widely shown that transport of ballast water in ships is one of the most widespread mechanism by which nonindigenous aquatic species introduction occur (McDowell, 2002; Ruiz et al., 2001; Cohen and Carlton, 1998; US Coast Guard, 2001; US Coast Guard and US Department of Transportation, 2002; Matej and Marko, 2004). The same mechanism might also cause the introduction of chemical pollutants to other regions. These nonindigenous aquatic lives and pollutants might disrupt the local ecological system, when the ballast water transported from other regions was discharged.

According to the International Maritime Organization (IMO) (Oemcke and VanLeeuwen, 2003) an estimated 10 billion tons of ballast water are transferred around the globe each year. The transportation is not limited to international or cross-ocean shipping. The coastwise transport of ballast water can also spread chemical pollutants and aquatic nuisance species along the coastline (Ruiz et al., 2001). However, few have attempted to address the possible intake of chemical pollutants with ballast water and whether the discharge of ballast water is accompanied by the threat of chemical pollution to the reception regions.

Since early 1970s, tributyltin (TBT) has been used as antifouling agent in boat and ship paint applied to the hulls of vessels. The harmful effects of TBT released by antifouling paints were first documented in France Arcachon Bay at the end of 1970s (Alzieu, 2000). In addition to direct leaches from the ship hull, TBT can also be released into the environment in the form of paint wastes from sandblasting and hydroblast, which are the necessary maintenance procedures in dockyard. Due to the wide applications of antifouling paints, considerable amounts of butyltin (BT) compounds have entered estuarine and marine ecosystems (Hoch, 2001).

Even at very low concentrations (<10 ng l^{-1}), TBT can cause shell anomalies and failure of spat in oyster, impotence in neogastropods and gastropods (Horiguchi et al., 1998a, b; Hong et al., 2002), and immunological dysfunction in fish (Shimizu et al., 2003). At present regulations on TBT-based paints are not in conformity

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across the world. Some countries have no restrictions on the use and release of TBT antifouling paints, while others, including Japan, France, and several North Sea states, have more stringent restrictions.

The aim of the present study was to assess the current levels of BT compounds in the ballast water transported by merchant vessels and to provide baseline data for future efforts to decrease the threat of chemical pollutants through ship ballasting practice. The time series of concentration of BT compounds in ballast water was established to demonstrate variations in BTs in different ballast tanks and its correspondence with the level of BT contamination in international seaports in which ballast waters were pumped onboard.

2. Material and methods

2.1. Sample collection

2.1.1. Water samples

Water samples were collected through tank sounding pipe directly into 50-ml centrifuge tubes (polypropylene, graduations printed on outer surface), throughout the study. The centrifuge tube was loaded on a carrier fabricated from a 25.4 mm-diameter stainless-steel pipe. The depths of water sampling were measured at the same time.

Ballast water was sampled at intervals from the surface, half-depth, and bottom of ballast water column in the Wing Tank and the Heel Tank of M.V. KC (Table 1) during 7-day voyage (August 23–29, 2004) from Keelung Harbor, Taiwan to Tokyo Harbor, Japan (Fig. 1). The sites of ballast water intake in the Wing Tank were mainly near the exit of the Keelung Harbor, and the depth of ballast water was approximately 2.8 m at the time of sampling. The sites of ballast water intake in the Heel Tank were at the innermost of Tokyo Port. The depth of water was approximately 3.2 m at the time of sampling.

Water samples were also taken from Keelung Harbor and five other Japanese international seaports which include Tokyo, Yokohama, Kawasaki, Yakkaichi, and Nagoya. Three subsamples were taken from each water sample (about 100 ml/subsample). These water samples were acidified to pH 4.8 with acetic acid–sodium acetate buffer (1 M) immediately after sampling, and were frozen as quickly as possible and transferred to the laboratory where they were stored at −20 °C.

Table 1
Information of container ship M.V. KC on which ballast water was sampled

Delivery date	April 2000	Depth to main deck	13.5 m
Cargo capacity	1660 TEU[a]	Draught	9.94 m
Service speed	21 mile/h	Voyage course	SE Asia—Taiwan—Japan
Length overall	180 m	Gross tonnage	16,266 GT
Breadth	25 m	Net tonnage	8739 NT
Deadweight	22,494 MT	Total ballasting capacity	7663 m^3

[a]20 ft equivalent unit container.

2.1.2. Sediment sample

Sediment samples (about 50 g) were collected from three locations around Keelung Harbor (Fig. 1). Sampling locations were chosen so as to provide sufficient representative coverage of the harbor. Samples were taken with an Ekman grab sampler (Wildco Wildlife, Saginaw, MI, USA) installed on a winch set of a research boat. Sediment samples were immediately frozen and transferred to the laboratory for storage and later extraction.

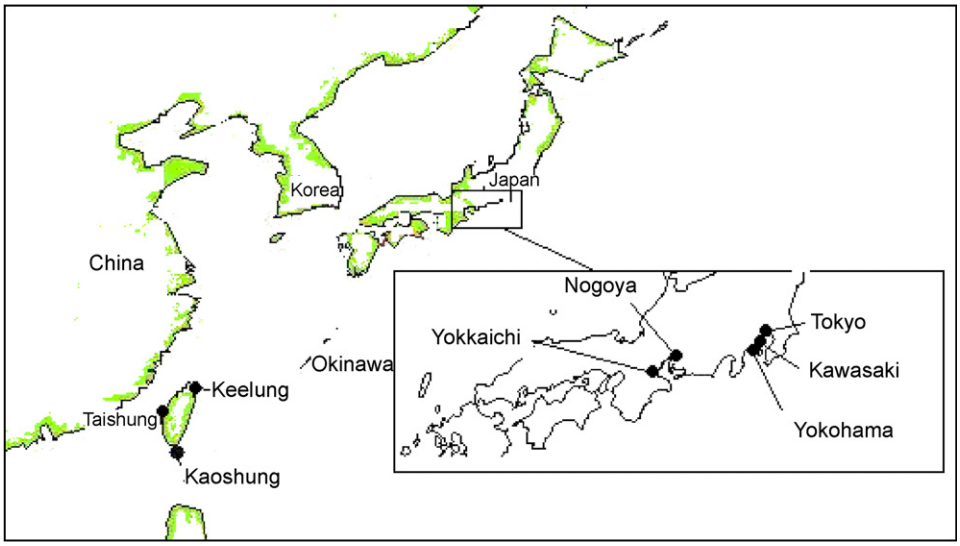

Fig. 1. Locations of international seaports M.V. KC have visited and ballast waters have been taken during its 7-day voyage, ● marks the sampling points of the port waters. Separated file: Fig. 1 mapTaiwanJapan.