Marine Pollution Bulletin 110 (2016) 767–777

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Accumulation patterns of lipophilic organic contaminants in surface sediments and in economic important mussel and fish species from Jakarta Bay, Indonesia

Dwiyitno [a,b,c], Larissa Dsikowitzky [a], Inga Nordhaus [e], Nuri Andarwulan [b,g], Hari Eko Irianto [d], Hanifah Nuryani Lioe [b], Farida Ariyani [c], Sonja Kleinertz [f], Jan Schwarzbauer [a,*]

[a] Institute of Geology and Geochemistry of Petroleum and Coal (GGPC), RWTH Aachen University, Lochnerstraße 4-20, 52056 Aachen, Germany
[b] Department of Food Science and Technology, Bogor Agricultural University (IPB), PO Box 220, Bogor 16110, Indonesia
[c] Research and Development Center for Marine and Fisheries Product Processing and Biotechnology (BBP4KP), Ministry of Marine Affairs and Fisheries, Jl. K.S. Tubun, Petamburan VI, Jakarta Pusat 10260, Indonesia
[d] Research Center for Fisheries Management and Conservation (P4KSI), Ministry of Marine Affairs and Fisheries, Jl. Pasir Putih II, Ancol Timur, Jakarta 14430, Indonesia
[e] Leibniz Center for Tropical Marine Ecology (ZMT), Fahrenheitstraße 6, 28359 Bremen, Germany
[f] Aquaculture and Sea-Ranching, Faculty of Agricultural and Environmental Sciences, University of Rostock, Justus-von-Liebig-Weg 2, D-18059 Rostock, Germany
[g] Southeast Asian Food and Agricultural Science and Technology (SEAFAST) Center, Jl. Puspa No. 1, Kampus IPB Darmaga, Bogor 16680, Indonesia

ARTICLE INFO

Article history:
Received 29 September 2015
Received in revised form 21 December 2015
Accepted 22 January 2016
Available online 4 February 2016

Keywords:
Tropical coastal ecosystems
Megacities
Bioaccumulation
Organic contaminants
Sediments
Fishery resources
Tropical aquaculture

ABSTRACT

Non-target screening analyses were conducted in order to identify a wide range of organic contaminants in sediment and animal tissue samples from Jakarta Bay. High concentrations of di-*iso*-propylnaphthalenes (DIPNs), linear alkylbenzenes (LABs) and polycyclic aromatic hydrocarbons (PAHs) were detected in all samples, whereas phenylmethoxynaphthalene (PMN), DDT and DDT metabolites (DDX) were detected at lower concentrations. In order to evaluate the uptake and accumulation by economic important mussel (*Perna viridis*) and fish species, contaminant patterns of DIPNs, LABs and PAHs in different compartments were compared. Different patterns of these contaminant groups were found in sediment and animal tissue samples, suggesting compound-specific accumulation and metabolism processes. Significantly higher concentrations of these three contaminant groups in mussel tissue as compared to fish tissue from Jakarta Bay were found. Because *P. viridis* is an important aquaculture species in Asia, this result is relevant for food safety.

1. Introduction

Jakarta is a booming coastal megacity in Indonesia with more than 10 million inhabitants. The growth of the city is involving the pollution of coastal waters and habitat degradation, having adverse effects on the coastal ecosystem, the Jakarta Bay. At least around 161 tons of solid waste per day and around 6.5 million tons of liquid waste per day are discharged into Jakarta Bay (BPS DKI, 2010; BPLHD DKI, 2010). The corresponding contaminants are delivered from various sources, such as domestic solid waste disposal, municipal and industrial wastewater discharges and oil spills (e.g. Uneputty and Evans, 1997; Dsikowitzky et al., 2016). More than 7000 industrial facilities are situated in the greater Jakarta region, the Jabodetabek area. Jakarta Bay provides several services, such as for transportation, supply of natural resources (seafood) and recreational activities. Regarding the long-term effects, the input of high amounts of organic and inorganic contaminants is leading to a contamination of fishery resources from Jakarta Bay. This can endanger the health of the local communities, as consumers of seafood from the bay. A number of organic contaminants have previously been reported to occur in water, sediments and mussels sampled in the Jakarta Bay, such as polycyclic aromatic hydrocarbons (PAHs), 2,2-bis(chlorophenyl)-1,1,1-trichlorethane and its metabolites (DDT), polychlorinated biphenyls (PCBs), tributyltin (TBT), polybrominated diphenyl ethers (PBDEs) and hexachlorocyclohexanes (HCHs) (e.g. Williams et al., 2000; Monirith et al., 2003; Sudaryanto et al., 2007a, 2007b). The concentrations of the insect repellent N,N-diethyl-*m*-toluamide (DEET) in river water and seawater from Jakarta were reported to be exceptionally high and to exceed by far all published concentrations in surface waters worldwide. This was attributed to the massive usage of the compound in the households of the Jakarta City area, leading to the discharge of large amounts of untreated municipal wastewaters into the relatively small river systems and the transport of huge DEET loads towards Jakarta Bay (Dsikowitzky et al., 2014).

Besides producing harmful effect to the environment, some organic contaminants have been utilized as molecular marker for monitoring

* Corresponding author.
E-mail address: loga-pub@emr.rwth-aachen.de (J. Schwarzbauer).

http://dx.doi.org/10.1016/j.marpolbul.2016.01.034
0025-326X/

the origin of anthropogenic emissions and the fate of anthropogenic contaminant in the environment, such as linear alkylbenzenes (LABs) (e.g. Takada et al., 1990). However, besides the numerous studies on persistent organic pollutants (POPs), only a very limited number of studies are available about less-known, emerging organic contaminants such as compounds with technical applications or from industrial sources from Asian coastal regions.

Less-known, emerging contaminants as well as priority pollutants and molecular markers such as LABs may be accumulated in organisms that play an important role as fishery resources. However, information on the bioaccumulation behavior of different organic contaminant groups in economic important fish and macroinvertebrate species based on field studies are limited (e.g. Porte and Albaigés, 1994). We use here the term "bioaccumulation" as being the difference between uptake and elimination mechanisms in an organism.

The aim of this study was to investigate the accumulation of organic contaminants by economic important fish and macrobenthic invertebrate species from Jakarta Bay. Thereby we wanted to get an overview on the contaminant burden of those species which are harvested for local consumption in a bay that receives enormous amounts of municipal discharges from the megacity Jakarta (Dsikowitzky et al., 2014). Because the uptake of particle-associated contaminants is one important exposure route, we considered also the contamination of surface sediments from Jakarta Bay for our investigation. A non-target screening approach was executed which allows for the identification of a wide range of organic contaminants in the investigated animal samples and includes emerging contaminants and well-known priority pollutants. Thereby, we were able to identify and quantify those organic contaminants which are the most relevant in terms of concentrations and detection frequency for the contamination of fishery resources from Jakarta Bay.

2. Materials and methods

2.1. Samples and sampling sites

This study was conducted in Jakarta Bay, located in the northern part of Jakarta. The whole ecosystem which is called the Greater Jakarta Bay Ecosystem (GJBE), stretches from 106°20′ to 107°03′ east longitude, and from 5°10′ to 6°10′ south latitude, and is administratively assigned to three provinces, i.e. Banten Province, the Capital City of Jakarta, and West Java Province. Jakarta Bay is a rather shallow bay with an average depth of 15 m which covers an area of about 514 km^2 (Nur et al., 2001). The bay receives water from 13 rivers some of which are flowing through the Jakarta Metropolitan area. The Northwest monsoon (October–March) brings rainfall to the Jakarta area, whereas the Southeast monsoon (April–September) coincides with the dry season. A number of eight economic important fish species were collected from local fishermen in Jakarta Bay in October 2012, May 2013 and October 2013. Furthermore, green mussels (*Perna viridis*) from aquaculture facilities were sampled (Table 1). Surface sediment samples from 22 stations in Jakarta Bay were taken with a stainless steel Van Veen Grab (20 × 20 cm^2) in October 2012 and May 2013. During sampling, all samples were cooled with ice and stored at −20 °C in the laboratory until analysis. The sampling sites of animal and sediment samples are indicated in Fig. 1.

Within the present study in total eight fish species belonging to seven different genera were studied. All examined fishes belonging to the Superclass Osteichthyes, Class Actinopterygii, Infraclass Teleostei and Superorder Acanthopterygii. They are separated within the orders of Perciformes (*Siganus guttatus* Bloch, 1787, *Siganus canaliculatus* (Park, 1797), *Lethrinus lentjan* (Lacepède, 1802), *Lutjanus mahogoni* (Cuvier, 1828), *Rastrelliger kanagurta* (Cuvier, 1816), *Argyrosomus amoyensis* (Bleeker, 1863)); Clupeiformes (*Ilisha elongata* (Bennett, 1830)) and Siluriformes (*Netuma thalassina* (Rüpel 1837). The migration behavior of the different fishes ranges from non-migratory to coastal or temporarily migratory (Table 1). The usual feeding mode of the investigated fish species ranges from omnivore to carnivore and herbivore (see Table 1). They are of different commercial values in Indonesia.

The mussel species *P. viridis* belongs to the Phylum Mollusca, Class Bivalvia, Subclass Pteriomorphia and Family Mytilidae. *P. viridis* is native of the Indo-Pacific region, primarily distributed along the Indian and the Southeast Asian coasts. It generally inhabits marine intertidal, subtidal and estuarine environments with high salinity. *P. viridis* is a characteristic species of the fauna of midlittoral and sublittoral zones, where it often constitutes dense populations (Rajagopal et al., 2006). The mussel is a filter feeder (see Table 1) that feeds on phytoplankton, zooplankton and suspended organic materials.

P. viridis accounts for almost half of the total output of farmed molluscs in Southeast Asia (FAO, 2009). The main species of marine foodfish produced in floating farms in Asia are different groupers (genus *Epinephelus*), Asian seabass, golden and mangrove snappers (genus *Lutjanus*). Minor species are for example rabbitfishes (*S. guttatus*, *S. canaliculatus*) (Chou and Lee, 1997).

2.2. Sample extraction and fractionation

An aliquot of approximately 20 g fresh wet sediment from an amount of at least 500 g sampled sediment were extracted based on the method described by Schwarzbauer et al. (2000) with a high-speed dispersion tool (Ultra-Turrax T-25 basic, IKA-Werke, Staufen, Germany) using mixtures of acetone and *n*-hexane. After concentration by rotary evaporation, the extract was dehydrated with Na_2SO_4, and

Table 1
Habitat, feeding mode, number of pooled individuals during sample processing and sampling periods of the investigated fish and mussel species from Jakarta Bay, Indonesia.

No	Common name/*Scientific name*/local name	Habitat/feeding habit	Pooled individuals per station	Migration behavior	Sampling period
1	Green mussel/*Perna viridis*/Kerang hijau	Pillar/filter-feeder	21–67	Non-migratory/sedentary, pelagic life of larvae	October 2012, May 2013, October 2013
2	Mahogany snapper/*Lutjanus mahogoni*/Ikan tanda	Demersal/carnivore	10	Non-migratory	
3	Mackerel/*Rastrelliger kanagurta*/Kembung	Pelagic/omnivore	10	Coastal migratory	
4	Croaker/*Argyrosomus amoyensis*/Gulamah	Demersal/omnivore	10	Coastal-estuarine temporarily migratory	October 2012, May 2013
5	shad/*Ilisha elongata*/Mata belo	Pelagic/carnivore	10	Coastal migratory	October 2012
6	White emperor/*Lethrinus lentjan*/Lencam	Demersal/carnivore	10	Non–migratory	October 2012
7	Goldlined spinefoot/*Siganus guttatus*/Baronang	Demersal/herbivore	6	Coastal-estuarine temporarily migratory	October 2012
8	White-spotted rabbitfish/*Siganus canaliculatus*/Baronang susu	Demersal/herbivore	10	Coastal-estuarine temporarily migratory	May 2013, October 2013
9	Sea catfish/*Netuma thalassina*/Manyung	Demersal/carnivore	5–10	Non-migratory	May 2013, October 2013