Title

A comparison of the bioaccumulation patterns of persistent organic pollutants (POPs) in barnacles and mussels in selected sites of Peninsular Malaysia

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Aim

1- To investigate bioaccumulation patterns of POPs in barnacles' soft tissues in Malaysian coasts

2- To assess the potentiality of barnacles to be used as biomonitors of POPs in coastal environment

3- To compare bioaccumulation patterns of POPs in barnacles' and mussels' soft tissues

Procedure

Barnacles (n=10) and green mussels (n=4) were collected from the west, south and east coasts of Peninsular Malaysia. Table 1 illustrates the GPS data, location types and names of the sampling stations. Mussels' sampling stations were selected according to their availability in barnacles' habitats, while barnacles were collected from both hot spots and remote areas in Peninsular Malaysia. The barnacle species collected in this study was *Amphibalanus sp.* in all stations, except TI1 and TI2 where *Tetraclita sp.* was collected (Fig. 1), while mussel species was *Perna sp.* Samples were transferred on ice to the lab and stored at -20 °C. Later, barnacles' and mussels' soft tissues were separated from the shells, homogenized and freeze-dried. The freeze-dried soft tissues were transferred to CMES for further analysis. Briefly, samples were extracted using an accelerator solvent extractor and spiked with surrogate standards. The extracts were then subjected to gel permeation chromatography (GPC) using hexane/DCM (1:1) for lipid removal. The extracts were concentrated and eluted using a glass column packed with

baked silica gel. For

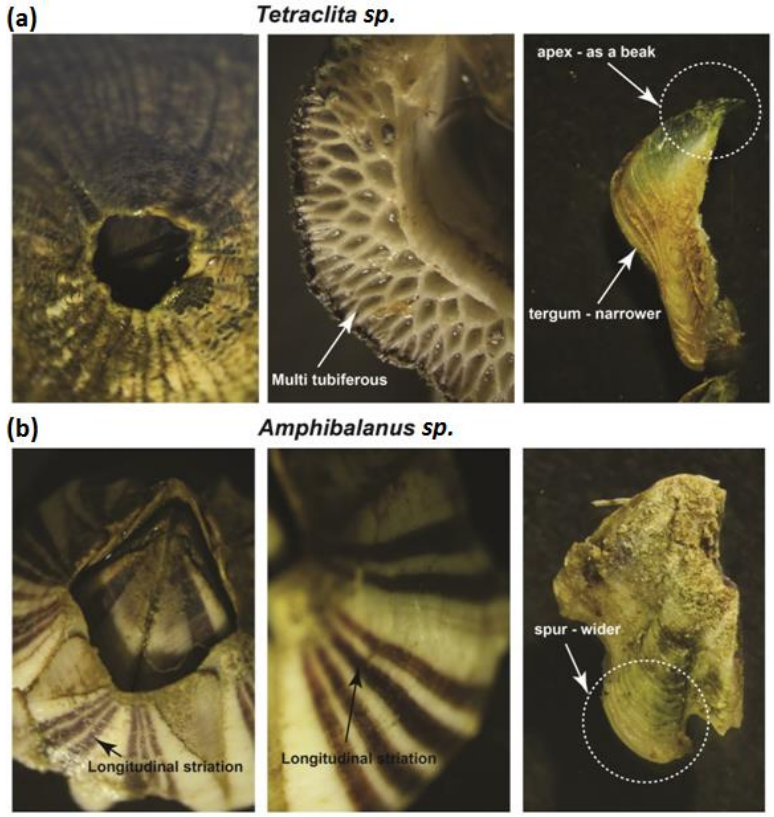

Fig. 1. (a) *Tetraclita sp.* from TI1 and TI2. (b) *Amphibalanus sp.* from the rest of stations

Table 1 GPS data, location names and types of the sampling stations

Station	Lat	Long	Location name	Area
JB 1	1.3612114	103.6246528	Johor Bahru St1	Beach (Jetty/Rural)
JB 2	1.3766826	103.6389131	Johor Bahru St2	Mangrove (Port/Industrial)
PK1	2.9554970	101.3616386	Port Klang St1	Mangrove (Port/Industrial/Urban)
PK2	2.9793902	101.3899040	Port Klang St2	Mangrove (Port/Industrial/Urban)
KS	3.1070735	101.3287641	Kampung Sementa	Mangrove (Industrial)
PR	4.8367822	100.6203783	Perak	Mangrove (Rural)
PG	5.3322557	100.4047592	Pinang	Beach (Industrial/Urban)
PD	2.5245472	101.7898851	Port Dickson	Beach (Old port)
TI 1	2.7403901	104.1302070	Tioman Island St1	Beach (Tourist)
TI 2	2.8536689	104.1918784	Tioman Island S2	Beach (Tourist)

this purpose, 80 ml of 5% DCM/hexane were used. The elution were further concentrated and internal standard was added. Later, the elution was evaporated to near dryness with gentle stream of nitrogen. Gas chromatography mass spectrometry was used to analyze target compounds.

Results and discussion

The maximum concentrations of ∑PCBs and ∑PBDEs in barnacles were detected at 301 and 251 ng g^{-1} lw both in PK2 (Port Klang). Port Klang is located at the end of the Klang River, the most polluted river in Malaysia passing through populated and industrialized areas of the capital city of Kuala Lumpur, while the Port itself is among the busiest in the world with heavy shipping traffic. A total of 12 PCB congeners were found in 100% of the barnacles, while CB153 was the predominant congener, similar to turtle eggs from Malaysia (van de Merwe et al., 2010), mussels from Netherlands–Belgium (Ael et al., 2012), molluscs from Senegal (Bodin et al., 2011), bivalves from Spain (Rodil et al., 2019) and fish from Baltic Sea (Burreau et al., 2004). As for PBDEs, BDE47 was the most frequent PBDE in barnacles, which is common in biota and have been widely detected around the world (Bayen et al., 2005). The highest concentrations of ∑PCBs and ∑PBDEs in green mussels were detected at 178 and 113 ng g^{-1} lw both in PK1 (Port Klang). Lower concentrations of PCBs and PBDEs (ng g^{-1} lw) were detected in mussels compared to barnacles from similar habitat, while the bioaccumulation patterns were to a large extent similar to barnacles. The concentrations of POPs in barnacles and the comparison of the outcomes with mussels showed that barnacles can be a good biomonitor for distribution of POPs in the coastal environment. Table 2 shows the maximum concentrations of PCBs and PBDEs in this study compared to some previous studies.

Table 2 Maximum concentration of PCBs and PBDEs from different studies

Location	**PCBs** (ng g^{-1} lw)	**PBDEs** (ng g^{-1} lw)	**References**
Mollusc, China	596	na	Wang et al. (2008)
Mussel, Malaysia	250	na	Monirith et al. (2003)
Mussel, Greenland	38.5	5.5	Christensen et al. (2002)
Barnacle, Malaysia	301	251	Present study
Mussel, Malaysia	178	113	Present study
Location	**PCBs** (ng g^{-1} ww)	**PBDEs** (ng g^{-1} ww)	**References**
Mangrove biota, Singapore	190	9.9	Bayen et al. (2005)
Mussel, Netherlands–Belgium	1688	12.4	Ael et al. (2012)
Bivalves, Scotland	na	2.74	Fernandes et al. (2008)
Barnacle, Malaysia	1.73	1.06	Present study
Mussel, Malaysia	3.95	2.51	Present study

na - not available

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