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Baseline

Polychlorinated biphenyls (PCBs) in a benthic ecosystem in Gwangyang Bay, South Korea

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ABSTRACT

Benthic ecosystem in Gwangyang Bay, a fast developing industrial area with steel production, port container handling, petroleum and other chemical processing in South Korea was studied. The average levels of polychlorinated biphenyls (ΣPCB) in the benthic components were: seawater 2.99 ± 0.13 (ng/L); sediment 294 ± 118 (ng/g TOC); [biota = ng/g lipid] starfish 92; prawn 131 ± 2; mussels 127 ± 22; crab 182 ± 114; clam 187; polychaeta 215; sea cucumber 497 ± 90; squill 603 ± 38; fish 396 ± 159. Levels in the inner bay samples were higher than the outer bay samples suggesting land based pollution. Good correlation ($r^2 = 0.79$; $p < 0.05$) existed between PCB concentration and lipid content indicating partitioning processes in action. PCB signature in the abiotic and biotic components shows enrichment of lower chlorinated congeners emitted by a unique source nearby, viz. steel manufacturing plant.

Gwangyang Bay in South Korea is at the center of Gwangyang Bay Area Free Economic Zone (GFEZ) that promotes steel production, port container handling, petroleum and other industries. For example, a steel works in Gwangyang is the largest facility of its kind in the world. It has been shown earlier using polychlorinated biphenyls (PCBs) as industrial markers that steel works leave a unique PCB signature in marine sediments, dominated by lower chlorinated isomers (Hong et al., 2005). This inquiry was extended to Gwangyang Bay benthic ecosystem whether nearby steel works influenced PCB bioaccumulation pattern. In addition, the overall transport and fate of PCBs in the benthic ecosystem was understood. PCBs are well studied substances in the environment. Although PCBs are now banned in most parts of the world, they are still released from old equipments, waste sites, municipal and domestic sewage plants; non-commercial sources (Hong et al., 2005, 2009; Kannan et al., 2010a; Diamond et al., 2010; Hu and Hornbuckle, 2010). Hence it is imperative to monitor their distribution globally and regionally. South Korea is a signatory of Stockholm protocol and is earnest in understanding the transport and fate of persistent organic pollutants (POPs) in South Korea and elsewhere. Thus, several industrial bays in the country are under close watch for pollution status (Hong et al., 2003, 2005, 2009; Kannan et al., 2007; Yim et al., 2005a; Li et al., 2008). Gwangyang Bay is one among the many industrialized bays in South Korea. It is semi-enclosed with tidal ranges up to 3.4 m. The bay borders three cities. Gwangyang Bay was rapidly industrialized with constant reclamation of land from the western and central parts of the bay to accommodate this growth. This tidal flat ecosystem which is under threat is inhabited by several unique benthic organisms, such as mudskipper fish, crabs, clams and lugworms (Kim et al., 2008). Gwangyang Bay has been designated as a special management area since 2000 for monitoring the status of persistent pollutants by the then Ministry of Maritime Affairs and Fisheries (MOMAF) (KORDI, 2003).

A survey was undertaken in Gwangyang Bay (Fig. 1) during 2001–2002 on the status of pollution in water, sediment and several benthic species such as clams, bivalves, starfish, sea cucumber, polychaeta, crab, prawn, and fish. The study focused on the occurrence, composition and possible sources of PCBs. Water was collected using *in situ* filtration and extraction sampler viz. INFILTREX II water sampler (Axys Environmental Systems Ltd.) equipped with 42 mm glass fiber prefilter (0.7 μm Whatman GF/F, 1.0 μm Gelman A/E) and XAD-2 resin (20–60 mesh) column (1.9 cm i.d., 2.5 cm o.d., 37 cm long). Surface sediment (~2 cm) from the bottom of the bay was collected using van-Veen grab and placed in glass jars with Teflon lined lid, frozen on dry ice and then transferred to the laboratory for storage at −20 °C until analysis. The organisms were collected in the following way: benthic fish and invertebrates using trawl at 1–2 knots speed at four locations (Sts. 1, 6, 8 and 13) and fishing pot (Sts. 3 and 6); polychaeta by sieving the bottom sediment after grab sampling (Sts. 3 and 6); mussels were handpicked from floating buoys (Sts. 4, 7 and 9). Sediment samples were collected in all stations but water samples were collected at four stations only due to restrictions in ship timing (Sts. 3, 4, 6 and 8) (Fig. 1 and Table 1).

The analytical procedure is after Hong et al. (2005). Fishes, clams, mussels, crab and prawn were dissected on board and

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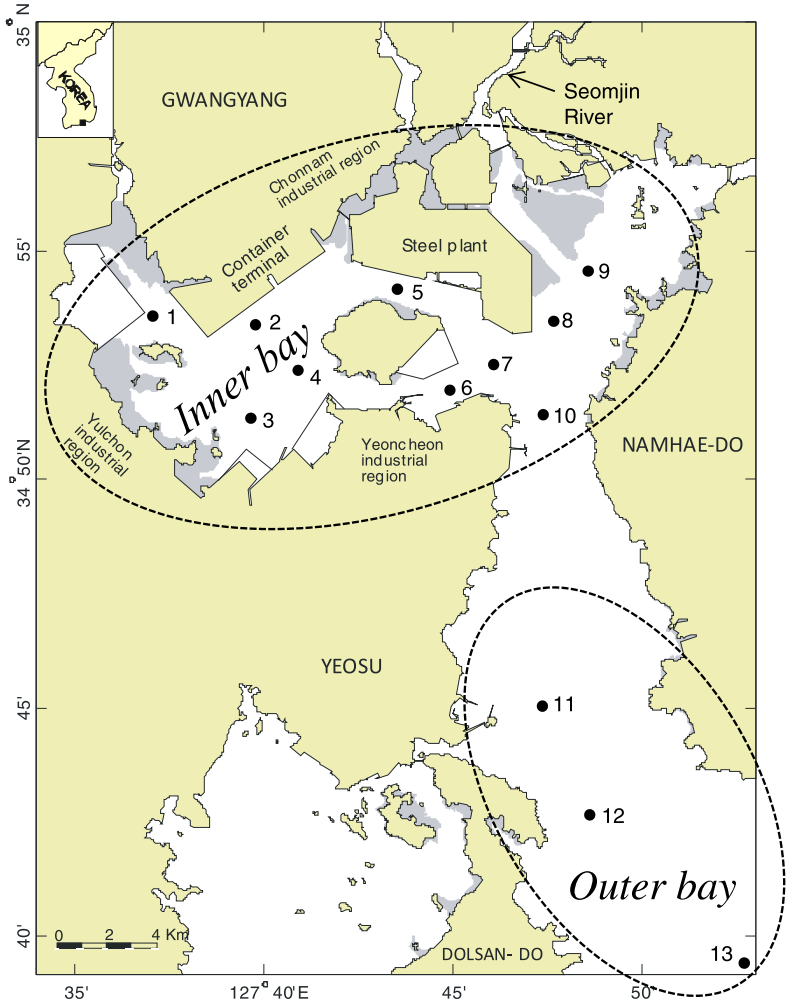

Fig. 1. Map showing Gwangyang Bay neighborhood and sampling locations (inner and outer bay). Shaded areas refer to intertidal mudflat zones.

Table 1
Concentration of ΣPCB (ng/g lipid wt.) in organisms from inner or outer bay. Concentration values in the inner and outer bay are compared for those available at both locations and enrichment factors are calculated (last column on the right).

Organism	Location (St.#)	Sample size (*n*)	ΣPCB	Enrichment factor (Inner to Outer bay)
Clam (*Scapharca broughtonii*)	Inner bay (1)	8	187	–
Sea cucumber (*Protankyra bidentata*)	Inner bay (6)[a]	12	497 ± 90	–
Squill (*Squilla oratoria*)	Inner bay (6)	5	629	1.1
	Outer bay (13)	6	579	
Polychaeta (*Tharyx sp. and Lumbrineris longifolia*)	Inner bay (3, 6)[b]	35	215	–
Crab (*Charybdis japonica*)	Inner bay (1, 3)	26	245 ± 47	4.4
	Outer bay (13)	15	56	
Prawn (*Leptochela gracilis*)	Inner bay (1, 8)	11	13 ± 2	–
Starfish (*Asterias amurensis*)	Inner bay (6)	20	92	–
Fish (*Pleuronichthys cornutus*)	Inner bay (6, 8)	4	396 ± 159	1.9
	Outer bay (13)[a]	6	213 ± 58	
Mussels (*Mytilus galloprovincialis*)	Inner bay (4, 7, 9)	45	126 ± 22	–

[a] Duplicate samples were obtained.
[b] Due to scarcity of specimen, samples collected from various stations were pooled.

tissues were taken for analysis. Muscle tissue was collected from fish for analysis. The entire viscera were analyzed in crustaceans, echinodermata and mussel. Worms were crushed whole for analysis. Due to scarcity of samples, organisms were pooled to get sufficient analytical size. This also helped to obtain a representative sample from the region of interest (Table 1). Biological tissue was homogenized using a Tissumizer and a 15 g aliquot was prepared for analysis. Sodium sulfate was added and ground. Sediment samples were homogenized and 25 g of sediment was placed in a porcelain mortar and mixed with sodium sulfate. This mixture was placed in a glass or ceramic thimble and extracted overnight with dichloromethane using a Soxhlet extractor with dichloromethane. For water samples, dissolved contaminants in XAD-2 resin columns were first eluted with 200 ml of methanol to remove water. A second fraction was collected by eluting with 200 ml of dichloromethane. The dichloromethane fraction was concentrated by ro-