

USING APPLE SNAIL (*AMPULLARIIDAE*) AS A BIOINDICATOR FOR POLYCHLORINATED DIBENZO-P-DIOXINS AND DIBENZOFURANS, POLYCHLORINATED BIPHENYL, AND POLYBROMINATED DIPHENYL ETHERS IN AN E-WASTE DISMANTLING AREA IN SOUTHEAST CHINA

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Abstract

In this study, 40 apple snails (*Ampullariidae*) and related soils samples were collected in June of 2008 from Taizhou, an intensive e-waste recycling area. Apple snail was used as a bioindicator to evaluate the contamination extent and spatial distribution of polychlorinated biphenyl (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans(PCDD/Fs), polybrominated biphenyl ethers (PBDEs). The total PBDE and total PCDD/Fs concentrations in these organisms were on the same order of magnitude. Among these three organohalogenes, PCBs were the most serious pollutant in the Taizhou area. And among all sampling sites, Fengjiang Town was the most intensively polluted spot. Σ PCBs concentrations of both apple snails and soil samples were negative related to the distance from Fengjiang Town, which indicated that Fengjiang Town was the primary source of PCBs in this area.

Introduction

The emergence of electrical and electronic waste (e-waste) has become a serious problem around the world. Although many countries have ratified the Basel Convention to ban the export of hazardous wastes (including e-waste), unregulated and even illegal trade of e-waste still occur to a large extent in developing countries such as China, India¹. A great number of toxic pollutants in these products, especially persistent organic pollutants (POPs) and heavy metals, are released to the ambient environment during the primitive dismantling processes. Previous works showed that very high levels of POPs and heavy metals have been detected in environmental media and biota from e-waste dismantling areas, such as Guiyu in Guangdong Province and Taizhou in Zhejiang Province^{2,3}. A bioindicator can be considered as an integrator of contaminations, which is able to bioaccumulate lipophilic organic pollutants to a large extent. Some aquatic species have been selected as bioindicators for assessing regional or global pollution⁴. In this study, apple snail was selected as a pollution bioindicator for evaluating the distributions and pollution patterns of PCDDs/Fs, PCBs, and PBDEs in Taizhou, Zhejiang Province. Apple snails are widely distributed in ponds, rivers and rice paddies in tropic and sub-tropic zones, including our study area. They live in close contact with benthic sediments and play an important part in local food webs and they are popular food source for various animals like fish, birds, as well as domestic ducks⁵. They

might thus be suitable to reflect the levels of contaminants in the ambient environment. The major objective of the present research is to illustrate the contamination extent and spatial distribution of the three selective POPs in our study area.

Materials and Methods

Taizhou is a well known e-waste recycling area in Zhejiang Province, southeast China, where E-waste has been primitively dismantled in small-sized waste recycling workshops since the late 1980s. A total of 40 apple snails and related soils samples were collected in June of 2008 in rice paddies from nearly 30 different town in Taizhou around Fengjiang (FJ) town, which is the most intensive recycling hotspot. The most typical category of waste electronic equipments dismantled in this spot was obsolete transformers that use PCBs as transformer oil. Soft tissues of the apple snail samples were separated and lyophilized for 48 h, thereafter grinded to fine powder and sealed in polyethylene bottles at 4 °C until analysis. Sample pretreatment, quality assurance and quality control, quantification of the data, and instrumental analysis followed our previously established methods⁶ with some modifications. 17 PCDD/Fs congeners (2378-TCDF, 12378-PeCDF, 23478-PeCDF, 123478-HxCDF, 123678-HxCDF, 234678-HxCDF, 123789-HxCDF, 1234678-HpCDF, 1234789-HpCDF, OCDF, 2378-TCDD, 12378-PeCDD, 123478-HxCDD, 123678-HxCDD, 123789-HxCDD, 1234678-HpCDD, OCDD), 14 PBDE congeners (BDEs 17, 28, 47, 66, 71, 85, 99, 100, 138, 153, 154, 183, 190, and 209) and 25 PCB congeners including 12 coplanar congeners (CBs 77, 81, 105, 114, 118, 123, 126, 156, 157, 167, and 169), six indicator congeners (CBs 28, 52, 101, 138, 153, and 180), and other congeners (CBs 3, 15, 19, 202, 205, 208, and 209) were analyzed in both apple snail samples and soil samples. Qualitative and quantitative results were obtained based on an isotope dilution method using high-resolution gas chromatography coupled with high-resolution mass spectrometry.

Results and Discussions

PCBs, PCDD/Fs and PBDEs in Apple Snails and Soils Concentrations of Σ PCBs (the sum of 25 PCB congeners) in the apple snail and soil samples collected from Taizhou ranged from 3.78 to 1812 ng/g dw (dry weight) and 0.55 to 90.10 ng/g dw, respectively. The most abundant PCB congeners were CB-28 and CB-138, accounting for 41.3% and 9.9% in apple snails, 28.8% and 14.8% of the total 25 PCBs in soil samples, respectively. The highest concentrations of Σ PCBs in both apple snails and soil were found in Fengjiang Town. Σ PCDD/Fs (the sum of 10 PCDF congeners and 7 PCDD congeners) in the apple snail and soil samples in this study ranged from 0.01 to 5.21 ng/g dw and 0.13 to 37.00 ng/g dw, respectively. Contrary to PCBs, PCDD/Fs concentrations in apple snail were lower than that in soil. Among the PCDD/Fs congeners, OCDD was the most predominant congeners, which accounted for 66.9% in apple snail samples and 79.7% in soil samples. Apple snail samples from Fengjiang also exhibited the highest concentration of the total PCDD/Fs. PCDD/Fs concentrations in Fengjiang soil sample was 627.9 pg/g dw, but it was much lower than the Baishuiyang sample. Of the 14 congeners analyzed, BDE-209 made up the majority of the total PBDEs in both snail and soil samples. The highest concentrations of BDE-209 in snail and soil samples were up to 45040 and 270180 ng/g dw, respectively, implying serious contaminations of PBDEs in the area. The snails were not depurated before being shucked, and thus the high concentrations of BDE-209 could be due to the presence

of ingested soil particles in the viscera. The Σ PBDEs (exclude BDE-209) ranged from 0.09 to 27.66 ng/g dw in apple snail samples and 0.06 to 31.28 ng/g dw in soil samples. The most seriously polluted samples also derived from Fengjiang Town.

Spatial distributions of PCBs The concentrations of Σ PBDE and Σ PCDD/Fs in both apple snail and soil samples were lower than Σ PCBs, which implied that PCBs were the dominant pollutants in this area. From Figure 1 it can be seen that Σ PCBs concentrations of both apple snails and soil samples were negative related to the distance from Fengjiang Town. This indicated that Fengjiang Town was the primary source of PCBs in this e-waste contaminated area. This study also indicated that apple snail was a reliable indicator for above pollutants in this area.

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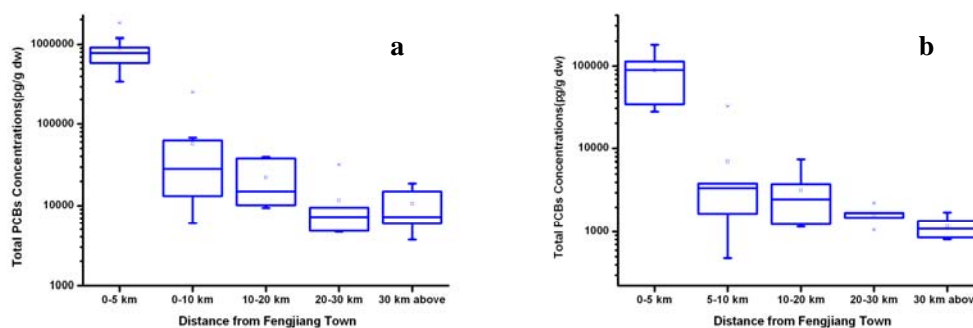


Figure 1a The negative relationship between total PCBs and distance from Fengjiang for collected apple snail samples. b: The negative relationship between total PCBs and distance from Fengjiang for soil samples. In the layout, the horizontal line in the box represents the median value and the vertical bars display the range of the data.

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