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Short communication

Human and environmental biomonitoring of polychlorinated biphenyls and hexachlorobenzene in Saxony, Germany based on the German Environmental Specimen Bank

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ABSTRACT

The objective of the present study was to investigate the principle relationships between concentrations in human and environmental matrices of polychlorinated biphenyls (PCBs) and hexachlorobenzene (HCB) in short distance comparable areas within Saxony, Germany by employing the data of the German Environmental Specimen Banking (ESB). Examples supporting this idea were presented by selecting data on blood plasma collected from students in University of Halle and pine shoots, egg matter of city pigeons, earthworm, and roe deer liver. Similar pattern for PCB 138 and PCB 180 was found for the human plasma and pine shoots samples during investigated years and the human data followed the corresponding environmental levels with some delay of approximately two years. However, PCB 153 that was the prevailing congener did not manifest this relationship. In addition, the correlation of the ratios of concentrations (human/environmental concentration) to some physicochemical constants such as molecular weight (MW), octanol–water partition coefficient ($\log K_{ow}$), Henry's law constant (K_H), and sorption partition coefficient ($\log K_{oc}$) of HCB, PCB 138, PCB 153, and PCB 180 were studied. The resulted negative slopes with all constants in case of blood plasma/city pigeons egg matter pairs suggested that the accumulation of lipophilic compounds is more pronounced in pigeon eggs than in human blood.

Introduction

Due to the hydrophobic and lipophilic nature of polychlorinated biphenyls (PCBs) and their resistance to degrade, these compounds bioaccumulate in the environment and are widely found in humans. Other persistent organic pollutants (POPs) such as hexachlorobenzene (HCB) and organochlorine pesticides were also widely used throughout the developed world. Although the HCB production was banned in Germany in 1993, some levels still exist in the environment and these chemicals are a matter of concern (Wang et al., 2010). In environmental health, biological monitoring of pollutant concentration in human tissue and fluids are used frequently for better assessment of exposure from multiple sources and routes. In Germany, the Human Biomonitoring Commission of the German Federal Environment Agency established scientifically based criteria for the application for human biomonitoring in 1992 (Wilhelm et al., 2003; Schulz et al., in press; Angerer et al., 2011). In this study, the levels of HCB, PCB 138, PCB 153, and PCB 180 in blood plasma and different environmental matrices collected in short distance comparable areas within Saxony, Germany areas were investigated. For human risk management, human biomonitoring data can be interpreted using the recently developed concept of biomonitoring equivalents (BE) using toxicokinetic data. In this regard, methodologies such as toxicokinetic models allowed to estimate the biomarker concentrations based on physico-chemical properties (Boogaard et al., 2011). Consequently, the bioconcentration ratios (human/environmental concentration) as a function of some physicochemical constants were studied.

Materials and methods

Investigated human and environmental samples

The investigated human data encompassed blood plasma sampled between 1995 and 2008 from students from University of Halle with an even number of female and male at the age of 20–29. Furthermore, different environmental samples were studied such as (1) pine shoots from the nature park Dübener Heide sampled during 1993, 1995, 1997, 1999–2004; (2) and (3) egg matter of city pigeons from the residential use areas in Halle and Leipzig sampled during 1997, 2000–2008, and 2000–2008, respectively; (4) and (5) earthworm (*Lumbricus terrestris*) from park areas of Halle and

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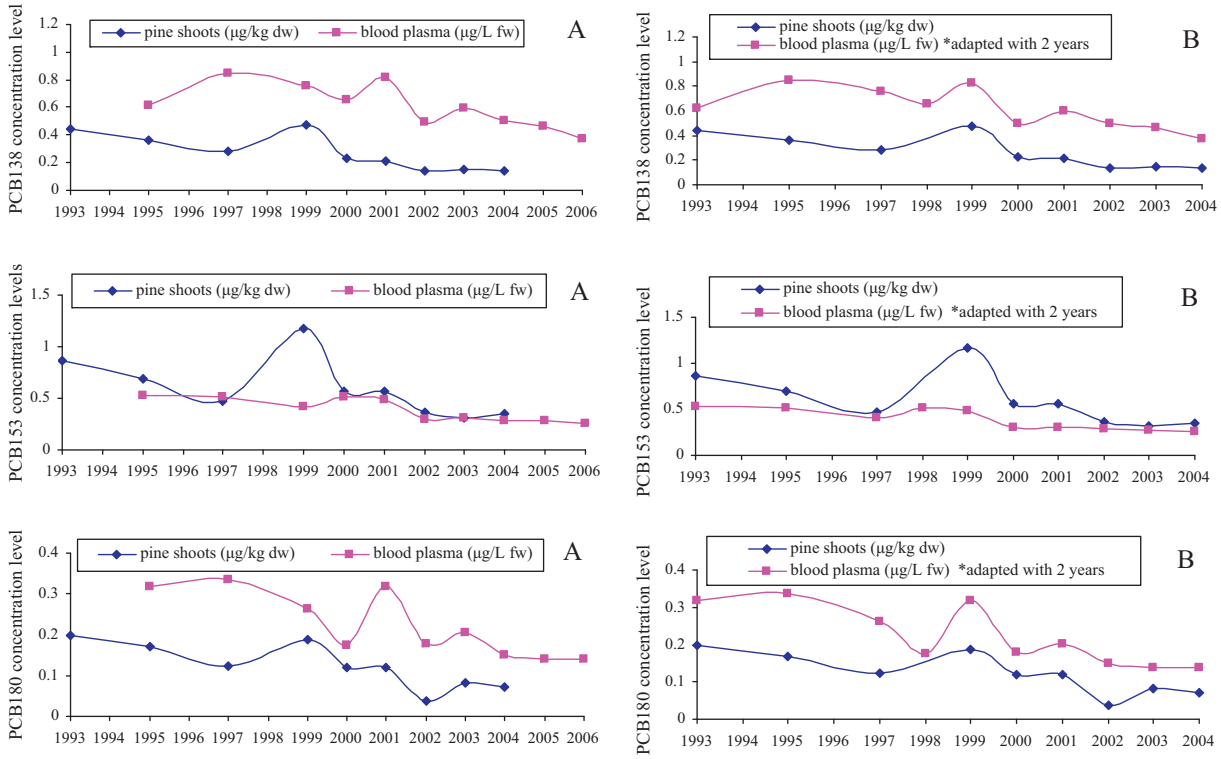

Fig. 1. PCB 138, PCB 153 and PCB 180 level in human blood plasma during 1995–2006 and pine shoots during 1993–2004 sampled from Halle and nature park Dübener Heide, respectively (A). Human data adapted by shifting by two years back (B).

Leipzig sampled during 2000–2008 and 1999–2008, respectively; (6) roe deer liver from nature park Dübener Heide sampled during 1995 and 1999–2008. These human and environmental data were selected due to the short distance between collected samples of approximately 60 and 40 km within nature park Dübener Heide–Halle and Leipzig–Halle, respectively. The number of the species used is presented in Table 1, whereas additional biometric and anamnestic parameters are given elsewhere (Federal Environment Agency).

Determination of PCB and HCB

Detailed information on clean-up procedure and instrumental parameters for analyzing environmental and human samples are given elsewhere (Federal Environment Agency). Hexachlorobenzene (HCB) and polychlorinated biphenyls (PCB 138, PCB 153, PCB 180) were identified and quantified in µg/L fw, ng/g fw, ng/g fw and ng/g fw for blood plasma, egg matter of city pigeons, earthworm and roe deer liver, respectively. Pines shoots samples were homogenized and grinded powder in sub-samples of approx. 10 g in the vapor phase above liquid nitrogen (Rappolder et al., 2007). Analysis for PCB was performed only and the results were presented in ng/g dw. The concentration levels of investigated species are presented in Table 2.

Evaluation of the data

The pair of human and environmental data within sampled year and compound were identified. In all cases, the human data were from the blood plasma sampled from Halle whereas the environmental data varied between the above mentioned matrices. The arithmetic mean (Federal Environment Agency) pair data within investigated years and within compound were divided such as human/environmental concentration, named as bioconcentration ratios. Consequently, the mean and standard deviation of resulted ratios within compound were calculated. In order to find a relationship between these ratios and the physicochemical properties for certain compounds, the molecular weight (MW), octanol–water partition coefficient ($\log K_{ow}$), Henry's law constant (K_H), and sorption partition coefficient ($\log K_{oc}$) constants were identified (Mackay et al., 1992). The used physicochemical properties were MW: 284.8, 360.9, 360.9, 395 g/mol (Baker et al., 2000); $\log K_{ow}$ (1): 5.5, 6.5, 6.5, 6.7 (Oliver, 1987); K_{ow} (2): 5.5, 6.7, 6.8, 7.2 (Ballschmiter and Wittlinger, 1991); K_H: 139, 69, 13.4, 102 Pa m^3 mol^{-1} at 298 K (Ballschmiter and Wittlinger, 1991), $\log K_{OC}$: 5.8, 7.6, 7.2, 7.30 (Oliver, 1987a) for HCB, PCB 138, PCB 153 and PCB 180, respectively. Finally, the linear correlation and slopes and y-intercepts were studied and discussed.

Table 1
Number species used.

Species (n)	1993	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Pine shoots	15	15		15		15	15	15	15	15	15	15	15	15	15
Human blood plasma		97	77	90	91	88	98	65	117	104	105	102	106	108	106
Egg matter of city pigeons				20			31	20	32	40	20	40	40	75	50
Earthworm							857	850	890	953	857	756	727	978	782
Roe deer liver		2				4	11	11	11	10	9	12	6	13	11