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Air–soil exchange of PCBs: Seasonal variations in levels and fluxes with influence of equilibrium conditions

Yücel Tasdemir*, Güray Salihoglu, Nezih Kamil Salihoglu, Askın Birgül

Department of Environmental Engineering, Faculty of Engineering & Architecture, Uludag University, 16059 Bursa, Turkey

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ABSTRACT

The variations in the occurrences of PCB congeners both in soil and air were investigated in conjunction with each other, and the changes in the fugacity fractions and flux levels were examined on a seasonal basis. Air and soil samples were collected concurrently two or three times in a month during a one-year monitoring at two different locations in Bursa, located in the northwestern Turkey. Fugacity fractions and net flux levels of PCB congeners were calculated.

Air and soil PCB levels increased together as the soil temperature increased, suggesting the influence of instantaneous air–soil exchange towards the equilibrium conditions. The flux levels and fugacity fractions also showed a positive significant correlation with soil temperature. Flux levels were positive for the dates with fugacity fractions above 0.5, indicating volatilization from soil to air.

1. Introduction

Polychlorinated biphenyls (PCBs) are a group of semi-volatile organic compounds (SVOCs) having toxicity, persistence, and bioaccumulative potential (Wang et al., 2008). They were widely used for industrial and commercial applications before their production has been banned or restricted gradually since 1970s (Breivik et al., 2002). Air-soil exchange is known to be one of the key processes that control presence and levels of PCBs in environment (Jones, 1994). SVOCs are thought to move towards equilibrium between soil and air, and recycle continuously (Wania and Mackay, 1993; Backe et al., 2004). Monitoring the distribution of these chemicals at environmental compartments such as soil and air, and evaluation of their movement is necessary to predict their potential health effects.

Dry and wet deposition from atmosphere to soil, and volatilization from soil to air also affect the levels of chemicals in the environmental compartments. Harner et al. (1995) reported that diffusive gaseous transport of contaminants was the most important pathway for the transfer from soil to atmosphere. Soils have been shown to have an important role to play in supplying and receiving contaminants from the atmosphere, and in the global cycling of persistent organic pollutants (Meijer et al., 2003; Sweetman et al., 2002). Because of the tendency of organic chemicals to accumulate in organic matter (Armitage et al., 2006; Sweetman et al., 2005; Cornelissen et al., 2005), soil properties such as organic matter content is an important factor that affects air–soil partitioning. It has also been shown that the levels of chemicals were affected by seasonal temperature variations (Hillery et al., 1997; Wania et al., 1998; Lee and Jones, 1999; Sofuoğlu et al., 2004; Cabrerizo et al., 2011).

Fugacity model has been suggested by Mackay (1991) to describe the equilibrium partitioning process between the environmental compartments. With the help of fugacity quotients and mass transfer coefficients, the movement of SVOCs between the environmental compartments has been studied by several authors (Cousins and Jones, 1998; Harner et al., 2001; Backe et al., 2004; Koblizkova et al., 2009; Masih et al., 2012).

The concentrations of PCBs in various environmental compartments have been extensively documented (Meijer et al., 2003; Pozo et al., 2006; Ren et al., 2007; Zhang et al., 2008; Li et al., 2010; Cindoruk and Tasdemir, 2010; Salihoglu et al., 2011; Birgul and Tasdemir, 2011). Several studies reported data on the interaction of PCBs in different environmental compartments (Alonso and Pastor, 2003; Backe et al., 2004; Cetin et al., 2007; Bozlaker et al., 2008; Ruzickova et al., 2008; Zhang et al., 2008; Salihoglu and Tasdemir, 2009). However, studies on the overall assessment of PCB concentrations and net flux levels at the air–soil interface on a seasonal basis are limited. Recently, Cabrerizo et al. (2009) developed an operational fugacity sampler, and measured

* Corresponding author.
E-mail addresses: tasdemir@uludag.edu.tr (Y. Tasdemir), gurays@uludag.edu.tr (G. Salihoglu), nkamils@uludag.edu.tr (N.K. Salihoglu), birgul@uludag.edu.tr (A. Birgül).

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