

UNIVERSITY OF THE PHILIPPINES

Doctor of Philosophy in Environmental Science

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Decades of leaching PCBs: Spatial Dispersion, Transformation and Plant Uptake from Soil

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ABSTRACT

Polychlorinated Biphenyls (PCBs) are a group of man-made organic chemicals known as chlorinated hydrocarbons. PCBs were banned in 1979 due to its toxicity and persistence in the environment. In the Philippines, there are little known inventory of the persistence of PCBs in the environment, but erstwhile PCBs hotspots in a former Military Base in Luzon are known. Access to the Base led to the initial studies on the variations of PCBs in soils and plants through time. Aside from concentration levels, the factors studied were the leachate potential, degradation of PCB Aroclors and congener patterns across soil type and moisture content on site, bioaccumulation factors between plants and soils and , as well as indices that may suggest potential routes of entry to the food chain. The PCB concentrations ranged between 17 - 1,040 $\mu\text{g L}^{-1}$ at 0 - 0.5 m depth, between 36 - 898 $\mu\text{g L}^{-1}$ at 1.0 - 1.5 m depth, between 20 - 73 $\mu\text{g L}^{-1}$ at 4 m depth and 21 $\mu\text{g L}^{-1}$ at 8 m depth. Total organic carbon was <1.0%. Soil particle size distribution was 4% gravel, 79% sand and 17% silt and 0% clay, while soil particle size outside the perimeter fence was 40% gravel, 46% sand and 14% silt and 0% clay. Moisture results ranged from 15% to 30%. Leachate PCB concentrations ranged between 17 - 1,040 $\mu\text{g L}^{-1}$ at 0 - 0.5 m depth, between 36 - 898 $\mu\text{g L}^{-1}$ at 1.0 - 1.5 m depth, between 20 - 73 $\mu\text{g L}^{-1}$ at 4 m depth and 21 $\mu\text{g L}^{-1}$ at 8 m depth. A greater percentage of more chlorinated congener (i.e., heptaCB) is a result from contamination by Aroclor 1260. The topsoil is dominated by highly chlorinated biphenyls: 6Cl, 7Cl, and 9Cl, accounting for more than 75% of the total concentration of PCBs. Surface soil obtained at 0.5m depth obtained the highest leachate median value in PCBs. As expected, the degree of PCB concentrations is inversely correlated to depth. There is also a negative correlation between the mean of the Toxicity Characteristic Leaching Procedure (TCLP) of PCBs versus the sampling depth. Linear regression analyses were used to determine the correlation of the factors such as depth, Octanol/Water Partition Coefficient (K_{ow}) and solubility affected Soil/Water Distribution Coefficient (K_d). Effects were found only when the soil depth is at 0.3 - 0.5 m (at 95% confidence level). K_d is positively correlated with K_{ow} while K_d has some level of negative correlation with solubility. No effect was found at 1.0 - 1.5 m, 4.0 m, and 8.0 m. Organic Carbon/Water Partition Coefficient (K_{oc}) showed high results exceeding the log K_{oc} criteria of 4.5; as a result, this is now a matter of concern on the potential adverse effects of the substance on terrestrial organisms within its vicinity. Roots had the highest BAFs PCB concentrations for *Duranta erecta* Linn. and *Lantana camara*.

Two-way ANOVA showed that bioaccumulation factors (BAFs) of *Duranta erecta* Linn. (Golden dew drops plant) and *Lantana camara* (*Kantutay* grass) had no significant differences between the leaves, trunks, and shoots. Based on these research data, mechanism of PCB pathway from soil to root and root to grass uptake is the first link to terrestrial exposure. High levels of obtained total PCB content from 2013 to 2017 exceeded the DENR and US EPA Regional Soil Screening Level for Industrial at 0.74 mg kg^{-1} . Variations and complexities of PCBs manifest over time. Slow degradation and persistence of PCBs exhibited its physical characteristics and resistance to external factors in the environment. The contamination of PCBs in the environment especially the higher chlorobiphenyls over decades of exposure, and proliferation of PCBs is an important environmental concern that may pose an environmental and health hazards.

Keywords: Aroclor, congener, leaching, polychlorinated biphenyls, vertical partitioning, bioaccumulation factor