

A Comparison of PCDF and PCDD Bioavailability among Terrestrial Invertebrates from the Tittabawassee River



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ENTRIX

ABSTRACT

Previous studies have indicated that the Tittabawassee River, located in central Michigan, USA, has elevated levels of polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-*p*-dioxins (PCDDs) in the sediments, floodplain soils, and biota downstream of the city of Midland. Floodplain soils and a variety of terrestrial invertebrates including earthworms were collected from reference and target areas ranging from Sanford MI to Saginaw MI for this study. Floodplain soil 2,3,7,8-tetrachlorodibenzo-*p*-dioxin equivalent (TEQ) concentrations ranged from 2.0 to 19 (ng/kg dry weight (dw)) in reference areas while target areas exhibited TEQ concentrations ranging from 140 to 4500 (ng/kg dw). Fresh worm TEQ concentrations were consistently greater than deparated worm TEQ concentrations in both the reference and target areas. At a representative target sampling area where eight orders of terrestrial invertebrates were sampled, the rank order of TEQ concentrations was as follows: fresh earthworms > coleoptera > deparated earthworms > isopoda > gastropoda > hymenoptera > lepidoptera > hemiptera. The predictive relationship between soil TEQ concentrations and terrestrial invertebrate TEQ concentrations was examined.

INTRODUCTION

This study was designed to measure polychlorinated dibenzofuran and polychlorinated dibenzo-*p*-dioxin levels in terrestrial invertebrates that typically comprise the diet of study area receptors. Earthworms are good indicators of the presence of chemicals in terrestrial ecosystems for several reasons. These reasons include: (a) they comprise 89 to 92 percent of the soil's invertebrate biomass; (b) they occupy a major position in trophic webs; (c) they ingest enormous quantities of soil; in one hectare of land, up to 300 metric tons are ingested by earthworms; and (d) they ingest chemicals present in the soil over their lifetimes (Tarradellas et al. 1982). Invertebrates that inhabit leaf-litter and vegetation, such as coleoptera and hemiptera will also be collected as study area receptor diets are rather diverse.

METHODS AND MATERIALS

- Soil and terrestrial invertebrate samples collected from the Tittabawassee River floodplain during 2003 and 2004.
- Soil samples are collected from 1 x 1 m² plots from which earthworms are collected. Half of the earthworms collected are allowed to deparate prior to preservation.
- Insects are sampled by mercury vapor lamp, aerial and sweep nets, and hand-picking. All are sorted to taxonomic order for order-specific analysis.
- Chemical extraction EPA methods 3540C and 3541
- Analyses of the seventeen 2,3,7,8 substituted PCDF/D congener concentrations in samples are conducted at AgriQuality Limited (Lower Hutt, New Zealand) using EPA method 8290
- All TEQ values based on mammalian World Health Organization toxicity equivalency factors (Van den Berg et al. 1998)
- The TEQ concentrations are calculated by assigning a proxy value of 1/2 the detection limit (DL) for congeners below the DL
- Concentrations of TEQ in soil are expressed as ng/kg on a dry weight basis and all biota are expressed as ng/kg on a wet weight basis.



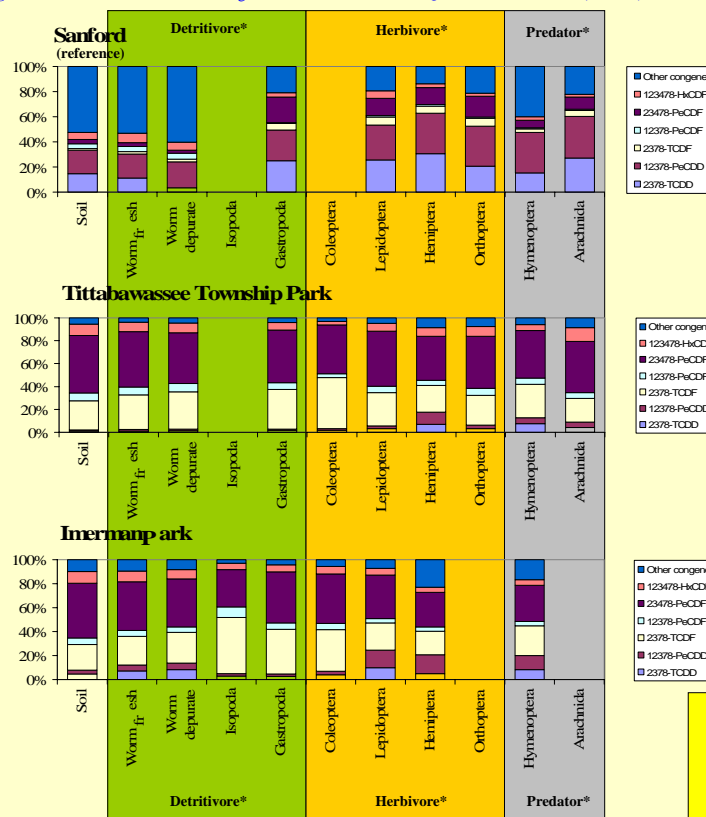
Congener patterns similar among feeding guilds

Table 1. Concentrations of TEQ (ng/kg) measured in soil and terrestrial invertebrates of the Tittabawassee River

	Sanford reference location			Chippewa Nature Center reference location			Tittabawassee Township Park target location			Imerman Park target location		
	N*	Mean	SD	N*	Mean	SD	N*	Mean	SD	N*	Mean	SD
Soil	7	4.18	±2.39	4	12.6	±7.67	8	2280	±1340	7	2050	±617
Earthworm fresh	1	0.686					1	129		1	96.4	
Earthworm deparate	1	0.612					1	83.5		1	76.1	
Isopoda										1	50.6	
Gastropoda	2	0.817	±0.758				1	49.1		2	49.8	±26.8
Coleoptera				1	3.81		1	347		2	85.5	±35.6
Lepidoptera	1	0.678					1	20.5		1	3.20	
Hemiptera	1	0.742		1	1.32		1	2.95		1	1.76	
Orthoptera	1	0.338		1	0.713		1	3.76				
Hymenoptera	1	1.65					1	5.62		1	9.49	
Arachnida	1	1.23					1	12.9				

* All samples are a composites of multiple grabs.

Figure 1: Percent PCDF and PCDD congener contribution to total TEQs in one reference area (Sanford) and two target areas.



*Terrestrial invertebrates grouped into feeding guilds based on diet.

RESULTS AND DISCUSSION

Mean total TEQ concentrations in soil and terrestrial invertebrates are higher in the target areas than in the reference areas. Mean TEQ concentrations measured in reference area soils are as low as 4.18 ng/kg (dry weight) while target location soils exhibit mean TEQ concentrations as high as 2280 ng/kg (dry weight). Mean TEQ concentrations of terrestrial invertebrates in reference areas are as low as 0.338 in orthoptera and as high as 3.81 ng/kg (wet weight) in coleoptera. Target location mean TEQ concentrations range from 1.76 in hemiptera and as high as 347 ng/kg (wet weight) in coleoptera. (Table 1).

CONCLUSIONS

- Congener patterns remain similar among feeding guilds within sites.
- Total TEQ concentrations are 10 times greater in soils than in terrestrial invertebrates in both reference and target areas.
- Mean TEQ concentrations measured in terrestrial invertebrates in target areas are 1.30 to 188-fold greater than those measured in reference areas.
- The six congeners that account for over 90% of total TEQ concentrations in target areas are listed here in rank order:
 - 2,3,4,7,8 PeCDF
 - 2,3,7,8 TCDF
 - 1,2,3,4,7,8 HxCDF
 - 1,2,3,7,8 PeCDF
 - 1,2,3,7,8 PeCDD
 - 2,3,7,8 TCDD
- Congener pattern in both fresh and deparate earthworms are nearly the same as congener patterns in soil at all sites.
- Total TEQ concentrations in reference area Orthoptera (grasshopper) are less than all other orders of terrestrial invertebrates.
- Total TEQ concentration for target area coleoptera (beetles) are the greatest of all terrestrial invertebrates.

REFERENCES

- Van den Berg et al. (1998) *Environ. Health Perspect.* 106: 775-79.
- Tarradellas, J., Diercxsens, P., and Bouche, M.B. (1982). Methods of extraction and analysis of PCBs from earthworms. *Intern. J. Environ. Anal. Chem.* 13: 55.

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Total soil TEQ 10 times higher than invertebrates

