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Review

A review of background dioxin concentrations in urban/suburban and rural soils across the United States: Implications for site assessments and the establishment of soil cleanup levels

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HIGHLIGHTS

- A review of available data to characterize background levels of dioxin-like compounds (DLCs) in U.S. soils.
- Background DLCs in urban/suburban soils were higher and more variable than in rural soils.
- Data indicate that background soil DLCs in urban areas may exceed regulatory remediation levels.

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ABSTRACT

Over the last several decades, dioxin releases have decreased >90%, leading to a corresponding decrease in human body burdens. In addition, the weight-of-evidence indicates that soil exposures have little impact on human body burdens of dioxin-like compounds (DLCs), with dietary sources being the greatest contributor. In spite of this, USEPA recently proposed substantially lower preliminary remediation goals (PRGs) for soil based on their new oral reference dose (RfD) for dioxin. As such, it is important to understand how these lower soil PRGs compare to background concentrations in urban/suburban and rural soils. The objective of this evaluation was to conduct a comprehensive review of available data concerning background levels of DLCs in U.S. soils. There was substantial variability in how the soil dioxin data were presented (e.g., raw vs. summary data, congener vs. toxic equivalency [TEQ] concentration, number of DLC congeners reported, etc.). In cases where TEQ estimates were based on outdated TEFs and congener-specific data was provided, TEQ concentrations were recalculated using the current WHO_{2006} TEFs. The data available for rural soils were generally more robust than for urban/suburban soils. Not surprisingly, background levels of DLCs in urban/suburban soils were higher and more variable than in rural soils: 0.1–186 vs. 0.1–22.9 ng/kg TEQ, respectively. In several cases, incomplete soil DLC data were available (e.g., DL-PCBs not included) and, as such, calculated TEQ concentrations likely underestimate actual background levels. Though the current data are somewhat limited, these findings indicate that background DLC concentrations in urban/suburban soils may exceed the USEPA's updated PRGs based on the oral RfD, and are expected to substantially exceed future PRGs to be developed based on the forthcoming dioxin cancer slope factor. This demonstrates a need to characterize anthropogenic background DLCs in non-rural areas across the US to avoid establishing soil screening levels and PRGs that are lower than background concentrations.

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1. Introduction

Dioxin-like compounds (DLCs) are ubiquitous in soils due to the wide variety of sources that have contributed to background levels across the U.S. (USEPA, 2003). These sources have historically included a variety of natural and anthropogenic sources such as medical, municipal and hazardous waste combustion, combustion of fuels, backyard barrel burning, forest fires, volcanoes, as well as a variety of industrial sources such as secondary copper smelting, chlorine bleaching of paper and pulp, and the production of chlorinated phenols (USEPA, 2003). While much of the focus has historically been on industrial sources, in fact natural sources have been found to result in high levels of DLCs in soils as well. Deardorff et al. (2008) characterized PCDD/Fs in ash and topsoil following the 2007 wildfires in California, and reported that the highest levels were found in areas where homes were burned, followed by areas of agriculture and brush. Concentrations in the samples were found to range from 1.3 to 1680 ng/kg TEQ (based on WHO_{2006} TEFs). Importantly, environmental releases of DLCs decreased by approximately 90% between 1987 and 2000 (USEPA, 2006). These reductions were achieved by several means, including regulatory activities, improved emission controls, voluntary actions on behalf of industry, and the closing of a number of facilities. As a result of this decrease in dioxin emissions from industrial activities, activities such as forest and brush fires, backyard barrel burning, etc. are now the primary sources of emissions. Nonetheless, because DLCs are persistent in the environment, they are present in nearly all soils in the U.S. at varying concentrations depending on historical activities/sources in the region. As such, it is essential to understand and characterize background levels of DLCs in urban, suburban, agricultural, and rural soils across the U.S.

Dioxin-like compounds are associated with a number of different health effects, and therefore the characterization of background levels of DLCs in soils is particularly important for evaluating human health risk, especially given recent activity by the U.S. Environmental Protection Agency (USEPA). In December of 2009, the USEPA Office of Superfund Remediation and Technology Innovation released a guidance document titled *Draft Recommended Interim Preliminary Remediation Goals for Dioxin in Soil at CERCLA and RCRA sites*. In this guidance document the Agency proposed interim residential soil preliminary remediation goals (PRGs) for DLCs of 3.7 and 72 ng/kg TEQ, and interim commercial/industrial PRGs of 17 and 950 ng/kg TEQ, based on cancer and non-cancer endpoints, respectively. The Agency ultimately recommended setting the draft interim residential soil PRG at 72 ng/kg TEQ (down from a value of 1000 ng/kg TEQ that had been used for decades (USEPA, 1998)) and setting the draft interim commercial/industrial soil PRG at 950 ng/kg TEQ (down from a value of 5000–20,000 ng/kg TEQ that had been used for decades (USEPA, 1998)). The rationale that the Agency provide for selecting these two values was that these PRGs "generally provide adequate protection against non-cancer effects," and in addition, "generally are protective for cancer effects at approximately the 1E-05 risk level, which is within USEPA's protective risk range of 1E-04 to 1E-06" (USEPA, 2009a). However, the USEPA never finalized their guidance document. Instead, following release of their final oral reference dose (RfD) for 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), the Agency developed new residential and commercial/industrial PRGs based upon this final RfD and posted these PRGs on the Superfund Program's Non-Cancer Toxicity Value for Dioxin and CERCLA/RCRA Cleanups Question and Answer website (http://www.epa.gov/superfund/health/contaminants/dioxin/dioxinsoil.html). The new residential and commercial/industrial soil PRGs developed by USEPA based on this final RfD and default exposure parameters are 50 ng/kg TEQ and 664 ng/kg TEQ, respectively. These soil PRGs also appear on the USEPA Regional Screening Level (RSL) tables (although the commercial/industrial value has been rounded down to 600 ng/kg TEQ on the RSL tables). As already noted, the USEPA has yet to release their updated oral cancer slope factor (CSF) for TCDD, but it is anticipated – based on the draft oral CSF released for public comment in May of 2010 – that the final value will be substantially higher (more conservative) than the oral CSF used to develop both the proposed interim PRGs (i.e., 3.7 ng/kg) and the current cancer-based RSL (i.e., 4.5 ng/kg). Thus, any cancer-based PRG developed based on the new cancer slope factor (once released) is expected to be well below both of these previously calculated cancer-based PRGs.

Notably, in the proposed interim PRG document (USEPA, 2009a), the USEPA claimed that the proposed residential soil PRG was expected to be higher than typical background levels for residential soils. To support this claim, the Agency cited the 1998 ATSDR *Toxicological Profile for Chlorinated Dibenzo-p-Dioxins* (ATSDR, 1998). The ATSDR toxicological profile presents a general overview of the concentrations of DLCs in soils at National Priority List (NPL) sites, industrial, urban, and pristine rural sites in the U.S. The data are extremely limited and difficult to interpret as presented in the ATSDR document because much of the data are limited to TCDD only, are presented as homologues detected in soils without mention of concentration, are presented as absolute concentrations of homologue classes rather than as TEQ, do not account for dioxin-like polychlorinated biphenyls (DL-PCBs), or are presented as TEQ concentrations based on outdated toxicity equivalency factors (TEFs). These limitations likely result in underestimates of soil DLC levels, and make it extremely difficult to understand whether the interim PRGs are in fact above or below typical urban, suburban, agricultural, and rural background soil concentrations. As such, the objective of this assessment was to conduct a comprehensive review of all available published and unpublished data that could be obtained concerning the