HUMAN HEALTH RISK ASSESSMENT (HHRA) NOTE NUMBER 2

CALIFORNIA DEPARTMENT OF TOXIC SUBSTANCES CONTROL (DTSC)
HUMAN AND ECOLOGICAL RISK OFFICE (HERO)

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ISSUE: Soil Remedial Goals for Dioxins and Dioxin-like Compounds for Consideration at California Hazardous Waste Sites

SUMMARY

This HHRA Note presents the recommended remedial goals for soils contaminated by dioxins and dioxin-like compounds expressed as dioxin toxicity equivalent (Dioxin-TEQs) concentrations. The US Environmental Protection Agency (EPA) has released only the non-cancer reassessment for dioxins (May 2010) (8); therefore, this note has been revised to present new information on how the non-cancer effects of dioxins and dioxin-like compounds can inform the development of health-protective remedial goals for mitigation sites in California. These goals may be further revised in the future, as new scientific information becomes available or when the U.S. EPA completes its reassessment of dioxins to also include the potential cancer risk.

These soil remedial goals do not supplant the US EPA Regional Screening Levels (RSLs) in a screening risk evaluation but are intended for use in the remediation process. The rationale for the use of these recommended remedial goals is provided in this note.

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Table 1 - Dioxin-TEQ Soil Remedial Goals for Sites in California

Exposure Scenario	**ng WHO-TEQ/kg dry matter (ppt)** (9)	**Comments**
Residential [a,b]	50	• 10^{-5} risk level[c] • Noncancer HQ = 1 • Compare to 95% UCL exposure concentration
Commercial / Industrial[d, e]	220 - 700	• 10^{-5} risk level to the HQ of 1 • Compare to 95% UCL exposure concentration
Agricultural [f]	<40	• Based on Germany Guideline (4) • Ceiling value

a) This is based on the US EPA residential soil RSL of 5 x 10^{-6} mg/kg (five parts per trillion (ppt)). The RSL was calculated based on a target carcinogenic risk of one-in-a-million (10^{-6}) (7). HERO is supporting a cleanup goal associated with a theoretical potential cancer risk of 10^{-5} because epidemiological studies have demonstrated that exposure to dioxin-contaminated soil is responsible for only a minimal contribution to the dioxin human body burden which suggest that the value of 10^{-5} is likely a large overestimation of the actual risk. The University of Michigan Dioxin Exposure Study (6), conducted on 946 persons, showed that less than 0.01% of the variation in serum dioxin concentrations could be attributed to polychlorinated dibenzo-p-dioxins (PCDDs) in soil and household dust. A study of women in West Virginia led to similar conclusions (3). The recommended remedial goal, based on both theoretical cancer risk and the information from the epidemiological studies, is the same as the US EPA non-cancer residential RSL of 50 ppt at the hazard quotient (HQ) threshold of one (7). If this remedial goal is used, EPA SW-846 screening level bioanalytical assays (4000 series) may be considered in initial site investigation activities, rather than the more sensitive (and more costly) 8000 series methods.

b) The recommended residential remedial goal should only be considered if farming or raising of food animals as the majority of the food supply for residents is not likely to take place at the site. Otherwise, the remedial goal should revert to 5 ppt, representing a 10^{-6} cancer risk level, and accounting for the more frequent soil exposure by residents and long-term ingestion of potentially contaminated food products.

c) Although this suggested residential remedial goal technically represents a theoretical 10^{-5} potential cancer risk, HERO supports this cleanup goal when animal farming as the main source of food for residents is excluded, because the studies referenced in footnote a) show that exposure to soil under normal residential conditions has minimal influence on the serum of exposed individuals and accordingly the 10^{-5} potential risk level is likely an overestimation of the actual potential risk.

d) The US EPA commercial/industrial, cancer-risk-based RSL is 22 ppt, representing a target risk of 10^{-6}. However, if the worker primarily works indoors, HERO recommends using remedial goal of 220 ppt, using the same reasoning as presented in footnote a). Depending on site-specific circumstances and through consultation with a HERO toxicologist, the non-cancer derived remedial goal of 700 ppt, representing a HQ of one may be adequately protective.

e) The commercial/industrial, cancer-risk-based remedial goal of 220 ppt may not be adequately protective if the receptor primarily works outdoors and is in direct contact with site soils while performing daily work activities so that regular incidental ingestion of contaminated soil may occur. In this case, the recommended remedial goal should revert to 22 ppt.

f) A HERO toxicologist should be consulted before using this remedial goal as a ceiling value, since an alternative remedial goal may need to be considered, based on site-specific agricultural land use. Agricultural use standards for some countries, as listed in Table 3, are in the range of California rural background concentrations.

Dioxin-TEQ remedial goals based on the protection of ecological health: The soil remedial goals derived herein are not necessarily protective of ecological organisms (receptors). Protectiveness is variable depending on the ecological receptors of concern at the site. Invertebrates and plants are generally not sensitive to dioxins, while some wildlife receptors can be markedly susceptible and could drive a risk-based cleanup. Consult with a HERO ecological risk assessor if your site contains habitat or could release dioxins to off-site habitat(s).

Table 2 – 2005 World Health Organization Human Toxic Equivalency Factors (TEFs) for Dioxins and Dioxin-like Compounds (9)

Compound	WHO 2005 TEF
Chlorinated dibenzo-p-dioxins	
2,3,7,8-TCDD	1
1,2,3,7,8-PeCDD	1
1,2,3,4,7,8-HxCDD	0.1
1,2,3,6,7,8,-HxCDD	0.1
1,2,3,7,8,9-HxCDD	0.1
1,2,3,4,6,7,8-HpCDD	0.01
OCDD	0.0003
Chlorinated dibenzofurans	
2,3,7,8-TCDF	0.1
1,2,3,7,8-PeCDF	0.03
2,3,4,7,8-PeCDF	0.3
1,2,3,4,7,8-HxCDF	0.1
1,2,3,6,7,8-HxCDF	0.1
1,2,3,7,8,9-HxCDF	0.1
2,3,4,6,7,8-HxCDF	0.1
1,2,3,4,6,7,8-HpCDF	0.01
1,2,3,4,7,8,9-HpCDF	0.01
OCDF	0.0003
Non-ortho substituted PCBs	
PCB 77	0.0001
PCB 81	0.0003
PCB 126	0.1
PCB 169	0.03
mono-ortho substituted PCBs	
105	0.00003
114	0.00003
118	0.00003
123	0.00003
156	0.00003
157	0.00003
167	0.00003
189	0.00003

TEQ concentrations are calculated by multiplying the measured congener concentration in a soil sample by its TEF (Table 2), and adding these converted values to produce the Dioxin-TEQ concentration for the sample. These TEFs were accepted by the DTSC Human and Ecological Risk Division in October 2006 and are equivalent to those adopted by the California Environmental Protection Agency (CalEPA) Office of Environmental Health Hazard Assessment (OEHHA) in January 2011 (2).

Table 3 - Current Agricultural Dioxin-TEQ Guidelines/Standards

Country/Entity	Landscape Scenario	ng WHO-TEQ per kg dry matter (ppt)	Comments	Reference
Finland	Agricultural/Residential	500	Limit value	4
Germany	Agricultural	5 – 40		5
Germany	Agricultural	<5	Target concentration	5
The Netherlands	Agricultural	1		5
The Netherlands	Dairy farming	10		5
Sweden	Sensitive use	10		5
Sweden	Less sensitive use	250		5
California ambient	Urban	7-20	Mean ~ 9	1
California ambient	Rural	1-6	Mean ~ 3	1

A range of standards have been proposed or put in place for agricultural land use scenarios by various regulatory entities as listed in Table 3. This is not meant to be a complete list but provides a range of remedial goals to consider for agricultural land use.

References

1. California Department of Food and Agriculture. Evaluation of Heavy Metals and Dioxin in Inorganic Commercial Fertilizers and California Cropland Soils. December 2004

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3. Diliberto, Janet J., et al. Cohort Study of Women in West Virginia: Serum Levels of Dioxin and Dioxin-Like Compounds. Organohalogen Compounds, Vol. 70: 000654. 2008.

4. Environment Protection and Heritage Council. National Dioxins Program – National Action Plan for addressing dioxins in Australia. October 2005.

5. Fiedler, Heidelore. Chapter 6. Dioxins and Furans (PCDD/PCDF) in The Handbook of Environmental Chemistry Vol.3, Part O Persistent Organic Pollutants, Springer-Verlag Berlin Heidelberg 2003.

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7. U.S. Environmental Protection Agency. Regional Screening Levels. https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables-may-2016

8. U.S. Environmental Protection Agency. Dioxin Reassessment (2010). Appendix A. Reanalysis of Key Issues Related to Dioxin Toxicity and Response to NAS Comments, Volume 1 (2012).

9. Van den Berg, M. et al. The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. Toxicological Sciences 93(2): 223-241. 2006.