

Regulatory Science: Ecological Risk Analysis With Censored Geochemical Values (Newsletter)*

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Toxic metals and organic compounds are commonly present at very low concentrations in water, sediments, soils, and rocks. Concentrations cannot be quantified with 99% certainty; if those chemicals are present the instrument cannot distinguish them from zero. Concentrations below laboratory reporting limits are censored because their values are unknown. Censored values can be 70-80% of the available data, a meaningful amount of valuable information.

Correct analysis of censored data is particularly important when performing an ecological risk analysis (ERA) as part of the CERCLA Superfund process. ERAs involve data summation and comparisons to a reference value. Incorrectly included censored data produce wrong results, potentially increasing expenses for responsible parties and ineffective restoration. Excluding censored values produces even greater errors.

In the past regulators directed censored values be dropped, all set to zero, all set to the laboratory reporting limit, or all replaced by substituting an arbitrary value between zero and the reporting limit. All four are wrong because they either lose valuable information in the original data or they add information that's not in the original data. Fortunately, regulators are slowly changing the statistical models.

ERAs are particularly sensitive to correctly incorporated censored data because values are summed when calculating toxic effects and errors strongly bias results.

Polychlorinated dibenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), and biphenyls (PCBs) are contaminants commonly found in complex environmental mixtures, including animal tissues. For more than a decade, EPA has estimated the combined risks to human health using a toxicity equivalence methodology. Ecological risk assessment application of this framework is slow, partly because of the variety of fish, bird, and mammals species to be considered.

A common task in environmental data analysis is summing a series of concentration values, e.g., when calculating an annual total mass of a contaminant entering a water body. It is more complicated when individual concentration

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values are unequally weighted, and these weighted values summed. This is how EPA-compliant ecological risk assessments are performed.

Ecological risk assessments require an overall numerical value of the effects on biota of chemicals such as dioxins, furans, and PCBs. Each of these contaminants is a set of chemical compound components, with each component (congener) having different toxicities to different organisms. By assuming individual congener toxicities are additive they are summed to calculate toxicity equivalent concentrations (TECs) for all congeners in the set to all organisms. TECs are used by human health regulators to recommend fish consumption limits; therefore, how a TEC is calculated can have serious environmental and economic impacts.

The toxicity of each chemical congener varies with the organism exposed to it; for regulatory purposes the relative toxicity of each dioxin or furan congener is scaled to the most toxic congener (2,3,7,8-tetrachlorodibenzo-*p*-dioxin; TCDD), by applying a toxic equivalent weighting factor (TEF). TEFs were established through consensus of panels of experts for each organism. TCDD has a TEF of 1.0, and less toxic congeners each have a value closer to zero. Measured concentrations are multiplied by the TEF to obtain the TEC for each congener. The total TEC is the sum of all individual TECs in the medium (usually sediments and soils). Congener concentrations may be below the laboratory reporting limits which means it is critical that these censored values are correctly incorporated into the summing process for a total TEC.

Dropping censored values, or substituting an arbitrary value for them, produces wrong total TECs and potentially adverse environmental and economic impacts.

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