Attachment 1-2

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Assessment of Whether to Develop Ecological Soil Screening Levels for Microbes and Microbial Processes

OSWER Directive 92857-55

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Executive Summary

Bacteria and fungi (i.e., microbes) are essential components of soil systems and the importance of microbial processes in terrestrial systems is well recognized. The Eco-SSL workgroup had lengthy discussions as to the merits of deriving microbial Eco-SSLs, and the potential significance of either having or not having Eco-SSLs for microbes in this guidance. As an outcome of these discussions, the Eco-SSL Steering Committee decided that Eco-SSLs for microbes would not be developed at this time for this guidance. The decision to not include microbial Eco-SSLs in this guidance should not be interpreted as any indication as to the perceived importance (or lack of) of microbes to soil ecosystems, or that microbes and microbial processes do not merit protection. Instead, it is the Steering Committee's recommendation that evaluation of risks to microbes and microbial processes at a Superfund site not be conducted at the screening level, but rather decisions as to the appropriate actions be discussed and decided among the decision makers (e.g., risk managers, risk assessors, responsible parties) as part of the baseline risk assessment. If determinations are made that microbes are appropriate assessment endpoints for a Superfund site, problem formulation and workplans should be developed to specifically address issues associated with scale and uncertainty for these sites.

Introduction

Microbes are essential components of soil systems. Microbes comprises nearly 90% of global biomass and biodiversity in ecosystems. In soil, microbial decomposition of organic material governs the rate of mineralization and the cycling of essential nutrients, and is an important determinant of soil fertility. Without the microbial biomass and the functions it performs, plants are not self-sustaining. The diversity of microbial taxa involved in various nutrient cycling processes can be related to the ubiquitous nature of certain substances. For example, relatively large numbers of microbial taxa can catabolize simple sugars and simple proteins, but substantially fewer taxa catabolize complex molecules such as lignin, keratin, or chlorinated biphenyls.

In non-agricultural settings, the importance of associations between plant roots and microbes (mycorrhizae) has gained recognition over the past twenty years. In particular, mutualism achieved between a host plant species and one or more fungal species is essential for certain plant species to flourish. Indeed, estimates are that more than 95% of all plant species and 99% of all plant individuals are mycorrhizal dependent - that is to say that elimination of mycorrhizal associations leads to dramatic shifts in the composition of the plant community. Even so, most associations are facultative and because there is great taxonomic diversity among fungal symbiots, the loss of one mycorrhizal species would not translate to a meaningful shift in primary production or structural shift in plant community composition. This is because individual plants often are colonized simultaneously by a few to several genera of mycorrhizae.

Although microbes are recognized as essential components of soil ecosystems, Eco-SSLs for microbes and microbial processes have not been included in this EPA Eco-SSL guidance. The decision not to provide these Eco-SSLs in this guidance was made following lengthy discussions among workgroup members that included both scientific and non-technical (e.g., policy) considerations. In support of these discussions, draft position papers on the subject were developed by the workgroup; one paper represented the merits for microbial Eco-SSLs for inclusion in this guidance, and the other paper presented reasoning for not deriving microbial Eco-SSLs for this guidance. In addition, a debate on this issue was conducted at the 20th Annual Meeting of the Society of Environmental Toxicology and Chemistry (SETAC 1999).

Considerations and Rationale for Not Deriving Microbial Eco-SSLs for this Guidance
The considerations and rationale for the Eco-SSL Steering Committee's decision not to derive EcoSSLs for microbes or microbial processes can be summarized as:

- This Eco-SSL guidance has been developed to support risk-management decisions for Superfund sites. As Superfund sites, these sites are identified as having significant contamination potentially present for many years or even decades. Contaminant risks of significance to the environment can be reasonably expected to be manifested to higher organisms (i.e., plants, invertebrates, wildlife). Therefore, the risk assessment should quantify risks for higher organisms. The absence of unacceptable risk to higher organisms would indicate that risks to microbes are not of a magnitude or significance to the ecosystem to warrant separate risk management considerations. There was a consensus within the Steering Committee that it is unlikely that site conditions would pose unacceptable risk only to microbes and not be reflected as unacceptable risk to plants, soil invertebrates, or wildlife. However, it may be important to develop endpoints in the baseline risk assessment to evaluate microbial processes. In the baseline risk assessment, attention can be focused on microbial processes as a further explanation of expected risks for plants, soil invertebrates, or wildlife, to address those situations where sustained dysfunction of microbial functions can be documented.

- There are a considerable number of published laboratory investigations that demonstrate contaminant effects to microbes or microbial processes, however, the actual significance and relevance of much of these data to Superfund sites is uncertain. Uncertainties exist as to whether laboratory microbial ecotoxicological studies are good surrogates for natural environments due to differences in factors such as scale, functional redundancies, and complexities. Based on the potential uncertainties associated with these data, the Steering Committee concludes that risk management would be better served by not making screening-level decisions based on these data; instead, assessments of potential risk to microbial communities and functions should be based on the baseline risk assessment that utilizes site-specific information rather than generic, screening-level data.

- The scale and dynamic nature of microbes presents a challenge to defining conditions that indicate actual or potential adverse conditions for microbes. Measurements of microbial function and community structure are subject to great spatial (across millimeter distances) and temporal (within minutes to hours) variation, which makes an evaluation of ecological consequence of any measured change challenging. Of the endpoints typical used in microbial ecology and toxicology, (e.g., population, diversity, respiration, enzyme activity, substrate use, mutation rate) each is modified substantially during testing. Microbial endpoints tend to be highly responsive to fluxes of temperature, moisture, oxygen and many other non-contaminant factors. While threshold response levels for plants, soil invertebrates, and terrestrial wildlife among different high quality studies are generally in good agreement (i.e., typically within an order of magnitude), microbial responses which can be dramatically influenced by testing conditions often range across several orders of magnitude among studies (e.g., from <10 ppm to >1,000 ppm) for a given chemical with no apparent explanation for the differences. Functional redundancy across broad taxonomic groups enables swings in community composition without remarkable change in rates of decomposition or community respiration. Consequently, it is exceedingly difficult to relate specific microbial activities with indications of adverse and unacceptable environmental conditions. For the most common microbial activities, functional redundancy easily masks population shifts.