Can Chemically-Based Sediment Quality Criteria Be Used as Reliable Screening Tools for Water Quality Impacts?[1]

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The US EPA (1991, 1994), California State Water Resources Control Board (1995) and others (e.g., Adams 1993, WEF 1992, AWWA 1994, MacDonald 1993, Long et al. 1995) have suggested that chemically-based sediment quality criteria, such as those evolving from equilibrium partitioning (EqP) and co-occurrence-based (CoO) assessment of potentially toxic chemicals in sediments, can be used to screen sediments for adverse impacts on the beneficial uses of the waterbody in which the sediments are located. Generally, the fundamental, inherent limitations of chemically-based sediment quality criteria are acknowledged by those who advocate the use of such criteria as "screening values." This approach, however, inappropriately presumes that values used for "screening" can justifiably be less reliable than those used in subsequent evaluation.

While values that are used to "screen" sediments or situations for inclusion in a group in need of further evaluation may be more inclusive, i.e., more conservative, than those which would serve as determiners of further action, they can be no less technically *reliable*. It is incorrect, indeed highly misleading, to assume that an *unreliable* value or approach is "conservative." To the contrary, an unreliable value or approach may well be under-protective, as can be the case with EqP and CoO-based approaches for sediment quality evaluation.

Unreliability of EqP and CoO Values

As discussed by Lee and Jones-Lee (1993a,b, 1995), and in references cited in those references as well as herein, CoO-based values are fundamentally flawed since they rely on the total concentrations of chemical constituents in sediments as a basis for assessing the water quality impacts of sediment-associated chemical constituents. Lee and Jones (1992) and numerous other authors have documented since the early 1970s that there is no relationship between the total concentrations of chemical constituents in sediments and sediment toxicity or the ability of the constituents in the sediments to bioaccumulate in aquatic organism tissue.

EqP values can apparently be reliably used to screen for a lack of adverse impact for selected chemicals provided that the predicted interstitial water concentrations are less than the water quality criterion. Such values, however, cannot be used to predict adverse impacts since there are a variety of other detoxification mechanisms that occur in sediments besides those that are used to normalize sediment chemical concentrations, i.e. TOC for some non-polar organics and AVS for non-iron heavy metals.

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One of the most significant fundamental problems with chemically-based sediment quality criteria - screen values is that they address only a small number of the potentially toxic chemicals in sediments. There are many thousands of chemicals that may be present in sediments, especially near urban and industrial areas, that could affect the beneficial uses of a waterbody. Only a few of these are considered in chemically-based sediment quality criteria and screening values. Further, and most importantly, some of the most frequent causes of sediment toxicity (low DO, ammonia, and hydrogen sulfide) are often ignored in chemically-based sediment quality evaluations.

Lee and Jones-Lee (1992, 1993b) have discussed that while EqP values cannot be used to reliably determine whether a sediment is toxic, they can be used as part of a sediment TIE to determine whether certain components of a toxic sediment are potentially responsible for the toxicity. If there is excess AVS compared to non-iron heavy metals, then it is highly unlikely that the heavy metals are the cause of the toxicity. Similarly, if the TOC normalized EqP predicted concentrations for certain nonpolar organics are less than the water quality criterion, then it is unlikely that those chemicals are the cause of sediment toxicity. Because of the high potential for unmeasured and unregulated chemicals to be present in sediments that can cause aquatic life toxicity, it will always be necessary to conduct toxicity tests on the sediments to properly screen for aquatic life toxicity-related beneficial use impairment (Wright 1992, Wright et al. 1992, Lee and Jones-Lee 1993b). Rather than wasting funds trying to use unreliable EqP or CoO-based sediment screening approaches, direct assessment of sediment toxicity should be made using readily available methodology that has been used by the US EPA and the US Army Corps of Engineers (USEPA/USACE 1991, 1994) for over 20 years in regulating contaminated dredged sediments.

It, therefore, may be concluded that chemically-based sediment quality criteria - "screening" values can under-estimate the impact of chemical constituents in sediments due to failure to consider all of the potentially toxic chemicals in sediments. They typically over-estimate the water quality impacts of the few regulated chemicals for which there are proposed sediment quality criteria - "screening" values as a result of failure to properly consider the toxic - available forms of constituents in the sediments.

The Regulatory Arena

In the real world, improper screening of sediments for their potential water quality impacts cannot be presumed to be rectified by further analysis. There are real ramifications of inappropriate screening of sediments whichever way the error is made whether the screening flags a benign sediment as a potential problem, or fails to identify a sediment that could pose water quality problems. Errors on either side can readily result in costly and time-consuming litigation. Failure to take "remediation" action on a sediment inappropriately screened "in" can lead to challenge from activists who view the retreat as relaxing concern or to claims of "backsliding." Failure to attribute real sediment-caused water quality problems to the right constituent can lead to expensive remediation programs without effecting an improvement in the designated beneficial uses of a waterbody. Further, it can incorrectly cause changes in NPDES discharge limitations for the waterbody. It is, therefore, highly important that any sediment

screening procedure be reliable for identifying those situations in which sediment-associated chemical constituents have real impacts on the designated beneficial uses of the waterbody.

It has been our experience in observing how numeric chemical concentration-based sediment screening and ranking procedures are used today, that it is difficult for a regulatory agency to reverse a decision once a sediment has been designated as a potential problem area. Some environmental groups and members of the public will not accept the explanation that further study has shown that the sediment was incorrectly designated as a potentially toxic sediment owing to the use of unreliable screening procedures. This situation has already resulted in appeals/litigation by environmental groups (Environmental Health Coalition of San Diego, CA vs. California Regional Water Quality Control Board, San Diego Region) to prohibit what they perceive to be a "relaxation" of designation of sediment toxic areas, even though further studies have shown that the initial screening results were inaccurate.

It is our conclusion, based on many years of work on the topic and review of the current literature as well as the findings of others, that EqP and CoO values are not reliable for screening sediments to identify those in further need of evaluation or for ranking sediments with regard to their potential impacts on the beneficial uses of a waterbody. Further, it is dangerous in today's adversarial regulatory arena to incorrectly classify a sediment as either "toxic" or "non-toxic" based on chemically-based sediment quality screening criteria. Such approaches can lead to significant over-regulation - remediation or under-regulation arising from the use of chemically-based unreliable sediment quality screening values.

References

Adams, W. J. (1993). Sediment quality criteria, authors reply. Environ. Sci Technol., 27:2, 205-6.

AWWA (1994). Sediment-quality criteria discussed. American Water Works Association MainStream, Denver, CO, 8, August.

California State Water Resources Control Board (1995). Draft functional equivalent document: development of the water quality control policy for implementation of the bay protection and toxic cleanup program. Sacramento, CA.

Lee, G. F., and R. A. Jones (1992). Sediment quality criteria development: technical difficulties with current approaches, and suggested alternatives (condensed version). Proc. HMCRI R&D 92 Conference on the Control of Hazardous Materials, HMCRI, pp. 204-211.

Lee, G. F., and A. Jones-Lee (1992). Water quality aspects of dredging and dredged material disposal. Handbook of Dredging Engineering, Ed. John B. Herbich, McGraw-Hill, Inc., NY. pp 9.59-9.67.

Lee, G. F., and A. Jones-Lee (1993a). Equilibrium partitioning-based values: are they reliable for screening contaminated sediment? Letter to the editor of Environ. Sci. & Technol., 27:994.

Lee, G. F., and A. Jones-Lee (1993b). Sediment quality criteria: numeric chemical- vs. biological effects-based approaches. Proceedings of Water Environment Federation National Conference, Surface Water Quality & Ecology, pp. 389-400, October.

Lee, G. F. and A. Jones-Lee (1995). Appropriate use of numerical chemical concentration-based water quality criteria. Human and Ecological Risk Assessment 1(1), 5-11.

Long, E. R., D. D. MacDonald, S. L. Smith, F. D. Calder (1995). Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments. Environmental Management, 19:1, 81-97.

MacDonald, D. D. (1993). Development of an approach to the assessment of sediment quality in Florida coastal waters. Prepared by MacDonald Environmental Sciences, Ltd., Ladysmith, BC. Prepared for Florida Department of Environmental Regulation, Tallahassee, FL, Vol. 1, 128pp, Vol. 2, 117pp.

US EPA (1991). Pre-draft guidance on the application of sediment quality criteria for the protection of aquatic life. EPAxxx/x-xx-xxx, US EPA Office of Science and Technology, Washington, DC, August.

US EPA (1994). Methodology for integrating and evaluating sediment chemistry and biological data housed in the national sediment inventory: an issue paper. Office of Science and Technology, Standards and Applied Science Division.

USEPA/USACE (1991). Evaluation of dredged material proposed for ocean disposal testing manual. EPA-503/8-91/001, Office of Water, Washington, DC.

USEPA/USACE (1994). Evaluation of dredged material proposed for discharge in waters of the US. - testing manual (Draft) inland testing manual. EPA-823-B-94-002, Office of Water, Washington, DC.

WEF (1992). Comments on US EPA EqP-based sediment quality criteria. WEF Sediment Criteria Work Group, Water Environment Federation, Alexandria, VA.

Wright, T. D. (1992). Evaluation of dredged material for open-water disposal: numerical criteria or effects-based? Handbook of Dredging Engineering, Ed. John B. Herbich, McGraw-Hill, Inc., NY. pp 9.59-9.67.

Wright, T. D., R. M. Engler, J. A. Miller (1992). Effects-based testing and sediment quality criteria for dredged material. Water Quality Standards for the 21st Century, EPA 823-R-92-009, Office of Science and Technology, Washington, DC.