Risk-Based Management of TBT-Contaminated Sediments in Norway: Remedial Approaches, Regulatory Requirements and Other Challenges

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Introduction: Sediments in many of Norway's fjords and harbors are impacted by various contaminants as a result of past industrial development and commercial operations on land and in water. Tributyltin (TBT) is one of the most notorious sediment contaminants. Even at relatively low concentrations, TBT is toxic to many aquatic organisms. An international ban on the use of TBT-bearing paints is scheduled to go into effect in January 2008, which should greatly reduce TBT inputs into fjords and harbors. Regardless, risks posed by TBT contamination already occurring in sediments will remain a major environmental challenge well into the future. If not managed in an appropriate and timely manner, existing sediment TBT contamination will continue to disperse and affect broader areas, thus exacerbating an already wide-spread, complicated and costly problem.

The goal of this paper is to discuss potential approaches for risk-based management (remediation) of TBT-contaminated sediments at impacted Norwegian sites, plus additional factors to consider when developing appropriate management strategies.

Methods: To meet the goal of this paper, we: (1) inventory management approaches that can potentially be used to reduce risks associated with sediment TBT; (2) discuss differences between and limitations related to specific approaches; and (3) identify additional factors to consider when developing case-specific strategies for managing sediment TBT.

Discussion: Risks posed by sediment TBT can be reduced using various ex situ and in situ management (remediation) approaches. All approaches reduce risk in essentially the same manner: by reducing TBT bioavailability and/or toxicity. Different approaches accomplish this in different ways, at different rates and to different degrees.

Ex situ, or removal-based, approaches (dredging), quickly and significantly reduce TBT bioavailability and/or toxicity simply by removing it from the system, although some residual TBT contamination typically remains behind due to limitations associated with even the "best" dredging techniques.

In situ management approaches (capping, treatment and natural recovery) reduce TBT bioavailability and/or toxicity in place by lowering TBT concentrations in pore waters contained within biologically active surface layers of sea-bottom strata. Such reductions may be achieved by rapid intentional or slow natural additions of new clean material overtop the contaminated sediment (in situ conventional capping or natural recovery, respectively). Reduced pore-water concentrations may also be achieved by adding reactive materials that encourage solid-phase sorption or microbial degradation of TBT, either in the contaminated sediment mass (in situ treatment) or in the overlying capping layer (in situ active capping). Sediment TBT appears to be relatively resistant to biodegradation, at least under anaerobic conditions, but seems to have a relatively high affinity for some sorbent solid phases. This indicates that in situ treatment and/or active capping approaches based on enhanced sorption may prove more effective.

No single TBT management approach should, or can, be applied to all cases. Instead, strategies must be developed on a case-specific basis, as a function of various case-specific factors such as: level and extent of TBT contamination; rate and degree of risk reduction desired; potential presence of co-located contaminants also requiring management; sediment conditions; site characteristics, costs, etc.

The Norwegian Pollution Control Authority (SFT) is currently in the process of revising and finalizing risk-based sediment quality guidelines which should contain regulatory direction for how risks posed by sediment TBT are to be managed. Thus, regulatory requirements – in addition to case-specific factors - will also dictate the approach taken for managing sediment TBT contamination.

Additionally, well-known challenges associated with measuring total sediment TBT concentrations in a representative, accurate and precise manner should also be carefully considered when establishing cleanup goals, selecting management approaches and designing post-remedial monitoring programs.