Norwegian Institute for Water Research

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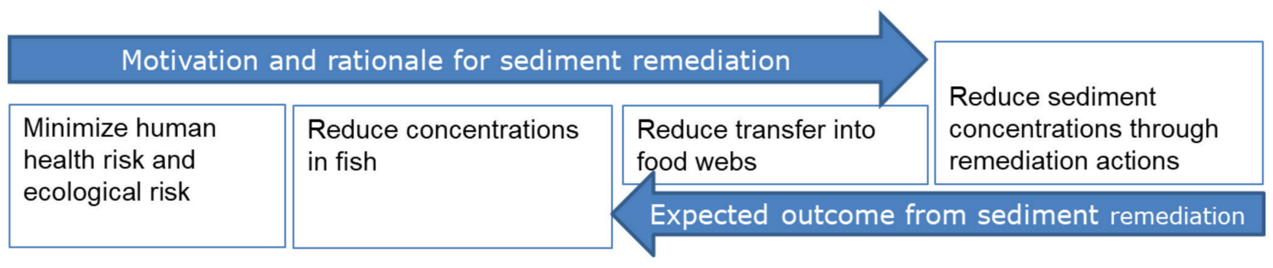
Establishing Cleanup Levels for Contaminated Sediment Sites in Norway Based on Bioavailability

Introduction

The cleanup of contaminated sediments is often motivated by the need to reduce risks to human health and the environment, with objectives typically defined as

- Take contaminants out of circulation
- Reduce flux to water
- Reduce transport to adjacent areas
- Reduce uptake into biota
- Reduce ecological and human risk

To meet this, cleanup strategies have typically aimed at reducing the sediment concentrations within the biologically active zone to reach defined concentration levels, and this has traditionally been carried out by dredging or isolation capping.



The goal to reach defined sediment concentrations of contaminants is in accordance with the goal of Good Chemical Status set in the Water Framework Directive (WFD), which in Norway are classified primarily on sediment and biota concentrations. However, the risk for exposure to biota is more related to pore water concentrations than to total sediment concentrations, as demonstrated in the Norwegian Guidelines for Risk Assessment of Contaminated Sediments (M-409/2015). No EQS have been defined for pore water.

Materials and methods

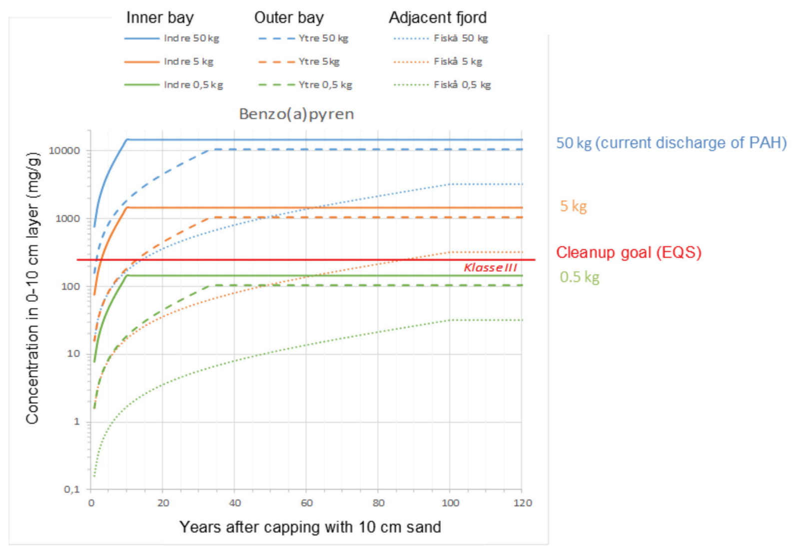
Here we present three examples of Norwegian remedial action plans where, for different reasons, proposed sediment cleanup levels are based on reduced bioavailability rather than total sediment concentrations

Mosjøen (Ranfjorden):

- Remediation site ~ 20 000 m^2
- Cost reduction during the construction phase would make the risk assessment approach feasible
- Kds calculated based on particulate and porewater (solid phases extraction) concentrations
- Water EQS and minimum Kd used to calculate dredging target level of 46 ppm PAH_{16}
- Capping layer of fine/coarse gravel design and applied after dredging

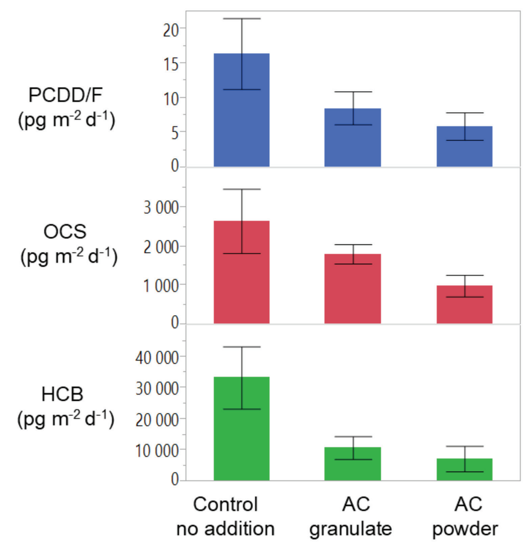
Kristiansand:

- Remediation site ~50 000 m^2
- Ongoing production and regular discharges not possible to stop as long as production is running.
- Site specific sediment/porewater K_d is 1-2 orders of magnitude higher than generic values used in the Norwegian risk assessment guidelines
- Even with BAT, discharges cannot be reduced to a level that will maintain cleanup levels below EQS for sediment
- A combination of reduced discharges and AC amendment reducing $\mathbf{C}_{porewater}$ by 80% was estimated to give acceptable $\mathbf{C}_{porewater}$ (=EQS_{water}).



Porsgrunn:

- Remediation site ~700 000 m^2
- Very soft sediments make traditional remediation approaches challenging
- A permanently submerged meadow covers 10% of area: this is an important habitat that should be conserved
- Test of activated carbon amendment has shown reduced flux of chlororganic contaminants from this sediment (i.e. <1% of current discharge)



Results and discussion

The bioavailability approach is in accordance with the Norwegian risk assessment guideline, which is based upon a tiered approach. Tier 1 is based upon screening levels of contaminants classified into 5 concentration classes ranging from natural background (class I) to severe impairment (class V). Sediment EQS are harmonized with upper limit concentrations of class II (AA-QS) and operational cleanup goals are most often set to achieve sediment concentrations below this limit.

Class I	Class II	Class III	Class IV	Class V
Background levels	No toxic effects	Chronic effects from long-term exposure	Acute toxic effects from short-term exposure	Severe toxic effects
	AA-QS, PNEC	MAC-QS, $PNEC_{acute}$	$PNEC_{acute}$ * safety factor	

Higher cleanup goals can be accepted if Tier 2 and 3 risk assessments are performed, based on more site specific data including measured pore water concentrations; however, few problem owners collect data sufficient enough to develop Tier 3 cleanup levels. In Mosjøen, Norwegian authorities have accepted a sediment cleanup level that i) is based on Tier 3 risk assessment with site-specific partitioning studies, and ii) is protective of pore water and surface water quality. The remedial action in Mosjøen was completed in 2017. For Porsgrunn and Kristiansand, the decision from Norwegian authorities to accept or reject similar approaches is pending.

Conclusions

Even though dredging and isolation may reduce the sediment concentrations right after remediation action has taken place, benthic fauna and flora are crucially disturbed during the operations, and the methods have no effect on resuspended or new potentially contaminated sediments settling on the remediated area. The use of active materials such as activated carbon is a low impact approach which limits the adverse effects from remediation, while reducing the bioavailability of the contaminants in question. Further, the active materials may have effect also on new settled sediments. However, long-term effects of AC amendment on certain species groups have been reported. This emphasize that the potential ecological impacts associated with the different remedial technologies should be taken into consideration when proposing cleanup strategies.