

# Challenges in remediation of contaminated sediments in Norway

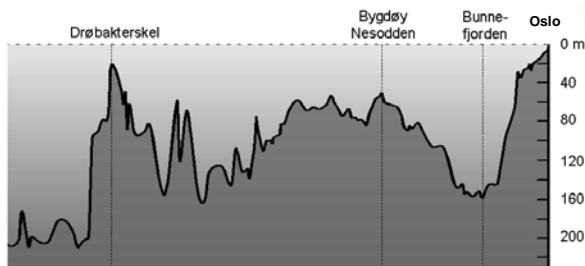
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**Introduction:** In Norway serious contamination of marine sediments has been found in fjords and coastal areas. This has resulted in restrictions on the consumption of fish and fishery products in many fjords. The Ministry of the Environment has identified the abatement of contaminated coastal, fjord and harbour sediments as a top priority for the coming years. Depending on the level of ambition cost estimates varying from 1.1 to 3.5 billion USD have been mentioned. As a result of the general depth of Norwegian fjord systems, there is a limited need for maintenance dredging. Large-scale remediation will therefore often be initiated based on environmental requirements only. However, large gaps in the required knowledge to solve these problems exist. Priority areas are:

- Development of technological solutions
- Documentation of efficiency of solutions
- Quantify environmental response after contaminant reduction

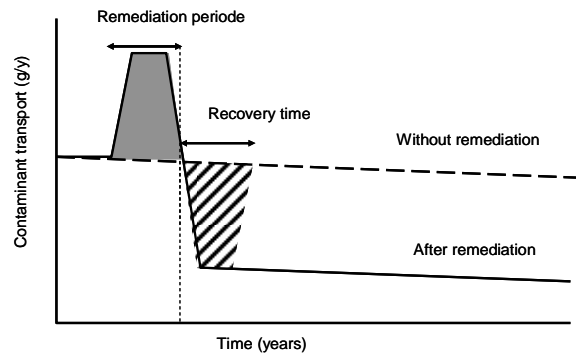
**Natural conditions:** The Norwegian coastline is characterized by deep threshold fjords with little circulation, forming deep often anoxic basins (fig. 1). The absence of major rivers results in low sedimentation rates and generally fine textured sediments. Urbanization and industrialization has resulted in considerable input of persistent contaminants, which accumulate at the bottom of the fjords. Strict environmental regulation during the last decades has resulted in a strong reduction in point sources of contaminant.



**Fig. 1:** Depth profile of the Oslofjord from the entrance at the threshold at “Drøbacterskel” (left) to the innermost parts near Oslo, a distance of approximately 50km.

Further environmental improvement requires an understanding of the contribution from diffuse sources like urban run-off as well as the potential for remobilisation of contaminants stored in the sediments.

**Technological solutions:** Given the size and extent of contamination in the Norwegian fjords, natural recovery by further source reduction might be a preferred option. However, sedimentation rates are so low that environmental improvement will not be achieved within several decades. Acceleration of the natural recovery process by capping solutions seems a more feasible option. This might involve the use of both passive and active materials in variable thicknesses. Sediment removal by dredging will only be feasible in the relatively shallow coastal zone; in addition storage areas have to be found. Stabilizing dredged material and application in near shore disposal site might combine storage and land reclamation.



**Fig. 2:** Change in contaminant load in response to remediation.

## Efficiency of solutions:

To be able to assess the efficiency of sediment remediation options, a proper understanding of the physical and chemical stability of the contaminants is required. This will allow a prediction of contaminant mobilization and migration under various environmental stresses as a result of remediation. It will also support the selection of an appropriate remediation strategy based on a realistic estimate of the potential environmental improvement (fig 2.).