Risk assessment for contaminated sediments

- Recommendations for Latvia

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Introduction

A delegation of four people from The State Environmental Service of the Republic of Latvia (https://registri.vvd.gov.lv/eng/jaunumi/2014/12/the-state-environmental-service-of-the-republic-of-latvia?id=252) visited NIVA on the 23rd and 24th of September 2024 to learn about practice for classification and risk assessment of contaminated sediments in Norway.

In this document we present the basis of environmental risk assessments for sediments in Norway. It includes an overview of the main documents in use. Our assessment tools are based on the EU Water Framework Directive but adapted to Norwegian conditions. Most of the key documents are in Norwegian, but we have tested that common AI digital tools (and even Google Translate) will work quite well when translating into English.

Content

Introduction

The risk associated with an event is often presented as a product of the probability that the event will occur and the consequences of that event occurring (probability x consequences). An event is deemed high risk if the probability of the event is high or the consequences of the event would be severe, or both. The relationship between probability and consequences is illustrated schematically in Figure 1. In a risk assessment, each of the probability and consequence categories must be described unambiguously and as quantitatively as possible to enable the risk associated with the event to be classified.

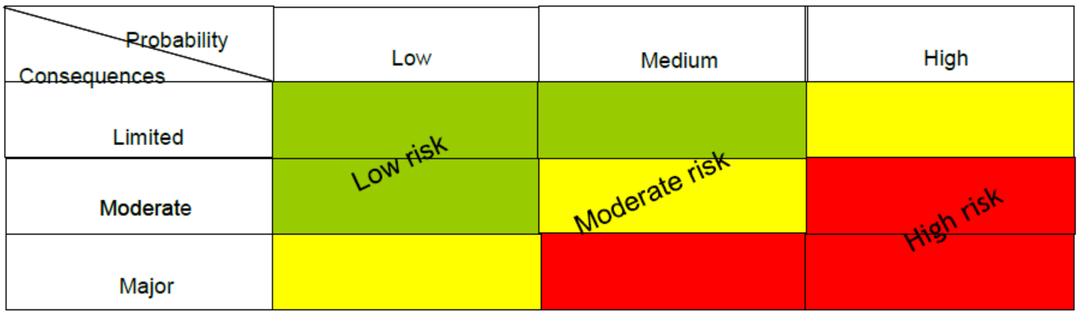

Figure 1 Risk matrix for the probability and consequences of a specific event.

Risk assessment of contaminated sediments

The formal definition of risk is used most often in an analysis of events for which both probability and consequences are variable. Norwegian guidelines cover an assessment of the risk posed by sediments in their existing state. In cases with contaminated sediments in an area, processes such as the spreading of hazardous substances through diffusion and uptake by organisms will always be occurring to a greater or lesser degree, and the probability of the event is thus equal to 1.

The probability of spreading via propeller erosion is dependent on the water depth. This probability is considered to be 1 in areas where there is ship traffic above sediments at a depth of less than 20 meters below normal sea level for sediments at greater depths. The risk assessment is thus first and foremost an impact analysis. Nevertheless, in Norway we use the term ‘risk assessment’ to refer to the assessment of the need for remedial measures to reduce risk to an acceptable level. See the recommendations for sediment management for more information on the sediment management methodology.

To aid the calculation of risk, a dedicated calculation tool has been prepared in Excel that includes all substance-related data and formulae featured in the guideline document M-409: Risk assessment of contaminated sediments.

A method for risk assessment of contaminated sediments has been developed in Norway. A guidance document for the risk assessment of contaminated sediment is available also in English. An Excel calculation tool for risk assessment of contaminated sediment has been developed in accordance with the guidance, and this is a very useful tool to describe the risks posed to organisms by the level of contaminants in a sediment area.

Veileder for risikovurdering av forurenset sediment; M-409 (1132 in English) *«Guidelines for risk assessment of contaminated sediments."* https://www.miljodirektoratet.no/publikasjoner/2018/november-2018/risk-assessment-of-contaminated-sediments/ Calculation tool: https://www.miljodirektoratet.no/publikasjoner/2020/april-2020/risikovurdering-av-forurenset-sediment--regneark/	

This document is a guideline created by the Norwegian Environment Agency, for assessing the environmental risk of contaminated sediments. It focuses on the risk of spreading (dispersion) of hazardous substances (contaminants), their potential impacts on human health, and potential effects on ecosystems. This is a management tool for environmental authorities, consultants and stakeholders evaluating marine sediments for potential remediation actions (cleanup).

Risk assessment is performed in three steps, each increasing in complexity and each step requires more specific, local data from the area in question. The basis of risk assessment is the combination of *probability* of something occurring and its *consequences*. Output is an understanding of risk to human health caused by sediments. The guidelines are harmonized with the system for classification of contaminated sediments. Risk assessment is dependent on seabed activities and area size. A stepwise illustration of the process is shown in Figure 2.

Step 1
Simple assessment, comparing contaminant concentrations in sediments against guideline values such as EQS. Requires data on contaminant levels, toxicity tests and sediment data (characteristics).

Step 2
More data is studied, such as spreading potential, human health risks and ecological effects. The transport of dissolved contaminants (with water) and particle-bound substances are studied, in addition to bioaccumulation and biomagnification properties in the food chain of the area.

Step 3
Provides a more comprehensive and locally based risk assessment with the use of site-specific data to further explain the risk estimates from step 2.

Risk assessment is used in Norway when deciding upon site-specific sediment remediation actions and goals:

- What is the actual site-specific environmental risk?

- What would be a relevant goal for remediation (improvement) given the risk?

The primary remediation goal should be that all sediment samples collected from the area should exhibit contaminant concentrations below EQS_{sed}, i.e. no chronic or acute effects on biota; the Predicted No Effect Concentration (PNEC). This implies that there are no active sources contributing to fresh contamination, and that remediation methods are feasible, cost/benefit supports the remediation action and goals are within reach.

Alternative remediation goals could be the $PNEC_{acute}$, represented by sediment concentrations in Class III or higher (see document M-608). This is possible if there are potential land-based contamination sources (e.g. urban runoff, industry, WWTPs) with ongoing discharges to the area. Could also be considered if the environmental risk is low, even though high sediment concentrations are found, or the ecological status is good.

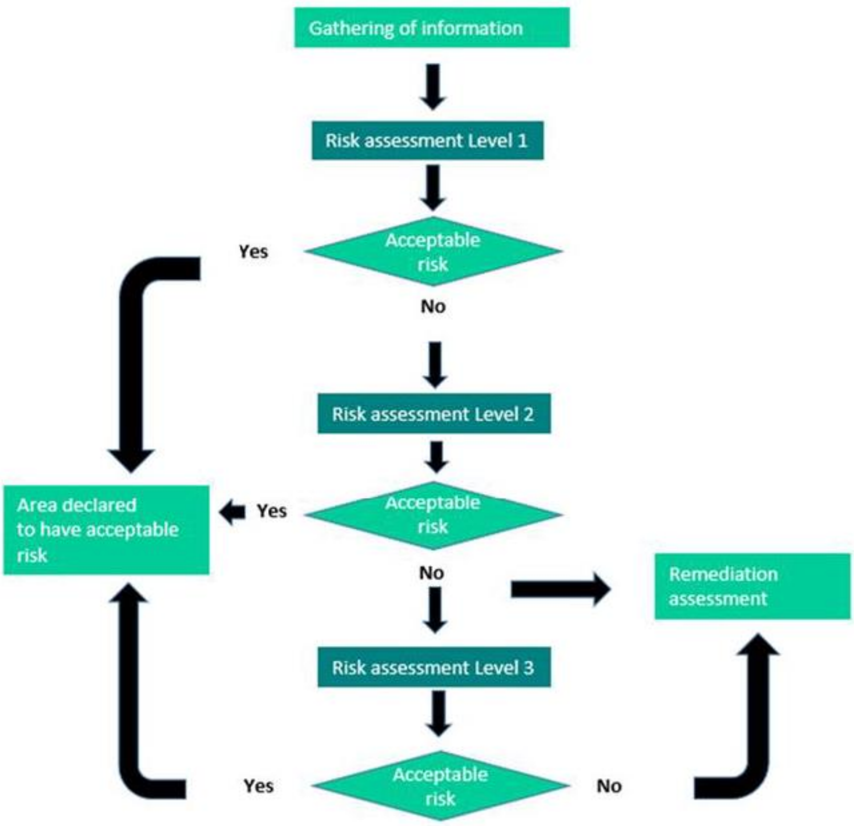

Figure 2 A stepwise general structure of the risk assessment system for contaminated sediments in Norway.

Figure 3 shows another illustration of the stepwise process of risk assessment for contaminated sediments. Risk is often determined by the bioavailability of the contaminants and uptake into biota (mussels, fish). Throughout the steps, a series of data must be collected and interpreted correctly. As step 1 involves comparison with EQSs, step 2 evaluates the dispersion potential, impact on human health and damage to the ecosystem in more detail. Several factors are considered, such as activities in the area, physical-chemical properties of the water body, and toxicity tests. Appendix V in document M-409 (1132) provides a thorough checklist for the risk assessment in step 1 and 2. The local conditions are taken more into account in step 3, providing a more reliable basis for evaluating the need for remediation.

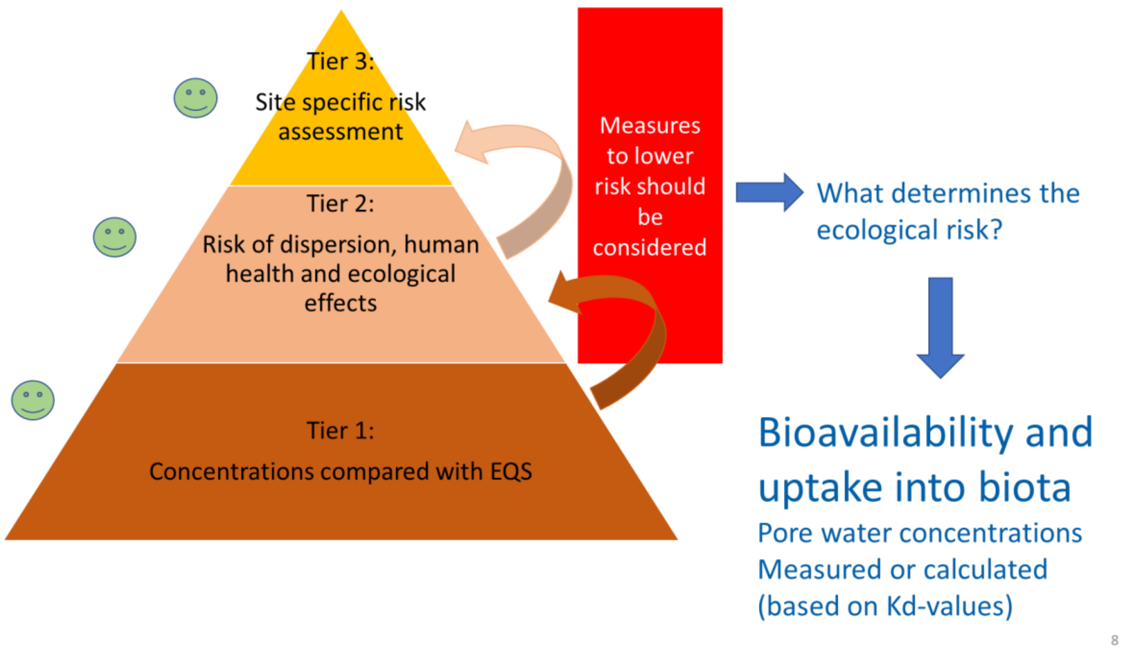

Figure 3 Illustration of the three-step process.

The results of the risk assessment must be documented in writing. The structure of a main technical report is outlined in Appendix VI, in document M-409 (1132). The report must contain complete documentation of the risk assessment carried out in Levels 1 and 2. The target group for the main report will be problem owners/clients, environmental authorities, and possibly the research and consultancy communities. Although the main technical report will include a summary, it may also be desirable to produce a separate summary report.

This should preferably be approximately 10 pages and should focus on:

- Objectives and assumptions
- Implementation
- Key results, preferably in the form of figures and tables
- Conclusions and recommendations.

The target group for the summary report will be administrative personnel and the public. Appendix VI in document M-409 (1132) does not include reporting from Level 3, as this will depend on the content and scope of the risk assessment. The main report for Level 3 should contain at least as much detail as the reports for Levels 1 and 2.

Risk calculation using the spreadsheet

A detailed Excel spreadsheet has been developed in Norway to perform a site-specific risk assessment (link above). This spreadsheet has been designed to execute calculations in accordance with the risk guidelines explained in document no. 409 (1132). It also performs comparisons with threshold values stipulated in the guidelines and ensures that the basis for all calculations is transparent. Detailed explanations for each step and data required are provided in the user guideline of the Excel document, such as:

- **Site specific data: default or actual data**
- **Sediment concentrations: measured**

- **Seawater concentrations: measured**
- **Porewater concentrations: measured (if applicable)**
- **Concentrations in benthic (bottom dwelling) fauna**
- **Concentrations in fish**
- **Ecotoxicity data: standard tests, if possible.**
- **Calculations of spreading potential, partition coefficients (K_d between water and particles)**
- **Human exposure**

Remediation measures

Improving the ecological or chemical status in a studied area of contaminated sediments may be carried out in several ways. Often, remediation actions are complicated and expensive with several risks associated with the different processes. Deciding upon a specific remediation action method involves measures such as:

- Cost
- Benefit
- Effect on chemical status
- Adverse effects

Different actions include dredging (removal), capping (covering with clean materials and/or an active layer that may potentially bind contaminants harder to particles), natural recovery (if a river supplies the area with clean particles to the area), or a combination of the above, see Figure 4. Impacts on bottom dwelling organisms should be considered. How long does it take for the ecosystem to recover? This is often a difficult question to answer.

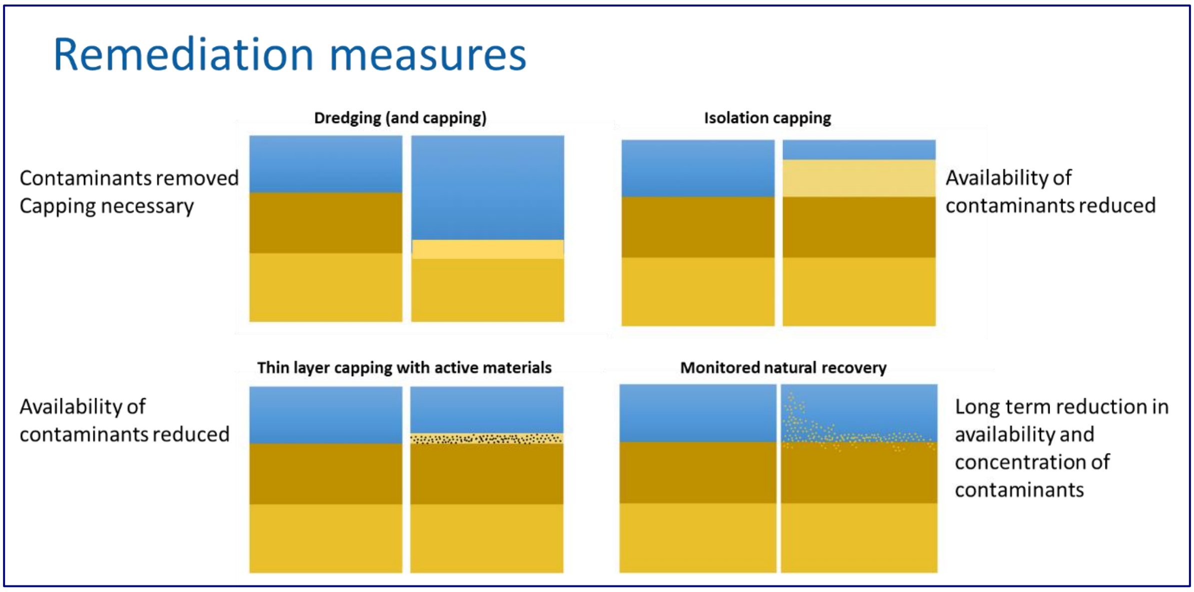

Figure 4 Examples of remediation measures.

Main Recommendations

As of 2024, Latvia does not have classification systems meant for contaminants in coastal marine sediments or freshwater sediments. Instead, an evaluation system contaminant levels in *soil* is used in Latvia to classify concentrations of contaminants in sediments. We highly recommend developing a classification system for environmental contaminants in marine and freshwater sediments in Latvia. This is mainly because the risk of exposure to organisms are quite different in soils compared to sediments with overlaying water. In addition, chemical processes in coastal sediments and freshwater sediments are quite different than chemical processes in soil. There are different organisms in coastal sediments and freshwater sediments – compared to organisms in soil on land. Monitoring of contaminants in sediments will be better by using classification systems directly derived from data for sediments.

The classification system and risk assessment tools we have in Norway could be adapted to Latvian environmental conditions. The main step would be to develop **sediment EQS's** that can be used for classification in Latvia. This can be done according to the same technical guidance document that was used to develop sediment EQS's in Norway, but it **must be developed based on Latvian conditions**. This means that Norwegian EQS for specific contaminants **cannot** be directly adapted.

References

Norwegian Environment Agency (NEA, Miljødirektoratet), 2018. Guidelines for risk assessment of contaminated sediments, Document M-409 (1132 in English).

Norwegian Environment Agency (NEA, Miljødirektoratet), 2020. Grenseverdier for klassifisering av vann, sediment og biota – revidert 30.10.2020 - Quality standards for water, sediment and biota – revised 2020.10.30. Document no. M-608.