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Risk-based prioritization of ground water threatening point sources at catchment and regional scales

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HIGHLIGHTS

- A Danish EPA handbook supports systematic large scale risk-based prioritisation.
- A flexible tool box guides the users through the necessary steps.
- Communication is supported by standardised GIS-themes, graphs and tables.
- Two case studies with very different challenges and needs are presented.
- The concepts are general and can be applied where similar challenges are faced.

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ABSTRACT

Contaminated sites threaten ground water resources all over the world. The available resources for investigation and remediation are limited compared to the scope of the problem, so prioritization is crucial to ensure that resources are allocated to the sites posing the greatest risk.

A flexible framework has been developed to enable a systematic and transparent risk assessment and prioritization of contaminant point sources, considering the local, catchment, or regional scales (Danish EPA, 2011, 2012). The framework has been tested in several catchments in Denmark with different challenges and needs, and two of these are presented.

Based on the lessons learned, the Danish EPA has prepared a handbook to guide the user through the steps in a risk-based prioritization (Danish EPA, 2012). It provides guidance on prioritization both in an administratively defined area such as a Danish Region, and within the bounds of a specified ground water catchment. The handbook presents several approaches in order to prevent the prioritization from foundering because of a lack of data or an inappropriate level of complexity. The developed prioritization tools, possible graphical presentation and use of the results are presented using the case studies as examples.

The methodology was developed by a broad industry group including the Danish EPA, the Danish Regions, the Danish Nature Agency, the Technical University of Denmark, and consultants — and the framework has been widely accepted by the professional community in Denmark. The concepts are quite general and can be applied in other countries facing similar challenges.

1. Introduction

Contaminated sites threaten ground water resources all over the world. In the European Environment Agency's most recent estimate, there may be as many as 3 million contaminated sites in the EU, of which about 250000 sites require clean up (EEA, 2007). These numbers are increasing and despite the scope of the problem, the available resources for remediation are very limited. For these reasons prioritization is crucial to ensure that resources are allocated to the sites posing the greatest risk. The key questions are: Which actions should be taken at each site and in which order? To answer these questions, risk assessment and prioritization of contaminated sites are required at the site,

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catchment and regional scale, and must be developed on the basis of data of varying quality — ranging from very detailed to very poor information.

The motivation for initiating clean-up is often determined by the measured impact, or estimated future impact on receiving waters or water supply wells. To address this need it has been proposed that risk assessments should be conducted at the catchment scale, where the risk of a contaminant point source to supply wells in the catchment is evaluated (e.g. Einarson and Mackay, 2001; Frind et al., 2006; Tait et al., 2004; Troldborg et al. 2008). The advantage of such a catchment-scale approach is that the risk of different sites is assessed for the same receptor and so can be compared, which is essential for prioritization. A different approach is to compare the risks of all contaminated sites in an administrative region instead of a water catchment. Both approaches are discussed here.

Until recently, risk assessment in Denmark has been conducted only at the site itself, while catchment and regional impacts have not been treated systematically. In order to develop systematic catchment scale approaches, different risk assessment and prioritization methods have been tested by Danish authorities and a flexible framework for transparent risk assessment and prioritization has been developed. This paper presents the new approaches for regional and catchment scale risk assessment employed in Denmark.

2. Background: the legal and administrative framework

Ground water resources are often threatened by many different sites and so it is crucial to obtain an overview of both the most hazardous sites, and how the cumulative impact of minor sites contributes to the overall impact on the quality of the ground water resource. If such a comprehensive overview is not obtained, there is a risk that investments in expensive remediation projects will not produce the desired results.

The Danish Regions are responsible for the publicly financed efforts to locate, investigate and remediate contaminated sites which:

1. Pose a risk to groundwater resources suitable for use as drinking waterand/or
2. Pose a human health hazard — either because of an impact on indoor climate or through contact with contaminated soil.

The Regions are the Danish public authority with the task of preventing, removing or limiting damaging effects of soil contamination on groundwater, human health and ecosystems. If a risk assessment indicates a threat to a receptor (reflected in exceeded threshold values), remediation is needed. The administrative workflow for determining which sites require cleanup is divided into a number of phases and is shown in Fig. 1.

Public remediation efforts must be organized and prioritized within the constraints of the available economic resources. Classical risk assessment does not handle the question of how to prioritize between different sites within a larger area when the available economic resources are insufficient to assess all of them within a limited time frame.

Other branches of the governmental also benefit from a better overview of the risks of contaminated sites. The Water Framework Directive and water action plans require coordinated efforts between different public authorities in order to ensure the best possible ground water protection. The increased need for interaction between authorities means that local scale risk assessment must be supplemented by broader consideration of contaminant impacts on catchment and regional scales.

In Denmark, the Water Framework Directive is being implemented by the Danish Nature Agency who manages government policy on the natural environment. The Nature Agency is responsible for mapping the threats posed by pollution from agriculture and point sources to the most vulnerable ground water resources. A major challenge for the Nature Agency is the need to view groundwater and surface water as a single connected resource, and this increases the demand for risk assessment methods which examine more than local impacts.

Since the Regions have the task of managing contaminated sites, while the Nature Agency focuses on groundwater resources, a collective overview of the groundwater threats is necessary to coordinate the public efforts — and do so cost-effectively.

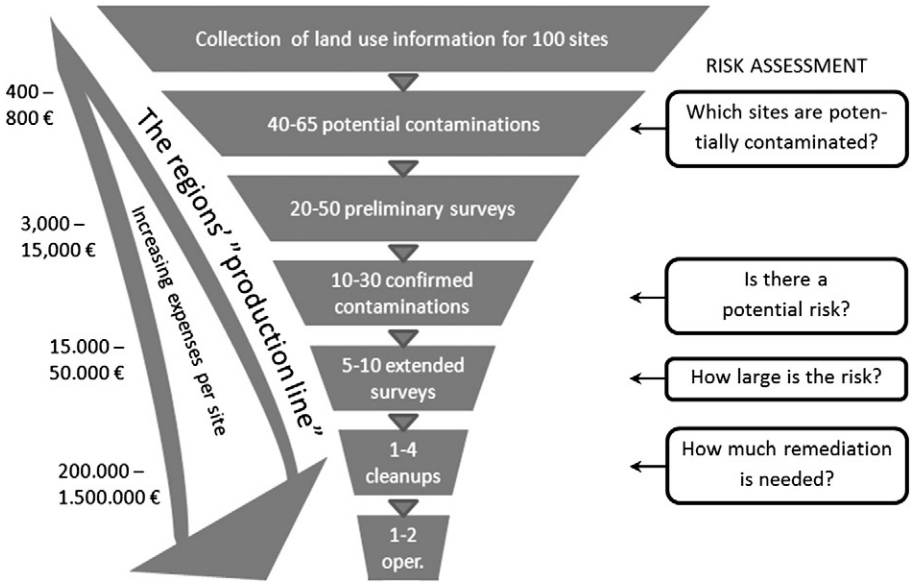

Fig. 1. Phases in the Danish administrative workflow to locate, investigate and remediate contaminated sites. The figure shows the number of sites typically proceeding to each phase. Out of 100 potentially contaminated sites, 1–4 will typically need to be remediated after a number of investigation steps. Risk assessment is needed to decide which sites should proceed to the next phase, and prioritization is needed to determine the order in which sites should be addressed. Data from the Danish Regions annual report to the EPA (Danish EPA, 2010). "Oper." means Operation and maintenance.