Multi-criteria assessment tool for sustainability appraisal of remediation alternatives for a contaminated site

Purpose: In order to improve and support decision-making for the selection of remedial techniques for contaminated sites, a multi-criteria assessment (MCA) method has been developed. The MCA framework is structured in a decision process actively involving stakeholders, and compares the sustainability of remediation alternatives by integrating environmental, societal, and economic criteria in the assessment. Materials and methods: The MCA includes five main decision criteria: remedial effect, remediation cost, remediation time, environmental impacts, and societal impacts. The main criteria are divided into a number of sub-criteria. The environmental impacts consider secondary impacts to the environment caused by remedial activities and are assessed by life-cycle assessment (LCA). The societal impacts mainly consider local impacts and are assessed in a more qualitative manner on a scale from 1 to 5. The performance on each main criterion is normalized to a score between 0 and 1, with 1 being the worst score. An overall score is obtained by calculating a weighted sum with criteria weights determined by stakeholders. The MCA method was applied to assess remediation alternatives for the Groyn 42 site, one of the largest contaminated sites in Denmark. Results and discussion: The compared remediation alternatives for the site were: (1) excavation of the site followed by soil treatment; (2) in situ alkaline hydrolysis; (3) in situ thermal remediation; and (4) continued encapsulation of the site by sheet piling. Criteria weights were derived by a stakeholder panel. The stakeholders gave the highest weighting to the remedial effect of the methods and to the societal impacts. For the Groyn 42 case study, the excavation option obtained the lowest overall score in the MCA, and was therefore found to be the most sustainable option. This was especially due to the fact that this option obtained a high score in the main categories Effect and Social impacts, which were weighted highest by the stakeholders.

Conclusions: The developed MCA method is structured with five main criteria. Effect and time are included in addition to the three pillars of sustainability (environment, society, and economy). The remedial effect of remediation is therefore assessed and weighted separately from the main criteria environment. This structure makes interpretation of criteria scores more transparent and emphasizes the importance of effect and time as decision parameters. This also facilitated an easier weighting procedure for the stakeholders in the case study, who expressed a wish to weigh the remedial effect independently from the secondary environmental impacts.