Sustainable Management of Contaminated Sediments

Gestion durable des sédiments contaminés

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ABSTRACT: Increasing sea transport volumes require expansion of ports and due to longer, wider and more deep-draught ships considerable dredging of sediments often contaminated with heavy metals and organic contaminants has to be implemented. Handling options have to be identified in each actual case and the choice of option should be based on a sustainability approach, considering economy, environment and social aspects. In the EU-funded project "Sustainable Management of Contaminated Sediments in the Baltic Sea" (SMOCS; www.smocs.eu) within the Baltic Sea Region Programme 2007-2013, tools for assessment and decision making are developed, i. e. Life Cycle Analysis (LCA), Risk Assessment (RA) and Multi Criteria Decision Analysis (MCDA). To develop the tools a series of case studies have been performed comparing different handling options such as land disposal, sea disposal, confined aquatic disposal and beneficial use in port constructions utilizing the stabilization/solidification technology.

RÉSUMÉ : L'augmentation des volumes de transport maritime nécessitent l'extension des ports, et l'arrivée de navires plus longs, plus larges et à plus fort tirant oblige le dragage considérable de sédiments souvent contaminés par des métaux lourds et des polluants organiques. Différentes options de gestion doivent être identifiés dans chaque cas concret et le choix de l'option doit être fondé sur une approche de durabilité, compte tenu de l'économie, l'environnement et les aspects sociaux. Dans l'UE, un projet financé par «La gestion durable des sédiments contaminés de la mer Baltique "(SMOCS; www.smocs.eu) au sein du programme régional de la mer Baltique 2007-2013, des outils d'évaluation et de prise de décision sont développés, i. e. Analyse de Cycle de Vie (ACV), l'évaluation des risques (RA) et la multi-analyse des critères de décision (MCDA). Pour développer ces outils, une série d'études de cas ont été réalisées comparant diverses méthodes de manutention telles que l'enfouissement, l'immersion en mer, l'immersion confinée aquatique et l'utilisation bénéfique dans les constructions portuaires en utilisant les technologies de stabilisation / solidification.

KEYWORDS: Contaminant, sediment, mangement, sustainablility, stabilisation, solidification.

1 INTRODUCTION.

Sea transport is increasing due to its environmental and economic benefits. Ports are therefore a key part of the multi module transport system in the society. In Sweden, for example, the ports manage more than 90% of the tonnage in the trade. To enable to manage this amount of trade, ports have to run and operate a port infrastructure that is robust, cost effective and environmentally sustainable.

The increase in sea transport as well as longer, wider and more deep-draught ships cause huge needs of maintenance and development dredging of sediments in fairways and ports. In the coming years several million cubic meters of sediments need to be dredged in the Baltic Sea. A large volume of these sediments is contaminated with heavy metals and organic contaminants (HELCOM, 2009). This highlights a key issue for the society in the future - what is the sustainable management of these sediments? To approach sustainable management assessments should not be limited to site specific emissions but also include other categories such as use of energy, resources and climate impact (Arevalo, 2007). Handling options for dredged sediments have to be identified in each actual case and the choice of handling option should be based on a sustainability approach, considering economy, environment and social aspects, see Figure 1.

There are many possible options for managing contaminated sediments; the two major ones are either to take action or no action. In practice, action can include treatment in situ or ex-situ implying numerous options incl. capping of sea deposits, beneficial use of treated sediments as construction material or capping in-situ.

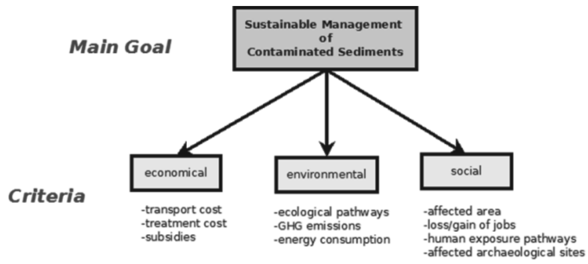

Figure 1. Sustainable management of contaminated sediments.

In the EU-funded project "Sustainable Management of Contaminated Sediments in the Baltic Sea" (SMOCS; www.smocs.eu) within the Baltic Sea Region Programme 2007-2013 tools for assessment and decision making are developed.

1.1 *Aim and objectives*

The aim of this paper is to presents results of case studies on assessment tools applicable in the sustainable management of contaminated sediments. The case studies include the stabilization/solidification (s/s) technology as one emerging sustainable handling option. Furthermore the authors present and invite stake holders to participate in networks to promote sustainable management in sediment handling and other port infrastructure.

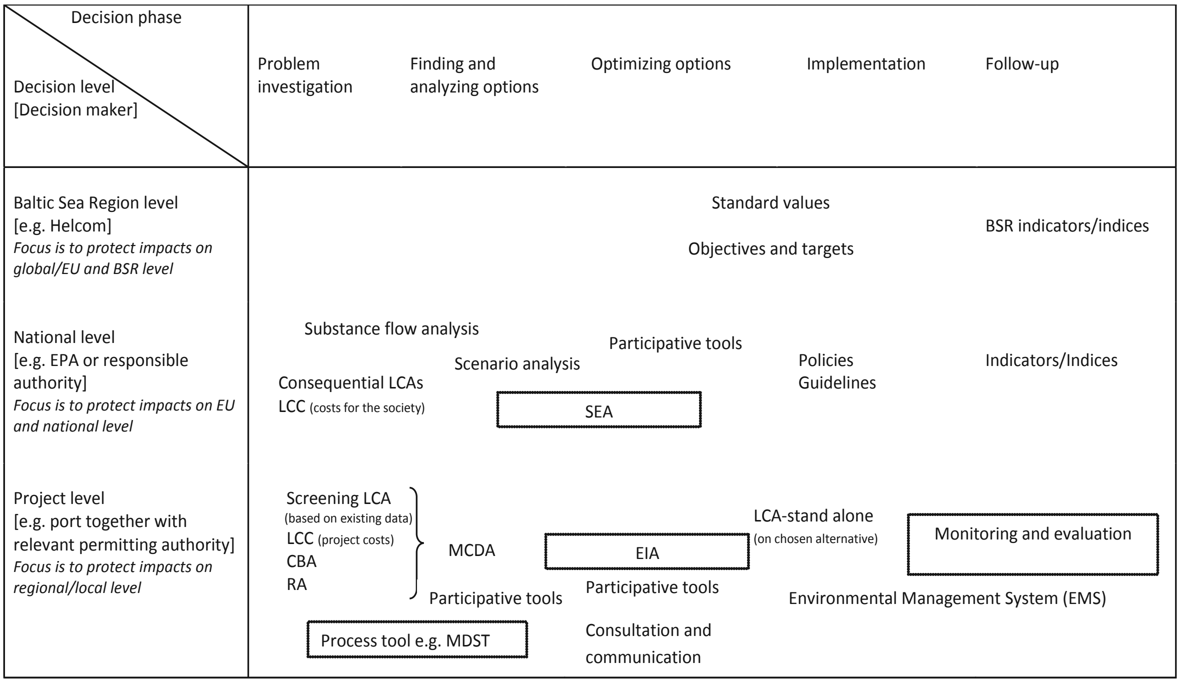

Figure 2. Examples of when different types of assessment tools which could be implemented in a decision process (Lundberg, et al, 2011).

2 TOOL-BOX FOR SUSTAINABLE MANAGEMENT

2.1 *Overview of tools*

There are several tools that could be used for sustainable assessment of contaminated sediments. The starting point for tools in decision making has to be based on an understanding of the nature of the decision that should be taken and the function and focus of the tool (de Ridder, et al., 2007). Therefore, the use of assessment tools depends on the decision level as well as the decision phase (se Figure 2).

Within the SMOCS project several case studies on assessment tools such tools have been performed. In this paper we present results from case studies using life cycle assessment (LCA) and multi criteria analysis (MCDA).

2.2 *Life cycle analysis (LCA)*

The purpose of a life cycle analysis (LCA) is to find out where in the life cycle the environmental load is the greatest and from what the impact is generated (ILCDA, 2011). This is mainly done through determining a material and substance flow. Thus is possible to assess the environmental impacts associated with all the stages of a product or a service/action life from-cradle-to-grave.

In the SMOCS project different management options of dredged contaminated sediments have been assessed by LCA (see Figure 3). The case studies have been based on sediment management in three ports; Port of Oxelösund, Sweden, Port of Gävle, Sweden and Port of Hamburg, Germany.

In the case studies of Port of Oxelösund and Port of Gävle, three possible management scenarios were compared. The scenarios were 1) utilization of sediment in quay construction by stabilization/solidification, 2) disposal in landfill and 3) disposal at sea. In the case study of Port of Hamburg, four management scenarios were compared. The scenarios were 1) disposal in river, 2) disposal at sea, 3) utilization of sediment in road construction or as landfill cover by METHA (Mechanical Treatment of Harbour Sediment), and 4) dewatering and disposal in landfill.

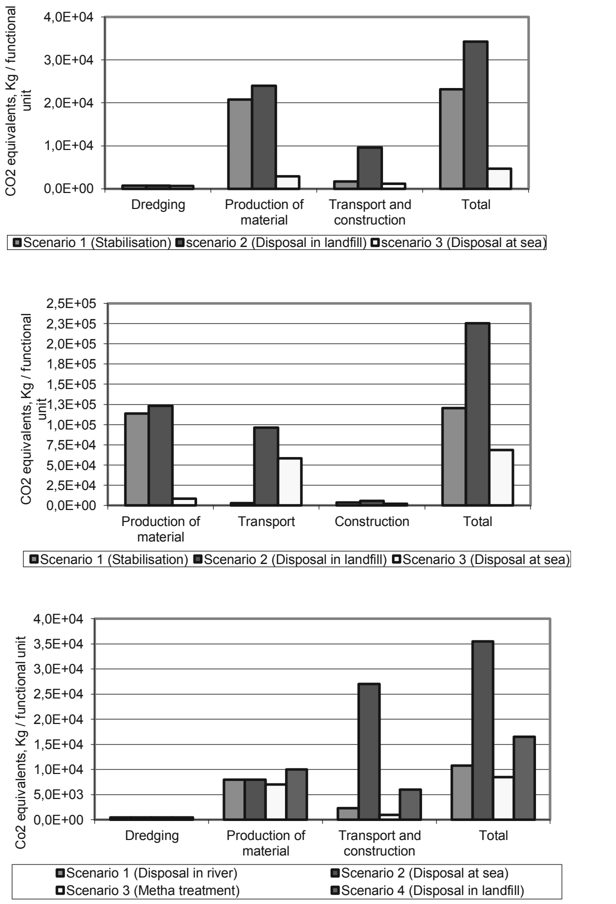

Figure 3. Port of Oxelösund, Port of Gävle, Sweden and Port of Hamburg, Germany (from top to bottom)

The system boundaries were chosen with a comparative LCA approach, i.e. identical activities in all scenarios were excluded, aside from dredging activities. The system boundaries were expanded and included also the beneficial utilization of the sediment. Hence, the functional unit included the handling of the sediment and also the production of the service that the sediment would provide when utilized in quay, road, bricks etc. Disposal scenarios also included the fulfillment of the service but sediment material was substituted with the production and use of conventional material.

LCA could provide the decision maker with a good view on environmental impacts for either a certain activity or for a comparison of different activities. The LCA could thus be used in an early decision phase for comparing relative differences in energy use and climate impact between different handling options.

LCA could also be used for displaying the relation between the energy use and climate impact from production of material, transport of material and construction work and maintenance respectively. This could be made with a stand-alone approach. With the standalone LCA approach, it could be possible to describe significant activities in each sediment management alternative. Such approach demands a more extensive data inventory but could provide information on which measures should be taken in each management alternative to reduce the energy use and climate impact. The stand-alone approach been tested in a SMOCS case study and the result is presented in Figure 4.

The data was collected from the cases of Oxelösund and Hamburg and completed with data on previously excluded activities such as dredging, transfers of dredged material.

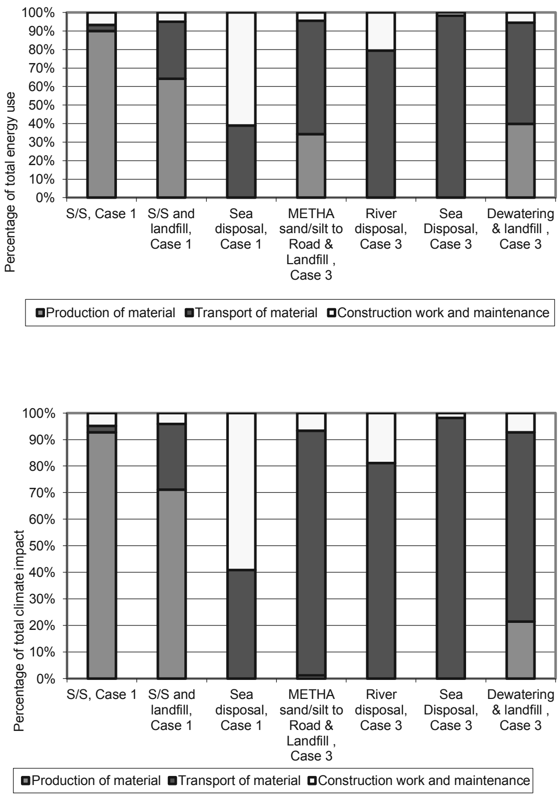

Figure 4. Percentage of total energy use (top) and climate impact (bottom) from the handling of sediments from in three categories of activities. Case 1 is Port of Oxelösund, Sweden and Case 3 is Port of Hamburg, Germany.

The overall conclusion from these LCA cases studies are that the selection of handling alternative for sediment management has major significance on the overall energy use and climate impact. Furthermore, the energy use and climate impact from transportation of materials and dredged material is often significant in the context of sediment management

2.3 *Multi Criteria Decision Analysis (MCDA)*

Multi criteria decision analysis (MCDA) is a tool that can integrate economic, environmental and social criteria and identifying the most sustainable handling alternative in a structured and rational way. Therefore, MCDA approach could be used at the project level for establishing the overall favorable handling alternative for management of contaminated sediments from a sustainability perspective. However, in order to be able to objectively score the performance of the different handling alternatives used in the MCDA other assessment tools are needed.

Within SMOCS MCDA case studies has been performed for the Port of Gothenburg and the Port of Lübeck integrating economic, social and environmental criteria for decision.

Fundamental steps in a MCDA are to (Belton and Stewart, 2001)

1. Identify possible handling options
2. Identify decision criteria and their indicators
3. Weight decision criteria's relative importance
4. Score the performance of the handling options in relation to each decision criterion
5. Calculate results

Results from the case study in the Port of Gothenburg are shown in Figure 5. A higher score should be interpreted as a better overall result, meaning that Rock chamber disposal and Solidification/stabilization are the most favorable options. A handling alternative scoring best on all decision criteria would result in the overall performance score 1.0. The bar colours show the contributions of environmental, social and economic criteria to the overall performance of each handling option. The impact of the port's weighting can be seen clearly: economic and environmental criteria are given 2 and 1.5 times the weight of social criteria, and hence these contribute more to the overall performance.

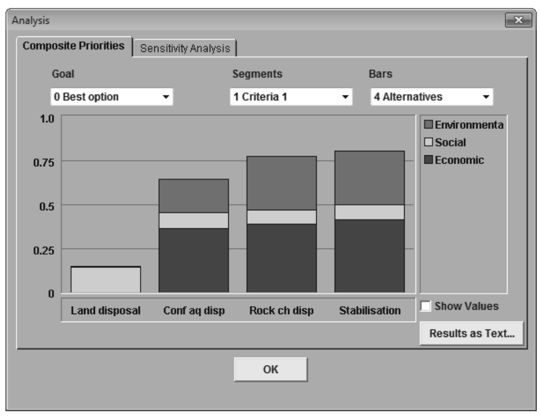

Figure 5. The MCDA results for the Port of Gothenburg case study showing the score of each handling option. A higher score means better overall performance.

3 CONCLUSION

MCDA provides a structured way of thinking through the whole range of decision criteria that should be taken into consideration when planning for handling contaminated sediments. MCDA can provide the transparency and documentation necessary for creating consensus between port owners and governmental organizations. This requires that a common opinion on decision criteria and weights can be established. It also requires that permit authorities embrace the concept of evaluating social, economic and environmental decision criteria together.

LCA is an appropriate tool for assessing energy and green house gas emission, information that give important input to the MCDA. The LCA could be used both for comparing different handling alternatives as well as displaying the relation between the energy use and climate impact from production of material, transport of materia, construction work, and maintenance.

The conclusion from the case studies using LCA and MCDA is that the selection of handling alternative for sediment management has major significance on the overall energy use and climate impact. Furthermore, it was shown that sediments utilized as construction material instead of disposed in landfill reduce energy use and climate impact significantly.

4 SMOCS DELIVERABLES AND A NETWORK ON SUSTAINABALE MANAGEMENT OF CONTAMINATED SEDIMENTS

The main deliverables of SMOCS consists of a guideline, tools for assessing sustainability and decision support, and a durable network. The guideline will address current and emerging technologies including verification of investigation and treatment technologies. The guideline will cover the whole process form planning to executing and control of treated sediments.

SMOCS has applied a highly participative approach. Therefore, the knowledge is compiled into the guideline in close cooperation with ports, maritime organizations, environmental authorities, construction industry as well as R&D performers. This approach is also a key starting point to establish a durable network.

The partners of the SMOCS project have agreed to establish a network for the period 2013-2017 on key issues and share experience, but also on development of further co-operation on identified issues. The topics covered are not limited to contaminated sediments thus including dredging and management of sediments in general as well as other port and authority issues if applicable.

The network is mainly based upon participants from the Baltic Sea Region. However as it exists in a European context, it is important that other regions can join and cooperate.

5 ACKNOWLEDGEMENTS

The SMOCS project is Part-financed by the European Union (European Regional Development Fund and European Neighbourhood and Partnership Instrument) the Baltic Sea Region Programme 2007-2013 and partly by the partners of the project being Swedish Geotechnical Institute, Luleå University of Technology, Sweden, Port of Gävle, Sweden, Lappenrannta University if Technology, Finland, Port of Kokkola, Finland, Maritime Institute, Gdansk, Poland, Port of Gdynia, Poland, Hamburg-Harburg University of Technology, Germany, Port of Klaipeda, Lithuania, and CORPI, Klaipeda, Lithuania

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