The GeDSeT project: (constitution of a decision support tool (DST) for the management and material recovery of waterways sediments in Belgium and Northern France)

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The GeDSeT project: constitution of a decision support tool (DST) for the management and material recovery of waterways sediments in Belgium and Northern France

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Abstract

The European InterReg IV GeDSeT project (2008-2013) is a contribution to a sustainable management of waterways sediments, in order to develop good practice. The present paper is one of the results of this project, carried out as a partnership between Ecole des Mines de Douai, ISSeP, CTP, INERIS and BRGM, members of the GIS-3SP cluster.

Waterways sediments are a major environmental issue in the Belgian Walloon - Northern France trans-boundary region. Sediment dredging allows the development of environmentally-friendly regional fluvial transport, but also generates important waste disposals. Therefore material recovery, for example, for reuse in buildings or infrastructure is a key issue, as it allows a reduction of waste and limits the need for natural resources for the same use.

The GeDSeT decision support tool (DST) aims to provide sediment management options with quantitative data, in order to evaluate various scenarios taking into account cost and sustainability and consequently to highlight good practise. The conception options are summarized in this paper as *a priori* selected relevant scenarios. These scenarios will be integrated into the tool to offer the possibility to perform a multicriteria analysis and assess *a posteriori* their relevance as regards the sustainable issues.

Keywords: Canal sediments; Dredging; Valorisation; Backfill; Decision support tool

1 Introduction

Waterways sediments are a major environmental issue in the Belgian Walloon - Northern France trans-boundary region for several reasons, all of them resulting from the dense habitat, industrial pattern, and waterways network, and of a long industrial history. The maintenance – both canals and rivers - meets several major issues: the preservation and improvement of navigability for regional fluvial transport, the management of floods, the environmental impacts of polluted sediments on surface and groundwater quality. Moreover, regular dredging results in huge amounts of waste (dredged sediments) with effects on land occupation and environmental impact of disposal/treatment sites. Sediment reuse in buildings or infrastructure is a key issue, as it allows a reduction of waste in disposal and limits the need for natural resources for the same use.

The GeDSeT decision support tool (DST) aims at providing sediment management options with quantitative data, in order to evaluate various scenarios and so provide support for discussions on the "best" option. In order to take into account, as far as possible all issues of sediment management in a global approach, a study of pertinent criteria for the assessment of different scenarios driven by sustainability concept has been performed. Those criteria have been introduced in GeDSeT tool as indicators of the result of the scenarios assessment.

The methodology followed to design the tool was detailed in a previous paper (Michel et al., 2011). The present article aims at describing the tool development and the selected scenarios in terms of sediment management options, scenarios discussed with professionals and waterways operators.

2 Methods – technical and methodology options

2.1 A "what-if" tool based on multicriteria analysis

The GeDSeT tool allows to evaluate different scenarios of sediment management based on several indicators, in order to take into account all the consequences (effects) of the chosen options ("what-if" tools, Golfarelli et al., 2006). The aim of this tool is not to highlight the best solution. Indeed, the assessment of a unique score per scenario is not performed; we consider that the prioritisation between the different impacts has to be performed by decision-makers themselves.

As it is aimed at assessing all consequences of a chosen option, (consequences of any type: environmental, economic…), the tool is based on multicriteria analysis (Linkov et al., 2006 ; Alvarez-Guerra et al., 2009 ; Steele, 2009).

2.2 System boundaries

To follow the principles of systemic analysis, system boundaries have to be defined in terms of spatial and socio economical boundaries in which positive and negative impacts are assessed (system boundaries, Finnveden et al., 2007).

The scenarios in terms of sediment management are usually assessed considering only the dredging step (with economic criteria as the prevailing ones). Existing decision aid tools aim at optimizing technical choices by comparing techniques on the basis of direct impacts associated to them (LIFE, 2002). For the GeDSeT tool, system boundaries were first extended from dredging and post dredging sediment management up to sediment final disposal or sediment reuse, and second to direct and indirect effects such as positive effects linked to sediment reuse. This is a classical approach in waste management analysis (Villeneuve et al., 2004, Finnveden et al., 2007, Gentil et al., 2010, Eriksson & Bisaillon, 2011): namely, the life cycle analysis approach. It allows to consider at first approach more sustainable options besides the lowest cost options, as their benefits within larger system boundaries can offset the extra local cost (or if other indirect positive effects could motivate the decision-maker or stakeholders to bear the extra cost) or environmental impacts.

2.3 Multicriteria analysis of scenarios of sediment management: indicators (criteria) related to sustainable development issues

The aim of the tool is to bring knowledge to decision-makers on alternative options, and to make them aware of all the possibly known consequences of their technical choices, either positive or negative, in a global approach. This implies the integration of consequences of all types, beyond those specifically associated to dredging: management of floods, navigability for regional transport, creation of recreation areas associated to the dredging operation (indirect improvement of living environment). This includes also direct costs (dredging, treatment…) and indirect costs (management of residues), impact on employment in addition to environmental impacts etc.

Sustainable development issues were used as a guideline to first of all identify consequences, and effects of technical choices all along the sediment management process, and secondly to translate these consequences into a limited number of indicators. This methodology proved to be efficient (Fèvre-Gautier, 2009, Michel, 2011). Sustainability concept considered here is the one defined as the development focussed on human well-being: obtaining the increase of well-being for as many human beings as possible today and tomorrow (Boulanger, 2009).

Each scenario is therefore assessed on the basis of the following six indicators:

- Four indicators related to environmental impacts (“fossil energy uses”, “climate”, “ecosystem quality” and “human health”). They are quantified through the impact characterisation method from life cycle analysis. This method allows to translate emissions (metals, for example) into ecotoxic effects, and into final effects on “ecosystem quality”; methodology in three steps described by Michel et al. (2011).
- Two other indicators: « regional economic development » (employment…) and « living environment » (risk perception, land value…), qualitatively assessed through stakeholders interviews.

In addition to those six indicators linked to the sustainable issues, two other indicators are also assessed to broaden the scope of the evaluation of the scenarios:

- Cost assessment based on industrial data collected (more details in the following paragraph)
- A decision risk level indicator, evaluating for each choice the level of risk incurred by the decision-maker. This risk may be in relation with the level of maturation of the considered technique, or with the perennial character of the management option (regulatory framework).

2.4 Modelling level and data required

The required modelling level of sediment management options is not detailed; key aspects of sediment management are not at the level of a specific technique. They are rather in dredging objectives and possibility of sediment re-use. Numerical models are implemented in the tool for its main components. They are based on spreadsheet functions (Power & Sharda, 2007).

It is supported by thematic databases filled in by data generated by focussed research tasks of the GeDSeT project (Laboudigue et al., 2011) and by information gathered during discussions with all stakeholders of sediment issues (operator, industrials, decision-makers); different types of data have been gathered: technical and scientific results, economic and social data and, where necessary, data assessed based on experts’ knowledge.

For the economic assessment of the chosen scenario, it is based on industrial data (current values diffused by industrial). It allows a first level of assessment but it should be adjusted for each case study to perform a significant one. Some confidential data could not be seen by GeDseT tool’s user but they were used to assess minimum, maximum and mean values suggested to users as guideline value.

2.5 Scenarios of sediment management

Scenarios of sediment management assessed by the tool integrate several technical options from dredging to final destination (landfill or re-use). Discussions with all stakeholders of sediment issues (operator, industrials, decision-makers) allowed also to identify relevant scenarios. Apart from the currently used options, during the collection of information, it appears that some technical options are worth in-depth investigation for the following reasons:

- They offer *a priori* a more sustainable solution than the current one ;
- Considered as new technologies, they may result in the development of a new local economic sector ;
- They would allow solving some constraints on natural resources or land occupation in the case of local/regional use conflict.

Among many technical options, the following one should be thus considered, evaluated and integrated in the tool:

- selective dredging and treatment for sediment re-use;

- reconversion of disposal sites to, for example, energy crops.

Indeed, selective dredging and treatment activities may create locally a secondary resource potential, as an alternative to primary resource extraction, and allow the development of reuse activities.
Considering the reconversion of disposal sites to energy crops, this option was especially identified because unlike food crops, moderate soil contamination does not result in immediate health risks. It is particularly attractive in a context of high pressure on land use. These scenarios are detailed in the paragraph 3.

2.6 Tool development

Tool development (based on Excel file) was based on the modelling of possible scenarios, step by step, along with data collection. To use this tool, users should first of all gather precise local characteristics (sediments nature, volume…). Secondly, a scenario of sediment management shall be chosen and defined; at each step of the scenario construction (selective dredging or not, treatment or not…) default data are suggested to users (cost data, treatment efficiency, etc, extracted from the database …) through dialog boxes (Figure 1). The user can then replace such data by more precise or accurate information he has under hand. A multicriteria analysis based on sustainable indicators is performed for the defined scenario. It is compared in any case to the effects of the "nothing is done" reference scenario. Those results are represented in a spidergram and expressed in percentages (assessed value per indicator compared to "the worst possible values").

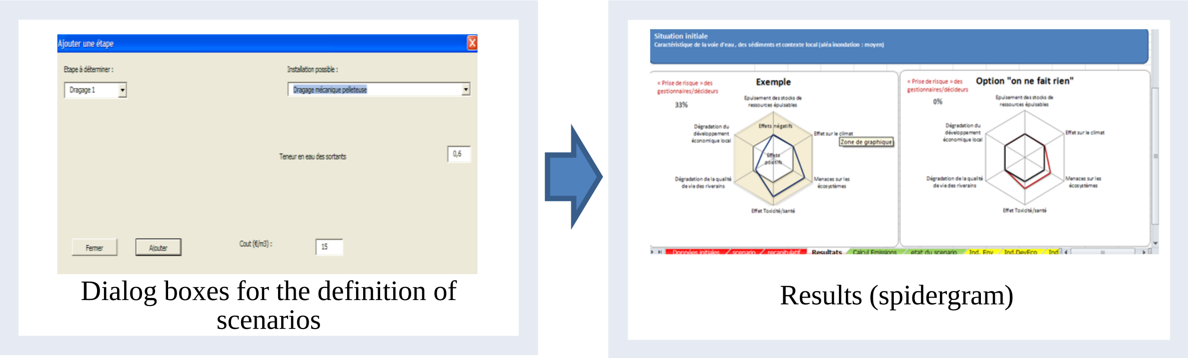

Figure 1. GeDseT tool

3 Applications and operational scenarios

The selected relevant scenarios detailed below were identified through exchanges with various stakeholders. All of them are contributions to solving the key waterways issue: how to cope with the huge volume of sediments to be dredged with the available budgets along with considering enlarged system boundaries (see above). Moreover, they are *a priori* relevant for sustainability issues. So, they are worth in-depth investigation. These scenarios of sediment management are integrated into the tool to offer the possibility to perform a multicriteria analysis of them on the basis of sustainable issues.

3.1 Scenarios for the dredging stage

Dredging operations can be carried out according to two methods:

- bulk dredging up to the restoration of a given clearance, most often using an excavator or a bucket on a barge, digging sediments without any sorting (Figure 2). This method does not require any precise geolocation. Sediments contamination is statistically estimated with representative lab analyses in order to determine their future management (French example: VNF, 2008) ;
- spot dredging, in which the volumes to be extracted are defined with precision on clearance criteria. This method is now applied in the Walloon region of Belgium, in order to reduce the

volume of dredged sediments to be managed, and therefore the requirements in land for disposals and the subsequent budgets. The volumes to be dredged are defined through bathymetric investigations, and their contamination is assessed through a sampling campaign led by the administration. The technical specifications for dredging tenders are based on these data. High precision GPS geolocation is needed during both campaigns and during dredging operations (DeRugeris and Nilson, 2007).

Figure 2. Bulk dredging, Lens canal, 2010

The required high precision dredging allows to consider a preliminary phase of selective dredging of the most contaminated canal sections. This can be performed if a detailed characterisation map was established, for instance using field analytical instruments instead of composite samples (Figure 3). It was shown by Alary and others (2011) that most often, pollution is concentrated in hectometric-size hotspots, while the remainder of the waterway shows a lower level of diffuse pollution. Once removed the most contaminated sediments, the remainder has lower average contaminant concentrations and may qualify for a lower category. It can be removed by bulk dredging, and either be valorised or managed under a less constraining status. The volume of highly contaminated sediment to be managed as hazardous waste may be thus significantly reduced. In the most favourable cases, the sediments extracted during the second phase can be directly valorised and shipped to a potential user.

This two-stage dredging model (Figure 3) is necessarily more expensive than a traditional one-stage model. It cannot qualify under the usual tendering process, if the decision scope is restricted to dredging operations. Conversely, the extension of the decision scope to other benefits (sediments volume, size and confinement performance of the disposal site) or sustainability criteria (material reuse, lower emissions, economic sector development) may revert the decision, if the outcome is considered at the regional scale.

This compared scenario is currently developed in the GeDSeT decision support tool (Figure 1).

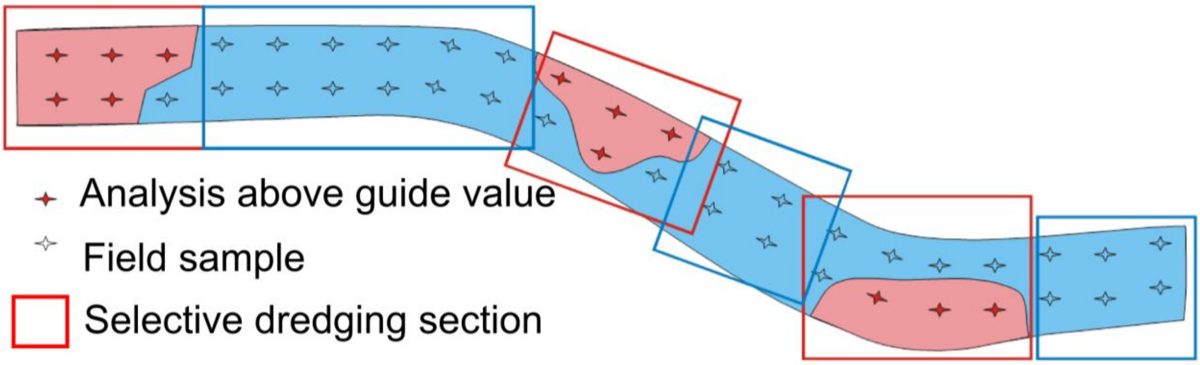

Figure 3. Schematic map of a selective dredging plan

3.2 Scenarios for treatment strategies

Numerous techniques were developed for the reduction of the level of contamination of sediment in order to facilitate reuse or disposal, similarly to off-site contaminated soil. Pilot or industrial scale facilities were built or are being developed, most often along waterways. More recently, mobile plants were developed on barges, allowing on-site processing.

Modular scenarios can therefore be elaborated:

- should sediments be dehydrated on a barge, as soon as dredged, in order to minimise their volume and facilitate their management? Even more efficient, make them readily usable if their contamination level is low? Ship them without any unloading/loading operation, if reuse applications or sites can be located along or near the same waterway, reducing therefore massively the CO_2 emissions due to transport and loading, and the cost of the whole process?
- is it possible to forward sediment loads towards the most appropriate and efficient treatment line (Figure 4) if adequate on-site characterisation data are available? Subsequently, ensure substantial reductions in management cost?

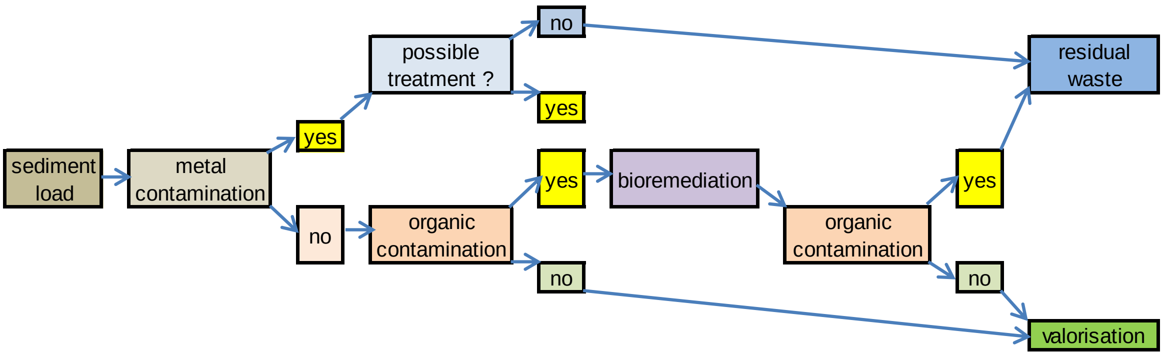

Figure 4. Simplified schema for selection of a treatment line

- is it possible to ship the most contaminated sediment loads directly by fluvial transport to, or near, the closest hazardous waste disposal site, reducing also the CO_2 emissions due to transport and cost of the process?

The combined effects of the above options can be significant, from the economic point of view as well as for sustainable issues linked to reduced environmental impacts (reduced fossil fuel needs and emissions) and land use.

3.3 Scenarios for valorisation options

Despite current regulatory obstacles to reuse and valorisation, it is expected that regulations will evolve in a direction more favourable to sustainability, and not exclusively to milieu protection. Indeed, reuse and valorisation of sediments allows to reduce

- the requirements in disposal sites (cost and land use), and
- indirectly, the requirements in primary materials extraction.

Currently, the main pathway for sediments valorisation is constituted by low value applications such as cover or backfill, alone or mixed with demolition waste. Valorisation as higher value minerals, or as components for structural products is indeed possible, but the volume of sediments that may be thus valorised is by far smaller. High value valorisation paths can receive only a minor part of the large volumes of sediments to be dredged.

Taking into account before dredging operations the possible uses, the delivery place and possible fluvial transportation route, and the elimination of loading/unloading operations will probably improve the economic feasibility of reuse.

This shows the importance of an early identification and planification of potential users of sediments (civil works, landfill cover, site remediation works, landscape hills) nearby any dredging operation.

3.4 Scenarios for disposal sites use

Disposal sites, either temporary (Belgium) or final (France) have known inconveniences (construction and operating costs, land use, neighbourhood acceptability). Attention should be given to their protection, for risk issues, but also their possible uses.

Under current regulations, most disposal site options require public access restrictions. The easy growth of vegetation on this new « soil » rich in organic matter designates sediment disposal sites as inaccessible green areas.

An alternative use could be for industrial energy crops, such as quick rotation willows or other woody vegetals.

4 Conclusions

The development of the GeDSeT decision support tool under a "what-if" model was not aimed at designing optimal management strategies, but rather to give all stakeholders a common white board to identify the positive and negative impacts of various scenarios.

- By taking into account larger system boundaries, it allows to gather indirect benefits for options that would not be retained in a local tendering process. The indirect costs of the cheaper options have actually to be borne by other public budgets.
- It allows to model the potential for regional economic development of innovative options, along with evaluating the level of risk associated with a decision.
- It confirms the benefits of early planning and of the integration of potential uses for sediments in waterways dredging plans.

The situations and methods were observed both in Belgium and France, and specificities resulting from a different waterways history were analysed in order to identify mutual benefits. Harmonisation is proposed between best practice and regulatory frameworks, in the perspective of improved environmental quality and local economic development across the border.

The transposition of the GeDSeT tool to another region or context is therefore possible, but it would require the collection of locally relevant data, the construction of new databases and the development of specific scenarios.

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