Beneficial use of sediments for our future: compared pathways for taking profit of them as resources for new challenges

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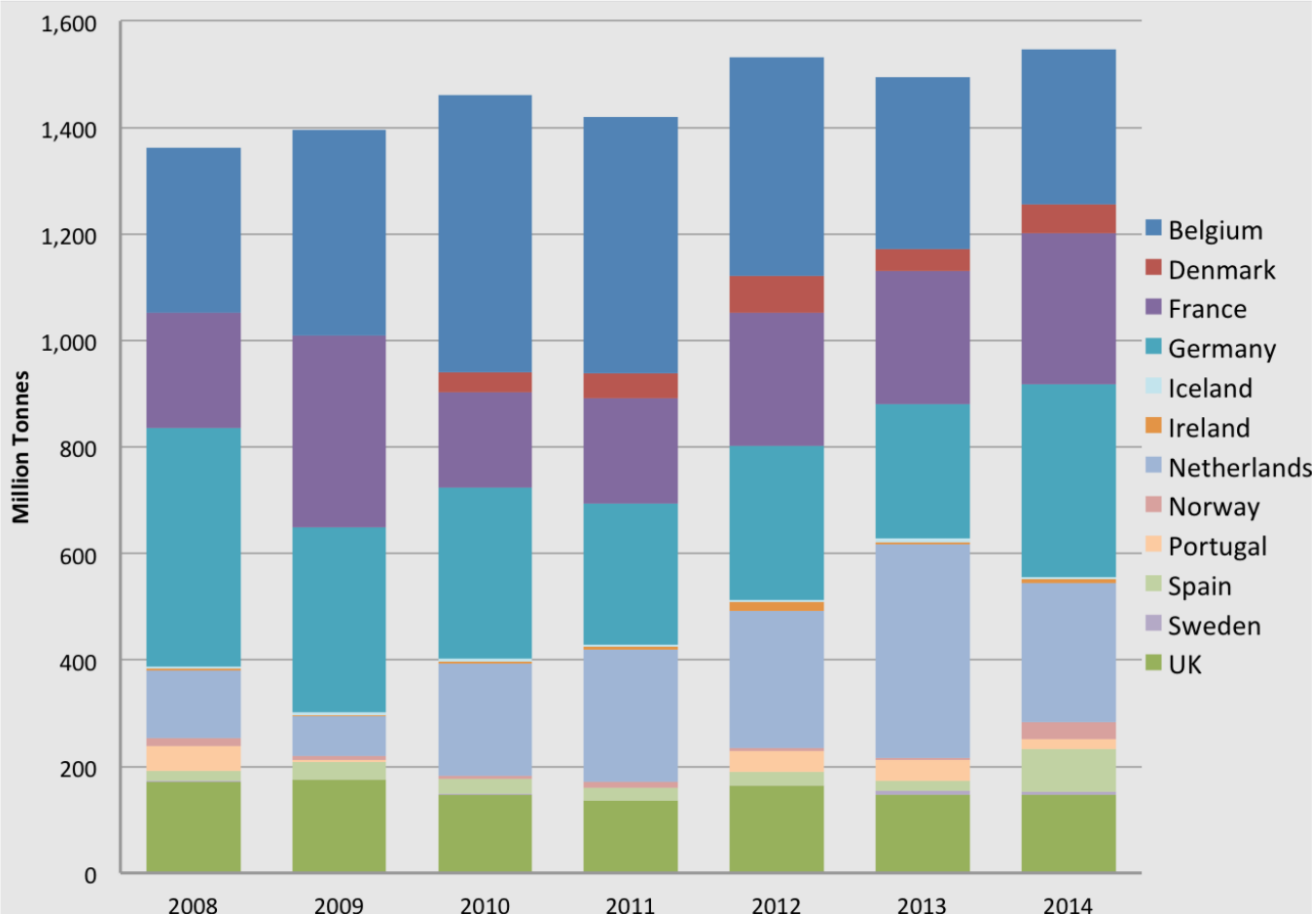
The issue

Sediments are made available in **massive quantities by dredging** operations for the needs of the development of **sustainable marine and waterways transport**.
This may end either as a huge flow of **waste**, or as a blessed **resource** for highly needed materials for climate adaptation works.
Operators need a clear roadmap to beneficial use options, in a Circular Economy perspective.
This includes alternatives for flood and coastal defense for climate change mitigation, based on eco system based approaches.
Many other options are available, to be classified under:

- **Marine and fluvial works** in which available sediments can be taken profit of, as close as possible from their origin,
- **Raw minerals**, to be used for beneficial applications instead of extracted primary minerals.

Since sediments are an ‘end of pipe’ resource this also includes ways to deal with **contaminants**.

How much ?

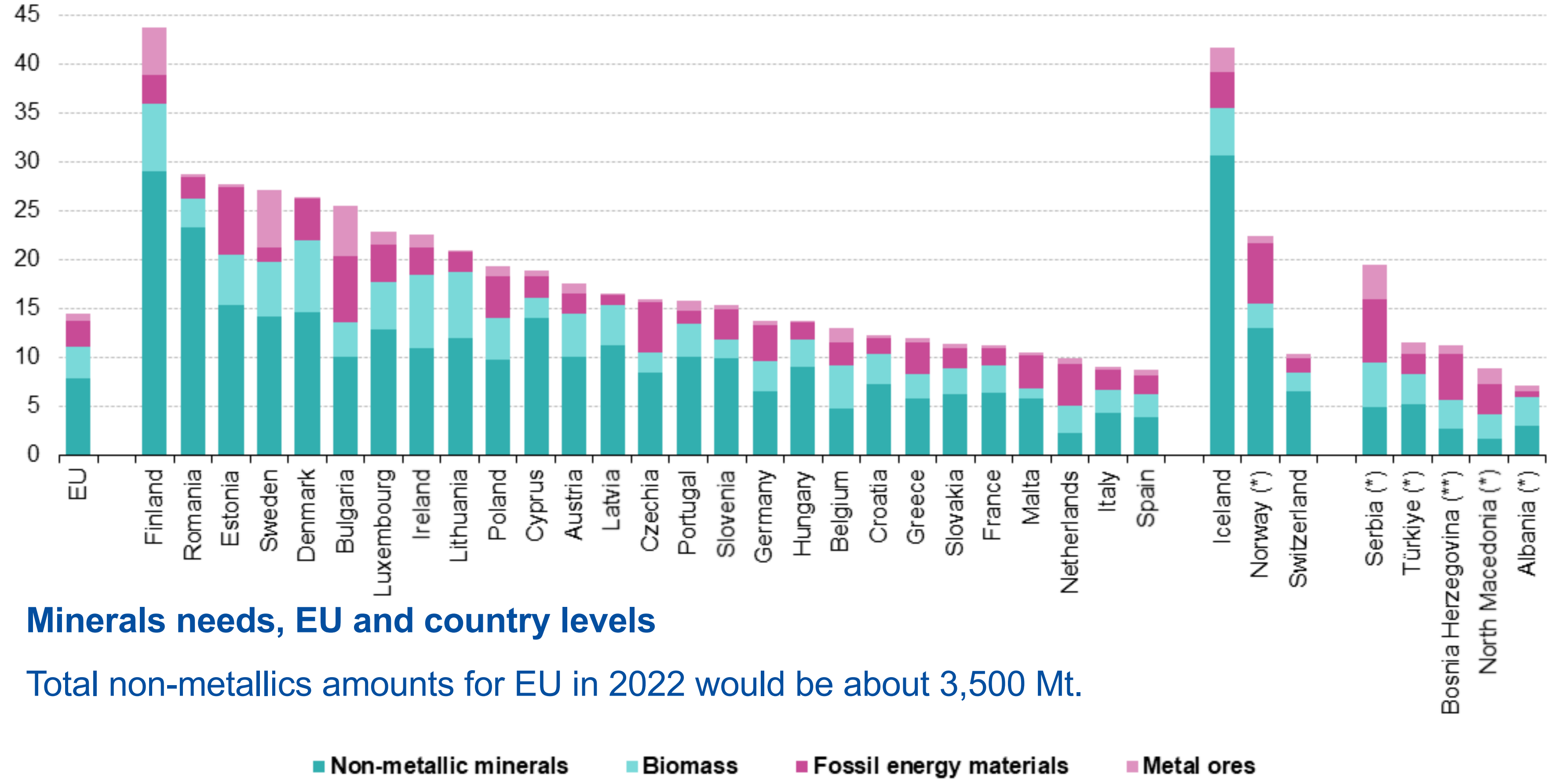


Relocation at sea (about 90% of harbour dredgings)

Total amounts, in millions of tonnes, of dredged material deposited in the OSPAR Maritime Area per country, per year, over the period 2008–2014. Source: OSPAR.

How much ?

Domestic material consumption by main material category, 2022
(tonnes per capita)



Minerals needs, EU and country levels

Total non-metallics amounts for EU in 2022 would be about 3,500 Mt.

(*) 2021 instead of 2022
(**) 2019 instead of 2022
Note: The 'Other products' and 'Waste for final treatment and disposal' categories are included in the 'Non-metallic minerals' category
Source: Eurostat (online data code: env_ac_mfa; demo_gind)

Our methods

Research for beneficial use options

European InterReg projects funded RTD for beneficial use options as an alternative to waste disposal (GeDSeT, CEAMaS, USAR, VALSE, SURICATES). USACE supports such initiatives in the USA.

The Pilot approach

Real size pilot tests were developed in the later projects to demonstrate the validity of BU pathways. They appear to be critical to convince site holders, operators, industries and authorities of the viability of BU alternatives vs. business as usual.

Technologies involved

- Geography (GIS based),
- Economics and social modelling,
- Engineering compliance,
- Environmental site monitoring and modelling.

Decision support tools incorporating their findings are used, not only to identify the best options, but also to simulate all options and promote stakeholder participation.

The Pilot approach

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Rotterdam example > see Dr Wijdeveld's presentation

The biggest pilot project led under EU funding was the relocation of 500,000 m3 of harbour sediment in the tidal influenced part of the river. The relocation provides sediment to wetlands, make them more resilient, and protects the river bank against erosion and flooding. Relocation saves on the transport distance of sediment to sea, saving on CO_2 and NOx emission (and on cost). It should not impact siltation of the navigation channel.

Scottish pilots > see Dr Torrance's presentation

Smaller pilot tests, each one dedicated to one beneficial use technology (Bioengineering, concrete, pozzolan), were developed at various sites.

Waterways pilots

To demonstrate the feasibility of beneficial use, a cycle path was built from dredged sediments after mineral processing and civil engineering tests (project VALSE).

Geography methods

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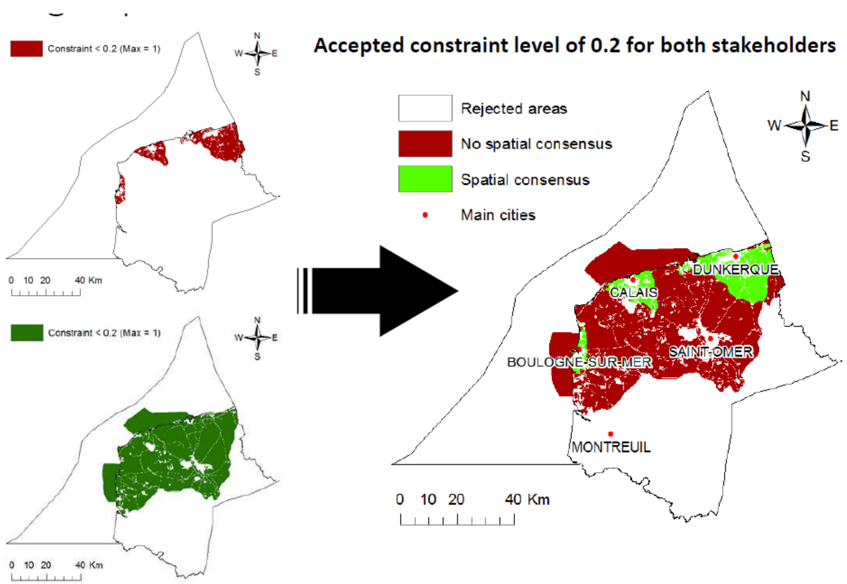
Technologies involved (GIS based)

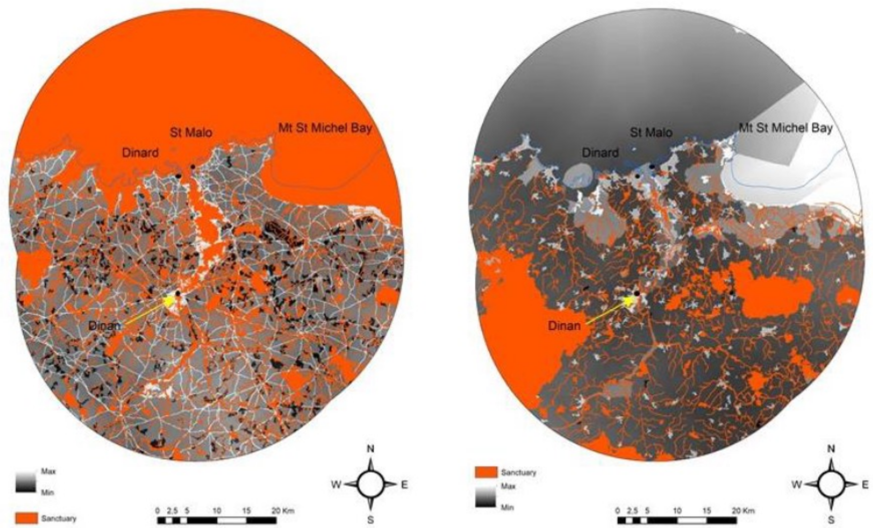
- Helping to define the best area for a beneficial use option,
- Providing a tool for stakeholder involvement and evaluating options,
- Identifying the possible benefits for the economy, the employment and the land use options.

GIS tools can be used to create variables that can feed decision support tools.

Building a spatial consensus from 2 different stakeholders



Decision maps according to an Environment local NGO (left) and a Watershed public manager (right)



Economics and social

Technologies involved: economics and social modelling

See Dr Harrington's presentation.

Beneficial use options (circular) are usually more expensive than Business as usual ones, especially Dumping at sea. It is therefore critical to identify and quantify the indirect benefits for the territories, the local economy and employment.

The time cycle of circular options benefits is longer than the time cycle of tenders, projects and political support. Indirect benefits must be quantified before any decision is made.

Economics and social modelling results can, and should, be used in Decision support tools, not only to identify the best options, but also to simulate all options and promote stakeholder participation.

photo California Dept of Water

Engineering compliance 1: civil works

Technologies involved: laboratory and pilot scale testing

To demonstrate the validity and reliability of any innovative option (alternative to Business as usual), testing in real scale the industrial processes on which the option is based is needed. This includes:

- Geomechanical aptitudes of the raw or stabilised sediments,
- Engineering compliance, including delays,
- End user specifications compliance for the intended use, including emissions,
- In France, the SEDIMATERIAUX approach provides a robust framework for testing, with the collaboration of regulatory bodies.

Performance testing results and cost estimates are critical for the industrial reliability of the option, for the necessary investments, and should be made available to Decision support tools.

Compression test (Zambon, 2018)

Treatment the fine part of the material below the threshold predefined in second module: Dehydration

Engineering compliance 2: agriculture and landscape

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Technologies involved: field, lab and pilot scale testing

To demonstrate the validity and reliability of any innovative option (alternative to Business as usual), testing in real scale the industrial processes on which the option is based is needed. This includes:

- Biological aptitudes of the raw sediments or technosoils with sediments,
- Plant growth compliance, including water management,
- End user specifications compliance for crops, including contaminants.

Laboratory testing and field testing results, as well as implementation and cost constraints are critical for the full size feasibility of the option, and should be made available to Decision support tools.

Cultivation tests
(photos USDA & Royal Haskoning, SedNet 2019)

Environmental site monitoring and modelling methods

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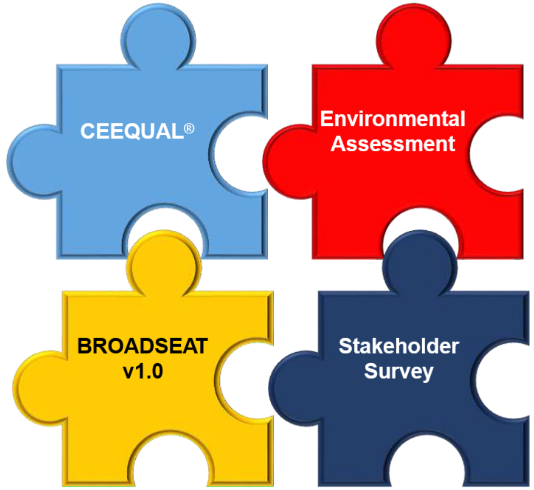
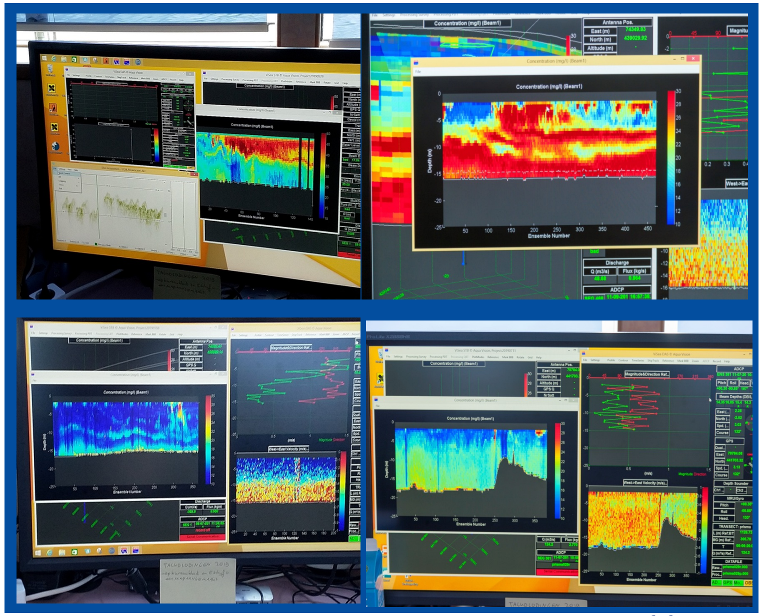
Technologies involved

- Environmental site monitoring and data collection, prior to works, during works and after completion,
- Environmental site modelling and potential hazards identification.





Decision support tools incorporating these findings are used, not only to identify the best options, but also to simulate all options and promote stakeholder participation.

Beneficial use options

Selecting a beneficial use option suitable for the site location and sediment characteristics is therefore critical. Beneficial use options are many, and can be classified under:

- Civil works in relation with harbours and waterways, including own needs, port expansion
- Flood and coastal protection works
- Construction (including roads or urban space and brownfields reclamation)
- Environmental enhancement or restoration, rehabilitation of borrow pits
- Habitat creation and improvement, including river course management and recreation areas
- Agriculture needs (freshwater sediments for soils: true circular use?, fertility additive, mitigating land subsidence, degraded soil restoration)
- Raw material uses (as a substitute for mineral extraction)

“Most of the current applications that include contaminated sediments fall within the raw material and remediation categories” (CEDA, 2019)

Recommended resource:

https://dredging.org/resources/ceda-publications-online/beneficial-use-of-sediments-case-studies

Beneficial use options

Propositions for case studies classification:

- Possible classification on saline/fresh water
- Classification for their content in organic matter, especially for agricultural use. Type of OM is also key (reactivity)
- Classification on grain size ? gravel, sand and sludge
- Classification on source: reservoirs, marine, waterways
- Salinity, organic matter, clay, sand contents (nature of the sediment)
- Contamination level as a classification (same as waste?)
- Differentiating on organic and inorganic

Starting from key essential characteristics of the sediment, a tree of options could arise ...

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Lessons learnt

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Results from SURICATES and all EU projects

- **Climate adaptation** operations must be on large volumes and at low cost, implying that potential reuse works are based on bulk sediments, with as little processing or storage as possible.
- These include coastline, harbour and river works, civil works and landscaping, and agricultural uses.
- Regardless of the type of application, the key features for the viability of a BU project lie in **distance between source and target, timing of operations, suitability of specifications and public support**.
- The main barriers are in the **extra cost** of BU vs. disposal, in **dissuasive regulations and permitting**, in **social acceptance** and in **risks associated with contaminants**.

Lessons learnt

Beneficial uses and circular applications as an alternative to disposal must be able to accommodate large volumes of sediments in a constrained timing, with varying levels of contamination.

High value, small volume pathways are less useful here than large volume bulk applications. BU must entail low costs, as disposal is still a cheap option.

Need to quantify the social and economic added value (job creation), in GHG emission reduction and carbon sequestration, in ecosystem robustness and reduction of toxic stress, and on risk reduction.

Circular projects must provide **indirect benefits for the territory or public works**, for which the availability of sediments can be seen as a trigger.

Conclusions

BU projects need to be assessed within larger system boundaries than the original project. They need to involve many stakeholders in the initial design phase of the project, and most often the intervention of administrations and communities

Acknowledgements

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Useful links

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Thanks