Flanders policy continues to focus on an integrated approach of contaminated sediments : legislation and code of good practice.

Katrien Van de Wiele[1], Goedele Kayens[1], Froukje Kuijk[1]

[1]OVAM, Flemish Waste Agency, Stationstraat 110, Mechelen, Belgium

Phone: +00-(32)-15284375
E-mail:
katrien.van.de.wiele@ovam.be

Conference topic: 6 Sediment Management Concepts and Policy

Introduction: *The European Water Framework Directive states that a good status of surface water and groundwater must be achieved. The remediation of contaminated sediments is indispensable linked on this. After all, contaminated sediments prevents the improvement of water quality and the ecological recovery of the watercourse.*

In Flanders, the remediation of contaminated sediments falls within the scope of the soil remediation regulation, but given the specific environmental characteristics of sediments makes the application of the existing decree procedures not evident. The remediation of contaminated sediments requires a unique approach.

The Flemish Soil Decree contains specific regulations for the investigation and remediation of contaminated sediments (Articles 124-135 of the Soil Decree). The Soil Decree defines the concept of 'waterbed' by referring to the Decree on the Integrated Water Policy, which defines the concept of 'waterbed' as: 'the bottom of a surface water body that is always under water or for a large part of the year'.

Methods: *Since it is not possible to immediately remediate all waterways, priorities are determined by a tool "Sedimentexplorer" and the most urgent waterways with contaminated sediments are tackled first.*
There are various ways in which contamination can come to light.

If the waterbed has been examined in a sediment assessment in accordance with Chapter 12 of the Soil Decree, the remediation obligation only arises after the Flemish Government has designated the watercourse as a priority for remediation. The watercourse manager is the person who has the obligation to conduct the investigation.

The investigation of the discharge point will be mandatory when carrying out an preliminary soil investigation of a company. If contamination is identified, this contamination will not prevent the transfer of the site, but agreements will have to be made between the transferor and the acquirer.

Results: *The OVAM works together with soil remediation experts, research institutions and other experts on a code of good practice: Assessment of contaminated sediments and banks - Code of good practice. Guidelines for investigation of contaminated sediments in the context of a preliminary soil investigation are also being developed.*

This code of good practice is a manual for the assessment of contaminated sediments for accredited soil remediation experts and watercourse managers.

Comparison of Freshwater Sediment Quality Guidelines (SQGs) for potentially toxic elements (PTEs): Gaps and Needs

Ahmedin Hiya [1,2], Gyozo Jordan [3], Zsofia Kovacs [4], Katalin Dudas [5], and The DSQ2 Team [6]

[1] Doctoral School of Environmental Sciences, Faculty of Science, Eötvös Loránd University, Pázmány Péter sétány 1/C., H-1117 Budapest, Hungary

[2] Department of Chemistry, Mai Nefhi College of Sciences, 12676 Mai Nefhi, Eritrea

[3] Geochemistry and Method Development, Mineral Economy Solutions, Geological Survey of Finland (GTK), Vuorimiehentie 5, 02151Espoo, Finland

[4] Sustainability Solutions Research Laboratory, National Laboratory for Water Science and Water Security, University of Pannonia, Egyetem u. 10, 8200 Veszprém, Hungary

[5] Hungarian University of Agricultural and Life Sciences, Páter Károly utca 1, 2100 Gödöllő, Hungary

[6] DanubeSediment_Q2 DSQ2 Project: https://interreg-danube.eu/projects/danubesediment-q2

Phone: +36-(20) -490-1972

E-mail: dinodiny6@gmail.com

E-mail: gyozo.jordan@gtk.fi

E-mail: Jzsofia.kovacs@outlook.com

E-mail: kata.9.dudas@gmail.com

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Introduction: The EU Water Framework Directive (WFD) employs a comprehensive strategy for waterbody management by integrating sediment quality guidelines (SQGs) to protect aquatic ecosystems. SQGs are essential for evaluating sediment contamination levels, establishing threshold values to differentiate uncontaminated sediments from those requiring remediation [1]. This synergy aligns SQGs with the WFD's benchmarks for mitigating sediment toxicity, promoting a unified, science-based approach to waterbody preservation across Europe [2]. This study examines the evolution of SQGs since the 1970s, demonstrating a transition from simple contaminant concentration comparisons to advanced assessments incorporating ecological impacts. Initial reliance on background values overlooked biodiversity and potential harm to aquatic organisms.

Methods: Freshwater SQGs from different national and regional agencies were collected and categorized into threshold effect concentrations (TECs) and probable effect concentrations (PECs). These categories aim to protect sediment-dwelling organisms in freshwater ecosystems [3].

Results: Statistical analyses reveal significant variability in PECs among metals. Ranking shows chromium has the least variable SQG (11%) while mercury has the most variable SQG (52%) among the 28 national and international SQG systems compared (figures in brackets show the MAD/Median relative variability in percent [4]). Statistical comparison also identified that mercury is the most toxic metal and zinc as the least, corresponding to the lowest and highest SQG values, respectively. For TECs, lead and copper exhibited the lowest (11.4%) and highest (37.1%) variability, respectively.

Discussion: These findings highlight the importance of refining SQGs to account for metal-specific toxicity and variability. The variability of the SQGs values among different metal(loid)s underscores the importance of refining these guidelines for effective environmental protection. By selecting SQGs with minimum variability, the study ensures precise and consistent evaluations of heavy metal contamination across diverse environmental contexts. Integrating these guidelines into the implementation of the WFD framework enhances sediment quality management by consistent application of threshold values across borders, hence fostering ecological sustainability and improved waterbody health.

Acknowledgements: This work was funded by the DanubeSediment_Q2 Project (DRP0200029), an Interreg Danube Region Programme project co-funded by the European Union, and supported by Stipendium Hungaricum Scholarship Programme

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Using sediment samples to assess substances in relation to the Water Framework Directive (WFD)

Signe Marie Ingvardsen[1] and Thomas Ruby Bentzen[1]

[1]COWI A/S, Visionsvej 53, 9000 Aalborg, Denmark

Phone: +45-56403567

E-mail: smin@cowi.com

Conference theme number(s): 6

Introduction: In Denmark, the permission for dredging and disposal of sediment from the sea is based on a hierarchy. 1. Bypass of sediment, 2. Utilization of sediment, and 3. Dumping. In connection with all three forms of disposal, an assessment of substances in relation to the Water Framework Directive (WFD) must be conducted. The ecological status is assessed based on a range of quality elements, including nationally specific substances, while the chemical status is assessed based on EU-prioritized substances.

Methods: Before dredging, the concentrations of various substances are necessary to carry out in order to perform an environmental assessment (EA). At the same time, sediment spreading, and release is essential. Prior larger dredging tasks, numerical modeling can be used, while for smaller dredging and dumping operations, simpler models may be applied.

Step 1: In Denmark, sediment samples are taken prior an environmental assessment. Review of the substances on the OSPAR/HELCOM primary and secondary lists are performed.

Step 2: The analysis of these substances is always carried out by laboratories that are accredited to perform such analyses.

Step 3: Using different sources, concentrations in sediment is compared with EQS. 1st priority: Environmental quality standards are established in legislation. 2nd priority: Environmental quality criteria set out in fact sheets from the Environmental Protection Agency, and 3rd priority: EU predicted no effect concentrations (PNEC)

Step 4: There are only a few environmental quality standards for sediments and biota; the remaining environmental quality standards are for water. Analyses are conducted from a national list and EU-prioritized substances list. Concentrations in sediment need to be converted to concentrations in water and then compared to the water quality standards. Here are several choices and assumptions that can affect the outcome. It is important to be conservative due to the precautionary principle, but the assessments should also be realistic.

Step 5: At the same time, several guidelines are used. The Environmental Protection Agency has created several guidelines [1], but guidelines from HELCOM [2] and OSPAR, as well as EU guidelines (Common Implementation Strategy (CIS)) [3], are also used.

Results: By using a combination of conservative calculation methods along with an assessment of sediment spreading, it can be evaluated whether EQS is being met and does not lead to a deterioration of the status of the surface water area and does not hinder the achievement of the established environmental objective, including through the measures specified in the action program.

Discussion: It is sometimes difficult to determine when there is a local and/or temporary impact and whether this falls under the WFD (Water Framework Directive). How are requirement values determined for a given substance in an emission when the environmental quality standards for that substance have already been exceeded in the surface water? Is it sufficient to look at the concentration of individual substances and the increase in the concentration of the substance in sediment, or should a calculation of the release to the water phase and the increase in the water phase also be made? Should the assessment be carried out across the entire water area, or is there a deterioration if there is a very local and temporary increase in concentration? What about the time perspective? AA-EQS is the EQS expressed as an annual average value. MAC EQS is the EQS expressed as a maximum allowable concentration.

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Assessment of dredged sediments in the light of the WFD-EQS. Justified trouble due to advanced assessment tools?

Henning Schroeder[1], Carmen Kleisinger[1]

[1]Federal Institute of Hydrology, Am Mainzer Tor 1, Koblenz, Germany

Phone: +49-(0)-261-13065449
E-mail:
Henning.Schroeder@bafg.de

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Introduction: As approach to Germany's most important seaport, Hamburg, the Elbe estuary is a waterway of great nautical importance, in which regular maintenance measures on a considerable scale are required to maintain the safety of shipping. In the context of the use and approval of different options for the disposal of dredged, mostly more or less contaminated sediments, the environmental impacts of the use of various disposal sites in the Elbe estuary and in the German Bight have been assessed in recent years. In preparing the respective impact assessments, a collaboration between the German authorities Federal Institute of Waterways Engineering (BAW) and the Federal Institute of Hydrology (BfG) has been established. On the one hand, a continually improved hydraulic numerical model for the transport and fate of the disposed sediments provide an essential basis for the impact forecasts. On the other hand, the requirements of EU directives like the water framework directive (WFD) have to be considered with increasing detail. The contamination of the dredged sediments as well as existing concentration gradients between the sediments of the North Sea and the Port of Hamburg make estimates of the pollutant input into the sediments and the surface water of the disposal area of considerable importance. Due to very low environmental quality standards (EQS) for some contaminants according to the WFD, problematic assessments arise for some ubiquitous pollutants whose concentrations in the dredged sediments were previously considered to be largely uncritical.

Methods: From the results of the hydraulic numerical modelling (carried out by the BAW), expected deposits of dredged material on the riverbed as well as expected discharge-related suspended matter inputs into the surface water of individual sub-areas are derived. With regard to WFD requirements estimates for the pollutant input into surface water are derived from these forecasts on suspended matter input, considering the quality of the dredged sediments since the assessment of organic pollutants according to the WFD takes place in the total water phase. For parameters for which a sufficiently good database has been collected as part of the surface water monitoring, furthermore, expected average and maximum concentrations are estimated. These expected average and maximum concentrations were finally evaluated based on criteria for the analytical detectability (measurement uncertainty, coefficients of variation of the measured concentrations) and the EQS according to WFD (annual averages and maximum allowable concentrations). In our view of the WFD, results appear problematic when the expected average and maximum concentrations exceed both the corresponding EQS (annual averages or maximum allowable concentrations) and the criteria for the analytical detectability. In this case, either a first-time exceedance of the EQS or the introduction of a pollutant that already exceeds the EQS on a measurable and observable scale is to be feared. Both would represent a potential violation of the prohibition of deterioration.

Results: Against this background, in the impact assessments in the Elbe estuary problematic results arise in addition to tributyltin, especially for the PAHs benzo(a)pyrene, benzo(g,h,i)perylene and fluoranthene, which already exceed the corresponding EQS more or less extensively in the study area (tidal Elbe and German Bight). In contrast uncritical assessments are obtained for most of the parameters that so far caused concern in connection with the disposal of dredged sediments and the assessment of these based on other assessment criteria in the Elbe estuary (e.g. cadmium, zinc, hexachlorobenzene, p,p`-DDE, p,p`-DDD, p,p`-DDT).

Discussion: The presentation will emphasize that advanced assessment tools, together with the very low EQS of some parameters, lead to legal uncertainties in connection with the relocation of dredged sediments. Critical results are obtained mainly for ubiquitous substances without their concentrations having increased significantly. On the contrary, decreasing pollutant levels are observed in the sediments of the tidal Elbe. At the end the extremely low EQS may threaten the maintenance of waterways although these contaminants are ubiquitous and do not represent the most severe contamination of the respective sediments.

The sediment's role in the management of beach and recreational use of water

Bergamin L.[1], Bruschi A.[1], D'Alberto M. [2] Fuscoletti V.[3], Lisi I.[1], Maggi C.[1], Mazziotti C.[4], Nerone E.[5], Nuvolone D[6]., Recchi S.[5], Romano E.[1], Tornambè A.[1], De Angelis R.[1] & ACeS working group[1]

[1] ISPRA. Italian Institute for Environmental Protection and Research, Roma, Italy
[2] Regione Abruzzo, Pescara, Italy
[3] ISS. Istituto Superiore di Sanità, Rome, Italy
[4] ARPAE. Agenzia regionale per la prevenzione, l'ambiente e l'energia dell'Emilia-Romagna, Cesenatico (FC), Italy
[5] IZS. Istituto Zooprofilattico Sperimentale Abruzzo e Molise, Termoli, Italy
[6] Agenzia regionale di sanità della Toscana, Osservatorio di Epidemiologia, Firenze, Italy

Phone: +39 3357942109
E-mail: *elena.romano@isprambiente.it*

Conference theme number(s): 6

Introduction: The recent challenges caused by global climate and environmental changes are making us rethink human health as something inseparable from the state of natural resources and environmental variables, converging on the "one health,, principles. The global recreational use of water in coastal areas, determines the need to guarantee increasingly better quality status. The EU Directive 2000/60 regulates the management of bathing water quality through monitoring and preventing pollution, to achieve a "good" environmental status, protecting human health, water resources, natural ecosystems, and biodiversity. The PNC ACeS Project (Water, Climate, and Health: from the Environmental Protection of Resources to Access to Water, to Safe Use) considers more environmental matrices (water, beach and marine sediments, biota) to understand their correlation with some chemical contaminants better, but also emerging pathogens (including antibiotic-resistant ones) in the bathing areas. Understanding how different environmental interactions can affect the bacteria tracer (i.e. adsorption/desorption processes) in the water column is also useful to validate numerical transport models that generally treat bacteria as free-living in current [1].

Methods: Two recreational coastal areas of the Tyrrhenian and Adriatic Seas (Italy) were selected for the physical, chemical, microbiological, and ecotoxicological characterization of all the environmental matrices. In each area, five sampling stations affected by industrial, urban, and agricultural discharges, plus a control one, were selected for the collection of water, beach and marine sediments, and filter-feeding bivalves during three campaigns (before, during, and after the bathing season) for two years. Marine sediments and organisms were sampled at 1 m water depth. Beach and marine sediments were analyzed for grain size, trace metals, PAHs, and PCBs, to which the analysis of *Escherichia coli*, faecal Streptococci, *Salmonella* spp. and, in addition for marine sediments a battery of three ecotoxicological tests were added.

Results: The analytical activity is still in progress, but the early results highlighted for all sediment the exclusive presence of the sandy fraction in both areas, without seasonal variations except for minimal changes probably due to seasonal events. The microbiological analyses revealed the absence of pathogenic bacteria in both areas in May and low values in July, at a few stations close to drainage channels.

Discussion: Microorganisms (i.e. bacteria, fungi, parasites, and viruses), significant in beach sands and some of this potential pathogens, have all been isolated. Accordingly, a concern is that this matrix may act as a reservoir or vector of infection, as well as a source of water contamination [2,3,4]. The location of marine sampling stations on the submerged beach justifies the sandy texture, devoid of fine fractions that are transported far from the coast. Contaminants are normally associated with clay fraction due to its mineralogical features and this was also demonstrated for bacteria [5]. However, it was found that they may also live in the pores of sand [6]. The absence of contamination before the tourist season and the peak after it let us suppose pathogenic bacteria may accumulate in sandy fraction which is a sink for this contamination for some months. The presence of breakwaters in the Adriatic coastal area may favor this process.

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Spanish Framework for coastal sediment management. Regulatory conditions and impact on sediment balance

Pilar Zorzo[1], Carla Murciano[1], Manuel Antequera[1]

[1]CEDEX, Centre for Port and Coastal Studies, C/ Antonio López 81, 28026 Madrid, Spain

Phone: +34-91 335 76 70
E-mail: pilar.zorzo@cedex.es

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Introduction: Sediment Management in Spanish coastal waters is regulated by three national laws: the Coastal Law, the Port Law and the Marine Environment Protection Law. The implementation of these laws has led to the development of technical instructions that regulate the extraction, placement and disposal of materials in coastal and transitional waters in accordance with the European Directives and International Conventions to which Spain is a Contracting Party.

The entry into force of this legislation has had a major impact on the evolution of sediment volumes according to their destination and on the quality of sediments that can be placed or disposed of in the marine environment without containment measures.

CEDEX, through the Centre for Port and Coastal Studies, has been deeply involved in providing technical and scientific advice to the Spanish administration, primarily to the General Directorate of of the Coast and the Sea and the State Port System.

Methods: Since the 1980s, CEDEX has carried out many studies to characterise dredged materials including management options, which have culminated in the development and proposal of Recommendations and Guides for approval by the competent Ministries to guarantee sustainable management of dredged materials, as well as beach restoration. Methodologies for classifying marine sediments are addressed by these guidelines including National Action Levels (NAL) for establishing the most appropriate management alternatives. Additionally, a procedure has been developed for dumping sites evaluation where the potential impact to protected areas has been considered in depth.

In addition, CEDEX is responsible for updating an inventory compiling volume sediment data and other associated parameters of all extraction works in Spanish coastal and transitional waters, including the destination of these materials.

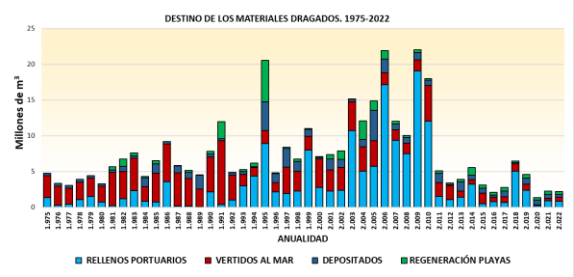

Fig. 1: Destination of dredged materials in Spain 1975-2022. Source: Inventory of dredged material in Spanish ports 2022 (CEDEX).

Results: Since 1975, 357 million of cubic meters of dredged material has been removed from ports in Spain. More than 200 million have been classified according to the Dredged Material Guidelines. 125 million have been dumped into the sea and 25 million have been used as beach fill material. The rest has been used in port landfills or placement in confined disposal facilities.

Discussion: The adoption of various pieces of legislation has had a strong impact on the reduction of the volumes of dredged material dumped into the sea, especially the most polluted ones, and has favoured a greater use of the best quality sediments in beach nourishment. The establishment of NAL for the classification of marine sediments has been based on many technical studies and on a discussion process in which scientific and technical personnel and the competent administrations have participated.

Acknowledgements: To the General Directorate of the Coast and the Sea and to State Ports Authority for their support in maintaining this line of activity, including its financing.

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Optimization of Sediment Restoration Through Combined Remedy and Risk Management

Senda Ozkan[1], Steve McGee[2], Keir Craigie[1], Gary Braun[1], Chris Moody[1]

[1]Tetra Tech, 19803 North Creek Parkway, Bothell, WA, USA
[2]Tetra Tech, 495 Junia Court, Powell, OH, USA

Phone: +00-(1)-0425-4827767
E-mail: senda.ozkan@tetratech.com

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Introduction:
In ongoing international efforts for sustainable management of impacted sediments, the decision-making process includes site investigations, exposure and risk assessment, development of risk management strategies, selection and implementation of a remedy followed by site monitoring to evaluate performance of sediment restoration.
The state of the practice of sediment restoration techniques include removal of impacted sediments from the aquatic environment, covering with clean material, in-situ treatment and/or natural processes while monitoring the sediments to ensure that contaminant exposures and risk to environment and human health is in decreasing trend. In majority of the contaminated sites, a combined remedy optimizes the process to achieve the remedial goal.
This paper presents the sediment restoration process utilized at a site to optimize restoration of impacted sediments through utilizing a combination of restoration technologies based on risk to environment and human health. The main objective of the optimization efforts is to manage further degradation of the health of sediment to achieve a balance between the protectiveness and long-term effectiveness of the risk management strategies.

Methods:
Sediment at a site in the USA mid-Atlantic region is impacted with PCBs, PAHs and metals. Multi-parameter decision analysis tools were used to facilitate final remedy selection, which included a multi-component remedy, including removal and in-situ treatment. In-situ treatment was proposed as sustainable restoration option to reduce removal, sediment disturbance, dewater and disposal of impacted sediment. Coordinated communication efforts were required to obtain regulatory approvals, the informed consent of stakeholders and the general public. Treatability testing was employed to document the effectiveness of proposed in-situ treatment amendments. Treatability studies demonstrated that the effectiveness of activated carbon application at doses of 2.5% and 5 % dry weight of the sediment resulted in 95% reduction in porewater concentrations and invertebrate bioaccumulation. As the project went from treatability study to implementation, the site became one of the largest in-situ treatment of PCBs in sediment to date with 5.5 hectare.
Multi-component remedy in the creek portion of the site included select removal followed by habitat restoration to reduce erosion and migration of contamination from upland.

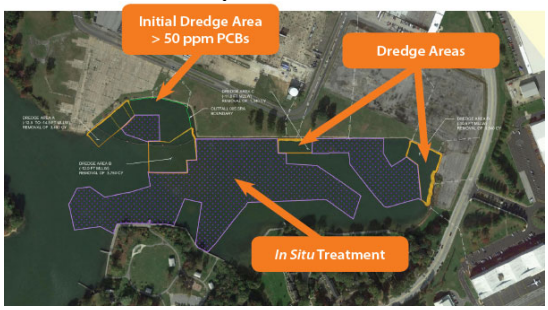

Fig. 1: Combined remedy in a cove.

Results:
Risk monitoring results show reductions in sediment porewater PCB concentrations and invertebrate tissue PCB concentrations. The total dissolved PCB concentrations in sediment porewater had reductions greater than the 80% target and reductions in tissue PCB concentrations were greater than the 70% target established for the project. Near sediment surface water concentrations were reduced by approximately 80% from baseline. Five-year monitoring of habitat restoration areas showed that functional goals of erosion protection, nutrient removal, and creating ecological diversity have been achieved.

Discussion: In-situ treatment of contaminated sediments is a sustainable risk management approach to restore the health of sediment if applicable to the site conditions. A well-designed habitat restoration is a nature-based solution to restore health of sediments by reducing erosion and promoting natural recovery.

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Sediment management concept of the River Elbe (Germany) – implementation status and an example for supporting research

Marvin Brinke[1], Meike Hahn[1], Jessica Reinmüller[1], Nils Keltsch[1], Sebastian Buchinger[1], Gregor Ollesch[2], Matthias Wolf[2]

[1]Federal Institute of Hydrology (BfG), Am Mainzer Tor 1, 56068 Koblenz, Germany Phone: +49-(0)-261-13065966
[2]RBC Elbe's Liaison Office, Otto-v.-Guericke-Straße 5, 39104 Magdeburg, Germany E-mail: brinke@bafg.de

Conference theme number(s): 6 Sediment Management Concepts and Policy

Introduction: Sediments are an integral part of water bodies and aquatic ecosystems, thereby fulfilling fundamental functions as a stream bed, habitat and with regard to biogeochemical cycles and ecosystem services. Sediment quantity and quality can vary and sediments interact with other environmental media - this is thus relevant for achieving the objectives of the European Water Framework Directive (WFD). Sediments and their management are also important for various utilisations of watercourses, such as navigation. The Elbe River Basin Community (RBC Elbe) and the International Commission for the Protection of the Elbe (ICPER) therefore identified the need to develop a sediment management concept in the first River Basin Management Plan for the WFD in 2009, as the directive itself only takes sediments into account to a limited extent. Such a concept was then developed nationally and internationally in the following years and published in 2013 and 2014. The central aim was to provide suggestions for good sediment management practice in the Elbe catchment area in order to achieve supra-regional action goals. Specific recommendations for action and management options were formulated based on an integral consideration of the aspects of quality, quantity and hydromorphology as well as navigation.

Current approach: The implementation steps of the sediment management concept to date with regard to qualitative sediment management will be discussed in this presentation, including the obstacles identified. To strengthen and improve the implementation process, an ad-hoc working group was established in the RBC Elbe in 2020, which is now established as a permanent sediment management expert group to continuously and actively accompany the further process. In addition, two sediment workshops of the German Federal Government and the German federal states were held in 2019 and 2023 to intensify the process, resulting in both a position paper (2020) and, as an update, a declaration of intent (2024) for joint action in the Elbe river basin district.
One important task of the sediment expert group is the prioritisation and estimation of effectiveness of measures. This likely can be supported by methods developed during research projects. In this presentation, examples of results from the still ongoing research project SOURCE, conducted at the Federal Institute of Hydrology (BfG), are shown. The aim of the project is to develop a methodological framework for identifying the pollutants responsible for ecotoxicological effects and their sources of input into federal waterways focused on the River Elbe and its tributary River Saale. This will be achieved by combining chemical analytical procedures, modelling of toxic effects and effect-based methods. For this purpose, cause-effect relationships between observed ecotoxicological effects and the pollutant load of waterways are considered.

Outlook: An important objective of the declaration of intent is that all necessary, proportionate, sediment-related and at best near-source measures to achieve the requirements of the WFD and also the European Marine Strategy Framework Directive (MSFD) should continue to be realised in the German Elbe catchment area. It was noted that the required reduction of sediment-related pollutant discharges and displacements will be achieved in particular if the necessary environmental policy weight is given to the sustainable reduction of pollutant loads (also internationally) and if there is a timely joint identification and realisation of measures, which are sustainably effective throughout the river basin.
Concerning the identification and prioritisation of these measures, methods applied and developed by projects such as SOURCE also allow for considering the high number of known and unknown pollutants as well as possible mixture effects to facilitate a more realistic sediment risk assessment and sediment risk management in the future.

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iNNO SED - Innovative Sediment Management in the Danube River Basin

Sándor Baranya[1], Barbara Kéri[1], Jelena Batica[2], Gordon Gilja[3], Helmut Habersack[4], Győző Jordán[5], Zoltán Barina[6], Albert Scrieciu[7], Roser Casas-Mulet[8], Katarina Mravcova[9], Jasminka, Alijagic[10], Kathrin Kopke[11]

[1]Budapest University of Technology and Economics, H-1111 Műegyetem rkp. 3, Budapest, Hungary
[2]Jaroslav Černi Water Institute, Belgrade, Serbia
[3]University of Zagreb, Zagreb, Croatia
[4]University of Natural Resources and Life Sciences, Vienna, Austria
[5]Aqua Terra Kft, Budapest, Hungary
[6]WWF Hungary, Budapest, Hungary
[7]National Institute of Marine Geology and Geoecology, Bucharest, Romania
[8]Technical University of Munich, Munich, Germany
[9]Water Research Institute, Bratislava, Slovakia
[10]Geological Survey of Slovenia, Ljubljana, Slovenia,
[11]University College Cork, Cork, Ireland

Phone: +36-(30)-309-3335
E-mail: baranya.sandor@emk.bme.hu

Conference theme number: 6

Introduction: Effective sediment management is vital for maintaining the health and functionality of river systems. In the Danube River Basin (DRB), human interventions such as river regulation, hydropower plants, and other human impacts have disrupted sediment continuity, resulting in sediment imbalances. The iNNO SED project addresses these challenges by delivering innovative, sustainable solutions to improve sediment quantity and quality within the DRB.

Objectives: The primary objective of iNNO SED is to establish the Danube Sediment 'Lighthouse' Knowledge Centre together with providing a Sediment Management Toolbox with transferable solutions for sediment challenges in large river basins. Key goals include: i) Enhancing sediment continuity and mitigating erosion in free-flowing sections; ii) Reducing sedimentation in impoundments while improving sediment quality; iii) Developing innovative sediment monitoring and modelling techniques; iv) Empowering stakeholders and the public through participatory tools and training.

Methodology: The project employs a holistic, interdisciplinary approach, integrating scientific, socio-economic, and environmental aspects of sediment management. Highlights include: i) Development of novel monitoring methods, such as AI-based sediment quality assessment and Earth Observation (EO) techniques; ii) Creation of Digital Twins for complex regions, including the Iron Gates and Danube Delta, to simulate sediment dynamics and inform management decisions; iii) Implementation of innovative, preferably nature-based solutions (NbS) at eight demonstration sites, addressing sediment-related challenges such as continuity restoration and pollutant reduction.

Expected Results: i) A comprehensive Sediment Management Toolbox, including a Sediment Atlas and actionable guidelines for replication and scaling; ii) Demonstrable improvements in sediment management at key demonstration sites, enhancing ecosystem health and reducing pollution; iii) Increased stakeholder capacity through targeted training, public engagement, and Citizen Science initiatives.

Impact: By improving sediment conditions across the DRB, iNNO SED supports biodiversity, sustainable inland navigation, and hydropower production. The project aligns with the European Green Deal and the Water Framework Directive, contributing to global sustainable development goals and serving as a model for sediment management in other large river basins worldwide.

Conclusion: The iNNO SED project exemplifies transnational collaboration and innovation in sediment management. Its integrated solutions and comprehensive approach aim to transform sediment-related challenges into opportunities for environmental restoration and sustainable development.

DanubeSediment_Q2 - Sustainable, Integrated Transnational Sediment Quantity and Quality Management in the Danube River Basin

Helmut Habersack[1], Sándor Baranya[2], Vlad Gabrian[3], Győző Jordán[4], Nevena Cvijanović[5], Peter Flödl[1], Marlene Haimann[1]

[1]University of Natural Resources and Life Sciences, Vienna, Austria
[2]Budapest University of Technology and Economics, Budapest, Hungary
[3]National Administration Romanian Waters, Bucharest, Romania
[4]Bálint Analitika, Budapest, Hungary
[6] Jaroslav Černi Water Institute, Belgrade, Serbia

Phone: +43-(1)-47654 81901
E-mail:
helmut.habersack@boku.ac.at

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Introduction: Sediment management is a critical issue in the Danube River Basin (DRB), as disturbances in sediment balance—both in quantity and quality—affect river morphology, ecosystems, flood risks, and navigation. The DanubeSediment_Q2 project addresses these challenges by aiming to achieve harmonized sediment management practices to support environmental objectives across the DRB.

Objectives: The primary goal of DanubeSediment_Q2 is to develop the first Integrated Sediment Management Plan (ISMP) for the DRB. This plan will include recommendations for sustainable sediment management and upscaling solutions to be adopted in future iterations of the Danube River Basin Management Plan and the Flood Risk Management Plan.

Methodology: To achieve its goals, DanubeSediment_Q2 employs an innovative co-design approach involving 14 project partners and multiple stakeholders across all across the Danube Region. The project develops and tests sediment management measures using data from an extended sediment monitoring network, modelling tools, and case studies in nine pilot sites. Key outputs include a new hydromorphological assessment method, a sediment risk assessment method, and practical solutions for sediment quantity and quality improvements. The development of the Integrated Sediment Management Plan will be done based on the procedure outlined in the Common Implementation Strategy for the water framework directive [1] and applying a co-design and co-creation to involve stakeholder.

Expected Results:
The project will develop the first Integrated Sediment Management Plan for the Danube River Basin which is expected to improve sediment balance, ensure continuity at barriers, reduce sedimentation in impoundments, mitigate riverbed and coastal erosion, and control polluted sediment transport. In the long run, this will contribute to dynamic river morphology, reduced flood risks, enhanced groundwater levels, and improved conditions for ecosystems, navigation, and hydropower.

Impact: The project will have a long-term impact by facilitating the adoption of harmonized sediment management practices, contributing to better flood risk control, reduced erosion, and improved water quality. Its outputs will influence the Danube River Basin Management Plan and Flood Risk Management Plan, benefiting governments, stakeholders, and local communities.

Conclusion: DanubeSediment_Q2 represents a vital step towards sustainable sediment management in the Danube River Basin. The project's collaborative approach and innovative methodologies will support the restoration of a healthy sediment system, essential for ecological balance and flood risk reduction in the region.

Acknowledgements:
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Data-driven approach to implement an integrated water and sediment management strategy in Flanders

Wim Clymans[1], Katrien Van de Wiele[2], Karolien Vermeiren[1], Goedele Kaeyens[2], Els Ryken[3], Marleen Van Damme[4] Froukje Kuijk[2] & Steven Broekx[1]

[1] VITO, Flemish Institute for Technological Research, Mol, Belgium
[2] OVAM – Flemish Waste Agency, Mechelen, Belgium
[3] VMM, Flemish Environment Agency, Aalst, Belgium
[4] DOV, Databank Ondergrond Vlaanderen, Gent, Belgium

Phone: +32-(0)-486-800575
E-mail: wim.clymans@vito.be

Conference topic: 6 Sediment Management Concepts and Policy

Purpose: In line with the European Water Framework Directive, Flemish authorities face significant issues with respect to the impact of pollution from urban wastewater and industry on surface and groundwater at the level of river basins. Historically contaminated stream sediments and those currently deposited are also known to negatively impact the water quality, and often spread gradually downstream causing damage to vulnerable ecosystems. Although the role of contaminated stream sediments has been acknowledged by authorities, an integrated approach to remediate and manage sediments is lacking. Flanders invested (since 2018) in the development of a data-driven approach to achieve an actionable policy. The project aimed 1) to develop a public tool where different authorities and stakeholders can consult data on sediments to streamline operational activities with respect to water and sediment management and 2) to set up a regional prioritization and financial support system to initiate concrete remediation projects across Flanders. The approach has been put to practice in a collaborative project between VITO, OVAM (the public waste agency of Flanders), VMM (the Flemish Environment Agency) and DOV. We present the web-based tool and it's implementation by the Flemish Government to prioritize their actions in the field.

Methodology: To support the decision making process on further examination, remediation and/or management of sediments, a web-based spatial tool called 'Sediment explorer' (dutch. Waterbodemverkenner) was developed. The Sediment explorer collects data from different local and regional authorities. A multi-criteria approach is used to derive the remediation priority of streams and are presented alongside maps with relevant environmental and policy data to support area-specific strategies. Additionally, a cost-benefit analysis is performed to compare costs for research and remediation with benefits for water quality, and reduced remediation costs downstream if complete or partial remediation of the identified contaminated sites is achieved. The regional prioritization builds on the Sediment explorer and cost-benefit analysis to list those water courses with highest policy priority for 1) sustainable remediation and 2) those up for remediation due to immediate health risks.

Results/Discussion: About 40% of measured sites have a physico-chemical contamination with significant ecological risks but often sustainable remediation is possible if appropriate measures are taken. A series of cost-benefit scenarios indicates that only 60-90% of all costs can be compensated by the benefits of remediation. Limited direct benefits of remediation suggest that additional incentives need to evoke remediation. It is therefore a strong plea for targeted prioritization and an area-specific approach. The Flemish government exemplified this by listing those water courses with the highest policy priority and provided financial support to remediate those waterbodies. As a result concrete actions have been initiated in several streams across Flanders.

Significance: Local and regional authorities use the web-based tool 'Waterbodemverkenner' to help streamline operational activities. The cost-benefit analysis result corroborates the concept of an integrated project approach where sediment remediation is not an end in itself, but a necessary precondition to achieve or safeguard other functions. For example, during urban development in cities or river restoration projects within protected nature areas. The data-driven approach allowed the Flemish government to set up financial incentives to kickstart remediation projects.

Banning the dumping of polluted sediments - The French choice

Dolbeau Xavier[1], Bataillard Philippe[2], Dréau Alain[3], Vayssié Aurélie[4], Bailly-Maître Marie-Laure[4] and Burtschell Lugdiwine[4].

[1]EGIS, 889 Rue de la Vieille Poste, 34965 Montpellier, France
[2]BRGM, 3 avenue Claude Guillemin, Orléans, France
[3]IDRA, La Haye de Pan, 35170 Bruz, France
[4]Ministère de l'Aménagement du Territoire et de la Décentralisation, Paris, France

Phone: +33-(0)-637329070
E-mail: xavier.dolbeau@egis-groupe.com; p.bataillard@brgm.fr

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Introduction: Since January 1, 2025, the discharge of polluted sediments and dredging residues at sea has been banned in France [1]. To make this ban effective, new content thresholds qualifying sediments as polluted have been defined, in addition to the N1 and N2 levels already available in French regulations. This study presents the choices that led to their establishment.

Methods: Based on a literature review of international regulations and practices relating to the management of dredged sediments, three ban threshold scenarios were proposed and assessed in terms of environmental and socio-economic consequences:

- "N2" scenario : setting the L2 guide values of current French regulation as the thresholds for prohibiting immersion.
- "ALT1" scenario: alternative 1 of the International Maritime Organization (IMO) study, corresponding to the 75th percentile of level 2 values available worldwide, all greater than or equal to N2, as thresholds for prohibiting immersion.
- "N*" scenario simulating the implementation of a 'triad' approach, including the use of ecotoxicological tests, likely to prohibit the dumping of part of the dredged sediments.

A flow chart describing the fate of sediments brought ashore has been drawn up. It presents the various stages of onshore management, distinguishing between: a possible granulometric separation of sand from silt brought ashore, re-drying of sand and/or dewatering of silt, followed by possible treatment prior to reclamation or disposal in storage facilities. Based on this flow chart, a calculation algorithm was created using quantitative parameters characteristic of sediments and their management method. The algorithm was transcribed into Excel® in order to automate the step-by-step calculations and thus obtain the financial cost (€) and environmental balance (GHG, land consumed, potential danger to the marine environment avoided) for each proposed scenario. The model's output is thus a decision-making tool, depending on the scenario chosen.

Results: According to the data collected in this study (CEREMA database), the volume of sediment dredged in France, exceeding the N1 threshold, is estimated at 14.3 million m3 per year, of which 400,000 m3 is currently brought ashore and managed. Simulations indicate that implementation of the new scenarios would lead to an increase of +87,600 m3 per year for scenario N2, +28,600 m3 per year for scenario ALT1, and +157,700 m3 per year for scenario N*. A hazard score was calculated for each dredging operation listed, and used to define a score for each scenario studied. Systematically, scenario N2 - which brings the largest volume of poor-quality sediment ashore - offers the greatest gain in terms of impact on the marine environment. However, the differences induced by the choice of scenario appear to be small on a national scale, indicating that sediments currently dumped are on average of fairly satisfactory quality, with disparities depending on the port and dredged area.

Discussion: In comparative terms, scenario N2 is the most protective for the marine environment according to the indicator used in this study, but would generate almost 5,000 tonnes of CO2 per year more than the current situation. Scenario ALT1, on the other hand, generates lower additional costs, emits fewer GHGs and consumes less land than scenario N2. It offers a more limited, but still significant, gain in terms of protection of the marine environment. For this reason, it has been selected by the French Ministry as the new threshold for prohibiting the dumping of sediments considered polluted.

References: [1] Article 11 de l'arrêté du 27 mars 2024.

Circular management of dredged sediments from port maintenance

Arash Sepehri [1], Alex Kirichek [1], Marcel van den Heuvel [2], Mark van Koningsveld [1, 2]

[1] Delft University of Technology, Delft, Netherlands
[2] Van Oord Marine Dredging and Marine Contractors, Rotterdam, Netherlands

Phone: +31645698766
E-mail: a.sepehri@tudelft.nl

Conference theme number(s): 6

Introduction: The concept of circularity is used as an alternative to linear flow materials in order to protect the environment from potential damage. To determine to what extent a sediment management project contributes to circularity practices, it is necessary to quantify how much of the dredged material is maintained within the system. Hence, defining boundaries for the system and circularity indicators for dredged material plays a vital role in measuring the circularity level of a certain project [1]. This study concentrates on defining circularity indicators for sediment management projects when a certain amount of material is diminished during the pre-processing stage. Besides, the perspectives of different stakeholders (e.g. port authorities, and dredging contractors) influence the selection of strategies for circular maintenance dredging [2].

Methods: To determine how the sediment management project contributed to a circular economy, the total amount of loss in the amount of sediment is measured during the pre-processing phase. The pre-processing operations might include washing, de-watering, treatment, desalination, degradation, etc. A certain tonnage of dried sediment (or cubic meters of slurry) is lost during each stage which reduces the circularity of the system. Figure 1 shows a simple schematic approach for sediment loss.

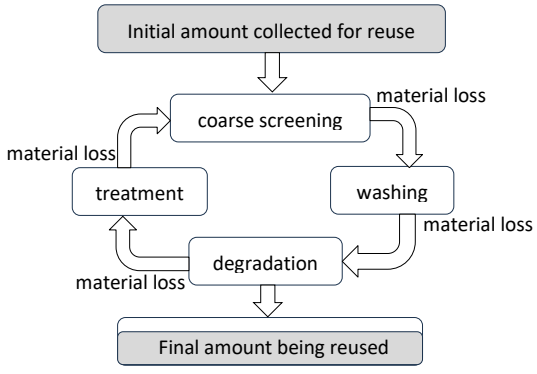

Fig. 1: Circular dredged sediment management [1]

The initial amount of collected sediments diminishes during each stage of pre-processing; therefore, the final amount being reused is relatively lower. As a result, the total contribution of the sediment management project to circularity practices is decreasing during each stage of pre-processing [3].

Results: Case studies of port maintenance are discussed to determine the impact of sediment pre-processing on the total loss before being re-used and the contribution of each project case to circularity practices. First, the pre-processing operations required to be specified for each case to monitor the sediment loss. Second, the amount of sediment loss in each stage is determined by tracking the input and output of each compartment. Third, the initial and final amounts are compared to measure to what extent the project is circular. Meanwhile, the circularity is also affected by sediment reusability and life cycle that are dependent on the sediment properties. Thereafter, other scenarios for dredging are discussed to provide a detailed insight into the optimal sediment management in each case. The scenarios focus on using different types of dredging vessels or vessels of the same type but with different properties. A discrete-event simulation is used to quantify a comparison between different dredging scenarios regarding efficiency and emissions.

Discussion: Scenario comparison is connected to trade-off quantification and the circularity index is studied along with other criteria such as emissions and the time needed to dredge the whole area. This trade-off can help stakeholders with different viewpoints to understand which strategies can be chosen for a certain case. Besides, the theoretical and managerial implications of this study are elaborated.

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Sediment management in hydropower reservoirs on Drava river

Dr. Polonca Ojsteršek[1], Dr. Boštjan Gregorc[2]

[1-2]Dravske elektrarne Maribor d.o.o., Obrežna ulica 170, 2000 Maribor, Slovenia Phone: +386-(2)-300-5453
E-mail: polonca.ojstersek@dem.si

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Abstract

Eight large and three small hydropower plants on the River Drava generating approximately 2.8 TWh of electricity per year, represent one of the most important pillars of electricity production in Slovenia, as the total production accounts for about a quarter of the electricity generated in Slovenia.

Like in many other hydropower reservoirs around the world sediment deposition reduces the energy potential of reservoirs, decreases good ecological potential of the reservoirs, reduces flood control, irrigation possibilities and impede other functions that the hydropower operator is obliged to provide.

Based on the yearlong bathymetry survey results of the reservoirs on the River Drava, it is evident that the amount of sediment deposited in the live storage is increasing rapidly and reducing the daily production capacity of the hydropower plants. The capacity of the total volume has been reduced by 29% by 2023 from the original 108.99 million m^3 of sediment deposited in the useful volume to 108.99 million m^3 of sediment deposited in the useful volume by 2023. From a sediment management perspective, this represents 544,000 m^3 of sediment in the useful volume of all reservoirs that would need to be relocated or removed for full energy recovery.

A number of measures can be applied to mitigate the effects of sedimentation, from flushing to removal and treatment of sediment for re-use in construction. To be optimally effective in the long term, these measures require a holistic approach, ranging from the development of hydraulic models for the entire hydropower chain, the preparation of a sediment management plan and an action plan for the implementation of the measures, taking into account the legal framework and seeking compromises with stakeholders. The paper will present how Dravske elektrarne Maribor d.o.o. approached the problem.