

Sustainable navigation in Malamocco-Marghera navigation channel (Venice Lagoon)

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A thorough and multi-disciplinary study has identified sustainable solutions to enhance navigation capacity along the Malamocco-Marghera Channel, in the Venice Lagoon, at the same time mitigating the erosion processes affecting the tidal flats surrounding the Channel, thus guaranteeing safe navigation conditions. Moreover, seeking synergies between port sustainability and mitigation of human and climate change impacts on endangered habitats is part of the challenge.

The study activities have been carried out within the "Channeling the Green Deal for Venice", a CEF European funded project that tackles the limited nautical accessibility of the port of Venice, fully respecting the environment and the UNESCO protected site of the Venice Lagoon. Following Public Tender procedures, Port of Venice awarded the study to a Consortium led by DHI S.r.l. and formed by DHI A/S, Force Technology, HS Marine S.r.l., Cetena S.p.a. and Around Water S.r.l..

To achieve the ambitious goal, a complex and structured combination of navigation and hydrodynamic/ sediment transport models have been planned and implemented. For the first time hydrodynamics, real time navigation and morphological models mutually interact to identify the best solutions.

The development of the design solutions moves within a series of needs and constraints of different nature: functional, environmental and economic, and involves alternating phases of study and analysis of the results with phases of confrontation with the Port Community. The most critical phenomenology, i.e. the displacement wave induced by passing vessels, is in fact directly linked to the dimensional relationship between the section of the Channel, the submerged hull of the ship and the speed with respect to the water. The first step aimed at defining the proper study of the geometry of the Channel suitable for ensuring the safety of navigation; consequently, the 3D hydrodynamic simulations have been replicated, with special focus on the displacement wave and its potential impact on the morphological response of the tidal flats around the Channel. After proper quantification of the local bed shear stresses in the

various areas of interest, both large scale and local design solutions aiming at preventing the erosion of the tidal flats and Channel banks have been identified. The result is complete framework of solutions, both infrastructural and management-led, that balance environmental and port performance needs.



Transforming Sediments into A Sustainable Material for Blocks Production

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Introduction: The construction industry faces increasing pressure to adopt sustainable practices that minimize environmental impacts and reduce reliance on non-renewable resources. Sediments, often regarded as waste or a by-product of dredging activities, present a unique opportunity for reuse in infrastructure applications.

This study explores the potential of transforming sediments into durable pavement stones through the patented GEOWALL compression technique. By utilizing sediments as a primary raw material, this approach addresses two key challenges: managing excess sediment sustainably and reducing the demand for traditional paving materials.

The research focuses on optimizing the compression process, evaluating the mechanical properties and the durability of the resulting stones, and comparing their performance with conventional alternatives. This innovative use of sediments demonstrates their viability as a sustainable construction material while supporting circular economy objectives. These stones can be used for various applications such as pavement stones, artificial reefs, sound barriers, dyke reinforcement ...

Methods: Sediments were collected, and tested for their chemical and physical characteristics. The results were then analyzed to check whether they were contaminated or not and to optimize the particle size distribution.

The sediment content was maximized, typically using more than 50% of the total material mass in order to emphasize sustainable reuse.

Optimization of Moisture Content:

Tests are conducted to ensure that optimum moisture content is determined through preliminary testing to achieve the best workability and compaction results.

Particle Packing and Mix Design:

Particle packing was optimized using a custom-developed model based on hundreds of data points collected from the NETICS database. This model ensured an efficient distribution of particles, improving block density and strength.

Binder Selection and Incorporation:

For each application and sediment type, binders are selected to meet environmental, strength and

durability requirements, balancing performance with sustainability.

Block Production:

The mixture was compacted under controlled pressure to form blocks, ensuring high density. The patented GeoWall press is used with compression from two sides. Fibers could be added to improve the flexural strength.

Testing and Validation:

Produced blocks were tested against the required standards for the specific, including compressive and flexural strengths, durability, erosion, and water absorption, to ensure compliance with industry requirements.

Applications:



Fig. 1: Different application of the blocs (from left to right: artificial reefs, pavement stones, dyke revetment, sound barrier)

Discussion: This methodology emphasizes optimizing sediment use, advanced particle packing, and the incorporation of fibers and effective binders, providing a framework for creating sustainable and high-performance stones. NETICS is working on creating a more commercialized approach and process of making blocks with a higher TRL level while upscaling aspects like production rates but also shapes and the possibility of creating openings.

Sustainable reuse of *posidonia oceanica* fibers and dredged marine sediments for lightweight and eco-friendly mortars

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Conference theme number: 3. Nature Based Solutions

Introduction: Marine sediments and *Posidonia oceanica* (PO) present significant environmental challenges that must be evaluated and managed. Dredging marine sediments is necessary to maintain navigable waterways and requires sustainable management to minimize ecological impacts. Similarly, PO, a key Mediterranean seagrass, bioindicator of water quality, shows specific challenges: during colder months, decaying PO accumulates along shorelines due to adverse weather, requiring effective management strategies. Balancing ecological preservation with economic and environmental needs is crucial to addressing these issues. Several studies have demonstrated that the addition of PO fibers to concrete mixes positively affects properties such as thermal conductivity and mechanical strengths. [1] At the same time, marine dredged sediments have shown potential for concrete development due to their mineralogical and chemical properties. [2] This study investigates the reuse of PO fibers and dredged marine sediments in cement mortars, evaluating their workability and mechanical performances to promote sustainable practices through the reuse of marine waste.

Methods: The mixes were based on cement, water, sand, PO fibers, and dredged marine sediment, used with different percentages. The cement used for the mortar samples was CEM II A-LL 42.5 R, a type II Portland cement characterized by very high normalized strength and high initial strength. The sediments, dredged from the port basin of Mola di Bari, were sandy, with a representative particle diameter of 0.35 mm; these were used in substitution of the sand in different proportions (1:3, 1:1, 3:1). The sand was a conventional silica sand with a diameter of 0.8 to 1.2 mm. The PO collected from the shores of Mola di Bari had a grain size between 2 mm and 0.063 mm, representative of the sand class, with an average particle size of 0.57 mm. Different PO fiber weight fractions (2.5% to 7.5% with respect to sand weight) were used. The water-to-cement ratio for all mixes was 0.5. Fresh properties were investigated by the flow test, which allowed to detect the workability of the samples. After 28 days of curing under conventional conditions, the uniaxial compressive and flexural strengths of the specimens were evaluated.

Results: The experimental investigation yielded good results for both workability and mechanical strength tests. The flow test showed promising outcomes: as the percentage of sediment and PO increased, workability decreased. Notably, mixes with 2.5% PO demonstrated workability comparable to that of traditional sand-based mortar. As PO content increased, specimen density decreased, leading to lower mechanical strengths. However, the compressive and flexural strength tests revealed satisfactory results for all mixes (2.5%, 5%, and 7.5% PO fiber content with respect to sand weight). While mechanical strengths decreased by approximately 50% compared to a traditional mortar, with a result of approximately 25 MPa, the highest strengths were observed in mixtures with 2.5% PO, reaching a value of 30 MPa. Failure modes became increasingly ductile as PO content increased.



Fig. 1 - Broken specimen, optical microscope

Discussion: The addition of PO fibers and dredged marine sediments affected both the fresh-state properties and the 28-day mechanical properties of the mortars. These findings are significant, as the workability and mechanical strengths of the composite mortars are comparable to standard mortars, with additional benefits such as reduced weight and increased ductility, which traditional mortars do not offer. Further experimental research will focus on extended curing times, exploring new mixes composition, and evaluating thermal properties.

References: [1] Benjeddou et al. (2022) *Effect of Posidonia oceanica Fibers Addition on the Thermal and Acoustic Properties of Cement Paste*;
[2] Chuet al. (2020) *A strength model for concrete made with marine dredged sediment*.

Valorization of Dredged Materials as Sustainable Construction Resources: An Overview

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Conference theme number(s): 3- Nature Based Solution

Introduction:

Globally, each year, an enormous quantity of dredged materials (DMs) is generated for the maintenance of navigable activities including harbors, rivers, and reservoirs. In recent years, DMs disposal on-land has increased due to the evolution of the regulations that eliminated the disposal in the oceans. The management of those materials has become a serious problem. On the other hand, the construction industry knew an important increase and request for raw materials to produce concrete and its derivatives. As a sustainable solution for this issue, several research studies attempted to recycle DMs in the field of civil engineering. Interest in DMs as construction materials has increased as noticeable from the large amount of published literature. This work presents a literature review on the reuse of DMs as sustainable construction resource (295 literatures) and constitutes a practical guide for the seeker of valorizing DMs. The findings presents: (i) a detailed state-of-the-art-review based on the published papers; (ii) Overview on recycling DMs in a non-structural application such as road construction, functional soil, and ceramics; (iii) Overview on recycling DMs as filler and aggregates including fine aggregates and artificial lightweight aggregates; (iv) Overview on the valorization of DMs as cementitious resource i.e., supplementary cementitious materials, binder for geopolymer, and a raw material for clinker production; (v) Overview on the industrial chairs and projects on valorizing DMs. The review revealed that extensive research works have been done on valorizing those materials in different civil engineering sub-fields. Encouraging findings on the different remediation pathways were reported. However, absence of in-depth research for large-scale application and long-term durability were noticed, as well as the absence of life cycle assessment on DMs as construction materials. However, despite the variability of DMs worldwide, the presence of metallic and metalloids trace elements, chemical instability, and most of the cases, DMs need to be treated before direct use, and even when DMs are not totally inert, the end-products are always under the required environmental limits. The evaluation of the vast experimental research showed that DMs are qualified to be considered as construction material

resources. The recycling of those materials will decrease the natural resources consumption in the civil engineering field alongside resolving their environmental problems.

Keywords: Dredged Materials; Recycling; Review; Sustainability; Valorization; Waste Management.

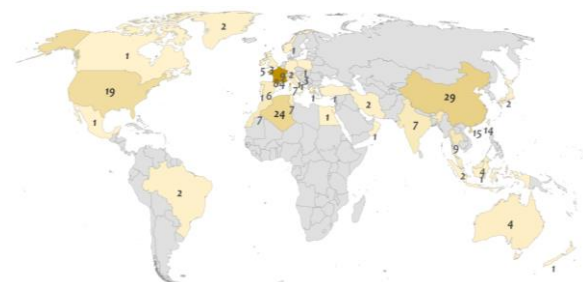
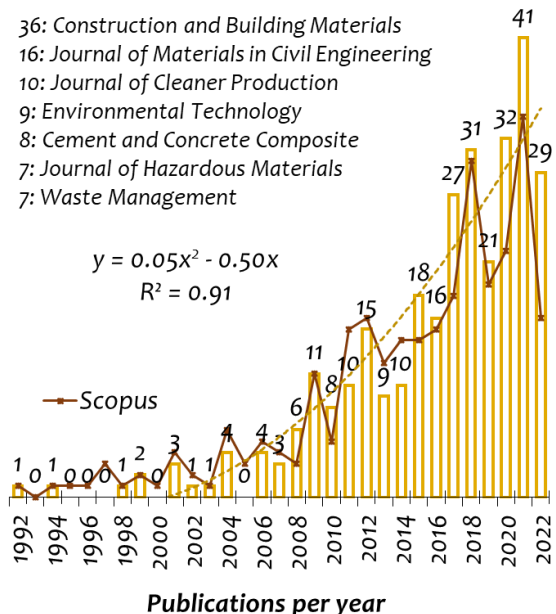


Fig. 1: Studies on recycling DMs in civil engineering: publications per year, and per the origin of the studied sediments.

References:

Safhi A. (2023), Valorization of dredged sediments as sustainable construction resource, CRC Press, ISBN 9781003315551

Enhancing Dike Safety with Ripened Dredged Sediment

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Introduction: The use of ripened sediment in dike reinforcement is an innovative approach addressing both water safety and environmental sustainability. Furthermore, it represents an opportunity to support the transition to a circular economy (CE) in the construction of flood defenses. The ripening process, including dewatering and other physical and biochemical processes, makes it suitable for use in critical infrastructure like dikes. This presentation, which is part of the *Rivierwerken* (River Works) research [1], explores key projects that demonstrate the benefits and challenges of incorporating ripened sediment in dike reinforcement.

Recent projects in the Netherlands: The Brede Groene Dijk (BGD, Wide Green Dike) project explores how water safety, ecological improvements in the Ems estuary, and CE principles can be integrated. Unlike traditional dike reinforcement, which typically uses hard materials, the BGD employs a gently sloping, green embankment, allowing for a more natural transition between the existing salt marsh and the dike. This innovative design requires a substantial amount of material. For the 750-meter stretch of the dike, 70,000 m³ of dredged sediment was used, sourced from the Ems-Dollard estuary. The material was ripened into clay in a deposit (Kleirijperij project) before application in dike strengthening.

The concept of the Meegroeidijk [3] (MGD, Growing Dike) is based on the natural geological process where deltas grow over time through the gradual deposition of sediments by rivers and the sea. Inspired by this process, the MGD project aims to use locally dredged sediment to strengthen dikes incrementally. The dredged sediment is directly placed on the dike, where it ripens.

Older projects worldwide: The reuse of dredged material for dike reinforcement has been tested in various projects worldwide. EcoShape (2020, [3]) provides a comprehensive inventory of past projects. Notable examples include:

- Afsluiting Lauwerszee (1970, Netherlands): Dredged material was used as a covering material

for the dike after it had ripened on the dike itself, with grass planted afterward.

- Wijdewormerringdijk (Netherlands): Area-specific sediment was used to reinforce the inner slope of a dike along a polder, which was drained in the 17th century.
- Garmerwolde (2015-2018, Netherlands): Sediment and sand were used to raise the dike along the northern side of the Eemskanaal.
- Rostock (2010-2015, Germany): A test dike was built to assess the behavior of ripened dredged material in dike construction, part of the EU project DredgDikes.
- Bremerhaven (Germany): A 900-meter-long dike was reinforced using dredged material from the harbor, replacing the original sand core with the dredged material.

The application of ripened sediment has also been tested in other international locations, including Gdansk (Poland), Antwerp (Belgium), Avilés (Spain), and Harwich (UK), showing the broad applicability of this technique.

Conclusion: Using ripened sediment for dike reinforcement is a sustainable solution. By transforming dredged sediments into high-quality construction materials, projects like BGD and MGD demonstrate the potential of CE approaches in flood protection. This method reduces the need for material transport and disposal while offering an eco-friendly way to strengthen dikes against rising sea levels and increasing extreme events. In addition to increasing dike height and strength to cope against extreme highwater, the sediment helps mitigate drying during extreme dry periods. Combining sediment recycling with dike maintenance also helps lower greenhouse gas emissions, creates job opportunities, and offers significant cost savings.

References: [1] Barciela- Rial & McLeod (2023). Report., [2] Gamberoni et al. (2024). Land+ Water, [3] EcoShape (2020). Report.

Open field ripening reduces shrinkage and increases compactibility of dredged sediment

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Introduction:

Increase of sea level and land subsidence necessitate heightening and strengthening of dikes and embankments, creating large material demands. On the other hand, maintenance of fairways, harbor basins, sluices, barrages and water reservoirs generate large volumes of dredged sediment. Physical and biogeochemical properties of freshly dredged, saturated sediment differ significantly from those of ripened, unsaturated soil. Beneficial use of sediment as earthen construction material therefore requires dewatering and further biogeochemical and physical ripening. If repurposed for dike construction, particularly the shrinkage potential of the material and hence its susceptibility to crack formation is of interest. Further, compactibility of the material determines key mechanical properties such as shear and tensile strength. Here, we investigate the effect of field ripening of partially dewatered dredged sediment (METHA material) on these parameters.

Methods: In December 2022, Elbe sediment partially dewatered in the METHA plant (Hamburg, Germany) using high intensity (HIP) and multi-compartment filter (MKFP) presses was deposited into 9 stockpiles of 1,000-2,200 m³, which were managed differently in terms of turning frequency (0, 2 and 4 times per year). Shrinkage, tensile strength, and compactibility were investigated over a 2-year period using the Coefficient of Linear Extensibility COLE[1], the Brazilian Splitting Test [2] and the Standard Proctor Test [3].

Results: The original, not yet ripened material (high-intensity press, HIP), showed the lowest Proctor density and the highest optimum water content, which increased (density) and decreased (opt. water content) with continued field ripening, also without stockpile turning (Fig. 1, top left). Turning, and hence enhanced exposure to air, increased compactibility, with turning four times yielding a greater effect than turning twice annually (Fig. 1, top right, and bottom). Field ripening strongly reduced the material's shrinkage potential, also found previously for laboratory-ripened material [4]. The greatest effect was seen after the first summer period (Fig. 2, cp. Mar and Nov 2023). In contrast to compactibility, shrinkage potential was not sensitive to stockpile management with no difference detected between the control (SP2, 4) and other stockpiles.

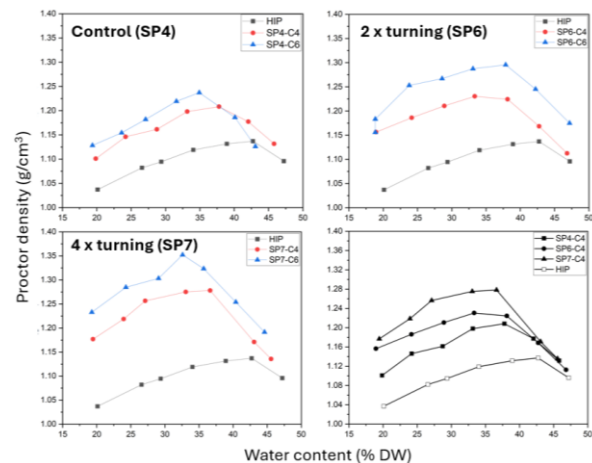


Fig. 1: Proctor curve in relation to time and stockpile turning frequency. C4 = Sept 2023, C6 = March 2024.

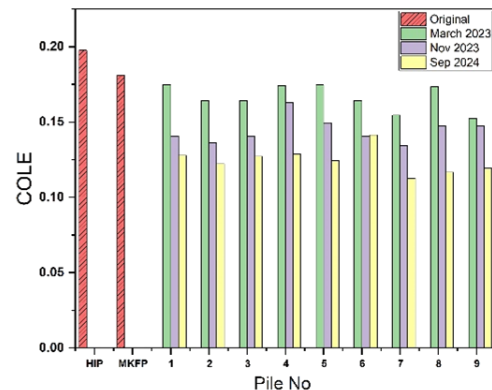


Fig. 2: Shrinkage potential (COLE) over time for original material (red) and 9 stockpiles.

Conclusions: Field ripening increases compactibility and reduces shrinkage and significantly enhances geotechnical properties of dewatered sediment for use in earthen constructions.

References: [1] Schafer & Singer (1976), <https://doi.org/10.2136/sssaj1976.03615995004000050050x>; [2] Akin & Likos (2017): <https://doi.org/10.1520/GTJ20160180>; [3] ASTM (2021), <https://doi.org/10.1520/D0698-12R21>; [4] Oing et al. (2019), <https://doi.org/10.1007/s11368-019-02384-6>

Rheology and settling processes of mud for defining critical limits for navigability in the Port of Felixstowe

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Introduction: The UK's largest container port at Felixstowe, faces significant sedimentation challenges, with approximately 2.4 million m³ of sediment requiring management annually [1]. To optimize maintenance strategies and enhance navigability, Harwich Haven Authority is exploring the implementation of PIANC's nautical bottom concept [2], which relies on understanding the rheological and settling behaviour of muddy bed in the port.

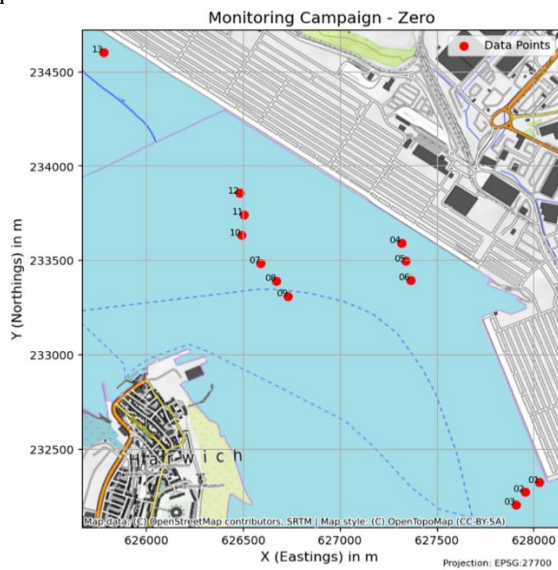


Fig. 1: Sampling and surveying locations at the Port of Felixstowe.

This study examines the shear strength (yield stress) evolution of soft mud layers by investigating their physical properties (e.g., density, organic matter, salinity, etc.), rheological behaviour such as yield stresses and thixotropy, and how these properties develop over time. By linking these temporal changes due to sediment settling and consolidation processes, the research aims to identify critical thresholds for navigability.

Methods: In this study, the analysis of both in-situ measurements and laboratory characterization on sediment samples was carried out. Sediment core samples were collected in the Port of Felixstowe using one-meter core sampler (the Frahmplot). The samples

were subsampled into suspended particulate matter, fluid mud, pre-consolidated sediment and consolidated sediment at various depths per location (see Fig 1). The bulk density, particle size distribution, organic matter content, mineralogy, settling properties and rheology of sediment samples were determined in the laboratory. To identify the rheological characteristics of fluid mud and their development over time, in-situ measurements of density and yield stress, acoustic surveys to map the lutocline and mud-bed interface were conducted using the Rheotune and dual-frequency echosounder which are commonly used for determining the nautical bottom [3].

Results: The analysis conducted on in-situ data and collected sediment samples revealed the following results:

- 1) The bed of the port consisted of predominantly silt and clay with slight variation of sediment's particle size, organic matter, mineralogy and salinity suggesting that the density and strength variation of bed were predominantly driven by settling and consolidation of mud.
- 2) The analysis of settling behaviour showed a special variation in gelling concentration (structural density) of mud.
- 3) Strong thixotropic behaviour of mud was observed on mud with yield stresses above 50 Pa, which was in line with previous studies (e.g., [4]).

Discussion: The correlation of the in-situ and lab yield stress data could be potentially improved by generating a broad rheological dataset for calibration of the in-situ measurements.

This study is funded by Harwich Haven Authority. The research is carried out within the framework of the MUDNET network. The authors would like to acknowledge Deltares for the use of FCL laboratory.

References: [1] Spearman and Benson (2022) *WODCON XXIII*; [2] PIANC (2014) *Harbour Approach Channels - Design Guidelines*; [3] Kirichuk and Rutgers (2020) *Terra et Aqua* **160**:16-26; [4] Shakeel et al. (2020) *J. Soil and Sed.* **20**: 2553–2562.

In-Situ capping of contaminated sediments in Puddefjorden, Bergen Harbour, Norway, using rock materials from tunnel boring machine (TBM)

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Introduction: The harbour of the ancient Hansatic city of Bergen, in western Norway, has been a centre of trade and travel since the 14th century. Since the 19th century, industry and shipping has dominated the city centre, releasing pollutants into the harbour and the nearby fjords. The fjord “Puddefjorden” close to the city centre, has housed several shipyards and different industries up until recently. This has contributed to heavily polluted sea sediments. During the last decade, however, residential housing projects have transformed the area from industrial activity to public access space. The outer part of Puddefjorden has still a lot of traffic by large vessels that could erode and move pollutants.

Methods: A sediment remediation project was carried out in Puddefjorden during 2017-2018. The project required a substantial amount of capping material. Infrastructure projects in and around Bergen were many at the time, one being the construction of a new railway tunnel. The project used a tunnel boring machine (TBM) which drilled through hard gneissic rock producing mainly sand and gravel, along with approximately 10 % silt, making the material susceptible to frost actions, and thus useless for many purposes. The sediment remediation project used the TBM material as capping material to isolate the contaminated sea sediments in Puddefjorden. The results from this project have been monitored and evaluated in 2019 and 2022.



Fig. 1: Puddefjorden in the 1990s while shipyards were still present.



Fig. 2: A small part of Puddefjorden in 2019 after the completion of the remediation project.

Results: An area of approximately 500 000 m² was in part dredged (minor areas) with subsequent capping between June 2017 and December 2018. The 50 cm thick cap in Puddefjorden has proved efficient in isolating contaminants in the underlying sediments and resisting erosion. The big vessels have not affected the cap significantly by propeller erosion.

Discussion:

The beneficial use of a low value material has proved very efficient as capping material of a polluted seabed in an active harbor. There is however need for detailed planning, sampling and monitoring in order to secure the needed quality of the capping material to prevent or reduce the environmental risk for mixing of grease used for lubrication of the cutters and also to test the TBM-material for chemical composition and grain size compatibility after excavation. Environmental monitoring show a minor recontamination of the remediated area in Puddefjorden, but the cause of the recontamination is believed to be the spread of contamination from land (urban runoff) or from the seabed outside the remediated area.

References:

In-situ capping of contaminated sediments in Bergen Harbour, Norway, using rock materials from Tunnel Boring Machine (TBM). Poster (C2_80) Ninth International Conference on Remediation and Management of Contaminated Sediments Batelle, New Orleans, January 2017.

Organic Matter Decomposition During Sediment Ripening

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Introduction: Dredging produces large sediment volumes with organic matter (OM) from natural and industrial sources, which even in small amounts, can significantly affect sediment properties [1]. For beneficial use of dredged sediment, OM stability is paramount. Sediment ripening aims to reducing and stabilizing the organic fractions [2], [3]. This study examines OM degradation in mechanically dewatered dredged sediment (METHA plant, Hamburg, Germany) during ripening, analyzing sediment respiration and the Tea Bag Index [4]. Together, these methods provide a comprehensive understanding of the dynamics of organic matter transformation during biological ripening of dredged sediment.

Methods: The dewatered sediment originating from Elbe river in the area of the port of Hamburg was deposited into 9 stockpiles of 1,000-2,200 m³. OM stability and the decomposition activity of the microbial community were investigated over a 2-year period by measuring CO₂ evolution and O₂ consumption during soil respiration using a gas chromatograph, and by determining the Tea Bag Index (TBI), a standardized approach to assess breakdown of labile and recalcitrant OM. Data from the ripening stockpiles are compared to the properties of ~60 years old historical sediment used as soil amendment (HS).

Results: The original material (high-intensity press, HIP) showed the highest cumulative carbon release, steadily declining from March to November 2023, reaching ~33% of the highest value within the first year of ripening (Fig. 1, left). A slight increase in March 2024 was followed by a sharp drop in September 2024 to below the "HS" sample level. The top layer consistently released more carbon than the bottom layer (Fig. 1, right), but appeared to become more similar to the bottom layer over time. The stabilization factor (S) increased during the early ripening phase (March to November 2023), then slightly decreased in March and September 2024 (Fig. 2, left), with the "HS" sample displaying less stabilization. The decomposition rate (k) decreased steadily throughout the ripening process, (Fig. 2, right). Complementary to the stabilization factor, k values of HS samples were higher than for ripening material.

Discussion: Ripening begins with drainage and ingress of atmospheric air, where oxygen enters the sediment, triggering chemical reactions and initiating OM mineralization [2, 3, 5]. Cumulative C release steadily declined, reflecting the depletion of labile organic matter as ripening progressed. Increased C release indicates a higher share of degradable OM and suggests environmental changes, such as higher precipitation [6, 8] or input of carbon by the vegetation [7]. The top layer, receiving more oxygen than the bottom, showed enhanced OM decomposition, especially in the beginning [9]. The decomposition rate (k) decreases over ripening, indicating labile OM depletion, while the stabilization factor (S) increases as recalcitrant OM becomes more dominant [4, 9].

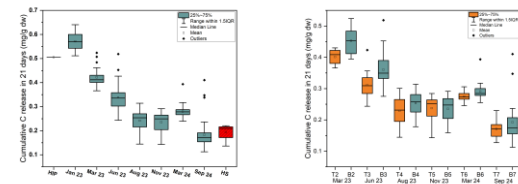


Fig. 1: Cumulative carbon release (left) and differentiation by top (T) and bottom (B) stockpile layers (right) over 21 days.

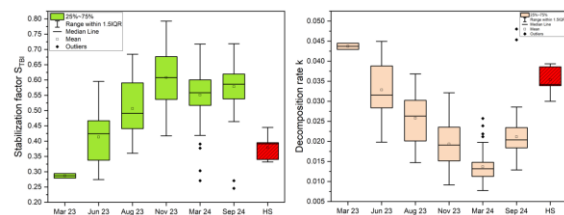


Fig. 2: Left: Stabilization factor (left) and decomposition rate (right) for tea bags incubated for 21-days.

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Capillary Suction Time: Assessing the Potential of a Rapid, Small-Scale Method for Determining the Material Properties of Dredged Sediment

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Conference theme number(s): 3

Introduction: The use of dredged sediments and nature-based solutions is increasing. However, designing end products or structures requires knowledge of sediment properties and mechanical behavior, highlighting the need for efficient methods to determine these parameters.

Materials and methods: This study used sediment from Lake Markermeer, Netherlands, within the Marker Wadden Building with Nature project. Three natural bulk materials were analyzed: bulk clay (SW1B), bulk sandy silt (NE1B), and sandy clay (NE2B), along with their fine fractions (SW1BF, NE1F). The reliability of a Triton 304M Capillary Suction Time (CST) device in determining material parameters was tested. The CST device consists of a metallic sample ring (radius R, height H) surrounded by concentric rings on filter paper. Water is drawn from the sample, creating a diffusing front. The experiment records the time taken for the water to reach the inner and outer rings, linking this time to sample properties. The analysis is based in the Gibson equation [2]:

$$\frac{\partial \phi_{\text{corr}}}{\partial t} - \frac{\partial}{\partial z} \left(\frac{(\rho_s - \rho_w) k \phi_{\text{corr}}^2}{\rho_w} \right) - \Gamma_c \frac{\partial^2 \phi_{\text{corr}}}{\partial z^2} = 0$$

where ϕ_{corr} is the corrected volumetric concentration of solids [1], ρ_s the particle density, ρ_w the density of water, k is the hydraulic conductivity and Γ_c the consolidation coefficient, which can be defined as:

$$\Gamma_c = \frac{2}{3 - n_f} \frac{K_k K_\sigma}{g \rho_w}$$

where fractal dimension n_f , permeability factor K_k and effective stress parameter K_σ are material parameters. They can be used to determine k and the effective stress σ_{eff} as a function of ϕ_{corr} as follows:

$$k = K_k \phi_{\text{corr}}^{-\frac{2}{3-n_f}}$$
$$\sigma_{\text{eff}} = K_\sigma \phi_{\text{corr}}^{\frac{2}{3-n_f}}$$

Material parameters were experimentally determined for replicates of each sediment type as follows: To determine K_σ and Γ_c samples were preconsolidated in

steps before performing the CST test (at 3 bar for 5 minutes in a filtration vessel). To determine the permeability factor K_k and fractal dimension n_f , the same initial sample used in the preconsolidated CST test was diluted in steps with 10 mL of Markermeer water before the CST measurement.

Results: Tab. 1 shows the material parameters for all analyzed materials and their replicates.

Tab. 1: Fractal dimension n_f , permeability factor K_k , effective stress parameter K_σ and consolidation coefficient Γ_c for all the replicate samples studied

Replica	n_f [-]	K_k [m/s]	K_σ [Pa]	Γ_c [m ² /s]
SW1B-I	2.68	6.6E-14	6.3E+09	2.7E-07
SW1B-II	2.71	2.3E-14	1.1E+10	1.8E-07
SW1B-III	2.68	4.2E-14	6.5E+09	1.8E-07
SW1F-I	2.43	2.1E-11	3.4E+07	2.5E-07
SW1F-II	2.29	8.6E-11	9.4E+06	2.3E-07
SW1F-III	2.22	2.4E-10	2.0E+06	1.3E-07
NE1B-I	2.68	8.6E-13	1.5E+08	8.1E-08
NE1B-II	2.68	9.1E-13	2.0E+08	1.2E-07
NE1F-I	2.45	3.0E-11	1.2E+07	1.3E-07
NE1F-II	2.40	6.4E-11	7.4E+06	1.6E-07
NE2B-I	2.44	3.4E-11	5.9E+06	7.3E-08
NE2B-II	2.49	1.4E-11	7.9E+06	4.6E-08
NE2BF-I	2.22	2.1E-10	1.4E+06	8.1E-08
NE2BF-II	2.27	1.1E-10	3.1E+06	9.4E-08

Discussion: All replicates of the same samples yielded similar results, which were consistent with the orders of magnitude reported in the literature. This demonstrates the potential of the CST test as a rapid method for determining material parameters in nature-based or beneficial sediment use projects.

References: [1] Barciela-Rial et al. (2022) *Frontiers Earth Sciences* **10**: 786108

[2] Barciela-Rial et al. (2024) *Frontiers Earth Sciences* **11**:1466650

Towards carbon neutral construction using Olivine and Calcined Sediment

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Introduction: Sediments, a natural byproduct of geological and hydrological processes, are abundant and often treated as waste, particularly in dredging activities. However, these materials hold significant potential as a valuable resource for sustainable construction.

This research focuses on transforming sediment into a valuable component for construction by calcining it to enhance its pozzolanic properties. This allows sediment to partially replace traditional Portland cement. By doing so, sediment becomes an integral part of a sustainable binder formulation, addressing both sediment management challenges and the construction industry's environmental footprint.

Olivine, a magnesium-iron silicate, is incorporated into the formulation to further enhance sustainability. Olivine replaces fractions of both sediment and cement, while actively absorbing carbon dioxide—up to its own weight—during its lifecycle. This dual approach leverages the synergy between calcined sediment and olivine to create a high-performance, low-carbon product. The study explores the binder's material properties, environmental benefits, and potential applications, offering a pathway to innovative sediment reuse while contributing to global carbon reduction goals.

Methods: To explore the potential of calcined sediment and olivine as potential sustainable binder components, a systematic experimental approach was adopted:

Sediment Calcination:

Samples of sediments with varying compositions were collected and calcined at 850°C. This process was designed to activate the sediment's pozzolanic properties, enabling it to act as a partial cement replacement.

Block Preparation:

The calcined sediments were used to produce test blocks. The formulations included varying proportions of calcined sediment and cement to evaluate the performance of each combination.

Olivine was incorporated as a partial replacement for either cement and/or sediment, taking advantage of its carbon sequestration capability.

Testing and Evaluation:

Blocks were tested for compressive strength at 7, 28, and 56 days to monitor their early strength as well as development over time.

Relative indices such as the Relative Activity Index (RAI) were calculated to quantify the reactivity and performance of the calcined sediment and olivine blends.

Results:

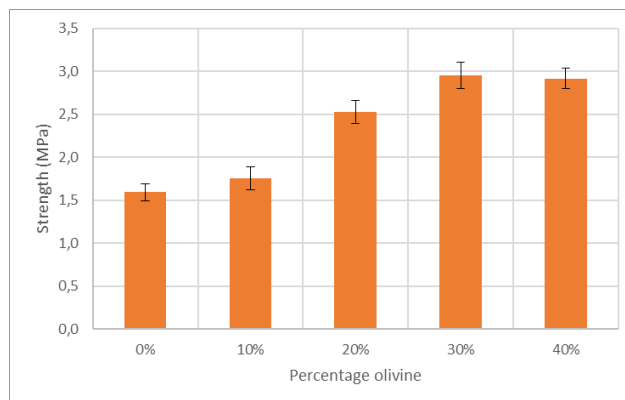


Fig. 1: Compressive strength blocks with different olivine percentages

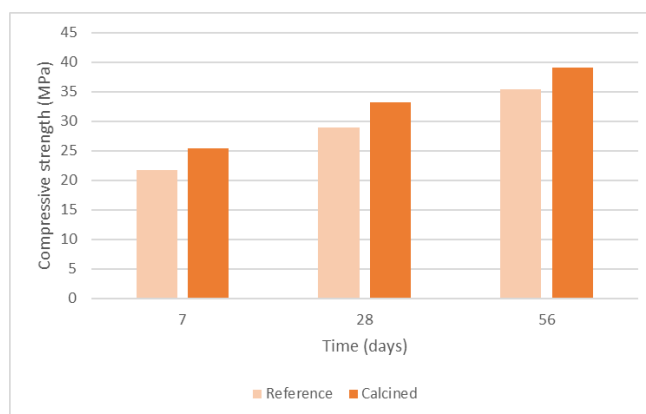


Fig. 1: Compressive strength of blocks with 10% calcined sediment

Discussion: These experiments will guide the development of a binder formulation that combines calcined sediments and olivine, aiming to maximize both sustainability and performance, the way for innovative and sustainable binder technologies.