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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 m^3, 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.

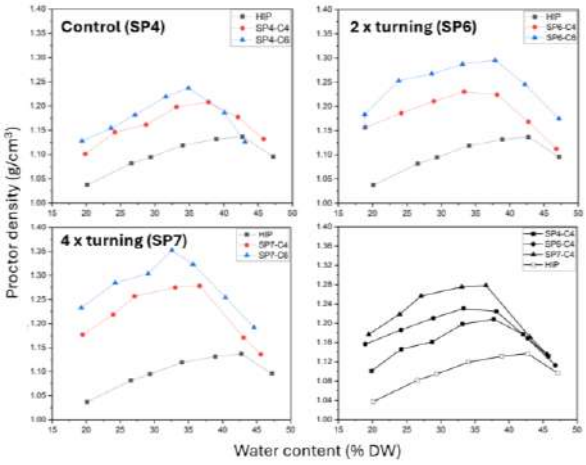

Fig. 1: Proctor curve in relation to time and stockpile turning frequency. C4 = Sept 2023, C6 = March 2024.

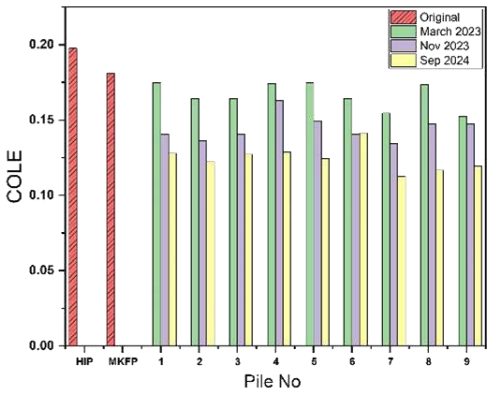

Fig. 2: Shrinkage potential (COLE) over time for original material (red) and 9 stockpiles.

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