Demonstrate and evaluate innovative sediment reuse solutions for flood and erosion protection - XRF quick scan of sediment composition

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Introduction

Beneficial use of dredged sediments is based on their potential as alternative resources, either in a harbour or waterways context. They can be considered as raw materials for industry needs, which implies addressing their current waste status or end-of-waste constraints. They also can be an integral part of beneficial use projects using sediments as a bulk component, including civil engineering and landscaping.

When dredged sediment is used as a bulk material, its acceptability is based on a continuous control of its properties. On-site analyses allow pre-dredging detail mapping at a denser scale than laboratory ones; monitoring dredgings during operations and during processing; and controlling their properties at the implementation site.

On-site instruments provide immediate results and allow dynamic or adaptive sampling strategies, as well as real time operational decisions. Confirmation by laboratory analyses is required for validation, but on-site sample screening for laboratory analyses improves their efficiency.

Material and method

Impact monitoring of the extraction and reallocation operations was part of the pilot program (1.145.000 tons of dredged sediment were reallocated between 2019 and early 2020). Receptor site being underwater, its baseline monitoring was done with traditional sampling and was part of Port of Rotterdam work program. Sediment was sampled underwater from a sampling vessel, using either an Ekman-type sampling bucket, either a weight operated coring device (Figure 1).

Fig. 1: Bucket and core-type sediment samplers.

Fig. 2: Hand press used to partly dehydrate sample.

All analyses were performed using a Niton XL3t980 GOLDD pXRF. For each sample, a pellet was made using a hand press to remove as much water as possible and solidify the sediment (Figure 2). Two measurements were made on different places of the same face of the pellet (Figure 3).

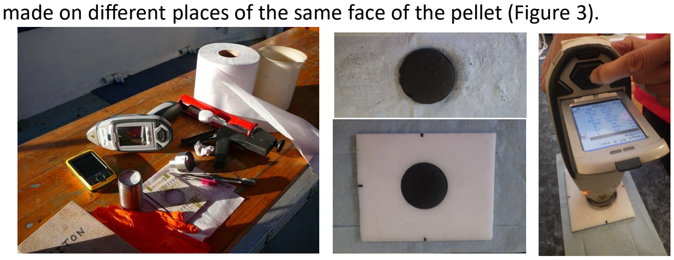

Fig. 2: Sample preparation, pellet and analysis with a pXRF.

The on-site baseline survey was therefore limited to real-time measurements during a bottom sediments sampling cruise, on February 6th, 2019 (T0). Then three operational campaigns (T1, T2 and T3) were led on July 2nd, September 4th, 2019 and February 18th, 2020. All were organised by Port of Rotterdam and Deltares with the participation of BRGM. Up to 20 points were sampled along the estuary (Figure 4), according to the campaign.

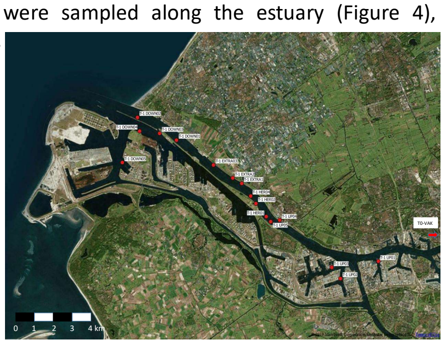

Fig. 4: Location of all sediments collected along the estuary during 4 campaigns.

Results and discussions

Inorganic analyses were performed in quasi-real time on board the sampling ships, using a handy dehydration press on freshly dredged samples (moisture content of the pellet controlled in laboratory are between 20 to 30%). It was possible to obtain a first measurement of the main contaminants (Pb, Zn, Cu, As) within minutes, between two sampling stops. This would have allowed refining the sampling plan if anomalies had been encountered at any sampled site. The higher level (UP02 and UP03) are in the docks on the side of the Rhine River (Fig; 4 and Tab. 1).

Tab. 1: Statistic parameters for Pb, As, Zn and Cu analysed by pXRF on the boat.

Statistic	Pb	As	Zn	Cu
Minimum	12	4	22	13
Maximum	195	66	643	128
Median	19	7	66	23
Mean	33	10	112	30
SD	41	14	138	26

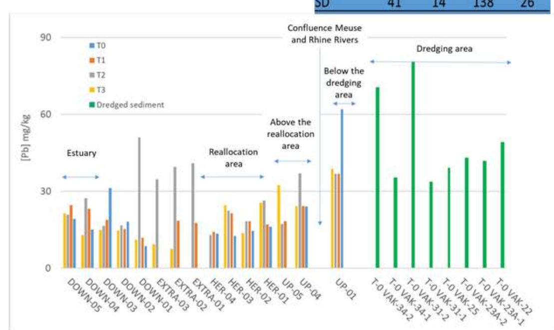

Fig. 4: Pb analyses in sediment samples on site from upstream to downstream

The mean value of the dredged sediment was 52 mg/kg of pressed sediment (ranging from 34 to 80 mg/kg). The analyses were done every four months since the T0 campaign and the contaminant levels stay stable overtime on the reallocation area (T0: 14±4 mg Pb/kg; T1 : 18±3; T2: 20±6 and T3: 21±7). No element anomalies were recorded beyond the expected geochemical background. Time-bound variations are limited and may reflect sampling heterogeneity. Total contaminants range decrease from upstream to downstream but are never very high (Tab. 1).

Conclusions: Benefits of on-site monitoring techniques

On-site analyses allowed performing a fast scan of the background level for key contaminants throughout the project area and their evolution during pilot works. Results show that upstream sediments are consistently less polluted than downstream sediments, and that the general level of contamination is low. It is therefore possible to use the upstream sediments and relocate them to a new place for bank nourishment in the estuary.

The on site analyses did not show any anomaly, and dredging and relocation operations were safely completed. However, the monitoring operation was performed on a spot basis rather than continuously.

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