Since 1990 nourishments are used to protect the Dutch hinterland from flooding. The concept of this framework is a building in nature approach of which the primary focus is coastal defense. In 2011 pilot project the Sand Motor has started where a more integrated approach is used; a Building with Nature approach where ecology and recreation play an important role besides coastal defense. The Sand Motor is a concentrated 21.5 M m² shore nourishment at the Delfland coast (Netherlands).

The Sand Motor is geochemically interesting compared to traditional nourishment methods: the Sand Motor contains twice the amount of sand that is yearly used for traditional nourishments, has a fresh water lens and will develop. In 20-30 years the Sand Motor will be fully incorporated in beaches and dunes.

**Methods**

**Fieldwork**
1. Grid (250 m x 250 m) • Sediment samples – surface • Pore water samples – 50 cm depth
2. Eight deep boreholes (10 m/20 m depth) • Sediment samples – every meter • Pore water samples – every meter
3. Three shallow boreholes (~30 cm) • Sediment samples – every 5 cm • Pore water samples – every 5 cm
4. Collection of 11 bog iron ore fragments

**Lab work**
Major and trace element measurement: • Pore water: IC, ICP-MS, alkalinity, pH • Sediment: ICP-MS (dissolution via aqua regia method), CS-analyser, XRD, SEM

**Bog Iron Ore Fragments**
- Iron: 41%
- Sulphur: 0.3%
- Arsenic: 495 mg/kg

Average concentration of 11 bog iron ore fragments
- Bog Iron ore fragments are impure iron deposits formed during the Pleistocene in bogs or swamps.
- Besides sand and shells, bog iron ore fragments were collected during dredging. As a result, the fragments are visible at the surface of the Sand Motor.

**Additional research:** can high contents of arsenic in bog iron ore fragments have an impact on recreational possibilities at the Sand Motor?

**Conclusion:** estimated human exposure is 22 times lower than the acceptable exposure due to contact frequency and low bioavailability of arsenic in bog iron ore fragments.

**Discussion**
- High pH values are correlated with freshening. Freshening occurs at the higher part of the Sand Motor. Variability in pH is seen at the inner part of the hook where microbial activity is present (see pictures).
- With depth trace element concentrations seem to be influenced by oxidation and reduction processes involving sulphur. At the surface the variability of trace elements is high.
- Bog iron ore fragments are increasingly present at the surface of the Sand Motor because of erosion caused by wind and water. The fragments contain high contents of arsenic and are expected to be present at a higher density at the Sand Motor in time.

**What’s next?**
- Comparison between a mega-nourishment, traditional nourishments and a non-nourishment site along the Dutch coast
- Study in more detail the influence of the river Rhine on the Sand Motor by looking at organic contaminants and nutrients.