INVESTIGATING COASTAL-POLLUTION USING FLOATING TRANSIENT ELECTROMAGNETIC (FLOATEM) COMBINED WITH GROUND-BASED SURVEYS

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In the 1950s and 1960s, a 12 hectares large area at Himmark Beach, the region of southern Denmark, was used to deposit around 53,000 cubic-meters chemical waste and 700,000-liter wastewater from industry. Himmark Beach is one of the ten most costly sites to remediate in Denmark. The contaminations are spreading through the subsurface structures in the coastal zones and migrating into the sea, posing a threat to wildlife, humans, and the groundwater. In order to fully characterize the site and make detailed remediation measures, it was decided to use initiate a detailed transient electromagnetic (TEM) mapping campaign to get a three-dimensional understanding of the geological structures, which in turn controls the contaminant pathways. Specifically, there is a shallow sand layer with high porosity right beneath the seafloor, which is underlain by an impermeable till layer. The main aim of the mapping was to detail the interface between sand and till to identify possible pathways for the pollution and pinpoint pockets in the till surface with increased contamination concentrations. The survey contained both ground-based towed measurements (tTEM) on land and waterborne measurements (FloaTEM) on the sea. The objective of the FloaTEM survey was to map the till layer starting from the shoreline and extending to the sea, whereas the onshore tTEM campaign aimed at identifying a local site with a thick impermeable clay sequence that could be used as a temporary host for the planned excavation of polluted sand without posing a threat to local groundwater resources. The tTEM survey was carried out using a single turn 3x3 m2 transmitter-coil and consists of low moment (LM) and high moment (HM) pulses of 3 A and 30 A respectively. For surveying on seawater, we used a 4-turn 4x4 m2 transmitter-coil with a 25 A HM pulse. The latest time gate was 1 ms for tTEM f and 3 ms for FloaTEM. Inversion results of the tTEM and FloaTEM surveys show a distinct three-layer sequence with increasing resistivity with depth. The layered sequence has been compared with the 154 boreholes drilled into the seabed. The comparison confirms that the layers correspond with the seawater column, saltwater saturated sand and in 1-9 m depth we find the till layer. In one part of the area, where there is limited borehole coverage, there is a distinct deepening in the till layer, which is filled with saturated sand, gravel and peat. This area is a potential highway for contamination transportation. Based on the results from the geophysics, the authorities have redefined their strategy for excavating the contaminated sand, gravel and peat. The geophysics was used to pin-point locations for new monitoring wells, and for designing the outline of the sheet pile wall, which will be constructed into the seabed around the contaminated zone during excavation.