Assessment of groundwater discharge and saltwater intrusion in the Belgian coastal area through geophysics

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ABSTRACT

Submarine groundwater discharge (SGD) and saltwater intrusion (SI) seem two opposite components of the complex interaction between freshwater aquifers and the sea, but are in fact complementary processes (Taniguchi *et al*., 2002). SGD is of major ecological importance since it can create an important nutrient flux towards the coastal waters, but it might also be the entry gate for contaminants (e.g. Burnett *et al*., 2006). SI leads to the inflow of salt or brackish water into the onshore freshwater aquifers, causing a risk for the quality of exploited drinking water.

The approximately 67 km long Belgian coastline along the North Sea has a complex geometry. A fragmented dune belt 100 m up to 2 km wide separates the sandy beach slope from the polder area. Rainwater infiltrates in the dune and polder areas and partly flows towards the sea as SGD. At the same time, the tides are locally responsible for the unusual presence of a salt water lens under the beach (Vandenbohede & Lebbe, 2006). In addition both SGD and SI are influenced by geological heterogeneity, making their characterization difficult. Two sites are investigated: the Westhoek area (near the Belgian-French border - characterized by a large, broad dune belt) and the area between Wenduine and Blankenberge (West of the Zeebrugge harbour - where the dune belt is relatively narrow). In order to detect zones where SGD occurs, the distribution of the fresh-/saltwater interface is mapped.

In this contribution, we propose to use a combination of frequency domain electromagnetic (FDEM) induction and electrical resistivity tomography (ERT). FDEM and ERT are both sensitive to the electrical conductivity of the pore fluid and therefore to its salinity. Both data types are collected from the dune area to the low water line. FDEM allows for fast surface mapping of the distribution of electrical conductivity, lower conductivities being correlated with zones of freshwater discharge. ERT profiles are used to further characterize the vertical distribution of the fresh/salt water interface.

Areas with higher resistivity are probably zones where SGD occurs. The freshwater discharge is expected to be closer to the dunes where the dune belt is more narrow (e.g. study area between Wenduine and Blankenberge, Figure 1) and closer to the low water line when the dunes are wider (e.g. area of the Westhoek). Figure 1 shows observed apparent conductivity values which are indicative for brackish/salt water. The conductivity increases towards the sea, which can be due to increasing salinity and/or a higher water table.

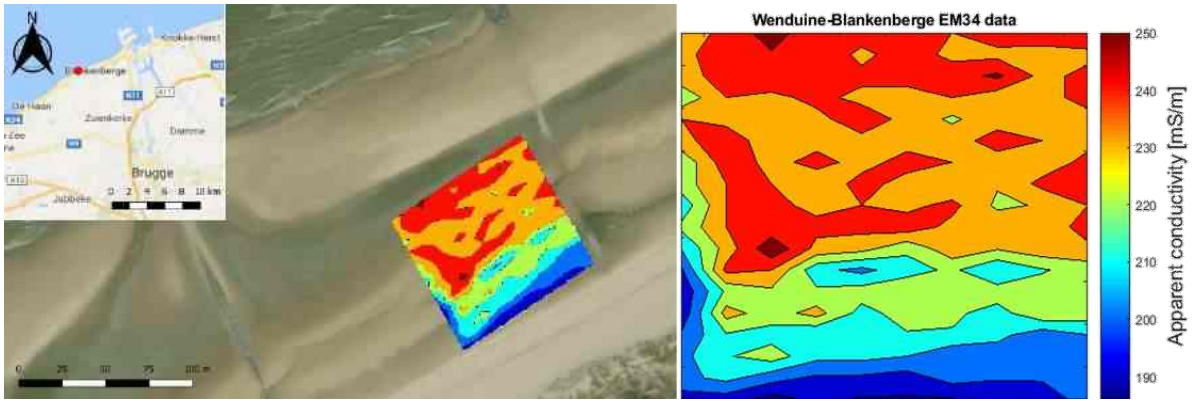

Figure 1. The first results of mapping with the EM34 device in the Wenduine area. The data was acquired on 14th February 2018 using the EM34 with horizontal dipole and a spacing of 10 m (frequency of 6.4 kHz), which gives an approximated depth of around 7.5 m.

Geophysics allows for fast mapping of SGD and gives an insight in the spatial variability of the process. It can be used as a preliminary assessment of SGD. Afterwards, a combination with for instance seepage meters and the study of groundwater tracers will give a good estimation on the quantity and quality of the outflowing groundwater. At the Wenduine area, discharge of groundwater recharged in the polder area is assumed further offshore (Walraevens et al., 2016). This discharge is potentially loaded with nutrients and maybe pesticides coming from agricultural activities. In order to locate the zone of discharge offshore, since it will probably be found under the low water line, continuous resistivity profiling will be performed.

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