Continuous monitoring of groundwater dynamics in coastal dunes

Beerlandt Jadon and Rauwoens Pieter

Hydraulica en Geotechniek, KU Leuven, Spoorwegstraat 12, 8200 Sint-Michiels, Belgium
E-mail: jadon.beerlandt@kuleuven.be

Freshwater lenses beneath Belgian dunes have historically safeguarded hinterlands against saltwater intrusion (SI). Unfortunately, urbanization and anthropogenic activities have diminished these lenses, necessitating new research into understanding the hydrogeological feedback mechanisms during the developmental phases of dunes. This understanding is critical for predicting the evolution of freshwater lenses, especially with rising sea levels and climate change impacting water resources. Engineered dunes, integrated with traditional dikes, are emerging as vital components of coastal defenses, contributing to nature-based solutions, notably providing a critical ecosystem service through their potential induced barrier against seawater intrusion.

Our research, centred in the artificial dune area of Raversijde, Belgium, focuses on comprehending, monitoring, and modelling freshwater lens development during the early stages of dune growth. To support this initiative, we have received the Brilliant Marine Research Idea (BMRI) grant, which has been instrumental in advancing our efforts.

The BMRI grant enabled the implementation of a continuous surveying system, enhancing our capacity for comprehensive and uninterrupted data collection. This includes the deployment of a continuous Electrical Resistivity Tomography (ERT) system and a new measuring pole equipped with different sensors to monitor the overall freshwater recharge. This instrumentation enables detailed and extended monitoring of environmental parameters critical for a more comprehensive hydrogeological model.

The IRIS Syscal Pro ERT device, facilitated by ILVO, constitutes the cornerstone of our methodology. The BMRI grant enabled us to rent, insure, and buy new accessories for the ERT Device, enabling its use for continuous and more flexible measurements in general. We incorporated the use of longer electrodes to address challenges related to higher surface resistances. Newly acquired multicore cables, spanning 72m with 1m electrode spacing, enhance flexibility, ease of use, and underground installation. The possibility to semi-permanently or switch flexibly between installations of the ERT device across diverse zones within the artificial dune area ensures a multifaceted dataset, capturing subsurface dynamics under varying conditions. The surveying system's capacity to measure up to 15 meters deep, with weekly GNSS surveys of buried electrodes, ensures a comprehensive understanding of subsurface conditions. Time-lapse inversion techniques, dependent on accurate topography, enhance the accuracy and reliability of our continuous monitoring system.

A new survey pole stands as a vital component for monitoring recharge dynamics. Equipped with a Pluviometer, pyranometer, soil moisture, EC sensor, and temperature logger, this instrumentation aims to provide a nuanced understanding of environmental parameters over an extended period. The Pluviometer records precipitation, the pyranometer offers insights into evaporation dynamics, while the soil moisture and EC sensors monitor the inflow of water into the dune. The temperature logger tracks temperature variations. Cross-referencing these parameters with data from a local weather station located a few kilometres away provides an additional layer of validation and precision.

The BMRI grant played a pivotal role in acquiring and deploying these advanced monitoring tools, ushering in a shift from sporadic field surveys to semi-continuous, high-resolution data collection. This methodological framework not only enhances our understanding of hydrogeological dynamics during early-stage dune growth but also establishes a robust foundation for predictive modelling and informed coastal management.

Keywords
Early-stage dune development; Nature-based solution; Saltwater intrusion; Hydrogeological feedback mechanism; Coastal protection; Artificial dunes; Geophysical surveys