

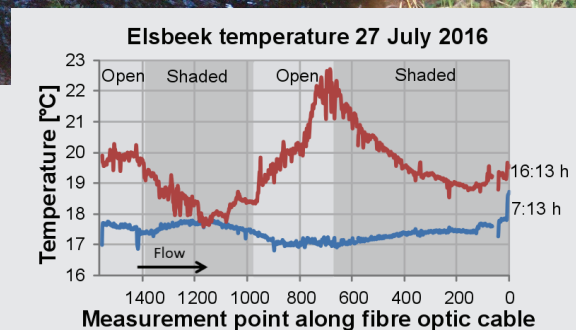


GROUNDWATER IN MULTI-STRESSED AQUATIC ECOSYSTEMS

Freshwater bodies in Europe are affected by multiple stressors such as water extraction and pollution. Deltares was one of the partners in the European FP7 project MARS (Managing Aquatic ecosystems and water Resources under multiple Stress). MARS investigated how these stressors affect freshwater ecology from the local to the European scales. Deltares focused specifically on the importance of groundwater, which is an element in the hydrological cycle that is often overlooked in freshwater ecological management.

High-resolution modelling of groundwater flows was combined with innovative measurements in the field. The modelling consisted of calculations of dynamic travel-time distributions of the groundwater contributing to streamflow in several lowland catchments in the eastern part of the Netherlands. Groundwater travel times are important determinants of streamwater quality and potential lag times in pollution plumes.

One of the new field techniques is Distributed Temperature Sensing (DTS). This technique uses fibre optic cables to make high-resolution measurements of temperatures in both time and space. Two streams were equipped with 1.5-km-long cables to locate seepage zones and to study the effect of groundwater discharge on the water temperature of the streams. Using these measurements, seepage zones were also located by using the temperature difference between surface- and groundwater: the latter has a fairly stable year-round temperature. This groundwater characteristic could be used to mitigate the effect of climate warming on stream temperature. Another innovative technique used was the TEC probe, which measures vertical temperature profiles of groundwater when the sensor is pushed slowly into the streambed. These vertical measurements contain information about the direction of



groundwater flow and, together with measurements of seepage fluxes, they demonstrated the highly heterogeneous contribution of groundwater to streams: locations were found where water infiltrated on one side of the stream while groundwater seeped up on the other side.

Groundwater affects streamwater quality and the chemistry of the stream water can therefore also be used to analyse the groundwater contribution. Radon-222 is an isotopic tracer that indicates the presence of groundwater seepage. This tracer was measured in the field at multiple locations and the results indicated where seepage occurred. The streamwater chemistry also was analysed in the laboratory and the results showed, for instance, that groundwater flowing from agricultural fields contained more nitrate, which will eventually end up in the streams.

A better understanding of how groundwater contributes to streams will help water managers working on restoration projects. Combining modelling and field measurements showed that linked groundwater-surface water systems are highly heterogeneous. Groundwater affects stream discharge, temperature and chemistry. As the slowly-flowing groundwater provides a connection between the catchment and the stream, it propagates stressors and buffers them in both time and space. The lagging effect of groundwater, however, can cause a slower recovery of ecosystems after restoration than expected.

Contact

Vince Kaandorp, vince.kaandorp@deltares.nl, t +31 (0)88 335 7486

Further reading

Kaandorp et al. (2018) <https://doi.org/10.1016/j.scitotenv.2018.01.259>