Dunea towards a multi-source drinking water system

Written by Franca Kramer, Suzanne van der Poel

For multiple decades Dunea has obtained water from the dammed Meuse and the river Lek as sources for drinking water production via managed aquifer recharge (MAR) in the dune area between Katwijk and Monster. However, due to climate change, these sources are under pressure. Therefore, Dunea has launched the multi-source programme. The goal of this programme is to make Dunea more redundant, robust, and prepared for the future by exploring new, additional sources and enlarge the strategic water reserve. This will make Dunea less reliant on the rivers Meuse and Lek, and able to efficiently handle the calamities by which the water intake is compromised. The calamities are usually caused by pollution- and/or drought events, or leakages in transport pipes.

Climate change increases the number of drought events. As a result, pollution-peak events in the river water occur more often. During these events, Dunea stops the river water intake and switches to the strategic water reserve for water production. This strategic water reserve is the freshwater lens below the dunes, located in a deeper aquifer than the MAR. The freshwater lens recharges itself with rainwater, infiltration water and lateral groundwater flow. However, when these events happen too often, the strategic water reserve cannot recharge in time before the next event occurs.

The multi-source programme started with a broad inventory of possible additional water sources. All options were graded and weighted by various criteria such as availability, water quality, and closeness to our distribution network. Brackish groundwater and water from Lake Valkenburg were selected as potential new sources. They will be explored further through a pilot research. Moreover, the current sources will be optimised, and the strategic water reserve expanded.

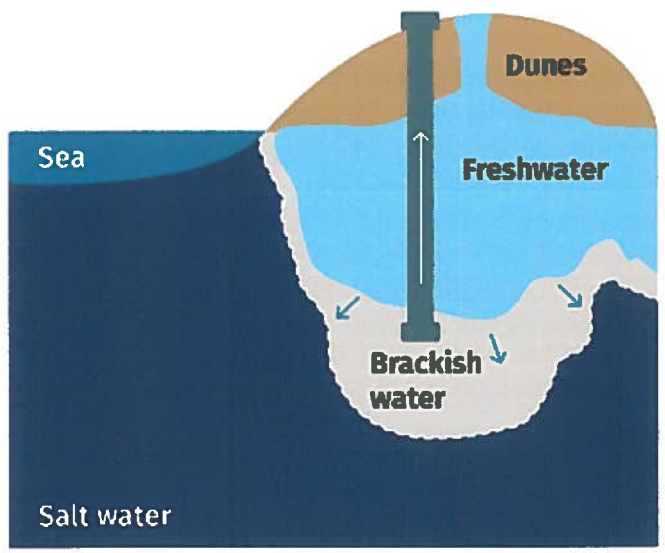
FreshMan project

Extracting brackish groundwater in the dune area will kill two birds with one stone. First, the strategic freshwater storage under the dunes will be expanded. Second, the gained brackish groundwater can be treated to produce drinking water. Moreover, the expansion of the freshwater lens in the dune area will serve as a barrier to future saltwater intrusion from the coastal zone. Thus, extra drinking water will be produced while expanding our strategic freshwater reserve (Figure).

Freshman stands for 'sustainable freshwater management in coastal zones'. The Freshman project is executed in cooperation with KWR, Allied Waters, de Watergroep, and IWVA and is partly funded by the EU-Life programme (LIFE19 CCA/NL/001222). The project will run for three years starting in January 2022.

Groundwater research

Two extraction wells and six monitoring wells are constructed to closely monitor the freshwater lens in the aquifer. The most innovative measurement equipment- cross-hole ERT, has been installed to determine a dynamic 3D-image of the fresh-salt-dynamics in the aquifer. Knowledge institute Deltares helps with the implementation and interpretation of this equipment. The fresh-salt-dynamics are particularly important in this project to monitor the growth of the freshwater lens. Moreover, this data is fed to a model which predicts the fresh-salt-interface. When the pilot becomes a success, this model will be used to design the location of the extraction wells and the effect on groundwater levels in the dune area on full-scale. The pilot is situated in a highly valuable, heavily protected nature reserve, which is also guarded by Dunea. Negative impact of the extraction of brackish water on nature values must be avoided at all costs.



Schematic illustration of the three different groundwater layers below the dunes.

Reverse osmosis

Brackish groundwater layer is located between 90 and 120 meters below ground level. This brackish water will be treated with reverse osmosis (RO). Brackish groundwater has an excellent water quality – free from pathogenic micro-organisms and -pollutants – because it is a deep anaerobic water source. Only the high salt and ion concentrations dictate that advanced water technology is required. RO is one of the few technologies capable of removing salts. The water can be treated almost directly, with only cartridge filtration as pretreatment to prevent particles from entering the RO membranes. RO is a membrane technique which can remove almost all components from the water. Water produced by RO is too pure to drink since it contains too little minerals. The produced water will be mixed with the conventional produced drinking water. In future, when a large amount of water is produced, this has an advantage for the conventional stream: less softening is required. RO also produces a waste stream, the concentrate, which will be discharged to the sewer during the pilot study. The salt content of the concentrate depends on the recovery of the RO production. In this study, we aim at a recovery of 50%, resulting in a concentrate stream with a similar salt content as sea water. In future, at full-scale, this concentrate will be discharged in the North Sea and its salt concentration will then cause minimal disturbance to the aquatic ecology.

Sustainability & research

During pilot research the sustainability of brackish groundwater as water source will be studied. RO consumes quite a lot of energy, especially pumping energy to push the brackish water through the membranes. Dunea will study how to minimise the energy consumption by producing water in the most efficient way and to recover energy from the concentrate stream using for example an energy recovery device (ERD) or other innovative solutions. Furthermore, chemical consumption will be studied, finding the most sustainable and minimal consumption. For both energy- and chemical consumption optimisation studies can be executed considering the water quality, water production and energy- and chemical use.

The brackish groundwater pilot is an excellent playground for a lot of research questions from different disciplines, from (geo)hydrology and process engineering to ecology and sustainability.

Lake Valkenburg pilot project

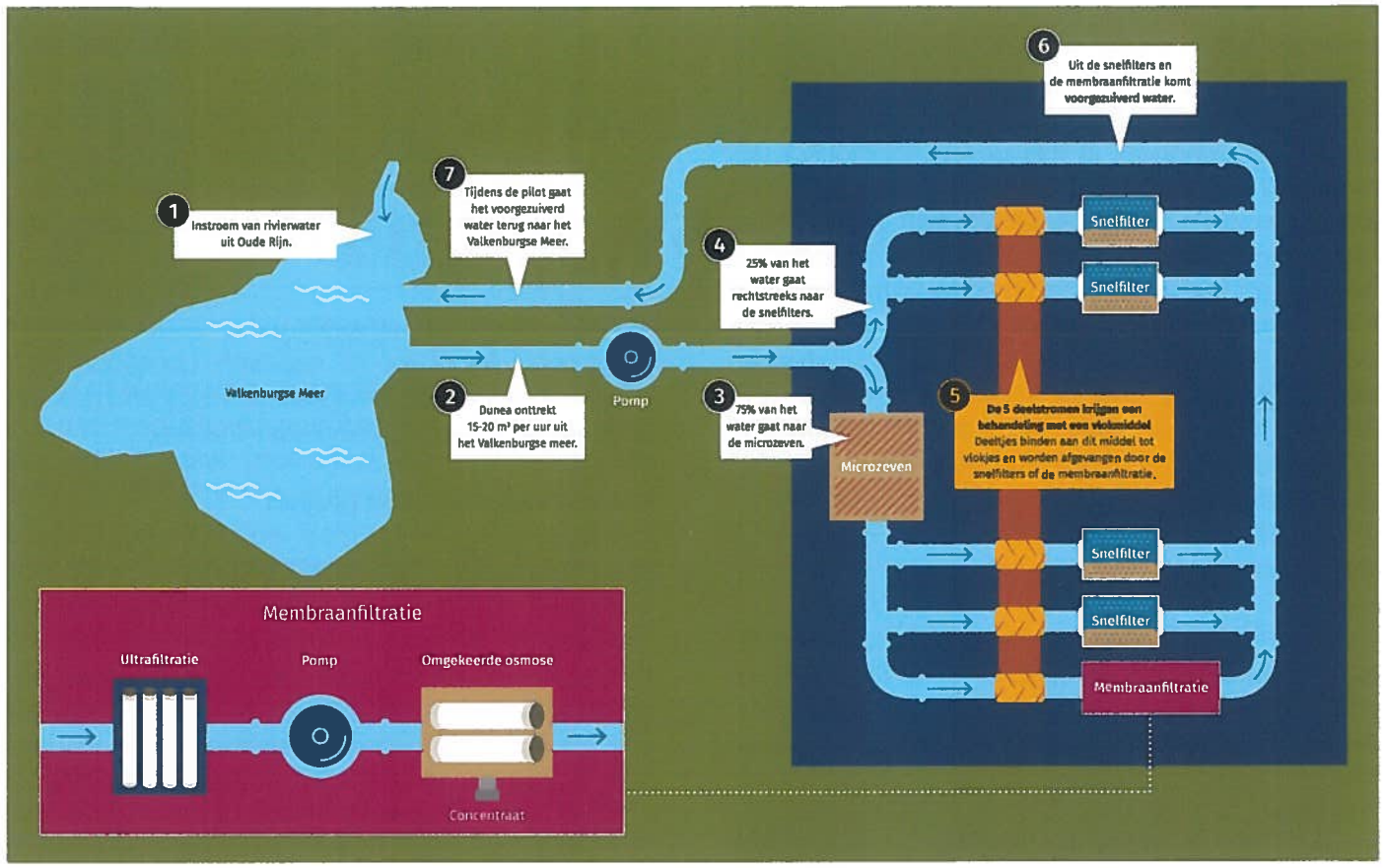
Lake Valkenburg is a located 5 km from production location Katwijk. The lake is fed by the river Oude Rijn and functions as a basin where concentration peaks of pollutants originating from the river are flattened. The water quality of this surface water is a challenge for drinking water treatment, as it contains algae, organic matter, suspended solids, phosphate, organic micropollutants, and too much salt. Therefore, the water will be treated with two different treatment trains: a conventional- and a membrane filtration treatment stream that will be mixed before dune infiltration. Infiltration water needs to meet the infiltration legislation (Infiltratie Besluit) which demands a high water quality. The mixing ratio will be determined during the pilot research, depending on the water quality of the produced water.

Two different treatment trains

The conventional treatment consists of micro sieves, coagulation, and rapid sand filtration, to remove algae, organic matter, suspended solids, and phosphate and the membrane filtration treatment of (micro sieves,) coagulation, ultrafiltration, and RO (Figure). RO is a membrane filtration technique that will remove all components present: both particulate and dissolved matter. The demineralised water will be mixed with the conventional stream in such a way that the water quality is suitable for dune infiltration. Moreover, the pilot has a flexible design where all combinations of treatment techniques can be compared and combined. This should lead to the most efficient water treatment design after three years of research, considering water quality, energy- and chemical consumption, and sustainability.

Pilot research & the future

The Lake Valkenburg pilot will treat 15 m3/h for research purposes. The treated water will be discharged back into the lake since there is no



infrastructure (yet) for infiltration in the dunes. When the pilot study is a success, Dunea aims to exploit lake Valkenburg as a new, additional water source in the near future. In order to do so, permits need to be granted and a raw water inlet and a pretreatment plant will have to be developed at the lake, designed and built based on the pilot research. At full-scale, a significant amount of water will be taken in, which will have an impact on the hydrology and ecology of the lake. Dunea studies how this can lead to an equal or improved water quality in the lake. A high water quality in the lake will not only be beneficial for water treatment, but also for recreation in and around the lake. Lake Valkenburg has all kinds of recreation, such as water sports and swimming; this purpose goes very well together with source protection for drinking water extraction.

Interested to learn more?

Both pilot projects will run for three years, starting coming year. During this period Dunea will conduct research on all kinds of topics: modelling fresh-salt change in the aquifer, environmental impact, strategic process engineering, pilot research at one of our pilots, energy consumption, ecological research, etc. If you are interested in contributing to these projects, don't hesitate to contact us for an internship or a graduation project! Send an email to f.kramer@dunea.nl

dunea.nl/multi-bronnen

About the author

Franca Kramer works as researcher at Dunea since 2019. She mainly works on the two pilot projects mentioned in this article. Before, she graduated from the master water management specialising in drinking water treatment at TU Delft and did PhD research studying ceramic nanofiltration membranes. Furthermore, she is an old-board member of the Dispuut Water & Environment.

dunea DUIN & WATER

Gold certificate for drinking water company Evides for circular pellets

Introduction

Evides Water Company provides safe and clean drinking water 24 hours a day, 365 days a year to 2.5 million consumers and businesses in the Dutch province of Zeeland, the southwest of the province of South Holland and the Brabantse Wal. Evides also offers customised industrial water services to large industrial customers in the Netherlands, Belgium and Germany, among other countries.

Evides works on ingenious solutions in the field of circularity every day. For example, in collaboration with Aquaminerals and the Dutch Drinking Water Companies, it recently received the cradle to cradle certificate level gold for its participation in the circular pellets project.

The Dutch drinking water companies supply softened drinking water to consumers. Softening reduces the concentration of calcium in water, thereby reducing limescale in domestic use. Softened water also reduces the dissolving rate of lead and copper, extends the life of household appliances and reduces the use of detergents and cleaning products. This means softening is good for public health, the environment and the climate, and saves money.

Pellets of 100% lime

In the groundwater treatment plant at Baanhoek and Halsteren, Evides softens the water in pellet reactors, which are named that way because they produce lime pellets as by-products of softening. For this purpose, along with a base- caustic soda or lime milk, a periodic grafting material is dosed. For years, sand was used for this purpose but now, we have switched to crushed calcite. This material, also known as 'Dutch lime', comes from The Calcite Factory in Amsterdam. The pellets (produced in Waternet's softening system) are heated, crushed and sieved into various products, including grafting material for use in the softening system. Multiple pellet reactors in the Netherlands and abroad are now running with these crushed lime pellets as grafting material.

Cradle-to-cradle certificate gold

The big advantage of lime as a grafting material is that the pellets no longer contain a sand core (Figure 1), but consist of almost 100% lime. This change in the softening process and the drying, crushing and sieving of the lime pellets has made many new applications possible. For example, replacement of lime from mining in the back of Desso's cradle-to-cradle carpet or replacing the microplastics in Naif's circular face scrub (Figure 2). It means that the use of lime from softening in Dutch products is a good news for the environment.

Figure 1. On the left a cross-section of a pellet (1 mm) with a sand core, and on the right a pellet (1 mm) with a lime core.

Figure 2. Left: Naif face scrub with calcite from Dutch drinking water. Right: Cradle-to-cradle carpet by Desso with lime from Dutch drinking water in the back.

Evides waterbedrijf