Holding back salinisation

A vertical underground osmosis filter for drinking water not only reduces energy consumption by 40% but could also prove to be a powerful means of preventing saltwater intrusion.

Jos Wassink

It’s a problem horticulturists in the Westland area know only too well: groundwater often contains too much salt. Many have already taken action to prevent this saltwater intrusion, which results from a combination of a relatively low volume of discharge from the rivers and high seawater levels. This means that the salty seawater intrudes far inland beyond Rutherford and also penetrates the soil because of low water levels in the adjacent polders. “It’s currently happening once or twice a year,” says Harrie Timmer, hydrologist at drinking water company Oasen in Gouda. “But if it becomes a structural problem, as some climate scenarios predict, the intruding brackish water will cause salinisation in our pumping stations. Oasen has groundwater for wells in such places as Ridderdorp and Hendrik Ido Ambacht, at depths of 20 to 100 m. The water sourced from these wells is drawn through the river five years back. By law, drinking water may contain up to 150 mg of salt per litre. Studies suggest that this limit will be exceeded in certain places if climate change turns out to be significant (a temperature increase of 2 °C and dry summers). This is why some drinking water companies are experimenting with special filtration methods. There is only really one way of filtering salt from water on a large scale: by using reverse osmosis. This technique has been used for large-scale seawater desalination for the past 20 to 30 years. The basic principle is simple: high pressure is used to push salt water up against a semi-permeable membrane that allows water to penetrate yet holds back salt ions (and other constituents). To purify seawater, a pressure of 40 to 80 bar is required, and the purification of just one cubic metre of drinking water consumes 6 kWh of energy. Brine is produced as a by-product: it amounts to 20% of the original inflow, with five times the salt content. The conditions for purifying groundwater are less extreme. The brackish groundwater contains around 500 mg per litre. In this case, the reverse osmosis installation works under a pressure of 8 bar to produce a flow with a double salt concentration (1 g per litre) and an equal flow of fresh water.

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This is the same system used by market gardeners and by two water purification plants in Zevenbergen (West Brabant) and Noordbergum (Friesland). The brine is then discharged into the sea or pumped back underground. The energy consumption is approximately 1 kWh/m3. A few years ago, membrane specialist Dr Bas Heijman (sanitary engineering section of the faculty of Civil Engineering and Geosciences) came up with a smart idea to make the process more energy efficient. He has just returned from Somalia, where he was working on making brackish water drinkable. Initially, he says, the water companies showed little interest in his energy-saving design – only Oasen in Gouda saw the potential. “It’s a great purification technique,” Timmer explains. “It may provide a remedy for salinisation and give us an opportunity to explore the regulations governing the discharge of brine.”

This is because the key to saving energy lies in the underground discharge of concentrated groundwater. The underground system consists of an inflow pipe, two pumps, and six filter tubes stacked on top of each other. The brackish water is pumped down through the filter tubes. The filters consist of a concentric tube for the freshwater, wrapped in a membrane filter and surrounded by a sealed cover. A big pump is used to suck the freshwater to the surface. The brackish water is left underground, separated from the inflow point – preferably by a layer of clay. Energy consumption can be almost halved by not pumping the brine to the surface. Almost halved, but not quite, because a small pump is required to propel the brackish water through the filters. Calculations show that the Puro system requires 0.6 kWh/m3 to produce 25 m3 of freshwater per hour. The entire structure, built by water treatment manufacturer Jost-Log and well-drilling company Haitjema, is 10 m in length and weighs around one tonne. TU Delft is supervising the installation by way of two PhD research projects. Geohydrologist and chemical engineer, Jeroen Posthumus (CEG), is researching unwanted brine crystallisation. Normally, anti-scalants are added to prevent deposits from forming on membranes and their immediate surroundings. However, additives are out of the question, as it is not permitted or desirable to introduce foreign chemicals into the subsoil. This increases the risk of scale deposits, leading to a decision to limit the concentration ratio to a factor of two. It may however be possible to increase production.

Frank Smits is conducting research into the effect of the Puro on salinisation in the local area for Waternet and TU Delft. Simulations carried out by his supervisor, Professor Theo Oelsen, have shown that freshwater wells eventually draw up the underlying, saline groundwater. With Puro, however, the concentrate penetrates more deeply into the soil, thereby pushing back the creeping effects of salinisation, and keeping freshwater fresh. Measurements will reveal whether there is actually a significant effect. They are currently awaiting a permit from the province of Zuid-Holland. The researchers understand the need for careful consideration, but also point to the hundreds of horticulturalists’ wells that are more or less tolerated. In any case, says Timmer, all that is required is a research permit for a limited time. The results of the research will provide greater clarity regarding saltwater intrusion, as well as potential remedies.

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View the animation on combating salinisation: http://youtu.be/HCKgq-62h-8