Popular science summary: An optimal barrier well application for the future

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Groundwater is one of the most precious freshwater sources on earth because of the quality and quantity. Recently, however, groundwater salinization caused by seawater intrusion (SWI) has been reported in many coastal areas, which is spoiling the potential sustainability of groundwater use. SWI is caused by anthropogenic reasons, such as sea level rise and over abstraction of groundwater. Considering climate change and population growth, SWI will be aggravated more in the future.

There are some countermeasures to SWI, however, this study focused on a negative hydraulic barrier with a barrier well, which is a popular approach because of the cost-effectiveness and applicability even in an arid area. However, remediation of SWI could take as long as decades or centuries. Considering the future when further SWI has been predicted, it will be required to find effective applications of barrier wells to protect the precious fresh water source.

In this study, an optimal well location and effects of groundwater reduction or sea level rise on the barrier efficiency were investigated through two lab-scale experiments and numerical analyses. Based on the simulation results, an effective barrier well application is suggested for the future.

In Experiment 1, the difference of the barrier efficiencies at 4 well locations were observed, based on the critical pumping rate to restore the production quality. As a result, a barrier well closer to the coast could remediate SWI at a lower pumping rate, and pumping from a lower part of the aquifer restored the aquifer condition better. However, it also revealed another disadvantage of a barrier well to aggravate the salinization on the coastal side.

In Experiment 2, the effects of groundwater level reduction on SWI was observed. It revealed that the reduction would cause further SWI and aggravate the disadvantage of a barrier well to salinize the coastal side.

In the numerical analysis to find an optimal barrier well, barrier efficiencies at 14 different locations were investigated in two different groundwater level conditions, based on the remediation rate and time as well as the general condition of the aquifer after the remediation. This analysis showed that the remediation rate and time was better when a barrier pumped at a lower part of the aquifer than pumping from the upper part. However, it also revealed there was no exact horizontal optimal location to install a barrier well, and found a prompt remediation by an inland barrier well and a better remediation by a coastal barrier well instead. Besides, coastal barrier wells can minimize the barrier well disadvantage to salinize the coastal side. However, the simulation showed groundwater level reduction or sea level rise would hinder the remediation of SWI by a barrier well and aggravate the barrier well disadvantage.

Based on the simulation results, a new barrier well application method, where an operational barrier well was shifted from inland to the coast step by step, was suggested to make the remediation faster and better, and minimize the barrier well disadvantage. This application takes advantage of the prompt remediation by an inland barrier well as well as the better remediation rate and the minimum disadvantage of a coastal barrier well.