Barriers to fluvial saltwater intrusion

Challenge: Sea level rise **Adaptation response:** Limiting saltwater intrusion

Description

Barrier systems are subsurface in nature; they fall into two categories: hydraulic barriers and physical barriers (Pool and Carrera 2010).

Hydraulic barriers can be divided into positive, negative and mixed barriers. In positive barriers freshwater is injected through recharge wells into the aquifer to raise the water table thus impeding the inland motion of saltwater. Negative barriers involve the interception of the intruding saltwater by pumping near the coast. A mixed hydraulic barrier combines a positive barrier and a negative barrier injecting freshwater inland to repulse the saltwater wedge and extracting saltwater near the shore to slow its advancement (Abdoulhalik et al 2017).

Physical barriers are constructed parallel to the coast and consist of a low-permeable material (such as steel or concrete) that acts to block the intrusion of saltwater into the aquifer. There are two types of physical barriers. Subsurface dams are imbedded in the impervious bottom layer of the aquifer only obstructing the lower part and allowing the natural discharge of freshwater to the ocean above. Cut-off walls extend from the top of the aquifer to a predefined depth (Abdoulhalik et al 2017).

Implementation

The effectiveness of positive hydraulic barriers relies on freshwater being injected at the toe of the saltwater wedge. As the wedge will always change position in real world scenarios both positive and mixed hydraulic barriers at times will be less effective in saltwater repulsion thus constituting a major limitation.

Negative hydraulic barriers are capable of slowing down the landward motion of saltwater but only if saltwater extraction rate exceeds the rate of the freshwater pumping rate thus involving a considerable and continuous amount of energy.

Although more expensive to establish the physical barriers show more promise with subsurface dams successfully established in Japan.

Environmental Benefits

- Maintains freshwater coastal aquifer.
- Concerns are associated with the negative and mixed hydraulic barriers is the disposal of abstracted saline groundwater from the wells close to the shore.

Socioeconomic Benefits

- Improved and sustained access to freshwater of adequate quality for domestic purposes.
- Improved health and safety conditions.
- Improved and sustained access to freshwater of adequate quality for livelihood activities.

Opportunities and Barriers

Opportunities:

- Increase production levels from coastal aquifers.

Barriers:

- Physical barrier technology is expensive to establish
- Operational costs of hydraulic barriers is considerable
- Efficiency of positive and mixed hydraulic barriers is varying as the saltwater wedge is never stationary in real world scenarios.

Implementation considerations*

Technological maturity:	2-4
Initial investment:	4-5
Operational costs:	4-5
Implementation timeframe:	2-4

* This adaptation technology brief includes a general assessment of four dimensions relating to implementation of the technology. It represents an indicative assessment scale of 1-5 as follows:
Technological maturity: 1 - in early stages of research and development, to 5 – fully mature and widely used
Initial investment: 1 – very low cost, to 5 – very high cost investment needed to implement technology
Operational costs: 1 – very low/no cost, to 5 – very high costs of operation and maintenance
Implementation timeframe: 1 – very quick to implement and reach desired capacity, to 5 – significant time investments needed to establish and/or reach full capacity
This assessment is to be used as an indication only and is to be seen as relative to the other technologies included in this guide. More specific costs and timelines are to be identified as relevant for the specific technology and geography.

Sources and further information

Antoifi Abdoulhalik, Ashraf Ahmed and G.A. Hamill 2017. A new physical barrier system for seawater intrusion control. Journal of Hydrology. DOI: 10.1016/j.jhydrol.2017.04.005

Barlow, Paul M. 2003. »Groundwater in Freshwater-Saltwater Environments of the Atlantic Coast« U.S. Geological Survey Circular: 1262 (U.S. Geological Survey Circular: 1262).

Linzey (editor) 2011. Prince Edward Island Department of Environment, Labour and Justice, Atlantic Climate Adaptation Solutions Association - Saltwater Intrusion and Climate Change.

Nurnawaty, M. Selintung, M.A. Thaha and F. Maricar 2016. Seepage Saltwater Reduction by Physical Barrier at Coastal Aquifer. International Journal of Applied Engineering Research ISSN 0973-4562 Volume 11, Number 23 (2016) pp. 11358-11362.

Pool, M., and J. Carrera. 2010. Dynamics of negative hydraulic barriers to prevent seawater intrusion. Hydrogeology Journal 18: 95–105.