Saltwater Intrusion and Freshwater Supply in Coastal Aquifers

Forty-four percent of the worlds population lives within 150 kilometers of the coast [UN Atlas of the Oceans, Human Settlements On the Coast]. In many of these areas, groundwater resources are relied upon heavily to support society's needs. As its name suggests, saltwater intrusion occurs when denser seawater encroaches into a freshwater aquifer (see Figure 1). Saltwater (or seawater) intrusion can pose a significant threat to coastal aquifers, particularly when population and consumptive use increase at the same time as sea level rises [Barlow and Reichard, 2010]. While it is a concern globally, saltwater intrusion is a paramount concern for small islands where freshwater resources are often limited to a shallow lens underlain by a brine (saltwater) aquifer, which is unsuitable for agricultural use or human consumption [Bricker, 2007].

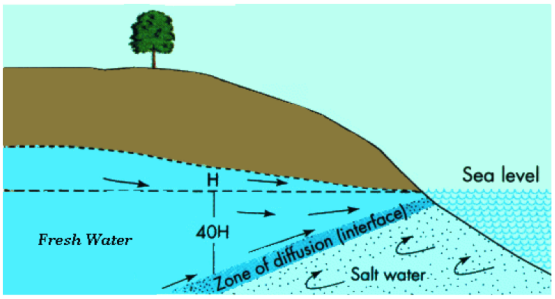

Figure 1: Idealized saltwater intrusion

The traditional mathematical system for describing density dependent subsurface flow consists of a continuity equation for the aqueous fluid phase (water) together with a transport equation for dissolved salt, and Darcy's law which relates groundwater velocities to gradients in pressure [Diersch and Kolditz, 2002]. These equations are coupled through the velocity and density, which depends on salt concentration. While some classical semi-analytical solutions exist when interfaces are assumed to be sharp [Cheng and Ouazar, 1999], numerical methods are typically required to obtain approximate solutions for real-world systems [Diersch and Kolditz, 2002]. Despite this reliance on numerical solutions, simulating saltwater intrusion remains challenging due to the potential for density-driven instabilities and the need to accurately represent mixing between saltwater and freshwater, since this directly affects the extent of intrusion [Diersch and Kolditz, 2002].

Among other things, the extent of intrusion is a function of groundwater well pumping rates and distributions, geology of the freshwater aquifer, rainfall levels, sea level height and tidal behavior. Using semi-analytical, numerical, and statistical tools, we will consider the impact of these factors on intrusion for idealized island and coastal systems and explore potential risks to freshwater supply given changes in sea level, consumption rates, and weather patterns.

References

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