Developing a Coupled Hydraulic-Mechanical-Chemical Model to Investigate Seawater Intrusion and Land Subsidence Due to Groundwater Over-exploitation in Pingtung Plain, Taiwan

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Abstract

Nowadays, due to economic development pressures and heightened uncertainties stemming from climate change-induced extreme weather events, groundwater overexploitation has commonly occurred. The decreases in groundwater level may induce seawater intrusion (SWI) and land subsidence (LS) in coastal areas. The strategies for dealing with and mitigating the effects of SWI and LS have become a pressing concern across the globe. Many projects and research have evaluated the impact and proposed management solutions to reduce SWI and LS influences. However, conventional studies perform independent models to study SWI and LS, ignoring the interactions between problems. This study thus employs the COMSOL Multiphysics software to develop a coupled model capable of simulating SWI and LS simultaneously and testing mitigation solutions. The Pingtung Plain, Taiwan, was selected as a case study. Leveraging the principles of poroelastic, solute transport, and density-dependent flow, our study successfully develops a coupled Hydraulic-Mechanical-Chemical (HMC) model and demonstrates its efficacy in simulating SWI and LS processes. The practical implementation underscores the pronounced influence of coastal groundwater extraction on both problems in this area. Therefore, the imperative arises for strategies to mitigate the adverse effects of groundwater withdrawal in this area. The result also showed that relocation pumping wells and managed artificial recharge efficiency reduced LS and SWI impact. The coupled HMC model is a valuable method for assessing and enhancing the efficacy of concurrent management strategies targeting both SWI and LS. This study forms the fundamental underpinning for our forthcoming research's subsequent in-depth development of optimal groundwater management.

Keywords: Coupled HMC, Land subsidence, Seawater intrusion, Pingtung Plain.