Thermo-poro-elastic effects in the anthropogenic uplift of Venice by deep seawater injection

N. CASTELLETTO, M. FERRONATO, G. GAMBOLA, C. JANNA & P. TEATINI

Department of Mathematical Methods and Models for Scientific Applications (DMMMSA), University of Padova, via Trieste 63, I-35121 Padova, Italy
castelletto@dmsa.unipd.it

Abstract To mitigate the flooding that periodically plagues Venice, a project of anthropogenic uplift of the city by deep seawater injection has been recently advanced. A pilot programme has been designed to test the feasibility of the proposal, improve the knowledge of the subsurface below the Venice Lagoon and help the calibration of the full-scale prediction models. The present communication aims at supplementing the proposal with the investigation of the role played by a temperature variation should the injection take place in non-isothermal conditions. A three-dimensional (3-D) nonlinear hydro-thermo-mechanical model is developed making use of lowest order Mixed Hybrid Finite Elements (MHFEs) and shock capturing Finite Volumes (FVs) for the coupled subsurface fluid flow and heat transfer, and Finite Elements (FEs) for the structural equilibrium. A set of computer simulations is performed using realistic information on the hydrogeological, geothermal, and geomechanical properties of the Northern Adriatic basin. A representative 750-m deep brackish aquifer is selected with the seawater injection programme planned with an overpressure of 1 MPa over a 3-year time period. Different scenarios are simulated depending on the temperature difference $\Delta T$ between formation water and injected seawater that is assumed to be taken from the Adriatic. Basically a $\Delta T$ according to season is addressed. The numerical results show that the $\Delta T$ impact on the pressure field is negligibly small relative to the isothermal case, while some influence is exerted by a thermal gradient on the predicted uplift, which can vary at the most by nearly 10% for an injection in ambient conditions.

Key words anthropogenic uplift; hydro-thermo-mechanical modelling; Venice, Italy