Groundwater pumping and sinking cities: back to the forefront due to global change

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Much attention is paid to sea level rise but the problem of land subsidence, induced by man-changed (fluid) groundwater conditions in the underground, can be by far more significant locally (Showstack, 2014). The 'sinking' regions correspond most often to coastal densely populated areas located in regions where compressible loose sediments are found. As they are usually under-consolidated and compressible, geological settings made of recent coastal and especially estuarine, deltaic and lacustrine sediments are particularly concerned. Venice, Mexico, Bangkok, Shanghai, Changzhou, Jakarta, Manila, New Orleans, Houston, Tokyo, Ho Chi Minh City, Hanoi, … are only a few examples among the numerous 'sinking cities' (Gambolati & Teatini, 2015).

Recent unconsolidated or semi-consolidated deposits form often a succession of layers that can be considered, from a hydrogeological point of view, as semi-confined or confined aquifer systems (Poland, 1984). In confined aquifers but also in unconfined aquifers, it is well known that the lowering of the piezometric head due to pumping or drainage induces additional effective stresses directly in the concerned aquifer and then, with a delay depending on their characteristics, in the compressible confining layers or in the compressible lenses of loam, clay, and peat included in the aquifer. This effective stress increase induces a drained consolidation process in the compressible layers.

Coupling the transient groundwater flow equation with geomechanical aspects, allows understanding the considered transient processes induced by the artificial lowering of the water pressure in the porous medium. For accurate calculations, used for understanding the observed subsidence and predicting the future subsidence, it is important to take into account the strongly non-linear effects as the variation of the specific storage coefficient and of the permeability during the consolidation process (Dassargues, 1995, 1997, 1998).

Recently this issue was back to the forefront of the scientific actuality as land subsidence plays an important role linked to global change and groundwater management challenges (Gorelick & Zheng, 2015).

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