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Groundwater and sinking coastal zones: how pumping and drainage create more trouble than climatic changes

by

DASSARGUES Alain
Hydrogeology & Environmental Geology, Aquapole, Dpt ArGEnCo, University of Liège, B52 Sart Tilman, 4000 Liège, Belgium,
*Corresponding Author. Email: Alain.Dassargues@ulg.ac.be

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SUMMARY.— Much attention is paid to sea-level rise due to climate change. However, the problem of land subsidence because of human-induced changes of (fluid) groundwater conditions in the underground can be by far more significant locally (Showstack, 2014). The 'sinking' regions correspond most often to densely populated coastal areas located in regions where compressible and under-consolidated loose sediments are found. This is the case in late Quaternary coastal settings consisting of estuarine, deltaic and lagoonal sediments. 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).

Late Quaternary, and more particularly Holocene 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, 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 silt, clay, and peat included in the aquifer.

Coupling the transient groundwater flow equation with geomechanical aspects, allows understanding of 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 such as the variation of the specific storage coefficient and of the permeability during the consolidation process (Dassargues, 1995, 1997, 1998).

Typical and emblematic examples involving regional as well as very local land subsidence will be presented showing the general approach. Land subsidence is an important issue linked to global change and groundwater management challenges (Gorelick & Zheng, 2015).

REFERENCES

DASSARGUES, A. 1995. On the necessity to consider varying parameters in land subsidence computations, *In* BARENDS, B.J., BROUWER F.J.J. & F.H. SCHRÖDER (Eds), Proc. of the 5th Int. Symp. on Land Subsidence, IAHS 234: 259-268.

DASSARGUES, A. 1997. Vers une meilleure fiabilité dans le calcul des tassements dus aux pompages d'eau souterraine, A) Première partie: prise en compte de la variation au cours du temps des paramètres hydrogéologiques et géotechniques (in French), *Annales de la Société Géologique de Belgique*, 118(1995)(2) : 95-115.

DASSARGUES, A. 1998. Prise en compte des variations de la perméabilité et du coefficient d'emmagasinement spécifique dans les simulations hydrogéologiques en milieux argileux saturés (in French), *Bull. Soc. Géol. France*, 169(5): 665-673.

GAMBOLATI, G. & P. TEATINI. 2015. Geomechanics and subsurface water withdrawal and injection. *Water Resources Research* 51: 3922-3955.

GORELICK, S.M. AND C. ZHENG. 2015. Global change and the groundwater management challenge, *Water Resources Research.* 51: 3031-3051.

POLAND, J.F. 1984. Guidebook to studies of land subsidence due to groundwater withdrawal, Studies and Reports in Hydrology, 40 Paris: UNESCO.

SHOWSTACK, R. 2014. Scientists focus on land subsidence impacts on coastal and delta cities, *Eos* 95(19): 159.