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Thirty-year land elevation change from subsidence to uplift following the termination of groundwater pumping and its geological implications in the Metropolitan Taipei Basin, Northern Taiwan

Chih-Tung Chen [a,*], Jyr-Ching Hu [a], Chia-Yu Lu [a], Jian-Cheng Lee [b], Yu-Chang Chan [b]

[a] *Department of Geosciences, National Taiwan University, Taipei 106, Taiwan, ROC*
[b] *Institute of Earth Sciences, Academia Sinica, Taipei 115, Taiwan, ROC*

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Abstract

Several levelling routes in the metropolitan Taipei Basin have been repeatedly conducted during the past decades, mainly in order to monitor the anthropogenic ground subsidence due to massive pumping of groundwater. We analysed the levelling data released from government and investigated the rate of ground level change from 1975 to 2003, which postdate the massive groundwater exploitation in Taipei area. Based on the contour maps created from the levelling data of 406 benchmarks, the overall subsidence rate in the Taipei Basin gradually decreased since 1975, and around 1989 the basin switched to slight uplift throughout a large part of the basin. Three mechanisms are proposed to be responsible for the observed land elevation changes, including shallow soil compaction, deformation within aquifer, and tectonic subsidence. The trend of the ground level change in 1975–2003 essentially demonstrated the effects of natural recharge to previously depleted aquifers, and is explained by the hydro-mechanical coupling of aquifer materials, i.e., elastic rebound, to the rising piezometric level. The rate of shallow soil compaction is estimated about 1–8 mm/yr throughout the basin according primarily to the shallow clay thickness. Asymmetric tectonic subsidence related to the Shanchiao Fault was estimated to be 1.75 mm/yr and 0.9 mm/yr in the western part and the central part of the basin, respectively. By subtracting the components of the soil compaction and tectonic subsidence from the surface land elevation change, the rebound of aquifer strata was estimated to be about 6.7 cm and 16 cm in western margin and Central Taipei, respectively. The amount of rebound is approximately 10% in magnitude comparing to the amount of previous anthropogenic subsidence due to massive groundwater pumping, totally about 2 m.

Keywords: Groundwater pumping; The Taipei Basin; Ground subsidence; Aquifer deformation; The Shanchiao Fault

1. Introduction

Excessive groundwater utilization in agricultural and urban area is known to cause rapid human-induced land subsidence and pose severe problems including damage to building and infrastructures, exhaustion of groundwater resources, increase of risks of inundation, and inland sea water intrusion, as documented in many places around the world (e.g. Bangkok, Thailand, Phienwej et al., 2006; Jakarta, Indonesia, Abidin et al., 2001; Ravenna, Italy, Teatini et al., 2005; Pingtung Plain,

* Corresponding author. Tel.: +886 2 33662927; fax: +886 2 23636095.
E-mail address: kthomasch@gmail.com (C.-T. Chen).

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