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Apparent groundwater age rejuvenation caused by excessive groundwater pumping in the Jakarta area, Indonesia

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In the Jakarta area (Indonesia), excessive groundwater pumping due to the rapidly increasing population has caused groundwater-related problems such as brackish water contamination in coastal areas and land subsidence. These problems have emerged recently in some hydrological studies. A comparison of ^{14}C activity between 1985 and 2008 shows apparent groundwater age rejuvenation in the deep aquifer under the DKI Jakarta. We use a numerical groundwater flow model to discuss and evaluate the process of this rejuvenation in the urbanized area. Before 1983, groundwater pumping was not intense and the groundwater discharge flow toward the coastline was dominant; however, this outward flux changed to inward flux into the deeper aquifer after the mid-1980s because of over-pumping in the urban area. The largest flux among six flux directions toward the deep aquifer under the DKI Jakarta became the 'vertical downward flux,' indicating shallower groundwater intruding into the deep aquifer due to excessive groundwater pumping from the mid-1980s. This flux increased to approximately 50% in the 2000s. This result is consistent with the detection of CFC-12 and SF_6 , an indicator of young groundwater, appearing in deep groundwater. As the rejuvenation ratio ' R ' was determined by using the ^{14}C activity in the groundwater, R increased with the CFC-12 concentration, exhibiting good correlation between R and the CFCs. We also estimated the 'vertical downward flux' at each well's screen depth using a numerical model estimation. The results show that the flux was larger in the urban groundwater depression area, especially in the shallower part of the deep aquifer, affecting the magnitude of the shallow groundwater intrusion. If this trend continues into the future, the groundwater potential would decline further and the deeper groundwater would be even more affected by shallow groundwater that is highly polluted by urban contaminants such as NO_3^- and by seawater intrusion. This would cause deterioration in the quality of the deep groundwater, posing a high risk for those using it as potable water. Although stopping excessive pumping is a difficult task for the rapidly urbanizing Jakarta area, it is necessary to reduce this over-pumping situation by either securing alternative water resources or introducing pumping regulations such as groundwater tax.

Keywords: Groundwater age, Apparent age rejuvenation, ^{14}C , Groundwater flow simulation, Jakarta