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Evaluation of natural capacity and social capability for sustainable use of subsurface environment in Asian cities

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In order to suggest sustainable management of subsurface environment in Asian coastal cities, natural capacities indices such as groundwater storage, recharge rate, redox etc., and changing society and environmental indices were evaluated for seven Asian cities during the last 100 years. Numerical modeling of the subsurface environment was established for Tokyo, Osaka, Bangkok, and Jakarta to evaluate the groundwater recharge rate/area, residence time, exchange of fresh/salt water. Using updated GRACE data, groundwater aging methods by CFCs and 85Kr, subsurface temperature analyses in urban and suburban area, and groundwater contamination analyses, revealed how deep did human impacts reach into the subsurface environment during the last 100 years. Changing society indices, such as population and income (Driving force), groundwater pumping and dependency (Pressure), groundwater level (State), land subsidence (Impact), and regulation of pumping (Response), have been made on a yearly basis for seven cities during the last 100 years. Five development stages of the city are recognized in Tokyo based on the DPSIR, and six other cities are compared with Tokyo for (1) land subsidence, (2) groundwater contamination, and (3) subsurface thermal anomaly. As results, we found that human impacts on subsurface environment reached to a few hundred meters depth during the last 100 years. The turnover time of groundwater was more than 10 times (acceleration of the groundwater circulation), material loads reached up to 3 to 6 times (Nitrogen), thermal storage was 2-3 times higher compared with the average increased by global warming during the last 100 years. Groundwater volume and material load to subsurface environment are manageable, however we need monitoring of material/heat accumulation in subsurface environment for sustainable use of subsurface environment. Integral management beyond the boundaries of surface-subsurface and land-ocean are necessary based on natural capacity and use of social capability such as late comers benefit.

Keywords: subsurface environment, natural capacity, capability, urbanization, groundwater, contamination