Human Impacts on Urban Subsurface Environments

This project assesses the effect of human activities on urban subsurface environments, an important but largely unexamined field of human-environmental interactions. Subsurface conditions merit particular attention in Asian coastal cities where population numbers, urban density and use of subsurface environments have expanded rapidly. The goals of this project are to evaluate the subsurface environments of seven Asian coastal cities for such problems as subsidence, groundwater contamination and thermal anomalies, and to suggest how they can be addressed or avoided.

Project Leader
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Professor Taniguchi earned his doctorate in hydrology from the University of Tsukuba. In addition to his work at RIHN he is a leader of the UNESCO-GRAPHIC Project “Groundwater Resources Assessment under the Pressures of Humanity and Climate Change”, and vice president of the International Committee of Groundwater of the IAHS/IUGG. He has published several books and journal articles on hydrology, geophysics and environmental science.

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Project background and objectives

Most environmental research focuses on above-ground environments. Subsurface environments, though they are involved in biogeochemical circulations and are critical to overall environmental quality, attract little attention, perhaps because they are invisible and difficult to evaluate. Subsurface environmental problems such as subsidence and groundwater contamination occur repeatedly in major Asian cities, though there is often a time lag between the “stage” of urban development and the point at which negative subsurface conditions are recognized. Improved understanding of the subsurface environmental changes associated with past and present urban growth should improve overall urban environmental quality in the future.

This project investigates subsurface environmental conditions in Tokyo, Osaka, Bangkok, Jakarta, Seoul, Taipei and Manila. It also assesses the degree to which groundwater resources may improve these cities' resilience to increasingly variable sources of surface water. Each city's historical development will be assessed through socio-economical analyses and historical records. Hydrogeochemical and in-situ/satellite-GRACE gravity data will describe groundwater flow and storage systems, and indicate where significant problems in subsurface environments exist. Chemical analyses of subsurface waters, sediments and tracers will allow us to evaluate contaminant accumulation and transport from land to ocean. Finally, we will use urban meteorological analyses to reconstruct surface temperature histories in the seven cities and to examine the impact of the urban “heat island” effect on subsurface thermal contamination.

Progress in 2009

Subsurface environments in the seven cities have been surveyed, and monitoring continues.

Natural and social data have been assessed in each city and compiled into a GIS database. Based on historical maps, land use/cover maps of 0.5 km mesh were composed for each city at three development stages (1930s, 1970s, and 2000s).

RIHN project members organized the 3rd RIHN international symposium, on Urban Subsurface Environments. A volume based on the symposium entitled “Human Impacts on Urban Subsurface Environments” will be published in 2010 (Springer Publishers).

Several cross-cutting themes, such as the relation between groundwater and religious sites and beliefs in Bangkok and Jakarta, have been identified and investigated.

Fifteen indices of urban social and environmental change and six indices of natural capacity were compiled.

Future works and challenges

We must continue analyzing how water use and quality is affected by water rights and regulation of surface and groundwater in each of the cities under study.

We will combine our social and ecological data and our subsurface ennvironmental model in order to analyze the impact of water resources, environmentalloads, economic processes and public policies on subsurface environments.

Land use/cover data taken in the 1930s, 1970s and 2000s will be used to evaluate the rate of groundwater recharge, thermal storage in aquifers, and subsurface contamination. Based on the above, we will develop several scenarios describing how better relationships between subsurface environment and society can be established.

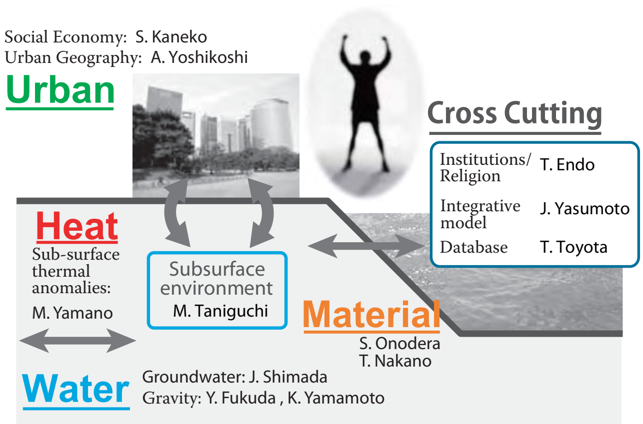


Figure 1 **Research Structure**

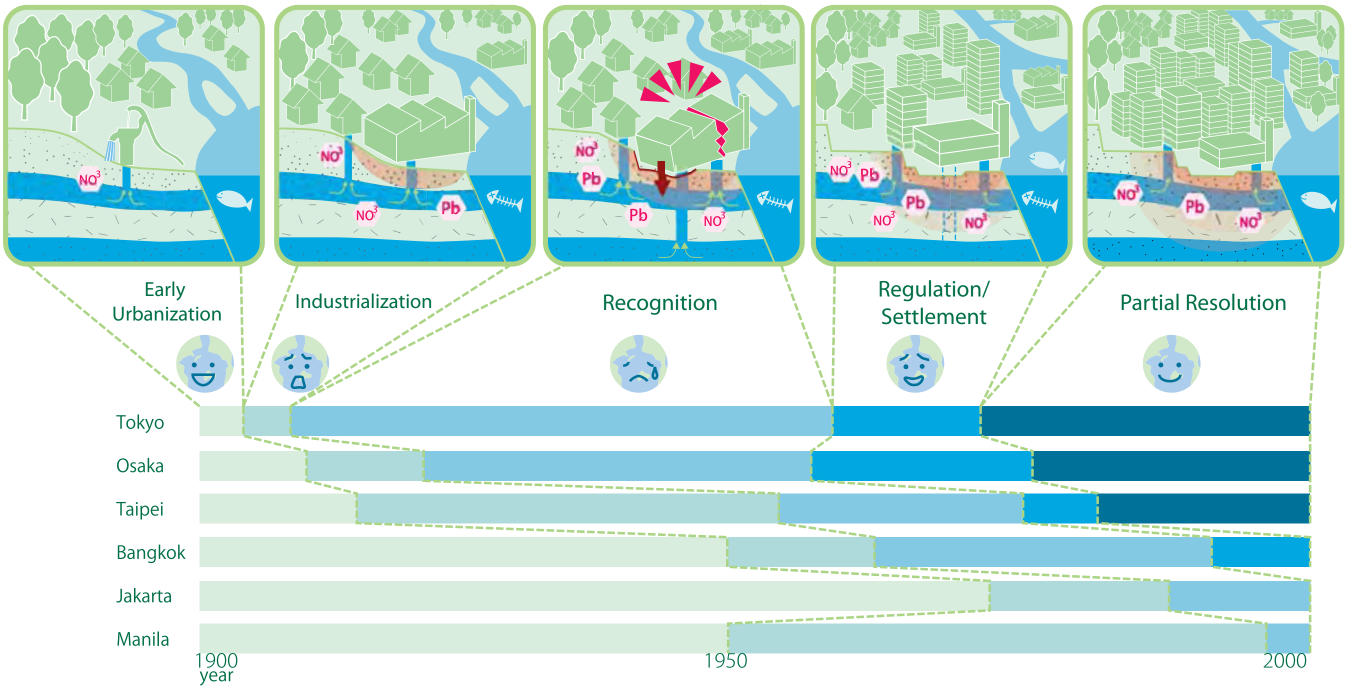
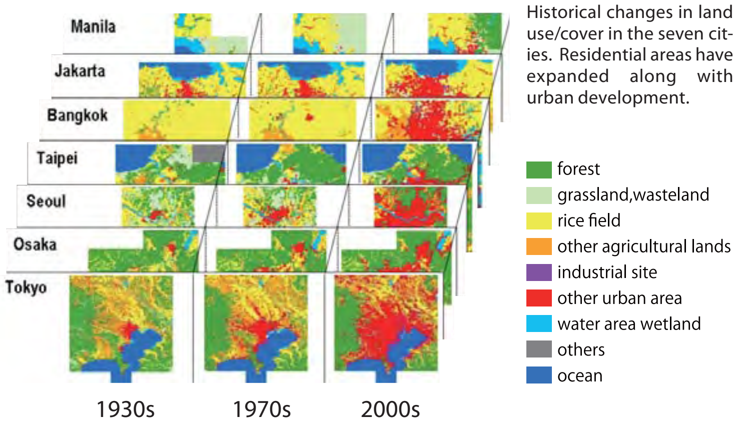


Figure 2 **Cross Cutting : Integrated Model**

Observed and statistical data are compared in seven cities based on five stages of development. The bar figure shows the stages of land subsidence at each city in comparison with Tokyo.



Historical changes in land use/cover in the seven cities. Residential areas have expanded along with urban development.

Groundwater models are used to estimate the total impact of natural and human processes on subsurface environments.

Groundwater storage and flow patterns are quantitatively modeled.

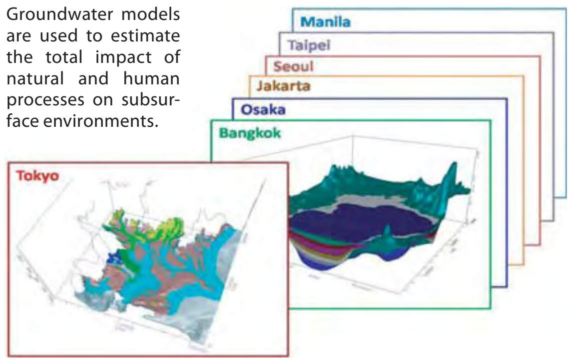


Figure 3 **Cross-cutting analysis: Integrated groundwater models/GIS**

Integrates observed and GIS data and constructs a framework for comparative analysis of the seven cities.

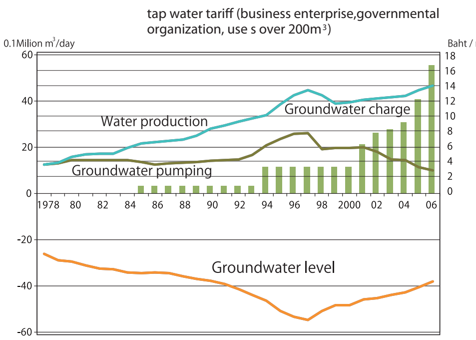


Figure 4 **Cross-cutting themes: Legal institutions**

In Bangkok, excessive groundwater pumping in the late 1970s led to land subsidence. The problem was solved through expansion of surface water infrastructure and the imposition of a charge for use of groundwater, which is now more costly than tap water.
Beyond 200m³/month, a special tariff of 15.81 Baht applies to each unit of water used.

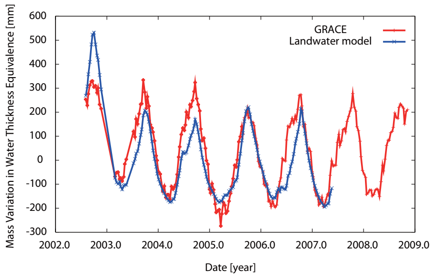


Figure 5 **Gravity GRACE**

Right: Inter-annual Earth mass trend observed by GRACE (2002 to 2009). Variations in mass over the land area correspond to changes in total terrestrial water storage, including groundwater. Mass is decreasing in and around the Bangkok area.
Above: Time series of GRACE-derived mass variation and model-derived terrestrial water storage over the Chao Phraya river basin. The two variables show good correspondence.