



Urban Development and the Role of Groundwater Management in Hanoi: Ensuring safety and sustainable groundwater use

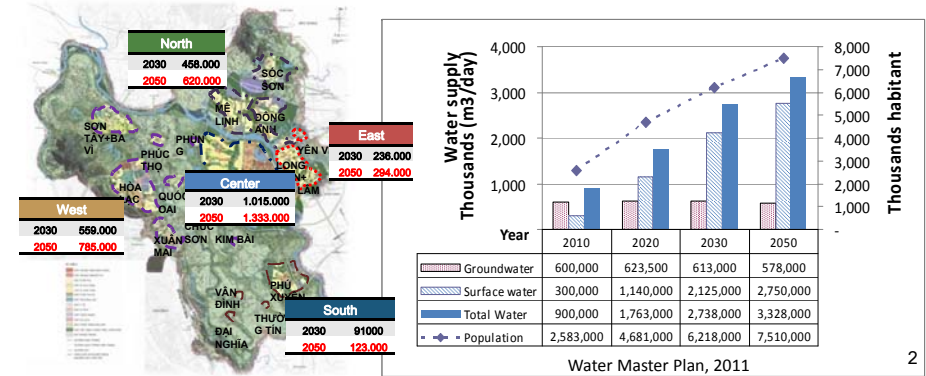


Prof. Satoshi Takizawa, The University of Tokyo
Groundwater Group

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The role of groundwater in urbanizing areas of Hanoi City

- Groundwater has been the primary source of water
- In the future, groundwater will remain an important water resource, especially in rapidly urbanizing areas in Hanoi suburbs where extension of public water supply may not catch up with urban development: groundwater pollution and lowering water level will remain major concerns



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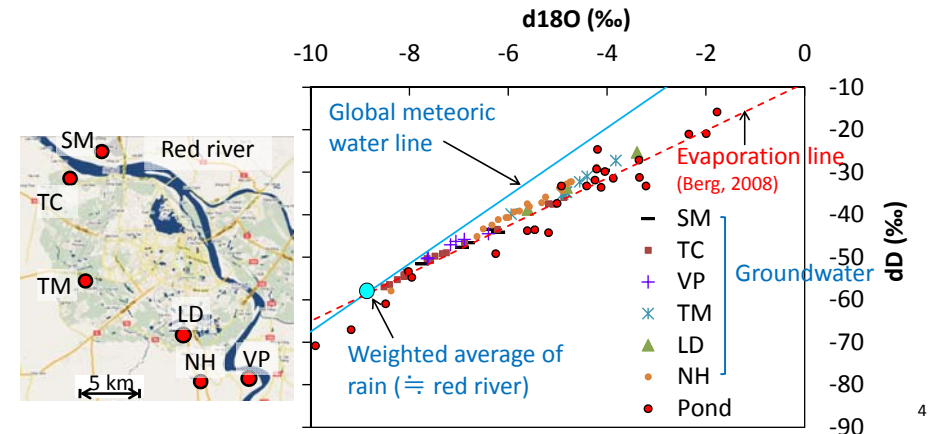
Toward safe and sustainable use of groundwater in urbanizing Hanoi City: challenges and key questions

1. Mitigation of water level drawdown by enhancing groundwater recharge
 - How exactly local groundwater was recharged?
 - How groundwater recharge will change by urbanization?
 - How much is the contribution of infiltration from ponds to groundwater recharge?
2. Adaptation for groundwater pollution
 - How people without public water supply obtain safe drinking water with allowable cost?
 - How effective are the treatment efficiencies of point-of-use (POU) water treatment devices used at households?

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Groundwater recharge estimated by stable isotopes

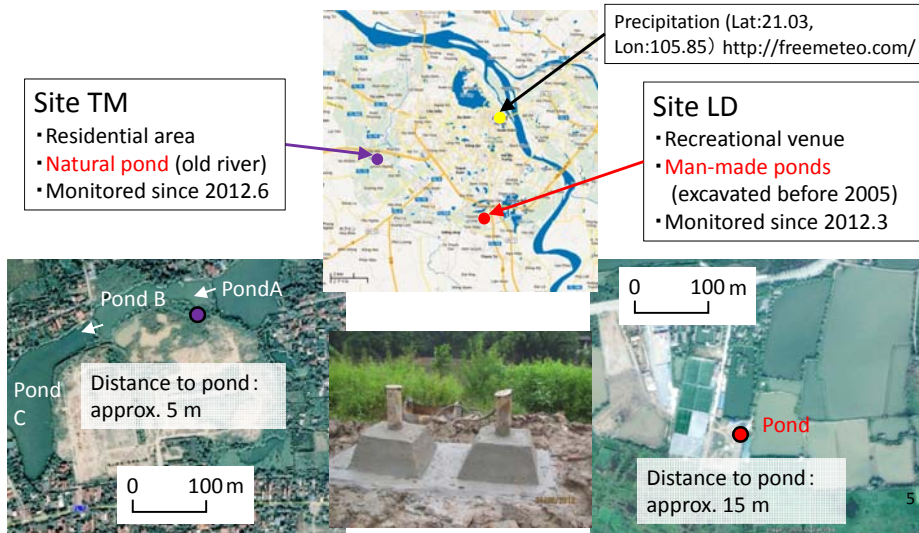
- Recharge from red river was dominant in riverine villages (SM, TC, and VP)
- Inland villages (TM, LD, and NH) were mainly recharged by lakes, ponds, and paddy fields that have evaporation process



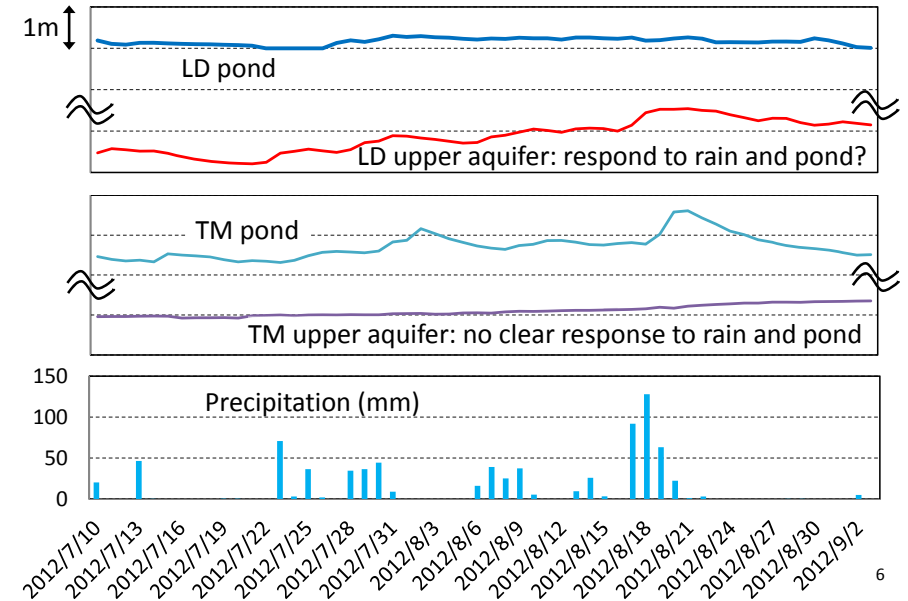
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Water level monitoring beside ponds

- Water levels of ponds and nearby groundwater were continuously monitored to assess the interaction between them

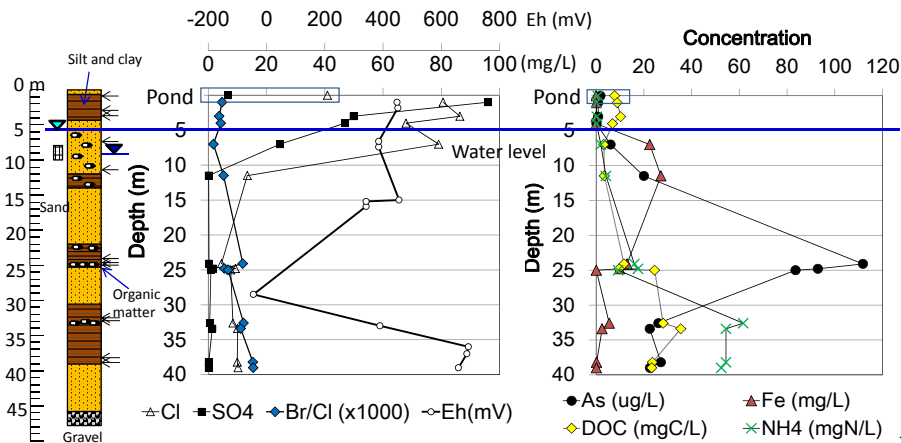


Water levels in LD and TM

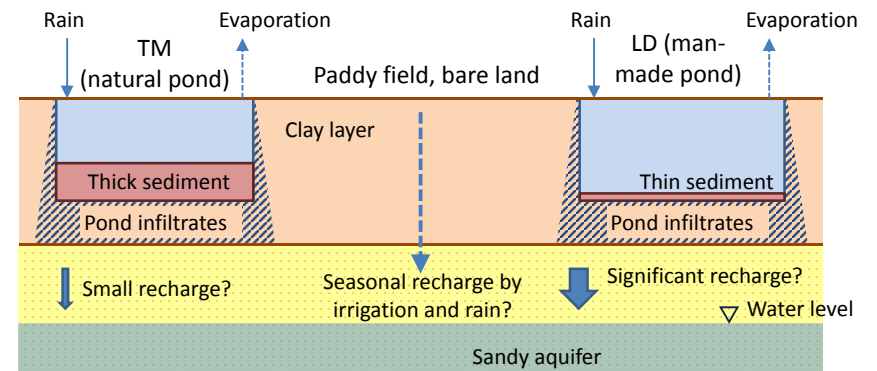


Soil pore water quality (LD)¹

- Infiltration from ground surface (e.g. wastewater) influenced upper aquifer
- As level in pore water was the highest at soil that were rich in organic matter (OM): OM enhanced dissolution of As-bearing iron minerals, or As associated to buried plants?
- As and DOC in upper aquifer, where pond infiltrate potentially influence, were not elevated at present



Enhancing groundwater recharge by utilizing pond infiltrates



- Given that pond infiltrates have significant contribution to local groundwater recharge, preservation of ponds and regular dredging work could effectively keep and enhance groundwater recharge
- Further studies are needed regarding the quantification of recharge from pond and its influence on groundwater quality

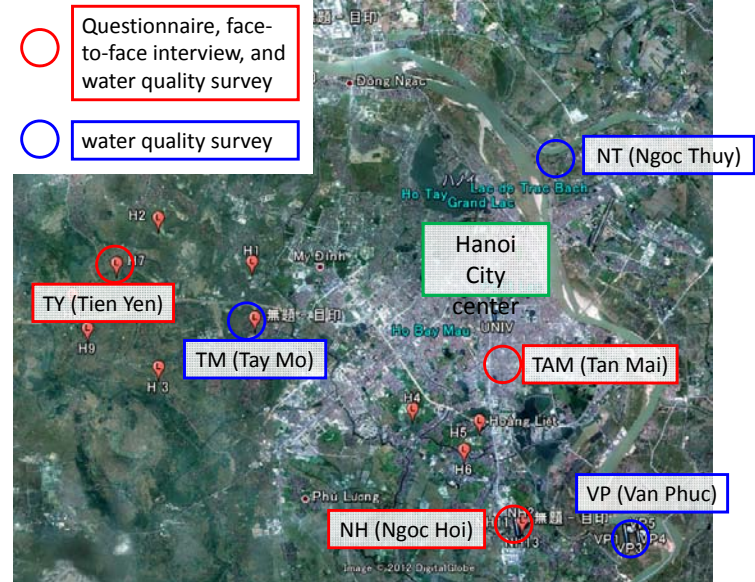
Investigation of current use of water resources and treatment methods in households

- Questionnaire survey and face-to-face interview at 170 household in 3 communes in Hanoi City
- Water sampling and analysis of tap water, groundwater, and rain water before and after treatments



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Study sites



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TAM (Tan Mai)

- Urban area
- Tap water is available to all households



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- NH (Ngoc Hoi) • Suburban area, tap water is available to limited households
- TY (Tien Yen) • Rural area, tap water is not available



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NH (Ngoc Hoi) • Suburban area, tap water is available to limited households

TY (Tien Yen) • Rural area, tap water is not available

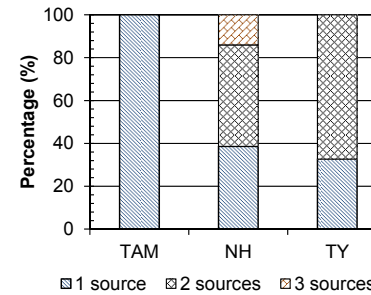


Sand filters

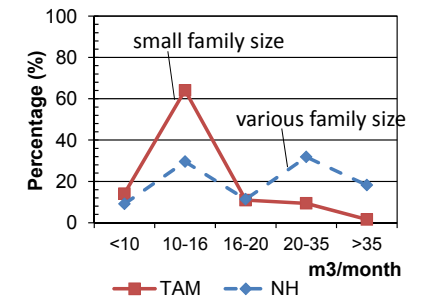
Number of water resources and treatment methods in households

- Commune TAM (urban area): tap water is the only source
- Commune NH (suburban area): tap water is available to limited households- multiple water sources (tap water, groundwater, rain water)
- Commune TY (rural area): tap water is not available- groundwater and rain water

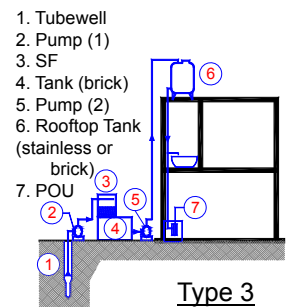
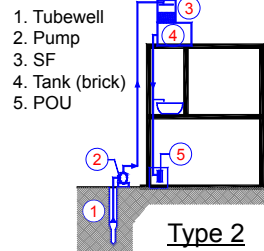
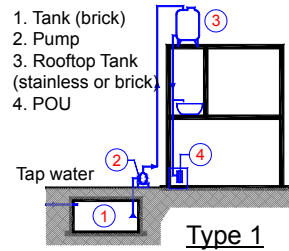
Number of water sources in households



Monthly water consumption

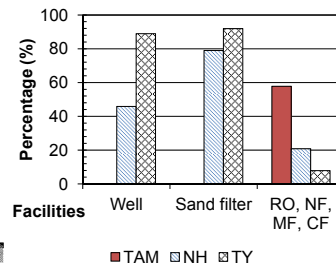


Point-of-use (POU) water treatment systems at households

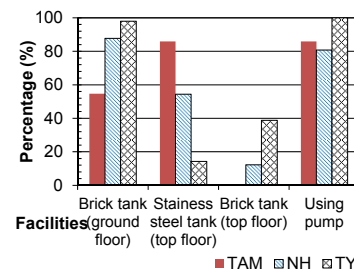


TAM: Type 1
NH: Type 1, Type 2, and Type 3
TY: Type 2, and Type 3

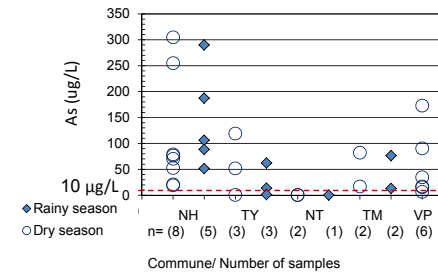
Usage of wells and POU devices



Water storage and pumping facilities



Water quality of groundwater and tap water (arsenic and iron) at households



(1) As criteria in Vietnam

- Centralized water supply (> 500 pop): 10 µg/L (WHO)
- Community Water Supply (< 500 pop): 50 µg/L

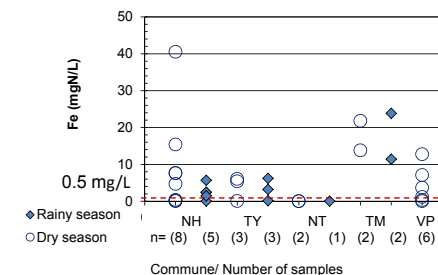
(2) Arsenic

- > 10 µg/L in 81% (n=26) samples
- Average 77 µg/L, max 305 µg/L

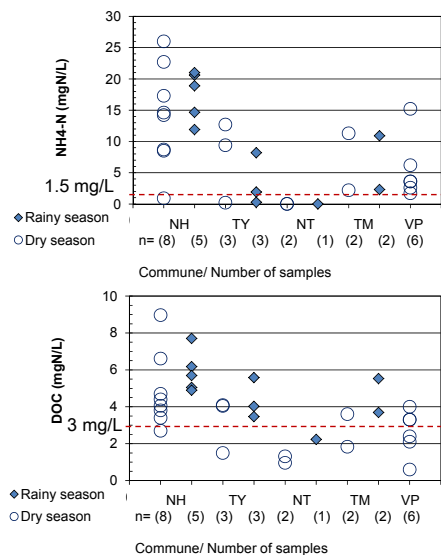
(3) Fe

- > 0.5 mg/L in 66% (n=21) samples
- Average 6.6 mg/L, max 40.4 mg/L

(4) Commune NH: elevated As and Fe



Water quality of groundwater and tap water (arsenic and iron) at households



- Commune NH: high in NH₄ and DOC
- Communes NT, TM, VP: low in NH₄ and DOC

NH₄-N

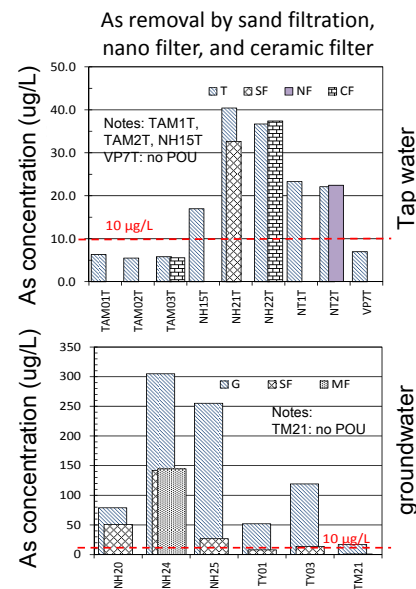
- >1.5 mg/L in 81% (n=26) samples
- Average 9.4 mgN/L, max 26 mgN/L

DOC

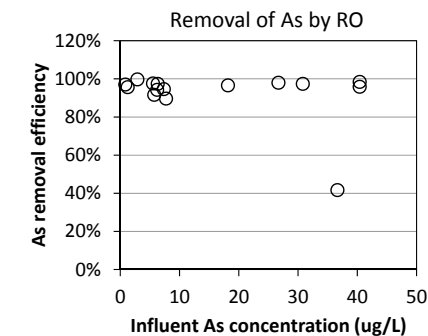
- >3 mg/L (Japanese criteria) in 69% (n=22) samples
- Average 4.0 mg/L, max 9.0 mg/L

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As removal by POU water treatment devices



- Sand filtration and reverse osmosis (RO) could effectively lower As level to below 10 µg/L
- RO had a high As removal efficiency except for one household
- Nano filter (NF), micro filter (MF), ceramic filter (CF) did not remove As



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Summary: how can we ensure safe and sustainable groundwater use?

1. Groundwater will remain to be an important water resource, especially in rapidly urbanizing areas in Hanoi suburbs
2. Both natural and man-made ponds were found to be potential sources of groundwater recharge; hence, they must be preserved in any urban development projects
3. Groundwater and rain water were used in the suburban area of Hanoi City to augment insufficient public water supply, but most of the households installed POU water treatment devices to purify water
4. Sand filter and RO are effective POU devices for As removal, but regular maintenance is required to ensure the performance
5. The best mix of surface and groundwater resources should be explored in the forthcoming research

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