Land Subsidence Management in Japanese Deltas

July 28, 2017

Tomoyuki OKADA
Director for International Coordination of River Engineering
River Planning Division, Water and Disaster Management Bureau
Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan
1. Land subsidence problems in deltas
2. Mechanism of land subsidence
3. Groundwater monitoring
4. Measures to prevent land subsidence
5. Conclusion
Contour lines show elevation (m) from Arakawa River Peil, which is 1.13m below Tokyo Peil (Average Tokyo Bay Sea Level).

Source: Tokyo Metropolitan Government Construction Bureau
Evidence of Land Subsidence

Original ground level when the well was bored

Land subsidence caused by the contraction of confining clay layer

Ground level in 1970

Source: Tokyo Metropolitan Government Environment Bureau
Groundwater levels and land subsidence rate change in parallel.

Ground water levels of each deep well were based on the average sea level of Osaka Bay. (Source: Kiyoo WADACHI in 1940)
Pressures of the water of confined aquifer and the confining clay layer are balanced.

When the water pressure of confined aquifer falls, the water in the clay layer is squeezed out.

Original natural condition when pumping began.

Ground water level falls and land subsides.

Source: Masaru MORITA, 2012
1) Groundwater originally came from precipitation infiltration (recharge).
2) Horizontal groundwater inflow in the unconfined aquifer (here, from right to left).
3) Run off, Spring water from cliff surface.
4) Pumping up from shallow wells.
5) Leakage into a lower confined aquifer.

- A spring depletes when an unconfined groundwater level falls below a spring discharge level.
- Rainfall infiltration can’t catch up with unconfined water leakage into lower confined aquifer.

Source: Masaru MORITA, 2012
A long and successive underground structure (from front to back in this figure) blocks groundwater flow (white arrow from left to right).

A linear underground structure blocks an unconfined groundwater flow and causes negative impact.

A long and successive underground structure (from front to back in this figure) blocks groundwater flow (white arrow from left to right).

Source: Masaru MORITA, 2012
The ground water level is converted based on the average Tokyo Bay Sea Level.

Industrial Revolution in Japan

1945 the end of WW II

the Post-war Economic Growth

1935

The first book about the land subsidence in Tokyo was published.

After the effective pumping regulation, the groundwater level has recovered.

The line shows a record of groundwater level at Tokyo University from 1900 to 2000.

Groundwater pumping regulation started.

Source: Masaru MORITA, 2012
Land subsidence in Tokyo lowland started in the 1920s. In the 1960s, the groundwater level dropped 2.5 m/year, and land subsidence advanced 10 cm/year. The pumping regulation of 1970s restored the groundwater level, but the subsided land is not recovered.

The ground water levels are converted based on the average Tokyo Bay Sea Level.

Source: Tokyo Metropolitan Government Civil Engineering Laboratory
River Act

- **Article 2**
  “A river is public property.”

- **Article 23**
  “Any person who intends to use the water of a river shall obtain permission of the river administrator.”

Civil Code

- **Article 207**
  “Ownership in land shall extend to above and below the surface of the land, subject to the restrictions prescribed by laws and regulations.”

Groundwater in Japan

River water in Japan

Who Owns Groundwater?
Objectives

1) Ensure the rational supply of industrial water
2) Conserve sources of groundwater in designated districts and prevent land subsidence

1. Industrial zones where land subsidence and other groundwater damage occurred shall be designated.
2. Wells with pump outlet of 21 cm$^2$ (currently 6 cm$^2$) and over shall get governor’s permission.
3. Boring new wells that do not meet the standard is prohibited.
4. Where the construction of unqualified well is prohibited, a substitute water source is provided.
The Code of Preventing Land Subsidence (1985-) aims to prevent land subsidence caused by groundwater pumping and to preserve groundwater.

Outline of the Code

- Objective
- Current situation
- Target area
- Limit of groundwater pumping
- Prevention measures of land subsidence
- Monitoring and survey
- Prevention of damages and recovery
- Promotion of the Code

Three Target Delta Areas

- Tokyo
- Osaka
- Saga
● Restoration of healthy hydrological cycle
  • Expand the recharge (permeable) area
  • Prevent groundwater flow obstruction
  • Prevent unconfined ground water leakage into the lower confined aquifer

● Groundwater as a future water resource
  • First priority of water resource is river water.
  • Groundwater supplements river water.

● Groundwater level is an indicator to measure the amount of water pumping.
Reference:
Groundwater Tells – Crisis in Hidden Resources (in Japanese)
Dr. Masaru MORITA, June 2012