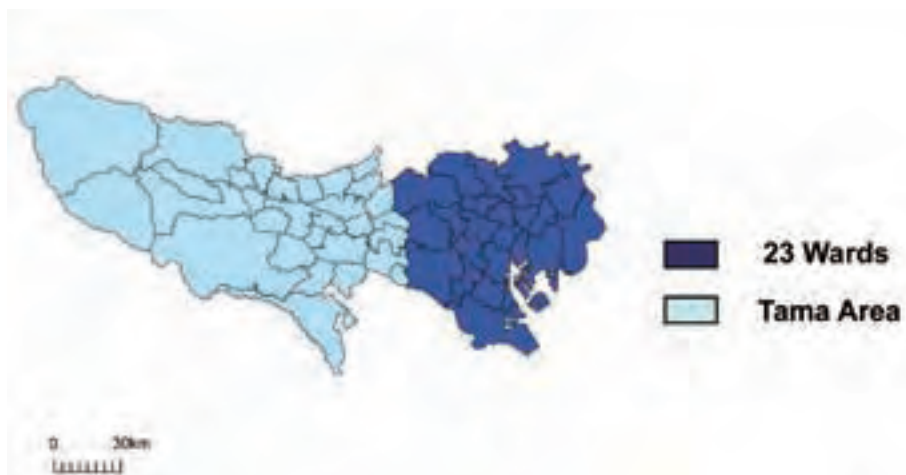


## 1. Background to the Study Area

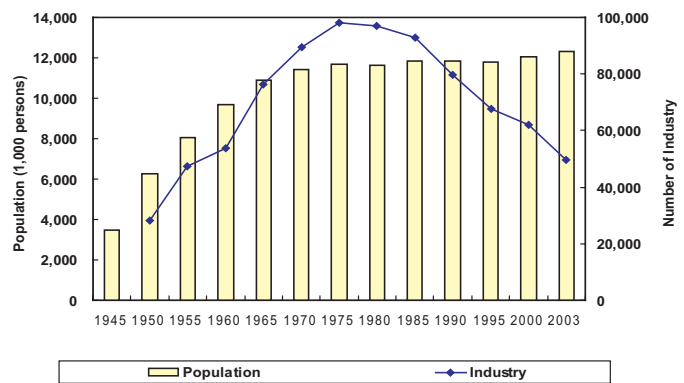
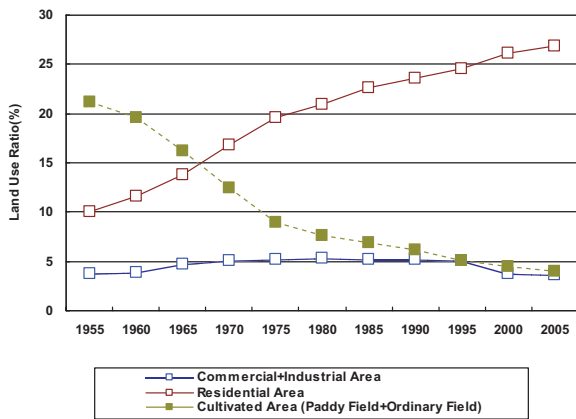
Tokyo is the capital city of Japan, and is the political and economic center. Tokyo has about 12.4 million of people and about 2,187.1km<sup>2</sup> of land, and is one of the most densely-populated cities in the world (5,660 persons/km<sup>2</sup>). The population of the city is about 10% of the national population, and is concentrated in both the area of the 23 Wards and the Tama Area, as shown in the following map. The 23 Wards of Tokyo are the only special wards in Japan.



**Figure 1. Map of Tokyo**

*Source: Digital Map 25000 (Administrative Boundary & Coastline), Geographical Survey Institute*

As did Osaka, Tokyo enjoyed rapid economic growth from the 1950s. With the growth, people and factories gathered in the area and, therefore, much cultivated land was converted to residential or industrial zones. The number of people and industries rapidly increased until the 1970s and 1980s, though now the numbers of both people and industries have decreased or are currently stable.



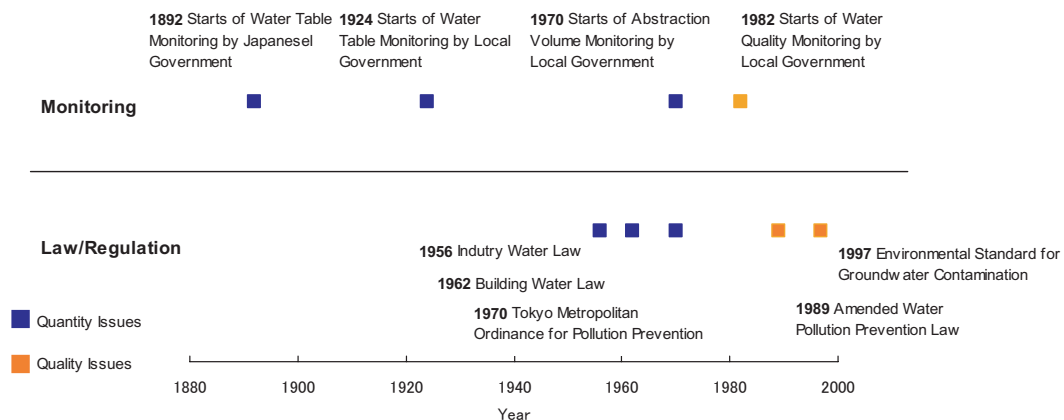
**Figure 2. Land Use Change and Annual Change of Population and Industry in Tokyo**

Source: Tokyo Metropolitan Government General Affairs Bureau 1947-2005, Ministry of Internal Affairs and Communications 1955-2005.

## 2. Groundwater Quality related Problems

Even though it has always been regarded as an important water resource, until the 1990's, groundwater quality in Tokyo was not managed systematically, as in other cities in Japan. The reasons are as follow:

- i. Although quantity related issues such as water table depletion and land subsidence have been major problems in Tokyo for decades, at the beginning the local government paid attention only to matters of quantity.



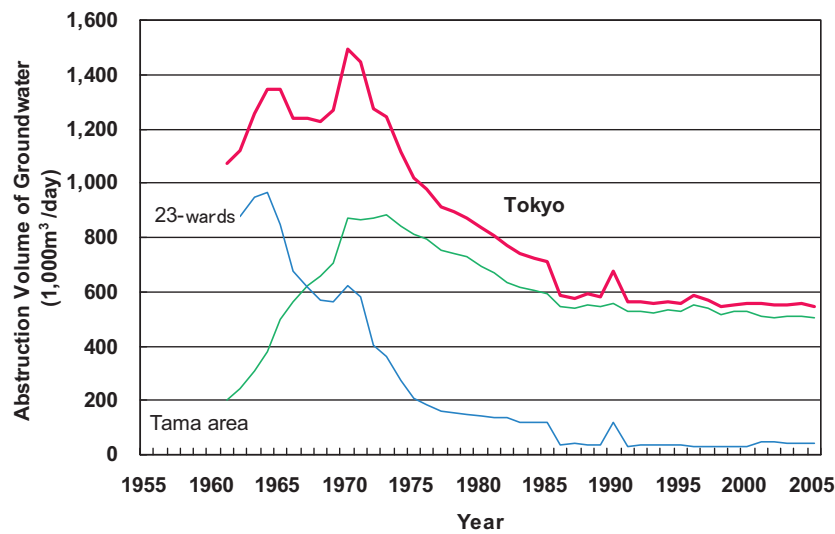
**Figure 3. History of Groundwater Management in Tokyo**

Source: Tokyo Metropolitan Government Environment Bureau 2006, Tokyo Metropolitan Government 1989.

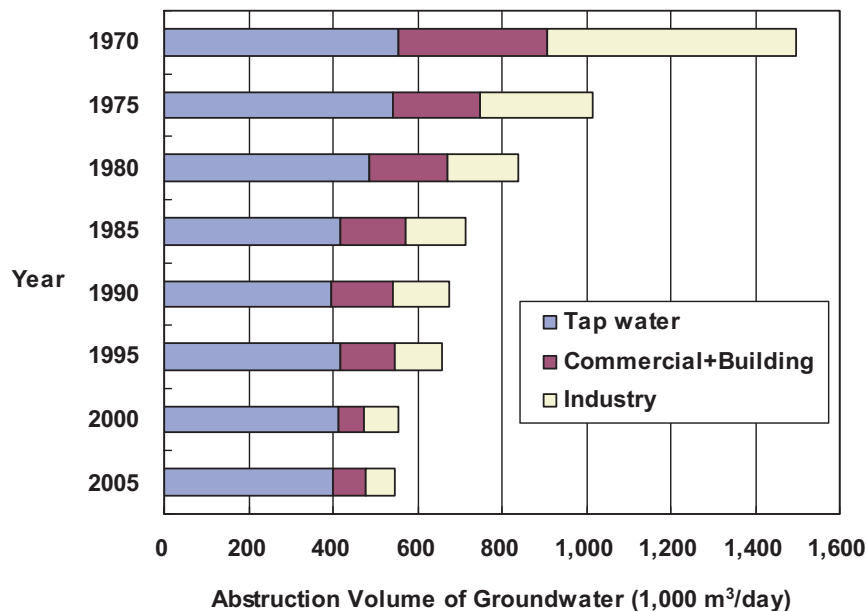
- ii. Because pollution of surface water of rivers, lakes and water in the gulf were considered more serious, the government prioritised mitigation or prevention measures for them. Therefore, the control of surface water were subjects only in “Law on Conservation of Public Water Body Quality” and “Law on Regulation of Industrial Wastewater” established in 1958 and “Water Pollution Prevention Law” established in 1970.

- iii. Groundwater in Tokyo has been used mostly for industrial and domestic uses. Groundwater abstraction volume

for industrial purposes decreased after enforcement of “Industrial Water Law” and “Building Water Law” that were intended to reduce groundwater abstraction for the mitigation of land subsidence. Groundwater was generally used for domestic purposes after treatment in water purification plants, and use of untreated groundwater by individual households is quite limited. Therefore, the groundwater quality was relatively easy to control for domestic use.

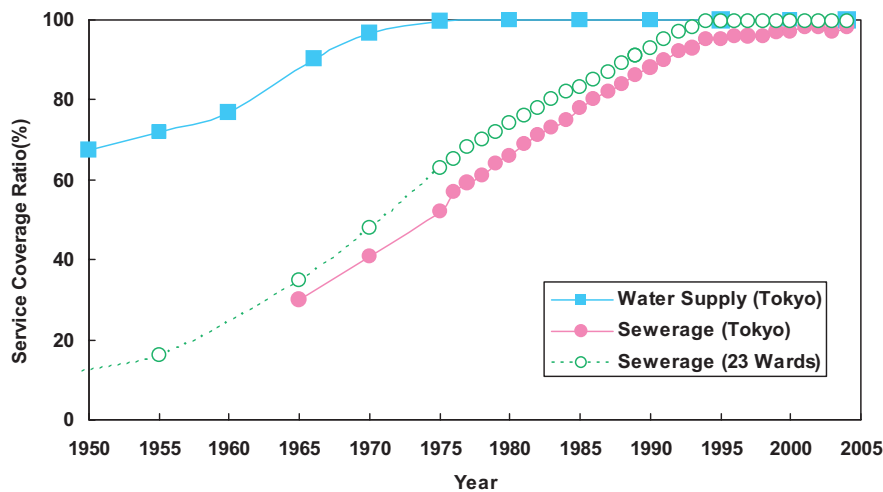


**Figure 4. Annual Change of Groundwater Abstraction Volume in Tokyo**  
 Source: Tokyo Metropolitan Government Civil Engineering Center 2006, Tokyo Metropolitan Government Environment Bureau 2006.



**Figure 5. Beneficial Use of Groundwater in Tokyo**  
 Source: Ministry of Health and Welfare, the Ministry of International Trade and Industry, the Ministry of Construction. 1971. Tokyo Metropolitan Government Environment Bureau 1976-2006.

- iv. Sea water intrusion to groundwater was confirmed in coastal areas from the 1950’s to the 1960’s. Not only was the regulation on groundwater abstraction effective to some extent in the prevention of sea water intrusion, also groundwater use in coastal areas decreased due to the transition to surface water use. As a result, the chloride contamination of groundwater has been less acknowledged as a problem than it should be.



**Figure 6. Service Coverage Ratio of Water Supply and Sewerage in Tokyo from 1950 to 2005**

Source: Source: Tokyo Metropolitan Government 2004, Suido Sangyo Shimbun1940-2004

- v. Sea water intrusion, pathogenic microbiological and nitrogen contamination from domestic wastewater or fertilizers were also identified in the past, but they were not considered to be serious problems, supposing that traditional pollution controls such as treatment at water purification plants or at sewerage plants would be effective.

Under the above background, groundwater quality was not monitored regularly until 1982 except in the case of groundwater for tap water use. However, because VOCs contamination occurred in the United States and in the Fuchu-district in Tokyo in 1981 and 1982, respectively, initiated by MOEJ in 1982, groundwater quality was investigated in the main cities of Japan, including Tokyo. The result of the survey clarified the existence of groundwater contamination, e.g. on VOCs, and led to mounting public opinion calling for its control. Especially, management of hazardous chemicals such as VOCs in industrial sectors was called into question by the public, because it was revealed that some factories regularly discharged wastewater containing VOCs into the ground.

### 3. Policy Response

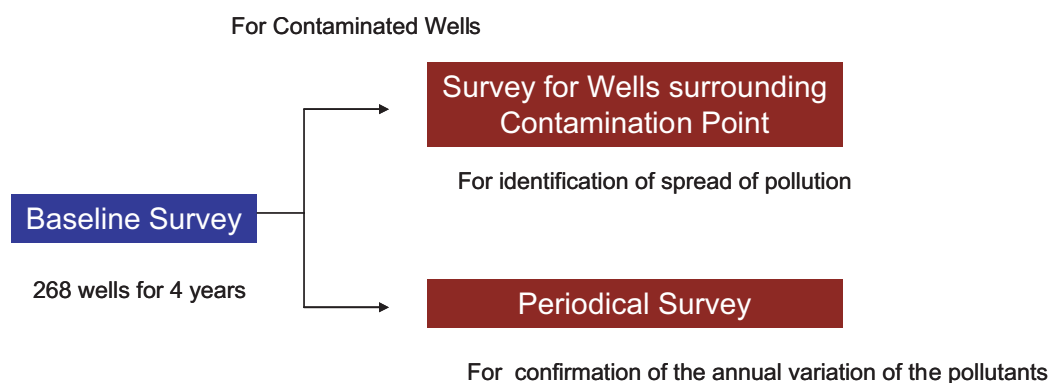
In order to address groundwater pollution control at the national level, the “Water Pollution Prevention Law” was amended in 1989 and set regulations on groundwater quality management. As shown in the following figure, four elements of groundwater quality management were determined in the law, (1) implementation of regular water quality monitoring by provincial government, (2) prohibition of discharging hazardous wastewater into the ground by industry, (3) mandatory notification for establishment of facility treating hazardous materials (Notification by industry and examination by the governor), and (4) implementation of emergent measures for accidental groundwater pollution (Notification by industry and examination by the governor). Of the four policy measures, three are for the prevention of pollution, while the other one is for mitigation. In addition to those measures, in order to support these groundwater pollution policies, the Environmental Standard for Groundwater Contamination was established in 1997.

Regular Water Quality Monitoring	Prohibition of Discharging Hazardous Wastewater into the Ground	Notification of Establishment of Facility treating Hazardous Materials	Emergent Measures for Accidental Water Pollution
Preparation of Annual Plan Implementation of Monitoring Reporting	Inspection Order to Improvement	Notification Examination Order to Changing Plan	Accidental Water Pollution Notification of Emergent Measures Order to Implementation

**Figure 7. Outline of Groundwater Quality Management in Tokyo**

Source: Tokyo Metropolitan Government 1989.

In order to effectively conduct regular groundwater quality monitoring within the limited budget, there are three types of surveys with different purposes, namely (1) Baseline Survey, (2) Survey for Wells surrounding Contamination Point, (3) Periodical Survey (figure 8);



**Figure 8. Outline of Groundwater Quality Monitoring in Tokyo**

Source: Tokyo Metropolitan Government 1989.

For the first step, Tokyo area is sectioned into 268 blocks with a monitoring well per block. One quarter of the blocks are monitored in a year, with another quarter checked during the next year. All blocks are scanned once within every four years. If groundwater contamination is identified in a well, several wells surrounding the contaminated well are monitored in order to identify the spread of pollution. In addition, that well is then monitored every year to confirm the annual variation of the pollutants.

In terms of the prohibition of discharging hazardous wastewater into the ground, the inspection to the industry under the law is conducted to check the situation of hazardous wastewater discharging. The following table shows the result of the inspection in 1992 and 1998. Although there were several factories which violated the law and were advised to voluntarily improve their wastewater discharging system, so far no factories in Tokyo have been forced by law to make changes to their water systems.

**Table 1. The result of Inspection to Industry in Tokyo**

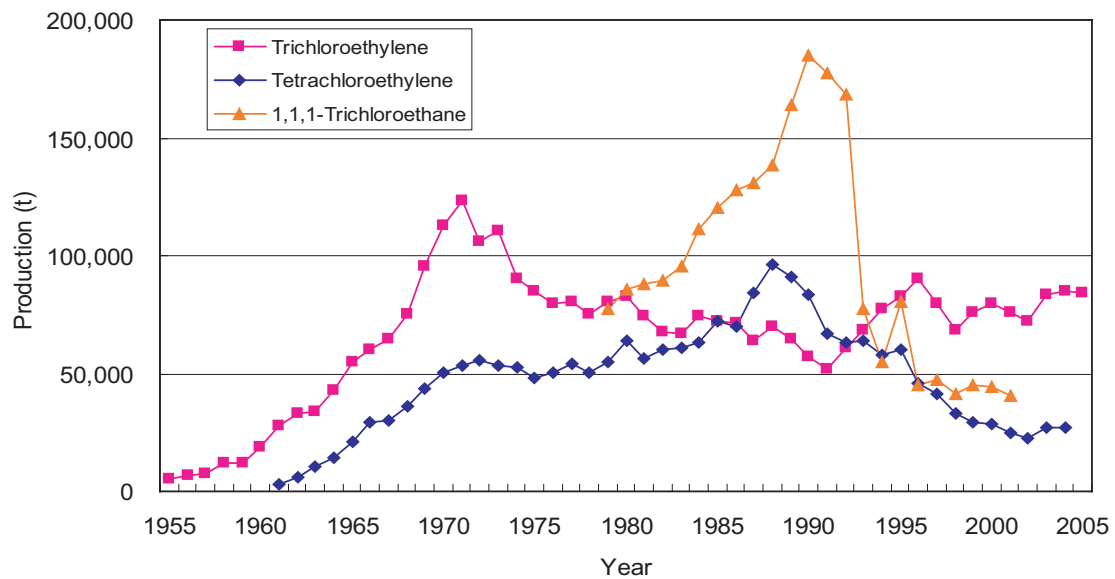
Year	Number of Factory for Inspection	Number of Factory committing the Violation
1992	194	7
1998	124	1

Source: Tokyo Metropolitan Government 1989, Tokyo Metropolitan Government 2004.

## 4. Effectiveness and Limitation of Policy Measures

Groundwater quality management in Tokyo was established to mainly address contamination by VOCs. Reviewing the policy measures from the standpoints of both supplying safe water and sustainable groundwater use, effectiveness and limitations are pointed out in the following;

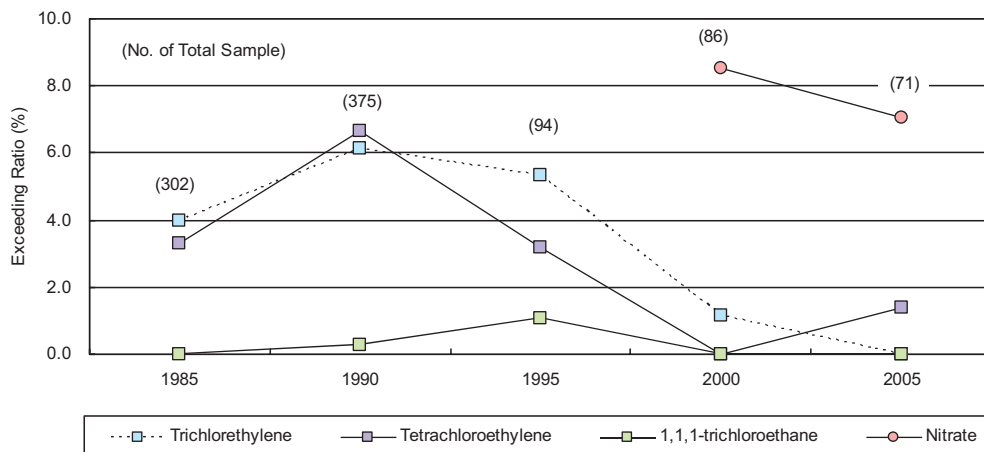
- i. It was not until 1980's that the Japanese Government paid attention to the VOCs contamination of groundwater and started addressing it. However, as shown in the following figure, because VOCs such as trichloroethylene and tetrachloroethylene have been produced and consumed in Japan before 1980's, groundwater was subjected to the risk of VOCs contamination before its problem was actualized.



**Figure 9. Production of VOCs in Japan (national level of data)**

Source: Ministry of Economy, Trade and Industry, 1955-2005

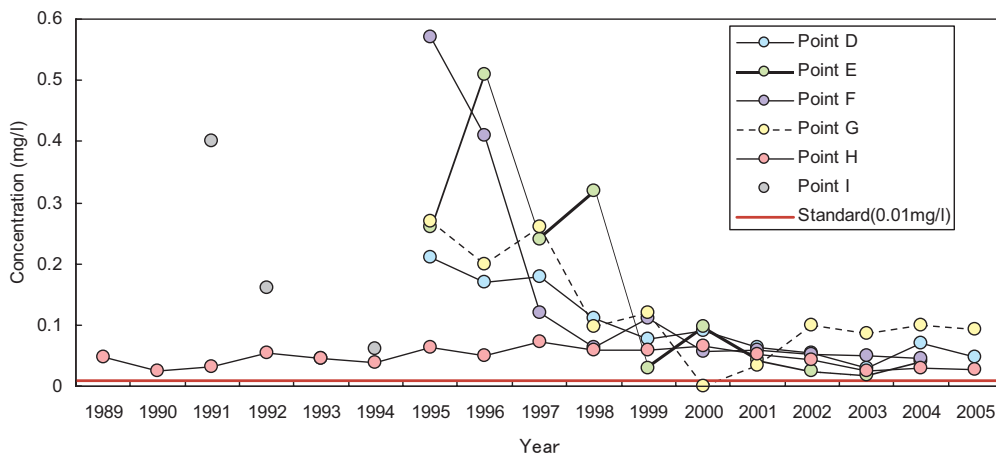
- ii. Pollution control of the prevention of VOCs contamination has succeeded to some extent, because newly contaminated wells were identified quickly from the result of the baseline survey.



**Figure 10. Result of Baseline Survey (VOCs and Nitrate)**

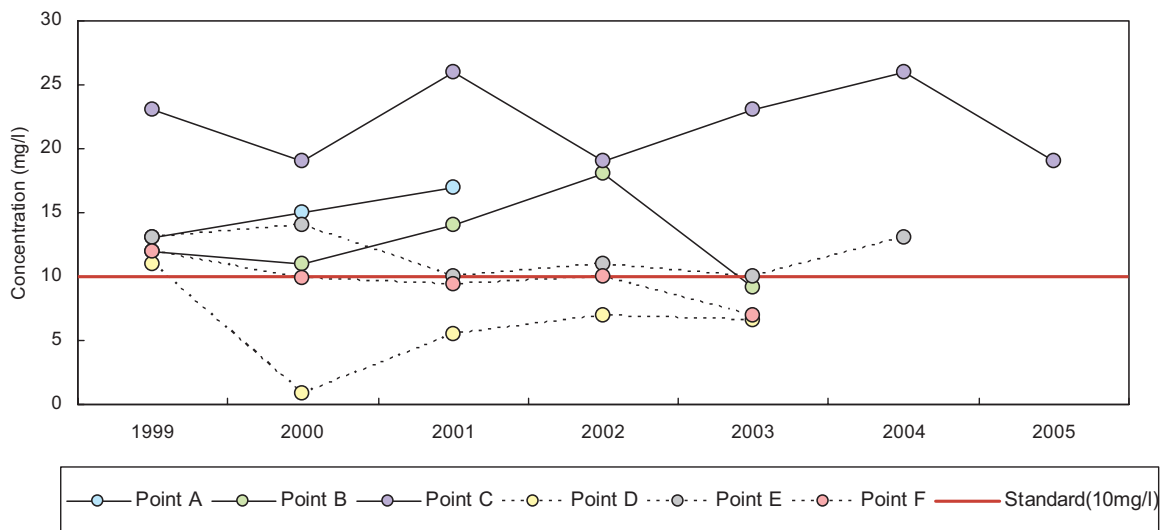
Source: Tokyo Metropolitan Government Environment Bureau 1989-2005

iii. However, once groundwater is contaminated by VOCs, it takes a long time for the contaminated groundwater to become improved to a level which is safe and which complies with the standard.



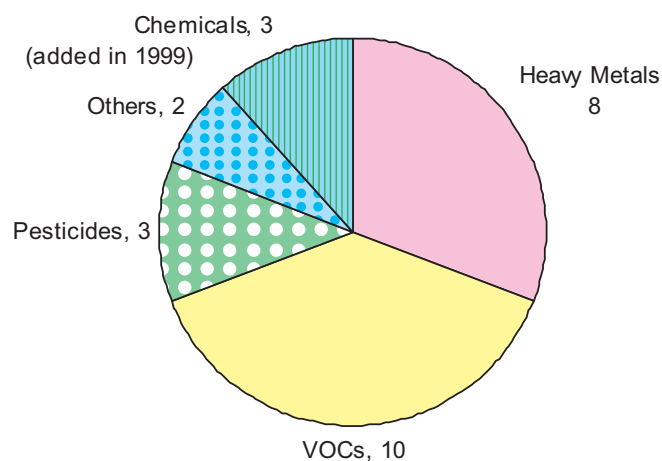
**Figure 11. Result of Periodical Survey (above: trichloroethylene, below: Tetrachloroethylene)**  
 Source: Tokyo Metropolitan Government Environment Bureau 1989-2005

iv. The following figure shows the result of periodical monitoring on the annual change of nitrate-nitrogen level of groundwater. The monitoring reveals that most contaminated wells have not been improved for long periods. Unlike VOC contamination, nitrate-nitrogen pollution of groundwater is pointed out to be caused by non-point sources such as chemical fertilizer of agricultural land or night soil of live stock. Because the current pollution control focuses on point source solution, especially pollutants from the industrial sector, it is not effective in preventing groundwater contamination caused by non-point sources. For improvement of nitrate contamination, pollution control measures for non-point sources should be developed.



**Figure 12. Result of Periodical Survey (Nitrate-Nitrogen)**  
 Source: Tokyo Metropolitan Government Environment Bureau 1999-2005

- v. Review and revision of the current water quality standard and monitoring system for drinking water have been conducted several times to address new type of pollutants, such as pesticides, dioxin, endocrine disturbing chemicals, and other hazardous chemicals. For groundwater, the national environmental standard was revised in 1999 to additionally regulate fluoride, boron and nitrate/nitrite-nitrogen. In addition, Tokyo started monitoring groundwater for dioxin in 1998. Because pollutants for groundwater will become continuously diversified, there will come a time when current groundwater quality management measures cannot solve the new types of groundwater pollution. Therefore, the new types of pollutants which can pollute groundwater should be investigated from the aspect of chemical and physical characteristics, and the risk to health, before the impact of the pollution become serious. When the result of the investigation demonstrates a high risk from a pollutant, it should be added to the indicator of quality standard and monitoring.



**Figure 13. Indicators of Groundwater Quality Standards**

- vi. In addition to current water use, water use not only for recreation or river purification, but also for emergency purposes are presently being studied in Tokyo. As a pilot project, surplus groundwater under the subway station is transferred to polluted rivers for purification. However, groundwater quality control required for the usability of the water should be conducted proactively.

## 5. Conclusion

Because contamination of groundwater causes the decrease of available water, it is a quite serious problem related both to issues of quantity and quality. However, in Tokyo, as with most cities in Japan, the establishment of a legal framework for groundwater quality management came later than with other water resources, as groundwater pollution did not become a serious problem until the 1980's. It was not until 1989 that the first law on groundwater quality management (amended "Water Pollution Prevention Law") was formulated.

Although the time period of efforts on groundwater pollution control is not so long, the experience of Tokyo on groundwater quality management provides several lessons for groundwater quality management in Asia.

First, the pollution control measures for groundwater which were provided after groundwater contamination by VOCs was first identified in 1980's have been effective to a certain extent. However, because the measures specialized in prevention of hazardous chemicals leaking into the ground from industry, it could not work for mitigation of



contaminated groundwater. In addition, contamination caused by non-point sources such as nitrate-nitrogen was not improved simply by the measures for point source.

Moreover, although Tokyo, the city which completed conventional quality control measures such as water supply and sewerage system, was able to address known pollutants for groundwater, in the 1980's it was quite weak in dealing with unknown contaminants such as VOCs. Because, groundwater is always exposed to increasingly complex pollutants, both continuous implementation of quality monitoring and periodical revision of indicators for groundwater standards monitoring are required. In addition, innovative pollution control measures for new type of pollutants should be developed for enhancing safe groundwater access in the near future.

Considering lessons from Tokyo on groundwater quality management, not only the continuously strengthening of current management measures, but also the creation of innovative pollution control measures for new types of contamination are required in order to promote sustainable and proactive groundwater use for Asia in the future.

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9784887880399

ISBN978-4-88788-039-9

