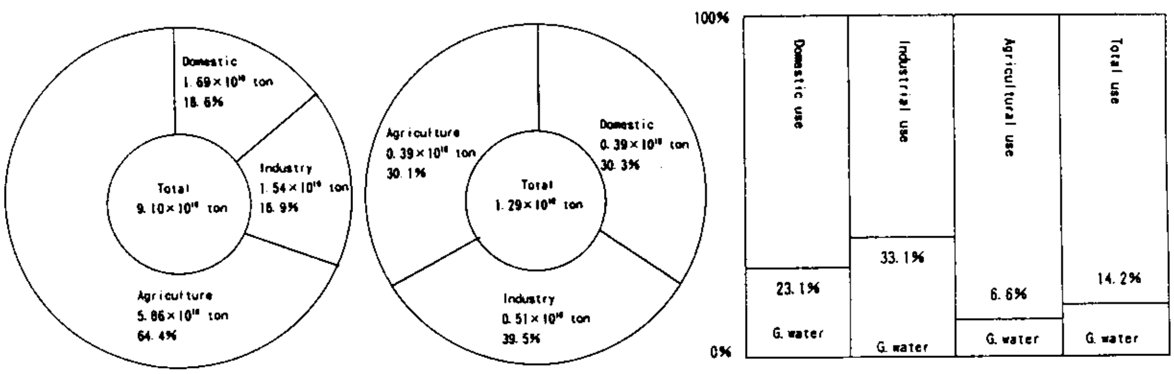
Chapter 8 ENVIRONMENTAL WATER QUALITY STANDARDS FOR GROUNDWATER

1. Water Resource of Groundwater

The migration of water in subsurface environment is extremely slow compared to surface water, through which numerous numbers of microorganisms living in soil keep removing organic substances and some parts of hazardous anthropogenic chemicals, coupling with the natural capability of biodegradation and ion exchange in soil. The groundwater is believed to be clean enough for drinking water, and not few countries of the world supply the potable water totally from abstracting groundwater. Approximately one fourth of the potable water of Japan are obtained from groundwater.

Fig. 8.1 shows the water use of Japan. The total water use across the nation counts for 91 billion ton per year, 16.9 billion ton (18.6%) of which is for domestic use, 15.4 billion ton (16.9%) for industrial use, and 58.6 billion ton for agricultural practice. Basically the groundwater contributes to water resource with 12.9 billion ton, which covers 23.1 % of domestic use, 33.1 % of industrial use, and 6.6 % of agricultural practice. Totally the groundwater extraction supplies 14.2 % of water use of Japan.



(a) Total water use (b) Groundwater use (c) Contribution of groundwater

Fig. 8.1 Groundwater use of Japan (1996)

2. Background of Groundwater Pollution

The subsurface water including groundwater contains various sorts of substances, some of which are of natural/anthropogenic origin. There exist many potential sources of groundwater pollution around human living sites. It is well known that some of waterborne diseases originate from groundwater pollution. The groundwater is likely to become contaminated in situation of domestic sewage land application and poorly constructed septic tank. This is because most of pathogenic organisms are removed with the filtering capability of soil, however, some viruses can easily penetrate through soil zone to groundwater.

The industrial sewage and sludge contain sometimes high level of heavy metals like cadmium, copper, iron, lead, manganese etc., so their land application can be a source of soil and groundwater pollution. In particular many metals tend to accumulate in the top layer of the soil, which will affect in many ways the soil ecology and sometimes agricultural products. In addition, During the last decade in Japan, volatile organochlorines like trichloroethylene and tetrachloroethylene were detected nation-widely in groundwater taken from industrial and urban areas. These organic chemicals have been utilized as solvent in many hi-tech industries, laundry firms and domestic usage.

Agricultural practice is also a potential source of groundwater pollution. Many chemicals including fertilizer are applied to cropland to raise the agricultural products, and consequently pesticides and constituents of fertilizer are discovered in cropland groundwater. In particular, nitrate-nitrogen groundwater pollution is becoming a great environmental issue in Japan as well other many countries.

3. Nationwide Survey Results

Over the last decade there have been warnings of a potential risk of environmental pollution by volatile organochlorines which are widely and effectively used in cleansing processes by many and various industries producing huge amounts of fine products. In Japan in 1974 the presence of trichloroethylene was first detected in well water of Tokyo Metropolitan. In 1981 the serious state of groundwater pollution in so-called Silicon-Valley, US was unveiled, revealing that some of the well-waters were highly contaminated at the concentration of up to 6.4 mg/L in 1,1,1-trichloroethane.

Considering the serious state of groundwater pollution in US and other developed nations, Japan Environment Agency (JEA) started across the country groundwater pollution surveys due to organochlorines in 1982. The total number of water samples analyzed was up to 1,499, of which 1,083 samples were from shallow groundwater, 277 samples from deep groundwater and 139 samples from surface water. Chemical analysis was done mainly on volatile organochlorines including nitrate/nitrite nitrogen, and detection rates for chemicals are demonstrated in Fig. 8.2,

1)the highest detection rate among eighteen chemicals took place in nitrate/nitrite nitrogen, and the highest concentration of nitrate nitrogen was raised to 80 mg/L. In addition, ten percentage of well water samples of 1,360 overshot the drinkable limit for nitrate, which is 10 mg/L in Japan and 11.3 mg/L directed by WHO(World Health Organization),

2)the nitrogen compounds distributed widely in the natural field, so except them, trichloroethylene, tetrachloroethylene and 1,1,1-trichloroethane were found at a high detection rate in the well-waters,

3)in particular trichloroethylene and tetrachloroethylene among three were detected at the rate of about one in three well-water samples, and also three percent of 1,360 well-water samples in both materials exceeded the guidelines for drinking water directed by WHO at that time.

4. Set-up of Groundwater Standard

4.1 Groundwater standards

Some legislation was compelled to be changed and modified to prevent and conserve groundwater environment, and a partial amendment of the Law of Water Pollution Control by JEA was implemented in 1989. Consequently any water containing hazardous chemicals including trichloroethylene and tetrachloroethylene is now prohibited in Japan from being injected and recharged into subsurface environment. Such legislation is capable of reducing new occasions of groundwater pollution. However, hazardous chemicals such as organochlorines are originally long-term resistant to biodegradation. Appropriate remediation operation should be taken place, otherwise, hazardous chemicals stay in soil and groundwater environment for many years.

In this context the JEA launched the standards for groundwater in 1997, in which 23 hazardous chemicals were designated and plus 25 chemicals to be monitored were determined. They are consistent with the standards for surface waters in order to meet the systematic control of water environment.

4.2Monitoring for Groundwater Environment

The nationwide groundwater surveys have been done, as following items so far,

(a)setting up the mesh scheme for example 5km×5km, sometimes narrower, groundwater are sampled and analyzed in each scheme,

(b)further surveys in order to determine the pollution area for groundwater region detected by the general inspection survey mentioned above, and

(c)the subsequent monitoring for the polluted groundwater confirmed by the survey (b).

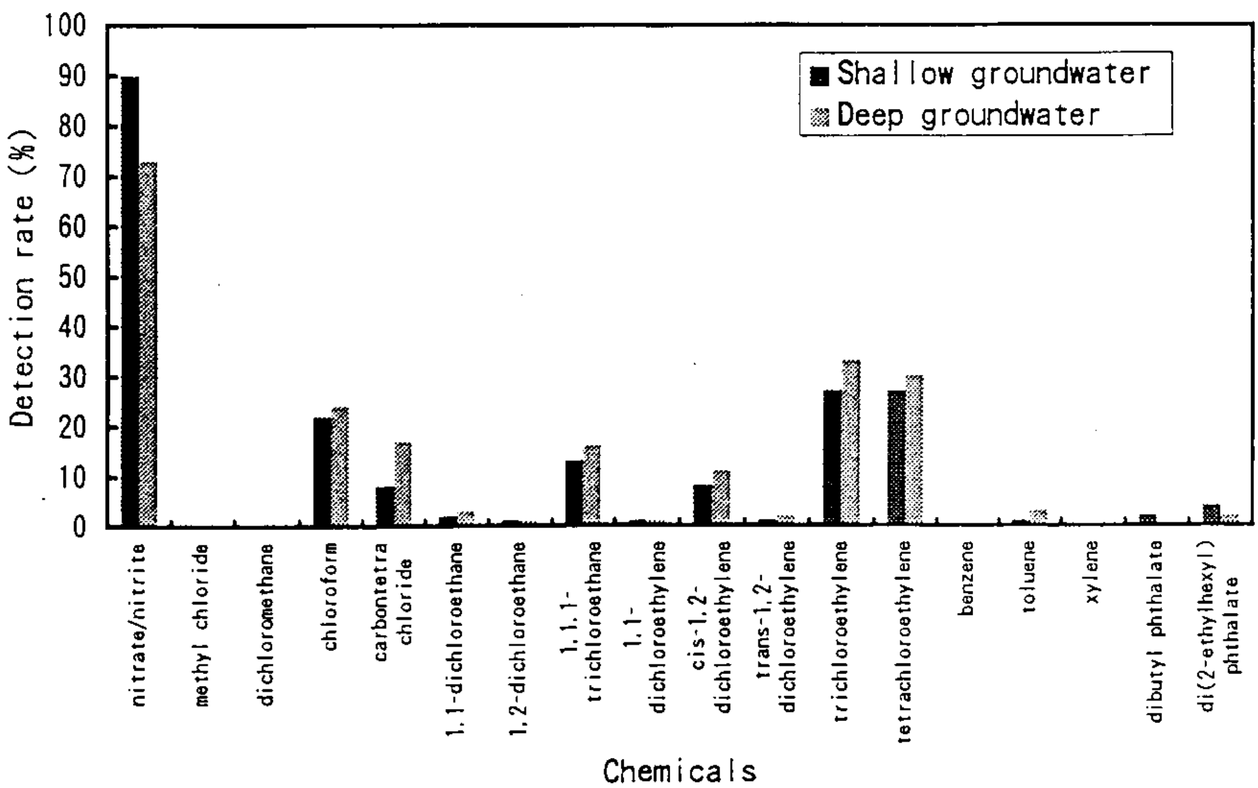


Fig. 8.2 Detection rate of chemicals discovered in the groundwater sample across the nation in 1982. The survey was conducted by Japan Environment Agency and the number of 1360 well water was analyzed.

The local government proceeds the groundwater monitoring every year, changing and extending the survey area. The groundwater is existing layered in subsurface environment, so that the only one survey for some scheme is not enough to detect the groundwater pollution. It is desired to check the groundwater quality, changing location and depth several times.

4.3 Evaluation of Establishment of Groundwater Standards

When hazardous chemical is detected in groundwater and over the standards, immediately groundwater standards should be remained. In many occasions wider range surveys are taken place according to the groundwater use. However, not always but sometimes, lead and arsenic in groundwater are coming from natural soil and rock. Even in this case, the groundwater standards are applied.

In addition the migration speed of groundwater is extremely slow, compared to surface water, monitoring frequency is determined, considering the groundwater use and flow scale. In this planning the seasonal change of groundwater quality is also considered. The results of groundwater surveys are basically evaluated with the annual mean value of hazardous chemicals in groundwater except of cyanide, which is concerned with acute toxicity.