21

Ground Water Contamination and Responses in Hadano City, Kanagawa Prefecture

Singo Tsuda

INTRODUCTION

Water is the birthplace from which all life has emerged, and places close to water give human beings a sense of relaxation and nostalgia.

The city of Hadano is the kind of place where consciousness regarding water is very high. Water-works commenced in 1890, using a natural spring as the water source; in 1970 a geological survey was done on the Hadano Basin and a simulation of the ground water balance was made; and on the basis of this, underground water development works were commenced in 1975.

In 1985 these water-related efforts won recognition when the "Hadano Basin Spring System" was chosen by the Environment Agency as one of the "100 national famous waters," further strengthening local water awareness.

In January 1989 Kobo's Spring Water (Photo 1), the best-known place for tasting water from the Hadano Basin Spring System, was reported to be contaminated with the

Photo 1 Kobo's Spring Water

Photo 2 Contaminated Substances Recovered from Underground

man-made agent tetrachloroethylene. Suddenly this delicious and safely drinkable water, the pride of the local community, could no longer be drunken in its natural state and was held to be a health hazard. This was a blow which spread insecurity among the people of Hadano.

In order to dispel the anxiety of the people and return the underground spring water to its original, safely drinkable state, the city government of Hadano put together a supplementary budget for FY1989, conducted a city-wide survey of the general situation, investigated drinking-water wells, set up a committee of inquiry on underground water pollution, asked specialists in the field for their opinions, and generally pushed ahead with research and countermeasures.

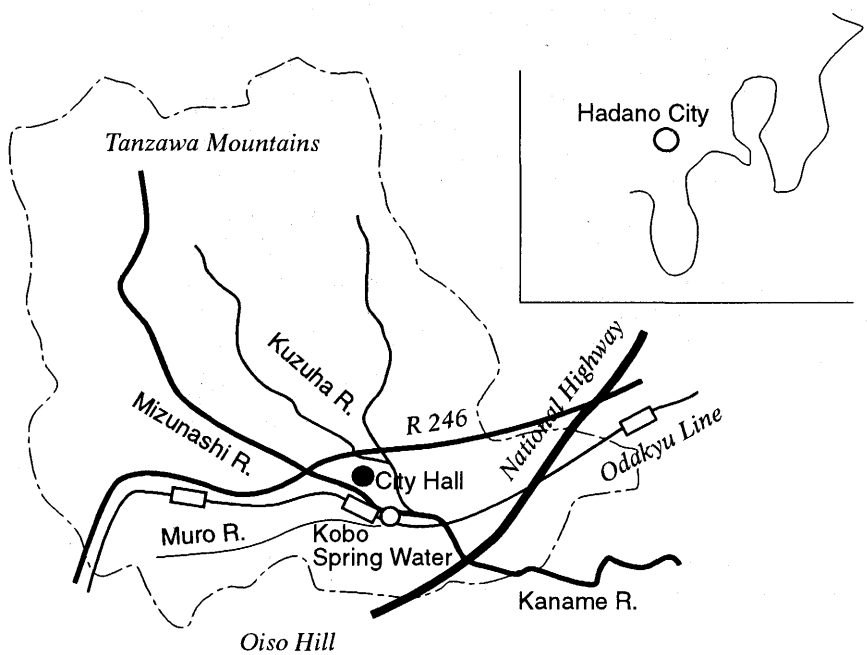
From FY1990 a full-scale investigation got underway into the mechanism by which pollution was getting into the underground water supply. At the same time legal measures were also under consideration, in a process which bore fruit with the July 1993 "Ordinance Relating to the Prevention and Cleansing of Pollution in the Underground Waters of Hadano City," under the auspices of which decontamination operations were conducted on the water channels and the surrounding land (Photo 2).

Fortunately, perhaps because of the favorable condition of the soil, the clean-up operation proceeded smoothly. Three different contaminants were found, namely trichloroethylene, tetrachloroethylene and 1,1,1-trichloroethane, and a combined total of over 9,500 kg of these substances were recovered from the ground. The quality of water directly underneath the area covered by the purification works rapidly improved.

Henceforth we hope to push ahead with purification works on ground water that has already leached into the soil, and thereby accelerate the improvement in water quality throughout the Hadano Basin Spring System.

The present report discusses how countermeasures against ground water contamination were drawn up. The writer will be happy if the report can be of some use to other local authorities or enterprises who may be struggling to find measures to deal with ground water contamination.

Figure 1 Location of Hadano City



1. Topography of Hadano City

Hadano is located on the western side of central Kanagawa prefecture, its center lying some 37 km from Yokohama and 60km from Tokyo. The city covers an area of 103.62 km², measuring roughly 13.6 km from east to west and 12.8 km from north to south. It is a suburb of the Tokyo Metropolitan area, with a population of around 165,000 people (Figure 1).

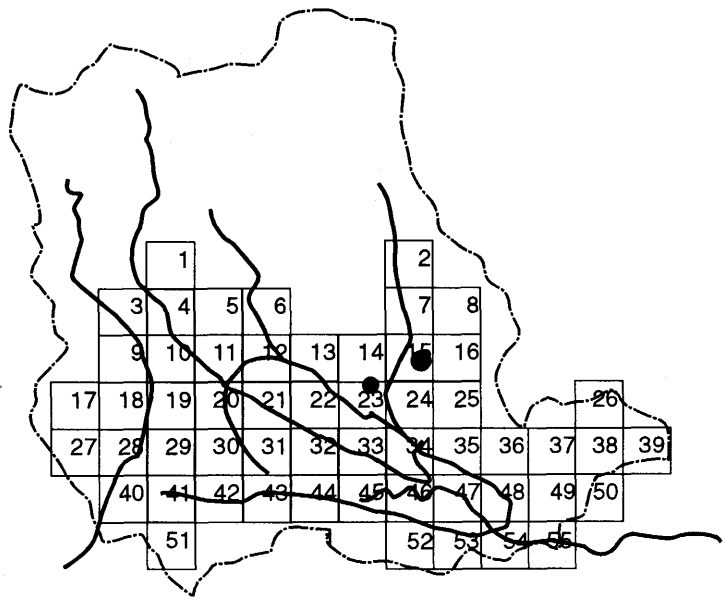
To the north rises the Tanzawa mountain range, known as "the roof of Kanagawa," while to the south a plateau called the Oiso hills runs east to west; the area in between forms the only typical basin region in Kanagawa Prefecture.

Many of the rivers that run through Hadano have their sources in the dips between peaks on the Tanzawa ridge; among them, the Mizunashi River, which springs from Mt. Tonodake, and the Kaname River, which springs from Mt. Harudake, flow into the basin and form an alluvial delta which is the present site of the city.

2. Original Impetus for Ground Water Contamination Countermeasures

In January 1989 it was reported in a weekly photo-journal that Kobo's Spring Water, the representative site for tasting water from the "Hadano Basin Spring System," one of the "100 national famous waters" chosen by the Environment Agency, was contaminated with

Figure 2 General City-wide Survey
(Dividing the city into a grind of 55 one-kilometer squares and showing the contaminated areas)



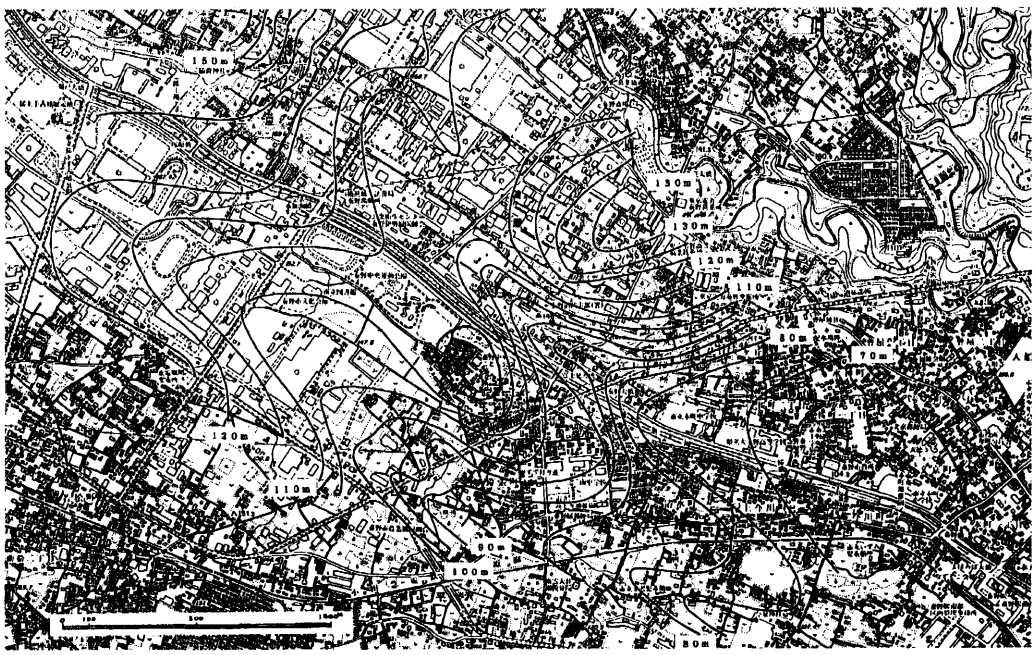
trichloroethylene and other organic chlorides. A subsequent municipal survey found that tetrachloroethylene was detected in the water at a concentration of 0.021 mg/liter, roughly double the government standard for drinking water.

3. General City-wide Survey

In 1989 a general survey of the situation throughout Hadano City was conducted, dividing the city into a grid of 55 one kilometer squares and inspecting the water at 70 locations. Water was found to exceed contamination limits at 13 locations. At the same time, to forestall any danger of damage to the citizens' health, a survey of drinking-water wells was carried out, chiefly in the southern part of the basin, where there are many such wells used by private individuals. Out of 256 wells inspected, 28 were found to exceed contamination limits. Thus in total water was tested in 326 locations and found wanting at 41 of them (Figure 2).

The maximum concentrations of offending substances found by the survey were as follows: trichloroethylene, 0.23 mg/l (in the district where ground water comes to the surface); tetrachloroethylene, 1.3 mg/l (in the district where ground water is recharged); and 1,1,1-trichloroethane, 0.16 mg/l (again in the district where ground water comes to the surface).

Figure 3 Third Basal Conglomerate Structure Contour Map



The survey showed that the contaminated area was 12 km² of mainly city area on both banks of the Mizunashi River, covering a district with a concentration of factories using the water, and the adjoining district downriver from it.

4. Survey to Establish the Causes of Ground Water Contamination

From FY1990 the city turned its attention to a survey designed to establish what was causing ground water contamination, focusing on the 8km² up-river portion of the 12 km² overall contaminated area.

The FY1990 survey covered geological structure, distribution of aquifer, contamination routes, etc. Kanagawa Prefecture took charge of surveying a 2.5 km² area on the left bank of the Mizunashi River where it went through the center of the city (as it fell into the field of a survey on establishing methods of identifying pollution sources), while Hadano City conducted the survey of the 5 km² on the right bank.

The survey started by establishing the surface distribution of contamination using the fingerprint method, followed by an all-core boring survey to establish geological structure and vertical distribution of contamination.

The fingerprint method entails fixing a collector in the ground for a set period of time. The collector absorbs in active carbon any contaminating substances which are diffused in its direction, enabling researchers to estimate absorption volumes at each survey point and produce a map of relative concentration distribution.

This method was used to survey 194 locations, 78 on the left bank of the river and 116 on the right, the points being intersections on a grid of 200 meter squares. High concentrations were detected in the vicinity of factories utilizing the river water and in the area where ground water comes to the surface.

Based on this result, yet another survey was carried out, this time analyzing geological structure, distribution of aquifer, contamination routes, for instance, by way of 19 bore-holes drilled at 14 locations on both banks of the Mizunashi River, chosen with reference to, among other factors, the positions of factories and the direction of flow of underground streams. Holes were bored to depths varying from 7 to 80 meters, the depth being decided separately at each location with respect to, for example, geological conditions and degree of contamination of ground water (Figure 3).

In the following year (FY1991) a supplementary boring survey was carried out, with six more holes being drilled at three locations, in order to clarify points left unclear by the previous year's survey on the causes of ground water contamination. Thus a total of 22 holes were drilled in 15 locations on the left bank, and 22 at 16 locations on the right bank, making 44 bore-holes at 31 locations in all.

The surveys made up to this point had already established the geological structure, distribution of aquifer, contamination paths, etc.; so from FY1991 onwards, the focus shifted to on-site surveys on factory grounds.

5. Spot Surveys of Surface Contamination

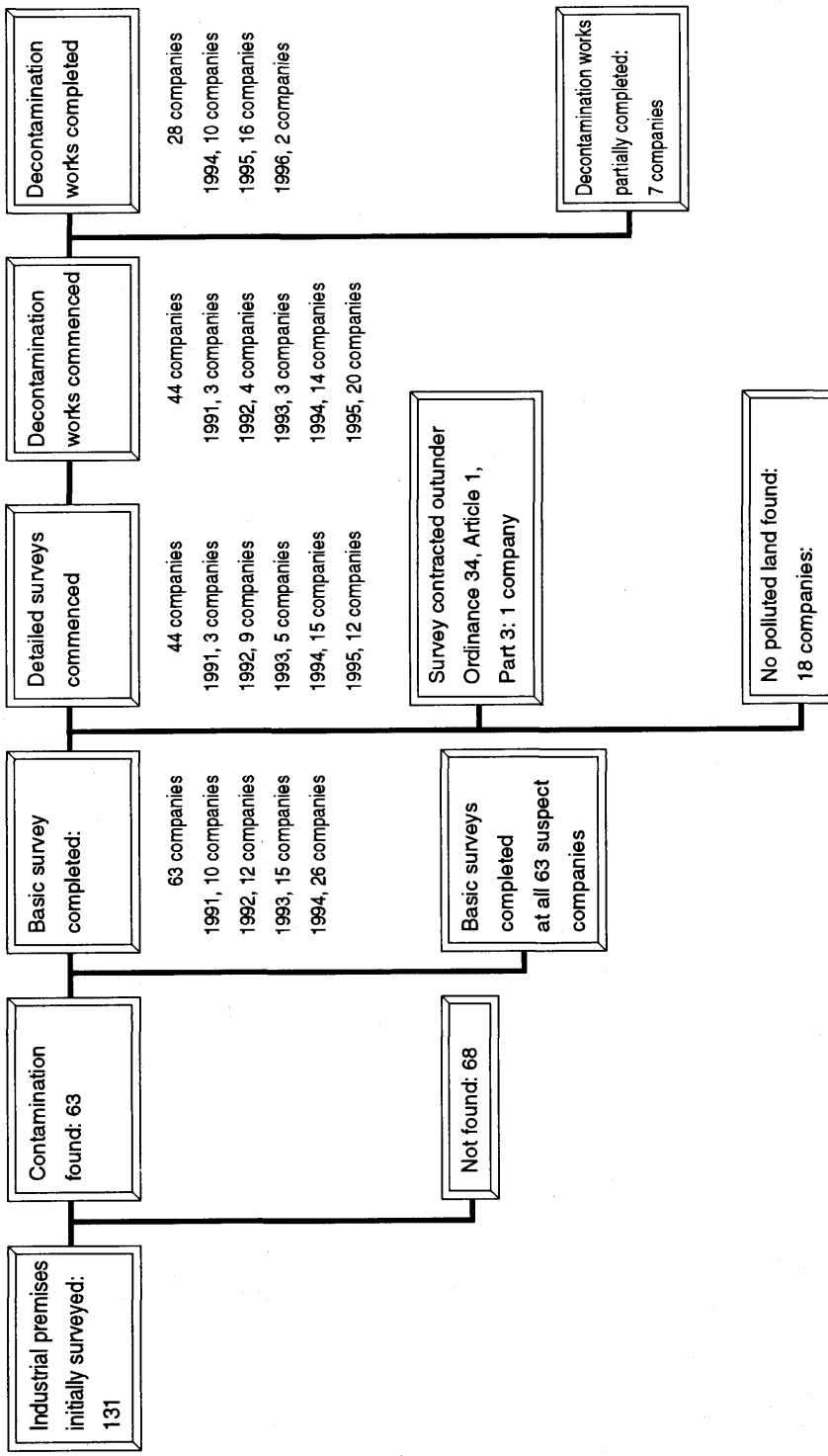
At the same time that these surveys on the causes of ground water contamination were being carried out, parallel surveys were being made of surface contamination on the premises of 103 companies, 64 of which were using water from the Mizunashi River, and the other 39 being former users. Boring bar/detection tubes were used for these surveys, sometimes pushing straight into the earth's surface where it was exposed, sometimes using an electric drill to open up a hole in the concrete floor of the industrial premises themselves. Soil contamination was established, albeit to varying degrees, at 61 companies.

When the "Ordinance Relating to the Prevention and Cleansing of Pollution in the Ground Waters of Hadano City" took effect on January 1, 1994, a further 28 companies were judged to be using the water and were subjected to similar surveys. Two of these tested positive, making a total of 63 companies where some degree of surface contamination was found.

6. The City Surveys

From 1991 onwards, based on the results of the ground water contamination and surface contamination surveys, more extensive on-site surveys (basic survey conducted according to the Ordinance) were carried out at the premises of companies showing evidence of contamination, starting with the largest-volume users and working downwards. By FY1994 these basic surveys, for which the city was, in principle, responsible under its own ordinance, had been completed at all 63 companies showing evidence of contamination. The survey method was as follows.

Figure 4 The State of Progress at Industrial Premise



7. Survey Method

The land covered by industrial premises was divided into a grid of 10-meter squares, and the intersections were inspected by the boring bar/detection tube method, thereby establishing the overall distribution of contamination and revealing one or more points of high concentration of contamination.

Trichloroethylene and other pollutants are resistant to decomposition and are also volatile, meaning that contamination that happened five or ten years earlier is still easily detectable. The only problem is that tests can be influenced by the presence of similar but different substances, with tetrachloroethylene triggering a reaction in a trichloroethylene detection tube, for example. This necessitates the use of a portable gas chromatograph with a photoionization detector (PID) attached, plus an ECD gas chromatograph, etc. in order to identify the contaminating substances.

Next a boring was conducted at points with high concentrations of contamination, with bore-holes being drilled in principle to a depth where the contamination could no longer be detected. This boring was carried out by "all-coring" waterless drilling, and at roughly three places a simple dissolution test was carried out at a depth of about 1 meter, using a PID portable gas chromatograph, enabling surveyors to achieve real-time assessments of soil and stratum contamination at the same time as they proceeded with drilling. This data was then used as the basis for selecting samples to be taken back to the laboratory for content analysis, and for deciding at what depth to halt drilling.

Because trichloroethylene and other similar pollutants are highly volatile, rapid and accurate pre-processing of samples at the survey site is essential; how well or badly this work is handled can have a major influence on the accuracy and reliability of survey findings.

This basic survey method was also used in the subsequent detailed surveys, carried out by the enterprises themselves.

The state of progress at the various industrial premises is shown in Figure 4. As of the end of July 1996, decontamination work had been completed at 28 companies (Figure 4).

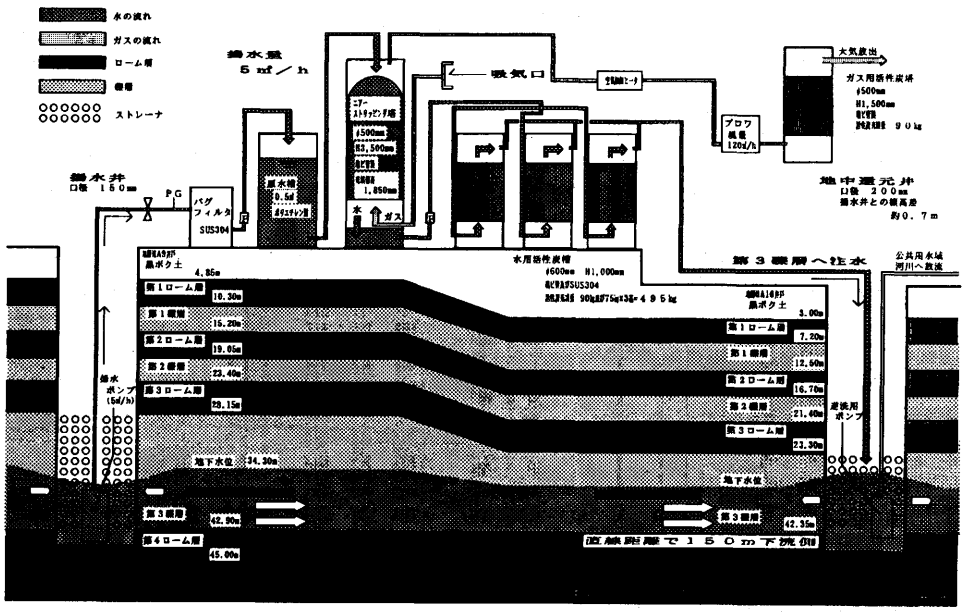
8. Decontamination Method

In Hadano City, to support the decontamination work of medium and small companies and laundry shops, we have two sets of vacuum extraction equipment and six simple decontamination systems which we lend out at no charge.

The decontamination techniques used by the 44 companies which have commenced or completed decontamination may be categorized as follows:

Decontamination technique		
1. Low-temperature heat treatment	1 firm(s)	Work completed
2. Gas-suction treatment for sealed soil	2	
On-the-spot- gas-suction treatment		
3. Industrial waste processing	3	Work completed
On-the-spot gas-suction treatment		at 2 firms

Figure 5 Flow-sheet Illustrating the Process by which Ground Water is Processed and Returned to the Ground



4. Industrial waste processing On-the-spot gas-suction treatment Pump-up treatment	2	Work completed at 1 firm
5. Low-temperature heat treatment On-the-spot gas-suction treatment	2	Work completed at 1 firm 1 firm under basic survey
6. On-the-spot gas-suction treatment Pump-up treatment	1	
7. On-the-spot gas-suction treatment	33	Work completed at 23 firms

The total volume of contaminated substances, namely trichloroethylene, tetrachloroethylene, and 1,1,1-trichloroethane, recovered from the ground in the course of decontamination operations so far has exceeded 9,500 kg.

At observation wells on the premises of companies engaged in decontamination works, improved water quality has been recorded, with the concentration of tetrachloroethylene in ground water declining from levels as high as 2.8 mg/l to a point where it could no longer be detected. There are also signs of improvement in water quality in the nearby wells supplying the municipal water system.

However, the flow of ground water is extremely slow, and decontamination works to promote water circulation have become essential.

Water circulates massively within the earth's atmosphere, and if one metaphorically thinks of this water circulation in terms of human blood circulation, and the contaminated ground water systems as if they were in the human body, then the evaporation of water and

its return to the atmosphere corresponds to the work of the arteries, while the return of water to the earth via rain and snow, continuing to the seas through rivers and subterranean channels, corresponds to the work of the veins. The pollution of ground water, the "blood" in the system, is what has caused the ground water contamination currently being revealed in many different places (Figure 5).

In Hadano City, we have now pushed this metaphor a step further, thinking about the balance between quality and volume of ground water, and looking for a cleansing process modelled on kidney dialysis. Practical experiments have been underway since August of this year on a decontamination technique whereby contaminated ground water is pumped up, cleansed, and then returned to the ground.

The circulation of ground water is being promoted, while the recovery of the famous water of the "Hadano Basin Spring System" is eagerly awaited.