Ground Water Pollution around the Northern Part of Yokkaichi City

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Abstract: Water pollution in the ground water has been widely found in the northern part of Yokkaichi city. The biggest illegal disposal site of industrial waste in central Japan was found in this area. In order to identify the source of this pollution, the authors have investigated the ground water pollution around this illegal landfill site. Investigation of well and the seepage water was carried out at 26 observation sites, and the concentrations of the following parameters such as pH, EC, COD, T-N, T-P, D-Fe, D-Mn, arsenic and 1, 4-dioxane were analyzed. Pollution of COD, T-P, T-N, D-Fe, D-Mn, arsenic and 1, 4-dioxane was found. However, relation between these pollutants and the illegal disposal is not apparent, and needs further investigation.

Key words: Pollution, illegal disposal, ground water.

1. Introduction

Yokkaichi city is situated in central Japan, about 30 km away from Nagoya city, and has the Suzuka mountain chain (almost 1,000 m height) 15–20 km west side, and has Ise bay on its east side. The city is well known as the air pollution caused by the Yokkaichi petroleum complex.

Half of this area is by an occupied diluvial deposit hill (about 40–70 m altitude) and the latter half (mainly the east side) is an alluvium plain, and many springs are found, clean water flowed out from them in earlier days.

The deposit hills are covered by broad leafed forest, and in the alluvium plain, there are rice fields and an old residential area.

About 40 years ago, the interchange of Higashi Meihan Highway was constructed nearby, due to the convenience pertaining to transport/accessibility conditions, many transporting facilities, warehouses, residences and also, many landfill site of industrial waste or municipal waste have been disorderly constructed. Recently, Toshiba Corporation

constructed a large semiconductor factory on the hill.

In 1981, Kawagoe Kenzai Co. constructed a land fill site. This company violated the approved legal emission limits twice, and has since then lost the right to use the land fill site based on a law court's decision in 1994. However, even 10 years after the ban, these illegally disposed wastes have been left in the site untreated, and the pollution is thought to be spreading [1].

The disposal site was constructed on a hill about 50–70 m above sea level, the width of an area 300 m × 300 m (about 100,000 m²), and the amount of disposed waste reached about 2.86 million tons (the largest in Japan).

Recently, wide spread water pollution of ground water has been found in and around the landfill site [2–5] and many toxic substances (arsenic, Pb and 1, 4-dioxane) are detected in the ground water [6].

However, few investigations of the surrounding area have been carried out until now. In order to identify the influence of disposal on the ground water, the authors have carried out the survey in the vicinity of the disposal site within 5 km of it.

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2. Method

2.1 Survey Date and Feature of the Site

2.1.1 Date

Survey was carried out in 2006–2011.

2.1.2 Survey Sites

Survey was carried out at 26 sites, the area belong to Tomida, Mochifuku, Oyachi, Shimonomiya, Heizu, Yamano-issiki and Tarusaka district, shown in Table 1 and Fig. 1.

2.2 Parameter and Method

Parameters and analytical methods used in this survey are as follows:

pH: glass-electrode;

EC: platinum electrode;

COD: acidic potassium permanganate method;

T-N: ultra violet spectrophotometric method;

T-P: molybdenum blue method;

1, 4-Dioxane: LC-MS method;

As: ICP-MS method;

Dissolved iron (D-Fe): simple method (Kyouritsu Rika Co. Pack test);

Dissolved manganese (D-Mn): simple method (Kyouritsu Rika Co. Pack test).

3. Results and Discussions

The analytical result of the ground water is shown in Tables 1–3.

An offensive odor similar to that of H_2S was found in the ground water at half of the investigated points as shown in Fig. 1. Such odor is considered which is usually associated with an anaerobic state in the ground water.

pH of the water was in the range of 5.9–8.0, these values are within the Japanese environmental quality standard.

Table 1 Features of the survey sites.

Site	Type of the water source and situation (district)	Distance from the boundary (m)	Well depth (m)
St1	Leaching water (Oyachi)	500	-
St2	Deep well for irrigation (Tarusaka)	800	200
St3	Artesian water from well (Heizu)	1,000	200
St4	Artesian water from well (Nakamura)	1,800	-
St5	Spring (Shimonomiya)	2,000	-
St6	Artesian water from well (Yamano-issiki)	1,500	200
St7	Deep well for irrigation (Yamano-issiki)	2,000	200
St8	Deep well for irrigation (Yamano-issiki)	2,000	200
St9	Deep well for irrigation (Yamano-issiki)	2,500	200
St10	Well (Oyachi)	1,100	5
St12	Leaching water from retaining wall (Heizu)	500	-
St13	Leaching water (Oyachi)	1,300	-
St14	Well (Ikaruga)	1,500	3
St15	Leaching water (Mochifuku)	1,600	-
St16	Leaching water (Mochifuku)	1,700	-
St17	Well (Mochifuku)	3,000	< 10
St18	Well (Tomida)	3,000	< 10
St19	Well (Oyachi)	1,300	30
St20	Well (Sakabe)	3,000	10
St21	Well (Heizu)	1,000	4
St22	Well (Oyachi)	1,100	< 10
St23	Well (Kayo)	1,700	60
St51	Leaching water, near disposal site (Heizu)	100	-
St52	Leaching water near disposal site (Heizu)	100	-
St54	Leaching water near disposal site (Heizu)	200	-
St55	Leaching water from disposal site (Oyachi)	0	-

Fig. 1 Survey area (Yahoo aerial photograph [7]).

- Survey site in which offensive odor was found.
- Survey site in which offensive odor was not found.

High value of EC has detected near the landfill site (St52, St54, St55).

The concentrations of COD are very high levels in near landfill site (St51, St52, St54, St55), and high concentration of T-N was also found at St55.

From Mie prefectural investigation data, very high values of EC, T-N, COD was found in residue water of the landfill site [8], therefore, this pollution is

considered an influence of the landfill site.

High concentration of T-P was found within about 1 km away from disposal site, and also Tomida district which is remote from them. However, phosphorus concentration of the water near the landfill site was relatively low, and the pollution of phosphorus is not only from disposal site but other sources should be considered.

A high concentrations of dissolved iron (D-Fe), dissolved manganese (D-Mn), were found widely in the ground water of the east side of the landfill site shown in Fig. 2. However, low concentration of D-Fe was detected in St51 and St54 where is regarded as an influenced area of the landfill site, and significant value of D-Fe was detected in remote area (St16).

High value of arsenic pollution which reaches the Japan environmental quality standard was found in the water within 2 km away from disposal site (St3, St8, St12) and also Tomida area (St16, St17, St18) [9] shown in Fig. 3, however, in waters in near landfill site (St51, St52, St54, St55) no arsenic has been detected.

In previous paper [10], simulation of the ground water movement and ion compositional analysis (component: Cl^- , NO_3^- , NH_4^+ , Mg^{2+} , Ca^{2+} , D-Fe) on ground water of the survey area was carried out. The

result showed that the ionic composition of the water of St54, St55 and St7, St8 are different from each other, and these waters are thought to be not directly related.

In other report [11], the correlation between ground water distribution in the landfill site and amount of the eluted arsenic from the disposal soil was not coincident.

These analytical results suggest the pollution of T-P, arsenic, D-Fe, D-Mn are not caused by direct influence of the landfill site, and another cause should be considered.

The 1, 4-dioxane was detected near the disposal site (St1, St54, St55) shown in Fig. 4 [12], these pollutants are regarded as leachate from the dumping site because high concentrations of 1, 4 dioxane (0.4–2.4 mg/L [3]) were found in the landfill site.

Table 2 Water quality in St1 to St9.

Parameter	St1	St2	St3	St4	St5	St6	St7	St8	St9
Temp. (°C)	16	18	22	22	15	17	19	24	17
pH	6.8	6.7	8.0	7.8	6.1	6.0	6.5	7.3	6.4
EC (mS/cm)	0.29	0.21	0.19	0.12	0.15	0.14	0.14	0.15	0.14
COD (mg/L)	3.2	1.0	2.1	0.7	1.3	1.63	0.9	2.0	< 0.5
T-N (mg/L)	1.4	1.2	0.70	0.49	2.1	0.47	0.83	1.2	1.9
T-P (mg/L)	0.03	0.31	0.58	0.33	0.06	0.06	0.23	1.5	0.02
D-Fe (mg/L)	10	8	< 0.05	< 0.05	0.2	4	5	0.8	0.05
D-Mn (mg/L)	3	0.8	< 0.25	< 0.25	< 0.25	< 0.25	1	< 0.25	< 0.25
As (mg/L)	0.005	0.002	0.012	-	-	-	< 0.001	0.014	-
Odor	Found	Found	Found	Found	ND*	ND*	Found	Found	ND*
Survey date	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007

*ND means “not detected”.

Table 3 Water quality in St10 to St19.

Parameter	St10	St12	St13	St14	St15	St16	St17	St18	St19
Temp. (°C)	15	-	-	18	18	15	13	14	16
pH	6.2	6.9	6.8	5.9	5.9	6.6	6.7	7.9	6.5
EC (mS/cm)	0.16	0.42	0.26	0.19	0.19	0.24	0.12	0.34	0.13
COD (mg/L)	0.5	2.7	2.0	< 0.5		2.7	0.8	0.7	0.9
T-N (mg/L)	2.4	1.2	2.5	5.9		2.0	3.7	2.3	0.7
T-P (mg/L)	0.15	0.17	0.05	0.07		0.24	0.82	0.96	0.06
D-Fe (mg/L)	< 0.05	7	10	< 0.05	< 0.05	10	< 0.05	< 0.05	1.5
D-Mn (mg/L)	< 0.25	1	1	< 0.25	< 0.25	0.7	< 0.25	< 0.25	< 0.2
As (mg/L)	-	0.020	< 0.001	-	-	0.01	0.006	0.006	< 0.001
Odor	ND*	Found	Found	ND*	ND*	Found	ND*	ND*	Found
Date	April 17, 2007	May 9, 2011	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007	April 17, 2007

*ND means “not detected”.

Table 4 Water qualities in St18 to St55.

Parameter	St20	St21	St22	St23	St51	St52	St54	St55
Temp. (°C)	-	18	21	16	-	-	-	-
pH	6.2	6.0	6.3	5.6	6.8	6.5	7.3	7.9
EC (mS/cm)	0.11	0.11	0.12	0.16	0.60	0.94	2.4	3.9
COD (mg/L)	< 0.5	1.2	3.4	0.5	16	23	14	64
T-N (mg/L)	1.5	0.88	0.36	0.21	6.4	3.3	2.0	86
T-P (mg/L)	0.02	0.05	0.58	0.03	0.63	0.45	0.25	0.35
As (mg/L)	-	-	-	-	< 0.001	-	-	< 0.001
D-Fe (mg/L)	< 0.25	< 0.05	< 0.05	0.2	1	8	0.3	10
D-Mn (mg/L)	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	2	5	< 0.25
Odor	ND*	ND*	ND*	ND*	Found	Found	Found	Found
Date	April 17, 2007	August 2, 2007	August 2, 2007	August 2, 2007	May 9, 2011	May 9, 2011	May 9, 2011	May 9, 2011

*ND means “not detected”.

Fig. 2 D-Fe in the water of the investigated area.
Unit: mg/L.

Toshiba Corporation is using much industrial water, and regarded as one of the sources of the pollution, however, waste water from them is discharged into the river (near St7) directly after water treatment, and its influence is regarded as low.

Domestic waste water in this area is mostly flowing to a municipal water treatment facility, so its influence is considered small.

Fig. 3 Arsenic in the water of the investigated area.
Unit: mg/L.

4. Conclusions

We have investigated the influence of the disposal site on the quality of the ground water in the northern part of Yokkaichi city. We found broad ground water pollution widely in this area, especially near the disposal site. High concentrations of COD, T-N, and 1, 4-dioxane found in the ground water around the disposal

Fig. 4 1, 4-Dioxane in the water of the investigated area (investigation: 9th May 2011).

Unit: mg/L.

site are suggesting an elution of these pollutants from disposal site. However, some pollutants such as arsenic, phosphorus, D-Fe, D-Mn are not considered to be caused by the landfill site directly, and more detailed investigations should be carried out in order to identify the causal relationship between the disposal site and the presence of pollutants [12].

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