

Assessment of Impact on Water Quality of Leachate at On-nuch Disposal Site Center in Bangkok

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The impact assessment of leachate on the quality of surface water and ground water around the On-nuch disposal site center in Bangkok was conducted by means of physical, chemical, and biological analysis of water. In addition, questionnaires for public opinion in terms of water for drinking, domestic consumption, and waste disposal were distributed. It was found that the dissolved oxygen (DO) and biochemical oxygen demand (BOD) of surface water were 0.39-2.30 mg/l and 650-1,525 mg/l, respectively. In the case of ground water, the results were shown within the quality standard of ground water of Thailand. The BOD and chemical oxygen demand (COD) of leachate were in the ranges of 1,375-1,450 mg/l and 2,744-2,822 mg/l, respectively. The comparison of surface water quality showed that the quality in the rainy season is much better than in the dry season. In contrast, the ground water quality in the rainy season is much worse than in the dry season. The characteristics of the leachate was nearly the same in both seasons. Even though the questionnaires indicated that most people along the canal used water for domestic consumption, they continued to discharge wastewater and dispose solid waste into the water (80% and 12%, respectively). In conclusion, the impact of leachate indicated that the surface water is more polluted than ground water.

Key Words: Leachate, Surface water, Ground water, Dissolved oxygen (DO),
Biological oxygen demand (BOD), Chemical oxygen demand (COD)

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การประเมินผลกระทบของน้ำชะขยะ บริเวณศูนย์ กำจัดมูลฝอยอ่อนนุชกรุงเทพมหานคร ที่มีต่อคุณภาพ น้ำผิวดินและน้ำใต้ดิน

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การประเมินผลกระทบของน้ำชะขยะ บริเวณศูนย์กำจัดมูลฝอยอ่อนนุช กรุงเทพมหานครที่มีต่อคุณภาพน้ำผิวดินและน้ำบาดาล โดยวิเคราะห์ดัชนีคุณภาพน้ำทางกายภาพ เคมี และชีวภาพ ตามวิธีในกลุ่มมีมาตรฐานการวิเคราะห์น้ำและน้ำเสีย รวมทั้งออกแบบสอบถามสำรวจความคิดเห็นเกี่ยวกับการใช้น้ำเพื่ออุปโภคบริโภค การกำจัดสิ่งปฏิกูลจากครัวเรือนของชุมชนบริเวณศูนย์กำจัดมูลฝอยอ่อนนุช ผลการศึกษาพบว่าน้ำผิวดินมีค่าออกซิเจนละลายอยู่ในช่วง 0.39-2.30 มิลลิกรัมต่อลิตร และมีค่าบีโอดีอยู่ในช่วง 650-1,525 มิลลิกรัมต่อลิตร ส่วนดัชนีคุณภาพน้ำบาดาลทุกตัวมีค่าเป็นไปตามที่มาตรฐานกำหนด สำหรับน้ำชะขยะมีค่าบีโอดีและซีโอดีอยู่ในช่วง 1,375-1,450 มิลลิกรัมต่อลิตร และ 2,744-2,822 มิลลิกรัมต่อลิตรตามลำดับ จากการเปรียบเทียบพบว่าคุณภาพน้ำผิวดินในฤดูฝนดีกว่าในฤดูแล้ง แต่สำหรับคุณภาพน้ำบาดาลพบว่าคุณภาพน้ำในฤดูฝนต่ำกว่าในฤดูแล้ง ส่วนน้ำชะขยะดัชนีคุณภาพน้ำมีค่าใกล้เคียงกันทั้งสองฤดู ส่วนผลการสำรวจความคิดเห็นของชุมชน พบว่าประชาชนทุกครัวเรือนที่อาศัยอยู่ริมคลองมีการใช้น้ำจากคลองเพื่อการอุปโภคเท่านั้น มีการปล่อยน้ำเสียและทิ้งขยะจากครัวเรือนลงคลองร้อยละ 80 และ 12 ตามลำดับ ดังนั้นโดยสรุปแล้วคุณภาพน้ำผิวดินมีความเสี่ยงที่จะได้รับผลกระทบจากน้ำชะขยะมากกว่าน้ำบาดาล

คำสำคัญ น้ำชะขยะ น้ำผิวดิน น้ำใต้ดิน ออกซิเจนละลาย ปริมาณความต้องการใช้ออกซิเจนของพวกจุลินทรีย์ ปริมาณออกซิเจนทั้งหมดที่ใช้ในการออกซิไดส์สารอินทรีย์

INTRODUCTION

Economic expansion, development, and population growth are the main causes of disposal problems. There are 3 major disposal sites in Bangkok, namely the On-nuch, Nongkham and Tarlear disposal sites. On-nuch is the disposal site for integrated solid waste, especially by open dumping, and as a result leachate is produced. The leachate, which is produced from micro-biodegradation, consists of dissolved and suspended portions. The different characteristics of leachate depend on waste composition biodegradation, types of micro-organisms, waste compaction,

soil moisture, and the flow rate and temperature of the waste. During the rainy season, this leachate can contaminate the surface water, ground water, and soil. It harms the environment and people who consume water from those contaminated sources.

There are several related works, which were performed by Thai and foreign researchers. The results found by Chang ⁽¹⁾ are shown in table 1. Sheu ⁽²⁾ and Pattamapirat ⁽³⁾ have studied the leachate characteristics from the On-nuch disposal site. (Table 2 and 3)

Table 1. Leachate characteristics at the On-nuch disposal site.⁽¹⁾

Water Quality Parameters	Range
BOD ₅	150-210 (mg/L)
COD	1,560-2,075 (mg/L)
pH	7.6-8.2
DO	0.3-0.8 (mg/L)
Total solid	4,046-6,600 (mg/L)
Alkalinity	2,100-3,250 (mg/L)
Cadmium	0.007-0.010 (mg/L)
Mercury	3.4-4.7 (mg/L)

Table 2. Leachate characteristics at the On-nuch disposal site.⁽²⁾

Water Quality Parameters	Range
BOD ₅	145-150 (mg/L)
COD	1,442-1,866 (mg/L)
pH	7.6-8.2
DO	0.1-0.2 (mg/L)
Alkalinity	2,110-3,370 (mg/L)

Table 3. Leachate characteristics at the On-nuch disposal site.⁽³⁾

Water Quality Parameters	Range
BOD ₅	178.2-1,881.1 (mg/L)
COD	980.7-9,214.6 (mg/L)
pH	7.0-8.6
Suspended solid	81.9-2,732.0 (mg/L)
Alkalinity	2,100-3,250 (mg/L)
Mercury	3.8-4.7 (mg/L)

Tharanit⁽⁴⁾ then studied leachate at the On-nuch and Nongkham disposal sites and their surrounding waterways during May and August 1992. They found that the mercury contamination in leachate storage pools was 2.47-39.13 ppb at the On-nuch disposal site and 1.13-3.74 ppb at the Nongkham disposal site. The manganese content detected from leachate storage pools and the surrounding waterways were at about the same level, 0.01-2.88 ppm.

In this research an impact assessment of leachate on the quality of surface water and ground water around the On-nuch disposal site center in Bangkok, is assessed. The objectives of this study were.

1. To survey and analyze the leachate characteristic at On-nuch disposal site and its surrounding surface water and ground water.

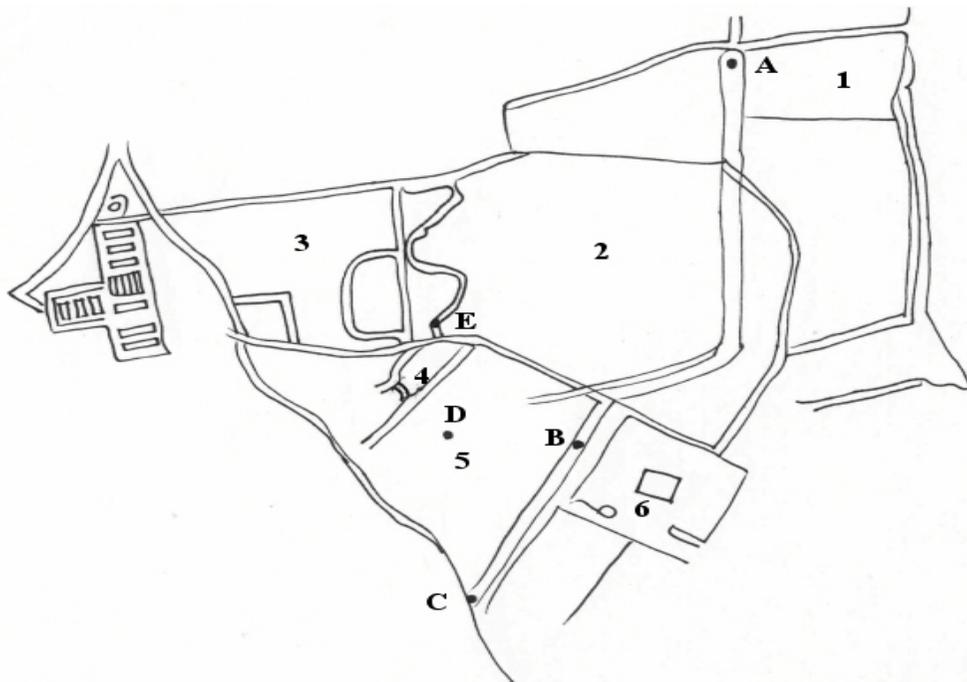
2. To compare the surface water and ground water quality with the water quality of the standard in Thailand.
3. To evaluate the impact and risk assessment of leachate on the quality of the surface water and ground water at the On-nuch disposal site.

MATERIALS AND METHODS

Sampling Sites

Water samples for physical, chemical and biological analysis were collected from 5 stations in the rainy and dry season (Figure 1). These stations are:

- Station 1: Khud Mai Canal before passing disposal site area
- Station 2: Khud Mai Canal at disposal site area
- Station 3: Khud Mai Canal after passing disposal site area
- Station 4: Ground water at disposal site
- Station 5: Leachate storage pool



- | | |
|-------------------------------|-----------------------------|
| 1. Office area | A: Water sampling station 1 |
| 2. Dumping yard area | B: Water sampling station 2 |
| 3. Ashing furnace | C: Water sampling station 3 |
| 4. Wastewater treatment plant | D: Water sampling station 4 |
| 5. Septic plant | E: Water sampling station 5 |
| 6. Waste transfer area | |

Figure 1. Water sampling station at On-nuch disposal site, Bangkok.

Sampling methods and methods for water quality analysis

Samples were obtained by grab sampling on 24th October 2001 (rainy season) and 29th November 2001 (dry season). We analyzed 18

parameters and a duplicates for each parameter except Total Coliform Bacteria and Fecal Coliform Bacteria (1 replicate) were analyzed.

Table 4. Methods for water quality analysis.

Water Quality Parameter	Method of Analysis
<i>Physical Properties</i>	
- Color	APHA Platinum-Cobalt Standard Method
- Temperature	Thermometer
- Transparency	Secchi Disc
- Conductivity	Direct Measurement Method
- Turbidity	Formazin Method
- Suspended Solid	Filtrate by Whatman GF/C
- Salinity	Electrical Conductance Method
<i>Chemical Properties</i>	
- Dissolved Oxygen (DO)	Modified Winkler Method
- Biochemical Oxygen Demand (BOD)	Dilution Method
- Chemical Oxygen Demand (COD)	Dichromate Reflux Method
- pH	HACH One Combination pH Electrode Method with a EC 10 Portable Meter
- Alkalinity	Sulfuric Acid Method
- Hardness	EDTA Titrimetric Method
- Nitrate-Nitrogen (NO ₃ -N)	Cadmium Reduction Method
- Mercury (Hg)	Atomic Absorption Spectrometry
- Cadmium (Cd)	Atomic Absorption Spectrometry
- Manganese (Mn)	Atomic Absorption Spectrometry
<i>Biological Properties</i>	
- Total Coliform Bacteria	Most Probable Number (MPN)
- Fecal Coliform Bacteria	Most Probable Number (MPN)

Questionnaires for public opinion

The questionnaires for public opinion in terms of water for drinking, domestic consumption and waste disposal were distributed.

RESULTS

The Results of water quality analysis

The results of water analysis are shown in Tables 5. The results from water sampling stations 1 – 5 showed that the levels of BOD, COD, and DO of surface water were 650-1,525 mg/l, 1,098-2,508 mg/l, and 0.39-2.30 mg/l, respectively (Figures 2 - 4). The manganese and cadmium contents were 0.430-2.680 ppm, and 0.002-0.20 ppm, respectively.

The results of public opinion

The questionnaires for public opinion in terms of water for drinking and domestic consumption showed that

all the people who live near Khud Mai Canal are using water from Khud Mai Canal in all seasons. In addition, 52 percents of the people improved the water quality before use, while 48 percent of them do not.

For waste disposal, the questionnaires indicated that 80 percent of the people disposed household waste into Khud Mai Canal and 12 percents of them disposed domestic waste disposal into the canal.

The results of questionnaires for public opinion in terms of the impact on health and the environment showed that all people are affected by the water pollution. All people are impacted in terms of mental health, 60 percent cited water pollution from microbe sources, 36 percent felt impacted in terms of health and 32 percent cited visual pollution.

Table 5. Surface water quality at On-nuch disposal site in both seasons.

Parameter	Unit	Station 1						Station 2						Station 3						Surface water standard value*
		rainy season			dry season			rainy season			dry season			rainy season			dry season			
		mean	SD		mean	SD		mean	SD		mean	SD		mean	SD		mean	SD		
1. Color	Pt-Co	378	1.41		410	1.41		1590	1.41		2435	5.66		171	1.41		183	1.41		natural
2. Temperature	°C	28.1	0.00		26.1	0.00		30.1	0.14		26.7	0.00		28.8	0.14		27.9	0.14		natural
3. Suspended	mg/l	56	0.00		180	1.41		119	1.41		579	0.00		51	0.00		105	0.71		none
4. Turbidity	NTU	35	0.00		39	0.00		120	1.41		141	1.41		33	0.00		36	0.00		none
5. Transparency	cm.	28	0.14		26.1	0.00		15	0.00		ND	-		29.1	0.14		27	0.00		none
6. pH	-	7.21	0.01		7.5	0.00		7.72	0.00		6.8	0.00		7.02	0.01		7.6	0.01		5.0-9.0
7. DO	mg/l	2.3	0.00		1.78	0.00		0.44	0.01		0.39	0.00		1.66	0.01		1.6	0.01		≥2.0
8. COD	mg/l	1176	55.44		1411.2	55.44		2352	110.87		2508.8	0.00		1097.6	110.87		1254.4	110.87		none
9. NO ₃ -N	mg/l	10.6	0.14		2.6	0.14		34.7	0.14		27	0.00		14.4	0.14		13.2	0.14		<5.0
10. Salinity	ppt	0.3	0.00		0.5	0.00		1.9	0.00		0.5	0.00		0.3	0.00		0.4	0.00		none
11. Conductivity	ms/cm	708	1.41		1042	1.41		3690	1.41		3100	1.41		712	0.00		905	1.41		none
12. Hardness	mg/l as CaCO ₃	196	0.00		454	2.83		796	0.00		1067.5	3.54		204	0.00		208	0.00		none
13. Alkalinity	mg/l as CaCO ₃	308	1.41		314	4.24		655	0.00		905	0.00		156	1.41		160	4.24		none
14. Manganese	ppm	0.43	1.1		0.475	0.50		2.68	0.50		1.136	0.80		0.689	0.30		0.471	0.60		≤1.0
15. BOD	mg/l	700	0		850	14.14		1525	35.36		1200	0.00		680	0.00		650	14.14		≤4.0
16. Coliform Bacteria																				
-Total Coliform Bacteria	MPN/100 ml.	11x10 ⁵	-		14x10 ⁵	-		140x10 ⁵	-		180x10 ⁵	-		17x10 ⁵	-		17x10 ⁵	-		none
	Colony/plate	100x10 ⁴	-		151x10 ⁴	-		113x10 ⁵	-		177x10 ⁵	-		166x10 ⁴	-		166x10 ⁴	-		none
-Fecal Coliform Bacteria	MPN/100ml.	2x10 ⁵	-		4x10 ⁵	-		33x10 ⁵	-		46x10 ⁵	-		4x10 ⁵	-		4x10 ⁵	-		none
17. Cadmium	ppm	0.002	22.7		0.01	16		0.01	9.6		0.02	3.9		0.004	5.7		0.004	18.8		≤0.05
18. Mercury	ppm	<0.0020	1.7		<0.0020	17.4		<0.0020	2		<0.0020	21.9		0.0027	2		<0.0020	4.5		≤0.002

* Surface water quality class 4, as ruled by the Notification of the Environmental Board, No.8, B.E. 2537 (1994)

ND Non detectable

Table 6. Ground water quality at On-nuch disposal site in both seasons.

Parameter	Unit	Station 4				Ground water standard value*	
		rainy season		dry season		Suitable Allowance	Maximum Allowable
		mean	SD	mean	SD		
1. Color	Pt-Co	17	0.00	19	0.00	≤5.00	≤15.0
2. Temperature	°C	28.8	0.00	26.2	0.00	none	none
3. Suspended	mg/l	14	0.00	3	0.00	none	none
4. Turbidity	NTU	2.27	0.00	2.1	0.00	≤5.00	≤20.0
5. Transparency	cm.	ND	-	ND	-	none	none
6. pH	-	7.24	0.01	7.2	0.00	7.0-8.5	6.5-9.2
7. DO	mg/l	2.76	0.00	1.29	0.01	none	none
8. COD	mg/l	172.48	22.17	392	0.00	none	none
9. NO ₃ -N	mg/l	2.4	0.00	0	0.00	none	none
10. Salinity	ppt	0.3	0.00	0.3	0.00	none	none
11. Conductivity	ms/cm	639	0.00	664	0.00	none	none
12. Hardness	mg/l as CaCO ₃	134	2.83	126	0.00	≤ 300	≤ 500
13. Alkalinity	mg/l as CaCO ₃	334	1.41	337.5	2.12	none	none
14. Manganese	ppm	0.43	1.1	0.478	0.50	≤ 0.3	≤ 0.5
15. BOD	mg/l	26	1.1	21	0.00	none	none
16. Coliform Bacteria							
-Total Coliform Bacteria	MPN/100 ml.	2x10 ²	-	2x10 ²	-	<2.2	none
	Colony/plate	16x10	-	13x10	-	≤500	none
-Fecal Coliform Bacteria	MPN/100ml.	<2x10 ²	-	<2x10 ²	-	none	none
17. Cadmium	ppm	0.005	7	0.006	3.8	0.00	≤0.01
18. Mercury	ppm	<2.00	0.9	<2.00	5.2	0.00	≤0.001

* Ground water quality standards for drinking purposes, as ruled by Notification of the Ministry of Industry, No.4 B.E.2521(1978)

ND Non detectable

Table 7. Leachate quality at On-nuch disposal site in both seasons.

Parameter	Unit	Station 5			
		rainy season		dry season	
		mean	SD	mean	SD
1. Color	Pt-Co	2807	1.41	2870	1.41
2. Temperature	°C	ND	-	ND	-
3. Suspended	mg/l	130	0.00	560	0.00
4. Turbidity	NTU	141	0.00	191	1.41
5. Transparency	cm.	ND	-	ND	-
6. pH	-	7.48	0.00	6.97	0.00
7. DO	mg/l	0.49	0.01	0.27	0.00
8. COD	mg/l	2744	55.44	2822.4	110.87
9. NO ₃ -N	mg/l	22.5	0.71	18	0.14
10. Salinity	ppt	1.3	0.14	0.8	0.14
11. Conductivity	ms/cm	2580	1.41	2520	1.41
12. Hardness	mg/l as CaCO ₃	426	5.66	1275	0.00
13. Alkalinity	mg/l as CaCO ₃	1052.5	3.54	937.5	3.54
14. Manganese	ppm	0.496	0.5	0.11	0.50
15. BOD	mg/l	1375	1.1	1450	0.00
16. Coliform Bacteria					
-Total Coliform Bacteria	MPN/100 ml.	220x10 ⁵	-	280x10 ⁵	-
	Colony/plate	214x10 ⁵	-	293x10 ⁵	-
-Fecal Coliform Bacteria	MPN/100ml.	46x10 ⁵	-	70x10 ⁵	-
17. Cadmium	ppm	0.012	14.7	0.007	7.5
18. Mercury	ppm	10.55	1.5	15.2	0.7

ND Non detectable

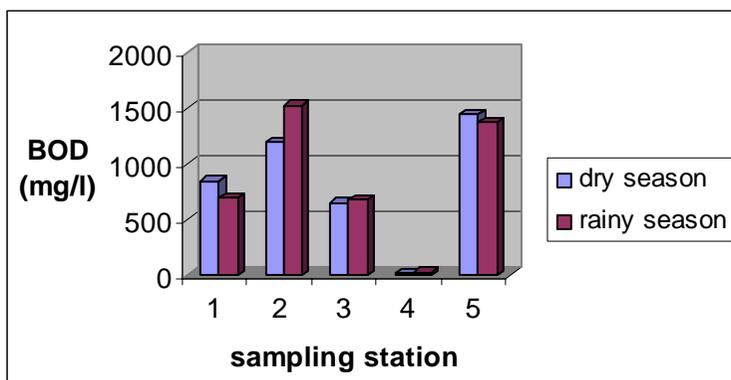


Figure 2. Biochemical oxygen demand (BOD) of surface water in dry and rainy seasons.

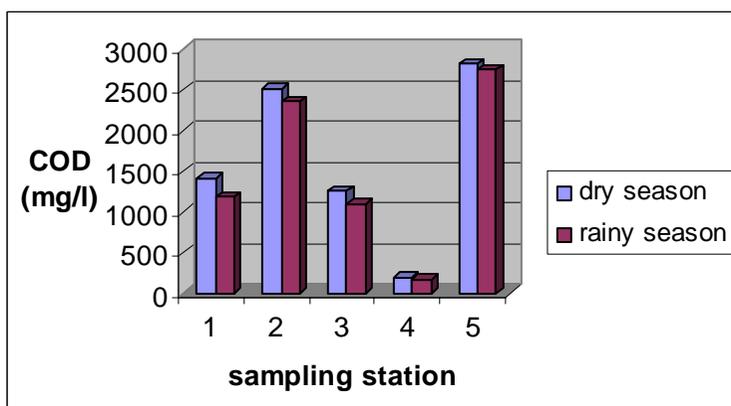


Figure 3. Chemical oxygen demand (COD) of surface water in dry and rainy seasons.

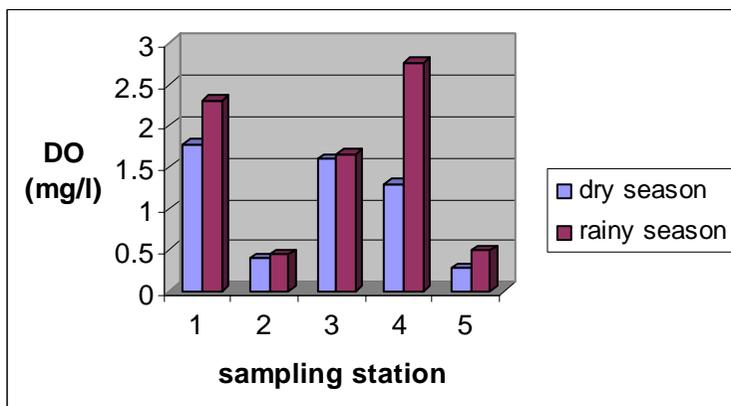


Figure 4. Dissolved oxygen (DO) of surface water in dry and rainy seasons.

DISCUSSION

The water quality analysis

Surface water

The surface water of Khud Mai Canal has high values of biochemical oxygen demand (BOD) (Figure 2), chemical oxygen demand (COD) (Figure 3), and coliform bacteria content. Then high BOD and COD show that the surface water has high organic loading. In addition, they are related to the low dissolved oxygen (DO) mean value (Figure 4). These values show that the surface water has a high oxygen requirement for biochemical degradation of organic material and to oxidize inorganic material. The surface water had deoxygenated rapidly and may have lost oxygen excessively.

Color, turbidity and suspended solid mean values are high. They are related to the transparency value, especially for the surface water (station 2) in the dry season. The surface of the canal is covered with aquatic plants, waste disposal, suspended solids.

In addition, high alkalinity, hardness, and nitrate nitrogen and manganese contents are related to the high conductivity value. We found that the mercury and cadmium contents were low because toxic waste disposals are separated from general garbage. The mercury content of surface water after passing the disposal site is high and it may be contaminated with from other waste, which is discharged into the canal.

The assessment of the water quality reveals that, on average, it is poorer than the surface water quality class 4, as ruled by Notification of the Environment Board, No.8, B.E. 2537 (1994).⁽⁶⁾ It is recommended that the water cannot be used for any domestic

purposes. Finally, the water quality in the dry season is worse than in the rainy season.

Ground water

As shown in Table 6, turbidity, pH, alkalinity, and hardness of the ground water do not exceed the ground water quality standards for drinking purposes, as ruled by Notification of the Ministry of Industry, No.4, B.E. 2521 (1978).⁽⁶⁾ Color, total coliform bacteria and cadmium content of the ground water are higher than standard values, but are not higher than the acceptable values. The mercury content of the ground water cannot be detected. The ground water can be used for domestic purposes. However, the ground water is not suitable for drinking. It may be contaminated by organic material from the leachate.

In addition as displayed in Table 7, the ground water quality in the dry season is better than in the rainy season, because the organic matter from waste can leach into the ground water. In the rainy season, the ground water is at a higher risk for contamination by leachate.

Leachate

Leachate has a high BOD, which is related to the high COD showing a high organic load. In addition, it has high alkalinity, hardness, and nitrate nitrogen and manganese content which are related to the high conductivity. The leachate is nearly the same in the rainy and dry seasons.

Table 8. Characteristics of leachate analysis in this research and other research.

Water Quality Parameters	Mean values		Pattamapirat ⁽³⁾	Chang ⁽¹⁾
	Dry season	Rainy season		
BOD ₅ (mg/l)	1375	1450	178.2-1,881.1	150-210
COD (mg/l)	2744	2822	980.7-9,214.6	1,560-2,075
pH	7.48	6.97	7.0-8.6	7.6-8.2
Suspended Solid (mg/l)	130	560	81.9-2,732.0	79-250
Alkalinity (mg/l as CaCO ₃)	1053	937.5	-	2,100-3,250
Cadmium (mg/l)	0.012	0.007	-	0.007-0.010
Mercury (mg/l)	0.0105	0.0152	3.8-4.7	0.006-0.025

Table 8 shows characteristics of leachate analysis, compared with data of Pattamapirat⁽³⁾ and Chang⁽¹⁾, showing the same range for almost all parameters except the mercury content, which decreased. This may be because waste or toxic waste was removed.

Impact and risk assessment

Impact and risk assessment of surface water

After field observations and sample analysis were completed, the results showed that Khud Mai Canal was contaminated from solid waste and leachate from the disposal site. This leads to a poor water quality, bad odor and high organic load (BOD). The water has excessive organic loading that cannot be self-purified. Microorganisms used more oxygen. DO rapidly decreased because under these conditions, the water pollution harms organisms in this surface water. Surface water had septicization. The high organic load, high suspended solid and solid waste may cause shallow

water in the future. Polluted water from Khud Mai Canal can spread to other linked water ways. Khud Mai Canal and nearby rivers share a high risk of contamination by leachate and solid waste from the waste disposal site.

Public opinions of all people (100%) who live nearly Khud Mai Canal is that they are impacted from the pollution in Khud Mai Canal such as visual pollution (32%), the source of spreading microbes (60%), physical health (36%) and mental health (100%). It may be concluded that the water pollution impact is harmful to human health.

Impact and risk assessment of ground water

The results of the water quality analysis show that the ground water is not impacted by leachate from the waste disposal site. The mercury content of ground water cannot be detected within the limitations of the instrument.

CONCLUSION

Surface water (Khud Mai Canal) contaminated by leachate and solid waste from the waste disposal site. The water quality is poor, there is a high organic load (BOD) and suspended solids. The canal may become shallow in the future. The water quality of Khud Mai Canal is lower than surface water quality class 4, as ruled by Notification of the Environment Board, No.8, B.E. 2537 (1994). This indicates that the water should not be used for any domestic purposes. Finally, water quality in the dry season is worse than in the rainy season.

Ground water is not impacted by leachate from the waste disposal site. The water quality of ground water in the dry season is better than in the rainy season.

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