DISTRIBUTION OF LEACHED WATER PENETRATION INTO GROUND-WATER AT PUBLIC WELLS AROUND THE END POINT LAND-FILL AREA (CASE STUDY OF TPA LEUWI GAJAH-BANDUNG)

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ABSTRACT

The objective of the research was to find out the distribution of leached water penetration into groundwater. The research was carried out from April to June 2001. Hydrochemical, Meteoric, and ^{18}Oxygen content methods were used for measuring the distribution of leached water penetration. The result indicated that the leached water distribution at public wells around The end point landfill area of Leuwi Gajah reached up to one kilometer from outside border on south-west direction following stream flow of small river of Cirendeu; while on other directions there were no indication of leached water penetration to public wells.

Keywords: Leached water, Landfill area

DISTRIBUSI PENYERAPAN AIR SAMPAH KEDALAM AIR TANAH PADA SUMUR PENDUDUK DISEKITAR TEMPAT PEMBUANGAN SAMPAH, *CASE STUDY* TPA LEUWIGAJAH, BANDUNG.,

ABSTRAK

Tujuan penelitian ini untuk mengetahui penyebab distribusi resapan air sampah ke dalam air tanah. Penelitian dilakukan pada bulan April-Juli 2001. Metode hidrokimia, garis meteoric dan kandungan oksigen 18 digunakan untuk mengetahui distribusi penyerapan air sampah ke dalam air tanah. Hasil penelitian menunjukkan bahwa distribusi penyerapan air tanah ke dalam sumur penduduk di sekitar Tempat Pembuangan Akhir (TPA) Leuwigajah mencapai satu kilometer diluar batas TPA pada arah barat daya dan arah tersebut mengikuti aliran sungai kecil. Sedangkan arah lain tidak terjadi penyerapan air sampah ke dalam sumur penduduk.

Kata kunci : air sampah, tempat pembuangan sampah.

INTRODUCTION

The major problem of city public waste management is the end point landfill area (Tempat Pembuangan Akhir = TPA). Pile of public waste at the end point landfill area can cause pollution on surface and ground water of surrounding area of TPA because of lixiviate or fluid called leached water that brings out of its waste pollutant. When the piles of public waste are left out for a longer time without being processed at the end point of landfill area, it will cause more pollution to the surrounding area particularly will contaminate the water body.

The government of Bandung city has been established Leuwi Gajah area as TPA since 1987 with the operational area of 9 hectare (PD Kebersihan Kota Bandung, 1999). However, the in-depth study on impact of leached water resulted from public waste to the water body of surrounding areas has never been conducted yet.

There are some methods to find out the distribution of leached water penetration into ground water surround the end point landfill area of public waste, i.e.: Hydro-chemical, meteoric line, and ^{18}oxygen content.

Hydro-chemical method is based on chemical elements or minerals dissolve in water, such as Cations of Na^+, K^+, Ca^+, Ca^{2+}, Mg^{2+}, Fe^{3+} and Anions of SO^{-2}_4, Cl^-, CO^-_3, and NO^-_3 (Friz, 1976). Hydro-chemical contains in each of aquifer layers has specific identity depends on the rocks passed by the water. Interaction between the water and the rock and the balance mechanism in between, cause dissolving and ionic circulation. The result of chemical analysis of ground water is generally drawn as tri-linear graph.

Meteoric line method is a model relationship between δ deuterium (^{2}H) and ^{18}O. Deuterium is an hydrogen isotope contains one proton and one neutron on its atomic core, and ^{18}O is oxygen isotope contains 8 protons and 10 neutrons on its core. The concept uses on this method is the development of isotope fraction resulted from evaporation, caused by the molecule weight different between heavy and light isotopes. When mass of water receives heat energy, water with light isotope composition will evaporate faster compared with water of heavy isotope; hence the latest will remain more than the other one. Water with light isotope is ^{16}O and ^{1}H, while water with heavy isotope is ^{18}O and ^{2}H (Abidin, 1997). World's surface and ground water can be compared with Standard Mean Ocean Water (SMOW) by using formula as followed:

$$\delta = (Rs - Rref) / Rref \times 1000^{o}/_{oo}$$

Where Rs is sample isotope ratio, Rref is reference isotope ratio, and δ is relativedifferent ratio.

Indonesia has a local standard known as JAWS (Jakarta Working Standard) and the relationship with SMOW and sample is :

$$\delta SMOW(X) = \delta SMOW(JAWS) + \delta JAWS(X) + \delta SMOW(JAWS) * \delta JAWS(X) * 10^{-3}$$

The result of calibration ratio of JAWS and SMOW is $\delta^{18}O$= -6.48% and $\delta^{2}H$ = 39.08%. In 1997, the local meteoric line of Bandung city and its surrounding has been determined using formula (Djiono, 1997):

$$\delta^2H = 7.8\ \delta^{18}O + 14$$

Isotope ^{18}O in water sample is determined by measuring mass of CO_2 as reaction equation of isotope circulation between H_2O (liquid) and CO_2 (gas):

$$H_2{}^{18}O + C^{16}O_2 \ \leftarrow\!===\!\rightarrow\ H_2{}^{16}O + C^{16}O^{18}O$$

Isotope ^{2}H in water sample is determined by measuring H_2 as reduction reaction of Zn (solid) and H_2O (liquid):

$$H_2O + Zn \ \xrightarrow{450°C}\ ZnO + H_2$$

^{18}O content method is based on pollution level using formula as followed:

$$X = [(Wi - Wh) / (WI - Wh)] * 100\%$$

Where X = percentage of ^{18}O content; Wi = percentage of ^{18}O sample; WI = percentage of the lowest^{18}O content; Wh = percentage of the highest ^{18}O content.

MATERIALS AND METHOD

The research was carried out from April to June 2001 supported by P.D. Kebersihan Kota Bandung and Laboratory of Hydrology, Centre for Research and Development on Isotope Energy, National Board for Atomic Energy, Jakarta.

Chemical materials such as: Zn, Nitrogen liquid, HNO3, CO2, alcohol, Red Methyl, H2SO4, Fe.(NH4)(SO4)2, Hg(CNS)2, K, Na, acetone, and dry ice were used for water well analysis; while, thermometer, stopwatch, GPS, distance meter, mass spectrometer, and AAS were used for measuring parameters required.

Hydro-chemical, Meteoric Line, and ^{18}O Content was the methods used for measuring the distribution of leached water penetration into ground water. Evaluation of ground water quality depends on its purpose, such as for drinking water, industrial, and irrigation. The water quality is determined using the established standard of quality; The standards of quality for drinking water are dissolved solid matter < 1,000 µs, pH = 6.5 – 8.5, temperature more or less than 3 centigrade of room temperature, $NO^-_3 < 10$ mg/L, $Cl^- < 250$ mg/L, $SO_4^{-2} < 400$ mg/L, and $Fe^{++} < 0.3$ mg/L (Friz, 1976); While the standard quality for irrigation water is depend on Natrium concentration, which is %Na = [(Na + K) / (Ca + Mg + Na + K)]* 100% (Asdak, 1996).

The procedure of experiment included: (1) determine public wells used for ground water samples, and several points along small river of Cirendeu (Cirendeu is a small river passed through the end point landfill area/TPA Leuwigajah) used for surface water samples; (2) determine three directions from the end point landfill area (TPA) as points of observation, which were: a) Centre, is point of Lwg A at TPA as a control for maximum penetration, b) Northen, is points of LWG D and LWG E located 500 meters of front side and over the hill from TPA as a control for minimum penetration, c) South-western, is points of LWG 3, LWG 4, LWG 5, LWG 10, LWG 11, LWG 12, LWG 13, LWG 14, LWG 15, LWG 16, LWG 17, LWG 18, LWG 10, and LWG 20, as samples of ground water from public wells and points of LWGB and LWGC as samples of surface water from small river Cirendeu. All points of observation followed the flow of ground and surface water along two kilometers from the border of TPA, d) Southern, is points of LWG 1, LWG 2, LWG 6, LWG 7, LWG 8, and LWG 9 which were not following the flow of ground and surface water along two kilometers from the border of TPA; (3) determine the position of all observation points and plotting to the map using GPS; (4) samples of all observation points were analyzed in the laboratory to measure hydro-chemicals, ^{2}H and ^{18}O of the samples.

RESULTS AND DISCUSSION

The result of determination and plotting of observation points is presented in Figure 1. Evaluation of hydro-chemical analysis for each sample based on standard quality of drinking water is presented in Table 1.

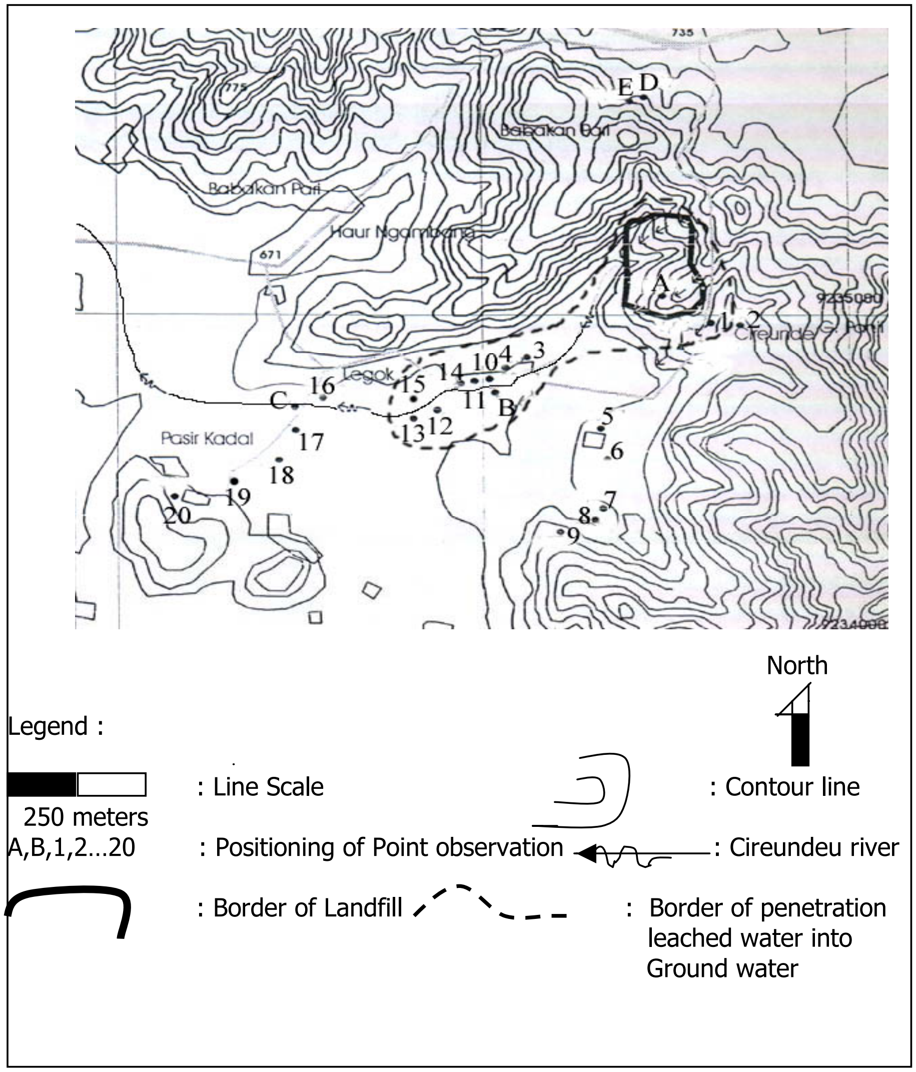

Figure 1 Position of observation points and border area polluted by leached water.

Table 1. Results of Hydro-chemical Analysis

No. sample	Anion (ppm)				Kation (ppm)				
	HCO_3^-	Cl^-	SO_4^{2-}	NO_3^-	K^+	Ca^{2+}	Na^+	g^{2+}	Fe
LwgA	1094,50	3670,50*	1,72	23,70*	3059,52	10,29	2168,5	49,07	12,5
LwgB	3010,35	1242,25*	30,69	25,70*	894,44	34,21	772,2	40,12	6
LwgC	1494,50	1225,67*	22,94	20,30*	743,05	34,87	655,55	44,44	-
LwgD	97,60	9,96	40,41	3,19	0,67	7,02	21,41	8,82	-
LwgE	125,05	4,59	27,97	0,20	2,64	7,16	19,68	7,70	0
Lwg1	247,05	90,51	14,58	12,80*	4,52	41,45	22,43	18,09	-
Lwg2	96,07	7,61	6,69	5,20	1,31	2,63	18,6	3,21	-
Lwg3	166,22	90,98	6,95	15,40*	1,49	36,19	22,53	19,04	-
Lwg4	106,75	57,73	9,49	17,70*	0,78	38,16	22,25	12,44	-
Lwg5	90,28	4,70	8,20	1,90	1,04	2,74	18,42	2,35	-
Lwg6	105,22	6,75	47,97	2,90	1,97	5,17	20,15	7,24	0
Lwg7	211,97	30,09	27,34	3,80	11,58	8,28	41,81	11,71	-
Lwg8	44,22	18,05	2,18	3,80	0,96	3,95	19,02	2,57	-
Lwg9	184,83	23,56	23,57	6,87	5,92	9,58	24,64	11,27	-
Lwg10	167,75	83,95	32,81	11,40*	9,41	8,51	51,4	16,86	0
Lwg11	64,66	23,49	18,57	12,10*	4,99	4,7	17,87	7,36	-
Lwg12	148,84	32,77	22,86	13,10*	7,94	6,47	33,41	10,66	-
Lwg13	150,97	42,65	33,91	10,60*	17,96	9,16	38,19	16,94	-
Lwg14	181,75	20,17	5,25	13,40*	1,2	4,74	20,04	9,35	-
Lwg15	178,42	112,07	10,68	16,60*	10,59	31,58	45,22	21,73	-
Lwg16	70,15	9,88	1,53	3,40	0,66	2,9	18,48	3,78	0
Lwg17	132,67	92,86	36,25	2,70	7,19	9,26	54,78	1,36	-
Lwg18	124,13	23,72	12,88	1,30	5,24	4,76	26,14	6,46	-
Lwg19	337,02	5,98	9,49	1,30	5,03	3,43	47,72	20	-
Lwg20	234,85	13,16	16,71	7,60	1,91	6,79	20,4	8,61	0
STD QLTY	-	250,00	400,00	10,00	-	-	-	-	0,3

Note: *) the value exceeded the threshold limit of standard quality.

Data from Table 1 showed that nitrate is a dominant element for polluting ground water and surface water at observation points through leached water penetration produced from public waste at the end point landfill area (TPA). The observation points that exceeded the threshold limit of standard quality were LWGB, C, LWG 1, LWG 3, LWG 4, LWG 10, LWG 11, LWG 12, LWG 13, LWG 14, and LWG 15. The result of ^{2}H and ^{18}O measurements is presented in Table 2 and Figure 2.

Table 2 Deuterium and 18 Oxygen analysis

Sampel	^{18}O ($^{o}/_{oo}$)	D ($^{o}/_{oo}$)	Sampel	^{18}O ($^{o}/_{oo}$)	D ($^{o}/_{oo}$)
Lwg A	- 4,34	- 41,1	Lwg 9	- 8,07	- 45,9
Lwg B	- 6,08	- 50,9	Lwg 10	- 6,76	- 37,9
Lwg C	- 6,52	- 54,7	Lwg 11	Not analysis	Not analysis
Lwg D	- 9,33	- 53,8	Lwg 12	- 7,53	- 47,1
Lwg E	- 9,43	- 56,3	Lwg 13	- 7,85	- 59,0
Lwg 1	- 6,92	- 42,5	Lwg 14	- 6,50	- 35,0
Lwg 2	- 7,38	- 44,1	Lwg 15	- 6,71	- 48,2
Lwg 3	- 6,78	- 54,1	Lwg 16	- 8,47	- 43,0
Lwg 4	- 7,14	- 40,8	Lwg 17	- 7,35	- 44,8
Lwg 5	- 7,41	- 43,1	Lwg 18	- 8,27	- 59,5
Lwg 6	- 8,56	- 62,6	Lwg 19	Not analysis	Not analysis
Lwg 7	- 8,46	- 63,0	Lwg 20	- 6,79	- 57,6
Lwg 8	- 7,37	- 54,0			

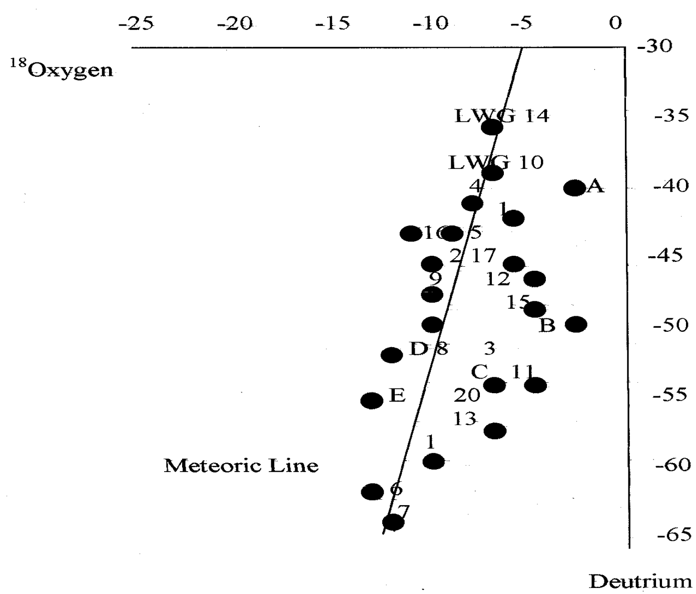

Figure 2. Graphic relationship between ^{18}O and deutrium in each sample.

Figure 2 showed that there are some points located below the meteoric line (at the right side of the line) that did not fulfill the standard of quality, which are LWG A, LWG B, LWG C, LWG 1, LWG 3, LWG 11, LWG 12, LWG 13, LWG 17, LWG 15 and LWG 20; while the rest of the points fulfilled the standard.

^{18}O Content method requires data of $\delta^{18}O$ provided from Table 2, then the percentage of ^{18}O Content was calculated for each sample and compared with the highest and the lowest ^{18}O Content as control. The result of this method is presented in Table 3. The data with asterisk (*) indicated that the value was exceeded the threshold limit up to 41%.

Table 3 Percentage ^{18}Oxygen in each point

No.	Point of observation	Mixing $^{18}O(^{o}/_{00})$	No.	Point of oervation	Mixing $^{18}O(^{o}/_{00})$
1.	Lwg A	100 *)	14.	Lwg 9	26,72
2.	Lwg B	65,81 *)	15.	Lwg 10	52,46 *)
3.	Lwg C	57,18 *)	16.	Lwg 11	-
4.	Lwg D	1,96 *)	17.	Lwg 12	37,33
5.	Lwg E	0	18.	Lwg 13	31,04
6.	Lwg 1	49,31 *)	19.	Lwg 14	57,56 *)
7.	Lwg 2	40,27	20.	Lwg 15	53,44 *)
8.	Lwg 3	52,06 *)	21.	Lwg 16	18,86
9.	Lwg 4	44,99 *)	22.	Lwg 17	40,86
10.	Lwg 5	39,68	23.	Lwg 18	22,79
11.	Lwg 6	17,09	24.	Lwg 19	-
12.	Lwg 7	19,06	25.	Lwg 20	31,87
13.	Lwg 8	40,47			

Table 3 showed that there are some points exceeded the threshold limit of the standard of quality, which are LWG A, LWG B, LWG C, LWG 1, LWG 3, LWG 4, LWG 10, LWG 14, and LWG 15; while the rest of the points fulfilled the standard.

According to the methods applied, there are some similar points of observation polluted and exceed the threshold limit. Those of points can be grouped and restricted by borderline as contour line. Thereafter, the farthest distance from TPA was measured. The result of plotting of polluted area is presented in Figure 1.

The results of water quality of the samples mentioned above were evaluated and compared with the standard quality for drinking water. However, when those results were compared with the standard quality for irrigation water, the whole points of observation fulfilled the standard. Hence, the ground and surface water surround the TPA can be used for agriculture irrigation practices.

CONCLUSION

Leached water produced from public waste at the end point landfill area (TPA) of Leuwi Gajah when it lets for certain period will penetrate into ground water. The distribution of leached water penetration depends on the flow of ground and surface water.

The distribution of leached water penetration into ground water of public wells around the end point landfill area (TPA) Leuwi Gajah reached up to one kilometer from the outside border of TPA to the south-west direction, following the flow of small river Cirendeu as surface and ground water.

According to the standard quality for drinking water, some surface and ground water could not be used for household; however, the ground and surface water arround the TPA can be used for agriculture irrigation practices based on standard quality for irrigation purpose.

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