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Analysis Of Physic And Chemical Properties In Groundwater Landfill In Indonesia

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Abstract: *Research on the physical properties (color, odor, turbidity, pH and solubility) and chemical properties (levels of aluminum, iron, manganese, nitrate, sulfate and chlorine) contained in the groundwater around landfill Bantar Gebang Bekasi and Galuga Bogor has been carried out on May - August 2015. The results showed that soil water consumed by the people living around the garbage dump its physical and chemical properties still below the standardized WHO or the Ministry of Health of the Republic Indonesia. Except that manganese levels above the standard is 0.92 mg/l around landfills Bantar Gebang and 0.97 mg/l around landfills Galuga Bogor. In general, the levels of chemicals in landfill around Bantar Gebang higher than landfill Galuga*

Keywords: *physical properties, chemical properties, groundwater, landfill*

I. Introduction

Water is an important in human life, water functions in the body for metabolism, body temperature stabilizers, and solvents. People needs water approximately 5-8 liters a day, it's can't be replaced by other materials, so it is very important for people to know water quality that they consume. Water used for drinking and eating must meet the health standards of physical factors (color, hardness, solubility, smell and turbidity) and of the chemical properties such as the levels of ions of iron (Fe), nitrate (NO_3^-), manganese (Mn), sulfate (SO_4^{-2}), chlorine (Cl), aluminum (Al), etc [1]. When the ions exceed the levels specified by the WHO or the Ministry of Health Republic Indonesia, then the water is unfit for consumption. Various diseases such as diarrhea, dizziness, hives and even serious diseases such as cancer, neurological and kidney can occur from consuming water containing bacteria or heavy metals. Bantar Gebang landfill Bekasi is the largest landfill with an area of 110.8 hectares and 5.974 tons per day of waste is disposed to that location. The smell of garbage can be detected up to a distance of 5 km. Around the landfill Bantar Gebang Bekasi and Galuga Bogor, many people settle down at location only 300 m from the landfill, they use ground water for drinking, cooking, bathing and washing. In fact, from initial observation, the water they consume look pale yellow, and smelly. This is presumably because there is infiltration of dirty water from the waste that accumulates near the settlement.

This study aims to determine the physical and chemical properties of the groundwater consumed the peoples that living around landfill. From initial observations water looks pale yellow and a bit smelly, so supposedly the ground water has been contaminated. Previous research reported that content of nitrate and chlorine in the soil water around Bantar Gebang above standardized WHO [2]. Although some of the waste has been made to become biogas and fertilizers [3], but the groundwater that consumed by population around Bantar Gebang have been contaminated [4]. Other researcher reported that groundwater around the landfill area in Tangerang, Bekasi, and Jakarta containing Mn and Cd above the WHO standard [5]. Research conducted by the University of Indonesia stated that the water uptake from landfill can seep in groundwater at distances up to 500 m [6]. So it is probable that the groundwater around the landfill Bantar Gebang Bekasi and Galuga Bogor used locals already unfit for consumption.

II. Methodology

This research uses the data survey at around landfill Bantar Gebang, Bekasi, and Galuga, Bogor, West Java Province, Indonesia as in Fig.1. This survey conducted in May-August 2015. The samples are 22 groundwaters in around landfill Bantar Gebang and 18 groundwaters in around landfill Galuga. Laboratory test was conducted at the University of Padjadjaran, Indonesia.

The analytical method used is: 1) Comparative analysis of physical and chemical properties based on the water quality standards, 2) Test the mean between locations with a distance less than 500 meters (< 500 m) and more than 500 meters (> 500 m) from landfill Bantar Gebang (also landfill Galuga), and 3) the spatial analysis. The physical and chemical properties are in Table 1. Water quality standards are obtained from the Regulation of the Ministry of Health no. 492/Menkes/IV/2010 about the requirements of drinking water quality.

FIGURE 1. Sample Points Location

TABLE 1. Water Quality Standards of Physical and Chemical Properties

Physical Properties	**Quality Standard**
Color (PtCo)	15
TDS (mg/L)	500
Turbidity (NTU)	5
Chemical Properties	**Quality Standard**
Al (mg/L)	-
Fe (mg/L)	1
Hardness $CaCO_3$ (mg/L)	500
Cl (mg/L)	600
Mn_{tot} (mg/L)	0,5
NO_3^- (mg/L)	10
NO_2^- (mg/L)	1
pH	6,5-8,5
SO_4^{2-} (mg/L)	400
$KMnO_4$ (mg/L)	10

Test of comparing two independent population means use the t test with he hypothesis H_o : $\mu_1=\mu_2$ (physical or chemical properties in locations with a distance < 500 m and location with a distance > 500 m have equal mean) and H_1 : $\mu_1>\mu_2$ (mean of physical or chemical properties in location with a distance < 500 m is higher than at locations with a distance of > 500 m). Decision-making is Ho rejected if $|t_{value}| > t_{\alpha 2,\, n1+n2-2}$ or $P_{value}<\alpha$. Spatial analysis consists of spatial dependency (autocorrelation) which test by Moran's I. It uses to perform autocorrelation between observations or location [7]. The hypothesis test for Moran's I is no autocorrelation as hypothesis null and the statistics test is $Z_{test} = (I - I_o)/\sqrt{\text{var}(I)}$. Var (I) is the variance of Moran's I and E (I) is the expected value. Reject null hypothesis if $Z_{test}>Z_{\alpha/2}$ and there is a spatial autocorrelation.

III. Results And Discussion

A. Characteristic of Physic and Chemical

Table 2 shows the characteristic of physical groundwater in landfill Bantar Gebang and Galuga. It also compare the samples with the mean, maximum and minimum value, and quality standards based Ministry of Health according to Regulation no. 492/ Menkes/IV/2010. All of the physical properties are still under the quality standard. The mean of color scale and TDS in landfill Bantar Gebang are higher than in landfill Galuga, but not turbidity. It was conclude that the groundwater quality in landfill Galuga was better than in landfill Bantar Gebang.

About the chemical properties, in landfill Bantar Gebang, the mean of Mn_{tot} and pH are above the quality standard (see Table 3). Some groundwater samples are also have NO_2^- which higher than quality standard. It also happens in landfill Galuga, which Mn_{tot}, NO_2^-, and pH are higher than quality standard. Comparing two locations, majority chemical properties in landfill Galuga are higher than in landfill Bantar Gebang.

TABLE 2. Characteristic of Physic Groundwater

Physic Property	**Landfill Bantar Gebang**		
	Mean	**Minimum**	**Maximum**
Color *(PtCo)*	7,05	5,00	10,00
TDS (mg/L)	132,14	22,00	380,00

Turbidity (NTU)	0,81	0,46	0,99
Physic Property	**Landfill Galuga**		
	Mean	**Minimum**	**Maximum**
Color *(PtCo)*	6,39	5,00	10,00
TDS (mg/L)	85,89	20,00	200,00
Turbidity (NTU)	0,87	0,66	0,99

B. Test of Comparing Two Independent Mean

This analysis is the hypothesis test for comparing two independent population means. The first is physical (or chemical) properties with the distance less than 500 m from landfill and the second is with the distance more than 500 m. This analysis also testing to determine whether there are different mean of quality water between two locations or whether the location (distance from landfill) is affect on quality water. Table 4 and V are shows the results in each location. In landfill Bantar Gebang, the mean of turbidity in location < 500 m was higher than in location > 500 m. In landfill Galuga, the mean of color and TDS in location < 500 m was higher than in location > 500 m. By t-test, the color scale in landfill Galuga with location < 500 was significantly higher than in location > 500 m. It shows that the location was affect on color in landfill Galuga.

About chemical properties in landfill Galuga, Al, Fe, Mn_{tot}, NO_2^-N, and pH in location < 500 m was higher than in location > 500 m. In landfill Galuga, Fe, Cl, NO_3^-N, pH, and $KMnO_4$ in location < 500 m was higher than in location > 500 m. The significantly t-test is NO_3^-N, which NO_3^-N in landfill Galuga with location < 500 was significantly higher than in location > 500 m.

TABLE 3. Characteristic of ChemicalGroundwater

Chemical Property	**Landfill Bantar Gebang**			**Landfill Galuga**			**Quality Standard**
	Mean	**Minimum**	**Maximum**	**Mean**	**Minimum**	**Maximum**	
Al (mg/L)	0,07	0,03	0,10	0,15	0,06	0,78	
Fe (mg/L)	0,25	0,08	0,60	0,42	0,20	0,66	1
Hardness $CaCO_3$ (mg/L)	170,82	67,00	450,00	216,50	43,00	452,00	500
Cl (mg/L)	135,26	23,99	309,87	68,01	25,88	156,87	600
Mn_{tot} (mg/L)	0,92	0,05	1,80	0,97	0,05	3,88	0,5
NO_3^- (mg/L)	0,36	0,03	0,99	0,28	0,03	0,94	10
NO_2^- (mg/L)	0,43	0,01	1,99	1,38	0,44	2,00	1
pH	7,70	6,56	8,92	7,39	6,47	8,98	6,5-8,5
SO_4^{2-} (mg/L)	16,18	7,00	32,98	8,73	6,09	12,76	400
$KMnO_4$ (mg/L)	0,43	0,11	0,99	0,47	0,10	0,88	10

TABLE 4. Test of location Effect on Physic Properties

Chemical Properties	**Landfill Bantar Gebang**			**Landfill Galuga**		
	Mean	**t_{value}**	**P_{value}**	**Mean**	**t_{value}**	**P_{value}**
Color (PtCo)		4,0249			-3,374	
Location < 500 m	5,000		0,9996	9,000		0,009*
Location > 500 m	7,368			5,385		
TDS (mg/L)	40,667	4,342			-0,433	
Location < 500 m	146,579		0.9998	92,800		0,336
Location > 500 m				83,231		
Turbidity (NTU)		-0,492			0,337	
Location < 500 m	0,853		0,3305	0,856		0,626
Location > 500 m	0,805			0,878		

Note : *) Significantly at α=5%

TABLE 5. Test of Location Effect on Chemical Properties

Chemical Properties	**Landfill Bantar Gebang**			**Landfill Galuga**		
	Mean	**t_{value}**	**P_{value}**	**Mean**	**t_{value}**	**P_{value}**
Al (mg/L)		-0,021			1,428	
Location < 500 m	0,070		0,4922	0,072		0,9107
Location > 500 m	0,069			0,177		
Fe (mg/L)	0,342	-0,738			-0,427	
Location < 500 m	0,231		0,2639	0,442		0,3419
Location > 500 m				0,413		
Hardness $CaCO_3$ (mg/L)		0,563			2,514	
Location < 500 m	148,333		0,6951	126,200		0,988
Location > 500 m	174,368			251,231		
Cl^- (mg/L)		1,821				
Location < 500 m	79,780		0,927	72,822	-0,424	0,3396
Location > 500 m	144,017			66,153		
Mn_{tot} (mg/L)		-1,269				
Location < 500 m	1,267		0,138	0,940	0,100	0,539
Location > 500 m	0,867			0,987		

NO_3^- (mg/L)			2,227					
Location < 500 m		0,151		0,151		0,567	-2,617	0,025*
Location > 500 m		0,389				0,176		
NO_2^- (mg/L)			-0,032					
Location < 500 m		0,443		0,488		0,995	2,530	0,984
Location > 500 m		0,431				1,557		
pH			-1,031					
Location < 500 m		8,290		0,1942		7,546	-0,387	0,3554
Location > 500 m		7,612				7,327		
$SO4^{2-}$ (mg/L)			1,261					
Location < 500 m		12,038		0,851		8,269	0,607	0,720
Location > 500 m		16,835				8,902		
$KMnO_4$ (mg/L)			1,757					
Location < 500 m		0,227		0,925		0,516	-0,614	0,276
Location > 500 m		0,465				0,430		

Note : *) Significantly at α=5%

C. Autocorrelation Test by Moran's I

Table 6 and Table 7 shows the autocorrelation test of physical and chemical properties by Moran's I. This analysis to determine the relationship and dependencies of chemical among sample points by α=5%. The hypothesis null is I = 0 or no dependencies among physical (or chemical) properties. In landfill Bantar Gebang, there are significantly dependencies about color scale (see Table 6). The moran's I coefficient of color scale is 0,286 with the P value 0,028. The positive value of coefficient shows the groundwater that has high color scale will be adjacent to the ground water that has a high color scale. It also occurs in TDS, Mntot and SO_4^{2-} in landfill Bantar Gebang and color scale, hardness $CaCO_3$, NO_2^-, and $KMnO_4$ in landfill Galuga.

TABLE 6. Moran's I Test of Physical Properties

Physical Properties	**Landfill Bantar Gebang**		**Landfill Galuga**	
	I	**P value**	**I**	**P value**
Color (PtCo)	0,286	0,028*	0,280	0,009*
TDS (mg/L)	0,311	0,011*	-0,172	0,359
Turbidity (NTU)	-0,167	0,409	-0,109	0,694

Note : *) Significantly at α=5%

TABLE 7. Moran's I Test of Chemical Properties

Physical Properties	**Landfill Bantar Gebang**		**Landfill Galuga**	
	I	**P value**	**I**	**P value**
Al (mg/L)	0,081	0,381	0,043	0,328
Fe (mg/L)	0,136	0,216	-0,179	0,337
Hardness $CaCO_3$ (mg/L)	0,168	0,111	0,385	0,000*
Cl (mg/L)	-0,105	0,696	0,018	0,538
Mn_{tot} (mg/L)	0,251	0,048*	0,019	0,498
NO_3^- (mg/L)	0,059	0,467	0,166	0,071
NO_2^- (mg/L)	-0,003	0,752	0,225	0,032*
pH	-0,038	0,948	-0,185	0,338
$SO4^{2-}$ (mg/L)	0,487	0,000*	-0,061	0,989
$KMnO_4$ (mg/L)	-0,111	0,671	0,329	0,004*

Note : *) significantly at α = 5%,

IV. Conclusion

Physical properties of ground water quality in landfills Bantar Gebang and landfills Galuga is still good because it was still under the quality standard. But, in general the groundwater quality in landfills Galuga was better than in landfills Bantar Gebang. About chemical properties, there are some properties which higher than quality standard, such as Mn_{tot}, NO_2^-, and pH. In general, the chemical groundwater quality in landfill Batar Gebang was better than in landfills Galuga.

Some of physical and chemical properties in location less than 500 m from landfill are higher than in location more than 500 m. It shows that the groundwater qualities which close to the landfill are not healthy to consumption. Test of comparing mean shows that the locations, or distance landfill with the residential area, are significantly affect color scale and NO_3^-N in landfills Galuga. Mean of this properties in location < 500 m are significantly higher than in location > 500 m. Spatial analysis by Moran's test shows that there is a dependency about color scale, TDS, Mn_{tot}, hardness $CaCO_3$, NO_2^-, and $KMnO_4$.

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