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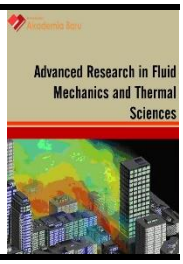

Physics-Chemical Analysis on The Surface and Ground Water: A Case Study in Aceh Province

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ABSTRACT

Environment is a habitat for all living things in the universe. Therefore, it must be preserved, especially on the surface and ground water. Environmental pollution in almost all over the world recently has been in a very alarming level. The main focus of this paper is to analyze the level of pollution on the surface and ground water that is influenced by industrial activities and other human activities. The method used in this research is field and laboratory investigations, and the material analyzed is the surface water and ground water samples. The analysis shows that industrial activities and human activities carried out so far correlated to the occurrence of pollution on the surface and ground water. The analysis showed that the heavy metal Ph at the highest water level of 0.01 mg/L was recorded in Lhokseumawe City. While the highest heavy metal Ph was also found in Lhokseumawe City by 0.0076 mg/L. The results of the analysis of heavy metals in groundwater analyzed at the three locations show that Lhokseumawe City is also the highest with 0.0076 mg/L compared to Bireuen and Aceh Utara District. While Aceh Utara District has the highest pollution for heavy metals Pb of 0.004 mg/L. Thus, there needs to be a supervision in active industries so that environmental pollution can always be stable in the future.

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1. Introduction

Surface and groundwater pollution over the past 10 years in some regions and even throughout the world has shown a very alarming rate [1,2]. This pollution occurs mainly because it is caused by several factors including industrial activity and the human activity itself. In some developing regions, industrial growth has increased very significantly followed by the increasing population in each country. Pollution on the surface of water and groundwater caused by various industrial companies in several countries has been investigated among them as was done by Mustafa *et al.,* [3], Ghosh *et al.,* [4], and Wu *et al.,* [5]. From many studies conducted, it was reported that pollution that occurs on the surface of water and groundwater, in general, is due to industrial activities.

Nitrate pollution presents on surface and groundwater is a major environmental problem throughout the world as reported by Nerantzis *et al.,* [6]. In their research, the SIAR model was used separately to analyze multivariate statistics in measuring and determining NO3 in surface and groundwater. An investigation of the potentially contaminated levels of surface water and groundwater contained in the two-dimensional domain has been carried out [3]. Where the results of an investigation carried out implied that the contamination of surface water and groundwater were caused by the pumping activity rate and erratic time period. Meanwhile, an analysis of groundwater pollution using a systematic method by combining numerical models had also been carried out [7]. Based on the results of their research it can be reported that the occurrence of pollution in phreatic aquifer groundwater was dominated by an intermediate level (45.27%). In addition, semi-limited aquifers constituted the second rank with relatively lower risk (30.29%) and at the intermediate level (38.17%). In China, it recently established an early warning against pollution in ground water as carried out by Huan *et al.,* [8]. In addition, China has also developed PMF and PCA-APCS-MLR receptor models functioning to identify latent sources of groundwater pollution [9].

Research on the analysis of environmental pollution has been carried out by several researchers beforehand such as those stated by Awaludin [10]. Groundwater pollution in Bandung has reached a very alarming level. While groundwater needs are required to reach an average health level of 86.4 liters/day/person. However, this cannot be fulfilled due to many factors especially with the increase of industrial companies. This increase is largely due to population growth and the increasing urban industry. Information about public discourse amid the attempts to negate the relevance of assessing scientific data and fact-based analysis that supports partisan opinions and ideologies has also been carried out by Sullivan *et al.,* [11]. Where the quality of surface and ground water in the United States has shown improvement over the last few decades. The reduction of pollution carried out has provided environmental, economic and social benefits to highlight the urgency to apply lessons in overcoming various environmental problems.

Furthermore, pollution in groundwater is also a major problem of air. Ground water pollution has reduced the consumption every day with the occurrence of drought in some areas. Ground water pollution in East China has also recently been studied by Fu *et al.,* [12]. This pollution can be reduced by presenting these two important biases so that the situation of water pollution can be improved by making policies and providing incentives to villagers so that these two biases can be overcome. Water supply is lacking due to air pollution as reported by Meyer and Elrahman [13]. Water pollution and reduced water supply have resulted in various health problems and resulted in human death. Meanwhile, in India, it was reported that surface water and groundwater had been contaminated by heavy metals [14]. Heavy metals that have been contaminated in groundwater and surface water include toxic traces, coliforms, and other organic and inorganic pollutants. Deaths caused by heavy metals occurred in Bangladesh especially to children. An analysis of the physics-chemical and concentration of heavy metals (HM) in the marble industrial waste and HM bioaccumulation in the

marble industry in the Mardan Industrial Zone (MIE) Mardan District, Khyber Pakhtunkhwa (Province), Pakistan has been reported [15]. Physics-chemistry was analyzed in 12 samples such as electrical conductivity (EC), pH, magnesium (Mg), turbidity, sodium (Na), potassium (K), calcium, hardness, chloride, and heavy metals, namely Copper (Cu), Zinc (Zn), Manganese (Mn), and Arsenic (As). Furthermore, the results of the analysis carried out were compared with the National Environmental Quality Standards (NEQS) of the WHO [16]. The results showed that most of the samples showed higher Physics-chemical parameters concerning permitted limits. An analysis of water quality is monitored seasonally at 33 sample locations collected at Gao-Bao-Shaobo Lake (GBSL) during 2016-2017 the results are collected over four seasons [17]. The results of the research conducted show that spatially, the western and southwestern GBSL are more relatively eutrophic and have been contaminated by heavy metals.

An analysis of environmental pollution on various physical-chemicals from the surface of the water and ground-waters has previously been done by many researchers. Various studies previously reported that the surface and ground waters is largely contaminated by heavy metals. This research focuses on physical-chemical analysis for surface and groundwater in three districts in Aceh Province region. This analysis was conducted to determine the impact on several industrial activities and human activities around. The study uses field and laboratory analysis methods based on SNI national standards.

2. Study Area

This research used laboratory analysis and field analysis methods. This case study work was carried out in three different districts within the Province of Aceh (Bireuen, Aceh Utara and Lhokseumawe). This analysis was conducted to determine the level for surface and ground water pollution in the area. The research locations in this paper are shown in Figure 1.

3. Material and Method

The analysis carried out in this paper is based on the field results and parameter analysis of surface and groundwater quality. Surface water samples were obtained from three different locations such as Bireuen district, Lhokseumawe City and North Aceh District. The samples analyzed in this paper include surface water and groundwater. While the parameters tested such as Ph, Fe, Mn, Hg, As, Cd, Se Zn and Pb for groundwater. While the parameters tested for surface water such as Ph, As, Co, Ba, Se, Cd, Cu, Fe, Pb, Mn, Hg and Zn. Analysis of the level of water pollution carried out in this paper was compared with the quality level set by the government (SNI 06.6989.25: 2005, SNI 6989.80: 2011, SNI 06-6859-2002 and SNI 06-6989.11-2004). Groundwater pollution was identified by detecting pollutants in groundwater. Comparison of groundwater chemical composition with surface water chemical composition and chemical composition of water-bearing rock layers can be used to determine the source of pollutants. The most common source of groundwater pollutants came from waste materials discharged by humans at the surface of the soil and cannot be filtered out by the soil layers [18,19].

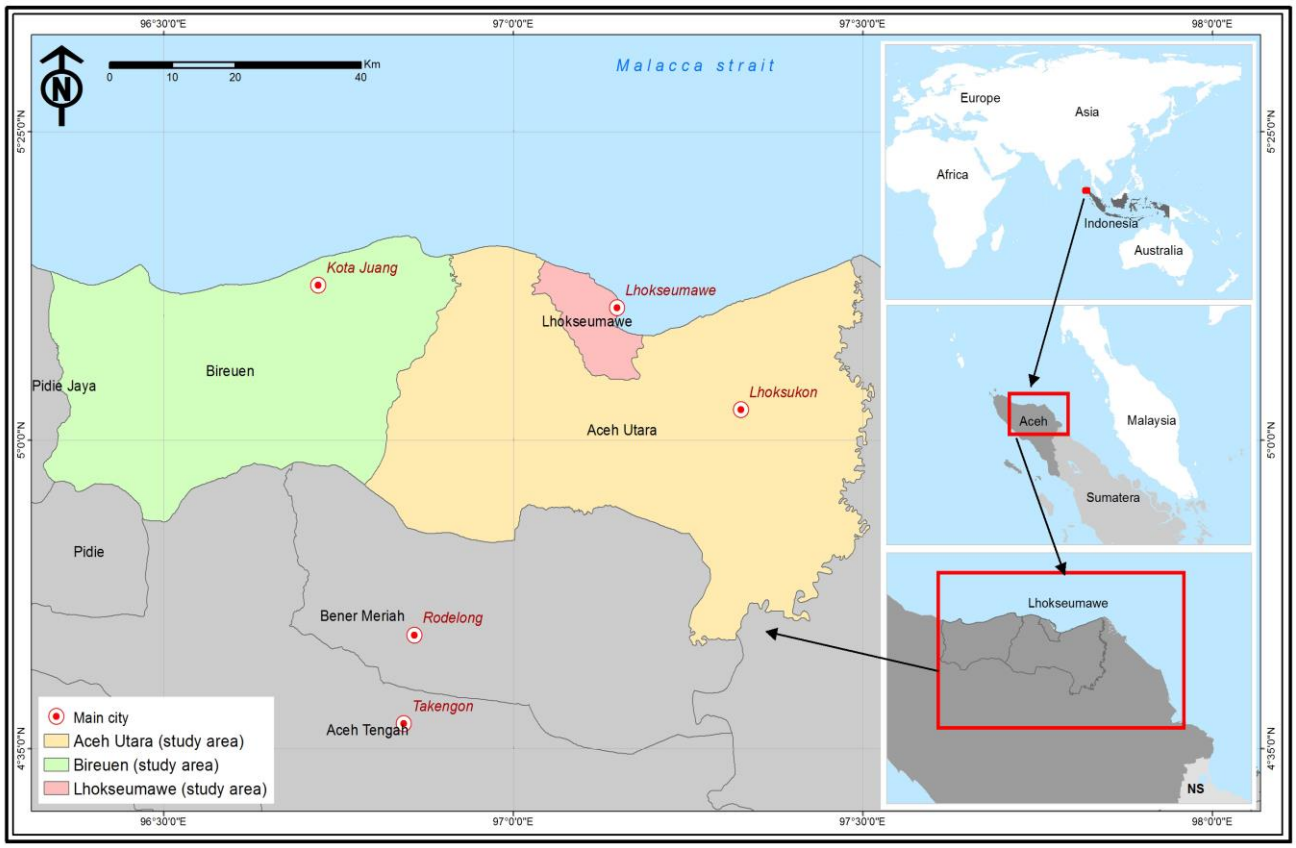

Fig. 1. Map of location data analysis

4. Results

The sample collection of this study was conducted in three different regions and coordinate points of Aceh Province. The analyzed sample consists of surface water and cleans water samples. All samples were collected from the study site and then below to the laboratory for further analysis. At the time of laboratory analysis, testing was carried out to determine the physical-chemical properties found in the whole sample. Chemical physical properties studied include heavy metals and others related to the purpose of the analysis. All samples were tested to determine the level of heavy metal pollution affected by various other industrial and human activities.

The results of the analysis of physical properties in the four coordinate points analyzed in this paper are shown in Table 1 and Table 2. The highest temperature was recorded at coordinate point of S: 05° 13’ 27.17” E: 096° 03’ 43.25” (Lhokseumawe City) with an altitude of 30.30°C. While the lowest temperature obtained at the coordinate point of S: 05° 12 ’13.35” E: 096° 58’ 24.01” (Aceh Utara) by 27.10°C compared to the coordinate point of S: 05° 12’ 12.99” E: 096° 29’ 25.80” (District of Bireuen) and S: 05° 13’ 43.949” E: 097° 03’ 28.71” (Lhokseumawe City) each reaching 30.10°C. The highest level of Dissolved Residue and Suspended Residue were recorded at Lhokseumawe City amounting to 767.40 mg/L and 45.30 mg/L, respectively. However, from the overall results analyzed, the physical characteristics analyzed were still below the permitted standard values.

Table 1
Physical characteristics of the surface of the water at Bireuen, Lhokseumawe and Aceh Utara

Bireuen District				Lhokseumawe City			Aceh Utara District		
Test Parameters	Result	Thresholds	Unit	Result	Thresholds	Unit	Result	Thresholds	Unit
Temperature	30.10	± 3	°C	30.30	± 3	°C	27.10	± 3	°C
Total Dissolved Solid (TDS)	629.00	1000	mg/L	541.00	1000	mg/L	585.00	1000	mg/L
Total Suspended Solid (TSS)	43.50	50	mg/L	43.20	50	mg/L	29.50	50	mg/L

An analysis of physical properties on the surface of the water and ground waters has also been carried out by previous researchers [20]. Where the results of the analysis carried out that heavy metals such as Cr, Mn, Co, As, Ni and Cd have been contaminated on the surface of the water and ground water. Based on the results of the analysis conducted in this study it can be concluded that temperature, dissolved residues and suspended residues have no impact on the surface of the water and ground water in this study area. This sample analysis was carried out as a reference to the construction of the oil drilling industry. The results of this analysis is to examine the environmental impact. Hence, when industrial development is carried out, the environmental pollution can be overcome as early as possible. Thus, the health of living things around can be guaranteed by a variety of industrial activities carried out every day.

Furthermore, an analysis was conducted to find out the impact of heavy metals found on the surface of the water and ground water. This research analysis stated that the heavy metals were contaminated by surface and ground waters. From the results of the analysis of the samples tested in the laboratory showed that the surface water and ground water have been contaminated by various heavy metals shown in Figure 2. The samples tested for Table 2 were taken from two locations or coordinates in Lhokseumawe City, Bireuen and Aceh Utara Districts. However, heavy metal pollution in the samples tested has not shown an alarming point. The pH value of NO_3 in the tested sample taken from the location or coordinates of the result was still below the specified quality standard.

The results of this study corroborated from the evaluation results from the surface and ground water had been interacted by natural water rocks (TDS, HCO_3−, F−) and anthropogenic pollution (NO_3−) conducted by Missi and Atekwana [21]. Heavy metals such as Zn> Cr> Cu> Pb> As> Cd> Hg were analyzed from surface water and sediments from Muara Sheyang in China [22]. Based on the analysis results heavy metals such as Cu, Pb, Cr and Cd had been significantly affected by anthropogenic activity. While heavy metals such as Co, Ba, Cd, As, Cu, Mn, Hg and Zn analyzed in this study indicated that the surface of the water in coordinates of Bireuen District had been contaminated by heavy metals. Moreover, the result from Lhokseumawe City, only Fe and Pb heavy metals that had not been contaminated in the water game as shown in Figure 2.

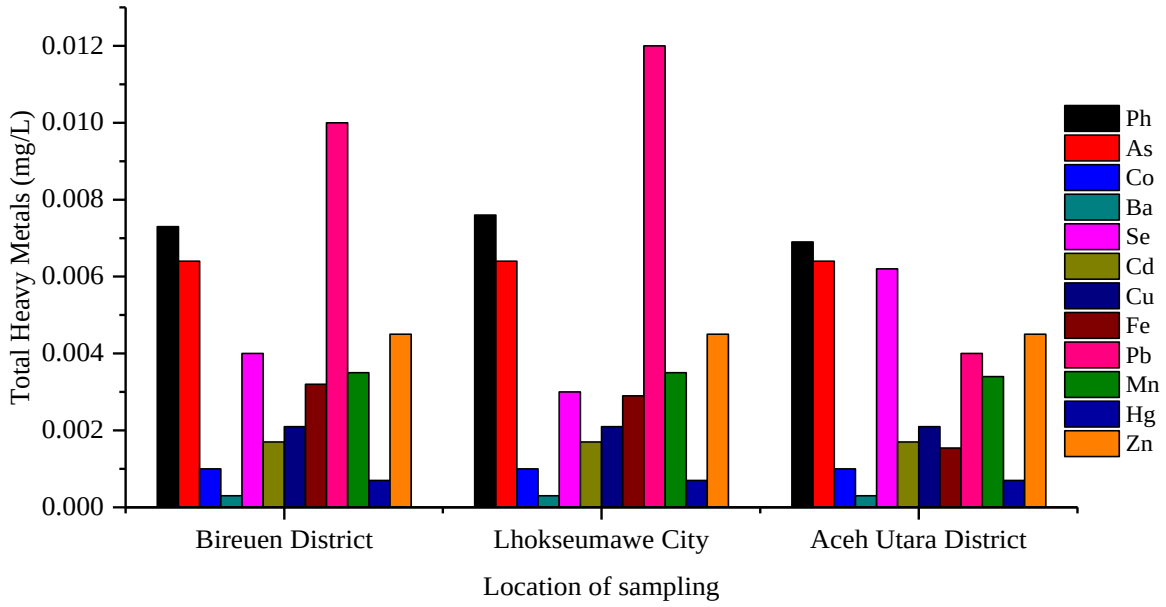

Fig. 2. Total heavy metals on the surface of the water for different place

Furthermore, sample analysis was conducted to determine the impact on heavy metal pollution on the surface of the water for Bireuen, Lhokseumawe and Aceh Utara. An analysis is needed to determine the impact on surface water pollution influenced by industrial and human activities. Water samples taken from the study site were analyzed in a laboratory and tested to analyze the level of heavy metal pollution. Surface water at coordinates of Lhokseumawe City was generally contaminated by weight (such as; Ph, As, Co, Ba, Cd, Cu, Fe, Mn, Hg and Zn). As for heavy metals (such as; Se and Pb) were still below the specified standard level shown in Figure 2. Meanwhile, at Aceh Utara District which had not been contaminated by heavy metals only had Fe and Pb.

Fortunately, the Ph at the water surface of the two coordinates is still below the maximum allowable standard. Besides, NO_3, Fluoride and Sulfate were still below the maximum standard set by the government or SNI standards. Analysis of heavy metals on the surface of the water had been widely done. However, the research location and the case that is carried out varying. The analysis carried out in this paper was specific to the chemical and heavy metal properties. The results of this analysis were used to predict the environment from various impacts on industrial activities and human activities. Also, this research was used for industrial development in the future. With the results of this analysis, human health impacts could be anticipated when various industrial activities were underway.

Next attempt of the research was the analysis of chemical properties and heavy metals in groundwater. This ground water sample was taken from two different locations at Bireuen District, Lhokseumawe City and Aceh Utara District shown in Figure 3. The analysis was carried out in the laboratory with sample testing to determine the chemical properties found in the groundwater. The chemical-physics analyzed are as shown in Table 2. The analysis shows that the color contained in groundwater has been contaminated by heavy metals for both regions. While the taste and smell of water have not been contaminated with heavy metals. In addition, water temperatures at both locations also have not shown in alarming levels. The highest groundwater temperature of 30.10°C was found at Lhokseumawe City, higher than the temperature of groundwater in Bireuen and Aceh Utara Districts.

TDS contents located in Lhokseumawe were higher than those in Bireuen. The level of turbidity of groundwater showed that it was still at a safe point. The highest groundwater drought of 0.75 NTU

was found in the Aceh Utara. While the level of drought in ground water in Bireuen and Lhokseumawe was 0.20 NTU and 0.10 NTU. While the highest TDS was recorded in Aceh Utara compared to Lhokseumawe and Bireuen respectively at 495.00 mg/L, 349.00 mg/L and 287.00 mg/L. Based on the results of the analysis, it was shown that the chemical properties were still at a safe point. However, to prevent ground water from falling, there was a need for supervision and policies from stakeholders. Therefore, ground water in the future would be maintained and the supply of ground water would be fulfilled. Overall, the results of the tests shown in Table 2 are still at a safe point and have not indicated the level of concern or have not been polluted. This is as the result obtained is still below the specified quality standard. However, this research focuses more on the discussion of heavy metal pollution in surface water and groundwater. While the results in Table 2 only see the extent of current pollution levels.

Table 2
Physical characteristics of the ground water at Bireuen, Lhokseumawe and Aceh Utara

Bireuen District				Lhokseumawe City			Aceh Utara District		
Test Parameters	Result	Thresholds	Unit	Result	Thresholds	Unit	Result	Thresholds	Unit
Turbidity	0.20	25	NTU	0.10	25	NTU	0.75	25	NTU
Color	<6.27	50	TCU	<6.27	50	TCU	<6.27	50	TCU
TDS	287.00	1000	mg/L	349.00	1000	mg/L	495.00	1000	mg/L
Temperature	27.01	+3	°C	30.10	+3	°C	29.30	+3	°C
Taste	N/A	N/A	-	N/A	N/A	-	N/A	N/A	-
Odor	N/A	N/A	-	N/A	N/A	-	N/A	N/A	-

After analyzing the chemical properties of ground water, next, an analysis of groundwater was carried out to investigate heavy metals that had been contaminated. The investigation into heavy metals in ground water was the same procedure as that carried out on the surface water. However, the heavy metals tested for groundwater was slightly different from the surface of the water. Heavy metals analyzed in laboratory tests included (Ph, Fe, Mn, Hg, As, Cd, Se, Zn and Pb). Groundwater in Lhokseumawe City area or precisely at Bireuen District had been contaminated with heavy metals such as Fe, Mn, As, Cd, Hg, Zn and Pb. Only heavy metals N, Se and SO_4 were not contaminated as shown in Figure 3 and detailed in Appendix-II. While in Aceh Utara District, the results showed a different result compared to the groundwater in Lhokseumawe City. Heavy metals had not been contaminated in groundwater in Aceh Utara such as Pb, $CaCO_4$, SO_4 and N. While the Ph and Organic Sat in the two regions studied were still below the standard level determined by the government or SNI standards. Research on the investigation into heavy metals in ground water had previously also been widely studied [23-26]. However, the results of several studies conducted previously reported that ground water, in general, had been contaminated by heavy metals. The level of contamination reported varied according to the place of the case study. The results of the analysis conducted in this paper were still at a safe point. However, in the future, there must be better supervision from various parties, especially the government as a policymaker.

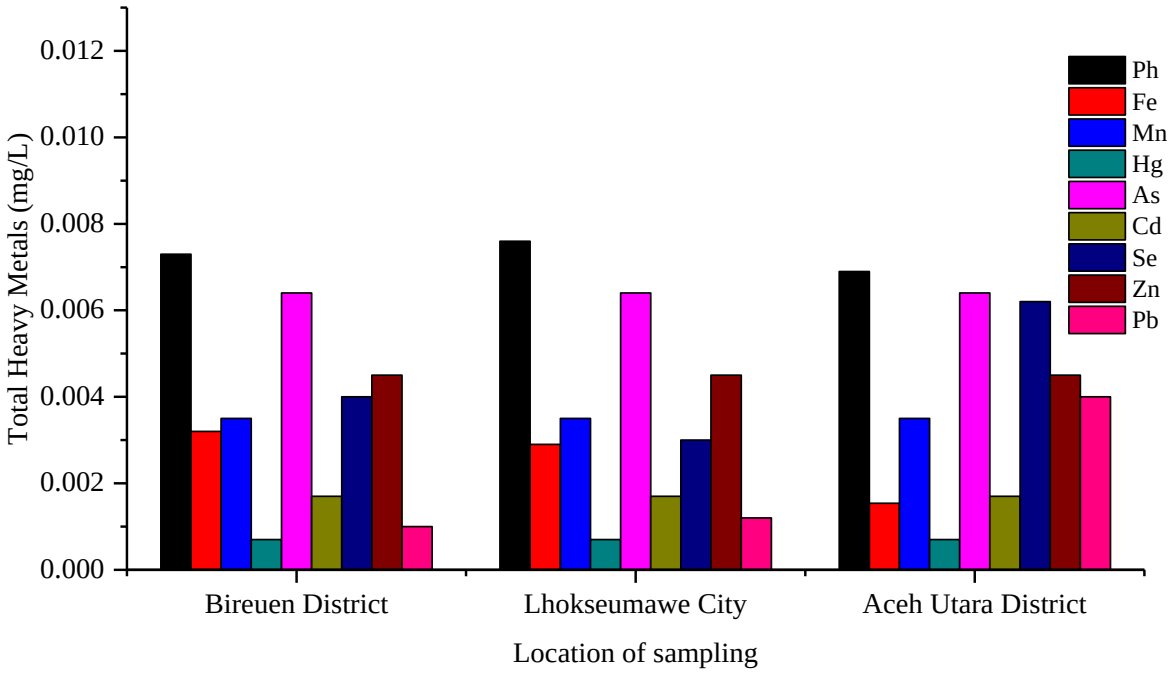

Fig. 3. Total heavy metals in the groundwater for a different place

Environmental pollution is not only carried out by industrial activities; however, people's unconsciousness of the environment can also have a considerable impact on the environment. The habit of people throwing garbage in rivers or places that are prohibited by the government is a source of water pollution, especially in urban areas, is shown in Figure 4.

Fig. 4. Condition of Lhokseumawe Reservoir Contaminated by Garbage

As a result of carelessly dumping garbage in the river by the community, the level of environmental pollution, especially water, has an impact on the health of the people around the river. As a result of irresponsible community actions, a number of points in the area have been contaminated with waste, such as food plastic waste, used bottles, household waste, leaves and

several other types of rubbish that are thrown away so that they have piled up on the edges of the reservoir. Environmental pollution caused by irresponsible community actions can be reduced by implementing policies and regulations as well as giving fines to every actor who littering carelessly. In this case, the government and stakeholders can make the policy. Thus, disposing of garbage which causes pollution to the environment can be as hot as being drained and reduced.

The right approach to replace or combine completion at the final processing site that has been implemented is by implementing the 3R principle approach (reduce, reuse, recycle), extended producer responsibility (EPR). Undang-Undang (UU) Republik Indonesia with Number 18 of 2008 concerning Waste Management mandates the need for fundamental changes in waste management that have been running so far. According to Pasal 19 of the UU, waste management is divided into two main activities.

5. Conclusions

Based on the results of the analysis conducted for surface water and groundwater in the study area as a whole have been contaminated by heavy metals. The results of the analysis conducted in this study are summarized below

i. The highest Pb heavy metals were found in Bireuen District and Lhokseumawe City of 0.01 mg/L and 0.012 mg/L, respectively. While the highest Se heavy metals were found in Aceh Utara District Kabupaten of 0.0062 mg/L.
ii. For heavy metals, the highest Ph for surface water was recorded in Lhokseumawe City by 0.0076 mg/L. While Bireuen and Aceh Utara districts were slightly lower than Lhokseumawe City with 0.0073 mg/L and 0.0069 mg/L, respectively.
iii. The highest Ph heavy metal analyzed for groundwater was found in Lhokseumawe City by 0.0076 mg/L. While the highest Se heavy metal of 0.0062 mg/L was found in Aceh Utara District.
iv. Pb heavy metal in groundwater from the three locations analyzed, Aceh Utara District was the highest at 0.004 mg/L compared to Kota Lhokseumawe and Bireuen.
v. Increased environmental pollution, especially in water because it is caused by the people who are not responsible for littering.
vi. The Indonesian government has implemented a policy on waste management as in UU no. 18 of 2008 in Pasal 19.

6. Suggestion

Environmental pollution, especially on the surface and ground water can be reduced by making appropriate policies made by stakeholders or the government. Regulations and supervision of industrial companies must be made so that environmental pollution can be dealt with as quickly as possible.

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