

Pb Distribution in Groundwater and Its Impact to the Health of Indonesia's Capital Citizen

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Abstract. This study aims to measure the Pb distribution in Jakarta Capital Region's groundwater and its recommendation based on the standards of The Health Minister Decree No. 492 / MENKES / PES / IV / 2010 about The Drinking Water Monitoring. The study also aims to analyze the impact of Pb intoxication in the human body. The study activity uses the field data that carried out by Geological Agency, Ministry of Energy and Mineral Resources, Indonesia from March to April 2015. The methods used in this study are direct observation and hydrogeological measurement to measure physics and chemistry parameters. The result showed that the Levels of heavy metals Pb (Lead) in the west – southwest of Jakarta Groundwater basin (Ciputat, Pamulang, Ciledug, Kebayoran, Pondok Cina, Pondok Jagung, and Serpong) are beyond the quality standards that has been suggested by the ministry of health . The government set the standard in 0.1 mg/L while these areas have the Pb content of up to 0.654 mg/L. In addition, Pb anomalies also occur in Muara Angke, Kamal Muara, and Kapuk Region of North Jakarta which has a very High level of Pb which is about 1.09 mg / Liter. Pb intoxication in humans can affect the reproductive system, mutagenicity, carcinogenicity, and have bad effects to the nervous system of infants and children.

1. Introduction

The research area is located at the coordinates of 106 ° 41 '19 482' - 106 ° 54 '46.5624 " east longitude and -6 ° 5' 49.0164" - 6°21'48.5964" south latitude. Administratively, the study area is located in The



Special Capital Region of Jakarta, Java Island. Topographically, the study area is classified as a flat area and ramps with the height from the beach to the mainland ranges from 0 m to 10 m[1].

Geographically, Jakarta is bordered by Banten in the west, West Java in the east, and the Java Sea in the north. Jakarta is an area with a high population density of 15,367 people / km²[2]. The purpose of this study is to determine the distribution of Pb in the groundwater of Jakarta. In addition, this paper also provide the theoritical analysis of the impact caused by this situation to the human body. The purpose of this study is to determine the distribution of Pb in the groundwater so that the people of Jakarta can realize the presence of Pb in their community, so that the people of Jakarta can avoid the use of groundwater in the area with high Pb content. The previous studies only focused on the Pb contamination in surface water and also in the pipeline, regardless of the quality of the aquifer.

Hopefully this research could become the benchmark for the government and private sectors in terms of directing people in the exploitation of water. In addition, the authors hope that this research could be the basis for the other academics in evaluating the quality of groundwater in Jakarta.

Lead contamination in the groundwater can be caused by industrial waste disposal that contaminate the river and also the increasing domestic waste[3]. Lead is a heavy metal that is used for the production of batteries, ammunition, cable leather, dye, glass, ceramics materials, metal casting, and others. The important properties of Pb metal are elasticity, low melting point, high density, and the ability to absorb the gamma radiation and X-rays. The molten lead is a good solvent to collecting silver and gold elements. In addition, the lead also could be used as a sound and vibration dampening material. The lead can affect the human body if it is inhaled or swallowed[4]. Lead is a toxic compound that the human body cannot digest. The high accumulation of Pb can cause death. It can lower the intelligence of the children and it can lead to the kidney disease in adults[5].

2. Geology

The study area is composed of alluvium Sediment Deposits from Holocene and Alluvial Fans from Pleistocene. In the north area there are also the quarter's Beach Ridge Deposits.. Alluvium deposits consist of clay, silt, sand, gravel, pebble, and boulder. Alluvial Fans consist of bedded fine tuff, sandy tuff, and interceded with conglomeratic tuff. The beach ridge deposit consists of well sorted coarse sand with molluscs' shell [6].

3. Method

The sampling method has been used for analyzing the chemical content of the groundwater in the laboratory. The measurement and sampling were conducted at 154 points of observation well in April 2015 by Resource Center of Groundwater and Environmental Geology. There are 40 dug wells, 41 drilled wells, 47 monitoring wells, and 26 production wells. The measurements are consist of TDS (Total Dissolved solid) measurement, EC measurement, and Ph. measurement using Electric Conductivity Meter and pH Meter. These parameters are based on the Regulation of the Health Ministry of the Republic of Indonesia No. 492 / Menkes / PES / IV / 2010 on Drinking Water Quality Requirements [7].

The sampling activities was using special water sampler produced by Geological Agency of Indonesia. The sampling in the dug wells was conducted by lowering the container into the wells at a certain depth to contain the water, removing and transferring the water into a sterile container and free of contaminants that can be closed tightly. The Sampling in monitoring wells was conducted by draining all the water in the well pipe, waiting until the well is filled back, and taking the samples in the filled-back well with tightly and sterile. The sampling in the production wells was conducted by opening the well's faucet, letting it flow until drain for 1 minute - 2 minutes and then inputting the tap water sample into a sterile container that sealed [8]. After the sample has been collected, analyzed the content of Pb in the Resource Center of Groundwater and Environmental Geology. After that, the data content of Pb is described in the form of Pb distribution map, to be analyzed. We plotted the data set and build the distribution with Mapinfo Software. After that, we interpreted interaction between groundwater and correlate it with the quality assesment that have been done.

4. Results and Discussion

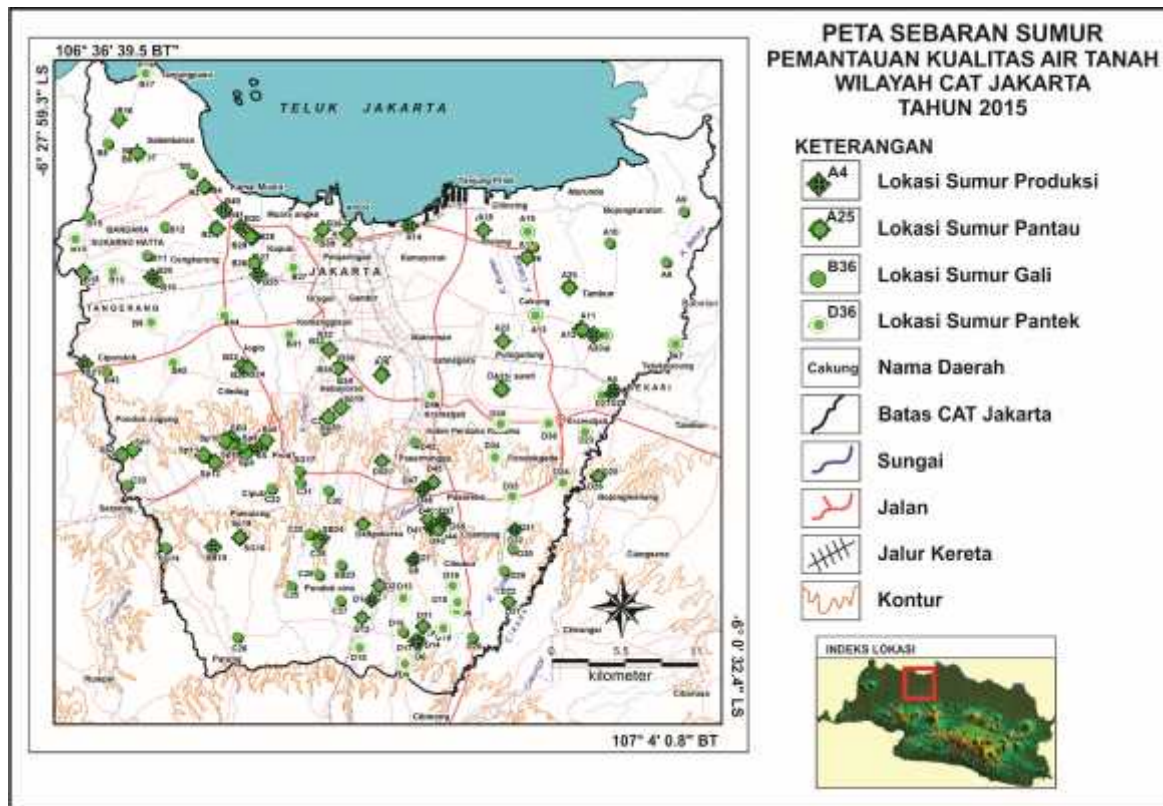


Figure 1. The Map of wells distribution for Groundwater Quality Monitoring in Jakarta.

The study was conducted by monitoring and testing the 154 locations of well in Jakarta. They are divided into four types of wells which are 40 dug wells, 41 drilled wells, 47 monitoring wells, and 26 production wells (Fig.1). Based on the lead level zonation map that have been made (Fig.2), several areas in Jakarta's groundwater contain the Pb starting from 0 mg / L to 1.09 mg / L. The western and the southwestern area of Jakarta, which are Ciputat, Pamulang, Ciledug, Kebayoran, Pondok China, Pondok Jagung, and Serpong contain the Pb content of 0 mg / L to 0.654 mg / L. The areas around Pulogadung have the Pb content of 0.218 mg / L to 0.436 mg / L. The northwestern area Jakarta, which is located around Soekarno Hatta International Airport and around the borders between The West Jakarta Municipality and Tangerang City, have the Pb content of 0.218 mg / L to 0.872 mg / L. However, the northern part of Jakarta which consist of Muara Angke, Kamal Muara, and Kapuk, has a very high Pb content up to 1.09 mg / L.

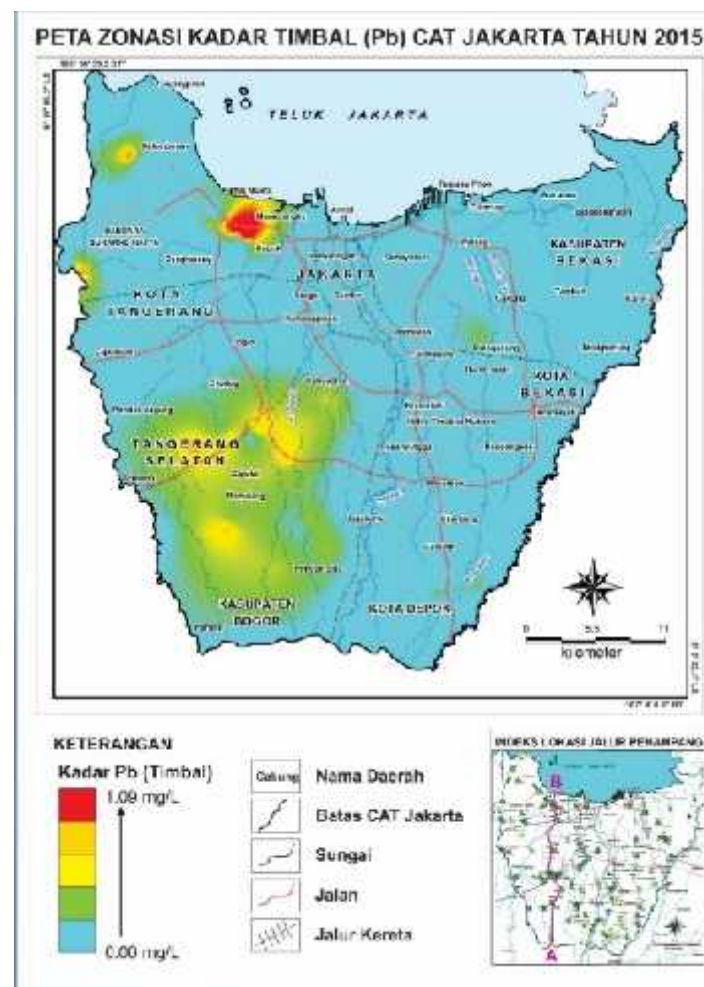


Figure 2. The Pb content zonation map of Jakarta Capital Province.

From the distribution of these wells, The East Jakarta territory is relatively secure from the existence of Pb. On the other hand, The South-west and North-west area of Jakarta contain the significant amount of Pb. Based on our analysis, this is because the area is affected by the chemical properties of volcanic rock that came from Mount Limbung and Mount Cibugis which are located in the south of Jakarta (Fig.3) and adjacent to the location of our study [9]. Although these areas exceed the standard limit according to the government, they are still within reasonable limits in nature and in its natural state in this particular area. But, it is absolutely not safe for public consumption. However, there are some areas such as in Salembaran, Kamal Muara, Muara Angke Kapuk, Pulogadung, and the southwestern part of the Soekarno-Hatta which are considered anomaly. This condition occurred because of the different geological condition between East Jakarta groundwater basin and other areas. Meanwhile, the situation in the western part is very likely happening because of the contamination of Non-natural waste which affect the groundwater.

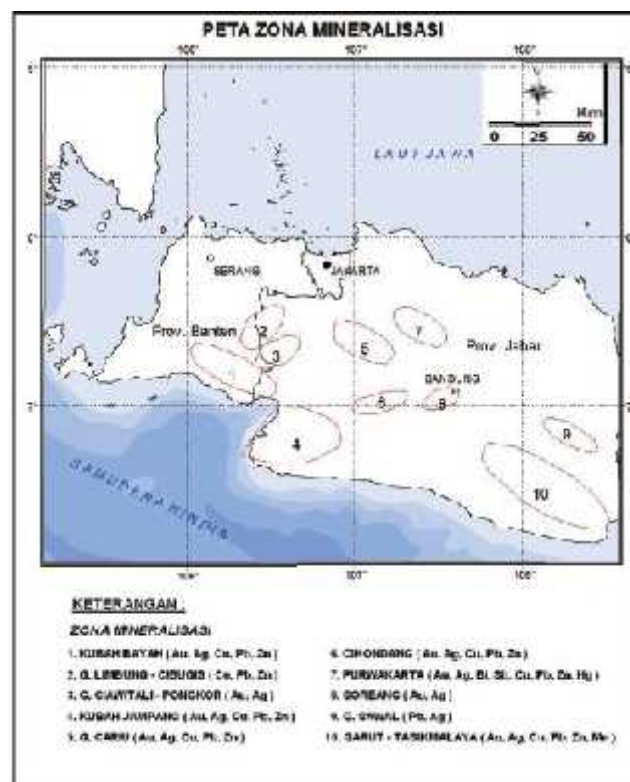


Figure 3. Metal Mineralization Zone in West Java and Banten (Sunarya, 1997).

Based on the Ministry of Health Regulation No. 492 / Menkes / PES / IV / 2010 on Drinking Water Quality Requirements, the maximum permissible levels of Pb content is 0.01 mg / L. but in the Jakarta area, the Pb content value exceeds the value of the government standard, It can cause the harmful effects on the human body.



Figure 4. Pb Content Diagram of Groundwater of Jakarta

When the water that has a high content of Lead is consumed, it will go into the digestive system as well as human blood. The absorption rate of the lead for the children is around 53% and 10% for the adults [10]. The increasing of gastric acid could also increase the intestinal absorption that could affect in the increasing absorption of lead [11].

This condition has an adverse health effect. Pb can enter human body through uptake of food (65%), water (20%) and air (15%). Pb intoxication will cause unwanted effects such as disruption of biosynthesis of haemoglobin and anemia, brain damage, kidney damage, rise in blood pressure also behavioral disruptions of children such as aggression, impulsive behavior and hyperactivity[11][12].

Based on World Health Organization (WHO) Guidelines for drinking water quality, water level with high Pb concentration has an adverse health effect to human and animals. Pb intoxication in

human will influence the reproductive system, mutagenicity, carcinogenicity, and has bad impact to neurological system in infant and children [11].

The severity of Pb intoxication depends on the exposure level. Blood Pb levels of 100-120 $\mu\text{g/dl}$ in adult and 80-100 $\mu\text{g/dl}$ in children will lead to acute intoxication, sign and symptom including dullness, restlessness, irritability, poor attention span, headaches, muscle tremor, abdominal cramps, kidney damage, hallucinations, loss of memory and encephalopathy. Signs of chronic Pb toxicity including tiredness, sleeplessness, irritability, headaches, joint pain and gastrointestinal symptoms appear in adults at blood Pb levels of 50-80 $\mu\text{g/dl}$. There are indications of increased hypertension at blood Pb levels 7-34 $\mu\text{g/dl}$ and high diastolic blood pressure in people aged 21-55, but the significance of this result has been questioned[11].

Blood Pb level at 40-50 $\mu\text{g/dl}$ will lead to gonadal dysfunction in men, including depressed sperm counts. In women with pregnancy will lead to preterm birth, and encephalopathy. Several study also investigate the effect of Pb in neurological effect, there are possible detrimental effects that exposure of Pb in children might have on their intellectual abilities and behavior [11] [13].

Table 1. Water quality standards based on physical and chemical parameters according to the government

Parameter	Standard Value	Parameter	Standard Value	Parameter	Standard Value
Turbidity (NTU)	5.0	$\text{K}^{+}(\text{mg/L})$		TDS(mg/L)	1000
Color (ICU)	15.0	$\text{Na}^{+}(\text{mg/L})$	200	Zn(mg/L)	3
Smell	tb	$\text{Li}^{+}(\text{mg/L})$		Cu(mg/L)	2
Taste	tb	$\text{NH}_4^{+}(\text{mg/L})$	1.5	Pb (mg/L)	0.01
DHL ($\mu\text{S/cm}$)	6.5-8.5	$\text{CO}_3^{2-}(\text{mg/L})$	-		
pH	500.0	$\text{HCO}_3^{-}(\text{mg/L})$	-		
CaCO_3 (mg/L CaCO_3)	0.30	$\text{Cl}^{-}(\text{mg/L})$	250.0		
Ca^{2+} (mg/L)	0.10	$\text{SO}_4^{2-}(\text{mg/L})$	250.0		
Mg^{2+} (mg/L)	200	$\text{NO}_2^{-}(\text{mg/L})$	200		
$\text{Fe}^{3+}(\text{mg/L})$	0.30	$\text{NO}_3^{-}(\text{mg/L})$	50.0		
$\text{Mn}^{2+}(\text{mg/L})$	0.10				

The above table (Table 1) is the parameters which are used as the basis of this study. Notice that the standard value of the Pb content is 0.01

5. Conclusion

Based on data analysis, it can be concluded that the western part of Jakarta Capital Region is an area contaminated by Pb, while the eastern part of Jakarta Capital Region is relatively safe from Pb contamination. The southern region of East Jakarta municipality is considered having safe groundwater from the Lead contamination. In contrast, the southern region of West Jakarta municipality contains the significant amount of Lead. That can be caused by the chemical properties of rocks that exist in the recharge area of the region. The recharge area of this region is located on the mount Limbung and Cibugis. With Pb content value is still within reasonable limits. However, the regions with the highest Pb contents are located in the North Jakarta Municipality which is located around Kapuk, Kamal, and Muara Angke. It is estimated that this situation occurs because of the domestic waste along with the factories waste.

Pb intoxication will cause unwanted effects such as disruption of biosynthesis of haemoglobin and anemia, brain damage, kidney damage, rise in blood pressure also behavioral disruptions of children such as aggression, impulsive behavior and hyperactivity. Pb intoxication in human will influence the reproductive system, mutagenicity, carcinogenicity, and has bad impact to neurological system in

infant and children. Footnotes should be avoided whenever possible. If required they should be used only for brief notes that do not fit conveniently into the text.

6. References

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