Groundwater Quality Assessment in Jakarta Capital Region for the Safe Drinking Water

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Abstract. This study aims to determine the quality of Jakarta Capital Region’s groundwater and its recommendation based on the standards set by the Indonesian government especially The Health Minister Decree No. 907 / Menkes / SK / VII / 2002 about The Drinking Water Monitoring. The study activity uses the 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 results show that most places in the study area have the low quality of groundwater which is below the drinking water quality standards according to the government. However, at the unconfined aquifer (depth of 0-40 meters), the certain areas such as in the Kramat Jati, Halim Perdana Kusuma, Tongkol-Pademangan, and Duren sawit are still relatively safe for consumption as drinking water. In addition, the confined aquifer (depth> 40 meters) such as in the area of Cibubur, Pasar Rebo, and Jagakarsa are considered safe for consumption as drinking water. This study is expected to be used as a benchmark for researchers, especially academics in the region in order to maintain the sustainable groundwater resources in the area.

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].
Jakarta at the heart of the Indonesian state development has attracted Indonesian citizens from the entire country to live there for work and other purposes. The population growth rate in the area from 2014 to 2015 is 1.02% with the population density of 15,366 people / km² [2]. As a result, a lot of land has changed its function to accommodate the wave of migration from the outside to be used as residential, industrial, and other public facilities. It raises concerns about the quality of ground water beneath the city. Although the majority of the Jakarta citizens uses the groundwater for Bathing and Washing purpose only, it is possible that residents may use it for drinking water due to water scarcity. The drinking water itself is a water through or through not the treatment process which are qualified and can be used to drink. Our thesis is that the groundwater quality in the Jakarta Capital Region doesn’t qualify as the drinking water.

This study aims to determine the quality of Jakarta Capital Region’s groundwater and its recommendation based on the standards set by the Indonesian government especially The Health Minister Decree No. 907 / Menkes / SK / VII / 2002 about The Drinking Water Monitoring[3]. The study activity uses the data that carried out by Geological Agency, Ministry of Energy and Mineral Resources, Indonesia from March to April 2015 which was done by the hydrogeological mapping method.

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.

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 molluses’ shell [4].

3. Method

The measurement and sampling were conducted at 154 points of observation well. 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. The sampling procedures occurs in this following step steps: sampling preparations, accessing the well before sampling and securing the well after sampling, measuring the water level, purging the well, and collecting and delivering the water sample[5]. The sampling has been used for analyzing the chemical content of the groundwater in the laboratory.

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. After the sample has been collected, we made a potentiometric map using groundwater and river water level data. We plotted the data set and build a water flow model based on the contours using te Surfer 9 (Contours) and Mapinfo (Layouting and plotting). After that, we interpreted interaction between groundwater and correlate it with the quality assessment that have been done.
4. Results and Discussion

There are two types of aquifers in the research area. The first is the unconfined aquifer that has a depth in the range of 0 to 40 meters below the surface. While the second is a confined aquifer that has a depth of more than 40 meters below the surface.

The above picture shows the distribution of wells in the unconfined aquifer (fig1). It can be seen that most of the well points are marked in red. The red color means that the water quality of those respective water wells couldn’t qualify as a drinking water according to the government standards. While the blue color means that the well can be used as a drinking water. The districts that have qualified as a drinking water are Kramat Jati, Halim perdana kusuma, and Duren Sawit districts which are located in The East Jakarta Municipality.
At the unconfined aquifer which has a shallow depth of no more than 40 meters, the flow direction tends to lead to basins which are located in the north, northwest and northeast of the study area as can be seen in Figure 2. The flow of water generally comes from the outside of the study area which is mainly from the south where there are mountains allowing it to become recharge areas to supply the water to the research area’s aquifer.
Based on the distribution wells in figure 3, which is the distribution of sampling wells in the confined aquifer, it can be seen that most of the well points were also marked in red. While the blue marks are located in The Jagakarsa region, Pasar Rebo, and Cibubur.

Figure 3. The map of wells distribution in the confined aquifer.

Figure 4. The flow Pattern map of the confined aquifer in the study area.
In the confined aquifer of the study area, the wells that are classified as safe that has mentioned earlier supply the water to other areas, according to the flow pattern map that has been made in Figure 4. That means, the areas like Jagakarsa, Cibubur and Pasar Rebo have the safe groundwater to be used as a drinking water.

Unfortunately, these two flow pattern maps are unreliable to become a prediction of the water quality distribution in the future. Because, the flow pattern in the study area is strongly influenced by the industrial installations’ exploitation and other infrastructure. Therefore, the flow pattern can change at any time depending by the progress of development or population growth in this region.

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           | K+ (mg/L)       | 200            | Zn (mg/L)       | 3             |
| Color (TCU)     | 15.0          | NH4+ (mg/L)     | 1.5            | Pb (mg/L)       | 0.01          |
| Smell           | ∅             | Cl– (mg/L)      | -              | Na+ (mg/L)      | -             |
| Taste           | ∅             | CO3²- (mg/L)    | -              | CaCO3 (mg/L)    | 0.30          |
| DIll (µS/cm)    | 6.5 – 8.5     | HCO3⁻ (mg/L)    | -              | Mg²⁺ (mg/L)     | 230           |
| pH              | 500.0         | SO4²⁻ (mg/L)    | 250.0          | Fe³⁺ (mg/L)     | 0.30          |
| Ca²⁺ (mg/L)     | 0.10          | NO3⁻ (mg/L)     | 200            | Mn²⁺ (mg/L)     | 0.10          |

The table above is the parameters and values which was used as the primary basis of this study. Based on the test results, most wells in the two aquifers couldn’t qualify as a drinking water caused by the excessive contents of iron, manganese, pH, Na, turbidity, and others, which automatically approve our hypothesis. The water cannot qualify when one or more parameters don’t pass the government standard that have been suggested. These wells are not recommended for consumption or can be consumed if they are purified through the certain methods such as reverse osmosis, ion exchange resin, or other methods available.

Generally, the groundwater in Southern region Jakarta is not safe to be consumed as the drinking water. This happens because the region has an excessive concentration of Fe and Mn. But, its TDS (Total Dissolved Solid) and SC (Specific Conductivity) value are still considered as fresh water. In contrast, in the northern region of Jakarta, the DC and TDS values are very high which already exceed the standard value of fresh water.

Table 2. Total Dissolved Solid value (Freeze and Cherry, 1979).

| Category       | TDS Value |
|----------------|-----------|
| Fresh water    | 0 – 1000  |
| Brackish water | 1000 – 10,000 |
| Saline water   | 10,000 – 100,000 |
| Brine Water    | >100,000  |
Most areas of the north Jakarta Municipality, Central Jakarta Municipality, and Tangerang city have TDS values which range between 2,000 to 16,000 mg / L that comes into the category of Brackish water to saline water according to the classification of Freeze and Cherry [6].

| Table 3. Specific Conductivity value (Mandel, 2012). |
|------------------------------------------------------|
| **Type of water** | **Specific Conductivity** |
| Distilled water  | 0.5 – 50 μS |
| Rain water       | 5.0 – 30 μS |
| Fresh water      | 30 – 2000 μS|
| Sea Water        | 45,000 – 55,000 μS |
| Salty water      | >90,000 μS |

The values of SC in the Northern Territory of Jakarta (North Jakarta Municipality and Central Jakarta Municipality) and Tangerang city were recorded in the ranges of 2000 μS to 32000 μS. Based on the classification provided by Mandel [7], the content of dissolved ions from the wells in these areas far exceeds the normal ground water standards which is 0 to 2000 μS. Both TDS and SC values may be caused by the influence of salt water intrusion from the north coast of Jakarta. Litanya and Putu (2009) found the anomaly gravity concentrations in Cilincing, north Jakarta that leads to the possibility of seawater intrusion. In addition, this high level of SC and TDS both in the north (Tangerang city and North Jakarta Municipality) and in the center (Central Jakarta Municipality) can be caused by the extensive industrial activity which could potentially breach the waste to the groundwater.

Meanwhile, in the south region of Jakarta (South Jakarta Municipality, South Tangerang City, and South territory of East Jakarta Municipality), The Fe and Mn values are already over the threshold that allowed by the government. This can be occured as a result of natural conditions of the region. Aquifers in the south region of Jakarta are supplied by the mountainous southern region that is dominated by young volcanic products (Turkandi et all, 1992). Iron and Manganese bearing volcanic rocks can cause the high level of those chemical elements in groundwater.

5. Conclusion
We can conclude that most districts in The Jakarta Capital Region have a generally unsafe groundwater for drinking water. But, there are some places in both aquifers that qualify the standards. The safe drinking water in the unconfined aquifer are located in Kramat Jati, Halim perdana kusuma, and Duren Sawit districts which are located in The East Jakarta Municipality. Additionally, there are some areas which have the safe drinking water in their confined aquifer which are Jagakarsa, Pasar Rebo, and Cibubur districts.

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