Assessment of Groundwater Quality Based on Geoelectric and Hydrogeochemical Parameters Around Slaughterhouses of Pekanbaru City, Indonesia

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Abstract. Groundwater management in an industrial environment is very necessary. This water is a source of consumption and sanitation for the community. The presence of the slaughterhouse industry near residential areas has the potential to pollute underground water if the waste is not managed properly. In Pekanbaru city, there is a slaughterhouse industry that operates around residential areas. The purpose of this study is to investigate groundwater contamination around the slaughterhouse. This study uses the integration of geoelectric and hydrogeochemical methods to investigate the level of groundwater contamination in several locations in the study area to see the sustainability of underground water both in quality and quantity. Based on the geoelectric method the flow pattern and depth of the aquifer have been successfully analyzed at intervals of 7.5 m to 11 m. and the results obtained from the geochemical method that the value of pH, BOD, COD, and NH3 is still below the standard threshold. Water quality index (WQI) is still classified as "good" with a score range of 25-50. Seemly, the slaughterhouse has implemented a waste management system properly, so it does not pollute the surrounding underground and surface water.

1. Introduction
Ground water is a natural resource that is widely used for consumption, activities, agriculture, and industrial use (Juandi and Syahril, 2017). Resource management includes several points including inventory, utilization regulations, permits, guidelines, control, and monitoring of catchment areas. This is achieved by relying on the principles of social functioning and economic value, public benefits, integration, harmony, balance and sustainability (Juandi, M. 2020). Inadequate information reduces the level of success in planning and managing groundwater sources. This is caused by complexity and feedback in human-environmental interactions, which require accurate data to improve efficiency and success in the planning and management of groundwater resources (Muhammad Juandi et al. 2017).

Groundwater management must also focus on the feasibility of the water for community use. This case needs to involve long-term analysis and assessment of the groundwater system and routine monitoring by the government (Juandi, & Syahril, 2017). Management must also aim to monitor the appropriateness of water used in the community, which is influenced by the detection of the Soft Soil (Islami, 2019). In order for sustainable management to be maintained, there is a need to avoid things that trigger complex problems later (Juandi, 2019). Further groundwater feasibility monitoring planning studies about the Hot Spring Area (Islami and Irianti, 2019, october). This needs to be supported by aquifer flow modeling for risk assessment.

Groundwater management relates to hydrological data for calculation and modeling, integrated geophysical image is required (Islami, and Irianti, 2019). However, more efficient studies of water
management involve sustainable use, and it is therefore necessary to regulate the use of groundwater, adjacent areas with industry and potentially lead to contamination of ground water (Van de Meens et al. 2011). Pekanbaru slaughterhouse located in Riau province is a supplier of fresh cut meat to the Pekabaru community in particular. The approach to assessing water quality is based on an experimental, meticulous comparison of parameter values with established quality standards. The use of this methodology enables the identification of appropriate sources of contamination and assesses the suitability of water for mass consumption. (Debels et al., 2005). Physical, chemical and biological parameters are used as feasibility parameters before water is used for various human needs (Sargaonkar and Deshpande, 2003). The assessment of water quality aims to describe the potential for water pollution in residential areas adjacent to slaughterhouse areas. The parameters used to determine water quality are Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), acidity (pH), dissolved solids (TDS) and NH3. In order to manage and maintain groundwater sources, it is necessary to assess the potential distribution and feasibility of water quality around the slaughterhouse industry. The geo-electric method is the cheapest and fastest method for providing groundwater analysis and distribution of interpretations of Slip Surface and Weathered Layer (Radil, et al. 2019). The study of groundwater involves a geophysical method that analyzes the distribution in two dimensions (Demirel et al. 2018; Santoso et al. 2006). Geoelectric applications for determining saltwater boundaries in alluvial aquifers have been reviewed (Loke et al. 2013). In this research, a new study links the characteristics of aquifers with hydrochemical parameters in the Pekanbaru slaughterhouse area. This research further provides a model of sustainable groundwater management for industrial and housing aspects to prevent water pollution in areas close to similar industrial zones.

2. Methodology

2.1. Study area
This research conducted by the direct measurement around the area of a slaughterhouse in Tampan district, Pekanbaru city. Geographically, the slaughterhouse is at the coordinates latitude of 0°25'59.5” and longitude of 101°23'46.1”. Geoelectric measurements carried out in 3 lines can be seen in Figure 1. Geoelectric measurement locations on lines 1, 2 and 3 of the slaughterhouse industry have different distances, namely 85 m, 257 m, and 248 m.

Figure 1. Location of slaughterhouse of Pekanbaru
2.2. Geoelectric Survey

![Figure 2](image)

Figure 2. (a) Resistivity meter and (b) activity of geoelectrical measurement in the location.

A total of 3 trajectories were investigated for 1D geoelectrical resistivity imaging with a length of 150 meters. Geodetic data is obtained using a topographic survey that produces information about coordinates and altitude. Then these coordinates are used for the measurement part in the geophysical survey. Geophysical data collection is done by the geoelectric method using the Schlumberger array (Juandi, 2019). This configuration utilizes 4 electrode-probes, i.e. 2 for currents and 2 for voltages. Measurements are taken by determining the potential in the middle electrode when the current in the outer rod fires into the earth as shown in Figure 2. Measurements are taken from the smallest to the largest electrode space, resistivity values are obtained automatically for each current and voltage pair of electrodes. To obtain a true resistivity profile, real data obtained from the field is processed computationally. Based on the pattern of potential line maps formed, it is possible to determine the direction of aquifer distribution below the surface of the area under investigation.

2.3. Water sample analysis

Water quality data from observation sites in Pekanbaru slaughterhouses are considered for calculating water quality index (WQI). 5 parameters for index calculations descriptive statistics of these parameters are presented in Table. The results in a value are categorized by WHO standards. It is clear that the water samples at 5 points are taken are still in the safe and non-hazardous category. Figure 1 shows the sampling location related to the effects of slaughterhouse waste with 5 sites. Sampling was also carried out distribution at several locations. The distance between sample points 1 to 5 toward the RPH industry is 88 m, 220 m, 135 m, 472 m and 581 m.

The characteristics of groundwater quality were analyzed using hydrogeochemical analysis. The parameters monitored from the sample include BOD, COD, TDS, pH and NH₃ which are measured directly during collection of groundwater samples. Figure 2 shows the study area, geoelectric measurement location, and groundwater survey. Groundwater samples were then analyzed for anion content using ion chromatography (Morales, 2000). Water samples are filtered in acids and adjusted to pH 4 and 7 standards to analyze the presence of heavy metals. Also, inductively coupled plasma is used as analyzing water samples to determine cation content (Hu et al. 2019).

| Parameter | Water standard (WHO, 2012) | w | wᵣ |
|-----------|---------------------------|---|-----|
| BOD       | <3                        | 5 | 0.2174 |
| COD       | <5.5                      | 5 | 0.2174 |
| TDS       | <500                      | 5 | 0.2174 |
| pH        | 6.5 - 8.5                 | 4 | 0.1739 |
| NH₃       | 0.35                      | 4 | 0.1739 |
| ∑w = 23   |                           |   |    |
| ∑wᵣ = 1  |                           |   |    |
For calculating WQI, firstly the weight factor \( w \) should be implied for each parameter in form of relative weight \( w_r \) factor. This factor represent a significant value of the parameter to the water quality. Relative weight factor \( w_r \) is the ratio of weight factor over sum of weight factor. Quality rating scale \( (q_i) \) is determined to scale the significant each parameter which expressed as (Saleem et al., 2016)

\[
q_i = 100 \times \frac{c_i}{S_i}
\]

where \( c_i \) is measured value of the parameter and \( S_i \) is the standard value as given in Table 1. Index \( i \) represent each parameter. For calculating water quality index, the \( P_i \) is first determined for each chemically parameters which was calculated by the following equation.

\[
P_i = w_r \cdot q_i
\]

Finally, WQI is calculate as sum of all \( P_i \) as followed

\[
WQI = \sum P_i
\]

The score of WQI can be used to predict the condition of water sample which consist of 5 rank as summarized in Table 2.

| Rank of WQI | Range of WQI | Type of Water          |
|------------|-------------|------------------------|
| 1          | 0-25        | Excellent              |
| 2          | 26-50       | Good                   |
| 3          | 51-75       | Poor                   |
| 4          | 76-100      | Very poor              |
| 5          | >100        | Unsuitable for drinking purpose |

3. Results and Discussion

3.1. Geological structure

In this study, a potential interpretation of the existence of groundwater where the soil layer consists of several layers. The study area is categorized as soil type Spodosol-Pedzolik Gleiik-Tropaquects. Spodosol is a soil type that developed from quartz sand deposits, and sedimentary rocks in the form of quartz sandstone. Podsolic is a land that has a profile development with horizon boundaries as shown in Figure 3. This study combines the geoelectrical method with hydrogeochemical analysis to determine the risk of pollution around the slaughterhouse in Tampan district, Pekanbaru city.
The results and discussion begin with an analysis of physical and chemical parameters of groundwater. The assessment of groundwater flow movements in the area of investigation is based on the correlation of three geoelectric pathways that have been carried out. This interpretation is obtained using the geoelectric method Schlumberger array.

3.2. Hydrogeochemical Groundwater

The measured hydrogeochemical parameter are given in Table 3. Water quality data from observation sites in Pekanbaru slaughterhouse are considered for the WQI estimation.

| Parameter | Measured value |
|-----------|----------------|
| Site 1    | Site 2    |
| Site 3    | Site 4    |
| Site 5    |           |
| BOD       | 0.464     | 0.464     | 0.464     | 0.725     | 0.725     |
| COD       | 6.257     | 6.041     | 4.715     | 4.19      | 5.485     |
| TDS       | 24        | 106       | 40        | 14        | 70        |
| pH        | 5.6       | 4         | 4.8       | 4.8       | 4.5       |
| NH₃       | 0.0368    | 0.0753    | 0.0158    | 0.0175    | 0.0228    |

The lowest pH value is in sample 2 and the highest pH value is in sample 1. Based on WHO standards, the pH quality of the water is said to be good if it has a pH range of 6.5 - 8.5. Samples that have been tested on average have a value below 6, the pH value of acid can increase corrosivity on metal objects which can cause irritation to the skin and also cause discomfort in water, so the chemical content in it can interfere with human health.

BOD test results when compared with quality standards are classified as safe and not dangerous. The low BOD concentration indicates the organic matter content at the sampling location. The concentration of BOD in water identifies the amount of organic matter in the water, the lower the amount of oxygen that microorganisms will determine to carry out the biological decomposition process. COD concentrations identify the oxygen content needed by microorganisms as well as for the oxidation process of chemically decomposed organic compounds, it is noted that COD in water is reasonable and only slightly higher than the good limit level at points 1 and 2.

TDS value is less than 250 mg / l and the highest is in sample 2 which is 106 mg / l and the lowest TDS value is in sample 4 which is 14 mg / l, this difference is because the distance of sample 2 to the RPH industry is closer than that of the other samples. According to clean water quality standards, the maximum allowable content for the TDS parameter is around 1500 mg / l.

3.3. Geoelectrical resistivity

Geoelectric survey and measurement through 3 location tracks. Figure 4 shows the geoelectrical profile of each track. Generally, all track show four geological formations as depict in Figure 5. The first track and the third tracks shown a similar structure, unless the fourth layer, sandstone formation is exist in first track, while sand layer is likely presence in track 3. Both tracks is separated about 150 m, so not surprise a quite different structure is happened. The second track L2 shows at a depth of 0.00 - 0.82 m is interpreted as a top soil layer, second layer is a dry gravel layer, third layer is a sand layer and the fourth layer is an aquifer (groundwater) layer at depth of 27.27 m. More detail about geological interpretation is shown in Figure 6. Distribution of underground water of three site is likely classified as shallow aquifer.
Figure 4. Resistivity profile and its predicting layer depth of each track. (a) Track 1, (b) track 2, and (c) track 3.

Figure 5. Estimated geological structure of all track L1, L2, and L4.

3.4. WQI analysis
WQI calculation results show the water quality class at 5 sites around the slaughterhouse water quality is still classified as good water as presented in Table 4, the quality of ground water that reaches the community is not exposed to the threat of waste from the slaughterhouse industry. This happens because the drainage system has its own separate channel and is separated from the sewerage used by the community.

From the depth range of the presence of water, indicating that the tendency of the groundwater is polluted by industrial waste if the shallow aquifer layer is classified as shallow soil infiltration closer to the aquifer layer. Planting trees and avoiding groundwater pollution (Hoekstra et al, 2019). This area has the potential to be used in underground water conservation, although it is not suitable for the designation of an industrial area. It is suitable for residential use because the conservation of
underground water sources remains safe. Based on this fact, the existence of the slaughterhouse industry which is in contact with community settlements states that water is categorized as safe and not dangerous.

Table 4. Water quality index

| Parameter | Measured value |
|-----------|----------------|
|           | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
| BOD       | 3.3625 | 3.3625 | 3.3625 | 5.2538 | 5.2538 |
| COD       | 24.7322| 23.8784| 18.6371| 16.5619| 21.6807|
| TDS       | 1.0435 | 4.6089 | 1.7392 | 0.6087 | 3.0436 |
| pH        | 3.478  | 7.4529 | 5.4654 | 5.4654 | 6.2107 |
| NH₃       | 1.8284 | 3.7413 | 0.785  | 0.8695 | 1.1328 |
| QWI       | 34.4446| 43.044 | 29.9892| 28.7593| 37.3216|

Classification: good, good, good, good, good

4. Conclusion
This study analyzes the potential of underground water using geoelectric surveys and hydrogeochemical analysis in residential areas that intersect with the Pekanbaru slaughterhouse industry. This investigation also examined hydrogeochemical groundwater samples from community wells and drilling results on geoelectric measurement trajectories. From the results of the investigation, several important points on the feasibility of groundwater used by the community. Groundwater potential is sufficiently large and medium areas with wide distribution and designation of catchment, residential and industrial areas. In addition, groundwater that has reached the community is still classified as safe and harmless, waste treatment from slaughterhouses has a low potential to pollute large but still needs structuring and supervision of the intersecting environment. This is because the population of settlements will continue to increase over time and the high level of groundwater demand.

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