Spatial quality of shallow groundwater in DAS Cijurey Regency of Majalengka, West Java

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Abstract. Considering when the water needs to surge, an alternative is required to obtain clean water—one of them by utilizing the presence of shallow groundwater. However, not all shallow groundwater has good quality to consume. Thus, the study aims to describe the groundwater quality spatial pattern and describe the link between the spatial pattern of groundwater quality with lithology, land use, and groundwater in DAS Cijurey, Majalengka regency. There are two types of parameters used, namely physical and chemical. The shallow groundwater Quality measurement was carried out in November 2019. The results showed the territorial distribution of groundwater quality and the connection between groundwater and the three influence factors at DAS Cijurey. The number of samples used is 41 points, groundwater quality sampling with a purposive random sampling method. As the parameters measured will be compared to 3 quality standards, namely, Ministerial Regulation No. 492/Menkes/PER/IV/2010, Government regulation of the Republic of Indonesia No. 82 2001, and Regulation of the Minister of Health RI No. 01/birhukmas/1975. After that, a decent water quality result (6 samples) is not feasible (35 samples) for consumption. The dominating factors of land use, i.e., settlement, for the dominating lithology are the unraveling volcanic rock and the depth of the water in its depths of 0-5 meters.

1. Introduction
Living things, especially humans, do various ways to meet water needs. When the need for water is soaring, several alternatives are needed to obtain this water, not only relying on one source to get water. One of the alternatives for water supply is to utilize groundwater. Groundwater is a natural resource whose availability in each region, both in quantity and quality, varies and is limited [1].

Groundwater comes from water on the ground, such as rainwater, lakes, etc., which is absorbed into the soil in the recharge area and flows into the discharge area [2]. The flow of groundwater in the soil from the recharge area to the discharge area takes a long time, depending on the distance and the type of rock it passes through [3].

Groundwater quality can be affected both naturally and artificially. Factors that affect naturally include lithology and land use. In the lithological factor, the chemical element content is very dependent on the type of rock in which the water is located and the lithological formation through which the water passes [4,5]. The land-use factor also has a significant role in the quality of the water that passes through it. The use of land in question is the land cover, which is a community that grows in a certain place (vegetation) [6,7,8]. Vegetation that has died and undergoes a decaying process will affect the soil pH. Soils that contain lots of dead plant remains will have a relatively low pH and are acidic.
Meanwhile, human-made factors that affect groundwater quality are human factors through the process of pollution. Pollution is divided into two, namely, both direct and indirect. Factors artificial means that the entry of certain chemicals into the groundwater due to no interference by human activities, such as in agricultural areas that are often used as fertilizer or pesticides with high levels, could contaminate the soil [9].

Based on observations, in Majalengka Regency, the use of shallow groundwater still dominates compared to using PAM water. Therefore, the importance of water quality for public health requires research related to water quality case studies. Meanwhile, in providing drinking water in accordance with the quality standards of drinking water quality, it is necessary to have a solution to the water problem. The method given is in the form of water neutralization of each physical and chemical parameter that exceeds the maximum limit following the Regulation of the Minister of Health of the Republic of Indonesia No. 492/MENKES/PER/IV/2010 concerning requirements for drinking water quality. The purpose of this paper is to describe the spatial pattern of shallow groundwater quality and to describe the relationship between the spatial pattern of groundwater quality and lithology, land use, and groundwater level depth.

2. Methodology

2.1. Research sites
This research was conducted on dug well water in the Cijurey River Basin, Majalengka Regency, covering three districts, namely Panyingkiran District, Majalengka District, and Maja District.

2.2. Data collection

2.2.1. Shallow groundwater quality data. Shallow groundwater sampling was carried out on November 4th-9th and was carried out during the dry season. Sampling was carried out during the summer due to maintaining data stability. Water parameters are taken to consist of physical parameters (pH, TDS, DHL, and turbidity) and chemical parameters (nitrate, sulfate, phosphate, ammonia, and calcium) [10,11,12,13]. Shallow groundwater samples were taken from 41 sample points. The sampling method used was purposive random sampling.

2.2.2. Shallow groundwater depth data. Shallow groundwater level measurements are carried out simultaneously with groundwater sampling. The tool used for measurement is the Solinst model 101 Water Level Meter) [14,15].

2.2.3. Lithology, topography (altitude and slope) data and land use. Secondary data collection for lithology data processed from geological data obtained from the Department of Energy and Natural Resources (ESDM) with a scale of 1:100,000. Altitude and slope data were obtained from DEMNAS data, while land use data were obtained from the Majalengka National Land Agency (BPN) with a scale of 1:25,000 and data was updated.
2.2.4. **Groundwater quality data processing.** Analysis of drinking water quality standards is carried out after testing the shallow groundwater quality of the water samples that have been taken [16-18]. The value obtained from the shallow groundwater quality test is compared with the water quality standard stipulated by Ministerial Decree No.492/MENKES/PER/IV/2010. This is done in order to know the threshold of the pollutant elements in the water. And for groundwater, quality mapping is done using the Inverse Distance Weighted (IDW) interpolation method for each parameter.

2.2.5. **Data analysis.** The data analysis used was descriptive spatial analysis and overlay analysis, which was strengthened by statistical analysis.

3. **Results and discussions**

3.1. **Physical parameters**

3.1.1. **pH or degree of acidity.** There were 23 samples that did not comply with the predetermined drinking water quality standards. Of the 23 samples, the pH value was less than 6.5, and there were no samples above 8.5 as the maximum quality standard. The pH values that dominate the range from 6.1 to 6.3 are located in plantations, shrubs and rice fields. Meanwhile, high pH values are located in settlements.

![Figure 1. Graphs and maps of pH distribution patterns.](image1)

3.1.2. **Dissolved solids (TDS).** There is 1 sample that exceeds the quality standard of drinking water, namely 500 ppm. It can be seen in the figure below that dominates the TDS parameter, which ranges from 200-300 ppm with a spread that is almost spread throughout the Cijurey watershed.

![Figure 2. Graphs and map of TDS distribution patterns.](image2)
3.1.3. Conductivity (Electrical Delivery Power/DHL). Just like the TDS parameter, DHL has 1 sample that is above the drinking water quality standard. Value ranging from 400-600 mg/l predominate in the Cijurey watershed.

![Figure 3. Graphs and map of DHL distribution patterns.](image)

3.1.4. Turbidity. In the turbidity parameter, there are 2 samples that exceed the quality standard of drinking water quality, namely 5 NTU [19]. And those that dominate around 3-5 NTU are located downstream of the river.

![Figure 4. Graphs and map of turbidity distribution patterns.](image)

3.2. Chemical Parameters

3.2.1. Nitrate. In the nitrate parameter itself, there were no samples found that exceeded the standard odor quality of the water quality, namely 50 mg/l [20]. Because all the samples tested had a maximum value of 29.7 mg/l. It was dominated by nitrates ranging from 5-10 mg/l, which are located downstream of the river. Meanwhile, with a high nitrate value in the middle of the river body.
3.2.2. Sulfate. None of the sulfate parameters exceeds the quality standard for drinking water quality, with a maximum of 200 mg/l. And it is dominated by sulfates, which have values between 40-80 mg/l which are located upstream and downstream of the river.

3.2.3. Phosphate. The phosphate parameter is the most samples that exceed the quality standard of drinking water quality. There were 25 samples whose values were above the maximum value of 0.2 mg/l. The phosphate value >0.2 mg/l predominates in the Cijurey watershed and is symbolized by dark purple. The high value of phosphates is due to detergents in wastewater and pesticides and insecticides used for agricultural land.
3.2.4. Ammonia. In the parameter, ammonia has 3 samples that exceed the quality standard of drinking water quality. With a maximum limit of 1.5 mg/l and dominated by nitrates ranging from 0-0.5 mg/l. The high ammonia value lies in the densely populated land use.

![Figure 8. Graphs and maps of ammonia distribution patterns](image)

3.2.5. Calcium. Meanwhile, the parameter of calcium has 2 samples, which is above the quality standard of drinking water quality. And the most dominant ranged from 100-150 mg/l with a diffuse pattern.

![Figure 9. Graphs and maps of calcium distribution patterns.](image)

3.3. The effect of physical factors on shallow groundwater quality

3.3.1. Lithological factors

| Types of Rocks            | Calcium | Sulfate | TDS         |
|---------------------------|---------|---------|-------------|
| Integrated Sedimentary Rocks | 85.2    | 34.2    | 192         |
| Loose Sedimentary Rocks    | 115.82  | 35.97   | 241.74      |
| Non-Degradable Volcanic Rocks | 157     | 150     | 390         |

Of the three types of calcium, sulfate, and TDS concentrations, the highest average value is non-biodegradable volcanic rock. The elemental value of calcium is still below 200 mg/l, with a content of 157 mg/l. The non-biodegradable volcanic rock type's sulfate content is 150 mg/l and the TDS content
value is 390 ppm. It can be concluded that the calcium, nitrate, and TDS content in non-biodegradable volcanic rocks are very large compared to other rock types.

3.3.2. Land use factors

| Land Use    | Nitrate | Phosphate | Ammonia |
|-------------|---------|-----------|---------|
| Settlements | 8.18    | 0.38      | 0.52    |
| Moors/fields| 7.15    | 0.36      | 0.21    |
| Rice fields | 4.31    | 0.37      | 0.18    |

From the three average values in the table, the residential land use has the highest average. The value of nitrate in settlements is 8.18 mg/l, phosphate value is 0.38 mg/l and ammonia is 0.52 mg/l.

3.3.3. Groundwater depth factor. In this study, the groundwater level was divided into 3 (three) classes, namely 0-5 m, 5-10 m, and >10 m, and according to 3 parameters (nitrate, phosphate, and ammonia). The results showed that the groundwater level's depth was related to the number of parameters that exceeded the threshold. It can be concluded that, at a depth of 0-5 m, there were no samples that exceeded the threshold for the elemental phosphate, there were 19 samples that exceeded the sulfate quality standard threshold (19/30), and 3 samples that exceeded the ammonia quality standard threshold (3/30). At a depth of 5-10 m, there were no samples that exceeded the threshold for phosphate and ammonia elements. There were 5 samples that exceeded the sulfate quality standard threshold (5/10). Meanwhile, at a depth of >10 m, only 1 sample exceeded the phosphate quality standard.

4. Conclusion

Based on the research done, the results of each parameter that have been tested and compared with the quality standard of drinking water quality, there are 6 sample points suitable for drinking or equivalent to 14.63%. Meanwhile, those who were not fit to drink consisted of 35 samples or the equivalent of 85.37%, with the results of an analysis of shallow groundwater samples that are not in accordance with drinking water quality standards, namely pH (23 samples), TDS (1 sample), DHL (1 sample), turbidity (2 samples), nitrate (0 samples), sulfate (0 samples), phosphate (25 samples), ammonia (3 samples), and calcium (2 samples).

Factors that influence shallow groundwater quality differences in the Cijurey watershed are lithology, land use, and groundwater depth. In terms of lithology, outcrops of non-decomposed volcanic rock types
have the highest pollution value than other rock types. Settlements with the highest pollution levels dominate the relationship between land use and shallow groundwater quality. The groundwater level depth factor shows that the highest level of pollution is at a depth ranging from 0-5 m.

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