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FEASIBILITY OF SHALLOW GROUNDWATER QUALITY AS DRINKING WATER IN BANTAN SARI VILLAGE, BENGKALIS ISLAND, RIAU PROVINCE

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ABSTRACT

Clean water plays a central role in human survival. The majority of clean water comes from groundwater. Shallow groundwater from dug wells does not necessarily have suitable quality for use because it is vulnerable to contamination. Bantan Sari is one of the villages located on Bengkalis Island. Besides having problem related to water availability, this area also has poor shallow groundwater quality. This study aims were to determine the quality of shallow groundwater in the study area and map its feasibility as a source of drinking water. This research is expected to be the basis for further research to improve groundwater quality on Bengkalis Island. The research methods included field data collection and laboratory analysis. The parameters measured consisted of color, TDS, DHL, pH, Fe and Mn levels. Based on the results of study, 14 dug wells were obtained. Groundwater color in study area were colorless (36%), yellow (7%), brown (21%), and reddish brown (36%). Groundwater TDS ranged from 59 mg/l – 560 mg/l. Groundwater DHL

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ranged from 107 mg/l – 1080 mg/l. Groundwater pH ranged from 6,49 – 6,74. Groundwater Fe levels ranged from 0,3 mg/l – 5,43 mg/l and groundwater Mn levels < 0,4 mg/l. Based on Minister of Health Regulation No.492/Menkes/Per/IV/2010 about drinking water quality requirements, it is known that only 1 sample (7%) is included in the drinkable category while the other 13 samples (93%) are included in non-drinkable category.

INTRODUCTION

Clean water plays a central role in human survival. In Indonesia, clean water usually comes from surface water, groundwater and rainwater. The availability of clean water is limited while seawater cannot be utilized directly due to its high salt content. Groundwater is an economic and strategic commodity in several areas. It is estimated that 70% of the population clean water needs and 90% of industrial water needs come from groundwater. Population growth has influenced the increase in groundwater demand while its availability has decreased both in terms of quality and quantity.

As the main water resource, groundwater has advantages compared to other water resources. Groundwater tends to be more stable in its availability than surface water such as rivers and lakes. Stable availability can help meet water needs throughout the year, regardless of seasonal or weather changes. The natural process of filtration that occurs when water percolates through the soil can improve groundwater quality. Some contaminants can be filtered or reduced before the water reaches the groundwater layer. Groundwater is often more easily accessible in rural areas than surface water resources which can be located far from settlements. This makes groundwater as the main water source that highly relied upon to fulfill daily water needs (Mairizki, F., Risti, P., A., Arief, Y.,P., 2020).

Shallow groundwater that comes from dug wells is generally utilized by communities in rural areas, but shallow groundwater does not always have quality that suitable for use. This is because shallow groundwater is vulnerable to pollution, whether it comes from garbage and waste disposal, agricultural and industrial activities, or due to the movement of geological formations that can cause contamination. Utilization of groundwater for domestic purposes including drinking water must meet established requirements. In this case, drinking water must meet physical, chemical and biological requirements based on Minister of Health Regulation No.492/MENKE/PER/IV/2010. Groundwater must be clear, odorless, tasteless, and free from harmful chemicals and bacteria. Therefore, monitoring of groundwater quality is necessary to ensure that the groundwater used is free from contaminants and can be utilized sustainably.

Bengkalis Island consists of swamp and land areas that are affected by tides, especially around the north and south coasts, as a result of high tides. Groundwater quality issues in coastal areas become more complex due to high population density, making them vulnerable to water quality degradation due to over exploitation and seawater intrusion problems (Bastira, S., H., et al., 2020). Several previous studies on groundwater conditions in the north coast of Bengkalis Island have been conducted. In the rural areas of Selat Baru, Jangkang, Deluk, and Bantan Tua, more brackish groundwater was detected in coastal areas, thus indicating the possibility of seawater intrusion and the occurrence of salinization-related phenomena (Putra, D., B., E., et al., 2021) ; (Putra, D., B ., E., et al., 2019). Most groundwater does not meet the Minister of Health Regulation criteria as either clean water or drinking water (Mairizki et al., 2023) ; (Putra, D., B., E., Yuniarti, Y., M. Sapari, D., H., 2017).

Bantan Sari is a village located on Bengkalis Island and shows geological characteristics where the area consists of one formation, namely the Old Sedimentary Formation (Qp). This formation consists of layers of clay, silt, clay gravel, plant remains, and sand that have acidic properties. In addition to water availability issues, the quality of shallow groundwater in this area is also inadequate. Nevertheless, the community still relies on this shallow groundwater for their daily needs. Based on this, researchers are interested in conducting this study with the aim of determining the quality of shallow groundwater in the study area and mapping its feasibility as a source of drinking water. This research is expected to be the basis for further research to improve groundwater quality on Bengkalis Island.

RESEARCH METHODS

1. **Place**

   The research area is located in Bantan Sari village, Bengkalis, Riau. Astronomically, the research area is located at coordinates 102°20'48.82"-102°21'55.27"East Longitude and 1°32'17.15"-1°31'13.52"North Latitude. The study area is ± 3 km^2. Measurement of TDS, DHL, and pH parameters were conducted at the Basic Geology Laboratory, Faculty of Engineering, Islamic University of Riau. Measurements of Fe and Mn parameters were carried out at the Research and Standardization Agency Laboratory, Padang.

2. **Tools and Materials**

   a. The equipments used in this research are :
      - Basic topographic map of the study area to facilitate observing the morphology of the study area
      - Global Positioning System (GPS) to provide information on the location point of the dug well data collection
      - Camera as documentation tool in data collection
      - Rope meter as measuring tool for the depth of dug well
      - YSI Pro Water Quality as measuring instrument for TDS, DHL and pH parameters
      - Atomic Absorption Spectrophotometer (AAS) to measure Fe and Mn levels
      - 100 ml and 250 ml beakers
      - 10 ml and 50 ml volumetric pipettes
      - 50 ml, 100 ml and 1000 ml volumetric flasks
      - 100 ml Erlenmeyer
      - Glass funnel
      - Electric heater
      - Vacuum set
      - Filters and membrane with 0.45 µm pore size
      - Analytical balance
      - Spray flask

b. The materials used in this study are :
   - Samples of dug well water
   - Distilled water
   - HNO_3 0,05 M solution
   - Fe metal standard solution with 99,9% purity
   - Mn metal standard solution with 99,9% purity
   - Acetylene gas (C_2H_2) HP with a minimum pressure of 100 psi

3. Research Procedure

a. Determination of Sampling Locations

In the initial stage, to confirm the sampling locations, grid formation on the topographic map was performed. The griding procedure was carried out to allocate sample points so that the representation of the research location becomes better. An illustration of grid modeling for the research area can be seen in Figure 1.

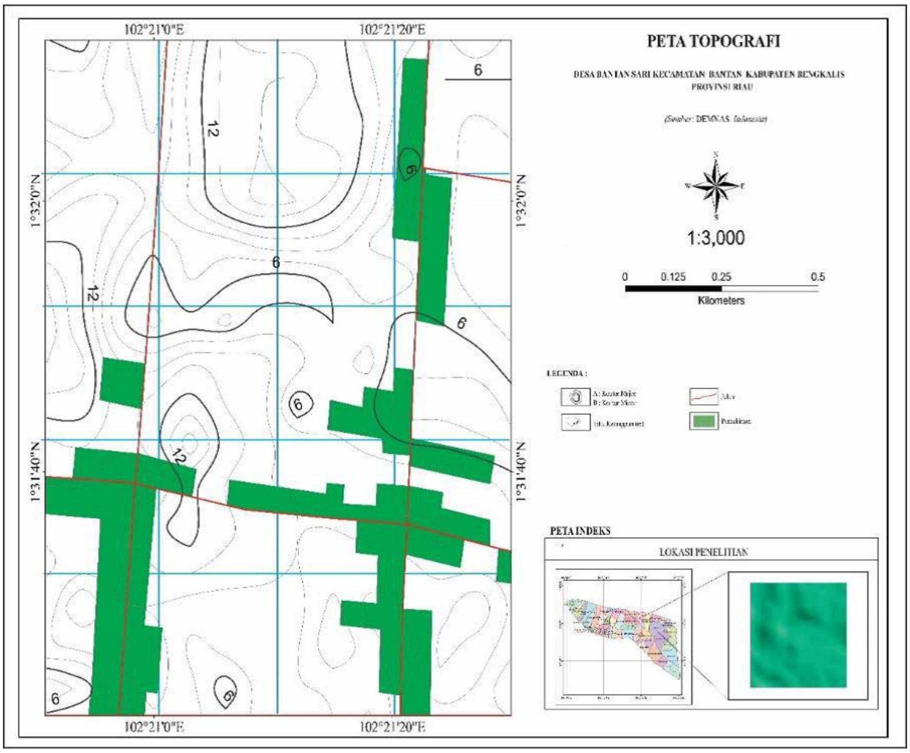

Figure 1. Grid Modeling of the Study Area

b. Sampling

Groundwater samples were collected from 14 dug wells. Next, the groundwater samples were transferred to sample containers that had been previously cleaned and taken to the laboratory for further analysis. An illustration of the groundwater sampling location can be seen in Figure 2.

Figure 2. Groundwater Sampling Location of the Study Area

c. Sample Measurement Method
   - Color measurement of groundwater samples using the sense of sight
   - Measurement of TDS, DHL, and pH of groundwater samples using the YSI Water Quality tool
   - Measurement of Fe and Mn levels in groundwater was carried out based on the Indonesian National Standard (SNI) 6989.84:2019

Based on the measurement results obtained, it was analyzed and compared with the quality standards for drinking water quality requirements in accordance with Minister of Health Regulation No. 492/Menkes/Per/IV/2010. The drinking water quality standards can be seen in Table 1.

Table 1. Quality Standard for Drinking Water Quality Requirements

No.	Parameter Type	Maximum Allowable Level
1.	Color	Colorless
2.	TDS	500 mg/l
3.	DHL	-
4.	pH	6,5 – 8,5
5.	Fe	0,3 mg/l
6.	Mn	0,4 mg/l

RESULTS AND DISCUSSION

1. Color Measurement

The measurement data of groundwater color can be seen in Table 2.

Table 2. Measurement of Ground Water Color

Sample	Color
A1	Reddish Brown
A2	Yellow
A3	Brown
A4	Reddish Brown
A5	Colorless
A6	Reddish Brown
A7	Colorless
A8	Brown
A9	Reddish Brown
A10	Reddish Brown
A11	Colorless
A12	Colorless
A13	Brown
A14	Colorless

Based on Table 2, it can be seen that 5 samples (36%) were colorless groundwater, 1 sample (7%) had yellow color, 3 samples (21%) had brown color, and 5 samples (36%) had reddish brown color. Based on the provisions in Minister of Health Regulation No.492/Menkes/Per/IV/2010, good quality water is colorless. In this case, only 5 samples (36%) that meet the standard, while 9 other samples (64%) did not meet the standard set by the Minister of Health.

Geological conditions can have an impact on the color of groundwater, which is influenced by soil properties and lithology in the study area. The study area mainly consists of peat soils, which are formed from the accumulation of semi-decayed plant remains, causing the color of groundwater to vary between brownish yellow to reddish brown. Soil types such as clay and silt can also cause the water to become cloudy. The presence of Fe and Mn in groundwater affects the color of groundwater. High concentrations of Fe and Mn can cause groundwater to have colors ranging from yellow to reddish brown. The presence of certain mineral deposits below the soil surface can also cause the color of groundwater. Some minerals that form deposits, such as iron oxide, can give water a certain color (Munfiah, S., Nurjazuli, Onny, S., 2013). The use of groundwater for washing should be avoided as it can cause discoloration of clothes, especially white clothes (Putra, A., Y., and Fitri, M., 2019).

2. TDS Measurement

The measurement data of groundwater TDS content can be seen in Figure 3.

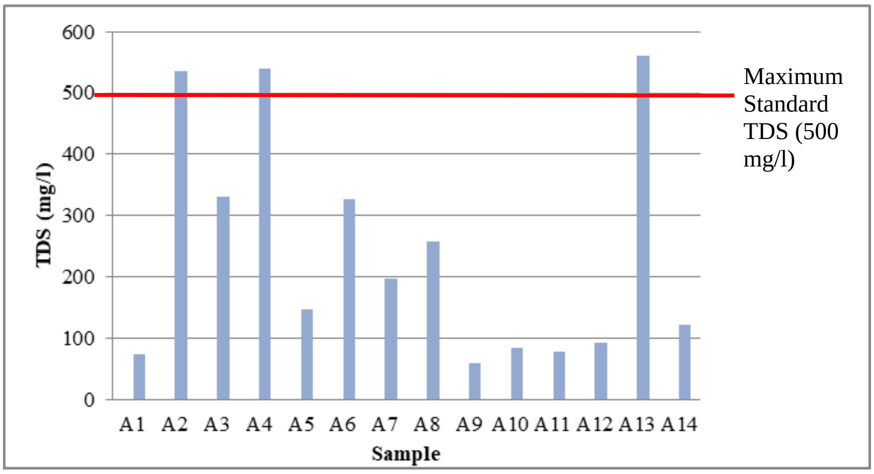

Figure 3. Groundwater TDS Measurement

Based on Figure 3, it can be seen that the TDS value of groundwater ranges from 59 mg/l - 560 mg/l. Based on Minister of Health Regulation No.492/Menkes/Per/IV/2010, good water quality has TDS value ≤ 500 mg/l. In the study area, there were 11 samples (79%) that meet the standard and 3 other samples (21%) did not meet the standard according to Minister of Health Regulation.

The TDS content of groundwater is influenced by various factors such as the dissolution of minerals from rocks, runoff from soil, and anthropogenic influences. Groundwater can experience mineral dissolution from the rocks it passes through. Mineral-rich rocks, such as limestone or saline rocks, can contribute significantly to the TDS content of groundwater. The process of water runoff through the soil can also cause an increase in TDS. Water percolating through the soil can dissolve minerals and chemical compounds, which then contribute to the TDS of groundwater. Human activities, such as agriculture, industry and waste disposal can also increase the TDS content of groundwater (Rinawati, et al., 2016). TDS consists of soluble organic or inorganic compounds, minerals and dissolved gases. Dissolved salts containing Mg, Na, SO_4, Cl ions can also increase the amount of TDS in groundwater. High TDS values affect the turbidity, color and taste of groundwater (Firdaus, et al., 2017).

3. DHL Measurement

The measurement data of groundwater DHL content can be seen in Figure 4.

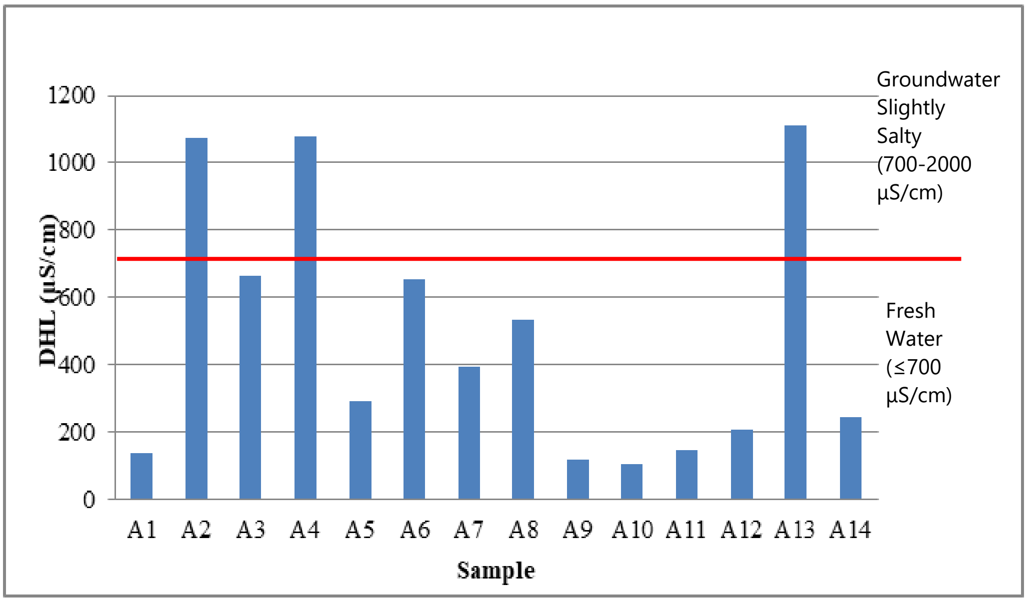

Figure 4. Groundwater DHL Measurement

Based on Figure 4, it can be seen that the DHL value of groundwater ranges from 107 mg/l - 1080 mg/l. In the study area, 11 groundwater samples have DHL value ≤700 µS/cm and belong to the freshwater type (79%) while 3 other groundwater samples have DHL value >700 µS/cm and belong to the slightly salty groundwater type (21%).

High DHL values in groundwater can be caused by several factors that affect the amount of ion dissolved in groundwater. High concentrations of salts and minerals in groundwater can increase the DHL value (Febriarta, 2020). Salts such as Na, Cl, Mg and Ca can increase electrical conductivity because these salts can become mobile ions in solution. The process of mineral dissolution from rocks below the ground surface can also increase the ions dissolved in groundwater. The environment of the study area, which is close to settlements and plantations, allows for an increase in ions dissolved in water, causing the DHL values in some locations to be high.

4. pH Measurement

The measurement data of groundwater pH can be seen in Figure 5.

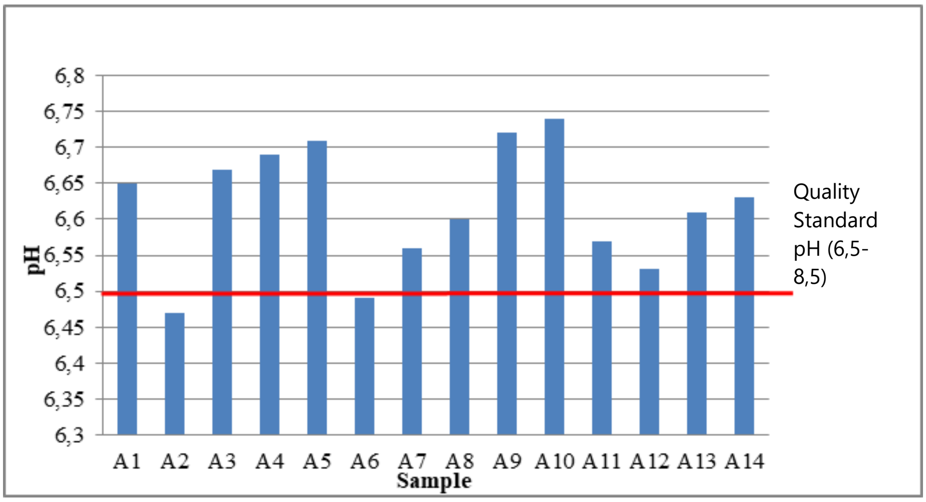

Figure 5. Groundwater pH Measurement

Based on Figure 5, it is known that the pH value of groundwater ranges from 6,49 – 6,74. Thus, it can be said that 12 samples (86%) meet the Minister of Health Regulation, while the other 2 samples (14%) did not meet the Minister of Health Regulation because the pH values < 6,5. Peat soil tends to be acidic because its formation process involves the accumulation of partially decomposed plant remains. Humic acid and fulvic acid produced from the decomposition of organic matter can lower the pH of groundwater. Typical vegetation in peat areas and the ongoing process of organic decomposition can enrich groundwater with acidic compounds that can lower pH.

Changes in pH can result in variations in the odor, taste, and color of water. For drinking water in particular, it should have a neutral pH to prevent dissolution of heavy metals and corrosion of drinking water distribution lines. Water with an acidic pH can increase the corrosiveness of metal materials and cause some chemical compounds to become toxic substances that can harm health (Hasrianti and Nurasia, 2018). Water with a pH that tends to be acidic can dissolve iron, thus increasing the iron content in the water. On the other hand, a high pH can give the water a bitter taste **(**Yuliani, N., Nurlela, Novia, A., L., 2017).

5. Fe Measurement

The measurement data of groundwater Fe content can be seen in Figure 6.

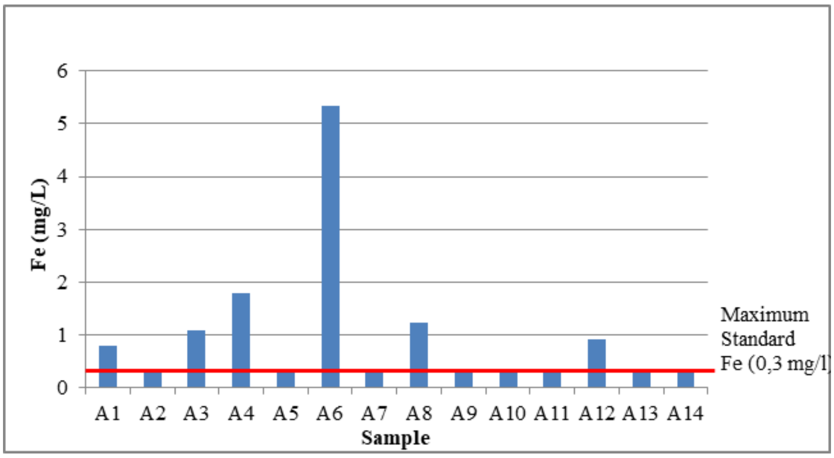

Figure 6. Groundwater Fe Measurement

Based on Figure 6, it can be observed that the Fe content of groundwater ranges from 0,3 mg/l – 5,43 mg/l. According to Minister of Health Regulation No.492/Menkes/Per/ IV/2010, good water quality has Fe value ≤ 0,3 mg/l. In the study area there were 8 samples (57%) that meet the Minister of Health requirements and 6 samples (43%) did not meet the Minister of Health requirements. Fe content in groundwater has an impact on the color of groundwater where groundwater containing high Fe generally shows a yellow to brownish color (Putra A.,Y., and Fitri, M., 2020).

The presence of Fe in groundwater can come from the soil itself, especially Fe-containing rocks, or it can come from industrial waste deposits. The presence of Fe minerals in geological formations below the ground surface can cause groundwater solutions to be rich in Fe ions. Rocks containing minerals such as magnetite, hematite or pyrite can contribute to the Fe content of groundwater. When Fe metal binds to organic acids that dissolve in peat water, this also affects the increase of Fe content in groundwater (Febrina, L., and Astrid, A., 2014). If the Fe level exceeds the quality standard, it can cause water taste, yellow color, precipitation on pipe walls, growth of Fe bacteria, and corrosion of metal objects (Putra, A.,Y., and Fitri, M., 2020). Excess Fe can also lead to health problems and the risk of poisoning, such as diarrhea, damage to the digestive system, and prolonged fatigue (Rahayu, B., Mery N and Tahril, 2013).

6. Mn Measurement

The measurement data of groundwater Mn content can be seen in Figure 7.

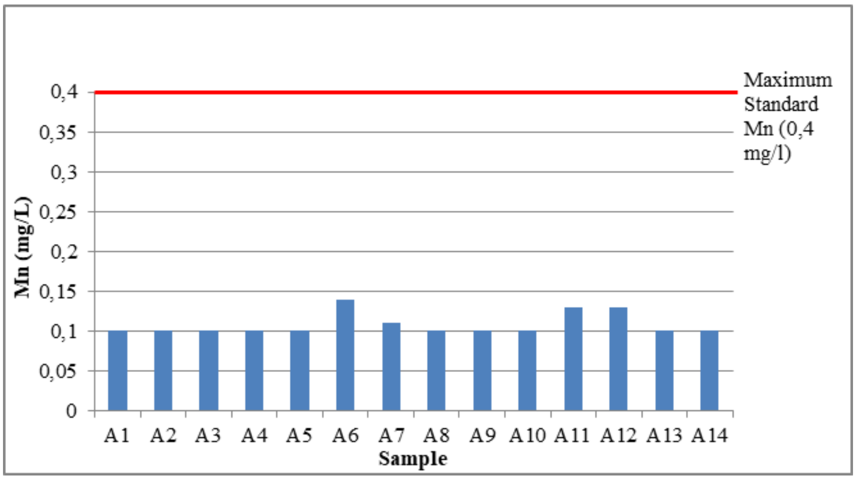

Figure 7. Groundwater Mn Measurement

Based on Figure 7, it can be seen that the Mn level in all groundwater samples is <0,4 mg/l. Therefore, it can be said that all groundwater samples (100%) have Mn levels below the Minister of Health quality standard. If the level of Mn in groundwater exceeds the standard, it has the potential to cause an unpleasant metallic taste and odor in the water, the appearance of brownish color on white clothes and potential interference with liver function if used as a source of drinking water continuously (Awliahasanah, et al., 2021).

Based on the conditions in the field, it can be interpreted that Mn levels in groundwater are present together with Fe levels derived from soil and weathering of rocks below the surface. Peat soils commonly found in the study area can contain Mn in the form of organic compounds or soluble minerals. The decomposition process of organic matter in peat soils can release Mn into groundwater.

7. Feasibility of Groundwater Quality as Drinking Water

The analysis results of the feasibility groundwater quality in the study area as drinking water can be seen in Table 3. The map of groundwater feasibility as drinking water can be seen in Figure 8.

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Table 3. Feasibility Analysis of Groundwater Quality

Sample	Color	TDS (mg/l)	DHL (µS/cm)	pH	Fe (mg/l)	Cl (mg/l)	Description
A1	Reddish Brown	73	136	6,65	0,79	0,1	Not Suitable for Drinking
A2	Yellow	536	1073	6,47	0,3	0,1	Not Suitable for Drinking
A3	Brown	332	664	6,67	1,09	0,1	Not Suitable for Drinking
A4	Reddish Brown	540	1080	6,69	1,8	0,1	Not Suitable for Drinking
A5	Colorless	147	293	6,71	0,3	0,1	Suitable for Drinking
A6	Reddish Brown	327	655	6,49	5,34	0,14	Not Suitable for Drinking
A7	Colorless	197	395	6,56	0,3	0,11	Not Suitable for Drinking
A8	Brown	258	535	6,6	1,24	0,1	Not Suitable for Drinking
A9	Reddish Brown	59	117	6,72	0,3	0,1	Not Suitable for Drinking
A10	Reddish Brown	84	107	6,74	0,3	0,1	Not Suitable for Drinking
A11	Colorless	78	147	6,57	0,3	0,13	Not Suitable for Drinking
A12	Colorless	93	209	6,53	0,91	0,13	Not Suitable for Drinking
A13	Brown	4219	8437	6,61	0,3	0,1	Not Suitable for Drinking
A14	Colorless	123	246	6,63	0,3	0,1	Not Suitable for Drinking

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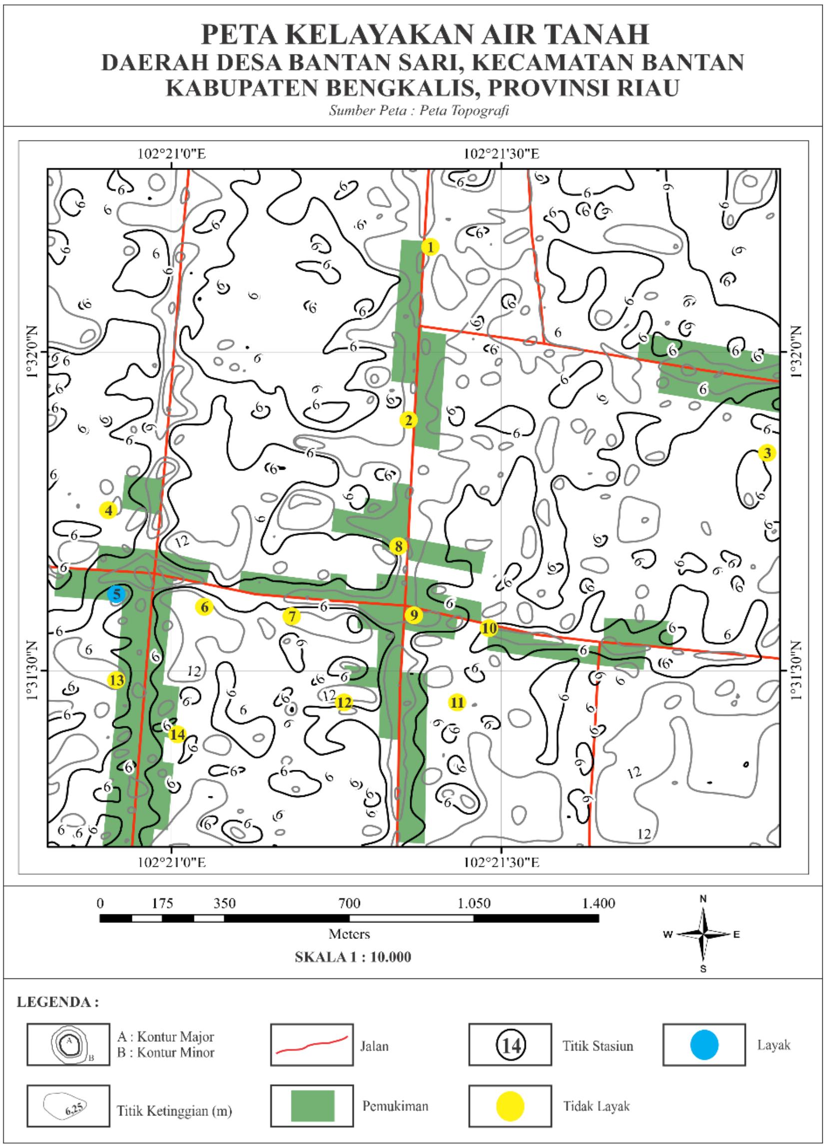

Figure 8. Feasibility Map of Shallow Ground Water Quality in Study Area

Groundwater is considered suitable for use as a drinking water source if all physical and chemical parameters measured meet the Minister of Health Regulation. If any one parameter does not meet the standard, then the groundwater is not suitable as a drinking water source. Therefore, from the results measured in Table 3, only 1 groundwater sample (7%) meets the criteria as water that can be consumed, while the other 13 samples (93%) are classified as water that not suitable for consumption.

Geological properties of the study area such as peat soil can affect groundwater quality. Peat soils tend to have high acidity and can cause the color of groundwater to be poor. Peat soils also tend to contain a lot of organic matter. The process of weathering plant remains in peat soil can produce organic compounds that give color to groundwater. The presence of Fe and Mn in the soil or rocks around the study area can also cause the color of groundwater to become yellow to reddish brown. These two metals are soluble in water and give groundwater its distinctive color.

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CONCLUSIONS

From the results of the research conducted, it can be concluded that the groundwater color in the study area are clear (36%), yellow (7%), brown (21%) and reddish brown (36%). Groundwater TDS ranges from 59 mg/l - 560 mg/l. Groundwater DHL ranged from 107 mg/l - 1080 mg/l. Groundwater pH ranged from 6,49 – 6,74. Groundwater Fe levels ranged from 0,3 mg/l – 5,43 mg/l and groundwater Mn levels ranged from <0,4 mg/l. Based on Minister of Health Regulation No.492/Menkes/Per/IV/2010 on Drinking Water Quality Requirements, from all the results of physical and chemical parameters, it can be seen that only 1 sample (7%) is included in the feasible category while the other 13 samples (93%) are included in the category not suitable for use as a drinking water source.

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