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Study of Groundwater Feasibility in Residential Settlements Near the Former Final Waste Disposal Place, Kutaraja District, Banda Aceh City

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ABSTRAK

Dengan meningkatnya jumlah peduduk maka jumlah air yang diperlukan semakin meningkat. Kota Banda Aceh membutuhkan lebih banyak air bersih setiap tahunnya. Total kebutuhan berkisar 130-150 liter/orang/hari. Penelitian dilakukan di Kecamatan Kutaraja. Tujuan penelitian mengkaji kelayakan airtanah disekitar bekas tempat pembuangan akhir. Penelitian dilakukan melalui survei lapangan yang meliputi pengukuran koordinat geografis lokasi sumur, menggunakan *grid sampling* menurut parameter fisik airtanah freatik. Hasil penelitian kelayakan airtanah di Kecamatan Kutaraja pada parameter suhu air tanah freatik yaitu maksimum 35°C dan suhu minimal 28°C. Hasil pengukuran parameter EC airtanah Kecamatan Kutaraja tidak layak dikonsumsi. Hasil Parameter fisika bau, warna, dan rasa masih memenuhi persyaratan. Parameter TDS dengan nilai TDS tertinggi sebesar 12020 mg/l. Pengukuran pH airtanah diperoleh hasil masih memenuhi syarat kualitas airtanah.

Kata kunci: Airtanah, Kualitas, Tempat Pembuangan Akhir, Daya Hantar Listrik, Kecamatan Kutaraja

ABSTRACT

As the population increases, the amount of water needed increases. Banda Aceh needs more clean water every year. The total needs range from 130-150 liters/person/day. The research was carried out at the Kutaraja department. The purpose of the research is to examine the properties of groundwater around the former final drainage site. The research was carried out through field surveys that included measurements of the geographical coordinates of the well location using a sampling grid according to the physical parameters of freatic soil water. The results of the ground water in Kutaraja district on the freatic ground water temperature parameter are a maximum of 35 °C and a minimum of 28 °C. Results Physical parameters such as smell, color, and flavor still meet the requirements. TDS parameters, with the highest TDS value of 12020 mg/l. The measured pH of the groundwater obtained still qualifies for groundwater quality.

Keywords: Groundwater, Quality, Landfill, Electrical conductivity, Kutaraja Sub-distric

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1. INTRODUCTION

The quality of water used to meet human requirements needs to meet water quality standards. However, many people do not know or understand about healthy patterns and maintaining good groundwater (Elvira, 2020). Water that is used in the daily routine according to regulations is called clean water. The requirements in question include quality in the fields of radiology, chemistry, biology, and physics to avoid side effects when consumed. (Ketentuan Umum Permenkes, 1990).

As the population increases, the amount of water needed increases. Groundwater is an important asset for human life because the availability of surface water is insufficient for needs that are exacerbated by pollution, urbanization, and industrialization (Permana, 2019). As a result, many residents use groundwater as their primary source to meet their daily needs. Of the total fresh water available on the surface of the earth, groundwater has about 20%, and the remaining 1% is in lakes, rivers, and the atmosphere (Kumar & Pati, 2022). According to Law Number 31 of 2018, groundwater is the amount of water available below the earth's surface to be collected by wells, water treatment systems, and pumps. Groundwater can be defined as a natural flow through rain or percolation on the earth's surface (Permen ESDM Nomor 31 Tahun 2018). Groundwater flow is a medium that has a continuous influence on the surrounding underground environment, so it can be contaminated or polluted due to negative environmental influences (Harjito et al., 2018). In the tropics, groundwater plays an important role in the context of fluctuations and increased contamination of groundwater (Singh et al., 2015).

Groundwater has many advantages when compared to other water sources. This makes groundwater a great option for drinking or other clean water purposes. The hydrological cycle consists of groundwater as its main component. The advantage of using groundwater as clean water is that its quality is better, groundwater reserves are larger, and the cost is relatively cheap because it does not require tendons and transmission networks to distribute (Afriyani et al., 2020).

Based on Table 1, the data "Clean Water Needs for Domestic Based on City Category" states that the domestic water needs of the city of Banda Aceh are in the medium city category with a population of 265,111 people. Meanwhile, the ratio for the medium city category is 200,000 to 500,000. The total need for clean water for Banda Aceh city residents is around 130–150 liters per person per day (Irwan & Jamal, 2020). As a result, it is very important for the Banda Aceh City authorities to run a water supply business known as PDAM to meet the public needs of the capital city of Banda Aceh.

The city of Banda Aceh needs more and more clean water every year. There are 580,649 active customers or households that need clean water, with the amount of water sold reaching 13,798,478 m3 (Badan Pusat Statistik Aceh 2019). The city of Banda Aceh is the central city of the province of Nanggroe Aceh Darussalam; it is also the center of economic, political, social, and cultural activities. Brahmanja (2014) stated that population growth must be accompanied by the availability of clean, quality, and adequate water. Because untested water comes from groundwater and surface water and needs to be treated before it can be used, (Brahmanja, 2014). The highest incidence of groundwater pollution is in urban areas because of the large population, where large amounts of waste are concentrated to contaminate groundwater (Shrivastava, 2018).

Darnas' research (2020) stated that the final processing site (landfill) is a location that is used as a final waste disposal site and the place where the waste disposal process first begins (Darnas et al., 2020). Waste disposal facilities (landfill) are engineered with special pollution control technology to minimize the impact they can cause. Landfills are usually above ground, in mines or pits (Ololade et al., 2019). Waste is generated, collected, transported, and then managed until it is disposed of. In choosing a landfill site, it is necessary to determine the location and carry out an analysis so that public health and the environment are not threatened (Darnas et al., 2020).

Kutaraja District is the subject of research because this area has hamlets that are close to the Final Disposal Site (landfill) of Banda Aceh City. The landfill, which has been established for 24 years (1994–2018), has now been converted into a transfer station after the Blang Bintang Regional Landfill finished operating in 2018. In Darnas's research (2020) on leachate control, it was stated that the calculation of the useful life of the Gampong Jawa landfill by waste reduction can be up to 2026 (Darnas et al., 2020).

Table 1. Clean Water Needs for Domestic Use Based on City Category

City Category	Total Population (people)	Water Needs (liters/person/day)
Metropolitan	> 1.000.000	170 - 190
Big City	500.00 – 1.000.000	150 - 170
Medium City	100.00 – 500.000	130 - 150
Small Town	200.000 – 100.000	100 - 130
District capital	< 20.000	90 - 100

Source: Department of Public Works, Types of Cities That Need Clean Water 2015 (Afriyanda et al., 2019).

Table 2. Number of Customers and Water Distributed by District of Banda Aceh

Subdistrict	Number of Population (Person)	Clean Water Needs (m3)	Value (Rp)
Meuraxa	60.118	1.857.230	9.327.525.700
Jaya Baru	41.812	1.078.673	5.641.921.590
Banda Raya	44.201	796.395	3.590.025.330
Baiturrahman	65.929	3.439.731	15.368.266.170
Lueng Bata	63.121	805.656	3.565.870.740
Kuta Alam	119.040	1.392.469	7.245.295.630
Kuta Raja	33.819	1.011.130	4.480.410.370
Syiah Kuala	96.874	2.201.028	11.335.457.700
Ule Kareng	55.735	1.216.166	5.498.986.940
Jumlah Total	580.649	13.798.478	66.053.760.170

Source: Badan Pusat Statistik Kota Banda Aceh 2019

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Kutaraja District has six gampongs, namely: Lampaseh Kota, Merduati, Keudah, Peulanggahan, Gampong Jawa, and Gampong Pande. As former landfills for Banda Aceh City, Gampong Jawa and Gampong Pande are nearby. It is very likely that the groundwater is polluted in both the village and its surroundings, especially if runoff and waste water generated by human activities infiltrate it. (Srikandi Fajarini, 2013). Land use can also affect phreatic groundwater catchment areas. Land use in Kutaraja district for public open space and private open space is 173,401 hectare (Afriyani et al., 2023). In Afriyani's research on the analysis of green open space (GOS) in the city of Banda Aceh, it was stated that Kutaraja District in particular needed 106,299 hectare of green open space. However, for now, the Kutaraja sub-district's green open space still lacks 67,102 hectare, which includes 58,241 hectare of public open space and 8,861 hectare of private open space (Afriyani et al., 2023). The benefits of green open space as groundwater absorption areas and groundwater storage (Syifa et al., 2020) Therefore, it is important for an area to have green open space so that there is a good groundwater storage area. Based on field observations, residents in Gampong Jawa and around the final disposal site use well water or phreatic groundwater for their daily needs, where it is feared that the quality of the groundwater used does not meet the quality of water that is free from pollutants. The use of wells or phreatic groundwater among Kutaraja sub-district residents is due to the PDAM water supply not being met in Kutaraja sub-district communities.

Based on this background, the source of water for the residents of Kutaraja sub-district is well water or phreatic groundwater. Thus, the main objective of this research is to analyze the groundwater feasibility of the community around the former landfill waste by measuring the residents directly to find out whether the groundwater around the landfill is polluted or not.

2. METHODS

Astronomically, Kutaraja District is located at 5°33' 8.834–5°35' 6.708" North Latitude and 95°18' 18.648–95°33' 19.044" East Longitude. Kutaraja District has an area of 358.47 hectare. The administrative boundaries of Kutaraja District are the Malacca Strait to the north, Krueng Raya to the east, Baiturrahman District to the south, and Meuraxa District to the west (Saputra, 2017).

The research was conducted on residents' wells around the former landfill in Kutaraja District. Kutaraja District is a residential area consisting of six gampongs, namely: Lampaseh Kota, Merduati, Keudah, Peulanggahan, Gampong Jawa, and Gampong Pande. The study was conducted for one month, from late May to June 2023. The study was conducted from morning to evening.

The research was carried out through field surveys involving quantitative analysis, including measuring the geographic coordinates of the well's location. In addition, a field survey was carried out to instantly identify 60 resident wells according to phreatic groundwater physical parameters such as color, smell, and taste. Apart from that, the field survey also evaluated the use of dug wells by residents. To obtain information about the use of dug wells, direct interviews with well owners were carried out through field surveys. Obtaining more accurate power, which will also be analyzed qualitatively, is the aim of this survey.

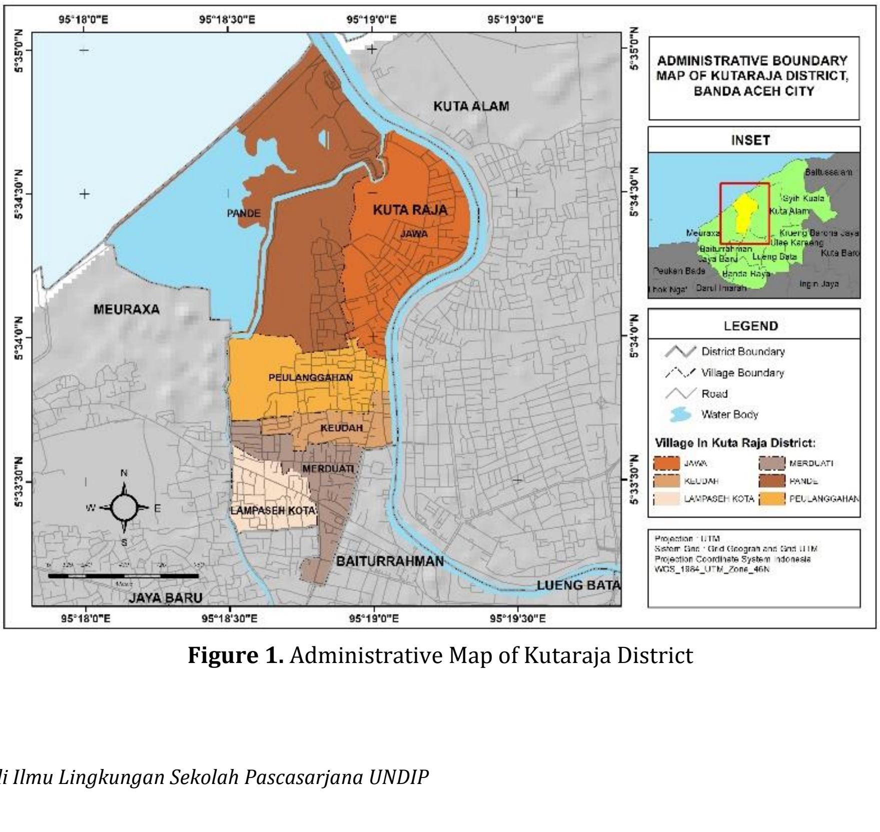

Figure 1. Administrative Map of Kutaraja District

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Figure 2. Documentation of pH and DHL Measurements

The sample in this study used phreatic groundwater in the entire Kutaraja sub-district. Groundwater samples were taken from 60 resident wells in six gampongs located in Kutaraja district. The sampling method is based on the position of the sampling grid, where the research area is divided based on each grid representing one sample. The next step is to mark the coordinates of the wells that have been sampled using the Avenza Maps application. The coordinates were processed using arcGIS to make a map of the groundwater flow patterns in Kutaraja District.

Examination of physical properties includes checking temperature, TDS (Total dissolving Solid), and EC (Electrical Conductivity). Parameters of temperature and EC of water samples were tested using a water checker. The water checker has many parameters that can be used as a reference for the test procedure so that the results are accurate. After being taken from the wells around the former landfill, the water samples were tested with a water checker. While the measurement of TDS parameters is carried out by means of laboratory tests. Measurement of the pH of phreatic groundwater samples begins with calibration of the pH meter. Then measurements were taken on phreatic groundwater samples.

3. RESULT AND DISCUSSION

Analysis of the feasibility of groundwater in Kutaraja District in field survey research includes electrical conductivity (EC), water pH, temperature, elevation, groundwater level, height of the well lip, height of the well lip from the water surface, and physical parameters such as color, odor, and taste. All groundwater monitoring and measurement data from 60 community wells were tabulated and compared according to the parameters of each observation.

3.1. Groundwater Temperature Analysis

Groundwater temperature in Kutaraja District, Banda Aceh City, obtained various measurement results. In accordance with the regulation of the Minister of Health of the Republic of Indonesia Number 492/MENKES, PER/IV/2010 concerning drinking water quality requirements, one resident's well has a maximum phreatic groundwater temperature of 35°C and a minimum temperature of 28°C in two resident's wells. Of the 60 community wells, the most common temperature was 30°C–35°C in 57 community wells.

Based on the temperature pie diagram, water temperatures below 30°C are considered normal temperatures. Meanwhile, a water temperature >30°C is considered hot. This can occur due to external factors such as seasons and weather patterns, water circulation, land cover, water depth, global warming, and human activities. Groundwater is used for various purposes, such as washing, bathing, or even drinking, but for consumption, it must be processed first or cooked. It can be concluded that 58 of the 60 wells do not comply with PPRI class I water quality standards Number 82 of 2001 and Minister of Health Regulation Number 32 of 2017. High temperatures have no pollution effects. Water temperatures that are higher than normal limits indicate that significant amounts of hydrolyzed chemicals, such as sulfur and phenol, or the decomposition of organic matter by microbes have occurred. Therefore, when the water situation is as follows, it is considered unfit for consumption (Earnestly, 2018).

The relationship between temperature and water quality is that water temperature is also inversely proportional to water quality. The higher the water temperature, the lower the quality. The lower the water temperature, the higher the water quality. Temperature can affect dissolved oxygen (DO) levels and pH values (Ou et al., 2018).

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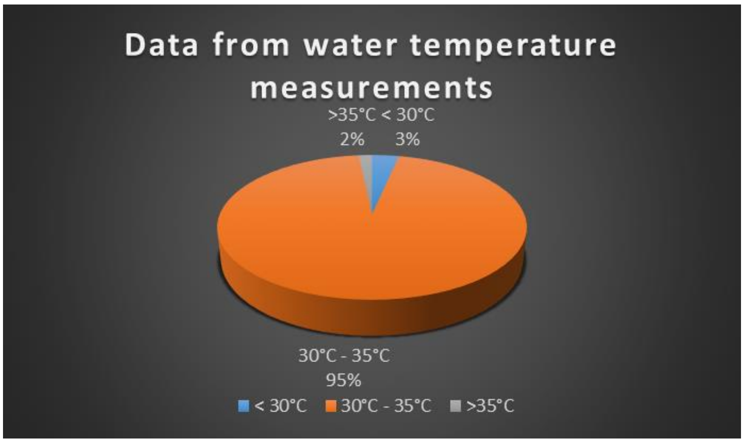

Figure 3. Pie chart of water temperature in Kutaraja District

Table 3. Data from Groundwater Measurements for Electrical Conductivity Parameters

No	Category	EC (Ps/cm)	Numbers of Wells	Percentage (%)
1	Fresh	< 1.200	0	0
2	Brackish	1.200 - 2.500	51	85
3	Saltwater	2.500 - 4.500	3	5
4	Very Salty	>4.500	6	10
	Total		**60**	**100**

Source: Santoso, 2010 in (Afriyani et al., 2020)

3.2. Analysis of Electrical Conductivity Parameters

Electrical conductivity is the ability of water to transmit electric current under the influence of salts, which can be ionized in solution (Leluno, 2020). If the water consists of a large amount of salt, then it will have a high value of electrical conductivity. Putranto's research shows that the value of electrical conductivity will be comparable to the TDS value, with the TDS property being affected by the formation of salts such as iron (ferons), which are considered to come from the weathering of volcanic rocks (Triadi Putranto et al., 2018).

In his research, Leluno said that EC tends to increase when there are more Cl- and Na+ ions in solution. The results of the EC inspection of Kutaraja sub-district showed that 85% (51 out of 60 wells) had brackish groundwater, 5%, or 3 wells out of 60, were included in the salty groundwater category, and 6 wells, or 10% of the total wells, were included in the very salty groundwater category.

In general, the EC value in Kutaraja sub-district has a dominant range of 1,200–2,500 mhos, which means that this type of groundwater has a brackish and salty taste. According to Afriyani's research, the presence of a high concentration of Cl-ions causes a taste (Afriyani et al., 2020). The distribution of EC values or conductivity levels in Kutaraja Sub-district has a certain pattern, meaning that the EC values of the upper part of Kutaraja Sub-district, namely Gampong Lampaseh Kota, Merduati, and Keudah, are dominantly brackish groundwater. While the lower part of the Kutaraja sub-district, namely Gampong Peulanggahan, Pande, and Jawa, found brackish groundwater, salty groundwater, and very salty groundwater, It can be concluded that the more sloping and close to the landfill site, the higher the EC value generated. The magnitude of the EC value also indicates that the area is a discharge area or discharge zone (Hadian, 2006).

Judging from the distribution of groundwater flow patterns in Kutaraja District (Figure 4), it can be concluded that groundwater moves partly to the south and partly to the north. This can happen because the pattern of groundwater flow follows the lows and highs of the landform. The landform of Kutaraja sub-district has sloping characteristics; therefore, the pattern of groundwater flow in Figure 4 does not have the same direction. It can also be seen that the well point in the very salty groundwater category borders the sea to the east of the location. It is possible that in the past, the evaporation process caused sulfate and chloride salts to precipitate and then dissolve in the groundwater; this could cause the groundwater to become saline.

The results of EC's research in Kutaraja sub-district, from 60 representative wells, it can be concluded that all wells in Kutaraja sub-district do not meet the water quality requirements for bathing, washing, toilet (BWT) needs and consumption of daily needs. In Nikita's research (2021) high groundwater levels can have a negative impact on body health such as skin, diarrhea, heart and hypertension, and last a long time if groundwater is used for living needs (Nikita et al., 2021).

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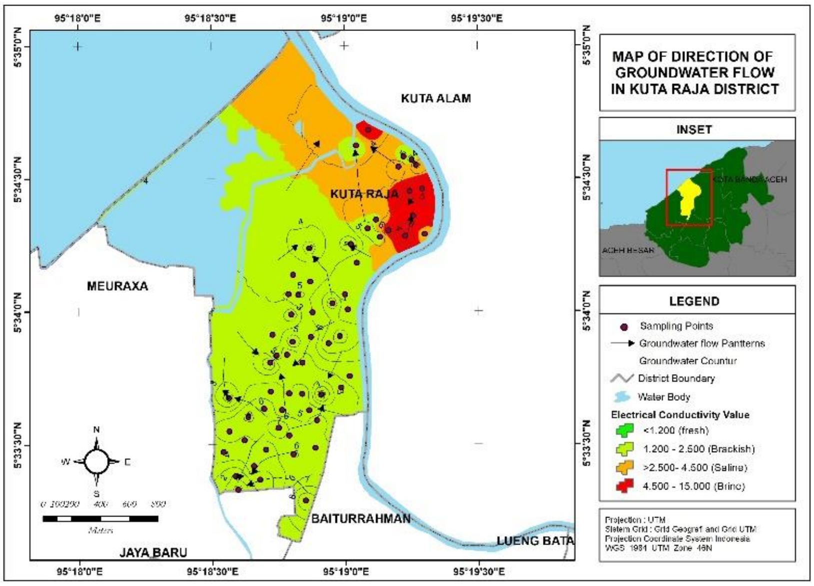

Figure 4. Map of the Flow Pattern and Electrical Conductivity of Kutaraja District Groundwater

Table 4. Research Results for Groundwater Parameters: Smell, Taste, and Color

No	Groundwater Conditions	Number of Wells	Percentage (%)
1	Clear, tasteless, and odorless	1	1,66
2	Yellow, tasteless, and odorless	42	70
3	Turbid, tasteless, and odorless	10	16,66
4	Slightly cloudy, salty taste, no odor	6	10
5	A bit cloudy and oily, salty taste, no smell	1	1,66

Source: Primary data, 2023

3.3. Odor, Taste, and Color Parameter Analysis

According to Regulation of the Minister of Health Number 492 of 2010 concerning the eligibility requirements for drinking water, good water to drink is water that is odorless, tasteless, and has a maximum total color unit (TCU) scale of 15 TCU for drinking water and 50 TCU for drinking water. clean (Permenkes, 2010). Based on the physical indicators in Table 4, of the 60 water well samples studied, 42 community well samples, or 70% of the well samples, were dominated by yellow, brackish, and odorless water conditions. 10 wells, or 16.66% of the residents' wells, were found to be cloudy, salty, and odorless. While the conditions were rather cloudy, salty, and odorless, as many as six wells, or 10% of the wells, were found. In oily and slightly turbid conditions, salty and odorless, one well was found with a proportion of 1.66%. One well (1.66%) had clear, tasteless, and odorless water, meaning that based on observations from 60 resident wells studied, only one well was considered normal in terms of smell, taste, and color parameters.

The 42 wells that were found to be yellow, tasteless, and odorless were mostly found in Gampong Jawa because the location of Gampong Jawa was very close to the landfill. Yellowish water can occur due to the presence of iron in the aquifer (Permana, 2019). Because Gampong Jawa residents' wells are located near the landfill, the color of the water is influenced by colored suspended matter and extracts of microorganic compounds. The results of the physical quality inspection showed that all wells in the Kutaraja district did not have a strong odor. This means that 60 water samples from community wells meet the requirements for drinking water quality in accordance with Regulation No. 492 of 2010 on odor parameters. Observation of the physical quality of taste showed that 10% (6 out of 60) of the wells had a salty taste, and 1 well, or 1.66%, had an oily, salty taste. From a total of 60 wells representing the Kutaraja sub-district, it can be concluded that all wells in the Kutaraja sub-district all meet the water quality requirements for BWT needs (bathing, washing, toilet) but are unfit for consumption.

3.4. Analysis of Total Dissolved Solids (TDS)

Based on the results of determining groundwater sampling points in the Kutaraja subdivision area, six sampling points were identified for TDS measurement, namely one sampling point in Gampong Pande, one sampling point in Gampong Keudah, and four sampling points in Gampong Jawa. Six sampling points were selected based on the high EC criteria for the phreatic groundwater. Astuti's research on the quality of irrigation water supports this theory by showing that the EC value in groundwater is higher in relation to TDS levels (Astuti, 2018). TDS is a solid in water in colloidal form. Ions, or compounds (Ruseffandi & Gusman, 2020). The number of dissolved particles with a diameter of less than 45 microns can indicate that certain organisms in water are more toxic (Lestari et al., 2021). The six samples are community wells used for household needs.

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Table 5. Research Data on Total Dissolved Solid Groundwater in Kutaraja District

Number	Class	TDS (mg/l)	Number of Wells	Percentage (%)
1	Fresh	0-1.000	3	50
2	Brackish	1.000-10.000	2	33
3	Saline	10.000-100.000	1	17
4	Brine	>100.000	0	0

Source: Afriyani, 2020

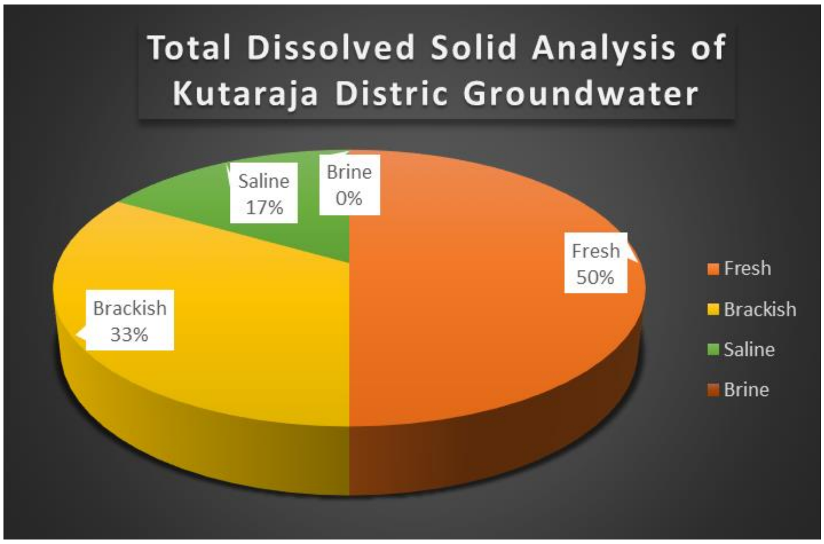

Figure 5. Pie Chart of Total Dissolve Solid of Water in Kutaraja District

Table 6. Groundwater Measurement Results for pH Parameters

Number	Groundwater pH Category	pH	Number of Wells	Percentage (%)
1	Acid	5,0 – 6,5	0	0
2	Nuetral	6,6 – 7,5	25	41,66
3	Alkali	7,6– 8,5	35	58,33

Source: Primary data, 2023

The highest TDS level allowed in the 2017 Minister of Health Regulation is 1,000 Mg/L for drinking water and 1,500 Mg/L for clean water. The results of examining the amount of dissolved solids, or TDS, in well water around the landfill identified varying values. According to Table 6, three wells are categorized as fresh wells with their respective analysis results, namely Gampong Keudah at 230.1 mg/l, an increase in Gampong Pande at 732.1 mg/l,then increased slightly in Gampong Jawa to 822.3 mg/l. Whereas in the brackish category, there are 2 wells located in Gampong Jawa with TDS of 2700 mg/l and 2113 mg/l, respectively.In the salty (saline) category, one well was found in Gampong Jawa with a TDS of 12020 mg/l and was the well with the highest TDS of all samples.

The results of the TDS study of six samples representing the entire Kutaraja sub-district can be concluded to show that only three wells that meet the requirements for TDS levels for drinking water and clean water are in the fresh category. The brackish and salty categories cannot be used for daily needs. The high TDS is affected by rock weathering, domestic waste, and soil runoff (Sari & Huljana, 2019). The high TDS values in the brackish and salty categories are caused by the location of the groundwater samples, which are very close to the landfill, because groundwater that has been contaminated by domestic waste makes many ions dissolved in groundwater show more intense interactions and longer contact times between groundwater and aquifers. Conditions in landfills often change over time from aerobic to anaerobic, allowing different chemical reactions to occur in groundwater (Longe & Enekwechi, 2020).

3.5. Groundwater pH analysis

The term pH refers to the level of concentration of H+ (hydrogen) -ions released in a liquid. According to Minister of Health of the Republic of Indonesia Number 492 of 2010 regarding drinking water quality requirements, the normal pH of water is between 6.5 and 8.5. Based on direct measurements of groundwater pH parameters, it shows that the average pH is around 7.80, which is still within the range permitted by the Minister of Health. The Gampong Pande well has the lowest pH, which is 6.9, while the highest pH is at 8.5 and has reached the maximum limit for drinking water quality requirements. This can occur due to the high levels of Ca^{2+} and Mg^{2+} ions, so it is necessary to examine the metal content in groundwater using an absorption spectrophotometer (Vidika A. et al., 2017).

Low and high pH values in water do not affect health, but for water that has a decreased pH of 6.5, it can cause damage to the metal (water pipes), which dissolves the elements lead, copper, and cadmium,

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produces an unpleasant taste, and is capable of making some chemicals become poisons. However, if the pH is above 8.5, it is capable of producing sediment (mud) in water pipes, which can then become a toxin not suitable for use in food processing because it can interfere with digestion (Putri et al., 2018). The overall results of groundwater tests on wells in the Kutaraja sub-district met the groundwater quality requirements on the examination of pH parameters, meaning that there were 41.66% of wells that had a neutral (normal) pH and 58.33% of wells that had an alkaline pH but were still within the standards of the RI Minister of Health, number 492 of 2010. Groundwater with a pH above 9 can cause damage to the stomach because it is alkaline.

4. CONCLUSION

Based on the results and discussion of groundwater feasibility research in Kutaraja District, Banda Aceh City, there are several significant results. The results of groundwater temperature measurements show variations, with the majority of wells having high temperatures, which indicate the presence of hydrolyzed chemicals or the decomposition of organic material by microbes. Kuta Raja also has a high level of electrical conductivity, which indicates that the groundwater is brackish or salty. Groundwater that is polluted with substances such as Cl- and Na+ ions can give the water a salty taste. Apart from that, groundwater flow patterns also influence the level of electrical conductivity; in the research area, higher DHL values were found at final waste disposal sites.

TDS measurement results show that most of the wells have high TDS levels, which exceed the permissible limits for drinking water and clean water. So, this groundwater is not recommended for consumption. So, in general, it can be said that the majority of groundwater in Kutaraja District, Banda Aceh City, does not meet the water quality requirements for consumption. This can have a negative impact on the health of people who use this groundwater for their daily needs. Action is needed to ensure a supply of clean water that is safe and suitable for consumption. It is hoped that in the future we can carry out more detailed research by carrying out laboratory tests on the quality of groundwater in Kuta Raja District.

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