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Analysis of Well Water Quality Status Due to Seawater Intrusion in Dapu-Dapura Village, West Kendari District, Kendari City

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Abstract

This study aims to determine the status of well water quality due to seawater intrusion in Dapu-Dapura Village, West Kendari District, Kendari City. The analysis method used is the IP (Pollution Index) method with Purposive Sampling technique to analyze samples from several wells in Dapu-Dapura Village, West Kendari District, Kendari City. The parameters measured are Temperature, Total Dissolved Solids (TDS), Electrical Conductivity (DHL), Potential of Hydrogen (pH), Sodium (Na+), Chloride (Cl-), Salinity andEscherichia coli. The results of the study showed that the Pollution Index value at station I was 0.466, at station II 0.453, and at station III 0.455. Therefore, the well water quality status in Dapu-Dapura Village is, West Kendari District, Kendari Citystill included in the classification of meeting quality standards based on class 1 quality standards in Government Regulation Number 22 of 2021.

Keywords:Well water, Pollution Index, Seawater intrusion, Water quality.

INTRODUCTION

Indonesia is one of the largest archipelagic countries in the world. This is because Indonesia has approximately 17,500 islands, consisting of 30% land and 70% water (Wulandari et al., 2024). Water's uses include drinking, cooking, bathing, washing clothes and household appliances, irrigation, transportation, and even power generation.(Guiseppina, 2024)Given the importance of water, it is essential to have a water source that can provide good water in terms of quantity and quality. In Indonesia, drinking water sources generally come from surface water, groundwater, and rainwater.(Manune et al., 2019).

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Kendari City is located in the southeastern part of Sulawesi Island, with an area of 271.76 km2, or 0.7% of the land area of Southeast Sulawesi Province. Hydrologically, the primary water resource for Kendari City residents to meet domestic and industrial needs comes from groundwater, both shallow groundwater obtained from dug wells and deep groundwater from drilled wells (Kete et al., 2020). Seawater intrusion is a groundwater problem in coastal areas because it directly impacts groundwater quality. Consequently, there are changes in the quality and quantity of groundwater itself. Groundwater that was previously suitable for drinking water has decreased in quality, making it unsuitable for daily use.

In 2016, groundwater conditions in Kendari City, based on salinity values, ranged from 0.1% to 1.15%, with an average value of 0.25%. This indicates that groundwater in this area is classified as freshwater to brackish or slightly affected by seawater intrusion. However, in 2019, this area experienced seawater intrusion. The analysis showed that 26.26% of the area was highly intruded, spread across several sub-districts, namely parts of Abeli District, parts of Mandonga District, Kendari District, and West Kendari District (Kete et al., 2020). (Sulpiana et al., 2023) also stated that as much as 6% of groundwater conditions in Kendari City have been highly intruded, spread across Abeli District, West Kendari District, Kendari District, Mandonga District, Nambo District and Poasia District with a total area of 15,573,441.57 Ha. Based on the above, it is certainly expected that the status of well water quality in Dapu-Dapura Village, West Kendari District, Kendari City still meets quality standards. The criteria for the status of well water quality are whether it is still suitable for use or not, in the sense that water quality is used to determine whether the water is safe enough for consumption or use for certain activities.

RESEARCH METHOD

This research was conducted in Dapu-Dapura Village, West Kendari District, Kendari City. The population used in this study was well water in Dapu-Dapura Village, West Kendari District, Kendari City. The wells used in this study were wells used by the community as a source of clean water and used for domestic purposes. The sample of this study was well water obtained in Dapu-Dapura Village, West Kendari District, Kendari City, consisting of 3 wells consisting of 2 drilled wells and 1 dug well. Data collection techniques in this study consisted of several stages, namely field observation, interviews and laboratory studies.

Data analysis was conducted from the results of testing or measuring water samples with three parameters: physical parameters, chemical parameters, and biological parameters, with the units expressed based on the parameters tested/measured. The values obtained from the measurement or testing results were tabulated and then analyzed using the Pollution Index (IP)

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method. Water quality analysis was conducted by comparing the quality of the well water from the Dapu-Dapura Village community measured with the well water quality standards according to Government Regulation Number 22 of 2021 concerning the Implementation of Environmental Protection and Management. Determination of Water Quality Status using the Pollution Index method. The pollution index calculation was carried out using the following formula:

$$PIj = \sqrt{\frac{(C_i/L_{ij})_M^2 + (C_i/L_{ij})_R^2}{2}}$$

The pollution index obtained from the calculation results is then entered into the water quality status based on the Decree of the Minister of State for the Environment Number 115 of 2003 concerning Guidelines for Determining Water Quality Status. The tool used in this study is a Water quality tester that can be used to measure the parameters of Temperature, TDS, Electrical Conductivity (DHL), pH and Salinity. The materials used in this study are questionnaire sheets used for interviews and well water samples in Dapu-Dapura Village, West Kendari District, Kendari City used for laboratory tests.

RESULTS AND DISCUSSION

Research result

The pollution index (IP) is a value that has been determined according to the water body, for example rivers, lakes and seas. As according to Sumitomo and Nemerow (1970) in the Decree of the Minister of State for the Environment Number: 115 of 2003. The Pollution Index is determined for a specific designation, then can be developed for several designations for all parts of the water body or part of a river (Sudirman et al., 2013). The pollution index of well water in Dapu-Dapura Village is presented in Table 1.

Table 1. Well Water Pollution Index in Dapu-Dapura Subdistrict

Location Point	IP	Quality Status
Station I	0.466	Meet Quality Standards
Station II	0.453	Meet Quality Standards
Station III	0.455	Meet Quality Standards

Table 1 shows the pollution index value of well water in Dapu-Dapura Village. From 3

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(three) observation stations, the pollution index value was obtained at Station I with a pollution index value of 0.466, at Station II the pollution index value was 0.453 and at Station III the pollution index value was 0.455. According to the Decree of the Minister of State for the Environment Number: 115 of 2003, the status of well water quality in Dapu-Dapura Village is classified as meeting quality standards.

DISCUSSION

Dapu-Dapura Village is one of the villages in West Kendari District. Residents in Dapu-Dapura Village obtain their daily water needs from several sources, namely the Regional Water Company (PDAM), mountain water, and even groundwater, both deep groundwater obtained from drilled wells and shallow groundwater obtained from dug wells. Based on research conducted in February under sunny weather conditions at the time of sampling. This study also used the Pollution Index method as stated in the Decree of the Minister of State for the Environment Number 115 of 2003 concerning Guidelines for Determining Water Quality Status which was then compared with Government Regulation Number 22 of 2021 using class 1 quality standards because well water is used as a domestic water source in Dapu-Dapura Village.

Physical Quality

Temperature Deviation

Temperature is a physical quantity. Abnormal temperatures indicate large amounts of dissolved chemicals in the water and can also indicate the decomposition of organic material by microorganisms, which can be harmful to living things (Chuzaini & Dzulkiflih, 2022).



Figure 1. Sample points against temperature deviation

Based on the results of the temperature parameter analysis above, different values were obtained due to differences in sampling time, well depth, surface conditions (open or closed) of the well, land cover and topography of the temperature parameter measurement station, however, the well water in Dapu-Dapura Village still meets the class 1 quality standard, namely

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a deviation of 3°C in Government Regulation Number 22 of 2021. This is in line with Rohmawati (2016) several things that influence the high and low water temperatures, namely sampling time, topography, sunlight, and rainfall.

Total Dissolved Solids (TDS)

Total Dissolved Solids (TDS) is the amount of solids dissolved in water, whether in the form of ions, compounds or colloids (Anwar et al., 2021).

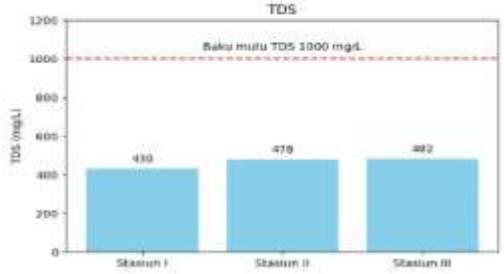


Figure 2. Sample points against TDS

Based on these results, when compared to the Class 1 quality standards stipulated in Government Regulation Number 22 of 2021, the TDS parameter for well water in Dapu-Dapura Village still meets the water quality standards for its intended purpose. Well depth plays a significant role in influencing TDS levels. This is evident from Station I, which has the deepest well depth of 22 meters and is located closest to the coastline, at 79.54 meters from the shoreline, yet it showed the lowest TDS value of 430 mg/L. Conversely, Station III, which has the shallowest well depth of 6 meters and is the furthest from the shoreline, at 289.25 meters, measured the highest TDS, at 482 mg/L. Meanwhile, Station II, which has a well depth of 17 meters and is located at a medium distance from the shoreline, at 160.5 meters, showed the lowest TDS value.

This indicates that well water taken from greater depths tends to have a lower dissolved substance content, as it has undergone a better natural filtration process below the surface of the ground. On the other hand, shallower wells are more easily contaminated by surface waste and the influence of human activities above the ground, resulting in higher TDS values. The results of the study indicate that there is a suspected geological layer or aquifer structure that can provide effective protection so that seawater intrusion in these wells does not occur significantly. In other words, groundwater quality at the study site is more influenced by aquifer depth than by distance from the coastline. This is in line with Kete et al., (2020) that the TDS

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value in water is strongly influenced by geological conditions, runoff from the land, and community activities that produce waste, both domestic and industrial.

Electrical Conductivity (DHL)

Groundwater electrical conductivity (EVC) is the ability of groundwater to conduct an electric current. EVC can be used to determine dissolved salt content. The EVC variable is often used to initially identify groundwater quality conditions (Sejati & Panji, 2024).



Figure 3. Sample points against DHL

The permissible value of Electrical Conductivity in water is 1500 µS/cm so that the Electrical Conductivity value of well water in Dapu-Dapura Village is still within the threshold. The results of Electrical Conductivity (DHL) measurements from three stations obtained a value at Station I of 840 µS/cm, this occurs because the well used was newly built so that the pumping of well water is still relatively low, even though the drilled well at Station I is close to the coastline, namely with a distance of 79.54 meters from the coastline. At Station II it is 956 µS/cm, this occurs because the distance between the well and the coastline is quite close, namely with a distance of 160.5 meters from the coastline and has been using drilled well water for its daily domestic needs for a long time.

At Station III it was 962 µS/cm, this happened because the type of well used was a dug well which had a shallower depth compared to a drilled well, so it was more easily affected by contamination from the surface and human activities around it and had a distance from the coastline to the well water of 289.25 meters. This is in line with (Suud et al., 2015) The Electrical Conductivity (DHL) of the soil occurs due to the existence of free salt content found in the soil water content and the exchangeable ion content found on the surface of solid soil particles.

Chemical Quality

Power of Hydrogen (pH)

Power of Hydrogen (pH) is the degree of acidity used to express the level of acidity or alkalinity of a solution (Wati & Sholihah, 2021).

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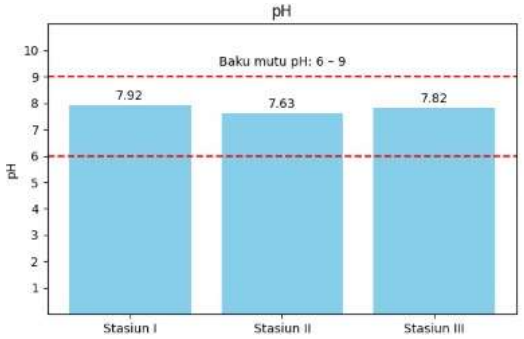


Figure 4. Sample points against pH

Direct measurements from three stations yielded Power of Hydrogen (pH) values at Station I of 7.92, Station II of 7.63, and Station III of 7.82. Based on Government Regulation Number 22 of 2021, the pH of well water in Dapu-Dapura Village at stations I, II, and III is within acceptable limits. Generally, wells closer to the coast are more susceptible to seawater intrusion, which can lead to decreased water quality. However, research shows that Station I, despite being closest to the coast, has the highest pH. This is supported by the depth of the wells at each station. Station I has a well depth of 22 meters, Station II has a well depth of 17 meters, and Station III has a depth of only 6 meters. Deeper wells draw water from more protected aquifer layers. Conversely, wells with shallower or moderate depths are more susceptible to impacts, even though they are farther from the coast. The pH value tends to remain unchanged despite seasonal changes (Zhang et al., 2020).

Sodium (Na+)

According to Murtinto (2008), sodium can also originate from seawater intrusion, where this element in seawater originates from the weathering of igneous rocks that dissolve and are then carried to the sea and accumulate. The main source of sodium is seawater.

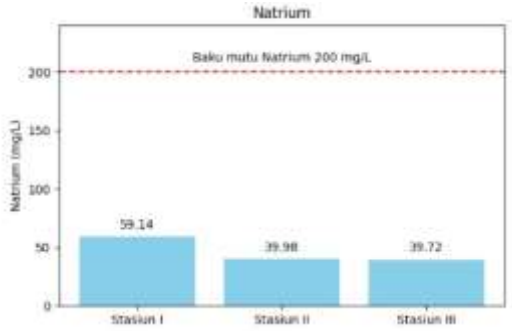


Figure 5. Sample points against Sodium

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The minimum sodium concentration allowed in water is 200 mg/L, so the sodium concentration of well water in Dapu-Dapura Village is still within the threshold. When viewed from other parameters such as chloride, Electrical Conductivity (DHL), and Total Dissolved Solids (TDS), which show a directional pattern, namely increasing from Station I to Station III. However, the sodium concentration obtained actually shows the opposite, where the highest sodium concentration is found at Station I at 59.14 mg/L with a well depth of 20 meters, while the lowest value is at Station III at 39.72 mg/L with a well depth of 6 meters. This difference is thought to be caused by local geological conditions and the type of well used. The wells at Stations I and II are drilled wells that draw water from deeper layers of the soil, making it more likely that minerals such as sodium from underground rocks will dissolve, resulting in a natural increase in sodium levels. This is in line with Djuwansah (2013) that basically the amount of Na+ dissolved in groundwater and Na+ bound as cations exchanged in the soil is always in equilibrium.

Groundwater dilution by rainwater will dissolve some of the exchangeable Na+, which will be washed away with the flow. However, if the input Na+ concentration is higher than the leached concentration, the soil will absorb it, resulting in accumulation, increasing the Na+ content in the soil. Meanwhile, Station III uses a dug well at a shallower depth, which tends to have a lower sodium concentration, this is due to the limited rock dissolution process that typically occurs in deeper soil layers.

Chloride (Cl-)

Chloride is one of the main organic anions found in natural waters, in greater quantities than other halogen anions. Chloride is usually found in the form of sodium chloride (NaCl), potassium chloride (KCl), and calcium chloride (CaCl2) (Aisyah, 2021).

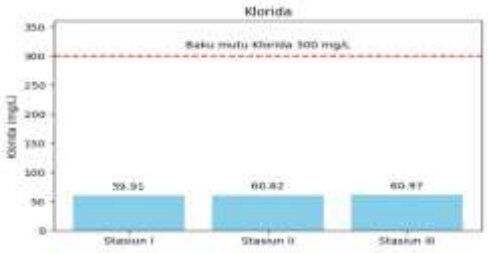


Figure 6. Sample points against Chloride

The maximum chloride ion level in clean water permitted under Government Regulation Number 22 of 2021 for Class 1 criteria is 300 mg/L. Laboratory analysis results indicate that chloride ion levels at three observation stations still meet quality standards. Therefore, it can be concluded that chloride ion levels in well water samples in Dapu-Dapura Village are still below

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the maximum permissible chloride ion level. In general, wells closer to the coastline tend to have higher chloride levels because they are more susceptible to seawater intrusion. However, the results of this study show a slightly different pattern, where chloride levels actually increase slightly at stations farther from the coast. This can be explained by considering the different well depths at each station.

Station I, closest to the coast (79 meters), has the deepest well depth of 22 meters, so the water taken comes from an aquifer layer that is more protected from seawater intrusion, resulting in relatively low chloride levels. Conversely, Station III, furthest from the coast (289 meters) but with the shallowest well depth of 6 meters, actually shows higher chloride levels because the water taken comes from the upper layer of the aquifer that is more vulnerable to seawater intrusion and mixing.

Station II, located 160 meters away and with a well depth of 17 meters, showed chloride levels between the other two stations. These results indicate that at the study site, well depth appears to have a greater influence on chloride levels than distance to the coast, with deeper wells tending to have better water quality with lower chloride levels, even though they are closer to the coastline.

Salinity

Salinity is the level of salinity or the amount of dissolved salt in water. (Ardaneswari et al., 2016) explains that salinity describes the total solids in water, after all carbonates have been converted to oxides, all bromides and ionides have been replaced by chlorides, and all organic matter has been oxidized.



Figure 7. Sample points against salinity

The permissible salinity value in water is 0.5‰ so that the salinity value of well water in Dapu-Dapura Village is still within a good threshold. The results of salinity measurements from the three stations obtained the same value of 0.4‰. This occurs because the distance of the three stations is still relatively close (289.25 meters from the coastline) causing the level of

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exposure to seawater intrusion to be the same, so that the salinity value appears relatively uniform despite the different geographical positions. This is in line with Arini (2023) that in zones with a relatively close distance to the coast, salinity is in the light intrusion category (0.0–0.9‰) and shows small variations between sampling points. Thus, the uniformity of salinity values in Dapu-Dapura Village is very likely caused by the distance of the stations which are still in the light intrusion zone and not far enough to form a significant salinity gradation.

Biological Quality

Escherichia coli

Escherichia coli and coliform bacteria are indicators for determining the suitability of drinks and food because their presence is an early sign of contamination from other bacteria that can cause disease. Escherichia coli is a gram-negative, non-spore-forming, rod-shaped bacterium that can ferment lactose (Hubaiba & Ahmad Saktiansyah, 2021).

The concentration of Escherichia coli from Station I to Station III of well water in Dapu-Dapura Village obtained the same result, namely 0 MPN/100mL. Thus, the results of Escherichia coli or fecal coliform in well water in Dapu-Dapura Village still meet the quality standards stipulated in Government Regulation Number 22 of 2021. At Station I, the well water used was a drilled well with a depth of 22 meters and a distance of approximately 10 meters from the septic tank. Despite its relatively close distance to the septic tank, this depth of 22 meters provides protection against microbiological contamination, namely Escherichia coli. Furthermore, this drilled well also has a closed structure, thus better protected from surface contamination. At Station II, the well water used was also a drilled well with a depth of 17 meters and a further distance from the septic tank, namely approximately 18 meters. This condition can minimize the occurrence of direct fecal contamination into the well. Furthermore, this drilled well also has a closed structure, thus better protected from surface contamination.

At Station III, the well water used is a dug well with a depth of only 6 meters and a distance from the septic tank of 8 meters. In addition, this dug well also has an open structure that is generally easily contaminated from the surface, but laboratory test results showed negative for Escherichia coli. This is influenced by the presence of a cement layer on the surface of the soil around the dug well which reduces the potential for infiltration of contaminated surface water into the well. This is in line with (Putri Berliana Octavira et al., 2024) that well construction must comply with health standards, namely the distance from the source of pollution with its construction, a watertight well lip, a watertight cement floor, a pump base and distribution pipes.

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Well Water Pollution Index in Dapu-Dapura Subdistrict

Water quality management based on the Pollution Index (PI) can provide input to decision-makers to assess the quality of water bodies for a specific purpose and take action to improve quality if quality declines due to the presence of pollutants. The pollution index of well water in Dapu-Dapura Village at three stations decreased from station I to station III. However, it still meets the class 1 quality standard set by Government Regulation Number 22 of 2021. The community uses this well water as a source of clean water for daily domestic needs.

At Station I, the Pollution Index analysis results were 0.466. Based on the Decree of the Minister of State for the Environment Number 115 of 2003, Station I is still categorized as meeting quality standards. The location of the Station I sample is closest to the coast compared to the samples at Stations II and III, which theoretically have a higher vulnerability to seawater intrusion. The results of direct measurements actually show that the TDS and DHL values are among the lowest when compared to the samples at Stations II and III. This indicates that the levels of dissolved substances in the water are still low and have not experienced a significant increase due to intrusion. Another factor supporting the good quality of the well water is the age of the well which is still new (recently built), so that the well water pumping is still relatively low.

At Station II, the Pollution Index analysis results were 0.453. Based on Decree of the Minister of State for the Environment Number 115 of 2003, Station II still meets the quality standards. At this station, well water is used as a source of clean water to meet daily domestic needs. The area surrounding the drilled well is residential, with no agricultural or plantation activities. This can reduce pollution from agricultural chemicals. Furthermore, the Station II sampling location is on relatively high ground, which helps reduce the potential for seawater to enter the aquifer system.

At Station III, the Pollution Index analysis results were 0.455. Based on the Decree of the Minister of State for the Environment Number 115 of 2003, Station III is still categorized as meeting quality standards. The well at Station III is a dug well with a depth of 6 meters and is located in a fairly dense residential area and is openly used by the community. The ground surface around the dug well has been cemented to help prevent seepage of contaminated water from the surface into the dug well. In addition, the use of pipes by residents for water collection also contributes to protecting the water from direct contamination, especially due to the open condition of the well.

The results of the study showed that the average pollution index value in Dapu-Dapura Village at the three stations showed an IP value <1.0, which means it still meets the water quality

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standards based on the Decree of the Minister of State for the Environment No. 115 of 2003. This condition indicates that even though there is potential for seawater intrusion, the quality of groundwater at the location has not experienced significant pollution so it is still safe and suitable for use to meet the domestic needs of the community.

CONCLUSION

The conclusion that can be drawn from this study is that the value of the well water pollution index in Dapu-Dapura Village, West Kendari District, Kendari City at station I is 0.466, station II is 0.453 and station III is 0.455 according to the Minister of Environment Decree No. 115 of 2003, the quality status of well water in Dapu-Dapura Village, West Kendari District, Kendari City is still included in the classification of meeting quality standards and has not been polluted so that well water is still safe and suitable for use to meet the domestic needs of the community.

SUGGESTION

The suggestions that the author can give are as follows:

1. For the community, it is important to maintain environmental sanitation around the well, such as ensuring that the septic tank is a safe distance from the well water source, does not leak, and regularly checks the physical condition of the well, especially open wells.
2. For the government, it is essential to regularly monitor water quality from domestic sources, especially in coastal areas vulnerable to seawater intrusion. The installation of well protection systems, such as cement lining and the use of well-bottomed water intake pipes and covered well surfaces, is essential to maintain water quality.

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