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Analysis of groundwater level fluctuations and groundwater quality at Benoa and Tanjung Benoa Village, Bali Province, Indonesia

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ABSTRACT

Benoa and Tanjung Benoa Village in Badung Regency is growing every year. Population growth impacts the increasing demand for clean water, which groundwater dominates. This affects the fluctuation of groundwater level and groundwater quality. This research method is descriptive and quantitative based on field observation and laboratory tests. Groundwater level fluctuations were observed for 12 months to determine the difference between the rainy and dry seasons. This research aims to determine changes in the dynamics of groundwater conditions in the Benoa and Tanjung Benoa villages. Based on the analysis results, the groundwater table fell 0.9 m in the dry season and rose 0.74 m in the wet season. The minimum pH value was 6.01; the maximum pH was 7.24. The average conductivity was 921-1,003 µs/cm. The average water temperature was 27.4˚C to 28.2˚C. The lowest chloride concentration averaged 68.69-76.40 mg/L, and the highest was 92.3-98.8 mg/L. Dissolved oxygen ranged from 5.9 to 7.2 mg/L.

ABSTRAK

Desa Benoa dan Desa Tanjung Benoa di Kabupaten Badung mengalami perkembangan setiap tahunnya. Pertumbuhan penduduk berimbas dengan meningkatnya kebutuhan akan air bersih yang didominasi dari air tanah. Hal ini berpengaruh pada berfluktuasinya level muka air tanah dan kualitas air tanah. Metode penelitian ini adalah deskriptif kuantitatif berbasis observasi lapangan dan uji laboratorium. Fluktuasi muka air tanah diamati selama 12 bulan untuk mengetahui perbedaannya pada musim hujan dan musim kemarau. Penelitian ini bertujuan untuk mengetahui perubahan dinamika kondisi air tanah di Desa Benoa dan Tanjung Benoa. Berdasarkan hasil analisis, permukaan air tanah turun 0,9 m pada musim kemarau dan naik 0,74 m pada musim hujan. Nilai pH minimum adalah 6,01; pH maksimum adalah 7,24. Konduktivitas rata-rata adalah 921-1.003 µs/cm. Suhu air rata-rata adalah 27,4˚C hingga 28,2˚C. Konsentrasi klorida terendah rata-rata 68,69-76,40 mg/L, dan tertinggi 92,3-98,8 mg/L. Oksigen terlarut berkisar antara 5,9 hingga 7,2 mg/L.

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1. Introduction

Water is a natural resource that people utilize for a variety of purposes. The most common form of water used by humans is groundwater. People rely heavily on groundwater to fulfill various requirements, including drinking, cooking, bathing, washing, water for potable, domestic, and agricultural purposes. Due to its many benefits, groundwater is used to satisfy the population's needs. The relative cleanliness of groundwater compared to surface water (river, sea, lake, and ambient water) is one of the benefits of groundwater. The prevalence of groundwater in the aquifer zone protects it from contamination [1–3]. In recent years, the tourism industry, modernization, and population growth on Bali's island have significantly impacted groundwater resources, particularly in the South of Kuta, Badung Regency, Bali Province, Indonesia. South Kuta is one of the most populous subdistricts in Badung Regency, with a population of approximately 131.400 and an annual development rate of 0,13% [4]. Benoa and Tanjung Benoa are villages in the South Kuta Subdistrict. Benoa Village has a population of 37.346 people, or approximately 32,78% of the total population in the region and Tanjung Benoa Village has a population of 5.766 people, or approximately 5,06% of the total population in the region [5], which puts pressure on the availability of clean water, particularly given the high risk of groundwater depletion. This phenomenon will affect the quantity and quality of groundwater, including land subsidence, decreased water quality, and marine intrusion, if it is not controlled. The unrestrained exploitation of groundwater will harm the equilibrium of nature.

According to [6], Regional Drinking Water Company (PDAM) Tirta Mangutama is responsible for the administration of public clean water in the Badung Regency area. In the Kuta and South Kuta areas, PT Tirta Mangutama collaborates with a third party, PT. Tirtaartha Buanamulia. The capacity that can be utilized by PAM PT Tirtaartha Buanamulia (PT. TB) with service area coverage covering South Kuta Sub-district (Pecatu Village, Ungasan Village, Kutuh Village, Benoa Village, Tanjung Benoa Village, Jimbaran Village) and a portion of Kuta Sub-district (Kedonganan Village, Tuban Village, Kuta Village) could not meet the community's water needs and this indicates a 19,16 l/dt water deficit. With a projected annual average growth rate of 7% in the number of house connections, the demand for pure water will continue to rise alongside population growth until 2015, when it reaches 1.067,46 lt/dt, and the number of house connections reaches 31.524 units. The imbalance of supply and demand in the PT. TB business area, where the demand for clean water exceeds the availability of clean water, is inseparable from clean water problems associated with usage patterns related to the level of welfare of the population, as well as the growing population growth that requires greater fulfillment of clean water, given the development of the South Kuta area, particularly Benoa and Tanjung Benoa Village, as a tourist destination [6]. Thus, the water deficit that occurs will be met from deep groundwater siphoned through boreholes.

To maintain and sustain the function of groundwater, it is necessary to survey groundwater conditions [7]. There have been numerous inventories of groundwater conditions that focus on contemporary needs. To the author's knowledge, groundwater conditions, including groundwater level and groundwater quality, have never been identified in the South Kuta region, particularly in Benoa and Tanjung Benoa Village. Benoa and Tanjung Benoa Village is included in the Nusa Dua groundwater basin based on hydrogeological conditions; lithologically, Nusa Dua groundwater basin is included in the karst area. Typically, karst-type aquifers contain three distinct categories of porosity simultaneously: matrix or intergranular porosity (pores between grains), crack porosity, and cavity porosity. In addition, this distinguishes this study from similar studies. Changes in groundwater conditions are essential information for groundwater administration and protection [8][9], particularly groundwater protection in karst-type aquifers. The purpose of groundwater management and conservation is to preserve groundwater to provide sustainable benefits to the population. The food and beverage industry is a highly desirable sector.

Based on the problems described, this research aims to determine changes in dynamics groundwater conditions in the Benoa and Tanjung Benoa Village area. The parameters used in this research are groundwater fluctuation and groundwater quality. The research results are visualized using Geographic Information System (GIS) technology. The results of this study are expected to be used as input in the management and protection of groundwater in the Benoa and Tanjung Benoa Village area, South Kuta District, Badung Regency, Bali Province.

2. Research Methodology

2.1. Location and Time of Research

This research was conducted in the South Kuta Subdistrict, precisely in Benoa and Tanjung Benoa Village, Badung Regency, Bali Province. The area of Benoa Village is approximately 28,28 km² and Tanjung Benoa Village is approximately 2,39 km^2. The administrative boundaries of Benoa and Tanjung Benoa Village are that the North side of Benoa Village is bordered by Benoa Bay, the South side is directly bordered by the Indian Ocean, Ungasan Village and Jimbaran Village are the boundaries on the West side. At the same time, the Badung Strait is the boundary on the East side of Benoa ang Tanjung Benoa Village. The research location can be seen in Figure 1. This research was conducted for 15 months, starting in January 2021 until July 2022, with the aim of observing the difference in groundwater level height during the rainy season and the dry season. There are 20 shallow wells as locations for measuring groundwater levels and taking groundwater samples for quality testing, which are carried out purposively (purposive sampling) in Benoa Village, Badung Regency. The sampling location can be seen in Figure 2 and Table 1.

Figure 1. Study location

Figure 2. Map of Shallow Well Location

Table 1. Shallow well location.

No	Shallow Well Location	Coordinate	
		Longitude	Latitude
1	Gg. Sale 3	115° 13' 4.55"	8° 47' 49.87"
2	Gg. Sale 3	115° 13' 4.2"	8° 47' 50.54"
3	Gg. Sale 3	115° 13' 2.7"	8° 47' 50.19"
4	Gg. Sale 3	115° 13' 2.25"	8° 47' 50.5"
5	Jl. Taman Giri	115° 11' 49.84"	8° 47' 16.29"
6	Jl. Srikandi	115° 13' 24.43"	8° 48' 17.4"
7	Jl. Pratama	115° 13' 26.75"	8° 48' 17.4"
8	Jl. Pratama Gg. Pendidikan	115° 13' 20.37"	8° 46' 44.69"
9	Jl. Pratama Gg. Bali Becik	115° 13' 26.87"	8° 46' 43.32"
10	Jl. Pratama Gg. Ksatria	115° 13' 21.67"	8° 46' 36.61"
11	Jl. Pratama Gg. Danu 1	115° 13' 27.97"	8° 47' 47.41"
12	Jl. Telaga Waja Proyek lavaya	115° 13' 6.14"	8° 46' 9.26"
13	Jl. Pratama Gg. Bidadari	115° 13' 19.6"	8° 46' 24.94"
14	Jl. Pratama	115° 13' 15.38"	8° 45' 43.35"
15	Jl. Taman Sari	115° 13' 8.25"	8° 45' 46.17"
16	Jl. Madya	115° 13' 6.14"	8° 45' 14.9"
17	Jl. Taman Sari 2	115° 13' 15.28"	8° 45' 49.98"
18	Jl. Taman Sari	115° 13' 9.5"	8° 45' 46.57"
19	Jl. Segara Windu	115° 13' 14.74"	8° 45' 20.87"
20	Jl. Pratama Gg. Nusa	115° 13' 31.26"	8° 47' 27.3"

2.2. Geological and Hydrogeological Setting

The study area is located south of Bali Island. According to [10], Benoa and Tanjung Benoa Village is included in the Nusa Dua groundwater basin based on hydrogeological conditions; lithologically, Nusa Dua groundwater basin is included in the karst area. Research location is composed of alluvium (cobble, pebble, sand, silt and clay; as river, lake and coastal deposit. Most of the areas of Benoa and Tanjung Benoa villages were formed from the South formation mainly consists of reef limestone, mari in places, partly bedded, recrystallized and fossiliferous [11]. Lithological composition of rocks and permeabilities consist of alluvial coastal deposits, composed mainly sands, and generally high permeability. Based on occurrence og groundwater and productivity aquifers, Benoa and Tanjung Benoa Villages are aquifers in which flow is intergranular with locally moderately productive aquifers (mostly incoherent aquifers of low thickness and transmissivity, wells yield generally less than 5 l/sec). Most of the areas of Benoa and Tanjung Benoa villages are dominated by karstified limestones, calcareous sandstones and maris. Generally moderate to high permeability, especially low in maris [12].

2.3. Data Collection

The data collected in the study were primary data and secondary data. Preliminary data is in the form of shallow groundwater samples taken from the dug well water of residents in Benoa and Tanjung Benoa Villages. A total of 20 external groundwater samples were taken purposively. Sampling was done directly using the grab sampling method, a momentary sampling method that shows the characteristics of the water at that time. In situ testing of groundwater samples was conducted directly at the location, and well water samples were tested in the laboratory. Other primary data is the groundwater level measured directly in the field. The equipment used in this research includes a Global Positioning System using a smartphone to determine the location coordinates of the dug wells at the research site, 50 (fifty) meters of rope with weights, and a meter to measure the depth of the groundwater level, and water quality tester equipment model number EZ-9909-SP for testing pH, TDS, salinity, and EC of well water samples in situ. While ex-situ testing is the parameters of dissolved oxygen (DO) and Chloride (Cl). Secondary data in this study are administrative maps of Benoa and Tanjung Benoa villages, a map of the Bali Island Groundwater Basin (CAT) at a scale of 1: 250,000, and a Bali Sheet Geology map scale 1: 250,000, and Indonesian Hydrogeology map Bali Island Sheet scale 1: 250.000.

2.4. Research Procedure

The method used in this research is descriptive quantitative based on experimental research method. This research aims to determine the fluctuation of groundwater level and groundwater quality in the research location to be mapped through spatial analysis. The stages of this research are as follows:

1. Data Collection

This stage is the stage of collecting data that will be used in processing and analyzing data. The data processed is data obtained previously from the field and supporting data (secondary data). Data collected from field activities include measurements on residents' dug wells and well water sampling. Well measurements were carried out at 20 locations in the research area. In this stage, several measurement activities were carried out, including the following:

a. Groundwater Level

The difference in data on the height of the well lip with the ground surface and the distance between the surface of the well lip and the groundwater table will produce groundwater depth data. The procedure for finding groundwater level fluctuation data is to find the coordinates of dug wells in the Benoa and Tanjung Benoa villages and measure the groundwater level depth at each predetermined point for 15 months, from January 2021 until July 2022.

b. Groundwater Quality

The water quality of dug wells in the study area can be determined by accurate water sampling. Groundwater sampling from shallow wells was carried out with a purposive sampling approach at 20 well points and in grab sampling. To obtain precise sample results, the sampling process must be carried out in the morning or sunny weather to maintain water quality and avoid water contamination by other substances. Then, try to prevent material sediment from being carried into the water so that the sterility of the water is maintained. This can be done by using a bottle. Samples that have been taken must be immediately analyzed by the laboratory before the specified time limit of 2x24 hours so that the sample does not expire.

2. Data Analysis and Processing

Data analysis consists of making maps and processing data from laboratory tests. Laboratory tests were conducted to obtain data that will be interpreted for the physical and chemical water content referring to the Quality Standard according to PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010. Water quality analysis is conducted to obtain values that will be used for groundwater quality analysis. These parameters include physical parameters, including color, taste, odor, temperature, electrical conductivity (EC), total dissolved solids (TDS), and chemical parameters, including dissolved oxygen (DO), power of hydrogen (pH), and Chloride (Cl). Measurement of color parameters using the sense of sight, taste using the sense of taste, odor using the sense of smell, temperature, DHL, TDS, salinity, and pH parameters using water quality tester equipment model number EZ-9909-SP and for measurements of dissolved oxygen (DO) and Chloride (Cl) conducted in the laboratory. Spatial analysis using ArcGIS software was conducted to map groundwater level fluctuations and the results of groundwater quality analysis in the study area. The spatial analysis process uses the Kriging Interpolation method.

2.5. Groundwater

Groundwater is underground water found below the water table in saturated soil or geological formations that collects in soil layers known as an aquifer [13]. An aquifer is a subsurface layer of water-saturated rock, such as sand, that can store and transmit water economically and in sufficient quantities [14]. Several bio-geophysical, political, and sociocultural factors influence groundwater availability in a region. A component of the hydrological cycle is groundwater. The hydrological cycle explains the connection between precipitation, surface flow, infiltration, evaporation, and groundwater. Rainwater, lake water, and other surface water sources transform into groundwater sources when they infiltrate the soil and aquifers and migrate toward the discharge area [15].

2.6. Groundwater Level Fluctuation

The rise and fall of groundwater levels due to natural and human-induced hydrological processes constitute groundwater fluctuations. Understanding these events is crucial because multiple mechanisms can operate simultaneously, necessitating precise observations [16]. Urbanization, seismicity, hydrometeorology (such as barometric pressure, transpiration, temperature, wind, intense sunlight, and precipitation), tidal influences, and external stress are all factors that cause variations in groundwater levels [17,18]. Observation well measurements of groundwater levels are the primary source of information on the hydrological pressures acting on the aquifer. Systematic water level observations will provide crucial data for assessing changes in groundwater resources, developing groundwater trend models and forecasts, and designing, implementing, and monitoring groundwater management and protection programs [19]. Observing and predicting groundwater level responses is essential for effective groundwater management and planning. These strategies were devised to prevent the mismanagement and overexploitation of groundwater. Due to complexity and non-linearity, simulating groundwater level fluctuations is challenging [16].

2.7. Groundwater Quality

The need for water for sanitary hygiene is rising with global population expansion. Natural water is balanced with the hydrological cycle and does not produce additional water [20]. Sanitary hygiene water is used for bathing, brushing teeth, washing food, pottery, and clothing. Sanitary water can also be drinking water uncooked. Human activities (anthropogenic activity) significantly affect groundwater quality, with more complex activities increasing groundwater susceptibility. Groundwater, a significant source of clean water, must meet regulations. Sanitary water must meet physical, biological, and chemical standards under Indonesian Health Minister Regulation. Odorless, tasteless, cloudless, and colorless water meets physical standards. Temperature, EC, and TDS are also needed. Water without hazardous compounds is clean chemically. Chemical characteristics of water quality include acidity, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), alkalinity, pH, Ca concentration (hardness), iron (Fe), manganese (Mn), nitrite (NO_2), nitrate (NO_3), and others. Microbiology does not damage biological water quality [20].

3. Result and Discussion

3.1. Groundwater Level Fluctuation

Groundwater level fluctuation is the difference in the depth of the water table during the rainy season and dry season. The groundwater level fluctuation data results are displayed as maps and graphs. Based on the results of field measurements that have been carried out and then analyzed using the kriging interpolation technique in the ArcGIS application. Based on the results of this analysis, it can be explained that the groundwater level at the study site ranges from a depth of 6.4 to 8.9 meters below the ground surface. From the results of the analysis, it is obtained that the value of the distribution of groundwater level fluctuations in Benoa and Tanjung Benoa Village has a value of 0.9 meters decrease in groundwater level from the peak of the rainy season in February 2021 to the peak of the dry season in August 2021. And for the increase in groundwater level of 0.74 meters from the peak of the dry season in August 2021 to the peak of the rainy season in March 2022. The groundwater level fluctuation maps and graph can be seen in Figure 3a and Figure 3b, respectively.

3.2. Electrical Conductivity (EC)

Measuring the ability of a substance to conduct electric current at a specific temperature expressed in units of micromohs per centimetre (µmhos/cm) is one way to find the value of Electrical Conductivity. PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010 is a reference to obtain research results that the electrical conductivity value ranges from 30-2000 µmhos/cm. The results of conductivity measurements based on groundwater conditions are outlined in the form of a map using kriging interpolation techniques can be seen in Figure 4. Figure 4 presents the results of the electrical conductivity (EC) test, which has a minimum value of 618 µs/cm and a maximum value of 1351 µs/cm.

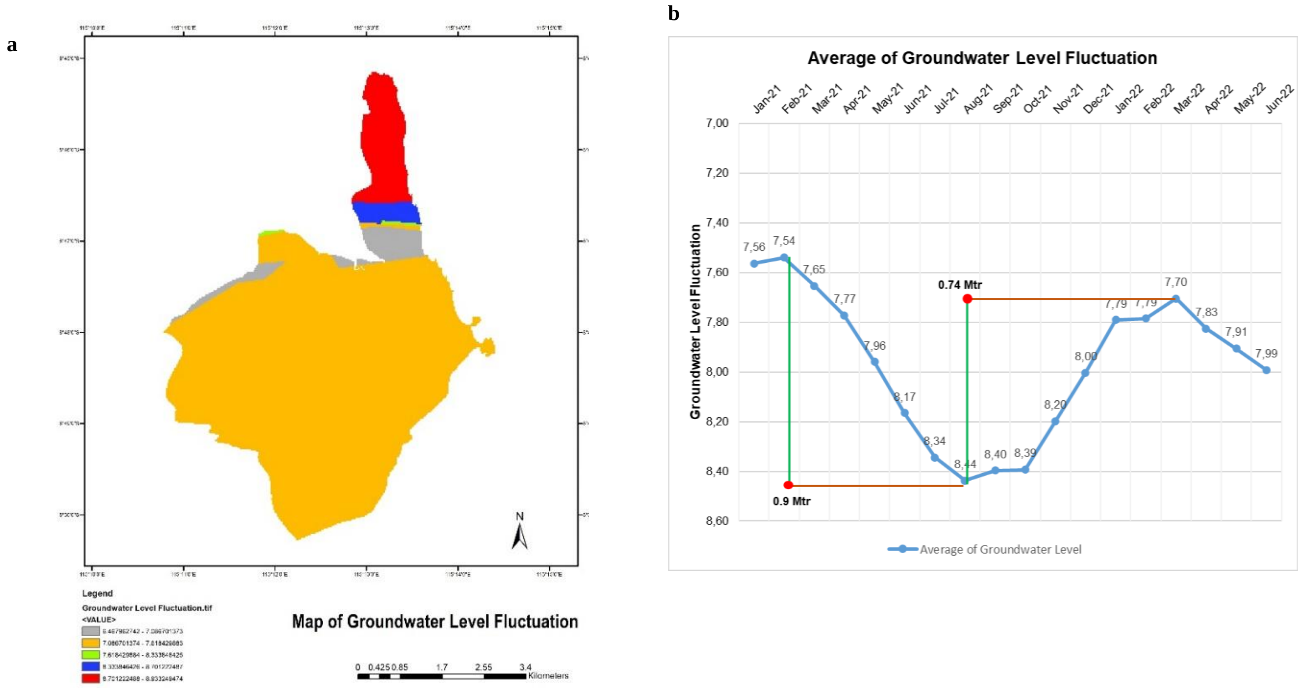

Figure 3. (a) Map of groundwater level fluctuation (b) Graph of average of groundwater level fluctuation

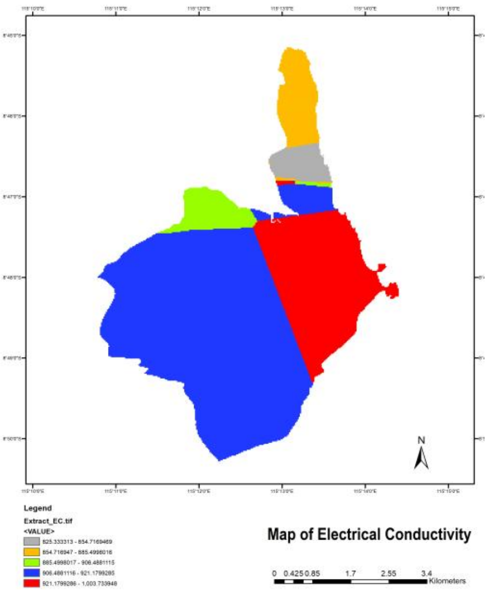

Figure 4. Map of electrical conductivity

3.3. Power of Hydrogen (pH)

In this study, the value of acidity (pH) is one of the essential parameters in an investigation because it is done to determine the acid/base levels contained in water. Deciding on alkalinity, CO2, and the acid-base equilibrium contained in groundwater is necessary if the pH value is obtained. The standard used for drinking water quality values has followed the PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010 with a value of 7 as a neutral value standard at pH value and the standard value of pH is 6.5-8.5, which can be seen in Figure 5a. The lowest pH value results are at the Gang Sale 3 location point, with a pH value of 6.01, and the highest is at the Jl. Segara Windu location point with a value of 7.24. According to observation, the Benoa village and Tanjung Benoa Village has an average pH of 6.8 - 6.9.

3.4. Total Dissolved Solid (TDS)

Total dissolved solids (TDS) are the solidification of solids dissolved in water. The turbidity of solids dissolved in water is not from TDS, because TDS cannot cause turbidity in water. After all, the amount of solids that are placed is small. According to PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010, the maximal value of TDS is 1000 mg/L. The regulation that researchers refer to get the quality standard value in TDS research. The results of the study on the quality average value of TDS measurements in Benoa and Tanjung Benoa Village can be seen in Figure 5b. From the figure above, it shows that Benoa Village has an average TDS value of < 500 mg/L with details in Figure 5b, where the grey color area has the smallest TDS value with a value of 429 - 444 mg/l, while the red color shows the highest TDS results with a TDS value between 467 - 501 mg/L. These values indicate that the TDS values in Benoa Village and Tanjung Benoa are still below the established quality standards.

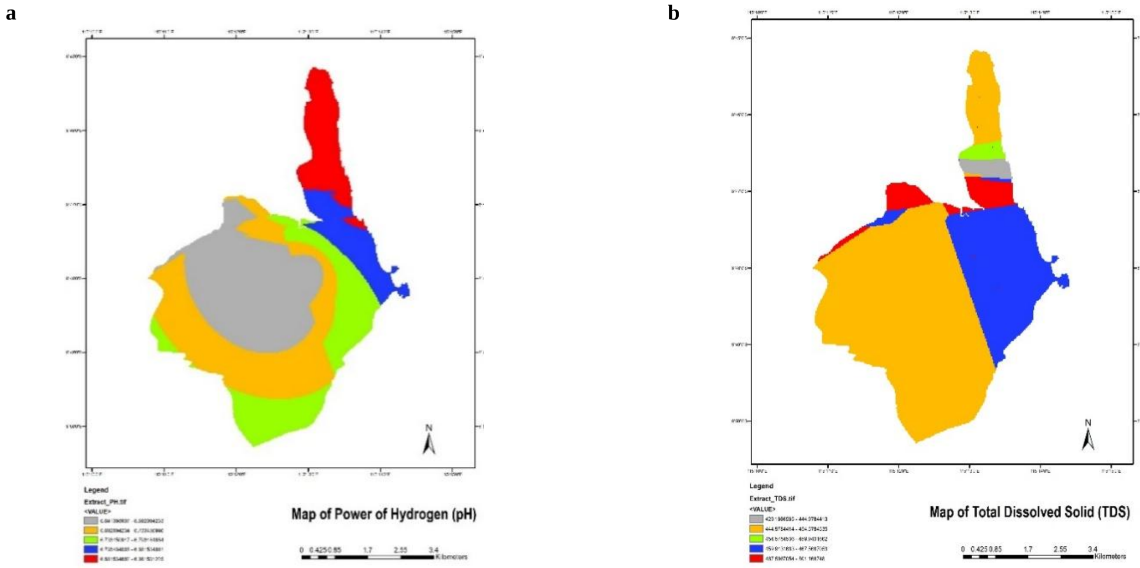

Figure 5. (a) Map of power of hydrogen (pH) (b) Map of total dissolved solids (TDS)

3.5. Salinity

Determination of salinity value is one of the essential parameters to be carried out in water quality testing because knowing the salinity value will obtain the level of salinity or dissolved salt content contained in groundwater. PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010 to obtain quality values and requirements and supervision of water quality, iron content, in clean water used is 0.1 mg/L. To find the salinity value of groundwater, groundwater sampling was carried out directly at the research site using a water quality tester, and the results of groundwater salt content in the field can be seen in Figure 6a. The results of salinity testing on well water samples at the research site show that the grey area indicates a low salinity value with a value of 0.042%, and the area with red color has the highest salinity value with a value of 0.049%. However, compared to the quality standard, the salinity value in Benoa Village and Tanjung Benoa is still lower than 0.1 mg/L. The results of the study on the quality average value of salinity measurements in Benoa and Tanjung Benoa Village can be seen in Figure 6a.

3.6. Temperature

Temperature can affect the chemical reactions of various substances in water. The groundwater temperature value is determined directly at the research location using the Water Quality Tester tool. As for the requirements of the research value using the PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010 with an air temperature value of ± 3˚C, where if the temperature (T) then the average temperature of water is 25˚C, then it can limit the water T in the range of 22˚C - 28˚C [21]. Based on the research results, the water temperature values in Benoa Village and Tanjung Benoa are presented in Figure 6b. Based on observations at the research site, the average temperature range from location point 1 to location point 20 ranged from 27.4˚C to 28.2˚C. Using the kriging interpolation technique in the Geographic Information System application, the highest temperature is found in the well on Pratama Road with a red color area, which has a temperature value of 28.2˚C. At the same time, the lowest temperature with an average temperature of 27.4˚C - 27.6˚C.

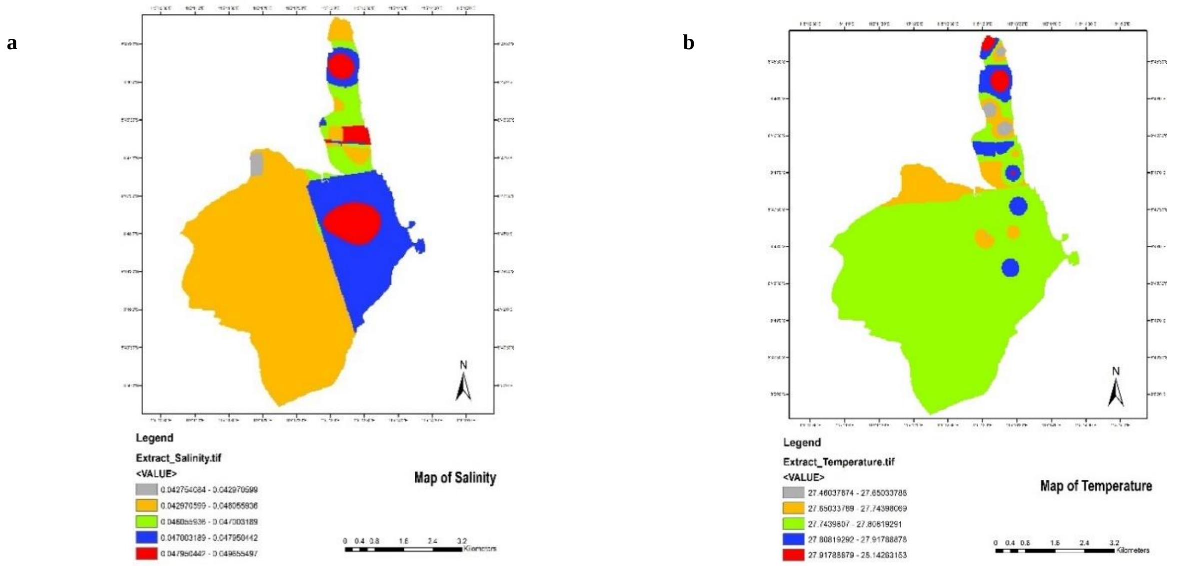

Figure 6. (a) Map of salinity (b) Map of temperature

3.7. Dissolved Oxygen (DO)

The diffusion of atmospheric oxygen and photosynthesis of plants in water comes from dissolved oxygen. PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010, for sanitary hygiene purposes, is the standard for determining groundwater quality in Benoa Village and Tanjung Benoa Village and for controlling groundwater quality. However, the DO value is not regulated in the PERMENKES 492/MENKES/PER/IV/2010. In this study, the standard DO value is adjusted to the Bali Governor Regulation No.16 Tahun 2016 with the DO value > 6.5 mg/L. The results of dissolved oxygen measurements based on groundwater conditions are outlined as a map image of the average dissolved oxygen value distribution in Figure 7a. Based on Figure 7, it can be shown that the results of DO levels at the sampling point of the grey area have the lowest levels with a value of 5.9 - 6, 2 mg/L, while the area that has a red color with a DO value of 6.9 - 7.2 mg/L. Based on the results of the study, it was found that the DO value in Benoa Village and Tanjung Benoa Village was above the established quality standard of > 6.5 mg/L.

3.8. Chloride (Cl)

Research on chloride ion (Cl) levels is one of the essential studies to do because chloride ion levels do not directly cause toxicity. Still, the excess salt content resulting from the salinity contributes to this extra salt, which can cause a decrease in water quality. The recommended maximum value of chloride ion is 200 mg/l, while the maximum allowable limit is 500 mg/l [22]. The study's results have been obtained; chloride ion levels in groundwater have an average value of 92.3 - 98.8 mg / L with blue-coloured areas shown, presented in Figure 7b. The test results show that the value of groundwater quality standards at the research location meets the criteria that have been determined and listed in PERMENKES of the Republic of Indonesia 492/MENKES/PER/IV/2010, where the chloride content obtained is smaller or equal to 250 mg/L so that the groundwater can be used for daily activities by the community, such as cooking, bathing, washing, and others.

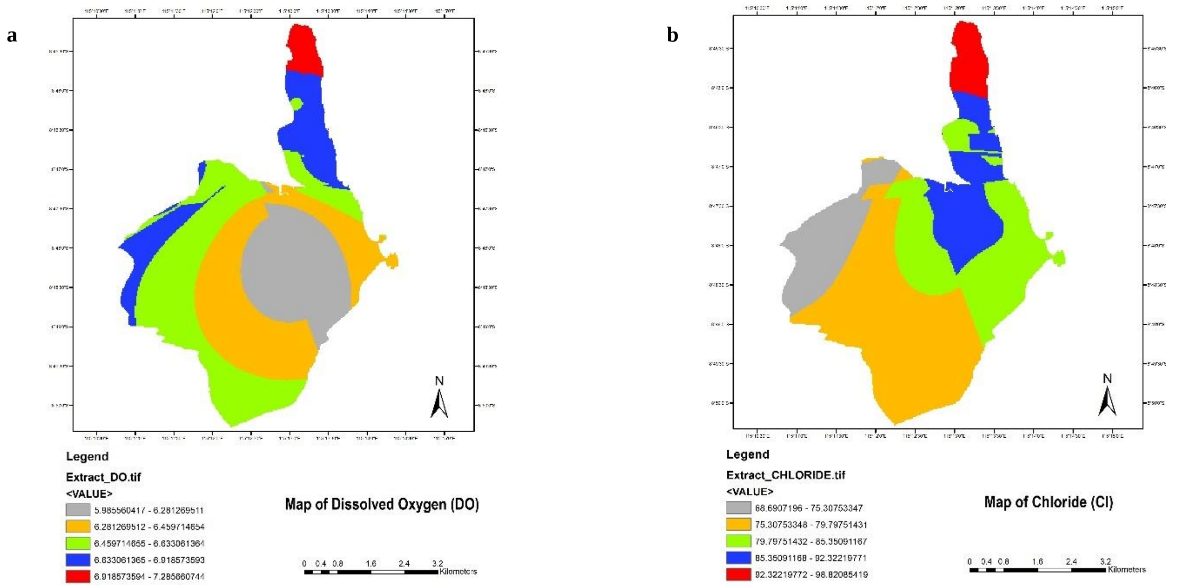

Figure 7. (a) Map of dissolved oxygen (DO) (b) Map of chloride (Cl)

4. Conclusion

Benoa and Tanjung Benoa villages are included in the Nusa Dua groundwater basin area, an alluvial karst aquifer. Based on the study's results, the rainy season peaked from February 2021 to August 2021, with a decrease in groundwater level of 0.9 meters. While the groundwater level increased from the peak of the dry season from August 2021 to March 2022, there was an increase in groundwater level of 0.74 meters. Based on the results of groundwater quality testing, the minimum TDS value is between 429 - 444 mg/l, and the maximum value is 467 - 501 mg/L. Based on the test results, shallow well water at Gang Sale 3 has the lowest pH value of 6.01 and the highest at Segara Windu Road, with a value of 7.24 and an average pH of 6.8 - 6.9. The average electrical conductivity value is 921 - 1,003 µs/cm. The average temperature at the study site ranged from 27.4˚C - 28.2˚C. At the same time, the matter of dissolved oxygen levels ranged from 5.9 - 7.2 mg/L. Chloride levels contained in groundwater at the study site are 68.69 - 98.8 mg/L, and these values are smaller than the required quality standards, which are smaller or equal to 250 mg/L. So, based on the results of groundwater quality testing in Benoa and Tanjung Benoa Villages, it can be concluded that groundwater quality is still good and suitable for daily domestic purposes.

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