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The Potential of Spring Water Analysis for Drinking Water at Ujung Gagak Village, Kampung Laut Subdistrict, Cilacap Regency

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Abstract: Limited clean water is the main problem in Ujung Gagak Village. The community can use no groundwater because the water is brackish and salty, which is unsuitable for daily activities. This study aims to analyze the potential of the Karang Cave spring to be used as drinking water. This spring plays an important role in the life of the people of Ujung Gagak Village when the dry season arrives. Using the grab sampling method, raw water sampling at the Karang Cave spring. Pollution Status Index (IP) quality of 5.08 is included in the moderately polluted category. Then, raw water samples are taken and processed in the Reverse Osmosis (RO) system. Parameters that exceeded the quality standard were total coliform of > 24,000 CFU/100ml, salinity parameter of 0.33‰, turbidity of 1.98 NTU, and hardness of 320 mg/L. However, treating it in an RO system for drinking water is necessary. Laboratory test results for water quality after processing, several parameters experienced a significant decrease, for the parameter salinity to 0‰, turbidity to 0.74 NTU, and hardness to 99 mg/L, total coliform decreased by 108 CFU /100ml. The results showed that the RO system succeeded in removing salt up to 99.5% and reducing the Concentration of turbidity, hardness, and total coliform. It is suitable for drinking water, but if you want to drink it immediately, you can cook it first, considering that the total coliform is still above the required quality standard.

Keywords: Drinking water; Karang Cave; Reverse osmosis; Spring water, Water quality

Introduction

Population growth, economic development, and living standards have increased water demand. A population that is overgrowing will require water resources that continue to grow (Wu et al., 2021). Water resources are important for human life and the lives of other creatures used for daily life in the industrial, agricultural, livestock, public facilities, and almost all aspects of life that need water (Santikayasa et al., 2022). Freshwater depends on the potential of groundwater, which is a vital water resource for long-term life because, during the rainy season, fresh water is supplied from rainwater, while during the dry season, fresh water is provided by groundwater. This problem shows that freshwater depends on the potential of groundwater, and if the groundwater is polluted, it causes limitations in using clean water (Din et al., 2023).

In 2020, this amount of water sufficiency will be expected to decrease to 1,200 m3/capita/year, along with an increasing population, which will cause water needs to increase (Sari et al., 2022). The clean water crisis is starting to be felt in several areas on the island of Java, which occurs every year with the availability of 1,750

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m3/capita/year, below the minimum adequacy standard of 2,000 m3/capita/year (Prihatin, 2013). Water scarcity can be caused by the low quality of raw water and the amount of environmental pollution that reduces availability (Paca et al., 2019). Limited provision of quality clean water for use can affect public health, economic productivity, and the quality of life of society as a whole.

Water limitations affect more than 40% of the global population, and 30% of people lack accessibility to safely managed drinking water. The parameters most determined in identifying water quality, namely biologically, consist of pathogens, polluting microbes, and toxin producers (Ito et al., 2021). Limited clean water is a problem in Ujung Gagak Village, Kampung Laut subdistrict, Cilacap Regency. Geographically, Kampung Laut subdistrict is surrounded by water. However, the community cannot use groundwater because the water is brackish and salty due to seawater intrusion. This thing happened due to environmental degradation. Freshwater pollution also occurs due to high tides, when seawater overflows, entering the river median. Then, there is siltation around the river, so this salty water can enter the shallow groundwater and make it brackish (Santosa, 2021).

The provision of clean water is fundamental to human health, and insufficient water will have an impact on human life (Kornita, 2020). Water, sanitation, and hygiene interventions must be implemented to increase availability and services, especially in cities and villages that are low-income and have limited clean water (Nelson et al., 2021). The quality of clean water must be controlled and its quality guaranteed. The provision of clean water must be able to serve the entire community to overcome or minimize the impact of water-related diseases (Issalillah et al., 2022).

Springs are potential water sources that have been used as the main source of clean water. Spring water comes from deep groundwater and is not affected by the seasons, and the quantity or quality is the same as deep groundwater (Baharuddin et al., 2021). The quality of the spring will depend greatly on the mineral layer of the soil through which it passes. Spring water is usually used as a source of drinking water by the surrounding community and must fulfill several aspects, including quantity, quality, and continuity (Chhimwal et al., 2022). There are two types of sources for the emergence of springs, namely gravity springs, which are springs that appear due to gravitational forces, and artisan springs, which are springs that emerge to the ground surface due to artesian pressure (Adiningrum, 2017). The existence of springs is closely related to the topography, land, vegetation, and geology of an area, where springs with large discharges are generally found in karst areas (Rohman et al., 2021). During the drainage period, springs generally always flow throughout the year, although some have different flow rates between the dry and rainy seasons (Sulistyorini et al., 2017).

One of the groundwater sources that has water discharge that is quite good in quantity and quality is spring water (Moore et al., 2021). According to the conditions of the spring that appears on the ground surface, it will easily experience contamination from outside (Laskar et al., 2022). The quality of water at springs is influenced by the nature of the spring and the location of the spring (Yuliantoro et al., 2021). The nature of open springs tends to be more polluted, such as organic matter or other pollutants, while the nature of closed springs is not easily polluted because the water that comes out to the surface is channeled directly through a pipe (Moldovan et al., 2020). Management can be carried out to maintain the quality and quantity of spring water sources, so it is necessary to consider and combine aspects of environmental conditions, spring characteristics, technological mastery, and community characteristics to avoid social conflict and scarcity of clean water (Nya et al., 2023).

Chemical and physical parameters that affect water quality require continuous monitoring to avoid health hazards before the water is used for drinking, irrigation, or industrial purposes, and biological indicators in water are detected by the presence of bacteria in the water, such as coliforms and fecal coliforms which indicate fecal contamination (Devane et al., 2020). Thus water must be assessed to ensure its safety for human consumption (Albaggar, 2021).

This research is located in Ujung Gagak Village, Kampung Laut subdistrict, Cilacap Regency. The total population of Ujung Gagak Village is 15,724 people, and the number of households is 1,604 (BPS, 2022). This village was formed due to a process of natural phenomena, namely Segara Anakan sedimentation, which includes a landmass. People take water from the Karang Cave spring on Nusakambangan Island in the dry season. The cave is the closest to Ujung Gagak Village. It can be reached in 30 minutes by boat.

The source of raw water from the Karang Cave spring on Nusakambangan Island plays an important role for the people of Ujung Gagak Village because it is a solution for water availability during the dry season. So, this study aims to analyze the potential of the Nusakambangan Island Coral Cave springs to be used as drinking water, analyzed using data on water quality before and after a processing process from laboratory test results so that it can be tested for its suitability as drinking water.

Method

This Research analyze for water quality testing was carried out at the UPTD Environmental Laboratory DLH Cilacap Regency. The grab sampling method takes water samples from the Karang Cave spring on Nusakambangan Island. Sampling uses sterile equipment and is by water research methods. The physical parameters measured were temperature, turbidity, color, and odor. The chemical parameters tested were pH, salinity, hardness, iron, manganese, and zinc, and the microbiological parameters tested were total coliform. Sample containers for water use polyethylene and microbiology bottles.

Figure 1. Location of the Karang Cave, Nusakambangan Island

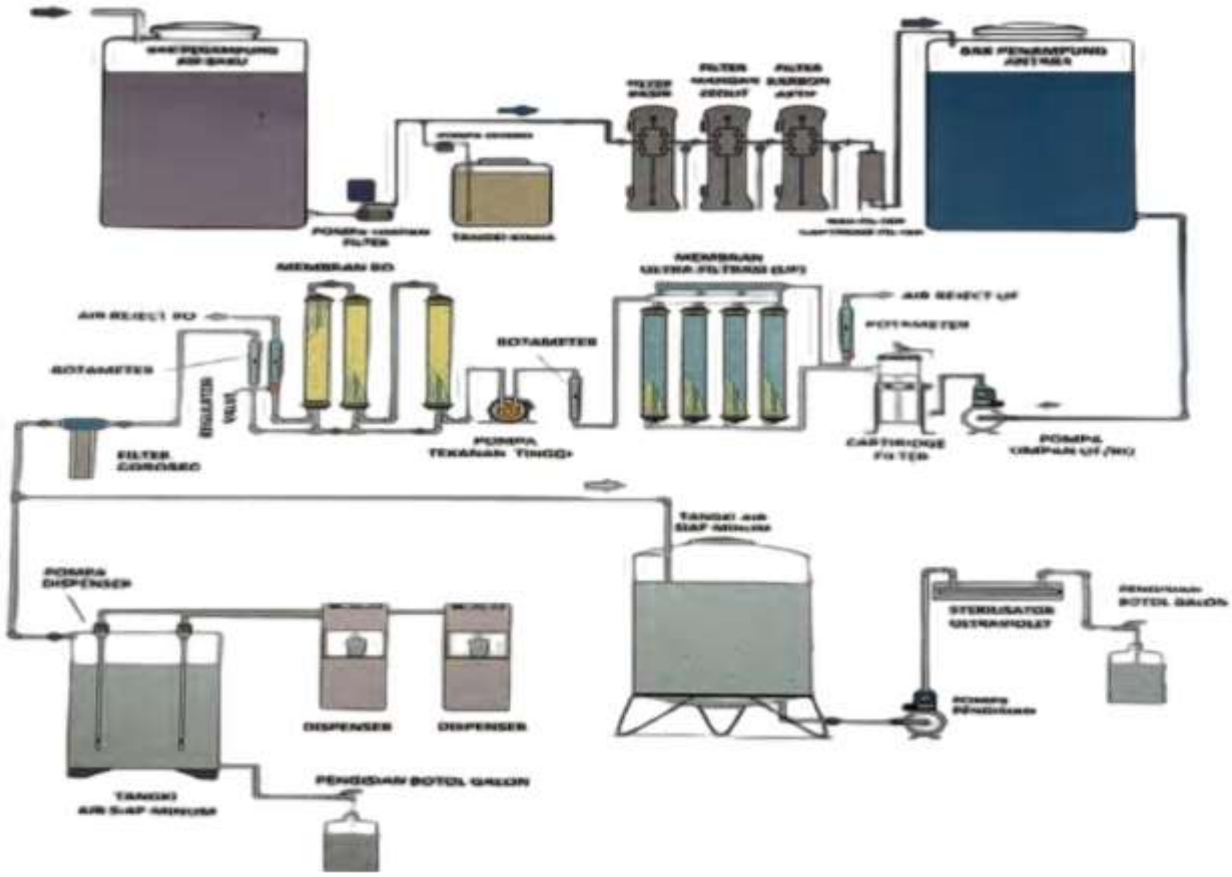

Figure 2. Flowchart of the spring water treatment process

The quality standard used as a reference as a requirement for clean water quality for drinking water is Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 concerning Environmental Health Quality Standards and Water Health Requirements for Sanitary Hygiene Purposes can be used for drinking water raw water. Then, to calculate the water quality status using the pollution index method based on the Decree of the Minister of State for the Environment Number 115 of 2003 concerning guidelines for determining water quality status, the following formula is used:

$$\text{Pij} = \sqrt{\frac{\left(\frac{Ci}{Lij}\right)^2 M + \left(\frac{Ci}{Lij}\right)^2 R}{2}} \quad (1)$$

Description:

Li = Concentration of water quality parameters in water quality standards (j)

Ci = Concentration of water quality parameters survey results
Pij = Pollution index for use (j)
Then, included in the evaluation range of pollution categories, the PI value is as follows:
$0 \leq PIj \leq 1.0$ = Meets quality standards (good condition)
$1.0 < PIj \leq 5.0$ = Light pollution
$5.0 < PIj \leq 10$ = Moderately polluted
$PIj > 10$ = Heavily polluted

This research uses design of Reverse Osmosis (RO) system for water treatment process. The installation of the RO system unit consists of a raw water reservoir, filter pump, dosing pump, chemical tank, sand filter, manganese zeolite filter, activated carbon filter, cartridge filter, intermediate reservoir, UF/RO feed pump, cartridge filter, rotameter, membrane ultrafiltration (UF), high-pressure pumps, reverse osmosis (RO) membranes, corosec filters, dispenser pumps, drink water tanks, dispensers and taps for filling gallon bottles. After processing, samples of the processed water are taken to analyze its suitability as drinking water.

Result and Discussion

The results of laboratory data for testing the quality of raw water from the Karang Cave spring, Nusakambangan Island, before being processed in a drinking water treatment system.

Table 1. Spring Water Quality Tests before the Process

Parameter	Unit	Quality Standards*	Test Results
Physics			
Temperature	°C	Air temperature +/- 3 °C	27.7
Turbidity	NTU Scale	25	1.98
Color	TCU Scale	50	42
Smell	-	No smell	No smell
Chemistry			
pH	-	6.5 – 8.5	7.2
Salinity	%o	-	0.33
Hardness	mg/L	500	320
Iron	mg/L	1	0.01
Manganese	mg/L	0.5	< 0.01
Zinc (ZN^{2+})	mg/L	15	0.03
Microbiology			
Total Coliform	CFU/100 ml	50	>24.000

Description:
*Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017

Table 1 shows that the temperature of the spring is 27.7°C when compared to the Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017 quality standard, which does not meet the requirements because it is more than 3°C. However, a suitable temperature in water is the same as an air temperature of 20 – 30°C. For polluted water, it has a temperature above or below air temperature (Silva et al., 2022). Regarding the degree of acidity (pH), the sample test results show a pH of 7.2. This pH indicates that the water from the spring meets the requirements for raw water quality for drinking water and sanitation hygiene needs because the acidity will increase if the pH is less than 6.5. Corrosiveness of metal objects causes some chemicals to become toxic and detrimental to health (Zhu et al., 2022).

Other parameters such as turbidity, color, odor, iron, manganese, and zinc do not exceed the required quality standard thresholds, while the *total coliform* still exceeds the quality necessary normal thresholds. The hardness parameter has a high hardness level even though it is still at the point of the quality standard. The salinity parameter does not exceed the threshold. In the classification of freshwater salinity levels, it is <0.5 ‰ brackish water with a salinity ranging from 0.5 – 30 ‰, salt water 30 – 50 ‰, and very salty water with a salinity > 40 ‰ (Rao et al., 2022). Based on the test results for salinity, the water quality from the spring is included in the freshwater category. However, the water still has a salt content of 0.33 ‰.

The Pollution Index (IP) calculation results determine the relative pollution level from waste close to the desired parameters. The Pollution Index (IP) can evaluate the pollution level in all parts of a water body or only a part of it. The pollution index consists of 2 indices: the average index, which indicates the moderate pollution of all parameters in one observation, and the maximum index, the most dominant polluted parameter. The pollution index uses single data that indicates current results only, and the calculation results will be compared with the water quality status according to the specified quality standards. So, the calculation using the pollution index method is used because water samples are taken only from one or a single time of water quality collection activity and describe the water quality results at that time only. In the calculation results for the Nusakambangan Island Coral Cave spring, the Pij value is 5.08. The PI value is moderately polluted because it is $5.0 < PIj \leq 10$. So, it must be processed first to be used as drinking water.

Based on the raw water quality test results from the Karang Cave spring on Nusakambangan Island, the raw water processing process was carried out based on the processing process in Figure 3. The system uses a *Reverse Osmosis* (RO) membrane, divided into three: freshwater membrane, brackish water membrane, and membrane salt/seawater. Each membrane type has different characteristics: its operational requirements and ability to retain salt particles dissolved in water (Zhai et al., 2022). Based on raw water quality data before the processing process, preliminary processing is required from several process units, namely oxidation and filtration. The oxidation process uses a $KMnO_4$ oxidizer, while the filtration process uses a fast sand filter, manganese zeolite filter, activated carbon filter, and cartridge filter.

Figure 3. Filtration process (sand filter, manganese zeolite filter, activated carbon filter, and cartridge filter)

The oxidation process uses $KMnO_4$ to oxidize iron, manganese, or other metals (Hassan, 2023). Apart from being an oxidizer, it is also a material for regenerating manganese zeolite filter media. After the oxidation process, the dosing pump works with a maximum capacity of around 4.7 liters per hour, enough to inject $KMnO_4$. Then, filtration was carried out with a quicksand filter. The water, iron, and manganese oxide solids formed in the reactor tank were retained in the quicksand filter.

In Zeolite, Manganese serves as a catalyst, and at the same time, iron and manganese, which are in water, are oxidized into forms of ferric-oxide and manganese, which are insoluble in water. However, it can be separated by precipitation and filtering. During the process, the ability of the reaction decreases, and finally, it becomes saturated. To regenerate it, you can add a KMnO4 solution to the saturated manganese zeolite so that manganese zeolite will re-form.

The active carbon filter functions to remove micropollutants such as organic substances and odors and absorb heavy metals. If the entire surface of the active carbon is saturated, the absorption process will stop, and at that time, the active carbon must be replaced with new active carbon. Then, the filter cartridge is equipped with a size of 0.1 μ m so that overall, the water product from this preliminary processing unit is expected to have the required quality. The insufficient filtration and filtration processes using a membrane were carried out, raw water samples were taken after being processed in the processing system, and the results of the raw water quality test of Gua Karang spring after the process are described in Table 2.

Table 2. Spring Water Quality Tests after the Process

Parameter	Unit	Quality Standards*	Test Results
Physics			
Temperature	°C	Air temperature +/- 3 °C	26.7
Turbidity	NTU Scale	25	0.74
Color	TCU Scale	50	36
Smell	-	No smell	No smell
Chemistry			
pH	-	6.5 – 8.5	8.1
Salinity	%o	-	0
Hardness	mg/L	500	99
Iron	mg/L	1	0.01
Manganese	mg/L	0.5	< 0.01
Zinc (ZN^{2+})	mg/L	15	<0.02
Microbiology			
Total Coliform	CFU/100 ml	50	108

Description:
*Regulation of the Minister of Health of the Republic of Indonesia No. 32 of 2017

The post-process water quality test results showed that the salt refining efficiency reached 99.5% with this RO process. The water quality test can be seen from the comparison in the graph in Figure 4 that the salinity parameter has decreased in Concentration to 0 ‰, in addition to the hardness parameter, as shown in Figure 5, shows that hardness has decreased in Concentration to 99 mg/L. The turbidity parameter, as shown in the graph in Figure 6, decreased the Concentration of turbidity to 0.74 NTU, and the total coliform parameter experienced a decrease in the concentration level, as shown in the graph in Figure 7, to 108 CFU/100 ml after processing in a treatment system which previously had higher levels, quite high, namely > 24,000 CFU/100ml.

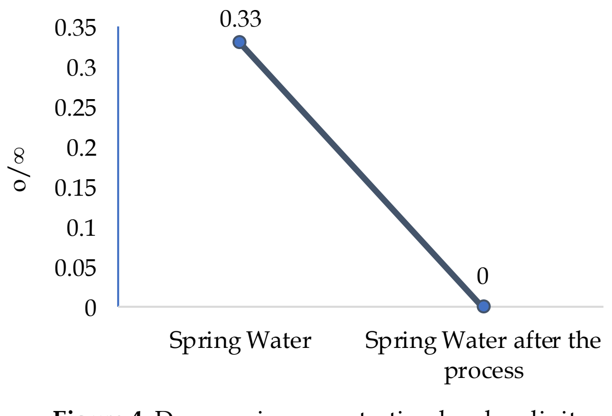

Figure 4. Decrease in concentration levels salinity

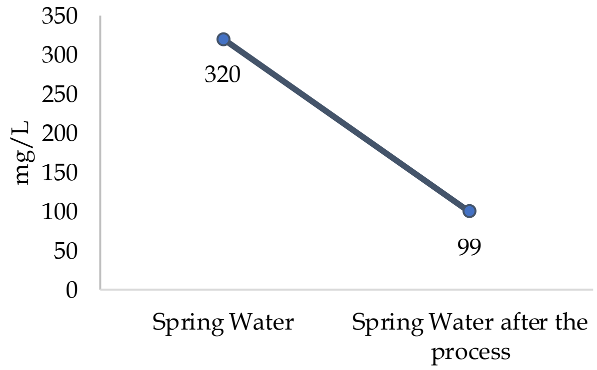

Figure 5. Decrease in concentration levels hardness

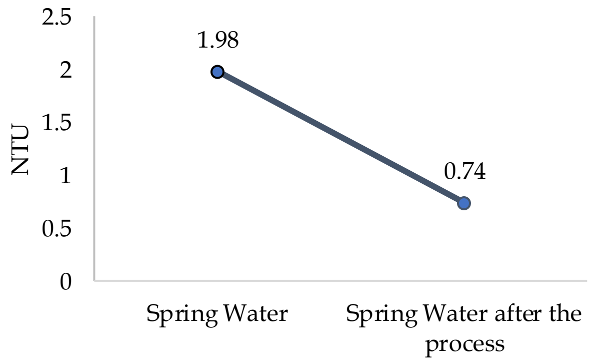

Figure 6. Decrease in concentration levels turbidity

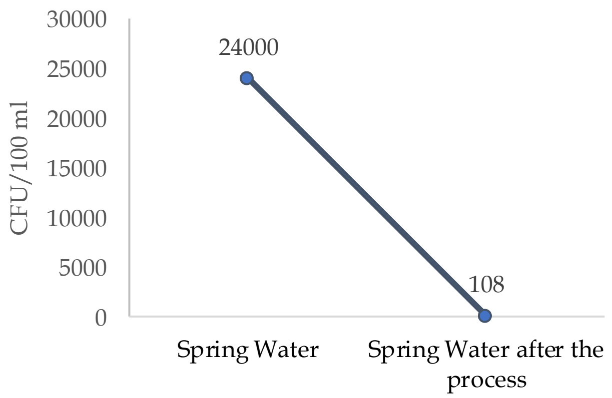

Figure 7. Decrease in concentration levels total coliform

Based on these results, the total coliform parameter still exceeds the required quality standard threshold of 50 CFU/100ml, so if you want to drink it directly, you can cook it first. Several factors affect coliform bacteria in drinking water: filter cleanliness, environmental conditions, and building conditions. System unit. Several other parameters meet the required quality standards, such as color, pH, iron, manganese, zinc

The minerals the body needs in small quantities, such as Fe, Mn, and Zn, are lower than the required quality standards, indicating that the RO process does not remove all the mineral content in the water. Hence, the resulting mineral water has mineral content that can be useful for the body. Regarding raw water quality from the Karang Cave spring, Nusakambangan Island is suitable for use as drinking water. The direct benefit based on interviews with the local community is that the community gets water that is suitable for use easily, water that is not brackish and not salty at a much lower price than having to go to the spring and rent a boat for IDR. 250,000,- one take. Communities can buy drinking water from the processing for IDR. 7.000,- for 1 gallon. The indirect benefit of implementing this RO system is that it is an example of a processing unit system with simple processing, so it is easy to apply to other areas with the same problem conditions.

Conclusion

The results of the water quality test before processing, the status of the water spring, and the pollution index were included in the category of moderately polluted with a PI value of 5.08. The results of laboratory tests showed that raw water from the Karang Cave springs still had parameters that exceeded the quality standards, namely total coliform. Other parameters are still within the required quality standard threshold. Then, after processing in the RO system, the water quality test results showed a significant decrease in concentration levels, such as the turbidity parameter, which was previously 1.98 NTU to 0.74. The hardness parameter also decreased in Concentration from 320 mg/L to 99 mg/L, the salinity parameter decreased to 99.5%, namely the salinity concentration level to 0‰, and the total coliform parameter decreased from >24,000 to 108 CFU. /100mL. Other parameters are still within safe limits suitable for consumption, so in terms of water quality, it is suitable for drinking. However, it is better to cook it before drinking, considering that the total coliform parameter is still above the required quality standard threshold. The direct benefits for the community are that they can use this raw water as drinking water properly and easily, not brackish and not salty, and at a much lower price than having to take it to a spring by boat.

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Author Contributions

Conceptualization, analysis & writing, proofreading – original draft preparation, editing, Adinda Dwi Safitri; supervision, validation, writing – review, Rachmadhi purwana; supervision, validation, writing – review, Suyud Warno Utomo

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Conflicts of Interest
The authors declare no conflict of interest.

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