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Water Quality in Thirty Freshwater Springs and Twenty Four Brackish Springs in the Karst Area to Realize Sustainable Water Resources Management

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Abstract: Clean water is an unlimited and sustainable need that must be fulfilled every day and meet an appropriate standard in terms of quantity and quality. The research objective in this study was to analyze the quality of water in thirty freshwater springs and twenty four brackish springs in the karst area of Buton Tengah Regency to achieve sustainable water resource management. Data on the quality of freshwater springs and brackish water springs chemically and biologically have been analyzed in the biology laboratory of FMIPA Universitas Halu Oleo, then the results are compared with the standards for water quality contained in the regulations of the Minister of Health and Government Regulation of the Republic of Indonesia. The results showed that the freshwater springs in Talaga Raya District exceeded the water quality standards for hardness parameter, while the brackish springs in Mawasangka Tengah, Mawasangka Timur, Lakudo, and Mawasangka Districts has exceeded the water quality standards for parameters of total dissolved solids, hardness, and chloride. However, these parameters are relatively easy to overcome so that the use of freshwater springs can qualify as drinking water, while the use of brackish springs should be used to meet domestic non-drinking water needs.

Keywords: water quality; karst; spring; Buton Tengah

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1. Introduction

Water is the main element of our life on this planet. Its existence is a necessity in the dry season or the rainy season. The need for clean water is an indicator of the quality of human life in terms of human health and well-being. It will be insufficient if the need for clean water is not fulfilled. Besides, it is difficult to imagine a clean and healthy living environment will be created without water [1]. Clean water is one of the basic human needs that is needed sustainably. The use of clean water is very important for household consumption, industrial needs, and public places. Because of the importance of the need for clean water, because it involves the lives of many people, it is only natural that the clean water sector should be given priority for handling. Fulfillment of clean water needs is very dependent on the availability of clean water sources, which can be obtained from groundwater and surface water, which can, in turn, be provided from rivers, springs, dams, and reservoirs [2].

Considering that clean water is an unlimited and sustainable need that must be fulfilled at any time, it must be able to meet the needs of the people it serves [2], not only with regard to sufficient discharge but in terms of quality that it meets applicable standards and in quantity and continuity. In the area of modern economic life, water is also the main thing for agricultural cultivation, industry, power generation, and transportation. In principle, all Indonesian people have the right to get clean water infrastructure and facilities that are decent and affordable [1].

Pollution caused by anthropogenic activities, waste, and overexploitation can make drinking water sources scarce, threatening the quantity and quality of water and related water supplies [3]. Also, the increasing area of critical land in various regions in Indonesia, including Southeast Sulawesi Province, especially Buton Tengah Regency, has caused the loss of land function as an element of the production, both as a medium for water management and as a protection for the environment. The loss of the function of water control is indicated by the occurrence of extreme fluctuations in flow rates, namely the occurrence of floods in the rainy season and droughts in the dry season. Besides, the declining function of environmental protection will also be a serious problem in the future. Changes in the area of protected areas or water catchment areas due to illegal logging and land-use changes result in critical land and decreasing the quality of water catchment areas in Buton Tengah Regency. Sources will have a direct impact on decreasing the quantity and quality of clean water for the population, originating from both sources water. Most of the water sources in Buton Tengah Regency come from groundwater and surface water, whose availability to meet community needs is decreasing, so it is necessary to plan and manage water resources [4].

Following the characteristics of the Buton Tengah Regency area, which is dominated by karst areas, most of the water sources are in the form of springs located between the rocks. Between the rocks, which are natural containers for water storage, are small caves. These caves are generally a source of water (springs), which are widely found in the Buton Tengah Regency area. Buton Tengah Regency is known as an area with the term "a thousand caves," so it is suspected that there are many springs scattered throughout the Buton Tengah Regency area [4]. Spring is generally a point where the ground surface and impermeable rock intersect with the water level, and water flows from an aquifer to the earth's surface. Its occurrence is largely dependent on rock recharge characteristics, such as lithology, porosity, topsoil permeability, surface hydrogeomorphological slopes, and rainfall [5–7]. Springs have provided water for communities for centuries and the revival of these traditional water sources is essential for sustainable regional growth [8].

In line with the national development policies and regional development of Southeast Sulawesi Province, the development of water resources or springs in Buton Tengah Regency is a top priority. Clean water is the basic need of the population to live properly in accordance with the principles of development policies within the framework of achieving the 100-0-100 Cipta Karya program (i.e., namely 100% access to clean water, 0% slum areas, and 100% access to good sanitation) [4]. Karst springs are an important source of drinking water, serving about 25% of the world's population [9], and regionally, it can become the dominant source of drinking water [10].

Most of the people who live in the capital of Buton Tengah Regency are served by SPAM (drinking water supply system). The source of water used generally comes from cave springs around residential areas. For people who live in rural areas, they cannot yet be served by SPAM, so that people experience problems in providing clean water to meet their daily needs [4].

Today, the use of clean water by humans is increasing, where everyone needs 160 L of clean water per day [11]. The quality of water from springs is very dependent on the mineral layer and the contents in the soil that is traversed. In general, water that comes from springs is of good quality, so it is widely used by the community as drinking water. To be used as drinking water, water sources must fulfill several aspects, one of which is interms of quality [12]. The quality of clean water can be viewed from a physical, chemical,

and biological perspective. Physical quality in terms of refers to smell, taste, and color; chemical quality can be examined through observations about hardness, pH, ion content, and so on; while the presence or absence of disease-causing microorganisms in water is a biological requirement for clean water.

Good clean water is one that meets the requirements issued by the government following Government Regulation of the Republic of Indonesia Number 82 of 2001, concerning Designation of Water Class Quality and Regulation of the Minister of Health of the Republic of Indonesia Number 416/Menkes/Per/IX/1990, concerning which concerns Requirements and Monitoring of Water Quality. According to the Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning Management of Water Quality and Control of Water Pollution, the water quality standard is a measure of the limit or content of living things, substances, energy, or components that exist or must exist, and/or pollutant elements that are tolerable in the water. Knowledge of water quality is important for selecting the type and intensity of action to preserve the functions of these water resources, and to ensure their sustainability, while generally paying special attention to vulnerable communities [3].

One of the most important initial stages in planning and managing water resources is to research researching the quality of springs in Buton Tengah Regency. The aim of research on the quality of springs in Buton Tengah Regency is to increase the availability of clean water sources for residents in Buton Tengah Regency. Research on the quality of springs in Buton Tengah Regency is one of the efforts made by the Buton Tengah Regency Government to meet the increasing demands for water sources in the region. Therefore, the Buton Tengah Regency Government in collaboration with the Universitas Halu Oleo Research and Community Service Institute carried out these activities. The results of research on the quality of springs in Buton Tengah Regency are the first steps to formulate a water resource allocation policy in Buton Tengah Regency. The results of this study are expected to be used as a reference in formulating policies on the allocation of water resources in the region. Based on research conducted by Fitra et al. (2019) [13] regarding the effectiveness of the processing process at the drinking water depot in Buton Tengah Regency, it was concluded that the raw water testing carried out at 12 refill drinking water depots obtained 100% results that did not meet the criteria for production water. Whereas in our study, we analyzed the quality of springs in the karst area of Buton Tengah Regency to investigate the availability of clean water sources that can later be used as drinking water for the people of Buton Tengah Regency.

In order to increase the availability of water for the people and other users in Buton Tengah Regency, and to realize sustainable water resource management, it is necessary to conduct a Water Quality Analysis of Thirty Freshwater Springs and Twenty Four Brackish Springs in Buton Tengah Regency. The implementation of this analysis is expected to provide an overview of the existing condition of the quality of springs and their potential development in the future. A study of the quality of spring water sources conducted by collecting and mapping the spatial springs will facilitate policymaking to determine a strategy for water resource development in Buton Tengah Regency. The preparation of a water source quality study will help the Southeast Sulawesi provincial government and the Government of Buton Tengah Regency to improve the quality of life and health of the people in Buton Tengah Regency, while supporting the achievement of the 100-0-100 Cipta Karya program and the Millennium Development Goals.

2. Materials and Methods

Analysis of the quality of clean springs for the people of Buton Tengah Regency, Southeast Sulawesi Province. Administratively, the research location covers the entire administrative area of Buton Tengah Regency, which consists of 7 sub-districts (namely Mawasangka, Mawasangka Tengah, Mawasangka Timur, Gu, Lakudo, Sangia Wambulu, and Talaga Raya, as shown in Figure 1) that oversee 76 villages/wards.

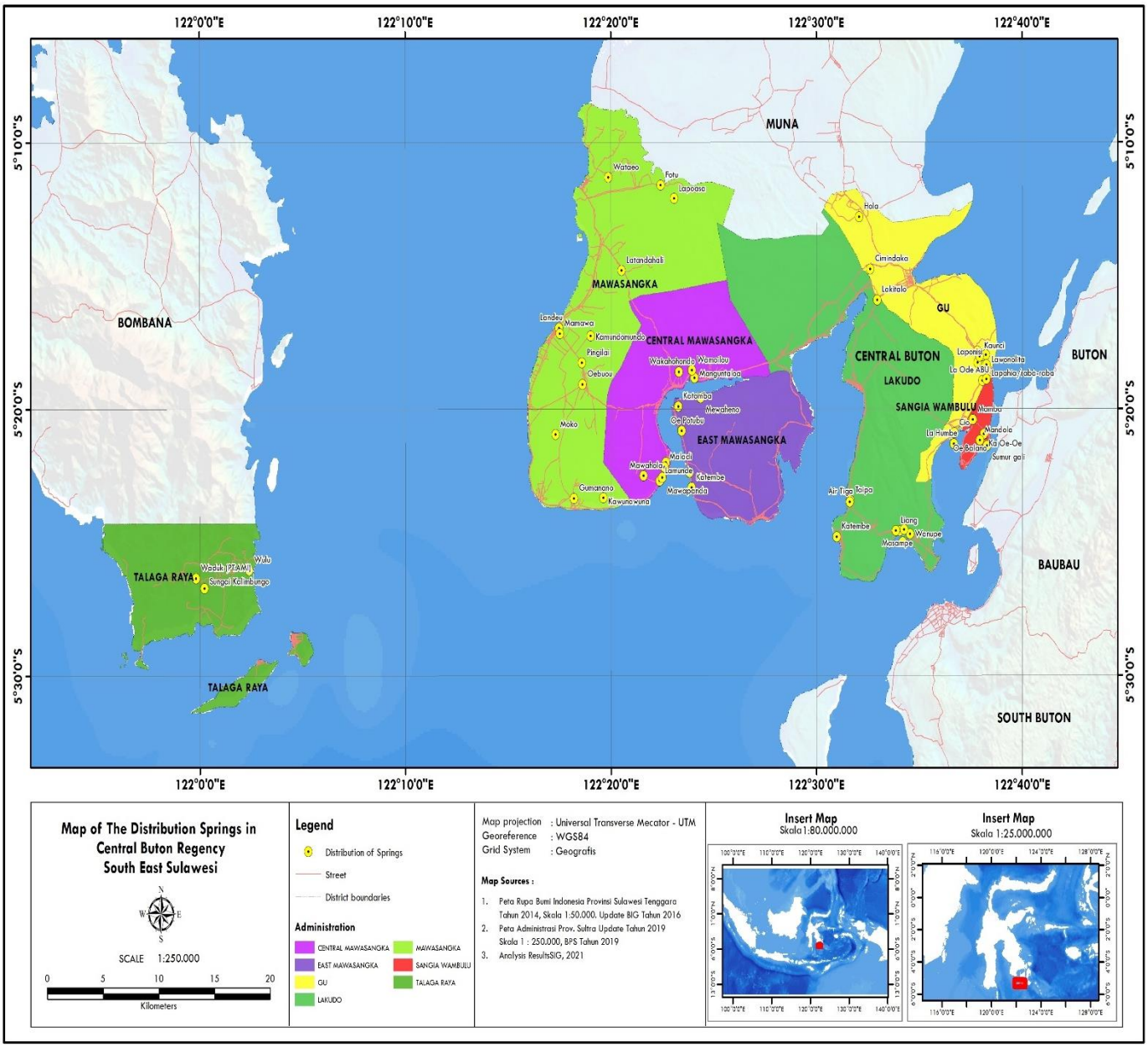


Figure 1. Map of research location.

This research was conducted during 2018 in Buton Tengah Regency, namely 7 districts including Mawasangka, Mawasangka Tengah, Mawasangka Timur, Gu, Lakudo, Sangia Wambulu, and Talaga Raya District. The samples of this study was divided into 2 groups, namely the quality of freshwater springs and the quality of brackish springs. Freshwater quality samples were taken at 13 different stations with 30 springs (can be seen in Table S1), while the quality samples of brackish springs were taken at 9 different. For more details, see (Table 1).

The method in this research is a direct survey method and laboratory analysis, this research did not use statistical analysis. The analysis was carried out at the Biology Laboratory of Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA) Universitas Halu Oleo. This research is descriptive quantitative, which describes the results of the comparison of the quality data of springs from laboratory tests with the applicable water quality standards and describes the results of the research based on a literature review.

The chemical and biological parameters of the quality of the springs to be tested and the analysis methods can be seen in (Tables 2 and 3).

Table 1. Samples of freshwater and brackish springs quality in each district of Buton Tengah Regency.

Station/Sample Code	Sample Description (Freshwater)	Station/Sample Code	Sample Description (Brackish)	District	Information
Freshwater 1 (Chemistry, Biology)	Composite: 1. Kaunci Spring 2. Cio Spring 3. Wadiabero Spring 4. Mapadingki Spring 5. Laponisi Spring 6. Oemposolo Spring 7. Lapahia Spring 8. Laabu Spring	Brackish 1 (Chemistry, Biology)	Composite: 1. Lakakoloto Spring 2. Lawonolita Spring	Gu	Composite means springs of the same category and close together, so that are combined into one sample of springs
Freshwater 2 (Chemistry, Biology)	Composite: 9. Cimindaka Spring 10. Hola Spring 11. Walando Spring 12. Labungkari Spring	-	-	Gu	
Freshwater 3 (Chemistry, Biology)	13. Wulu Spring	-	-	Talaga Raya	
Freshwater 4 (Chemistry, Biology)	14. Gua Koo Spring	Brackish 2 (Chemistry, Biology)	Composite: 3. Maguntaloa Spring 4. Maobu Spring 5. Wamoilou Spring	Mawasangka Tengah	
Freshwater 5 (Chemistry, Biology)	15.Wakahohondo Spring	Brackish 3 (Chemistry, Biology)	Composite: 6. Lamunde Spring 7. Mawapanda Spring 8. Watorumbe Bata Spring 9. Mawahola Spring	Mawasangka Tengah	
Freshwater 6 (Chemistry, Biology)	Composite: 16. Wahumbia Spring 17. Koliwutono Spring	Brackish 4 (Chemistry, Biology)	Composite: 10. Katembe Spring 11. Oe Melobu Spring 12. Oe Potubu Spring 13. Oe Katomba Spring	Mawasangka Timur	
Freshwater 7 (Chemistry, Biology)	18. Mawaheno Spring	-	-	Mawasangka Timur	
Freshwater 8 (Chemistry, Biology)	19. Baruta Analalaki Spring	Brackish 5 (Chemistry, Biology)	14. Mamba Spring	Sangia Wambulu	
Freshwater 9 (Chemistry, Biology)	Composite: 20. Oe Balano Spring 21. Kaoe-oe Spring 22. Mandola Spring	-	-	Sangia Wambulu	
Freshwater 10 (Chemistry, Biology)	Composite: 23. Lakitalo Spring 24. Matawine Spring	Brackish 6 (Chemistry, Biology)	15. Kampolele Spring	Lakudo	
Freshwater 11 (Chemistry, Biology)	Composite: 25. Lahunsa Spring 26. Podi Spring 27. Laulawi Spring	Brackish 7 (Chemistry, Biology)	Composite: 16. Wanupe Spring 17. Kambara Spring 18. Masampe Spring 19. Liang Spring 20. Kapala Kampo Spring	Lakudo	
Freshwater 12 (Chemistry, Biology)	28. Lapoasa Spring	Brackish 8 (Chemistry, Biology)	21. Wataeo Spring	Mawasangka	
Freshwater 13 (Chemistry, Biology)	Composite: 29. Oe Buou Spring 30. Pinggilai Spring	Brackish 9 (Chemistry, Biology)	Composite: 22. Gumanano Spring 23. Kawuna-wuna Spring 24. Moko Spring	Mawasangka	

Table 2. Chemical parameters of spring quality and analysis method.

Parameters	Method Specifications	Method Explanation	Information	Materials Used
Total Dissolved Solids (TDS)	Gravimetry	Gravimetry is an analytical chemical method to determine the quantity of a known substance or component by measuring the weight of the component in its pure state after going through the separation process.	Ex-Situ	Analytical scales
Acidity (pH)	SNI	SNI is a standard that applies nationally in the country of Indonesia, compiled and formulated by the Technical Committee and stipulated by the National Standardization Department.	Ex-Situ	pH meter
Hardness ($CaCO_3$)	Titrimetry	Titrimetry, also known as titration, is a quantitative chemical analysis method commonly used to determine the concentration of a known analyte.	Ex-Situ	25 ml burette (0.05 mL accuracy), 250 mL erlenmeyer, 100 mL measuring cup, rubber ball, spatula, dropper pipette, 25 mL beaker glass, and 10 mL volume pipette.
Chloride (Cl)	Argentometry	In analytical chemistry, argentometry is a type of titration involving silver (I) ions. This is used to determine the amount of chloride present in the sample. The sample solution is titrated against the silver nitrate solution at a known concentration. The chloride ion reacts with the silver (I) ion to give insoluble silver chloride.	Ex-Situ	pH meter, glass funnel, 250 mL erlenmeyer, 50 mL burette, statif, 25 mL volume pipette, and 50 mL measuring flask.
Sulfate (SO_4)	Spectrophotometric	Spectrophotometry is a quantitative measurement method in analytical chemistry on the reflection or light transmission properties of a material as a function of wavelength.	Ex-Situ	Spectrophotometer
Nitrate (NO_3)	Spectrophotometric		Ex-Situ	Spectrophotometer
Nitrite (NO_2)	Spectrophotometric		Ex-Situ	Spectrophotometer
Iron (Fe)	Spectrophotometric		Ex-Situ	Spectrophotometer
Dissolved Oxygen (DO)	Titrimetry	Titrimetry, also known as titration, is a quantitative chemical analysis method commonly used to determine the concentration of a known analyte.	Ex-Situ	DO meter
Biological Oxygen Demand (BOD)	BOD meter	BOD analyze the amount of oxygen needed to digest organic matter biologically.	Ex-Situ	DO meter

Table 3. Biological parameters of spring quality and analysis method.

Biological Parameters	Method Specifications	Method Explanation	Information	Materials Used
Total Coliform	Tube method / Most Probable Number (MPN)	Most Probable Number (MPN) is a test that detects the fermentative nature of Coliform in the sample.	Ex-Situ	MPN table

The results of the chemical parameter analysis will be compared and adjusted to the water quality standards that have been determined based on the Regulation of the Minister of Health of the Republic of Indonesia Number 416/Menkes/Per/IX/1990 concerning Requirements and Monitoring of Water Quality and the results of the analysis of biological parameters will be compared and adjusted according to quality standards that have been determined based on the Government Regulation of the Republic of Indonesia Number 82 of 2001 concerning Water Class Quality Designation.

3. Results

3.1. Spring Quality

Clean water is very important for human life. The use of clean water for daily activities certainly prevents humans from disease. Most of the human body consists of water, which functions as a solvent and constituent of all human body systems. So that water used for human activities does not harm humans, it is necessary to know the requirements for clean water. The quality of clean water can be viewed from a chemical and biological perspective. Chemical quality can be examined through observations about hardness, pH, ion content, and so on, while the presence or absence of disease-causing microorganisms in water is a biological requirement for clean water. Apart from the quality aspect, the quantity and availability of water must also be adequate to meet human needs. Water is used by humans for bathing, drinking, washing, farming, fishing, and so on. Each of these activities requires varying amounts of water. Water sources on the surface of the earth can be processed into drinking water using various techniques that have been developed so that the need for drinking water that meets the requirements of the Minister of Health of the Republic of Indonesia can be met for all levels of society.

Water class is a rating of water quality that is still considered suitable for use for a certain designation. Water class as a water quality rating according to Government Regulation Number 82 of 2001 (concerning Water Quality Management and Water Pollution Control) consists of four classes, namely: (a) First class, water whose designation that can be used for drinking water, raw water, and/or other uses that require the same water quality for that purpose; (b) Second class, water designated for water recreation infrastructure/facilities, freshwater fish farming, animal husbandry, water for irrigating crops, and/or other designations uses requiring the same water quality as the said use; (c) Class three, water the designation of which that can be used for the cultivation of freshwater fish or livestock, water for irrigating crops, and/or other designations uses which require the same water quality as the said use; and (d) Class four, water the designation of which that can be used to for irrigating crops and/or other uses requiring the same water quality for that purpose.

Each of the water classes above requires a certain quality of water which is considered suitable for use or certain uses. In other words, water quality criteria are measures of water quality for each water class. Water class and water quality criteria in Government Regulation Number 82 of 2001 serve as a reference for the government or local government in determining the water classes at of water sources in their administrative areas. The water class is determined by considering the administrative area of water sources. Determination of water class at water sources that are in two or more provinces or at transnational borders is stipulated by a Presidential Decree. Determination of water class in rivers that are in two or more regencies/municipalities can be regulated by provincial regulations. Determination of water class at water sources located in a regency/city is stipulated by a regency/city regulation. If the class of water has not been determined, the water quality standard is deemed to be subject to class 2 regulation.

3.2. Quality of Springs from the Aspect of Chemical Parameters

The chemical parameter test results of freshwater spring samples in the Buton Tengah Regency are presented in (Tables 4 and 5).

Table 4. Results of laboratory analysis of chemical parameters of freshwater spring samples in Gu, Talaga Raya, Mawasangka Tengah, and Mawasangka Timur Districts.

Parameters	Unit	Freshwater 1	Freshwater 2	Freshwater 3	Freshwater 4	Freshwater 5	Freshwater 6	Freshwater 7	Quality Standards
Total Dissolved Solids (TDS)	mg/L	530	300	450	510	600	790	590	1500
Acidity (pH)	-	6.53	6.20	6.04	6.84	6.87	6.77	6.97	6.5–9.0
Hardness ($CaCO_3$)	mg/L	204	275.4	571.2 *	193.8	197.8	332.3	220.3	500
Chloride (Cl)	mg/L	229.5	25.80	25.80	227.6	509.6	553.2	259.9	600
Sulfate (SO_4)	mg/L	37	23	28	33	45	66	41	400
Nitrate (NO_3)	mg/L	2.10	1.92	1.45	2.9	1.78	2.01	1.02	10
Nitrite (NO_2)	mg/L	0.10	0.02	0.02	0.09	0.10	0.02	0.02	1
Iron (Fe)	mg/L	0.02	0.01	<0.01	0.01	0.02	<0.01	0.01	1.0
Dissolved Oxygen (DO)	mg/L	3.03	3.85	3.15	3.59	4.00	3.11	3.52	-
Biological Oxygen Demand (BOD)	mg/L	6.20	5.50	6.11	6.18	5.70	4.99	6.01	-

Information: * = Exceeds water quality standards; Source: Results of biological laboratory analysis, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Halu Oleo, 2018.

Table 5. Results of laboratory analysis of chemical parameters of freshwater spring samples in Gu, Talaga Raya, Mawasangka Tengah, and Mawasangka Timur Districts.

Parameters	Unit	Freshwater 8	Freshwater 9	Freshwater 10	Freshwater 11	Freshwater 12	Freshwater 13	Quality Standards
Total Dissolved Solids (TDS)	mg/L	330	290	270	370	440	300	1500
Acidity (pH)	-	6.80	6.80	6.84	6.77	7.21	7.32	6.5–9.0
Hardness ($CaCO_3$)	mg/L	240	234.6	150.9	204	248.8	150.2	500
Chloride (Cl)	mg/L	13.83	10.13	40.55	35.94	276.5	230.5	600
Sulfate (SO_4)	mg/L	15	8.0	6.0	7.0	15	10	400
Nitrate (NO_3)	mg/L	0.99	1.81	3.10	1.56	2.06	1.81	10
Nitrite (NO_2)	mg/L	0.02	0.02	0.12	0.02	0.03	0.02	1
Iron (Fe)	mg/L	0.01	0.02	<0.01	0.02	0.01	0.03	1.0
Dissolved Oxygen (DO)	mg/L	3.33	3.71	3.81	3.79	3.50	3.60	-
Biological Oxygen Demand (BOD)	mg/L	5.60	7.02	6.10	6.21	4.88	6.40	-

Source: Results of biological laboratory analysis, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Halu Oleo, 2018.

The results of laboratory analysis of samples of brackish springs in Buton Tengah Regency are presented in (Tables 6 and 7).

Table 6. Results of laboratory analysis of chemical parameters of brackish spring samples in Gu, Mawasangka Tengah, Mawasangka Timur, and Sangia Wambulu Districts.

Parameters	Unit	Brackish 1	Brackish 2	Brackish 3	Brackish 4	Brackish 5	Quality Standards
Total Dissolved Solids (TDS)	mg/L	940	13,000 *	12,000 *	13,600 *	850	1500
Acidity (pH)	-	7.05	6.99	7.17	7.15	7.30	6.5-9.0
Hardness ($CaCO_3$)	mg/L	303.9	461	410	493	338.6	500
Chloride (Cl)	mg/L	414	691 *	4562 *	1059 *	599	600
Sulfate (SO_4)	mg/L	72	97	95	99	64	400
Nitrate (NO_3)	mg/L	3.81	3.41	3.80	3.66	2.02	10
Nitrite (NO_2)	mg/L	0.11	0.10	0.04	0.11	0.02	1
Iron (Fe)	mg/L	0.02	0.03	0.02	0.01	0.02	1.0
Dissolved Oxygen (DO)	mg/L	3.61	2.65	2.65	3.81	3.96	-
Biological Oxygen Demand (BOD)	mg/L	5.66	5.70	5.70	6.11	6.03	-

Information: * = Exceeds water quality standards; Source: Results of biological laboratory analysis, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Halu Oleo, 2018.

Table 7. Results of laboratory analysis of chemical parameters of brackish spring samples in Lakudo and Mawasangka Districts.

Parameters	Unit	Brackish 6	Brackish 7	Brackish 08	Brackish 09	Quality Standards
Total Dissolved Solids (TDS)	mg/L	15,000 *	16,200 *	390	18,000 *	1500
Acidity (pH)	-	6.91	7.05	7.61	6.76	6.5–9.0
Hardness ($CaCO_3$)	mg/L	718 *	775 *	248.8	1024 *	500
Chloride (Cl)	mg/L	1612 *	1981 *	1884.3 *	4470 *	600
Sulfate (SO_4)	mg/L	119	121	9.0	137	400
Nitrate (NO_3)	mg/L	3.46	3.06	1.82	1.93	10
Nitrite (NO_2)	mg/L	0.12	0.10	0.02	0.02	1
Iron (Fe)	mg/L	0.02	0.01	0.02	0.03	1.0
Dissolved Oxygen (DO)	mg/L	3.60	3.62	3.92	3.41	-
Biological Oxygen Demand (BOD)	mg/L	5.90	4.99	5.05	6.07	-

Information: * = Exceeds water quality standards; Source: Results of biological laboratory analysis, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Halu Oleo, 2018.

3.3. Spring Quality from the Aspect of Biological Parameters

The results of laboratory analysis of samples of freshwater springs and brackish springs in Buton Tengah Regency are presented in (Table 8).

Table 8. Biological parameters quality standards for each designation class.

Biological Parameter	Unit	Quality Standards Based on Water Class (Government Regulation of the Republic of Indonesia Number 82 of 2001)				Freshwater	Brackish	Information
		I	II	III	IV			
Total Coliform	Individual/100 mL	1000	5000	10,000	10,000	11–460	9–240	Suitable

Source: Results of biological laboratory analysis, Fakultas Matematika dan Ilmu Pengetahuan Alam (FMIPA), Universitas Halu Oleo, 2018.

4. Discussion

Changes in the area of protected areas or water catchment areas, due to illegal logging and land-use change, resulting in critical land and decreasing quality of water catchment areas in Buton Tengah Regency will have a direct impact on decreasing the quantity and quality of clean water sources for the population. Most of the water sources found in Buton Tengah Regency come from groundwater and surface water, whose availability to meet community needs is decreasing, so it is necessary to plan and manage water resources.

Following the characteristics of the Buton Tengah Regency area, which is dominated by karst areas, most of the water sources are in the form of springs located between the rocks. Between the rocks, which are natural containers for water storage, are small caves. These caves are generally a source of water (springs), which are widely found in the Buton Tengah Regency area. Fulfilling for clean water needs of the community that lives in the capital of Buton Tengah Regency is mostly served by the drinking water supply system. The source of water used generally comes from cave springs around residential areas. For people who live in rural areas, they cannot yet be served by the drinking water supply system, so that people they experience problems in providing clean water to meet their daily needs. Geographical, topographical, and geological conditions, as well as different aspects of human resources in each region of Indonesia, are responsible for the availability of raw water and the different conditions for clean water services, which can have different implications for the provision of clean water for each region. To minimize the differences that may occur, and to realize the provision of clean water that is of good quality and can meet existing needs, a guidelines for the operation of a Drinking Water Supply System is needed. Clean water that is deemed fit for use for certain uses is determined based on water class [4].

Determination of water class in a water source is carried out based on the results of an assessment conducted by the government and/or local governments. The results of this study contain information regarding: (1) The condition of the current water quality (existing quality); (2) a Water utilization plan according to the desired class criteria; and (3) Water quality to be achieved (objective quality). Based on these three pieces of information, the determination of water class is carried out to maintain the quality of the water source or to change the quality of the water source from a lower water class to a higher water class. The assessment for the determination of the water class is closely related to the next instrument; the water quality standard and the water quality level of each class are compiled based on the possibility of their use for a designated beneficial water use. Assessment of raw water quality is very important to maintain the quality of water resources for sustainable development and to improve the quality of drinking water to prevent significant public health problems [3].

Water quality greatly determines human health. According to a report by the United Nations Environmental Program (UNEP) in 2010, every year the number of children under five who die from diseases related to poor water quality reaches 1.8 million. Countries in the world apply high quality standards for drinking water so that the water is safe for consumption, but not all countries can apply quality standards properly, especially developing countries, so the quality of their drinking water is still very poor [14].

Several developing countries, some water sources are used as garbage dumps disposal sites for garbage or human waste, as well as places for bathing, washing clothes, and even washing cooking utensils. Utilization of water for activities like the ones above can cause disease. The level of water quality of each class is arranged based on the possibility of its use for a designated beneficial water use. Many research studies have assessed the quality of spring water in the world, concluding that hydrochemical analysis provides a better understanding of possible changes in spring quality [15–19].

(Tables 4 and 5) above are present data from laboratory test results of freshwater samples from Buton Tengah Regency. From these data, it can be seen that for freshwater samples in taken from the seven sub-districts in Buton Tengah Regency (namely Talaga Raya, Mawasangka, Mawasangka Tengah, Mawasangka Timur, Lakudo, Gu, and Sangia Wambulu districts), in general, none exceeded the quality standard requirements for water based on the Regulation of the Minister of Health of the Republic of Indonesia Number 416/Menkes/Per/IX/1990, except for the Freshwater 3 sample taken from Talaga District, which exceeded one parameter, namely hardness or $CaCO_3$. High hardness is related to the salts dissolved in the water, especially Ca and Mg.

Judging from the origin, the word hardness comes from the root word "hard", which means containing lime. Hard water is water that contains Ca^{2+} and Mg^{2+} ions, that's because the two ions are dominant when compared to other substances or dissolved. So therefore, we can conclude that the definition of water hardness is the content of certain salts in water, especially carbonate salts from Ca^{2+} and Mg^{2+} ions, although the actual hardness can also be from salts other than these two ions (for example, sulfate and bicarbonate salts). The nature of water that is constantly flowing makes it erode and transport various substances from the field in its path. Therefore, many substances are dissolved in it, including salt or lime. Water containing the $Ca(HCO_3)_2$ and $Mg(HCO_3)_2$ salts are called temporary hard water. It has a non-permanent hardness. It is so named because the hardness will be lost by heating the bicarbonate ion (HCO_3^-), which will break down and form carbonate deposits in the form of $CaCO_3$ salt. The number of Ca^{2+} and Mg^{2+} ions will decrease or disappear because they have formed the salt.

This is in accordance with the statements of [20,21] that total water hardness is defined as the number of multivalent cations, which are generally calcium (Ca^{2+}) and magnesium (Mg^{2+}), as these are the most common in natural freshwater systems. Hardness of water is due to moisture and carbon dioxide reacting with calcium and magnesium ion present on the earth's surface [22]. The existence of calcium, magnesium, and carbonate ions on the earth layer influences the hydrochemistry of groundwater [23]. Water hardness can vary

widely depending on location and water source, with 0–60 mg/L being considered "soft", 61–120 mg/L as "moderately hard", and above 180 mg/L as "very hard" [24]. In general, some degree of water hardness (25–100 mg/L as Ca^{2+}) is recommended for cultivation because Ca^{2+} provides important functions and benefits [21].

The hardness that water has is very detrimental to humans. Although it is not immediately dangerous if drunk, this water can have adverse effects, such as forming calcium and magnesium salts that which are difficult to dissolve in water (for example, calcium carbonate ($CaCO_3$) and magnesium carbonate ($MgCO_3$)). This sediment salt often settles in the pipe or boiler, and if left for a long time, can cause blockage and damage to the boiler or pipe. Another adverse effect is the deposition of soap anions, which reduce the effectiveness of washing and lead to wasteful soap consumption. When hard water meets soap, what happens is the ions contained in the hard water destroy the surfactant effect of the soap. When they meet, they form a solid deposit (soap scum). In the world of the water hardness industry, hard water business people never goes unnoticed by business people: hard water can damage steam engines, and machines that use hard water vapor in their pipes can break down.

This is in accordance with the statement of [25] that the Presence of hardness ions in the municipal drinking water is the a major health concern. So to minimize the hardness of drinking water to the Environmental Protection Authority (EPA)'s quality standard, expensive treatments are available. This directly affects rural and low-income communities. According to the US Geological Survey [26], water hardness varies widely in the US and is classified into different categories: soft water (0–60 mg/L $CaCO_3$), moderately hard (60–120 mg/L $CaCO_3$), hard (120–180 mg/L $CaCO_3$), and very hard (more than 180 mg/L $CaCO_3$). Similar variations have been reported in Korea by the Korea Water Resources Corporation [27].

How to deal with a hardness, and to remove Ca^{2+} and Mg^{2+} ions in hard water, can use the following alternative methods can be used: (1) Cases of temporary hardness can be easily eliminated by heating. Through heating, compounds containing bicarbonate ions will be able to precipitate on the bottom of the cross-section. (2) The addition of lime (CaO) and soda ash (Na_2CO_3) is quite effective. Lime and soda ash can raise the pH and supply CO_3^{2-} ions, which are needed to precipitate Ca^{2+} ions into calcium carbonate ($CaCO_3$). Meanwhile, a relatively high pH can cause Mg^{2+} ions to be deposited in Mg $(OH)_2$ compounds, which can be separated from the solution. (3) The dilution technique works by mixing pure (non-hard) water with water that has a high hardness level, which will reduce the concentration of Ca^{2+} and Mg^{2+} ions so that the hardness level can decrease. (4) The deionizer technique is quite expensive; however, it can produce water with zero hardness. (5) Zeolite compounds can be used. Zeolites are hydrated, natural, or artificial aluminosilicates, with an open 3-dimensional water crystal structure. This compound contains a lattice in which water molecules are contained. Heated water is mixed with zeolite, and the zeolite absorbs water molecules containing Ca^{2+} and Mg^{2+} ions so that the water hardness level decreases.

This is in accordance with the statement of [25] that X-ray diffraction, scanning electron micrograph, and Fourier infrared transfer analysis confirms that zeolite has participated on hardness removal. Overall, zeolite is highly efficient for hardness removal and can be employed in the drinking water treatment plants. The degree of hardness has been categories as temporary and permanent, temporary hardness can be reduced by boiling, but permanent hardness required specific treatment [28].

The potential for springs in Buton Tengah Regency is quite large, including the potential for freshwater and brackish water. Regarding The potential of freshwater and brackish water: in addition to quantity, the potential for quality is also very important.

From the laboratory test data, it can be seen that the brackish water samples were taken from 7 sub-districts in Buton Tengah Regency (namely Mawasangka, Mawasangka Tengah, Mawasangka Timur, Lakudo, Gu, and Sangia Wambulu Districts) generally meet the water quality standard requirements based on the Regulation of the Minister of Health

of the Republic of Indonesia Number 416/Menkes/Per/IX/1990 concerning Requirements and Supervision of Water Quality, except for two parameters (namely Total Dissolved Solids (TDS) and Chloride) in Mawasangka Tengah District, 3 parameters (namely TDS, Hardness, and Chloride) in Lakudo District, and 3 parameters (namely TDS, Hardness, and Chloride) in Mawasangka District. The potential for springs in Buton Tengah Regency is quite large, including the potential for freshwater and brackish water. The potential of freshwater and brackish water in addition to quantity, the potential for quality of freshwater and brackish water is also very important. The results of laboratory analysis of samples of brackish springs in Buton Tengah Regency are presented in (Tables 6 and 7).

TDS refers to any minerals, salts, metals, cations, or anions dissolved in water. This includes anything present in water other than pure water molecules (H_2O) and solid waste (solid waste is particles/substances that are insoluble and do not settle in the water, such as wood grain and others). In general, the total dissolved solids concentration is the sum of the cation ions (positively charged) and anions (negatively charged) in water.

The main sources for TDS in receiving water are agricultural and residential runoff, leaching of soil contamination, and point sources of water discharge pollution from industrial or sewage treatment plants. The most common chemical constituents are calcium, phosphate, nitrate, nitrite, sodium, potassium, and chloride, which are found in nutrient runoff. The more common and hazardous elements of TDS are pesticides that arise from surface water runoff. Certain total dissolved solids that occur naturally arise from the weathering and dissolving of rock and soil.

Some of the dissolved solids come from organic materials such as leaves, sludge, plankton, industrial waste, and dirt. Other sources come from include runoff from urban areas, and fertilizers and pesticides used on lawns and livestock. Besides, Dissolved Solids also come from inorganic materials such as rock and air, which may contain calcium bicarbonate, nitrogen, phosphorus, iron, sulfur, and other minerals. Most of these materials form salts, which are compounds that contain both metals and non-metals. Salt usually dissolves in water to form ions. Ions are particles that have a positive or negative charge. Water can also pick up metals such as lead or copper as they travel through the pipes used to distribute water to consumers. It should be noted that the effectiveness of water purification systems in removing dissolved solids will decrease over time, so it is advisable to monitor the quality of filters or membranes and replace them if necessary.

Not all regions have good water resources. Coastal areas and small islands in the mouths of rivers or the middle of the high seas are areas that are very poor in clean water sources, so that problems arise in meeting the need for clean water, especially during the long dry season. The quality of groundwater is very dependent on rainfall. In the dry season, freshwater from rainwater is no longer available, so groundwater will be easily contaminated by seawater. Pollution of groundwater quality as a result of seawater contamination is called an intrusion. The characteristic of seawater intrusion is groundwater that feels brackish or contains high levels of chloride and TDS. Water sources found in such areas are generally of poor quality (brackish or salty, i.e., TDS > 3000 ppm), in terms of both groundwater and surface water. To get freshwater that is safe to drink and cleaner than water quality standards, we use membrane technology (reverse osmosis/RO). This membrane technology uses materials in the form of activated carbon from mangrove charcoal and pottery as filters. Both of these filters are capable of filtering 0.1–1 micron size bacteria. Thus, the freshwater produced is completely free of Coliform bacteria. With techniques such as processing brackish water into freshwater, it is not difficult to convert salty seawater to freshwater, although the problem is the cost. This can be overcome if there is sponsorship from the business world and the government.

This is in accordance with the statement of [29] that content of solids in water can be measured based on Total Dissolved Solids (TDS) and Total Suspended Solids (TSS). TDS contain various solutes (be it organic, inorganic, or other materials) with a diameter < 10–3 µm contained in a solution dissolved in water. The main sources of TDS in waters are runoff from agriculture and households, and industrial waste. Changes in TDS con-

centrations can be dangerous because they will cause changes in salinity, changes in ionic composition, and changes in the toxicity of each ion [30].

The high levels of TDS are caused by the large number of organic and inorganic compounds that dissolve in water, including minerals and salts. In seawater, the high TDS value is because it contains a lot of chemical compounds, which also results in high salinity and electrical conductivity [31]. The TDS value of water is strongly influenced by rock weathering, runoff from the soil, and anthropogenic effects (in the form of domestic and industrial waste) [30].

Chloride is an anion forming sodium chloride, which causes a salty taste in clean water. Cl^- levels in water are limited by standards for various uses, namely drinking water, irrigation, and construction. The chloride concentration in water can increase suddenly in the presence of contact with used water. Chloride reaches natural water in many ways. Human waste, especially urine, contains chloride in about the same amount as chloride that is consumed through food and water. Amount is approximately 6 grams of chloride per day, and it increases the amount of Cl in the used water by about 15 mL above the concentration in the carrying water. Besides that, there is a lot of industrial wastewater that contains quite a large amount of chloride.

Chloride itself is an anion forming NaCl, which causes a salty taste in water. The source of chloride in water comes from minerals in the soil, be it topsoil or minerals in rocks in the soil. In addition, other sources of chloride can come from domestic wastewater or human urine, and can also come from seawater carried by rainwater. This is in accordance with the statement of [32] that Chloride is one of the main inorganic anions found naturally in water. The presence of excess chloride in the water indicates that the water is contaminated. The chloride content in water affects the salinity of the water. The higher the chloride concentration, the saltier the water will be, which will cause a decrease in the quality of the water. Another factor that affects the chloride content is likely the condition of minerals in the soil [33]. This is based on research conducted by [34], which states that sources of chloride can also come from minerals in the soil, be it a cover (top soil) or minerals in rocks in the soil.

Globally, water contaminated with pathogenic microorganisms is the biggest cause of human disease. Water polluting organisms are grouped into three types, namely bacteria, viruses, and parasites, where these organisms can cause typhoid, dysentery, colitis, cholera, polio, hepatitis, and many more [35]. Testing water quality with biological parameters using indicators of total Coliform bacteria content. Coliform bacteria can be sourced come from waste, agricultural runoff, contamination with feces, and others. Open defecation and inadequate septic tanks can lead to the penetration of sewage into water sources in rural areas of the world [36–38].

In general, in terms of biology, the water originating from this location is in lightly polluted conditions where the laboratory test results found total Coliform bacteria in all samples, but all of them are still below the quality standard threshold (laboratory test results are attached). Biologically, the water in the research location was found to have be total Coliform bacteria ranging from 11–460 individuals/100 mL for freshwater and 9–240 individuals/100 mL for brackish water. Based on the water quality standards, the number of bacteria in the water at the research location does not exceed the threshold required, that so it can still be used for designation classes I, II, III, and IV.

Total Coliform bacteria are a type of Coliform bacteria that come from environmental pollution by organic materials. Total Coliform is the first bacterial indicator used to determine whether water is safe for consumption. From the laboratory test results for, freshwater samples from each district are as follows: Gu, 28 and 11 individuals/100 mL; Talaga, 240 and 120 individuals/100 mL; Mawasangka Tengah, 93 and 64 individuals/100 mL; Mawasangka Timur, 460 and 23 individuals/100 mL; Sangia Wambulu, 20 and 15 individuals/100 mL; Lakudo, 93, 120, 120, and 20 individuals/100 mL; and Mawasangka, 28, 15, 23, 75, and 28 individuals/100 mL. The values for brackish water samples from each district are as follows: Gu, 93 individuals/100 mL; Mawasangka Tengah, 75

and 9 individuals/100 mL; Mawasangka Timur, 20 individuals/100 mL; Sangia Wambulu, 11 individuals/100 mL; Lakudo, 210, 75, and 240 individuals/100 mL; and Mawasangka, 21 and 64 individuals/100 mL.

The microbiological requirement of water is that it does not contain germs such as dysentery, typhoid, cholera, and other pathogenic bacteria that cause disease. The presence of total Coliform bacteria in water samples from fresh and brackish water sources was caused by environmental conditions and the distance from where the samples were taken, so that the water might be contaminated with organic matter, but however, the number of individuals from each freshwater and brackish water sample did not exceed the quality standard of each water class, so the water can be maximally utilized for its purpose. In general, for the water biology class, the water potential in Buton Tengah Regency is included in class 1.

If the water quality standard is already above the standard or following these standards, what happens is that will determine the size of the investment in the provision of clean water, both for the water purification installation and the operating and maintenance costs. This is in accordance with the statement of [33] that biological contamination can be identified by the discovery of Coliform bacteria (pathogens) as an indicator of water pollution. The presence of Coliform bacteria in the water indicates the presence of microbes that are anthropogenic or toxicogenic, which are harmful to health.

5. Conclusions

The water quality (freshwater and brackish springs) of all springs in Buton Tengah Regency is still relatively good. All key parameters (namely chemical parameters and biological parameters) have not generally exceeded the quality standards. The exceptions are the freshwater springs in Talaga Raya District, which exceeded the water quality standards for the hardness parameter; and the brackish springs in Mawasangka Tengah, Mawasangka Timur, Lakudo, and Mawasangka Districts, which exceeded the water quality standards for the parameters of total dissolved solids, hardness, and chloride. However, these parameters are relatively easy to overcome so that the use of freshwater springs can qualify as drinking water, while the use of brackish springs should be used to meet domestic non-drinking water needs.

Supplementary Materials: Supplementary materials can be found at https://www.mdpi.com/2071-1050/13/5/2679/s1.

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