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Clean Water Quality Study in Bima City

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Abstract: Changes in water quality are the main focus in water management because they can have a major impact on the ecosystem. Water quality includes physical, chemical and biological conditions. Coverage of clean water and drinking water inspection data in Bima City reached 97.41%, while the feasibility percentage based on clean water and drinking water quality tests only reached 51.13%. The low percentage of appropriate clean water quality requires special attention. Based on this, researchers studied problems related to water quality, supply and level of need for clean water in Bima City. This research is an analytical observational study, and sampling was carried out using a non-random purposive sampling technique, and analyzed descriptively. Based on the results of physical water quality tests on 31 samples, the results showed that the physical quality of water met the requirements, the chemical quality of water in all measured samples met the requirements for class 1 and 2 clean water quality standards for the parameters DO, COD, total chlorine, nitrate, nitrite, and six valence chrome, while the BOD, Phosphate and Iron values did not meet the requirements (1/31 samples). The biological quality test showed that 12 samples did not meet the requirements for total coliforms (38.7%) and 3 samples showed the presence of E. coli bacteria (9.7%). On the other hand, it was recorded that 95.8% of respondents used shallow drilled wells for clean water; pump wells for 12.5% of respondents; PDAM constituted 16.6% of respondents; shallow drilled wells and PDAM 16.6%; and those using shallow drilled wells and hand pump wells 12.5%. Meanwhile, 37.5% use clean, untreated water and 62.5% use refilled drinking water.

Keywords: Water Quality; Water Sanitation; Water Use; Water Sources; Water Quality Tests

Introduction

Water quality is a major issue in water resources development because any change in water quality will have a significant impact on the environment (Rashid, et al., 2018). Water quality includes physical, chemical and biological conditions that can influence the availability of water for human life, agriculture, industry, recreation and water use and other purposes (Giri, 2021).

Water resources management is faced with various problems (Garrote, 2017). Generally, the problem consists of three aspects, namely: (1) lack of water, (2) abundance of water and (3) water pollution (Syeed, et al., 2023). An increase in water demand causes excessive exploitation of water resources, causing a decrease in the environmental carrying capacity of water resources which can ultimately reduce water supply (Wassie, 2020). Apart from that, improper water management and poor water quality can cause the possibility of water pollution in both water bodies and surface water (Hasan, et al., 2019).

In Government Regulation Number 20 of 1990 concerning Water Pollution Control, water pollution is defined as the entry or introduction of living creatures, substances, energy and/or other components into water by human activities so that the quality of the water decreases to a certain limit which causes the water to no longer be useful. according to its purpose. Providing clean water is of particular concern, including in Indonesia and throughout the region, including Bima City, because it is one of the main issues in the

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Millennium Development Goals (MDG's). One of the main problems is the lack of clean water sources and access to clean water and drinking water (Mueller & Gasteyer, 2021).

In the 2020 Human Resources Development Report of the Republic of Indonesia through Bappenas, BPS and UNDP, it is stated that currently in every district/city throughout Indonesia, there are quite significant differences in the need for clean water and sanitation. The target for fulfilling clean water in Indonesia by 2020 is 75% with sanitation at 80%, in accordance with the commitment of world leaders in Johannesburg at the 2002 Summit (Murthy, 2021).

Poor sanitation and clean living habits as well as unsafe clean water quality contribute to 88% of child deaths due to diarrhea throughout the world and cause child nutrition problems (Soboksa, 2021). This condition can have serious implications for the quality of human resources and the productive capacity of a nation in the future (Hernita, et al., 2021). In Indonesia, diarrhea is still the main cause of death for children under five years old. The 2020 Riskesdas report, diarrhea is the cause of 51% of deaths of children aged between one month and one year, and 25% of deaths of children aged between one and four years (Indonesia Unicef, 2012).

The morbidity rate due to diarrhea, one of the main sources of which is poor water sanitation, is quite high in Bima City. Diarrhea cases in children reached 43.5%, while for all ages it was 51.5% in 2022. This figure is higher than the previous two years, namely 40% and 37.9%. According to data from the Environmental Health Program of the Bima City Health Service, the coverage of clean water and drinking water inspection data in Bima City reached 97.41%, while the percentage of feasibility based on clean water and drinking water quality tests, water quality that is physically, chemically and bacteriologically appropriate is only reached 51.13% (Bima City Health Service, 2023). The low percentage of appropriate clean water quality needs special attention because high clean water quality is a reference for the availability of water sources for healthier people in Bima City in ensuring and improving the level of public health. Based on this, researchers aim to study problems related to the quality of water used by the people of Bima City, both physically, chemically and biologically.

Method

The type of research used is analytical observational with a cross sectional approach. The research was carried out from October to November 2023. The sampling technique used non-random purposive sampling technique. The population in the study was all clean water and surface water in Bima City, while the sampling location criteria were determined by the researcher. The samples used in the research were clean water and surface water taken in the upstream, central and coastal areas of Bima City. Research procedures include: Water Quality Data Collection in Bima City; Preparation of Tools and Materials; Determination of Sample Number; Water Sampling; Water Quality Measurement; Respondent data was collected through filling out questionnaires and interviews, then analyzed descriptively.

Result and Discussion

The research began with structured interviews with respondents to explore information and data related to the need for and access to drinking water and clean water from several informants representing Bima City which can be seen in Table 1.

Table 1. Research Respondents

Respondent	Address	Sampling Time	Type and Number of Samples taken	Use
Misbah	Ex. Manggemaci RT. 04 RW. 01	27 Oct 2023/ 09.24 WITA	1. Shallow Drilled Wells	Clean water
Penatoi River	Ex. Penatoi	27 Oct 2023/ 09.24 WITA	2. River water	Clean water
Ahmad	Ex. Mande RT. 01 RW. 01	27 Oct 2023/ 09.24 WITA	3. Shallow Drilled Wells	Clean water
Hj. Mahfiah	RT. 12 RWs. 05 Ex. North Rabangodu, Bima City	01 Nov 2023/08.05 WITA	4. Shallow Drilled Wells 5. PDAM	Clean water
Hafsah	Ex. Call	01 Nov 2023/08.17 WITA	6. Shallow Drilled Wells	Clean water
Kindergarten. Doro Londa	Ex. Sambinae	01 Nov 2023/08.24 WITA	7. Shallow Drilled Wells	Clean water
Hadija	Ex. Code I RT. 08 RW. 04	01 Nov 2023/08.38 WITA	8. Shallow Drilled Wells 9. PDAM	Clean water and drinking water
Hj. St. Nurbaya	Kodo I (TKN No. 15 Kodo Kota Bima)	01 Nov 2023/08.41 WITA	10. Shallow Drilled Wells	Clean water and drinking water
Suhada	Ex. Lampe RT. 01 RW. 01	01 Nov 2023/09.02 WITA	11. Shallow Drilled Wells	

Respondent	Address	Sampling Time	Type and Number of Samples taken	Use
			12. Hand Pump Well	Clean water and drinking water
Nurhayati	Ex. Lampe RT. 09 RW. 04	01 Nov 2023/09.14 WITA	13. Shallow Drilled Wells	Clean water and drinking water
Isna	Ex. Wait RT. 01 RW. 01	02 Nov 2023/08.40 WITA	14. Shallow Drilled Wells 15. PDAM	Clean water and drinking water
Mukhdar	Ex. Wait RT. 01 RW. 01 (Al Ikram Mosque)	02 Nov 2023/08.45 WITA	16. Shallow Drilled Wells	Clean water
Treatise	Ex. Dodu RT. 08 RW. 04	02 Nov 2023/09.16 WITA	17. Shallow Drilled Wells 18. PDAM	Clean water and drinking water
Ayan	Ex. Dodu RT. 01 RW. 01 (Darul Furqan Islamic Boarding School)	02 Nov 2023/08.15 WITA	19. Shallow Drilled Wells	Clean water and drinking water
Aisha	Ex. West Jatibaru RT. 08 RW. 03	03 Nov 2023/10.20 WITA	20. Drilled Wells 21. Hand Pump Well	Clean water
Baiyah	Ex. West Jatibaru RT. 08 RW. 03	03 Nov 2023/10.25 WITA	22. Drilled Wells	Clean water and drinking water
Nur Kurniati	Ex. Malay RT. 07 RW. 05	04 Nov 2023/09.04 WITA	23. Drilled Wells	Clean water
Nurina Widiastuti	Ex. Malay (SDIT Al Hikmah)	04 Nov 2023/09.16 WITA	24. Drilled Wells	Clean water
Abdul Majid	Ex. Tanjung RT. 07 RW. 06	04 Nov 2023/09.28 WITA	25. Drilled Wells	Clean water
Antun Hilmatun	Ex. Tanjung RT. 07 RW. 06 (SMPN 13 Tanjung)	04 Nov 2023/09.42 WITA	26. Drilled Wells	Clean water
Jamaludin	Ex. Dara (Dara Terminal)	04 Nov 2023/10.05 WITA	27. Drilled Wells 28. Hand Pump Well	Clean water and drinking water
Nurhidayah	Ex. Dara RT. 02 RW. 01	04 Nov 2023/10.27 WITA	29. Drilled Wells	Clean water
M. Saleh	Ex. Pane (Grand Mosque)	04 Nov 2023/11.02 WITA	30. Drilled Wells	Clean water
Suraya	Ex. Paruga RT. 07 RW. 02	04 Nov 2023/11.17 WITA	31. Drilled Wells	Clean water

Based on information obtained from a total of 24 respondents, 31 water samples were taken from 24 shallow drilled wells; 3 hand pump wells as well 4 samples sourced from PDAM. Samples and respondents from the 3 sample collection areas can be seen in Table 2.

Table 2. Respondents and Samples based on sampling area

Sampling Area	Sampling location	Number of Respondents (people)	Number of samples taken	Type of sample taken
Upstream	1. Ex. Code 2. Ex. Nungga 3. Ex. Dodu 4. Ex. Lampe	8	12 (S8, S9, S10, S11, S12, S13, S14,S15, S16, S17, S18, S19)	1. Shallow drilled wells (12) 2. Hand pump well (2) 3. PDAMs (2)
Middle	1. Ex. Paruga 2. Ex. Pane 3. Ex. Penatoi 4. Ex. Manggemaci 5. Ex. Mande 6. Ex. North Rabangodu 7. Ex. Call	7	8 (S1, S2, S3, S4, S5, S6, S30, S31)	1. Shallow drilled wells (7) 2. PDAMs (1) 3. River (1)
Coastal	1. Ex. Sambinae 2. Ex. Jatibaru 3. Ex. Malay 4. Ex. Cape 5. Ex. Virgin	9	11 (S7, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29)	1. Shallow drilled wells (9) 2. Hand pump well (2)

From the upstream area, 8 respondents responded and obtained 12 samples of shallow drilled well water, 2 samples of hand pump well water and 2 samples of PDAM water. In the central region, 7 respondents were responded to and 7 shallow well water samples were obtained, 1 river water sample and 1 PDAM water sample, while in the downstream region 9 respondents were responded to and 9 water samples were obtained. shallow well and 2 hand pump well water samples. On 31 clean water samples from each of the upstream, middle and downstream areas of Bima City taken during the research, water quality checks were carried out including physical, chemical and biological parameters. A summary of test results based on the study area can be seen in Table 3.

Table 3. Summary of physics quality test results based on study area

Region	Sample Code	Test results				Note.
		Temperature (°C)	TDS (ppm)	DHL (µS/cm)	Salinity (%)	
Upstream	S8	27.8	412	1,002	23	Qualify
	S9	30.2	387	1,342	19	Qualify
	S10	29.4	509	1,224	25	Qualify
	S11	30.5	256	1,354	30	Qualify
	S12	28.9	365	1,005	32	Qualify
	S13	29.5	227	965	33	Qualify
	S14	29.5	276	1,324	32	Qualify
	S15	28.7	356	1,224	31	Qualify
	S16	29.4	276	1,254	25	Qualify
	S17	29.1	365	1,187	27	Qualify
	S18	30.2	365	1,005	30	Qualify
	S19	29.4	298	1,023	35	Qualify
Middle	S1	31.7	312	1,025	24	Qualify
	S2	29.5	287	1,041	21	Qualify
	S3	30.5	411	978	34	Qualify
	S4	28.5	376	1,234	32	Qualify
	S5	29.7	365	1,187	28	Qualify
	S6	28.9	298	1,453	33	Qualify
	S30	28.3	76	1,502	24	Qualify
	S31	28.1	101	1,245	23	Qualify
Coastal	S7	27.8	358	1,326	35	Qualify
	S20	33	387	1,435	34	Qualify
	S21	33.7	551	1,023	37	Qualify
	S22	31.8	568	998	21	Qualify
	S23	28.7	163	983	24	Qualify
	S24	28.7	60	1,224	25	Qualify
	S25	29.4	184	1,347	27	Qualify
	S26	29.1	50	1,085	32	Qualify
	S27	27.9	287	1,346	35	Qualify
	S28	30.1	379	1,225	45	Qualify
	S29	27	69	1,315	31	Qualify

Physical water quality parameters were carried out on all samples which included testing temperature, total dissolved solids/TDS, electrical conductivity and salinity/salt content in the water. Based on the test results, the physical quality of water samples in all sampling areas meets the requirements in accordance with the physical water quality reference values in Minister of Health Regulation No. 492/MENKES/PER/IV/2010 and Republic of Indonesia Minister of Health Regulation No. 2 of 2023. The results of chemical quality testing of clean water can be seen in Table 4.

Table 4. Summary of clean water chemical quality test results based on study area

Region	Sample Code	Test results											Note.
		pH	COD (mg/L)	BOD (mg/L)	DO (mg/L)	Chlorine (mg/L)	Fe (mg/L)	PO_4 (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	NH_3 (mg/L)	CR^{6+} (mg/L)	
Upstream	S8	7.4	21	1.54	6.38	0.07	0.09	0.18	0.300	0.01	0.09	0	BOD exceeds reference value
	S9	6.9	12	4.67	5.82	0.04	0.05	0.16	0.31	0.02	0.04	0.01	Qualify
	S10	6.91	25	3.45	5.41	0.02	0.14	0.16	0.24	0.02	0.04	0.02	Qualify

Region	Sample Code	Test results pH	COD (mg/L)	BOD (mg/L)	DO (mg/L)	Chlorine (mg/L)	Fe (mg/L)	PO_4 (mg/L)	NO_3 (mg/L)	NO_2 (mg/L)	NH_3 (mg/L)	CR^{6+} (mg/L)	Note.
	S11	6.54	34	2.78	6.12	0.08	0.17	0.15	0.25	0.01	0.02	0	Qualify
	S12	6.91	25	2.09	5.36	0.02	0.21	0.18	0.24	0.02	0.04	0.01	Iron exceeds reference values
	S13	7.2	23	3.56	5.64	0.03	0.07	0.02	0.21	0.01	0.03	0.01	Qualify
	S14	6,8	36	4.12	6.24	0.05	0.11	0.05	0.38	0.012	0.31	0	Qualify
	S15	7.21	31	5.56	5.62	0.04	0.09	0.01	0.22	0.02	0.04	0.01	Qualify
	S16	6.92	24	5,11	5.26	0.02	0.08	0.01	0.23	0.01	0.02	0.01	Qualify
	S17	6.5	33	4.56	7.12	0.04	0.14	0.03	0.26	0.11	0.02	0	Qualify
	S18	6.91	21	3.78	5.26	0.01	0.13	0.01	0.23	0.01	0.02	0.02	Qualify
	S19	6.4	13	3.12	7.14	0.06	0.16	0.02	0.36	0.01	0.06	0	Qualify
Middle	S1	7.1	21	5.31	7.67	0.08	0.13	0.16	0.315	0	0.07	0.01	Qualify
	S2	6,8	24	2.54	6.54	0.03	0.09	0.13	0.411	0.02	0.08	0	Qualify
	S3	7.1	31	3.78	7.67	0.08	0.06	0.16	0.315	0	0.07	0.01	Qualify
	S4	6.92	16	3.11	8.12	0.07	0.10	0.21	0.285	0.019	1	0.01	Qualify
	S5	6.83	24	2.14	7.12	0.06	0.07	0.20	0.214	0.016	0.17	0.01	Phosphates exceed reference values
	S6	6.92	25	3.34	8.12	0.07	0.09	0.20	0.285	0.019	1	0.01	Qualify
	S30	7.2	15	3.12	6.90	0.05	0.11	0.02	0.19	0.01	0.03	0.01	Qualify
	S31	7.6	24	2.56	8.45	0.05	0.14	0.01	0.313	0.01	0.04	0.01	Qualify
Coastal	S7	6.9	34	4.33	5.82	0.03	0.15	0.16	0.28	0.02	0.04	0.01	Qualify
	S20	6.9	26	4.12	7.38	0.05	0.11	0.03	0.26	0	0.13	0	Qualify
	S21	7.2	25	3.56	7.45	0.06	0.09	0.01	0.21	0.03	0.05	0.01	Qualify
	S22	7.4	31	4.22	8.23	0.05	0.08	0.02	0.31	0.04	0.05	0.01	Qualify
	S23	6,8	32	3.45	7.34	0.02	0.15	0.01	0.29	0.02	0.03	0.01	Qualify
	S24	6.4	35	3.56	7.49	0.05	0.16	0.02	0.26	0.01	0.04	0.01	Qualify
	S25	7.2	24	2.65	6.31	0.05	0.11	0.01	0.31	0	1.04	0.01	Qualify
	S26	6.4	28	2.67	5.80	0.04	0.09	0.01	0.25	0.12	0.05	0.01	Qualify
	S27	6,8	30	4.56	7.88	0.02	0.15	0.02	0.21	0.21	0.04	0.01	Qualify
	S28	6,7	34	6,11	6.94	0.06	0.09	0.03	0.31	0.011	0.03	0.01	Qualify
	S29	6.9	32	2.45	7.54	0.07	0.09	0.02	0.27	0.01	0.02	0.01	Qualify

The chemical quality of clean water in the upstream area which was tested for the parameters COD, DO, BOD, nitrate, nitrite, phosphate, ammonia and hexavalent chromium met the requirements in 10 samples (83.3%), but in 2 samples (16.7%) did not meet the requirements because there was a decrease in BOD values (<2 mg/L) in sample 8 (S8) and an increase in iron/Fe levels (>0.2 mg/L) in sample 12 (S12). In the central region, 7 samples (87.5%) met the requirements, while 1 sample (12.5%) had increased phosphate levels (>0.2 mg/L). while in the downstream area, in all samples (100%), the chemical quality of clean water meets the requirements in accordance with Government Regulation Number 82 of 2001, for the minimum limit of DO content in waters for class II water categories, Minister of Health Regulation No. 492/MENKES/PER/IV /2010, Government Regulation Number 22 of 2021 for class 2 water and Republic of Indonesia Minister of Health Regulation No. 2 of 2023. Meanwhile, the results of biological water quality checks can be seen in Table 5.

Table 5. Summary of clean water biological quality test results based on study area

Region	Sample Code	Test results Total coliform	Fecal coli	Coli count	Note.
Upstream	S8	22	2	TTD	Qualify
	S9	84	9	TTD	Coliforms exceed reference values
	S10	17	<2	TTD	Qualify
	S11	36	2	TTD	Qualify
	S12	120	17	TTD	Coliforms exceed reference values
	S13	94	9	TTD	Coliforms exceed reference values
	S14	22	2	TTD	Qualify
	S15	79	9	TTD	Coliforms exceed reference values
	S16	150	15	TTD	Coliforms exceed reference values
	S17	11	2	TTD	Qualify
	S18	49	2	TTD	Qualify
	S19	25	2	TTD	Qualify
Middle	S1	47	4	TTD	Qualify
	S2	58	6	TTD	Coliforms exceed reference values
	S3	63	8	TTD	Coliforms exceed reference values

Region	Sample Code	Total coliform	Fecal coli	Test results Coli count	Note.
	S4	84	9	TTD	Coliforms exceed reference values
	S5	40	<2	TTD	Qualify
	S6	12	<2	TTD	Qualify
	S30	22	<2	TTD	Qualify
	S31	21	<2	TTD	Qualify
Coastal	S7	34	2	TTD	Qualify
	S20	220	22	1	Coliforms exceed reference values
	S2	36	<2	TTD	Qualify
	S22	1,600	38	9	Coliforms exceed reference values
	S23	21	2	TTD	Qualify
	S24	48	4	TTD	Qualify
	S25	47	4	TTD	Qualify
	S26	33	4	TTD	Qualify
	S27	70	8	TTD	Coliforms exceed reference values
	S28	15	2	TTD	Qualify
	S29	920	15	2	Coliforms exceed reference values

Table 6 shows that in the upstream area, 5 samples (41.6%) experienced an increase in total coliforms (>50 CFU/100 ml) for non-piped water (S9, S12, S13, S15, S16). In the central region, 3 samples (37.5%), total coliforms exceeded the reference value (S2, S3, S4). Meanwhile, in the downstream area, 4 samples (36.4%) experienced an increase in total coliforms (S20, S22, S27, S29), 3 samples (27.3%) showed the presence of the indicator bacteria pollutant E. coli (S20, S22, S29) and 3 samples (27.3%) experienced an increase in total coliforms and showed the presence of E. coli (S20, S22, S29).

The reference values used for each test parameter can be seen in Table 6.

Table 6. Reference values for clean water and drinking water quality

Parameter	Reference Value	Reference
pH	6.5-8.5	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Temperature	Air temperature ±3 0C	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
TDS	<500 mg/L	Minister of Health Regulation No. 492/MENKES/PER/IV/2010
DHL	20 - 1500 µS/cm	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Salinity	≤0.5ppt	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
COD	10 mg/L	Republic of Indonesia Government Regulation Number 82 of 2001
BOD	2 mg/L	Republic of Indonesia Government Regulation Number 82 of 2001
DO	4 mg/L	Government Regulation Number 82 of 2001, for the minimum limit of DO content in waters for class II water categories
Chlorine	250 mg/L	Minister of Health Regulation No. 492/MENKES/PER/IV/2010
Iron	0.2 mg/L	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Phosphate	0.2 mg/L	Government Regulation Number 22 of 2021 for class 2 water
Nitrate	20 mg/L	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Nitrite	1.0 mg/L	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Ammonia	1.5 mg/L	Minister of Health Regulation No. 492/MENKES/PER/IV/2010
Valence chrome 6	0.01 mg/L	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Total coliform	50 /100 ml	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
Fecal coli	50 /100 ml	Republic of Indonesia Minister of Health Regulation No. 2 of 2023
E. Coli	TTD	Republic of Indonesia Minister of Health Regulation No. 2 of 2023

Bima City Demographic Data

Bima City is an autonomous city located to the east of Sumbawa Island, West Nusa Tenggara Province, Indonesia. Based on data on the population of Bima City in 2023, there will be 161,362 people with a density reaching 694 people/km2. Based on a geographical point of view, Bima City is located to the east of Sumbawa Island with coordinates of 118°41'00"-118°48'00" East Longitude and 8°20'00"-8°30'00" South Latitude. The area of Bima City is 222.25 km2. Bima City has land use areas such as rice fields covering an area of 1,923 hectares (94.90% is irrigated rice fields), moorland and gardens covering an area of 3,632 ha, forests covering an area of 13,154 ha, fields and huma covering an area of 1,225 ha and a coastal area of 26 km. The land conditions in Bima City are dominated by rocky mountains, resulting in the local community's livelihood being farmers such as corn and other hard crops.

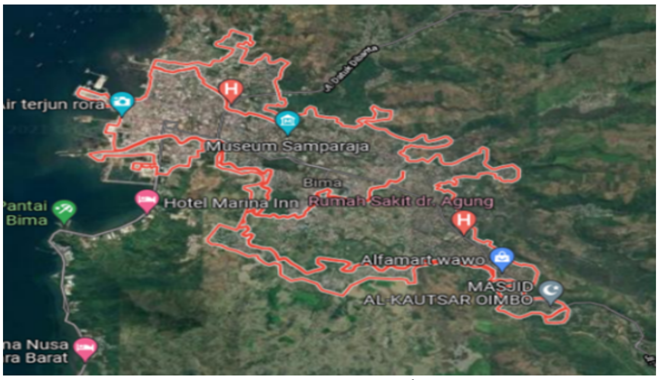

Figure 2. Location map of Bima City

Clean Water Quality

The research used 24 respondents, where all respondents had access and ability to provide clean and drinking water. The selection of water sampling locations and respondents was based on data from several areas in Bima City with possible difficulties in accessing clean water in early 2023. Several areas that have indications of difficulties in water access are: Tanjung Village, Paruga Village, Dara Village, Sambinae Village, Sambinae Village, Manggemaci, Sadia Village, Rontu Village, Kendo Village, Penanae Village, Melayu Village, East Jatibaru Village, Jatibaru Village, Kodo Village, and Dodu Village (BPBD Bima City, 2023).

Of the 8 respondents who were research informants in the upstream area, all respondents used shallow drilled well water as a source of clean water, 2 respondents used shallow drilled wells and hand pump wells as sources of clean water and 2 respondents used shallow drilled wells and PDAM as water sources clean. In the central region, out of 7 respondents, 6 respondents used shallow drilled wells as a source of clean water, 1 respondent used river water and 1 respondent used PDAM shallow drilled well water, while in the downstream area 9 respondents responded, where all respondents used drilled wells. shallow as a source of clean water and 2 respondents used shallow drilled wells and hand pump wells as sources of clean water (Table 3).

To fulfill drinking water supply, 7 out of 8 respondents in the upstream area (87.5%) use clean water as drinking water without first processing it for consumption; in the central region, all respondents (8 respondents) use clean water only as clean water, while for drinking water, they use refills with an average need of 1 gallon (19 liters) for 2-3 days depending on the number of members in one household, while in the downstream, 2 out of 9 respondents (22.2%) use clean water as drinking water without treatment (Table 2).

During the dry season, the provision of clean water in several areas experiences difficulties. Bima City BPBD, at the beginning of 2023, conducted a survey of clean water supplies and communities affected by drought and lack of clean water in Bima City, which can be seen in the Table 7.

Table 7. Communities with difficulty accessing clean water in early 2023

Ward	Number of families affected	Number of People Affected
Kel. Tanjung	2,006	7,907
Kel. Paruga	503	1,368
Kel. Dara	1,200	2,855
Kel. Sambinae	350	1,000
Kel. Manggemaci	409	1,351
Kel. Sadia	31	91
Kel. Rontu	65	147
Kel. Kendo	172	708
Kel. Penanae	297	700
Kel. Melayu	1,260	3,780
Kel. Jatibaru Timur	428	1,287
Kel. Jatibaru	226	513
Kel. Kodo	33	96
TOTAL	6,980	21,803

Source: Bima City BPBD Report (2023)

The availability of groundwater in Bima City varies during the dry season. Based on the results of research carried out from October to November 2023, groundwater is available in every shallow drilled well and hand pump well so that several of the respondent communities do not experience difficulties in providing clean water. Several respondents who still use clean water for consumption as drinking water did not show or have a history of disease due to water hygiene during the interview process. Differences in physical, chemical and biological water quality in each sampling area are as follows:

a. Upper Region

At the research location in the upstream area, of the 12 samples tested, all samples met physical quality requirements, where there was no significant increase in water temperature, good water TDS and salt content (salinity) and electrical conductivity that did not exceed reference values (Table 4). When physically observing water sources, researchers did not find any indication of sources of pollution from human activities, etc., where Rohmat D., et al, 2020 said that human activities and the role of climatology are several factors that can influence the availability of clean water. Human activities, such as industry, can result in environmental pollution if the waste is not processed first and is thrown directly into rivers. This causes pollution of aquatic ecosystems which are also a source of water for human needs (Bashir, et al., 2020)

Good water temperature according to the quality standards stipulated in the Republic of Indonesia Minister of Health Regulation No. 2 in 2023 is 25 ± 3°C. Water temperatures that do not comply with quality standards indicate the presence of dissolved chemicals in quite large quantities or that there is a process of decomposition of organic material by microorganisms

(Naubi, et al., 2016). Temperature has a big influence on the solubility of oxygen, the higher the water temperature, the less oxygen content in the water, besides that increasing temperature is very favored by microorganisms for metabolism and reproduction (Bok, et al., 2023).

Meanwhile, chemically, 10 test samples met the requirements, but 1 sample (S8) had an increased BOD value and 1 sample (S12) indicated an increased iron content (Table 4). samples with BOD values that do not match the reference value are samples originating from shallow drilled well water taken from respondents in Kodo I RT Village. 08 RW. 04., while samples with high iron content were water samples taken from hand pump wells located in Lampe RT. 01 RW. 01.

Apart from increasing water temperature which plays a role in activating pathogenic bacteria and parasites in water, several water quality parameters that may also be influenced by temperature are DO, BOD and COD (Said, 2021). DO, BOD and COD will affect water quality. If the BOD value is higher, the water quality will be worse and the DO (dissolved oxygen) value will decrease due to the large number of microorganisms in the water.

Meanwhile, iron or ferrum (Fe) is a silvery white metal, tough and can be formed. The presence of iron in water is dissolved which causes the water to turn yellowish red, gives off a fishy odor, and forms a layer like oil. Excessive iron levels, apart from causing a red color to appear, can also cause rust on equipment made of metal (Joko, T., 2020). This is in accordance with the respondent's statement regarding complaints about some rusty kitchen equipment which was assumed to be caused by the use of clean water.

Meanwhile, for biological quality, 5 samples (S9, S12, S13, S15, S16) were taken from PDAM water, Kodo I RT. 08 RW. 04, shallow drilled well, Lampe RT. 01 RW. 01 and RT. 09 RW. 04, PDAM Nungga Subdistrict RT. 01 RW. 01 as well as shallow drilled wells in Nungga RT Village. 01 RW. 01 contains coliform bacteria that exceed the reference value for piped and non-piped clean water (>10-50 CFU/100 ml) (Table 5).

b. Central Region

A total of 8 clean water samples (S1, S2, S3, S4, S5, S6, S30, S31) were obtained from 7 respondents and consisted of: 6 shallow drilled wells, 1 sample from PDAM water and 1 sample from river water at the sampling location in the central area of Bima City, namely Manggemaci, Penatoi, Mande, Panggi, North Rabangodu, Pane and Paruga subdistricts (Table 2). The results of physical water quality testing for all samples met the requirements (Table 4).

In the chemical quality test, 7 samples (87.5%) met the requirements, except for 1 sample (S4) containing phosphate (PO4) levels that exceeded the reference value (>0.2 mg/L) (Table 4). The samples came from shallow drilled well water taken from respondents in Rabangodu Utara Subdistrict, RT. 12 RWs. 05. The main source of nitrate and phosphate naturally comes from waters through the process of decomposition, weathering, decomposition of plants, remains of dead organisms, and waste (domestic, industrial, agricultural, livestock and feed waste) which will be broken down by bacteria into nutrients. (Wattayakorn, 1988 in Patty, 2014). Phosphate is one of the pollutant parameters that can cause eutrophication in water bodies. Phosphates are generally found in wastewater as organic compounds, orthophosphates, and polyphosphates. The main sources of phosphate accumulation in wastewater are agricultural (manure generated during livestock production), household (human waste and synthetic detergents), and industrial activities. Fertilizers used on agricultural land or households are also transferred to surface waters through runoff, rain, and melting snow. Based on previous research, wastewater contains dissolved and particulate forms of phosphate (Yang, et al., 2021).

Meanwhile, the results of testing the biological quality of clean water showed that 3 out of 8 clean water samples (37.5%) had total coliform values higher than those required for non-piped clean water (Table 5). The sample is river water (S2) taken from the Kel River. Penatoi and 2 samples from shallow drilled wells taken from respondents in Mande RT. 01 RW. 01 and in Rabangodu Utara Subdistrict RT. 12 RWs. 05.

An increase in the total number of coliforms in the sample could be caused by contamination by pollutants from outside the water pipe used or the groundwater source from the drilled well is too shallow so that the pollution is caused by bacterial contamination from surface water. Basically, the use of pipes is susceptible to pollution and contamination. Non-fecal coliform bacteria, including Aerobacter and Klebsiella, do not come from human feces, but come from dead animals/plants (Li, et al., 2021).

c. Coastal Area

Physical testing of clean water quality on water samples taken in the coastal area of Bima City was carried out on 11 samples from 9 respondents who were used as research objects. Based on laboratory test results, all samples meet the physical quality requirements of water (Table 4). Likewise, in chemical testing of clean water quality, all samples met the requirements for the chemical parameters of the water tested, namely BOD, COD, DO, nitrate, nitrite, ammonia, phosphate and 6 valence chrome parameters (Table 5).

In Bima City, especially for people living on the coast, groundwater quality has experienced degradation. The physical quality test carried out in situ in 2022, namely Total Dissolved Solid (TDS), showed an average TDS of 512 ppm. Meanwhile, other parameters, such as total hardness, iron, total coliform and feces experienced fluctuating increases (Bima City Health Office, 2022). In this research, the quality of chemically clean water in coastal areas tends to meet the requirements. All test analytes which are mandatory chemical parameters for testing clean water quality do not exceed reference values as requirements for the chemical quality of clean water (Tsaridou & Karabelas, 2021).

Meanwhile, in testing the biological quality of water, 11 samples were taken in the coastal area of Bima City, namely samples 20, 22, 27 and 29 (Table 5). The four samples were each taken from: 2 water samples from shallow drilled wells in Jatibaru RT Village. 08 RW. 03, 1 water sample was taken from a shallow drilled well at Dara Terminal and 1 sample came from a shallow drilled well in Dara RT Subdistrict. 02 RW. 01 showed an increase in the number of coliform bacteria that exceeded the reference value and 3 of the samples indicated E. coli bacteria as an indicator of water pollution.

Physical Quality of Water

In Bima City, especially for people living on the coast, groundwater quality has experienced degradation. The physical quality test carried out in situ in 2022, namely Total Dissolved Solid (TDS), showed an average TDS of 512 ppm. Meanwhile, other parameters, such as total hardness, iron, total coliform and feces experienced fluctuating increases (Bima City Health Office, 2022).

One of the parameters that must be measured to determine water quality is physical parameters, such as temperature, turbidity, color, electrical conductivity, TDS, taste and smell (Omer, 2019). A decrease in water quality can be indicated by an increase in the levels of measured physical parameters. For example, an increase in color parameters and a change in special odor can indicate the presence of chemicals such as iron metal, manganese and cyanide originating from waste disposal. Apart from that, an increase in water temperature and an unpleasant odor in the water indicate contamination with coliform bacteria and fecal coli (E. coli) (Corrillo-Gimez, 2019).

An increase in water temperature can be caused by an increase in environmental temperature around the water source and can be an estimate of an increase in the number of microorganisms in the water, especially if clean water is used for consumption without processing (Handayani, et al., 2018). In general, of all samples tested in all areas as research objects (upstream, central and coastal areas of Bima City), the quality of clean water physically meets the requirements, with a slight increase in water temperature which fluctuates because it is influenced by the surrounding environmental temperature. In coastal areas, the average dissolved solids/TDS value is >500 mg/L in 2022 as reported by the Bima City Health Service, whereas in this study, there was a decrease in the average TDS value in the 31 water samples tested, namely 302.4 mg/L which indicates that, in general, the dissolved solids of all analytes in clean water are not excessive.

Chemical Quality of Water

Good clean water is water that is not excessively polluted by chemical substances that are harmful to health, including iron (Fe), fluoride (F), manganese (Mn), degree of acidity (pH), nitrite.

(NO2), Nitrate (NO3), phosphate, hexavalent chrome, Ammonia and free from heavy metals within permitted limits (Ningrum 2018).

The results obtained from measuring the chemical parameters of clean water samples (Table 5) show that all water chemical parameters were measured below the maximum threshold for class 1 and 2 clean water quality standards for the parameters DO, COD, total chlorine, nitrate, nitrite and six valence chromium. , while the values of BOD, Phosphate (PO4) and Iron exceeded the respective thresholds in 1/31 samples (3.3%). Iron ion content exceeded the reference value (>0.20 mg/dl) in 1 sample (S12) in Lampe RT. 01 RW 01 (upstream area of Bima City). The main causes of increasing iron levels in clean water are: (1) Low pH so that it can dissolve metals; (2) An increase in temperature will increase the degree of corrosiveness; (3) Dissolved O2 oxidizes ferrous ions to become ferric and then forms a precipitate and (3) High levels of dissolved iron are influenced by bacteria by oxidizing iron so that it dissolves in water. This is consistent with the high coliform count (120 CFU/100 ml) in sample 12 (S12).

Another sample in the upstream area, namely the 8th sample (S8) taken from a shallow drilled well in Kodo I Village, contained oxygen levels needed for biological activity of aquatic biota (BOD) which were lower than the required standard (<2 mg/L). BOD is the main indicator in wastewater. The characteristic of domestic liquid waste is high BOD, so one way to reduce BOD is processing using phytoremediation techniques. A lower BOD value in clean water is actually not a dangerous thing, because a low BOD value indicates that the metabolism of bacteria, including pathogenic bacteria, is lower, so the water tends to be more sterile.

Meanwhile, an increase in phosphate levels that exceeded the reference value (0.2 mg/L) (Table 3) occurred in shallow beer well water samples in North Rabangodu Village (central region). According to Minister of Environment Decree No.51/MENLH/2014, the phosphate content in water is good for biota life in the water itself, however if phosphate exceeds the reference value and clean water is used for consumption without prior processing it can accumulate and be harmful to the body. The process of phosphate formation is influenced by temperature and pH. The average temperature of the water samples measured at the research location ranged from 27-33.1 °C and the pH was 6.4-7.6. This is supported by Effendi (2013) who explains that phosphate formation occurs quickly at higher temperatures with a pH that tends to decrease

Biological Quality of Water

Based on the National Water Quality Index (IKA) value, the 2022 Bima City IKA value is in the second lowest rank with a value of 20.25. One of the main factors is the biological parameter, namely the number of E-Coli bacteria. In Indonesia, in 2017, the total annual morbidity rate caused by poor sanitation and hygiene including water quality that did not meet standards was 124,271,743 people, with a total of 50,132 deaths. In 2018, it was reported that the prevalence of diarrhea in Indonesia was 423 per 1000 population for all ages, with a mortality rate of 2.5%.

The morbidity rate due to diarrhea, one of the main sources of which is poor water sanitation, is quite high in Bima City. Diarrhea cases in children reached 43.5%, while in all ages it was 51.5% in 2022. This figure is higher than the previous 2 years, namely 40% and 37.9% (Satu Data, 2022). Meanwhile, according to data from the Environmental Health Program of the Bima City Health Service, the coverage of clean water and drinking water inspection data in Bima City reached 97.41%, while the feasibility percentage was based on clean and drinking water quality tests, water quality that was physically, chemically and physically appropriate. bacteriological only reached 51.13% (Bima City Health Service, 2022).

Laboratory examination of the quality of biologically clean water is carried out using several tests, namely testing total coliforms, fecal coliforms (fecal coliforms) and examining E. coli bacteria as an indicator of water pollution. Laboratory test results (Table 6) show that 12 samples did not meet the requirements for total coliforms (38.7%) and 3 water samples had a tendency to contain E. coli contaminant bacteria (9.7%), but all samples were not contaminated with fecal coliform bacteria. indicates that it is not contaminated with human or animal waste.

In the upstream region, 5 samples contained total coliforms exceeding 50 CFU/100 ml which occurred in the upstream region, 3 samples in the central region and 4 samples in the coastal region, of which 3 samples indicated the presence of E. coli bacteria. Bacterial contamination of soil and water is common in urban areas including Bima City, this is caused by excessive population density, unhealthy toilets and waste disposal (Unicef Indonesia, 2020). The 2017 World Bank report states that only 11.3% of the population has a sewage system. Pipe systems are susceptible to contamination due to leaks and negative pressure caused by irregular supply.

Based on the results of interviews and direct observations of respondents at water sampling locations, on average respondents have faecal disposal facilities with a septic tank location of more than 10 meters and have no risk of water pollution from domestic waste or human and animal waste. This is in accordance with the results of laboratory tests where no indication of the presence of fecal coliform bacteria was found using the CDEC method as the gold standard for biological water examination. This shows that the clean water in the study was not contaminated with human or animal waste.

If you look at the data from the Bima City Health Service in 2022, of the 97.41% of clean water and drinking water examined during 2022, the percentage of physical, chemical and bacteriological suitability of clean water and drinking water only reached 51.13%, the results Research shows that it is likely that most of the unsuitability of clean water and drinking water is based on the biological unsuitability of the water with the total number of polluting bacteria and coliforms exceeding the reference value. This shows that the results of the research carried out are in accordance with preliminary water quality data from the Bima City Health Service in the previous year.

According to the Regulation of the Minister of Health of the Republic of Indonesia Number 492/MENKES/PER/IV/2010, clean water is water used for daily needs whose quality meets health requirements and can be drunk if it has been cooked. The requirements for clean water are tasteless, odorless and colorless, free from chemical contamination such as heavy metals and microbiology. Free from microbiological contamination, namely the water used as clean water is free from the presence of coliform and feces contamination. The permitted clean water standard for piped water is 10/100ml of water, while non-piped water is 50/100ml of water and there is no indication of the presence of E. coli.

The main problem is that poor water quality will have an impact on health. Water is a good medium for the life of pathogenic bacteria, for example Escherichia coli bacteria. E. coli in the open lives in the soil. If pollution occurs (characterized by high BOD), the soil becomes a good growth medium for these bacteria and causes an increase in the concentration of E. coli. When it rains, more bacteria carried by groundwater enter the river. Thus, high concentrations of E. coli will be detected in groundwater, indicating soil contamination.

According to Kuswandi (2001), fecal E. coli bacteria enter waters through river flows and rainwater runoff so that the abundance of bacteria will be higher when it rains. This situation is caused by the concentration of organic matter (N and P), changes in salinity and temperature as well as increased light intensity. E. coli can grow well at temperatures between 8°C-46°C with an optimum temperature below 37°C.

Although the results of the Coli bacteria examination cannot directly indicate the presence of pathogenic bacteria, the presence of E. coli bacteria in water can be used as an indicator of the presence of pathogens. Meanwhile, coliform bacterial contamination in water can come from various sources, namely raw materials used from polluted water, poor distribution and unhygienic water locations.

Coliform bacteria are a group of microorganisms that are commonly used as indicators, where these bacteria can be a signal to determine whether a water source has been contaminated by pathogens or not. Observing the presence of pathogens can practically be done by testing for the presence of pollution indicator organisms such as coliform bacteria. These bacteria come from the same source as pathogenic organisms (Tia Milka et al., 2018).

The increase in the total number of coliforms and the discovery of E. coli bacteria in the samples taken can also be caused by contamination by pollutants from outside the water distribution pipes used. Basically, the use of pipes is susceptible to pollution and contamination. Apart from that, disinfecting clean water using materials containing magnesium sulfate and chlorination of water sources is highly recommended to minimize contamination by pathogenic microorganisms.

4. Recommendations for Improving Clean Water Quality

Several things that can be recommended to the Bima City Government:

a. The Health Service needs to ensure optimization of the implementation of the National Community-Based Total Sanitation Program (STBM) with five pillars which require an approach that mobilizes the community;
b. The Bima City Government through BRIDA and the Bima City Public Works Department need to study and utilize innovative technology in providing quality clean water;
c. The Bima City Government needs to appoint a special technical implementation unit in providing clean water and drinking water suitable for consumption;
d. The Bima City Health Service and Environmental Service need to maximize monitoring activities for the quality of clean water and drinking water in a more comprehensive manner.

Meanwhile, recommendations based on research areas are presented in Table 8.

Table 8. Recommendations for improving clean water quality based on research object areas

Recommen-dation		Type of activity	Implementation Procedures	P.I.C
Upstream Section	1	Improve/normalize DO/BOD values in clean water	• Reducing the TDS value/total dissolved solids in water by filtration processes or using precipitating chemicals. • Improving Aeration for the Activated Sludge Process. by increasing aeration in processing tanks/water sources. Activated sludge uses beneficial bacteria to digest hazardous waste and clean water through a biological process. • Carrying out coagulation and flocculation using a variety of flocculants available today, including aluminum-based versions such as aluminum sulfate as well as iron-based types such as ferric chloride and ferrous sulfate. • Keeping the Temperature Low. Lowering the temperature can increase beneficial bacteria to reduce BOD in water treatment tanks. Lower temperatures lead to higher DO levels and lower BOD levels.	• public health Office • Department of Public Works • Public
	2	Removal/decreasing iron levels	• Aeration • Sedimentation • Filtration	• public health Office • Department of Public Works • Public
	3	Decrease in the number of bacteria	• Disinfection of water sources with chlorine or materials containing CaOCl components • If water is to be consumed, the water is treated first through a heating process at a temperature of 55°C - 60°C for ten minutes which will kill most of the	• public health Office • Department of Public Works • Public

			pathogens or disease germs present/contained in the water. A more effective way is to cook or boil the water we are going to consume until it boils • The process of ultra violet radiation and heating water using sunlight using a metal container or plastic bottle. Where 1 part of the container is painted black. To anticipate the dangers of using plastic, you should use plastic bottles with recycling logo number 1 or PETE/PET (polyethylene terephthalate). • Use bottled or refilled water with quality that meets the requirements. • Ensure the position of the septic tank is more than 10 meters from a clean water source	
Middle part	1	Decreasing phosphate levels is the main contributor to eutrophication apart from nitrate and nitrite	• The coagulation-flocculation process has shown great potential in removing phosphate from wastewater • Physicochemical processing methods are very effective and reliable; they are used singly either as primary treatment or as a follow-up to other phosphate removal methods. Common coagulation-flocculation involves the utilization of metals, including aluminum, iron, and calcium, to act as coagulants. Polyaluminium chloride is used to treat municipal wastewater with 80% of the total phosphate removal efficiency • Biological processes such as conventional activated sludge treatment • Chemical precipitation uses lime, calcium, magnesium, aluminum and iron salts • Physical processes such as reverse osmosis and electrodialysis • Settle the water before using it as clean water	• public health Office • Department of Public Works • Public
	2	Decrease in the number of bacteria	• Disinfection of water sources with chlorine or materials containing CaOCl components • If water is to be consumed, the water is treated first through a heating process at a temperature of 55ºC - 60ºC for ten minutes which will kill most of the pathogens or disease germs present/contained in the water. A more effective way is to cook or boil the water we are going to consume until it boils • The process of ultra violet radiation and heating water using sunlight using a metal container or plastic bottle. Where 1 part of the container is painted black. To anticipate the dangers of using plastic, you should use plastic bottles with recycling logo number 1 or PETE/PET (polyethylene terephthalate). • Use bottled or refilled water with quality that meets the requirements. • Ensure the position of the septic tank is more than 10 meters from a clean water source	• public health Office • Department of Public Works • Public
Downstream Part	1	Decrease in the number of bacteria	• Disinfection of water sources with chlorine or materials containing CaOCl components • If water is to be consumed, the water is treated first through a heating process at a temperature of 55ºC - 60ºC for ten minutes which will kill most of the pathogens or disease germs present/contained in the water. A more effective way is to cook or boil the water we are going to consume until it boils	• public health Office • Department of Public Works • Public

	• The process of ultra violet radiation and heating water using sunlight using a metal container or plastic bottle. Where 1 part of the container is painted black. To anticipate the dangers of using plastic, you should use plastic bottles with recycling logo number 1 or PETE/PET (polyethylene terephthalate). • Use bottled or refilled water with quality that meets the requirements. • Ensure the position of the septic tank is more than 10 meters from a clean water source

Conclusion

Based on the research results, conclusions can be drawn: (1) Research respondents in all test areas who used shallow drilled wells for clean water were 23 respondents (95.8%); hand pump well for 3 respondents (12.5%); PDAM as clean water for 4 respondents (16.6%); shallow drilled wells and PDAM for 4 respondents (16.6%); and 3 respondents (12.5%) used shallow drilled wells and hand pump wells. Meanwhile, for drinking water supplies, 9 respondents (37.5%) used clean, untreated water, and 62.5% used refillable drinking water with an average need of 1 gallon (19 liters) for 2-3 days; (2) The physical quality of water (temperature, TDS, DHL, salinity) in 31 samples tested in the laboratory met the requirements with a tendency for a slight increase in temperature in some test samples; (3) Water chemical quality in all measured water samples is below the maximum threshold for class 1 and 2 clean water quality standards for the parameters DO, COD, total chlorine, nitrate, nitrite and six valence chromium, while the values of BOD, Phosphate (PO4) and Iron exceeded the threshold in 1/31 samples (3.3%); (4) The biological quality of clean water samples showed that 12 samples did not meet the requirements for total coliforms (38.7%) and 3 water samples showed the presence of E. coli bacteria (9.7%), but all samples were not contaminated with fecal coliform bacteria; (5) Several recommendations proposed: Optimization of the five pillar STBM Program, Utilization of innovative technology in providing sanitation and clean water; There is a need for a unit providing clean water and drinking water suitable for consumption and more comprehensive water quality monitoring.

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Author Contributions
Asryadin, preparation of the original text, results, discussion, methodology, conclusions; did analysis, proofreading, reviewing and editing.

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We have no conflict of interest.

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