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Water Quality Monitoring in Blue Nile State, 2019

[1]Abdalgadir.O.M; [1-1] M.G.Ahmed; [1-2] A.M.Ateem; [1-3] Sawsan Omer Fadul FadelElsid, [2] Abdalmagid, M.A.

[1] PhD, Public health consultant (Medical Entomologist).

[1-1] BSc Pharmacy,MSc Public Health, MSc Business Administration (MBA)

[1-2] BSc Public Health, MSc of Epidemiology

[1-3]MBBS, MSc, University of Gezeira.

[2] Senior Public Health Specialists, Khartoum State Ministry of Health
Corresponding author: Osammeldine Muzamil Abdalgadir

Communicate person: mabdemajed@gmail.com

ABSTRACT

Background: The quality of water is affected by an increase in anthropogenic activities and any pollution either physical or chemical causes changes to the quality of the receiving water body

Objectives: This study aimed to assess the water sources and identify the risks.

Materials and methods: Descriptive cross sectional study water source-based was conducted in Blue Nile State. **A** number of 543 samples from different water sources were taken in the seven localities of Blue Nile state and assessment of water quality was conducted according to WHO Guidelines.

Results: The mean value of turbidity was 22.6 NTU, the mean pH was 7.3, the mean TDS value was 17.9 mg/l and the mean EC value was 22.8µS/cm. The mean value of Flour was 2.90 mg/l, the mean value of No_3 value was 13.6 mg/l and the mean value of Fe was 10.3 mg/l.

Conclusion: On the basis of findings, it was concluded that drinking water of the study areas was that all physico– chemical parameters except increased of turbidity and Fe levels above WHO recommendations. All the Blue Nile state sources of drinking water sampling sites were consistent with World Health Organization standard for drinking water (WHO).

Keywords: *water quality monitoring, Blue Nile state, Sudan.*

Introduction:

Although the world's multitudes have access to water, in numerous places, the available water is seldom safe for human drinking and not obtainable in sufficient quantities to meet basic health needs (1). The World Health Organization (WHO) estimated that about 1.1 billion people globally drink unsafe water

and most diarrheal diseases in the world (88%) is attributed to unsafe water, poor sanitation and unhygienic practices. In addition, the water supply sector is facing enormous challenges due to climate change, global warming and urbanization. Insufficient quantity and poor quality of water have serious impact on sustainable development, especially in developing countries (2).

Te quality of water supplied by the municipality is to be measured against the national standards for drinking water developed by the federal governments and other relevant bodies (3). These standards considered some attributes to be of primary importance to the quality of drinking water, while others are considered to be of secondary importance. Generally, the guidelines for drinking water quality recommend that faecal indicator bacteria (FIB), especially Escherichia coli (E. coli) or thermo tolerant coliform (TTC), should not be found in any 100 mL of drinking water sample (2).

Despite the availability of these standards and guidelines, numerous WHO and United Nations International Children Emergency Fund (UNICEF) reports have documented faecal contamination of drinking water sources, including enhanced sources of drinking water like the pipe water, especially in low-income countries (4).

Water-related diseases remain the primary cause of a high mortality rate for children under the age of five years worldwide. These problems are specifically seen in rural areas of developing countries. In addition, emerging contaminants and disinfection by-products have been associated with chronic health problems for people in both developed and developing countries (5). Efforts by governmental and non-governmental organizations to ensure water security and safety in recent years have failed in many areas due to a lack of sustainability of water supply infrastructures (6).

Water quality, especially regarding the microbiological content, can be compromised during collection, transport, and home storage. Possible sources of drinking water contamination are open field defecation, animal wastes, economic activities (agricultural, industrial and businesses), and wastes from residential areas as well as flooding. Any water source especially is vulnerable to such contamination (13). Thus, access to a safe source alone does not ensure the quality of water that is consumed, and a good water source alone does not automatically translate to full health benefits in the absence of improved water storage and sanitation14. In developing countries, it has been observed that drinking-water frequently becomes re-contaminated following its collection and during storage in homes (7).

Previous studies in developing countries have identified a progressive contamination of drinking water samples with E. coli and total coliforms from source to the point of use in the households, especially as a result of using dirty containers for collection and storage processes (8) . Also, the type of water treatment method employed at household levels, the type of container used to store drinking water, the number of days of water storage; inadequate knowledge and a lack of personal and domestic hygiene have all been linked with levels of water contamination in households (9). The current study aimed to assess the water sources and identify the risks.

MATERIALS AND METHODS:

Study design:

Descriptive cross sectional study water sources-based.

Study area:

Blue Nile State lied in southern part of the country bordering from southeast Ethiopia, southwest of South Sudan and north is Sinner state. With an area of 38,000 km square and 1,250.00 populations. Blue Nile River is crossing the state from south to north fed by numbers of streams and tributes. This gives unique feature for agricultural and live stocks herding activities. Rainy season starts early in June and ends in late October. Elroseres High Dam famous hydro-electric project, that supplies country with electricity and irrigation water sources, particularly Aljazeera agriculture scheme and it is rich of mechanized agriculture in Al Tadamon locality. BNS is served by number of (160) health facilities (HFs). The population at Blue Nile State depends on different water sources. Water from network, which covers approximately (25%) of the population; The other sources are out network e.g., Hand pumps, water yards, dug wells (open/closed), river, seasonal streams, open sources (shallow wells, hafeers) usually water in BNS is common risk factor that could contribute to occurrence of out breaks (9).

Study population:

Water resources in Blue Nile State.

Inclusion criteria:

All water resources were included in the survey.

Exclusion criteria:

None.

Sample size and sampling technique:

All water resources in the targeted 7 localities in Blue Nile State randomly.

Data collection and instruments:

HCFs were assessed using a validated water quality monitoring (WHO checklist).

The data collected as follows;

- Sanitary inspection for the water sources and HFs was conducted using WHO standard form.
- Water sources coordinates were identified using GIS app for mapping purpose.
- Free Residual Chlorine readings in the targeted water sources were taken using digital devices and pool testers.
- Samples for bacteriological testing using the rapid test (H2S) and multiple tube method were taken for detection of microorganisms.
- Samples for water chemical & natural parameters were taken and measured using the recommended chemical testing kits.
- Joined field supervisory visits were conducted to evaluate WASH in HFs using WHO standard form.

Ethical considerations:

Permission was taken from all localities to conducted the water survey

Data analysis:

Data was analyzed using SPSS version 24.0. Descriptive and inferential statistic was used where appropriate. P-value considered significant at less than 0.05 levels.

Results:

Basic information:

Table 1 shows that the majority of water sources type in Blue Nile State was significantly H.P (69.6%), storage tanks (18.4%), 2.4% O.H.D.W , surface water 4.2%, water tap 0.2%, water stations 3.1% and Jamam 2%.

Table 2 indicates that most of water sources were significantly managed by government 47.7%, 32.8% were managed by community, 19% managed by organizations and only 0.6% was managed by private.

Bacteriological parameters:

Table 3 shows that the level of E.Coli/100 ml significantly in Group (0) was 64.1% and in group B was 28.4%, group C 6.1%, group D 0.6% and group E was 0.9%.

Table 4 indicates that acceptability of water sources among 543 samples taken the acceptable level of E.Coli/100 ml in 501 (92.3%) samples.

Table 5 illustrates that water sources classification according to sanitary inspection scores shows that 45.3% of the samples were Low priority action is required, high priority action is required (38.5%), urgent priority action is required (7.2%), and no action is required (9%).

Table 6 shows that the water sources classification according to risk analysis indicates 38.3% of water sources were group as H.P.A (High Action Priority , L.A.P (Low Action Priority) 44.2%, N.A.R (No Action Required) 9.2%, UA (Urgent Action) 8.1% and 0.2% Not Applicable (NA).

Water sources physical parameters:

Table 7 shows that 38.3% of the sample their turbidity level was ranged between 0-5 NTU, 24.9% was ranged between 6-9.9 NTU, 27.6% was ranged between 10-19.9 NTU , 2.2% ranged between 20-29.9 NTU and 7% was 30 NTU and above.

Table 8 indicates that the acceptable level of turbidity was found among 343 (63.2%) samples.

Water source pH between 0-6.5 was 5%, 6.6-7.5 was 61.9%, 7.6-8.5% was 29.3% and more than8.5 was 3.9as shown in table 9.

Table 10 shows that the acceptable pH was found among 522 (96.1%) samples.

The TDS level between 0-101 mg was 93.7%, 1002-2001 mg was 5.5% and more than 3002 mg was 0.7%, table 11.

The TDS acceptability samples was 510 (93.9%), table 12.

The Water source EC range between 0-400 µS/cm was18% and more than 400 µS/cm was 82%, table 13.

The acceptable EC samples was only 102 (18.8%), table 14.

Table 21 shows that the mean value of turbidity was 22.6 NTU, the mean pH was 7.3, the mean TDS value was 17.9 mg/l and the mean EC value was 22.8µS/cm.

Table 22 shows that the mean value of Flour was 2.90 mg/l, the mean value of No3 value was 13.6 mg/l and the mean value of Fe was 10.3 mg/l.

Water source chemical parameters:

Table 15 shows that the flour range between 0-2 mg was 99.3% and more than 2 mg was 0.7%.

The acceptable samples for flour was540 (99.3%), table 16.

Table 17 indicates that the range of No3 between 0-51 mg was 99.6% and between 101-151 mg was 0.4%.

Table 18 shows that the acceptable samples of No3 were 541 (99.6%).

Table 19 illustrates that the Fe range between 0-0.4 mg was 45.9%, between 0.5-0.9 mg was 46.5%, 1 mg was 3.7% and more than 1mg was 3.9%.

Table 20 shows that the acceptable samples for Fe were 245 (45.1%).

Table 1. Distribution of type of water source by localities in Blue Nile State

Locality		Type of water source							
		H.P	O.H.D.W	Jamam	Station	Storage tanks	Surface water	Water tap	Total
Al Tdamon	n	5	1	6	4	3	15	0	34
	%	1.3%	7.7%	54.5%	23.5%	3.0%	65.2%	.0%	6.3%
Bau	n	29	1	0	1	5	8	0	44
	%	7.7%	7.7%	.0%	5.9%	5.0%	34.8%	.0%	8.1%
Eldamazin	n	64	1	0	5	51	0	0	121
	%	16.9%	7.7%	.0%	29.4%	51.0%	.0%	.0%	22.3%
Elkurmuk	n	77	0	4	0	9	0	0	90
	%	20.4%	.0%	36.4%	.0%	9.0%	.0%	.0%	16.6%
Elrosieris	n	104	5	1	6	15	0	1	132
	%	27.5%	38.5%	9.1%	35.3%	15.0%	.0%	100.0%	24.3%
Giesan	n	63	1	0	0	10	0	0	74
	%	16.7%	7.7%	.0%	.0%	10.0%	.0%	.0%	13.6%
Wad almahi	n	36	4	0	1	7	0	0	48
	%	9.5%	30.8%	.0%	5.9%	7.0%	.0%	.0%	8.8%
Total	n	378	13	11	17	100	23	1	543
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**69.6**	**2.4**	**2.0**	**3.1**	**18.4**	**4.2**	**0.2**	

$\chi 2$=323.3; df=36; P-value =.000 (Significant)

Table 2. Management of water sources by localities in Blue Nile State

Locality		Management of water source				Total
		Community	Government	Organization	Private	
Al Tdamon	n	21	12	0	1	34
	%	11.8%	4.6%	.0%	33.3%	6.3%
Bau	n	1	23	20	0	44
	%	.6%	8.9%	19.4%	.0%	8.1%
Eldamazin	n	0	120	0	1	121
	%	.0%	46.3%	.0%	33.3%	22.3%
Elkurmuk	n	46	6	37	1	90
	%	25.8%	2.3%	35.9%	33.3%	16.6%
Elrosieris	n	101	26	5	0	132
	%	56.7%	10.0%	4.9%	.0%	24.3%

Giesan	n	8	27	39	0	74
	%	4.5%	10.4%	37.9%	.0%	13.6%
Wad almahi	n	1	45	2	0	48
	%	.6%	17.4%	1.9%	.0%	8.8%
Total	n	178	259	103	3	543
	%	100.0%	100.0%	100.0%	100.0 %	100.0%
Overall (%)		**32.8**	**47.7**	**19.0**	**0.6**	

$\chi 2$=457.8; df=18; P-value =.000 (Significant)

Bacteriological parameters:

Table 3. Grouping of E.Coli/100 ml in Blue Nile State

Locality		E.Coli/100 ml					
		Group A (0 Cells)	Group B (1>10 Cells)	Group C (10>100 Cells)	Group D (100>1000 Cells)	Group E (Uncountable cells)	Total
Al Tdamon	N	4	16	14	0	0	34
	%	1.1%	10.4%	42.4%	.0%	.0%	6.3%
Bau	N	34	2	6	2	0	44
	%	9.8%	1.3%	18.2%	66.7%	.0%	8.1%
Eldamazin	N	75	44	2	0	0	121
	%	21.6%	28.6%	6.1%	.0%	.0%	22.3%
Elkurmuk	N	70	14	5	1	0	90
	%	20.1%	9.1%	15.2%	33.3%	.0%	16.6%
Elrosieris	N	65	59	3	0	5	132
	%	18.7%	38.3%	9.1%	.0%	100.0%	24.3%
Giesan	N	57	16	1	0	0	74
	%	16.4%	10.4%	3.0%	.0%	.0%	13.6%
Wad almahi	N	43	3	2	0	0	48
	%	12.4%	1.9%	6.1%	.0%	.0%	8.8%
Total	N	348	154	33	3	5	543
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**64.1**	**28.4**	**6.1**	**0.6**	**0.9**	

$\chi 2$=186.8; df=24; P-value =.000 (Significant)

Table 4. Water acceptability from bacteriological view in Blue Nile State

Locality		Water acceptability		Total
		Acceptable	Not acceptable	
Al Tdamon	n	20	14	34
	%	4.0%	33.3%	6.3%
Bau	n	36	8	44
	%	7.2%	19.0%	8.1%
Eldamazin	n	118	3	121
	%	23.6%	7.1%	22.3%
Elkurmuk	n	85	5	90
	%	17.0%	11.9%	16.6%
Elrosieris	n	123	9	132
	%	24.6%	21.4%	24.3%
Giesan	n	73	1	74
	%	14.6%	2.4%	13.6%
Wad almahi	n	46	2	48
	%	9.2%	4.8%	8.8%
Total	n	501	42	543
	%	100.0%	100.0%	100.0%
Overall (%)		**92.3%**		**7.7%**

$\chi 2$=70.5; df=6; P-value =.000 (Significant)

Table 5. Water sources classification according to sanitary inspection scores in Blue Nile State

Locality		Sanitary Inspection Score				Total
		Low priority action is required (1-3)	High priority action is required (4-6)	Urgent priority action is required (7-9)	No action is required (0)	
Al Tdamon	n	5	18	9	2	34
	%	2.0%	8.6%	23.1%	4.1%	6.3%
Bau	n	22	13	6	3	44
	%	8.9%	6.2%	15.4%	6.1%	8.1%
Eldamazin	n	75	42	2	2	121
	%	30.5%	20.1%	5.1%	4.1%	22.3%
Elkurmuk	n	45	13	3	29	90
	%	18.3%	6.2%	7.7%	59.2%	16.6%
Elrosieris	n	26	84	17	5	132

	%	10.6%	40.2%	43.6%	10.2%	24.3%
Giesan	n	35	36	0	3	74
	%	14.2%	17.2%	.0%	6.1%	13.6%
Wad almahi	n	38	3	2	5	48
	%	15.4%	1.4%	5.1%	10.2%	8.8%
Total	n	246	209	39	49	543
	%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**45.3**	**38.5**	**7.2**	**9.0**	

$\chi 2$=206.5; df=18; P-value =.000 (Significant)

Table 6. Water sources classification according to risk analysis in Blue Nile State

Locality		Risk analysis					Total
		H.A.P	L.A.P	N.A.R	U.A	NA	
Al Tdamon	n	18	5	2	9	0	34
	%	8.7%	2.1%	4.0%	20.5%	.0%	6.3%
Bau	n	17	16	3	8	0	44
	%	8.2%	6.7%	6.0%	18.2%	.0%	8.1%
Eldamazin	n	42	75	2	2	0	121
	%	20.2%	31.3%	4.0%	4.5%	.0%	22.3%
Elkurmuk	n	16	43	28	3	0	90
	%	7.7%	17.9%	56.0%	6.8%	.0%	16.6%
Elrosieris	n	79	27	6	20	0	132
	%	38.0%	11.3%	12.0%	45.5%	.0%	24.3%
Giesan	n	34	37	3	0	0	74
	%	16.3%	15.4%	6.0%	.0%	.0%	13.6%
Wad almahi	n	2	37	6	2	1	48
	%	1.0%	15.4%	12.0%	4.5%	100.0%	8.8%
Total	n	208	240	50	44	1	543
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**38.3**	**44.2**	**9.2**	**8.1**	**0.2**	

$\chi 2$=203.9; df=24; P-value =.000 (Significant)

Water sources physical parameters:

Table 7. Water source turbidity range in Blue Nile State

Locality		Turbidity range					Total
		0-5 NTU	6-9.9 NTU	10-19.9 NTU	20-29.9 NTU	30 NTU and above	
Al Tdamon	N	9	2	2	0	21	34

	%	4.3%	1.5%	1.3%	.0%	55.3%	6.3%
Bau	N	35	1	8	0	0	44
	%	16.8%	.7%	5.3%	.0%	.0%	8.1%
Eldamazin	N	44	51	17	6	3	121
	%	21.2%	37.8%	11.3%	50.0%	7.9%	22.3%
Elkurmuk	N	16	34	34	4	2	90
	%	7.7%	25.2%	22.7%	33.3%	5.3%	16.6%
Elrosieris	n	10	36	77	2	7	132
	%	4.8%	26.7%	51.3%	16.7%	18.4%	24.3%
Giesan	n	65	3	3	0	3	74
	%	31.3%	2.2%	2.0%	.0%	7.9%	13.6%
Wad almahi	n	29	8	9	0	2	48
	%	13.9%	5.9%	6.0%	.0%	5.3%	8.8%
Total	n	208	135	150	12	38	543
	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**38.3**	**24.9**	**27.6**	**2.2**	**7.0**	

$\chi 2$=414.0; df=24; P-value =.000 (Significant)

Note: Turbidity standard is (5 NTU) However up to 9.9 is acceptable in rainy season

Table 8. Water source turbidity acceptability in Blue Nile State

Locality		Turbidity status		Total
		Acceptable	Not acceptable	
Al Tdamon	n	11	23	34
	%	3.2%	11.5%	6.3%
Bau	n	36	8	44
	%	10.5%	4.0%	8.1%
Eldamazin	n	95	26	121
	%	27.7%	13.0%	22.3%
Elkurmuk	n	50	40	90
	%	14.6%	20.0%	16.6%
Elrosieris	n	46	86	132
	%	13.4%	43.0%	24.3%
Giesan	n	68	6	74
	%	19.8%	3.0%	13.6%
Wad almahi	n	37	11	48
	%	10.8%	5.5%	8.8%
Total	n	343	200	543
	%	100.0%	100.0%	100.0%
Overall (%)		**63.2**	**36.8**	

$\chi 2$=110.7; df=6; P-value =.000 (Significant)

Table 9. Water source pH range in Blue Nile State

Locality		pH range				
		0-6.5	6.6-7.5	7.6-8.5	>8.5	Total
Al Tdamon	n	2	3	20	9	34
	%	7.4%	.9%	12.6%	42.9%	6.3%
Bau	n	0	24	16	4	44
	%	.0%	7.1%	10.1%	19.0%	8.1%
Eldamazin	n	8	75	35	3	121
	%	29.6%	22.3%	22.0%	14.3%	22.3%
Elkurmuk	n	4	55	28	3	90
	%	14.8%	16.4%	17.6%	14.3%	16.6%
Elrosieris	n	3	82	45	2	132
	%	11.1%	24.4%	28.3%	9.5%	24.3%
Giesan	n	8	61	5	0	74
	%	29.6%	18.2%	3.1%	.0%	13.6%
Wad almahi	n	2	36	10	0	48
	%	7.4%	10.7%	6.3%	.0%	8.8%
Total	n	27	336	159	21	543
	%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**5.0**	**61.9**	**29.3**	**3.9**	

$\chi 2$=113.6; df=18; P-value =.000 (Significant)

Note: Accepted pH Range is: (6.5 up 8.5)

Table 10. Water source pH acceptability in Blue Nile State

Locality		pH status		
		Acceptable	Not acceptable	Total
Al Tdamon	N	25	9	34
	%	4.8%	42.9%	6.3%
Bau	N	40	4	44
	%	7.7%	19.0%	8.1%
Eldamazin	N	118	3	121
	%	22.6%	14.3%	22.3%
Elkurmuk	N	87	3	90
	%	16.7%	14.3%	16.6%
Elrosieris	N	130	2	132
	%	24.9%	9.5%	24.3%
Giesan	N	74	0	74
	%	14.2%	.0%	13.6%
Wad almahi	N	48	0	48
	%	9.2%	.0%	8.8%
Total	N	522	21	543
	%	100.0%	100.0%	100.0%

Overall (%)	**96.1**	**3.9**

$\chi 2$=57.5; df=6; P-value =.000 (Significant)

Table 11. Water source TDS range in Blue Nile State

Locality		TDS range 0- 1001 mg	1002-2001 mg	> 3002 mg	Total
Al Tdamon	n	31	3	0	34
	%	6.1%	10.0%	.0%	6.3%
Bau	n	26	17	1	44
	%	5.1%	56.7%	25.0%	8.1%
Eldamazin	n	117	3	1	121
	%	23.0%	10.0%	25.0%	22.3%
Elkurmuk	n	89	1	0	90
	%	17.5%	3.3%	.0%	16.6%
Elrosieris	n	129	2	1	132
	%	25.3%	6.7%	25.0%	24.3%
Giesan	n	72	1	1	74
	%	14.1%	3.3%	25.0%	13.6%
Wad almahi	n	45	3	0	48
	%	8.8%	10.0%	.0%	8.8%
Total	n	509	30	4	543
	%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**93.7**	**5.5**	**0.7**	

$\chi 2$=108.8; df=12; P-value =.000 (Significant)

Note: TDS Maximum permissible level is: > 1001 mg/L

Table 12. Water source TDS acceptability in Blue Nile State

Locality		TDS status		Total
		Acceptable	Not acceptable	
Al Tdamon	n	31	3	34
	%	6.1%	9.1%	6.3%
Bau	n	26	18	44
	%	5.1%	54.5%	8.1%
Eldamazin	n	117	4	121
	%	22.9%	12.1%	22.3%
Elkurmuk	n	89	1	90
	%	17.5%	3.0%	16.6%
Elrosieris	n	129	3	132
	%	25.3%	9.1%	24.3%
Giesan	n	72	2	74
	%	14.1%	6.1%	13.6%

Wad almahi	n	46	2	48
	%	9.0%	6.1%	8.8%
Total	n	510	33	543
	%	100.0%	100.0%	100.0%
Overall (%)		**93.9**	**6.1**	

$\chi 2$=104.6; df=6; P-value =.000 (Significant)

Table 13. Water source EC range in Blue Nile State

Locality		EC range		
		0-400 µS/cm	> 400 µS/cm	Total
Al Tdamon	n	15	19	34
	%	15.3%	4.3%	6.3%
Bau	n	22	22	44
	%	22.4%	4.9%	8.1%
Eldamazin	n	22	99	121
	%	22.4%	22.2%	22.3%
Elkurmuk	n	2	88	90
	%	2.0%	19.8%	16.6%
Elrosieris	n	9	123	132
	%	9.2%	27.6%	24.3%
Giesan	n	1	73	74
	%	1.0%	16.4%	13.6%
Wad almahi	n	27	21	48
	%	27.6%	4.7%	8.8%
Total	n	98	445	543
	%	100.0%	100.0%	100.0%
Overall (%)		**18.0**	**82.0**	

$\chi 2$=133.8; df=6; P-value =.000 (Significant)

Note: EC Maximum permissible level is 400 µS/cm

Table 14. Water source EC acceptability in Blue Nile State

Locality		EC status		Total
		Acceptable	Not acceptable	
Al Tdamon	n	15	19	34
	%	14.7%	4.3%	6.3%
Bau	n	24	20	44
	%	23.5%	4.5%	8.1%
Eldamazin	n	22	99	121
	%	21.6%	22.4%	22.3%
Elkurmuk	n	2	88	90
	%	2.0%	20.0%	16.6%

Elrosieris	n	9	123	132
	%	8.8%	27.9%	24.3%
Giesan	n	1	73	74
	%	1.0%	16.6%	13.6%
Wad almahi	n	29	19	48
	%	28.4%	4.3%	8.8%
Total	n	102	441	543
	%	100.0%	100.0%	100.0%
Overall (%)		**18.8**	**81.2**	

$\chi 2$=149.1; df=6; P-value =.000 (Significant)

Water source chemical parameters:

Table 15. Water source F (Flour) range in Blue Nile State

Locality		F Range		Total
		0-2 mg	> 2 mg	
Al Tdamon	n	32	2	34
	%	5.9%	50.0%	6.3%
Bau	n	44	0	44
	%	8.2%	.0%	8.1%
Eldamazin	n	121	0	121
	%	22.4%	.0%	22.3%
Elkurmuk	n	88	2	90
	%	16.3%	50.0%	16.6%
Elrosieris	n	132	0	132
	%	24.5%	.0%	24.3%
Giesan	n	74	0	74
	%	13.7%	.0%	13.6%
Wad almahi	n	48	0	48
	%	8.9%	.0%	8.8%
Total	n	539	4	543
	%	100.0%	100.0%	100.0%
Overall (%)		**99.3**	**0.7**	

$\chi 2$=18.1; df=6; P-value =.006 (Significant)

Table 16. Water source F (Flour) acceptability in Blue Nile State

Locality		F status		Total
		Acceptable	Not acceptable	
Al Tdamon	N	32	2	34
	%	5.9%	66.7%	6.3%
Bau	N	44	0	44
	%	8.1%	.0%	8.1%
Eldamazin	N	121	0	121
	%	22.4%	.0%	22.3%
Elkurmuk	N	89	1	90
	%	16.5%	33.3%	16.6%
Elrosieris	N	132	0	132
	%	24.4%	.0%	24.3%
Giesan	N	74	0	74
	%	13.7%	.0%	13.6%
Wad almahi	N	48	0	48
	%	8.9%	.0%	8.8%
Total	N	540	3	543
	%	100.0%	100.0%	100.0%
Overall (%)		**99.3**	**0.7**	

$\chi 2=20.4$; df=6; P-value =.006 (Significant)

Table 17. Water source NO_3 range in Blue Nile State

Locality		No_3 Range		Total
		0-51	101-151	
Al Tdamon	n	33	1	34
	%	6.1%	50.0%	6.3%
Bau	n	44	0	44
	%	8.1%	.0%	8.1%
Eldamazin	n	121	0	121
	%	22.4%	.0%	22.3%
Elkurmuk	n	90	0	90
	%	16.6%	.0%	16.6%
Elrosieris	n	132	0	132
	%	24.4%	.0%	24.3%
Giesan	n	74	0	74
	%	13.7%	.0%	13.6%
Wad almahi	n	47	1	48
	%	8.7%	50.0%	8.8%
Total	n	541	2	543
	%	100.0%	100.0%	100.0%
Overall (%)		**99.6**	**0.4**	

$\chi 2$=11.7; df=6; P-value =.069 (Not significant)

Note: NO_3: Maximum permissible level is > 51 mg/L

Table 18. Water source NO_3 acceptability in Blue Nile State

Locality		NO_3 status		
		Acceptable	Not acceptable	Total
Al Tdamon	n	33	1	34
	%	6.1%	50.0%	6.3%
Bau	n	44	0	44
	%	8.1%	.0%	8.1%
Eldamazin	n	121	0	121
	%	22.4%	.0%	22.3%
Elkurmuk	n	90	0	90
	%	16.6%	.0%	16.6%
Elrosieris	n	132	0	132
	%	24.4%	.0%	24.3%
Giesan	n	74	0	74
	%	13.7%	.0%	13.6%
Wad almahi	n	47	1	48
	%	8.7%	50.0%	8.8%
Total	n	541	2	543
	%	100.0%	100.0%	100.0%
Overall (%)		**99.6**	**0.4**	

$\chi 2$=11.7; df=6; P-value =.069 (Not significant)

Table 19. Water source Fe range in Blue Nile State

Locality		Fe range				Total
		0-0.4	0.5-0.9	1.0	>1.0	
Al Tdamon	n	11	14	5	4	34
	%	4.4%	5.6%	25.0%	19.0%	6.3%
Bau	n	27	16	0	1	44
	%	10.8%	6.3%	.0%	4.8%	8.1%
Eldamazin	n	47	68	5	0	120
	%	18.9%	27.0%	25.0%	.0%	22.1%
Elkurmuk	n	46	34	4	6	90
	%	18.5%	13.5%	20.0%	28.6%	16.6%
Elrosieris	n	37	89	5	1	132
	%	14.9%	35.3%	25.0%	4.8%	24.4%
Giesan	n	49	15	1	9	74
	%	19.7%	6.0%	5.0%	42.9%	13.7%
Wad almahi	n	32	16	0	0	48
	%	12.9%	6.3%	.0%	.0%	8.9%
Total	n	249	252	20	21	542
	%	100.0%	100.0%	100.0%	100.0%	100.0%
Overall (%)		**45.9**	**46.5**	**3.7**	**3.9**	

$\chi 2=102.6$; df=18; P-value =.000 (Significant)

Note: Fe maximum permissible level is: > 0.4 mg/L

Table 20. Water source Fe acceptability in Blue Nile State

Locality		Fe status		Total
		Acceptable	Not acceptable	
Al Tdamon	n	8	26	34
	%	3.3%	8.7%	6.3%
Bau	n	27	17	44
	%	11.0%	5.7%	8.1%
Eldamazin	n	46	75	121
	%	18.8%	25.2%	22.3%
Elkurmuk	n	46	44	90
	%	18.8%	14.8%	16.6%
Elrosieris	n	37	95	132
	%	15.1%	31.9%	24.3%
Giesan	n	49	25	74
	%	20.0%	8.4%	13.6%
Wad almahi	n	32	16	48
	%	13.1%	5.4%	8.8%
Total	n	245	298	543

%	100.0%	100.0%	100.0%
Overall (%)	**45.1**	**54.9**	

$\chi 2$=52.7; df=6; P-value =.000 (Significant)

Table 21. Mean ± (SE) of water samples physical parameters in Blue Nile State

Locality		Turbidity	pH	TDS	EC	P-value
Al Tdamon	Mean	161.0	7.8	510.5	616.9	.000
	SE	29.7	.29	60.9	109.4	
Bau	Mean	2.1	7.567	951.248	616.9	.000
	SE	.59	.09	77.79	92.8	
Eldamazin	Mean	8.2	7.2	494.5	748.824	.000
	SE	.78	.06	36.5	46.2	
Elkurmuk	Mean	9.7	7.23	646.7	1277.6	.000
	SE	.6224	.1081	17.9	40.8	
Elrosieris	Mean	19.8	7.3	636.7	1185.404	.000
	SE	7.14	.08	16.07	40.07	
Giesan	Mean	7.2	6.9	607.4	919.9	.000
	SE	2.93	.09	79.5	35.2	
Wad almahi	Mean	33.8	7.2	355.6	509.7	.000
	SE	22.9	.07	61.3	48.7	
Total	Mean	**22.6**	**7.3**	**595.4**	**925.8**	.000
	SE	**3.6**	**.04**	**17.9**	**22.8**	

Table 22. Mean ± (SE) of water samples chemical parameters in Blue Nile State

Locality		F	NO_3	Fe	P-value
Al Tdamon	Mean	30.5	121.23	156.7	.000
	SE	26.4	119.18	153.1	
Bau	Mean	.74	41.8	.34	.000
	SE	.07	39.9	.07	
Eldamazin	Mean	.62	2.22	.49	.000
	SE	.04	.09	.02	
Elkurmuk	Mean	1.9	1.7	.62	.000
	SE	1.1	.13	.08	
Elrosieris	Mean	1.1	1.7	.62	.000
	SE	.03	.05	.02	
Giesan	Mean	.96	3.4	.42	.000
	SE	.04	.09	.06	
Wad almahi	Mean	1.10	12.8	.52	.000
	SE	.045	9.3	.15	
Total	Mean	**2.90**	**13.6**	**10.3**	.000
	SE	**1.64**	**8.0**	**9.6**	

Discussion:

Safe drinking water is a basic need for good health, and it is also a basic right of humans. Fresh water is already a limiting resource in many parts of the world. In the next century, it will become even more limiting due to increased population, urbanization, and climate change (10).

This study aimed to assess the water sources and identify the risks of water sources in Blue Nile State. This study showed that the majority of water sources type in Blue Nile State was significantly H.P (69.6%), storage tanks (18.4%), 2.4% O.H.D.W, surface water 4.2%, water tap 0.2%, water stations 3.1% and Jamam 2%.

Most of water sources were significantly managed by government 47.7%, 32.8% were managed by community, 19% managed by organizations and only 0.6% was managed by private.

Comparable study in South Africa showed that many communities have access to treated water supplied by the government. However, the water is more likely to be piped into individual households in the urban than rural areas. In many rural communities, the water is provided through the street taps and residents have to collect from those taps and transport the water to their households (11).

The study proved that level of E.Coli/100 ml significantly in Group (0) was 64.1% and in group B was 28.4%, group C 6.1%, group D 0.6% and group E was 0.9%. However the acceptability of

water sources among 543 samples taken the acceptable level of E.Coli/100 ml in 501 (92.3%) samples. The water sources classification according to sanitary inspection scores shows that 45.3% of the samples were Low priority action is required, high priority action is required (38.5%), urgent priority action is required (7.2%), and no action is required (9%). In addition the water sources classification according to risk analysis indicates 38.3% of water sources were group as H.P.A (High Action Priority , L.A.P (Low Action Priority) 44.2%, N.A.R (No Action Required) 9.2%, UA (Urgent Action) 8.1% and 0.2% Not Applicable (NA).'

The total coliform group has been selected as the primary indicator bacteria for the presence of disease causing organisms in drinking water. It is a primary indicator of suitability of water for consumption. If large numbers of coliforms are found in water, there is a high probability that other pathogenic bacteria or organisms exist. The WHO and Ethiopian drinking water guidelines require the absence of total coliform in public drinking water supplies. This finding in line with WHO (12) risk associated in Wondo Genet campus drinking water is low risk (1–10 count/100 ml).

Moreover the study indicated that 38.3% of the sample their turbidity level was ranged between 0-5 NTU, 24.9% was ranged between 6-9.9 NTU, 27.6% was ranged between 10-19.9 NTU , 2.2% ranged between 20-29.9 NTU and 7% was 30 NTU and above. The acceptable level of turbidity was found among 343 (63.2%) samples. The turbidity of water depends on the quantity of solid matter present in the suspended state. It is a measure of light emitting properties of water and the test is used to indicate the quality of waste discharge with respect to colloidal matter. The mean value of turbidity was 22.6 NTU. In contrast study showed that the mean turbidity value obtained for Wondo Genet Campus (0.98 NTU) is lower than the WHO recommended value of 5.00 NTU (10).

Water source pH between 0-6.5 was 5%, 6.6-7.5 was 61.9%, 7.6-8.5% was 29.3% and more than8.5 was 3.9 %. The mean pH in the study was 7.3. The acceptable pH was found among 522 (96.1%) samples. Present investigation was similar with reports made by other researchers' study (13; 14).

The TDS level between 0-101 mg was 93.7%, 1002-2001 mg was 5.5% and more than 3002 mg was 0.7%. The TDS acceptability samples were 510 (93.9%).

Water has the ability to dissolve a wide range of inorganic and some organic minerals or salts such as potassium, calcium, sodium, bicarbonates, chlorides, magnesium, sulfates etc. These minerals produced un-wanted taste and diluted color in appearance of water. This is the important parameter for the use of water. The water with high TDS value indicates that water is

highly mineralized. Desirable limit for TDS is 500 mg/l and maximum limit is 1000 mg/l which prescribed for drinking purpose. In our study the mean TDS was 17.9mg/l. Similar value was reported by Soylak *et al*. (15), drinking water of turkey. High values of TDS in ground water are generally not harmful to human beings, but high concentration of these may affect persons who are suffering from kidney and heart diseases. Water containing high solid may cause laxative or constipation effects according to Sasikaran *et al*. (16).

The study proved that the Water source EC range between 0-400 µS/cm was18% and more than 400 µS/cm was 82%. The acceptable EC samples were only 102 (18.8%). Pure water is not a good conductor of electric current rather's a good insulator. The mean value of EC in the study was22.8µS/cm. Increase in ions concentration enhances the electrical conductivity of water. Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not exceeded 400 µS/cm. Similar value was reported by Soylak *et al*. (15) drinking water of turkey. These results clearly indicate that water in the study area was not considerably ionized and has the lower level of ionic concentration activity due to small dissolve solids. The flour in the study area range between 0-2 mg was 99.3% and more than 2 mg was 0.7%. The acceptable samples for flour were 540 (99.3%). The mean Flour concentration in the study was 2.90 mg/l .This value was lower than recommended by WHO standard. This study indicated that the range of No_3 between 0-51 mg was 99.6% and between 101-151 mg was 0.4%. The acceptable samples of No_3 were 541 (99.6%). The mean value of nitrate in the study was 13.6 mg/l. Nitrate one of the most important diseases causing parameters of water quality particularly blue baby syndrome in infants. The sources of nitrate are nitrogen cycle, industrial waste, nitrogenous fertilizers etc. The WHO allows maximum permissible limit of nitrate 51 mg/l in drinking water. These results indicate that the quantity of nitrate in the study site is acceptable which matched that in Wondo Genet campus (11). The Fe range between 0-0.4 mg was 45.9%, between 0.5-0.9 mg was 46.5%, 1 mg was 3.7% and more than 1mg was 3.9%. The acceptable samples for Fe were 245 (45.1%). The mean value of Fe value in the study was 10.3 mg/l. The concentration of trace metals (Fe) present in water samples was higher than recommended by WHO.

Conclusions:

On the basis of findings, it was concluded that drinking water of the Blue Nile State was that all physico–chemical parameters in all the sources of drinking water sampling sites, and they were consistent with World Health Organization standard for drinking water (WHO). The samples

were analyzed for intended water quality parameters following internationally recognized and well established analytical techniques.

It is evident that all the values of nitrate (No_3), Flour (F) fall under the permissible limit but increased of Fe level. Water turbidity showed extreme variations in the concentrations. In addition, bacteriological determination of water from sources of drinking water sources was carried out to be sure if the water was safe for drinking and other domestic application. The study revealed that all the sources of water sampling sites were not contained fecal coliforms.

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Abbreviations:

Abbreviation	Meaning
E.Coli	Escherichia Coli
EC	Electrical Conductivity
F	Flour
H.P	Hafier Pond
H.P.A	High Priority Action
L.A.P	Low Action Required
N.A.R	No Action Required
NA	Not Applicable
O.H.D.W	Open Hole Dug Well
SPSS	Statistical Programme for Social Science
TDS	Total Dissolved Solids
UA	Urgent Action

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