

Research Article

Evaluation of Physico-Chemical Parameters of Drinking Water Quality in Magburaka Town, Tonkolili District, Sierra Leone

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Abstract

This study evaluates the physico-chemical quality of drinking water from various sources in Magburaka Town, Tonkolili District, Sierra Leone, to identify potential health risks associated with water consumption. Water samples were collected from five sources, including hand-dug wells, taps, and streams, during a three-month period encompassing the dry and wet seasons. The samples were analyzed for key parameters such as pH, temperature, turbidity, dissolved oxygen, and concentrations of heavy metals and other chemical contaminants. The results highlighted variations in water quality across different sources, with some samples exhibiting parameters outside the acceptable limits set by WHO guidelines. Specifically, concerns were noted regarding elevated levels of heavy metals like lead and zinc, which pose health risks upon prolonged exposure. The study emphasizes the impact of local environmental factors, such as mining activities and agricultural runoff, on water quality. Additionally, the research underscores the importance of adequate water treatment and proper sanitation practices to mitigate health risks associated with contaminated water. The findings advocate for improved water management policies, routine monitoring, and community education on water safety. This research contributes valuable data to inform interventions aimed at enhancing water quality and safeguarding public health in Sierra Leone, particularly in rural and semi-urban settings where reliance on untreated water sources remains high. Overall, the study underscores the critical need for sustainable water resource management and infrastructure development to address waterborne health hazards in the region, the research therefore recommends that further researchers should embark on a comparative study on the correlation and a clear cut of laboratory analysis on drinking water quality in other cities and its associated diseases.

Keywords

Hand Dug, River, Tap, Well, Treatment, WHO, Physico-chemical Parameters

1. Introduction

Getting clean, safe, and pure drinking water is one of the top objectives for people in developing nations. Most rural residents in Asia and Africa rely on surface and ground

water for their drinking needs. According to the World Health Organization [16], 58% of the 159 million people who were still gathering drinking water directly from surface

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water lived in sub-Saharan Africa, and 1 in 3 people still lack access to safe drinking water [8]. In 2015, 844 million people, or just 10% of the world's population, still lacked access to basic drinking water services [13], and only 71% were using safely managed drinking water. Additionally, it is projected that 1.2 billion people worldwide do not have access to adequate or readily available safe water. A rise in both human and animal populations may be the cause of this [4]. Our organs require water to function normally and to maintain the water balance in our bodies, making it an essential nutrient [6]. Water makes up 60% of an adult human being's bodily weight on average. The World Health Organization and regulators typically use the average adult water intake of two liters per day to calculate drinking water guidelines and WHO standards [15]. The purpose of this study was to use physico-chemical parameters to evaluate the water quality in the Tonkolili district of the water samples that were obtained in the northern region of Sierra Leone.

On Africa's west coast is the tiny, tropical nation of Sierra Leone. Seven rivers are among the many water resources that Sierra Leone possesses. In addition to monitoring the treatment practices of the hand-dug well, tap water, and the chosen river in the two districts, this study evaluates the physical and chemical characteristics of the water. The six-month wet season in Sierra Leone is marked by intense rains and 90% humidity. There are significant groundwater resources in Sierra Leone as well. Water is, however, limited throughout the dry season; only 11–17% of the yearly river discharge takes place between December and April, with April seeing the lowest discharge. It is particularly difficult for Sierra Leone to supply its people with safe drinking water in the months of March and April. According to 2019 research by the Centers for Disease Control and Prevention, 98% of Sierra Leoneans lack access to clean drinking water, which leads to a lack of basic sanitation in most families. Three-quarters of the earth's crust is made up of lakes, streams, rivers, and seas. In addition, water is found in the soil beneath the surface of the earth as a huge groundwater reserve and as water vapor in gaseous form. But during the dry season, water is limited: only 11–17% of the yearly river discharge happens between December and April, with April seeing the lowest discharge. Sierra Leone has a difficult time providing its people with clean drinking water, particularly in March and April. 98% of Sierra Leoneans lack access to safe drinking water, and as a result, most families lack basic sanitation, according to 2019 research from the Centers for Disease Control and Prevention. Lakes, streams, rivers, and seas make up three-quarters of the earth's crust. In addition, there is water in the form of water vapor and a huge groundwater reserve in the soil beneath the surface of the planet.

In low-income nations, almost 80% of the population uses water for drinking [7]. Millions of people in developing nations die each year from diarrhea and other water-related illnesses due to inadequate access to water and sanitation,

making it one of the major causes of death globally [14]. Additionally, 30% of amphibians and more than 50% of freshwater fish species are in danger of going extinct due to poor water quality [9]. Fresh water's quality is just as vital as its quantity. In Sierra Leone, poor sanitation and water quality are significant issues in both rural and urban areas. Limited availability to safe drinking water is a defining feature of Sierra Leone's water supply.

Following its independence in 1961 and throughout the International Drinking Water and Sanitation Decade (1981–1990), Sierra Leone's government made significant efforts to expand access to clean drinking water and sanitary facilities [2]. The Guma Valley Water Company provided water and sanitation to the areas of Freetown and the surrounding areas during this time, while the Ministry of Energy and Power's Water Supply Division handled water supply and sanitation outside of Freetown. Many villages in Sierra Leone still lack access to pipe-borne water and proper sanitation despite these efforts. Significant efforts were made by the government of Sierra Leone to increase access to safe drinking water and sanitation facilities after independence in 1961 and during the International Drinking Water and Sanitation Decade (1981–1990) [2]. During these years the Water Supply Division of the Ministry of Energy and Power was responsible for water supply and sanitation outside Freetown, while the Guma Valley Water Company supplied the areas in Freetown and its environments. Despite these efforts, there is still little or no access to pipe borne water and adequate sanitation in many communities in Sierra Leone. For many people in various regions of Sierra Leone, alternative water sources like groundwater and rainfall have taken over as their main supplies of drinking water.

According to the high standards at which water quality refers to the physical, chemical, and biological properties of water. It is most used in reference to a range of standards that can be used to evaluate compliance with water treatment. Water supply is greatly impacted by water quality, which also frequently dictates available supply options [16]. Several parameters, including temperature, chemical concentrations, pH, and nutrient levels, are also included in the term "water quality." Although human activity can result in drastic changes in water quality from which natural settings may not always recover, these levels naturally vary between various freshwater environments. The Local Government Act of 2004 established a new decentralization policy that transferred water supply authority from the federal government to local councils in non-capital locations. The Guma Valley Water Company is still responsible for providing water in Freetown. Thankfully, many internal and external groups are working to improve Sierra Leone's poor water quality.

Water is essential to the proper operation of every cell and organ that makes up our complete anatomy and physiology. This highlights how crucial water is to the regular upkeep of our bodies and the avoidance of illness. According to estimates from the World Health Organization (WHO), water

and sanitation issues account for up to 80% of health issues in underdeveloped nations. Additionally, eight glasses of water a day can cut the incidence of bladder cancer by 50%, colon cancer by 45%, and possibly even breast cancer [17]. People in poor nations like Sierra Leone are facing severe health issues because of the insufficient supply of safe and clean drinking water and the frequent contamination of the supplies that are already available. According to WHO/UNICEF [15] report, one of the largest percentages of people in sub-Saharan Africa lack access to clean water and sanitation. Therefore, the research is aimed at evaluating the physico-chemical parameters of drinking water quality in the Magburaka township.

2. Data and Methodology

2.1. Study Area

The capital and major city of Tonkolili District in Sierra Leone's Northern Province is Magburaka. According to the

Republic of Sierra Leone Census [10], its population was 16,313; as of right now, that number is estimated to be 40,313. It is situated along the Rokel River at around 8°43'1 N 11°56'36 W. Magburaka is located roughly 80 miles (135 km) east of Freetown, the capital of Northern Sierra Leone, and just 26 miles (42 km) southwest of Makeni, the region's economic hub. The dry season in Magburaka is hot, muggy, and partially cloudy, whereas the wet season is warm, oppressive, and overcast. The average annual temperature fluctuates between 660 °F and 980 °F, and it is rarely lower than 600 °F. The average temperature is above 1030 °F. The hot season, which lasts from February to April for two and a half months, has daily highs that average more than 950 degrees Fahrenheit. April is the hottest month of the year in Magburaka, with highs of 950 °F and lows of 760 °F on average. With an average daily high temperature below 850F, the cool season lasts for 4.1 months, from June 26 to October 28. August is the coldest month of the year, with an average low temperature of 720F and a high temperature of 820F [12].



Figure 1. Map of Sierra Leone showing Tonkolili district (Source: author, 2024).

2.2. Sampling Area

Five water samples were taken in Magburaka, Tonkolili

District, from a hand-dug water well and a hand-pumped well upstream, middle stream, and downstream. These sources were chosen because they are frequently used for household or agricultural purposes. The stream was chosen because it is

the site of several mining operations and there is an agro-based industry a short distance from the stream [5].

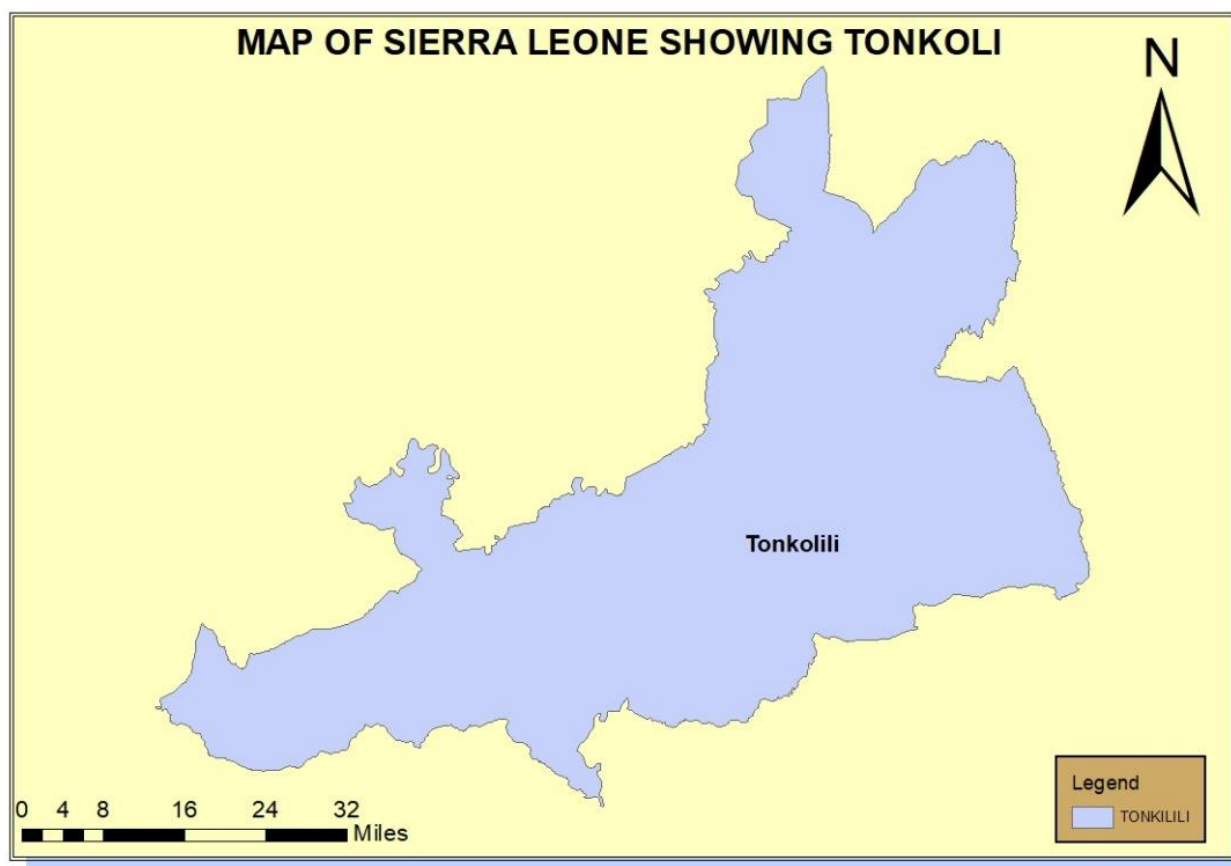


Figure 2. Map of the study area (Source: Author, 2024).

2.3. Sampling

Five (5) distinct samples were used in the investigation, which was conducted at five separate sources in the Magburaka Tonkolili District: the upper, middle, and lower streams as well as a hand-dug well and a tap well. All water samples were gathered in polyethylene bottles throughout the morning sampling period. In order to take a sample of stream water, a closed bottle was submerged in the water to a specific depth, and then it was opened inside and closed again to bring it to the surface. To create an integrated sample, the samples were gathered from three distinct locations and combined. The bottle was set beneath the tap to take a sample of tap water, and the tap was then opened to fill it. Numerous physical and chemical interactions would alter the water sample's quality between the time of collection and the actual analysis; consequently, the sample was kept as quickly as possible to reduce this change. Chemical preservatives were added, and the temperature was lowered, to preserve the water samples. While the evaluations of the other characteristics were carried out in the laboratory, the water's taste, color, and odor were assessed on the spot following collection. For three

months, from September 2022 to November 2022, the study was conducted; after being brought to the lab, the obtained water samples were subjected to pertinent laboratory analysis.

2.4. Samples Collection and Analysis

To prevent contamination and the effects of light and temperature, samples were collected in the field by trained researchers using a 500ml sterilized sample bottle. The containers were rinsed three times with the samples to prevent contamination, and the sample bottles were sealed and kept in a dark environment at a constant temperature range of 5-150 C. After that, the water samples were brought to the laboratory (Directorate of Water Resources, within the district's Ministry of Water Resources). Within six hours of the samples being taken, all tests were completed by a qualified technician in a designated space with ideal circumstances for assessing the quality of the water.

At the site of sample collection, temperature, pH, conductivity, and turbidity measurements were made on-site using a variety of calibrated standard instruments in compliance with the recommended protocols and methods of the American Public Health Organization [1] and American Society for

Testing and Materials (ASTM) [3]. This was accomplished by inserting a digital thermometer into a sample of water and turning on the electrode. They checked the temperature. In degrees Celsius, duplicate readings were taken.

The pH of the water samples was measured using a digital pH meter, which was first calibrated (verified) to make sure it was in good working order. After pouring about 10 mL of water sample into a clean glass beaker and inserting the probe, the pH meter's selector was turned on, and the pH value was read and recorded instantly. The process was repeated twice for all other samples, and before each experiment, the probe was rinsed with distilled water.

The laboratory's digital conductivity meter was used to measure conductivity. To calibrate the meter, the temperature knob was first set to 25 oC. Then, by rotating the screw on the back of the device, the function knob was twisted to verify and set the display value to 1.00. After dipping the probe into a 0.1 M potassium chloride (KCl) solution, the cell constant knob was used to set the reading to 1.408. After that, the function knob was turned to conduct, and the value that was shown was noted. A clean beaker was filled with 10 milliliters of each sample. One by one, the probe was dipped into each sample. Following its removal from one sample, it was properly cleaned with distilled water and wiped with a tissue before being dipped into another sample. The conductivity value is the fixed or stable value that has been shown on the screen. To guarantee precision and uniformity, the procedure was carried out three times for every sample.

Using a Nephelometer turbidity unit (NTU) and the HACH 2100Q turbidimeter, turbidity was measured in the lab. First, standards like 20, 60, 80, 100, and 10 (verification standards) were used to calibrate the device. Following calibration, each sample is shaken multiple times before a portion is placed into its designated clean oiled turbidity vial. After being filled to the white line, the turbidity vial was carefully inverted multiple times before being put inside the turbidimeter. After 60 seconds, the last readings were taken, and the average was calculated. To guarantee precision and uniformity, this pro-

cedure was carried out three times.

2.5. Physical and Chemical Laboratory Analysis

The filter method was used to measure TDS in water samples in compliance with the suggested standards of Sawyer [11] and APHA [1]. The scientific literature has acknowledged and cited the processes below for their accuracy and precision. Prior to starting the vacuum filtration process, a specific volume of the water sample was put into a pre-weighed glass fiber filter with a predetermined pore size. After measuring the TDS of the water samples using the gravimetric method, the filtrate of the TDS was heated to above 1000 C in an oven until all of the water had evaporated. The residual mass of the residue indicates how much TDS is present in a sample.

Chemicals and heavy metals such NO₂, NO₃, PO₄, NH₃, Cu, Zn, Fe, and Cd were analyzed using the WAGTECH PHOTOMETER, 7100, to examine their chemical characteristics. Prior to the analysis, the operational handbook was consulted. A blank solution (reference, 0.00 mg/L) was first made to calibrate the photometer. A single chemical tablet was placed in a test tube containing ten milliliters of water, crushed, and combined to form a homogenous mixture. The tablet was then allowed to stand for ten minutes to fully color. After inserting the cell holder, the lid was closed. Each sample's concentration was measured in milligrams per liter after the photometer was set to the correct wavelength and powered on.

3. Results

The physical and chemical parameter data from five distinct sites; hand-dug wells, tap water, upstream, middle stream, and downstream stream water in Magburaka Town, Tonkolili District; are shown in Tables 1 through 4. The findings are displayed using the statistical techniques (mean, variance, and standard deviation) listed below.

Table 1. Samples from Magburaka, Tonkolili District for the month of September.

Parameters	Samples					Mean ($\bar{x}$)	Stdev.S (σ^2)	Var.S (σ)	WHO
	Up stream	Middle Stream	Down Stream	Hand Dug Well	Tap Wa- ter				
Water Temperature (°C)	25.70	25.33	25.30	24.73	24.30	25.06	0.55	0.31	-
pH (pH Units)	7.15	6.79	7.04	7.09	7.05	7.02	0.14	0.02	6.5-8.5
Turbidity (NTU)	6.29	5.80	4.82	0.42	4.15	4.30	2.32	5.39	<5.0
TDS (mg/l)	0.00	3.00	0.00	0.00	0.00	0.60	1.34	1.80	500
Dissolved Oxygen (% Sat.)	89.30	88.60	67.30	75.50	85.50	80.27	9.55	91.14	80 - 120%
Salinity (ppt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0

Parameters	Samples					Mean ($\bar{x}$)	Stdev.S (σ^2)	Var.S (σ)	WHO
	Up stream	Middle Stream	Down Stream	Hand Dug Well	Tap Wa- ter				
Electrical Conductivity ($\mu\text{S}/\text{cm}$)	0.00	4.00	0.00	0.00	0.00	0.80	1.79	3.20	300
Nitrate (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<10
R. Chlorine (mg/l)	0.00	0.01	0.03	0.00	0.00	0.01	0.01	0.00	0.3-0.5
Aluminum (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.2
Copper (mg/l)	0.00	0.00	0.00	3.09	11.05	2.83	4.79	22.92	<1.0
Fluoride (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<1.5
Iron (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.3
Arsenic (mg/l)	1.15	0.32	0.00	3.59	11.75	3.36	4.90	23.97	0.01
Cadmium (mg/l)	2.84	2.82	8.41	1.51	4.06	3.34	2.66	7.09	0.01
Lead (mg/l)	2.84	2.82	8.41	1.51	4.06	3.34	2.66	7.09	0.1
Nickel (mg/l)	0.01	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.05
Mercury (mg/l)	1.05	0.55	4.52	11.32	3.39	2.51	4.32	18.67	0.001

Table 2. Samples from Magburaka, Tonkolili District for the month of October.

Parameters	Samples					Mean ($\bar{x}$)	Stdev.S (σ^2)	Var.S (σ)	WHO
	Up stream	Middle Stream	Down Stream	Hand Dug Well	Tap Wa- ter				
Water Temperature (°C)	23.63	23.80	23.80	23.00	23.25	23.49	0.36	0.13	-
pH (pH Units)	6.92	6.98	6.93	4.60	7.02	6.41	1.06	1.12	6.5-8.5
Turbidity (NTU)	4.44	4.07	12.10	6.29	0.35	3.44	4.30	18.47	<5.0
TDS (mg/l)	3.00	0.00	0.00	0.00	0.00	0.60	1.34	1.80	500
Dissolved Oxygen (% Sat.)	90.00	88.20	86.00	88.50	101.10	90.61	5.95	35.45	80 - 120%
Salinity (ppt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Electrical Conductivity ($\mu\text{S}/\text{cm}$)	5.00	0.00	0.00	0.00	4.00	1.80	2.49	6.20	300
Nitrate (mg/l)	0.016	0.012	0.00	0.00	0.017	0.01	0.01	0.00	<10
R. Chlorine (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3-0.5
Aluminum (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.2
Copper (mg/l)	4.34	2.45	2.12	1.68	53.04	12.73	22.56	508.91	<1.0
Fluoride (mg/l)	0.00	0.00	0.00	0.00	0.10	0.02	0.04	0.00	<1.5
Iron (mg/l)	0.00	0.00	0.00	0.02	0.40	0.08	0.18	0.03	<0.3
Arsenic (mg/l)	0.01	0.00	0.66	8.41	0.39	1.89	3.65	13.34	0.01
Cadmium (mg/l)	0.98	107.18	4.05	2.26	1.51	4.29	46.96	2205.51	0.01
Lead (mg/l)	0.98	107.18	4.05	2.26	1.51	4.29	46.96	2205.51	0.10
Nickel (mg/l)	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.05
Mercury (mg/l)	2.83	1.08	0.58	0.64	0.13	0.68	1.05	1.10	0.00

Table 3. Samples from Magburaka, Tonkolili District for the month of November.

Parameters	Samples					Mean ($\bar{x}$)	Stdev.S (σ^2)	Var.S (σ)	WHO
	Up stream	Middle Stream	Down Stream	Hand Dug Well	Tap ter				
Water Temperature (°C)	24.67	24.57	24.55	23.87	23.78	24.28	0.43	0.18	-
pH (pH Units)	7.04	6.89	6.99	5.85	7.04	6.75	0.51	0.26	6.5-8.5
Turbidity (NTU)	5.37	4.94	8.46	3.35	2.25	4.42	2.36	5.58	<5.0
TDS (mg/l)	2.00	0.00	0.00	0.00	0.00	0.40	0.89	0.80	500.00
Dissolved Oxygen (% Sat.)	89.65	88.40	76.65	82.00	93.30	85.79	6.63	43.95	80 - 120%
Salinity (ppt)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical Conductivity (µs/cm)	5.00	0.00	0.00	0.00	3.00	1.60	2.30	5.30	300
Nitrate (mg/l)	0.02	0.01	0.00	0.00	0.02	0.01	0.01	0.00	<10
R. Chlorine (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.3-0.5
Aluminum (mg/l)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	<0.2
Copper (mg/l)	5.44	2.65	3.21	2.68	58.40	5.92	24.58	604.22	<1.0
Fluoride (mg/l)	0.00	0.00	0.00	0.00	0.10	0.02	0.04	0.00	<1.5
Iron (mg/l)	0.00	0.00	0.00	0.01	0.30	0.06	0.13	0.02	<0.3
Arsenic (mg/l)	0.11	0.00	0.12	8.44	0.52	1.84	3.70	13.66	0.01
Cadmium (mg/l)	0.86	105.12	2.03	1.88	1.41	3.45	46.32	2145.76	0.01
Lead (mg/l)	0.87	1.7.14	2.05	1.88	1.41	1.47	0.53	0.28	0.1
Nickel (mg/l)	0.00	0.00	0.00	0.00	0.10	0.02	0.04	0.00	0.05
Mercury (mg/l)	1.83	1.08	0.48	0.46	0.11	0.54	0.68	0.46	0.001

Table 4. Comparison of statistical mean of the physico-chemical parameters data for the three months.

Parameters	The mean of Physiochemical Parameters for each month			WHO Permissible Limits
	September	October	November	
Water Temperature (°C)	25.06	23.49	24.28	-
pH (pH Units)	7.02	6.41	6.75	6.5-8.5
Turbidity (NTU)	1.58	3.44	4.42	<5.0
TDS (mg/l)	0.60	0.60	0.40	500
Dissolved Oxygen (% Sat.)	80.27	90.61	85.79	80 - 120%
Salinity (ppt)	0.00	0.00	0.00	0.00
Electrical Conductivity (µs/cm)	0.80	1.80	1.60	300
Nitrate (mg/l)	0.00	0.01	0.01	<10
R. Chlorine (mg/l)	0.01	0.00	0.00	0.3-0.5
Aluminum (mg/l)	0.00	0.00	0.00	<0.2
Copper (mg/l)	2.83	4.58	5.92	<1.0

Parameters	The mean of Physiochemical Parameters for each month			WHO Permissible Limits
	September	October	November	
Fluoride (mg/l)	0.00	0.02	0.02	<1.5
Iron (mg/l)	0.00	0.08	0.06	<0.3
Arsenic (mg/l)	3.36	1.89	1.84	0.01
Cadmium (mg/l)	3.34	4.29	3.45	0.01
Lead (mg/l)	3.34	4.29	1.47	0.1
Nickel (mg/l)	0.00	0.00	0.02	0.05
Mercury (mg/l)	2.51	0.68	0.54	0.001

4. Discussion

4.1. Physical Parameters

Water Temperature: The temperature of water samples ranged from approximately 23.49 °C to 25.70 °C, aligning closely with typical ambient temperatures and the natural conditions of the region. Slight fluctuations are expected due to environmental factors and the time of sampling. Water temperature influences the solubility and mobility of chemical substances; higher temperatures may facilitate increased microbial activity and chemical reactions, potentially impacting water quality.

pH values across the samples varied from 6.41 to 7.15, predominantly within the WHO permissible range of 6.5 to 8.5. The pH of water influences its corrosivity and interaction with pipe materials, affecting the leaching of metals and other contaminants. Slightly acidic conditions (pH below 7) in some samples could indicate natural acidity or pollution from acidifying agents, which could enhance corrosion and metal leaching, notably affecting heavy metal concentrations. While specific turbidity values are partially discussed, the generally low turbidity readings (e.g., 1.58 NTU in some months) indicate relatively clear water, meeting the WHO limits (<5 NTU). However, higher turbidity readings in other months suggest the presence of suspended particles, likely from runoff, erosion, or inadequate sanitation at the sources. Elevated turbidity hampers disinfection efficiency and can harbor pathogenic microorganisms, posing health risks. The values reported (e.g., 80.27% to 90.61% saturation) fall within acceptable ranges (80-120%). Adequate DO levels are vital for maintaining aquatic ecosystem health and inhibiting microbial growth. Variations observed are influenced by seasonal changes and biological activity, with higher DO during certain periods indicating better water quality.

4.2. Chemical Parameters

Total Dissolved Solids (TDS): TDS levels ranging from 0.40 mg/l to 0.60 mg/l are well below the WHO limit of 500 mg/l, indicating that the water is relatively low in dissolved salts and minerals. Such low TDS typically signifies good quality water without significant mineral buildup, though it may also suggest a lack of mineralization, which could be a natural characteristic of the region's aquifers.

4.3. Heavy Metals and Trace Elements

The concentrations of copper, such as 2.83 mg/l in September and increasing to 5.92 mg/l in November, significantly exceed the WHO permissible limit of 1.0 mg/l. Elevated copper levels may originate from natural mineral deposits, corrosion of household plumbing systems, or mining activities. Excess copper can cause gastrointestinal issues and liver damage upon long-term exposure. The arsenic levels (3.36 mg/l in September, decreasing to approximately 1.84 mg/l) greatly surpass the WHO threshold of 0.01 mg/l. High arsenic concentrations are particularly concerning due to their carcinogenic potential and chronic health effects, including skin lesions and various cancers. The elevated levels are likely attributable to natural mineralization and possibly anthropogenic activities. Observed concentrations of Cadmium (3.34 mg/l to 4.29 mg/l) are markedly above the permissible limit of 0.01 mg/l. Cadmium exposure can lead to kidney damage, skeletal damage, and is classified as a human carcinogen. The source may include mining runoff or industrial discharges. Elevated lead levels (3.34 mg/l to 4.29 mg/l in some months) far exceed the WHO limit of 0.1 mg/l, indicating significant contamination risks. Lead is notorious for neurotoxicity, especially in children, affecting cognitive development and causing severe health impacts. Other Heavy Metals (Nickel, Mercury): The data show nickel at 0.00–0.02 mg/l and mercury at 2.51–0.54 mg/l, with mercury levels in September exceeding the permissible limit of 0.001 mg/l, posing addi-

tional health risks; levels remained below the permissible limit, indicating no immediate concern for fluorosis.

The presence of heavy metals such as arsenic, lead, cadmium, and mercury at elevated levels suggests contamination sources linked to natural mineralization, mining activities, or improper waste disposal. Such contamination poses serious health threats, including arsenic poisoning, neurological damage, kidney disease, and increased cancer risk. The data indicate that a significant proportion of water sources may not be suitable for direct consumption without adequate treatment.

5. Conclusion

Based on the comprehensive analysis of physico-chemical parameters of drinking water sources in Magburaka, Tonkolili District, the study underscores the critical importance of assessing water quality to safeguard public health. The results reveal that while some water sources meet the World Health Organization (WHO) standards for safe drinking water, others exhibit parameters exceeding permissible limits, particularly concerning heavy metals such as lead and zinc. These elevated levels pose serious health risks, including neurological, developmental, and other chronic conditions, emphasizing the urgent need for intervention. The variation in water quality can be largely attributed to environmental factors, such as proximity to mining activities, agricultural runoff, and improper sanitation practices, which significantly influence the chemical composition of surface and groundwater sources. Moreover, seasonal variations impact parameters like turbidity and dissolved oxygen, further complicating water safety management. The findings highlight that reliance on untreated water sources remains a significant challenge for communities, underscoring the necessity for implementing effective water treatment solutions, regular monitoring, and community awareness programs. To mitigate health hazards, it is imperative that local authorities and stakeholders invest in infrastructural improvements, enforce environmental regulations, and promote sustainable water management practices. Additionally, capacity building for local personnel in water quality assessment and treatment is vital. Overall, ensuring access to safe, clean, and potable water requires a coordinated effort that integrates environmental protection, public health policies, and community participation to achieve sustainable water security in Sierra Leone. The physical parameters largely indicate water sources with acceptable clarity and temperature conducive for human use, though some fluctuations highlight the influence of seasonal changes and environmental factors. Conversely, the chemical analysis reveals significant concerns, especially regarding toxic heavy metals that exceed safe limits and threaten public health. The findings underscore the necessity for regular monitoring, implementation of effective water treatment methods, and addressing environmental pollution sources to ensure safe drinking water for the communities in Magburaka. These

measures are vital to prevent waterborne diseases and long-term health complications associated with contaminated water sources. The researcher, therefore, recommends that government should provide funding for research aiming at collecting and organizing data and information on drinking water quality and its associated effects. This can provide Sierra Leone with accurate data on fiscal, economic, social and environmental impacts and Further researchers should embark on a comparative study on the correlation and a clear cut of laboratory analysis on drinking water quality in other cities and its associated diseases.

Abbreviations

Al	Aluminium
APHA	American Public Health Associations
As	Arsenic
ASTM	American Society for Testing and Materials
Cd	Cadmium
CDC	Centers for Disease Control
Cu	Copper
DO	Dissolved Oxygen
F	Fluoride
Fe	Iron
Hg	Mercury
KCl	Potassium Chloride
NH ₃	Ammonia
Ni	Nickel
NO ₂	Nitrogen Dioxide
NO ₃	Nitrate
NTU	Nephelometer turbidity unit
Pb	Lead
pH	Potential of Hydrogen
PO ₄	Phosphates
TDS	Total Dissolved Solid
WHO	World Health Organization
Zn	Zinc

Author Contributions

Sahr Emmanuel Lebbie: Supervision, Validation, Writing – review & editing, Resources, Funding acquisition

Ahmed Wopa Wurie: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Project administration, Resources, Software, Visualization, Writing – original draft

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Conflicts of Interest

There is no conflict of interest regarding the publication of the paper, declared the author.

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Biography



Sahr Emmanuel Lebbie is a renowned Sierra Leonean environmentalist, an articulate and creative person with good organizational and industrial managerial skills, and competent in chemical analysis, quality control, human resource development, and administrative and research work at Njala University, Department of Chemistry. Presently, he is pursuing his PhD in environmental sciences and engineering at Harbin Institute of Technology, China. Mr. Lebbie completed his master's in environmental chemistry from Njala University in 2021 and his bachelor's degree in environmental chemistry from the same university in 2019. In addition, he holds a French Certificate from IMATT College, Freetown, in 2023, and a Generic Research Competency License Supervising Certificate for the Postgraduate Supervision Course, Editorial Assistant and Technical Editing, APA Referencing, and Canons of Research from Njala University in 2024. Recognized for his exceptional skills and academic excellence, he was employed as a lecturer at Njala University and as an associate lecturer in the Health Sciences Department, Central University, Sierra Leone. He has participated in multiple international research collaboration projects recently, and he has published several publications in the field of environmental sciences. His contributions have significantly advanced the understanding of local ecological challenges, and he continues to mentor students, fostering a new generation of researchers.



Ahmed Wopa Wurie is a scholar at the Africa Centre of Excellence for Mycotoxin and Food Safety (ACEMFS), Federal University of Technology, Minna, Niger State, Nigeria. His primary research areas are molecular biology, bioinformatics, gene editing, drug discovery, antimicrobial resistance, environmental chemistry, nanotechnology, biotechnology, artificial intelligence, organic chemistry, and other related biosciences. He is presently pursuing his Master of Science in Molecular Biology and Bioinformatics at the Africa Centre of Excellence for Mycotoxin and Food Safety (ACEMFS), Federal University of Technology, Minna, Niger State, Nigeria: Ongoing. He earned a

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