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Quality Assessment of Drinking Water in Sumve Kwimba District

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ABSTRACT: *The aim of this study was to analyze physical-chemical and bacteriological quality of the drinking water in Sumve ward in Kwimba district (Mwanza). A total of 120 samples from a piped water supply scheme were collected applying EWURA, and TBS TZS 789:2008 procedures. Bacteriological parameters were analyzed using the most probable number method to detect and count the total coliform and Escherichia coli (E. coli). The physicochemical parameters were analyzed using standard methods to examine Total Dissolved Solids (TDS), temperature, electric conductivity, pH iron, manganese, chloride, fluoride, nitrate, ammonia and total hardness. The results were compared against drinking water quality standards laid by World Health Organization (WHO) and Tanzania Bureau of Standard (TBS). The total bacteria count in the water samples ranged from 300CFU/100ml to 4200CFU/100ml which exceeds those recommended by WHO of less than 10 coliform cells/100ml of water and those of TBS of 0/100ml. Water samples found with E.Coli numbers ranged between 10/100ml to 200/100ml which is above the permissible level of 0/100ml specified by WHO and TBS. The physicochemical results of the water samples ranged as follows: pH(8.13 to 8.52), turbidity(0.38 to 1.73NTU), Total Dissolved Solids (371mg/l to379mg/l), electrical conductivity (790 to 820 µs/cm),), temperature(26.9^{0}C to 27.9^{0}C), Nitrate(7.24 to 12.4 mg/l), Ammonium(2.85 to 4.6 mg/L), Manganese(2.4 to 4.9 mg/l), Chloride(13/l to 19.9 mg/l), Fluoride(0.82mg/l to 4.4 mg/l), Iron(0mg/l and 0.08mg/l), and total hardness. The physiochemical parameters were within permissible limits except Manganese, Ammonium and electrical conductivity. The presence of Total Coliform and E. coli indicated fecal matter contamination of the water implying that not safe for human consumption. It was recommended that the water source should be protected from pollution and must be disinfected by chlorine before usage for drinking or human consumption.*

Key words: *Bacteriological, Drinking water quality, physicochemical parameters, Sumve, TBS, WHO,*

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I. INTRODUCTION

Drinking water quality is a relative term that relates the composition of water with effects of natural processes and human activities. Deterioration of drinking water quality arises from introduction of chemical compounds into the water supply system through leaks and cross connection [1]. The quality of drinking-water may be controlled through a combination of protection of water sources, control of treatment processes and management of the distribution and handling of the water [2]. According to [3] drinking-water is only one vehicle for disease transmission. Disease agents such as *Salmonella typhi*, *Vibrio cholerae*, *Giardia lamblia* and hepatitis A virus, are frequently transmitted via contaminated drinking-water and, where this is the case, improvements in drinking-water quality may result in substantial reductions in disease prevalence. A study by [4] described that the suitability of water for various uses depends on the biological and physicochemical properties of water. These parameters are directly connected to the safety of the drinking water to human use. The physiochemical parameters usually do not have an immediate impact on human health. However, some physiochemical parameters are important in giving a guide to the quality of water treated and distributed to the consumers [5]. Pathogens[1] are shown to be present in water in most incidences of water borne disease, either

[1] Pathogens are disease-causing microorganisms such as those causing waterborne diseases such as cholera, gastro enteritis, hepatitis, etc.

due to contamination of the source, no treatment, or to a failure of treatment [6]. According to [7] a quality standard sets the acceptability levels of concentration for pollutants in water to be used for various purposes, e.g., drinking, irrigation, aquaculture, etc.

According to [8] failure to provide effective treatment of water sources and safe distribution can expose the community to the risk of disease outbreaks as well as other adverse health effects. [9] Stated that consumption of contaminated water has resulted into epidemics and loss of many lives, especially in developing countries like Tanzania. The usual source of drinking water is the streams, rivers, wells and boreholes which are mostly untreated and associated with various health risks.

The quality of water influences the health status of any populace, hence, analysis of water for physical, biological and chemical properties contents are very important for public health studies. Physical properties of drinking water quality mainly include residual chlorine, temperature, color, odor, taste, turbidity, PH, electrical conductivity, and total dissolved solids and regards to examination of quality test categorized in to physiochemical and aesthetical parameters. [10] Reports that chemical contamination of drinking water is often considered a lower priority than microbial contamination by regulators, because adverse health effects from chemical contaminations are generally associated with long-term exposures, whereas the effects from microbial contamination are usually immediate. As reported by [11] chemical contamination can affect the taste and appearance of water, lead to community anger, detrimental economic impacts and in some cases serious morbidity.

Worldwide, the microbiological content of water is tested to monitor and control both quality and safety. Such tests are undertaken to ensure that the water used for drinking, food preparation, and bathing is safe [12]. The type and numbers of microorganism present water determine the microbiological properties of water [13]. A diversity of microorganisms can be present even in very good quality domestic waters. Most of these microorganisms are harmless but if the water is, polluted pathogens may be present [14]. The most predominant water borne disease, diarrhea, has an estimated annual incidence of 4.6 billion episodes and causes 2.2 million death every year [15]. The need to assess the microbial quality of the drinking water has become imperative because it has a direct effect on the health of individuals [16].

It is difficult to determine the presence of all the different pathogenic organisms and therefore the presence of certain indicator organisms are used to give an indication of the possible presence of pathogens. Most water-borne diseases are caused by fecal pollution of water sources; therefore, the majority of tests aim to detect coliforms and E. Coli [17]. Total Coliform bacteria (TC) are a group of bacteria that are regularly present in environmental waters. E. coli is a sub-group of TC that is more associated with the feaces of people and warm blooded animals [18]. High *E. Coli* and total coliform (TC) counts in water are usually manifested in the form of diarrhea, fever and other secondary complications [19]. [20] reports that coliform are indicator of the general hygienic quality of the water and potential risk of infectious diseases. Drinking water quality should be completely free from pathogenic microorganisms, physic-chemical element in concentration that causes health impact [21]. Therefore, the main objective of this study was to determine quality of drinking water supplied to Sumve ward in terms of bacteriological and physicochemical parameters. The results were then compared against drinking water quality standards laid down by [22] and World Health Organization (WHO).

The study was prompted by the fact that, water supplied to Sumve people without undergoing any kind of treatment and the water source is unprotected (see figure 2). This may pose a danger of outbreak of waterborne diseases due to the fact untreated water may contain disease causing microorganisms.

II. MATERIALS AND METHODS

2.1 Area of the study

Sumve ward is located in Kwimba District in Mwanza Region, Tanzania (Fig 1). According to [23] Population and Housing Census in Tanzania Sumve ward had the population of 16,436. The primary economic activity in the village of Sumve is the farming of rice, maize and cotton, often at the subsistence level.

Figure 1. Kwimba District and Sumve ward location within Mwanza Region.

Sumve ward receive water supply services from a piped water supply scheme which is operated, and managed by Water User Association (WUA) known as Jumuiya ya Watumiaji Maji Sumve (JUWAMASU). Ground water accessed via borehole is the major source of water in Sumve. This scheme serves about 5160 people. JUWAMASU supplies water to villages known as Badeshi A, Badeshi B, Sumve ya Lugulu and Sumve eneo all located in Sumve ward. JUWAMASU water supply system consists of a rising main made of Galvanized Steel (GS) that conveys water to about 2.6km from the intake to 90 m^3 storage tank by pumping. This water supply scheme is installed with 297 flow meter gauges for individual customers, 10 flow meter gauges installed at domestic points and 12 flow meter gauges at institutes such as hospitals. Thus installed flow meter gauges in total number sum up to 319. From storage tank water is distributed to consumer's points by gravity action. The raw water from the source is supplied to the consumers without being treated. For that case, many residents of Sumve drink water of unknown quality which becomes source of waterborne diseases such as gastroenteritis, and cholera. To that effect initiative was taken to assess quality of drinking water that is supplied to Sumve, and taken into consideration that there is no any recent scientific research that has been conducted to assess quality of drinking water supplied to Sumve ward.

2.2 Sampling Design and Strategy

2.2.1: Sampling

A total of 120 water samples were collected from ten locations with 12 samples from each location from JUWAMASU piped water supply scheme. The locations were respectively designated as 1- Intake location, ,2 - Conveyance pipe 1.5km from intake, 3- Storage tank, 4- Distribution network 1(Sumve Eneo), 5-Domestic Point 1 (Mazezele tap), 9- Domestic Point 2 (Budushi A), 10 - Domestic Point 3 (Sumve eneo sokoni), 12 - Domestic Point 4, (Sumve ya Lugulu A), 14- Distribution network 2 (Budushi A) and 15- Distribution network 3 (Budushi B). Water samples were collected applying the procedures indicated by EWURA, [24] and [25]. Clean and sterile bottles were used to collect the water samples. The sampling bottles were washed with distilled water and then rinsed with the water from the collection point before sampling.

Samples for bacteriological analysis were collected in a 200 mL sterilized glass bottles, while those for physicochemical analysis in polyethylene bottles (500mL capacity), respectively. After samples were collected bottles were tightly capped and properly labeled. Water samples collected for bacteriological analysis were kept in ice box then transported to the Laboratory within 4 hours to prevent from any physicochemical alteration and unwanted growth of microbes.

2.2.2 Sample analysis

The analysis of the collected samples was conducted using standard laboratory procedures including classical laboratory methods HACH spectrophotometer [26]. Mwanza Urban Water Supply and Sanitation Authority (MWAUWASA) laboratory was used for the analysis. Bacteriological analysis was carried out to determine total coliforms (TC) and E.Coli and physicochemical parameters analyzed were: pH, temperature, electrical conductivity, total dissolved solids (TDS), fluoride, chloride, nitrate, manganese, iron, ammonium and total hardness. Of the 13 physicochemical parameters the pH, Temperature, Total Dissolved Solids (TDS) and Electrical Conductivity (EC) were assessed on site, while the others were analyzed in the laboratory.

Analysis of bacteriological parameters was done by Most Probable Number (MPN) method. A 100ml portion of the water sample was passed through membrane filter and the sample was placed onto a plastic petri dish containing M-Endo agar. Endo agar plates were examined, and the number of coliform colonies was determined after 24 h of incubation at 37°C. *E. Coli* analysis was done by diluting samples 1:10 and 1ml sample was inoculated on petri-film culture media. MFC Broth was used as growth medium. Incubation was carried out at 44.5 °C for 24 hours. The physicochemical parameters were analysed using standard instruments. Each water sample was analyzed for Total Dissolved Solids (TDS), temperature, electric conductivity, pH iron, manganese, chloride, fluoride, nitrate, ammonia and total hardness. The temperature, potential of hydrogen (pH) and electrical conductivity were carried out in-situ at the site of sample collection due to their unstable nature. pH was measured using a digital portable pH meter. Standardization of the pH meter was done using buffer solutions: starting with acidic (pH4) and neutral (pH 7) making adjustments for temperature and asymmetry potential required by the instrument before the sample was poured into a test tube. A mercury filled centigrade thermometer calibrated from 0^0C to 100^0C was used for temperature measurements. This was done by dipping the thermometer into the sample and recording the stable reading.

Conductivity was done using a conductivity meter (4510 model). The probe was dipped into the container of the samples until a stable reading was obtained and recorded. Turbidity was measured using photoelectric turbid meters turbidity meter (2100Q). The values obtained were expressed in Nephelometric turbidity units (NTU). Gravimetric Method was used to determine total dissolved solids. Water samples were measured into a pre-weighed evaporating dish which was then dried in an oven at a temperature of 103 to 105^oC for two and half hours. The Total Dissolved Solids was then calculated using the formula:

$$\text{Total solids (mg/L)} = \frac{(W_2\text{-}W_1)\ \text{mg x } 1000}{\text{mL of sample used}}$$

Where W_1 = initial weight of evaporating dish

W_2 = Final weight of the dish (evaporating dish + residue)

Nitrate values were determined using spectrophotometer. Approximate 25 ml of water sample was filled into a sample cell and an indicator was added. The sample color changed from colorless to yellow.

Chloride was determined by potentiometric titration silver nitrate solution with a glass and silver-chloride electrode system. Standard silver nitrate titrant, 250ml of 0.05 M silver nitrate solution was prepared in a volumetric flask. Potassium chromate was used as indicator. Potentiometric analysis of fluoride content (as F– ion) in solutions by using fluoride ion-selective electrode was used to determine free fluoride dissolved in water. Total Hardness was measured using EDTA (Ethylene Diamine Tetra Acetic Acid) as titrant with ammonium chloride and ammonium hydroxide buffer solution (PH-10) and Erichrome Black T as indicator. 25mL of the samples was placed in different clean 250mL conical flask. To this were added 3mL of ammonium chloride in concentrated ammonia buffer and 2 drops of Eriochrome Black T indicator. This was titrated against 0.01M ethylenediaminetetraacetic acid (EDTA) solution until there was a color change from violet to blue. Hardness was calculated as follows:

$$\text{Hardness in mg/L } CaCO_3 = \frac{\text{V x M x } 1000}{\text{mL of sample used}}$$

Were M = Molarity of EDTA Used

V =Volume of EDTA used.

2.2.3 Data Analysis

The relevant data were processed and analyzed through manually and for computer based analysis MS Excel of Office spreadsheet 2007 version was used. Basic statistical parameters such as minimum, maximum, mean, median and deviation standard were used to analyze the data and to evaluate the dispersion of the values for each parameter.

III. RESULTS AND DISCUSSIONS

3.1 Bacteriological quality of drinking water

The bacteriological analysis for the presence of Total *Coliforms*, and *Escherichia coli (E. coli)* was conducted and results are listed in Table 1. Bacteriological analysis of water samples in this study indicated high values of TC, greater than the WHO maximum limit of 0/100ml from all the sampling points. Total coliform population in water ranged between 300-4200 MPN/100 mL.

Minimum coliform population of 300/100 mL was detected in water samples of Domestic point 2(Budushi A) and Domestic point 4(Sumve ya Lugulu A), whereas, a maximum total coliform population was found in water samples of Storage tank (4200 CFU/100mL). Too high total bacterial count in storage tank means that the source has been contaminated by pathogens. The primary reasons for contamination could be the intrusion of contaminated storm water into the source (see figure 2).

Figure 2: Pump house at the intake flooded with surface runoff

Although, the water samples collected from source, conveyance pipe, storage tank, Domestic point 2 and distribution network 3 were found free from *E.Coli* there is a possibility of presence of other microbes like viruses and protozoa. On the other hand, laboratory results revealed that *E.Coli* of the water samples collected from domestic point 1, domestic point 3, domestic point 4 and the distribution network 2 were above the permissible level of 0/100ml specified by WHO and TBS. In contaminated samples *E.Coli* numbers ranged from 10/100ml to 200/100ml; highest *E.Coli* count were found in domestic point 3(Sumve eneo sokoni) and Domestic point 4(Sumve ya Lugulu A). This indicates that even if water does not become contaminated at the source, water gets contaminated further at the point of use when compared to the source. Leakage of distribution pipes provides a potential portal for the entrance of wastewater from runoff and permit pathogens present in wastewater and soil to enter the distribution network.

Since coliform is indicative of feacal contamination, the implication is that most of the water samples studied in Sumve were of very poor sanitary conditions, which is in agreement with the findings of [27]. The summary of results and the descriptive statistics (mean ± standard deviation, minimum, median, maximum values) of the bacteriological parameters of the analyzed water samples are summarized in Table 1

Table 1. Bacteriological parameters of the collected water samples

Parameters	Water sampling points identified															Water quality Standards	
	1	2	3	4	5	9	10	12	14	15	Max	Min	STDEV	Median	Mean± STD	WHO	TBS
Total Coliform CFU/100mL	4000	4000	4200	3800	4100	300	400	300	500	800	4200	300	1883.97	2300	2500±1883.97	10CFU/100ml	0CFU/100ml
E.Coli	0	0	0		10	0	200	200	100	0	200	0	87-46	0	0±87.46	0CFU/100ml	0CFU/100ml

3.2 Physicochemical test results

The descriptive statistics (mean ± standard deviation, minimum, median, maximum values) of the physicochemical parameters of the analyzed water samples are summarized in Table 2.

Turbidity of 10 NTU or less represent very clear waters, 50 NTU or greater represents cloudy water and river water with a turbidity range of 100-500 is very cloudy and muddy. In drinking water, the higher the turbidity level, the higher the risk that people may develop gastrointestinal diseases, where contaminants such as viruses or bacteria can become attached to the suspended solids. Topography, vegetation, geology, agricultural activities, and precipitation greatly influence raw water turbidity [28].

In the current study the results showed the average turbidity of 0.38 to 1.73 NTU with a mean pH value 0.96NTU. Low pH value 0.38 was recorded in domestic point 3and high pH value 1.73NTU was recorded in storage tank. The mean value of 0.96NTU is below the given range of 5NTU to 25NTU specified by both Tanzania Bureau of Standards and WHO. The turbidity level at storage tank was found to be slightly high compared to other sampling points. This observation can be linked with high presence of algae inside the tank, high level of manganese from the water system, and may also be caused by corrosion from the tank materials.

TDS concentration values were found to range between 371mg/l to 379 mg/l, with mean concentration of 375mg/l. Minimum TDS concentration 371 mg/L was observed from Domestic Point 1 (Budushi A) water sample, while maximum TDS concentration 379 mg/L was observed in water samples collected from the intake.

The total dissolved solids levels are not supposed to exceed 500 to 1500 mg/L according to TBS standards and maximum allowable limit of 1000 mg/l of WHO standards. Hence all water samples drawn from selected sampling points were observed to meet that of WHO and TBS maximum allowable and recommended values.

The palatability of drinking water has been rated to its TDS level as follows: excellent, less than 300 mg/litre; good, between 300 and 600 mg/litre; fair, between 600 and 900 mg/litre; poor, between 900 and 1200 mg/litre; and unacceptable, greater than 1200 mg/litre. Water with extremely low concentrations of TDS may also be unacceptable because of its flat, insipid taste. Sometimes water with high TDS value indicates that water is highly mineralized [29]

Electrical Conductivity measurement is an excellent indicator of TDS, which is a measure of salinity that affects the taste of potable water. A sudden increase of the conductivity of water indicates that there is a source of dissolved ions in the vicinity. Hence, conductivity measurements can be used as a quick way to locate potential water quality problems. EC values were found to range from 790 to 820 µs/cm with a mean EC 803 µs/cm. Distribution network 2 (Budushi A) water sample with lowest EC value 790 µs/cm and at the source water sample with highest EC value 820 µs/cm. WHO recommends EC value for drinking water is 400 µs/cm. whereas, present study results show that all water samples EC value cross the permissible limits of WHO standards, but slightly lower than TBS standards of 1000 µS/cm.

Temperature of water samples in this study were found to range between 26.9^{0}C to 27.9^{0}C with a mean pH value 27.3^{0}C, highest value of 27.9^{0}C was recorded from water samples collected at Conveyance pipe 1.5km from intake and lowest value of 26.9^{0}C was recorded from water samples collected at Domestic Point 4, Sumve ya Lugulu. According to [30] temperatures above 25^{0}C are unacceptable. Testing the temperature of water has usually no practical significance in the sense that it is not usually possible to give any treatment to control the temperature of water.

pH of water samples in the current study were found to range from 8.13 to 8.52 with a mean pH value 8.28. Low pH value 8.13 was recorded in water sample of intake and high pH value 8.52 was recorded in water sample of Storage tank. A pH of 7 is neutral, >7 is alkaline and < 7 is acidic. Drinking water with increased acidity (pH< 6.5) can corrode plumbing, fittings and pipes. Drinking water with increased alkalinity (>8.5) can lead to encrustation of plumbing and pipes fittings and a bitter taste. WHO specify pH value for drinking water as 6.5 to 8.5, whereas pH values recommended by TBS ranges from 6.5 to 9.2. Hence all pH values of analyzed water sample are within the permissible limits and fit for drinking although pH values of all water samples indicated slightly alkalinity. Possibly presence of alkalinity might be due to increase of temperature that lowers the solubility of Carbon dioxide, or it can be due to leakage in distribution pipes through which domestic waste water enter and cause alteration in pH values of water.

Chloride concentration of analyzed samples were found to range from 13/l to 19.9 mg/l with a mean chloride value of 15.87mg/l. Low chloride value 13mg/l was recorded in water sample Distribution network 1 (Sumve Eneo) and high chloride value of 19.9mg/l was recorded in water sample from Intake location. The chloride levels in drinking water should not exceed acceptable value of 200 mg/L according to WHO standards and TBS allowable value of 800 mg/L. Hence, the values in the present study are on lower side considering TBS and WHO maximum permissible limits.

Fluoride ions have dual significant in water supplies. High concentration of F- causes dental fluorosis (disfigurement of the teeth). At the same time, a concentration less than 0.8 mg/L results in 'dental caries'. Fluoride concentration in water samples in this study were found to range from 0.82mg/l to 4.4 mg/l with a mean fluoride value of 3.57mg/l. Low chloride value 0.82mg/l was recorded in water sample of Domestic Point 4, Sumve ya Lugulu A and high fluoride value of 4.4mg/l was recorded in water sample from Intake location. Fluoride levels can be increased by contamination of fertilizers, human as well as animal waste.

Mn, greater than the WHO maximum limit of 0.1 mg/l and 0.5mg/l of TBS were observed at all the sampling stations of JUWAMASU water supply scheme. The concentration levels of Mn ranged between 2.4 to 4.9 mg/with mean value of 3.30mg/l. Sampling station Domestic Point 4, (Sumve ya Lugulu A) and Distribution network 3 (Budushi B) had the highest Mn levels compared to other sampling stations. Higher values of Mn greater than WHO and TBS maximum limits at all the sampling stations is affirmed by the fact that manganese occurs naturally in groundwater which is the source of water in this study case. However, presence of manganese could be as a result of farming near the intake, use fertilizer and runoff. The intake of manganese can be high as 20 mg/day without apparent ill effects.

Water samples in this study indicated ammonia concentration values were found to range between 2.85 to 4.6 mg/L with a mean ammonium concentration 3.63mg/l. mg/L. Highest ammonium concentration 4.6 mg/L was seen in samples collected from intake locations and lowest ammonium concentration 2.85 mg/L was seen in samples of Distribution network 1 (Sumve Eneo). The allowable concentration value for ammonium is not mentioned by WHO, 1 mg/l is the lowest value specified by TBS. The high concentration of ammonia in analyzed samples water indicates the possibility of sewage pollution and the consequent possible presence of pathogenic micro-organisms. Since farming is the main economic activity of Sumve people ammonia may be produced from fertilizers and decomposition of organic matter from manure.

The levels of nitrate at the sampling stations in this study ranged between 7.24 to 12.4 mg/l, with mean value of 8.6mg/l, high value of 12.4mg/l being observed at the source and 10.01mg/l observed at Conveyance pipe 1.5km from the source. The lowest value of 7.1mg/l was observed from samples collected at Distribution network 2 (Budushi A). High values of nitrate at the source could be mainly due to farming near to the source surroundings and use of fertilizers. In general, the nitrate-N mean levels in this study was found to be below the maximum contamination levels of 50 mg/l set by the WHO, also lower than the TBS limits of 10 to 75mg/l.

Iron levels of the water at all the sampling stations in this study ranged between 0mg/l and 0.08mg/l with mean value of 0.03mg/l, highest level of 0.08mg/l was noted at Conveyance pipe 1.5km from source, whereas, samples collected from Domestic Point 3 (Sumve eneo sokoni) and Domestic Point 4, Sumve ya Lugulu A were free from iron. The iron mean value of 0.03mg/l does not exceed WHO organoleptic standard (0.3 mg/L). It is also below the TBS limits of 0 to 1mg/l. Iron may also be present in drinking water as a result of the use of iron coagulants or the corrosion of steel and cast iron pipes during water distribution. Concentration of iron in drinking water at levels above 0.3 mg/l iron stains laundry and plumbing fixtures.

Total Hardness is of the amount of Ca^{2+} and Mg^{2+} ion in the water sample. Magnesium salts are important contributors to the hardness of water which break down when heated, forming scale in boilers. The magnesium concentration may vary from zero to several hundred milligrams. The most desirable range of hardness is between 80 and 100 mg/L as less than 80 mg/L may result in corrosive water. Hardness values exceeding 500 mg/L are generally unsuitable for domestic purposes without treatment. No health concerns are associated with drinking hard water but more often it appear undesirable as it builds up (scaling) in pipes and water heaters. Hard water also wastes soap as it reduces the ability of the cleansing agent by reacting with it first before forming lather. The recommended limit for Calcium is 75 mg/L, as when it is in excess, it may contribute to the formation of kidney or bladder stones. The recommended limit for magnesium is 50 mg/L as excessive magnesium may give water a bitter taste, but is normally not a health hazard.

Calcium values were found to range from 51 mg/l to 61 mg/l with a mean calcium value of 54mg/l mg/l. Low calcium value 51mg/l was recorded in water sample of Distribution network 1 (Sumve Eneo), and high calcium value of 61 mg/l was recorded in water sample from Distribution network 3 (Budushi B). The mean values recorded for Magnesium was 39mg/l, with the highest value of 44mg/l recorded from samples taken from Domestic Point 2 (Budushi A), and lowest value of 35mg/l observed from samples collected from Domestic Point 1 (Budushi A).

TBS specification for calcium ranges from 75 to 300mg/l and WHO recommends limit of 75mg/l, and TBS specification for Magnesium ranges from 50 to 100mg/l, and WHO recommends 50mg/l. Hence none of the samples cross the maximum permissible limits of WHO and TBS standards. The summary of results of physic-chemical analysis is indicated in Tables 3.

Table 3. Physical and chemical parameters of the collected water samples

Parameters	Water sampling points identified															Water quality Standards	
	1	2	3	4	5	9	10	12	14	15	Max	Min	STDEV	Median	Mean± STD	WHO	TBS
Turbidity (NTU)	1.2	1.51	1.73	1.08	0.38	0.77	0.69	0.7	0.85	0.72	1.73	0.38	0.41	0.81	0.81±0.4	5 NTU	5 – 25
pH	8.13	8.28	8.52	8.42	8.27	8.21	8.22	8.26	8.24	8.42	8.52	8.13	0.12	8.27	8.3±0.11	6.5 – 8.5	6.5 - 9.2
Temperature(°C)	27.8	27.9	27.5	27.8	27.3	27.2	27.1	26.7	27.1	26.9	27.9	26.7	0.41	27.25	27.3±0.40	Nm	Nm
EC (µS/cm)	820	819	802	816	796	798	795	791	790	795	820	790	11.66	797.00	797±12	120	1000
TDS (mg/l)	379	377	373	376	371	374	373	374	372	376	379	371	2.46	374.00	374±2.5	750	500
Fluoride(mg/l)	4.4	4.25	4.13	4.02	3.68	3.86	3.94	0.82	3.01	2.98	4.4	0.82	1.06	3.90	3.9±1.1	**1.5**	500 – 2000
Manganese(mg/l)	2.5	2.4	2.5	2.4	3.2	3.6	3.4	4.9	4.8	4.9	4.9	2.4	1.06	3.30	3.3±1.06	0.5	4
Chloride(mg/l)	19.9	19.6	15.3	13	13.8	14.8	15	15.2	16.2	15.7	19.9	13	2.25	15.25	15.25±2.25	**250**	0.5
Ammonium(mg/l)	4.6	4.2	3.31	2.85	2.99	3.48	3.4	4.12	3.76	3.21	4.6	2.85	0.57	3.44	3.44±0.57	1.5	200 – 800
Calcium(mg/l)	56	52	51	54	51	52	53	59	58	61	61	51	3.59	53.50	51±3.59	75	100
Magnesium	40	36	37	35	39	44	38	42	40	37	44	35	2.78	38.50	38±2.78	30	75 – 300
Iron(mg/l)	0.06	0.08	0.02	0.01	0.04	0.01	0	0	0.01	0.01	0.08	0	0.03	0.01	0.01±0.03	0.3	50 – 100
Nitrate(mg/l)	12.4	10.01	9.43	8.57	9.23	7.24	7.25	6.68	7.1	8	12.4	6.68	1.75	8.29	6.68±1.75	45 -50	1

IV. CONCLUSIONS AND RECOMMENDATIONS

Quality of water supplied to Sumve people by JUWAMASU meets the WHO and TBS water quality criteria in terms of pH, turbidity, temperature, total dissolved solids, electrical conductivity, Fluoride, Chloride, Iron and total hardness. However, the following parameters were found to be higher than WHO and TBS maximum required levels; Mn, Ammonia, EC, coliforms and E. Coli. The presence of bacteria and coliforms in all the water samples analyzed imply that consumers of that water are vulnerable to the risk of waterborne diseases. The poor sanitary condition and unprotected source of water in Sumve are mainly responsible for this poor water quality. Unprotected source is likely to be polluted by surface run-off, while, old pipes and leakages in pipes provide way to wastewater and other contaminants in the drinking water. Disinfection by chlorine will be the most appropriate treatment method that can destroy coliforms. A regular monitoring of the water quality is recommended for improvement to prevent disease. Also farming near the source should be discouraged so that none of the agricultural runoff finds its way into the water source. Water sources must be protected from contamination by human and animal waste which can contain a variety of Bacterial, Viral, Protozoan and Helminthic Parasites.

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REFERENCE

[1]. Napacho Z.A and Manyele S. V. Quality assessment of drinking water in Temeke District (part II): Characterization of chemical parameters African Journal of Environmental Science and Technology. 4(11), 2010, 775-789.

[2]. EWURA. Water and Wastewater Quality Moniroring Guidelines for Water Utilities. Dar es Salaam: EWURA 2009.

[3]. WHO. Guidelines for drinking water quality, 4rd ed.\ Recommendations, vol. 1. WHO Press, World Health Organization, Geneva 27, Switzerland 2011.

[4]. Lukubye, B and Andama M. Physico-Chemical Quality of Selected Drinking Water Sources in Mbarara Municipality, Uganda. Journal of Water Resource and Protection, 2017, 9, 707- 722

[5]. EWURA. Water and Wastewater Quality Moniroring Guidelines for Water Utilities. Dar es Salaam: EWURA 2009.

[6]. WHO Guidelines for drinking water quality, 4rd ed.\ Recommendations, vol. 1. WHO Press, World Health Organization, Geneva 27, Switzerland (2011).

[7]. Napacho Z.A and Manyele S. V. Quality assessment of drinking water in Temeke District (part II): Characterization of chemical parameters African Journal of Environmental Science and Technology. 4(11), 2010, 775-789.

[8]. Durmishi, B.H., M. Ismaili, A. Shabani, Sh. Abduli. Drinking Water Quality Assessment in Tetova Region**.** American Journal of Environmental Sciences 2012 8 (2): 162-169,

[9]. Mato, R. R. A. M. Groundwater pollution in urban Dar es Salaam, Tanzania: Assessing vulnerability and protection priorities Eindhoven: Technische Universiteit Eindhoven DOI: 10.6100/IR554794. 2002.

[10]. WHO Guidelines for drinking water quality, 4rd ed.\ Recommendations, vol. 1. WHO Press, World Health Organization, Geneva 27, Switzerland (2011).

[11]. Durmishi, B.H., M. Ismaili, A. Shabani, Sh. Abduli. Drinking Water Quality Assessment in Tetova Region**.** American Journal of Environmental Sciences 2012 8 (2): 162-169,

[12]. Amiri H, Alkendi R, R., Yasser, Ahmed T. Quantification of bacteria in domestic water storage tanks in Sharjah Ala. Journal of Water Resources and Ocean Science 2013; 2(5): 125-132

[13]. WHO. Water safety in the distribution systems. Geneva: WHO 2014.

[14]. Daniels B. and Mesner, N Drinking Water Facts: Coliform bacteria; Utah State University. Water Quality Extension 2010.

[15]. WHO (2000), Global Water Supply and Sanitation Assessment Report

[16]. Anyanwu and Okoli, Evaluation of the bacteriological and physicochemical quality of water supplies in Nsukka, Southeast; Nigeria. African Journal of Biotechnology. 11(48), 2012 10868-10873.

[17]. El-Taweel GE, Shaban AM Microbiological quality of drinking water at eight water treatment plants. Int. J. Environ. Health Res., 11, 2001. 285-290.

[18]. EPA Technical Brief Environmental Technology: Verification Program. Ince 2010.

[19]. Sivaraja, R. and Nagarajan, K. Levels of indicator microorganisms (total and fecal coliforms) in surface waters of rivers Cauvery and Bhavani for circuitously predicting the pollution load and pathogenic risks. International Journal of Pharm Tech Research 6(2) 2014, 455-461.

[20]. Edberg, S.C., Rice, E.W., Karlin, R.J., & Allen, M.J., Escherichia coli: the best biological drinking water indicator for public health protection: Symposium Series Society for Applied Microbiology, 29, 2000. 106S–116S

[21]. Lukubye, B and Andama M. Physico-Chemical Quality of Selected Drinking Water Sources in Mbarara Municipality, Uganda. Journal of Water Resource and Protection, 2017, 9, 707- 722

[22]. Tanzania Bureau of Standards National Environmental Standards Compendium: TZS 789. Drinking (potable) water: Specifications 2008.

[23]. National Bureau of Statistics (NBS), Tanzanian Household Budget Survey 2012. Dar es Salaam: downloaded from http://www4.worldbank.org/afr/poverty/databank/docnav/default.cfm. Dar es Salaam: Tanzania,National Bureau of Statistics. 2012.

[24]. EWURA. Water and Wastewater Quality Moniroring Guidelines for Water Utilities. Dar es Salaam: EWURA 2009.

[25]. Tanzania Bureau of Standards National Environmental Standards Compendium: TZS 789. Drinking (potable) water: Specifications 2008.

[26]. HACH. Data Logging Calorimeter Hand Book, DR/820-DR/890. 1997.

[27]. Anyanwu and Okoli, Evaluation of the bacteriological and physicochemical quality of water supplies in Nsukka, Southeast, Nigeria. African Journal of Biotechnology. 11(48), 2012 10868-10873,

[28]. Tenge J. M, Lusweti J. K, Ng'wena. G. A. M Assessment of Drinking Water Quality from the Malakisi River in Western Kenya. International Journal of Innovative Research and Development. 2015. 2278-0211

[29]. Werkneh A. A, Zimbelachew M. B, Kelemework A, Jemal Y. D. A. Physico-Chemical Analysis of Drinking Water Quality at Jigjiga City, Ethiopia. American Journal of Environmental Protection. Vol. 4, No. 1, 2015, pp. 29-32.

[30]. Garg, S. (2006). Water Supply Engineering. New Delhi: Khanna P. 18th Edition Publishers Distributors, 2nd Edition.

Mohammad Mobarak Hossain." SMV And Lead Time for T-Shirt Manufacturing."American Journal of Engineering Research (AJER), vol. 7, no. 5, 2018, pp.26-33.