Assessment Of Drinking Water System: A Case Study Of Juba City South Sudan

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Abstract- A sustainable drinking water system increasingly becomes a problem with an increase in population density. The purpose of this study is to assess the drinking water system in Juba city and compare its water quality parameters with the WHO standard. The systematic review method is applied to identify relevant information and the gray literature data collected from the Ministry of Water Resources on the treated water quality parameters such as water temperature, pH, water conductivity, TDS, and residual chlorine for January, March, June, and August 2018. The results of the study show that the temperature 25.9, 30.0, 27.3, 29.5°C were above the WHO guideline value 25°C has increased the taste and color in the water. The water conductivity 1420, 1331 ms/m is above the WHO guideline value 400 mS/m due to the anthropogenic factors that have been throw into the River Nile. While for 132, 138 mS/m were below the WHO guideline value 400ms/m its shows the less discharge of waste into the River Nile. The residual chlorine 1.6, 1.5, 1.5, 1.8 mg/L were above the WHO guideline value 0.2 mg/L, which means the treated water quality is not well disinfected. The pH of 7.9, 7.3, 7.3, 7.9 mg/L was found normal in range with the WHO guideline value 6.5, 8.5 mg/L. The TDS of 482,590,572 mg/L, were found to be Normal with the WHO guideline value 600 mg/L, it shows the treated water quality is safe for drinking and the TDS for August 719 mg/L is above the WHO guideline value 600 mg/L. It's due to the exposure of the waste into the River Nile. The result reveals that the under-investment in drinking water system infrastructure in Juba city has seriously impacted the drinking water system availability and water quality. Therefore, this study has recommended the development of a drinking water system and the treatment of water quality to meet the WHO permissible level.

Index Terms- Drinking water system, surface water, water quality treatment, parameters, Juba city

I. INTRODUCTION

Safe and adequate drinking waters are the most essentials requirement of life and a determinant of the living standard and health of the people in a nation. Improving drinking water quality is the concern of many governments worldwide to protect human health[1]. The drinking water systems have been described commonly as supply chains built up by three main sub-systems raw water, treatment, and distribution. Together these sub-systems cover the entire supply chain, from the source of the water through the treatment plant and distribution network to the customers tap[2]. However, given the complexity of processes occurring during the water transport through distribution systems, the drinking water quality may deteriorate, leading to the growth of pathogens, taste, odor, and operational issues corrosion and discoloration[3].

Natural water is an essential material for both lives of animals, plants, and human beings, on the earth. Safe access to drinking water is essentials for health and the basis for a human right that is integral to the United Nations Resolution 64/292 of 2010[4]. Reports indicated that around 1 billion people faced safe access to drinking water, and more than 5 million people die each year from water-related diseases. According to WHO and UNICEF joined report. Almost 1.8 billion people use drinking water sources contaminated with feces that put them at the risk of contracting cholera, typhoid, dysentery, Polio, and hepatitis A[5].

In South Sudan mostly depended on aid organizations for water help, this has not been enough, and water becomes increasingly expensive and unaffordable. Without available clean water, the population has no alternative but to settle for dirty water. That increases the likelihood of catching disease and infections. Because of this, the country South Sudan still host to 98% of the world's remaining Guinea worm cases, and a third of children under the age of 5 suffer from diarrhea. Making improvements to water access be crucial in South Sudan for the country's future. That is why the (DROP4DROP Organization) has established a role within South Sudan, repairing broken bore-wells and providing wash initiatives and training[6]. The majority is vulnerable to several life-threatening diseases. The under-investment in the water infrastructure has seriously affected the drinking water system availability. South Sudan is now facing challenges to meet the 2030 Sustainable Development Goals formulated in 2015 as the 2030 Agenda through the water as key to Sustainable Development[7, 8].

There were always problems with the communities' drinking water in Juba city. People often used to get sick and suffer from diarrhea, and then cholera broke out. "The Population of the people used to get their drinking water from various places, never making sure whether it was safe or not? They usually used to collect it from the river that was dirty and polluted," According to UNICEF, 32 percent of the South Sudanese population doesn't have access to clean drinking water. Due to limited access to safe water, a third of the children under the age of five suffer from

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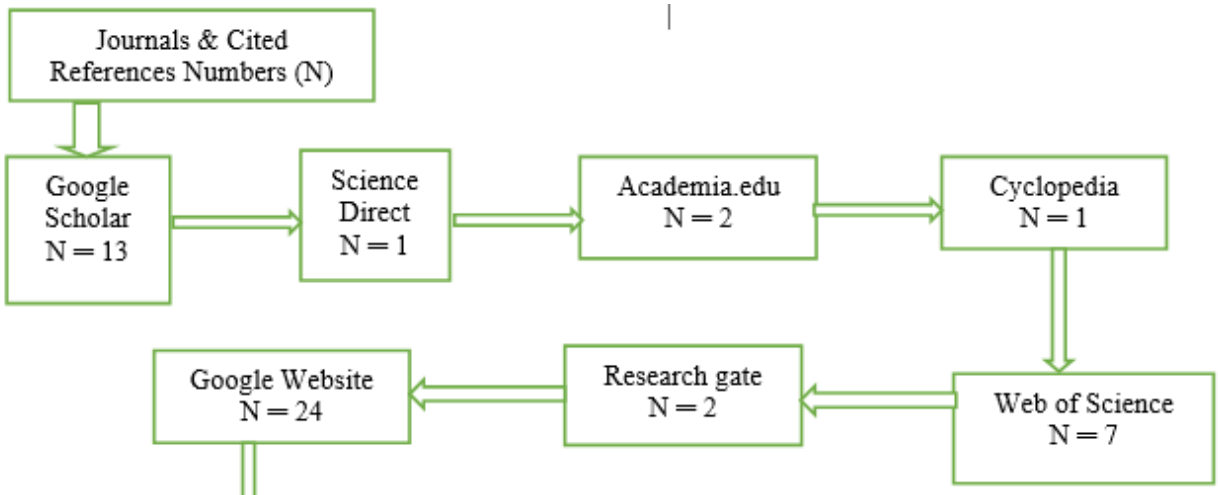
diarrhea[9]. Most of the Juba city populations rely on water tankers of which often distributed raw river water that is not suitable for human consumption. The primary cause of the Waterborne disease is microbiological contamination, associated with the ingestion of fecally contaminated water, according to the WHO 2011[10].

The Juba city 2005-2006 cholera outbreak was the clear manifestation of such microbiological pollution[11]. Therefore, the mains purpose of this study is to assess the conditions of the drinking water system in Juba city and compare its water quality parameters with the WHO guideline value.

II. Materials and Methods

The systematic review method is applied to identify the relevant literature topics and published papers in some of these journals and electronic databases[12], Such as Web of Science, Research gate, Science direct, Google Scholar, Academia, Cyclopedia, and Google website. The title of the search engine entered is as follows the water quality, drinking water, water management, water supply, and water distribution. The information was from the journals and websites. The gray literature data such as water temperature, pH, water conductivity, total dissolved solids, and residual chlorine of January, March, June, and August 2018, were collected from the ministry of water resources & irrigation (MWRI) Juba-South Sudan. The publication information searched from the five scientific Journals websites and the other information from the google website. Therefore, **Fig.1** is showing the detailed process of the schematic diagram of the search engine strategy of the websites and journals.



Search Papers Titles	Cited References Numbers
Drink Water System (Water Safety, Quality, Access and supply)	24
Drinking Water(Water source, quality, treatment and Pollution)	13
Water Treatment	1
Water Pollution and Water Safety	2
Water Supply and Safety	2
Water Quality(Water Source, production, Management, Water Temp)	7
Climatic Conditions	1
Total for Cited References	**50**

Fig.1. Showing Schematic Diagram of the Search Engine Strategy and Cited References Number

III. Study Area

Juba city is within the Southern part of South Sudan in Central Equatoria State. Juba is perhaps currently among the fastest

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developing places in the world, particularly the growth in its population is noticeable. In 2019, its estimated population in **Table 1**. The city has been characterizing by rapid development, urban sprawl, and inadequate services provision in **Fig.2**. Its geographical coordinates are 4º 51' 0" North and 31º 37' 0" East at the western bank of the River Nile. It is estimated to occupy a 12-kilometer area in diameter from the center of town included surrounding rural lands, which encompasses roughly100 kilometers in diameter[13].

Table 1 Population growth in Juba from 1972-2019.

Years	**1973**	**1993**	**2005**	**2010**	**2019**
Population	56,737	114,980	250,000	548,953	1,577,902

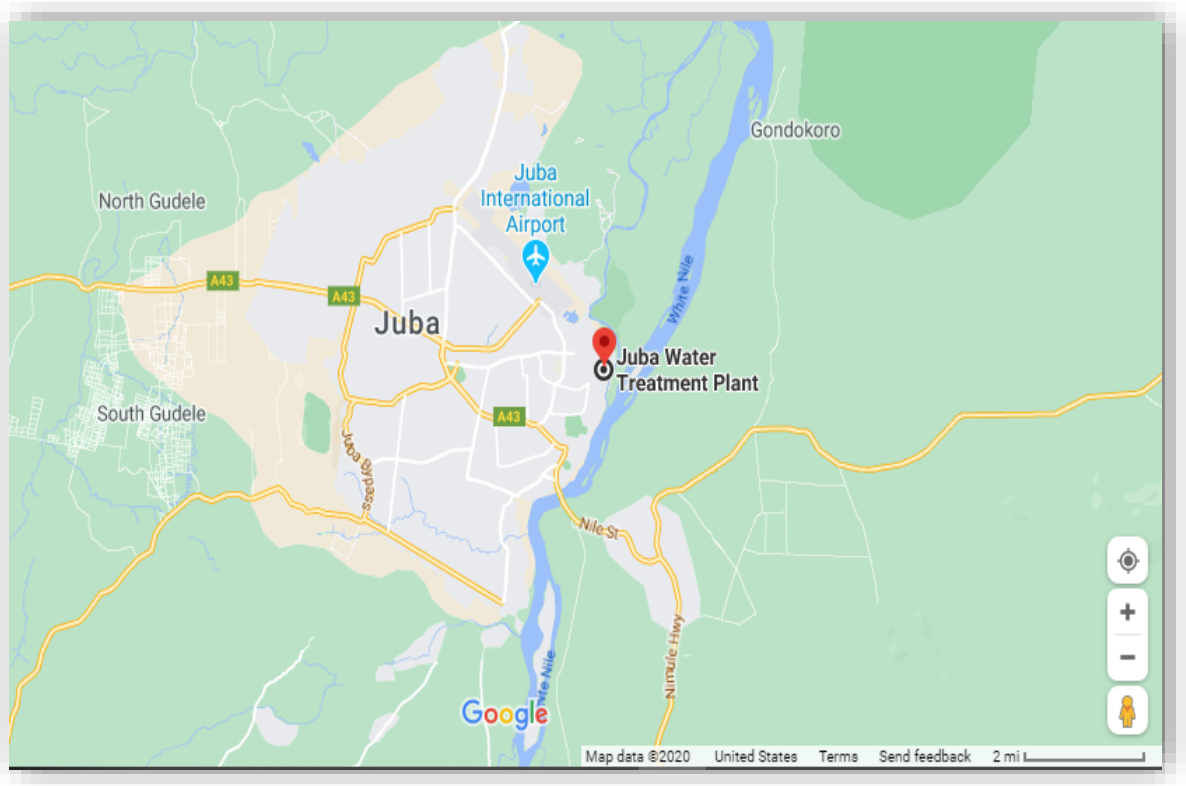

Fig.2. Juba city water treatment plant

3.1.1 Overview of Juba City Climatic Conditions

Juba city has a tropical wet and dry climate, and as it lies near the equator, temperatures are hot year-round. And little rain falls from November to March, which is also the time of the year with the hottest maximum temperatures reaching 38°C in February and more than 100 millimeters of rain falls per month from April to October as shown in Fig. (a) and (b)[14].

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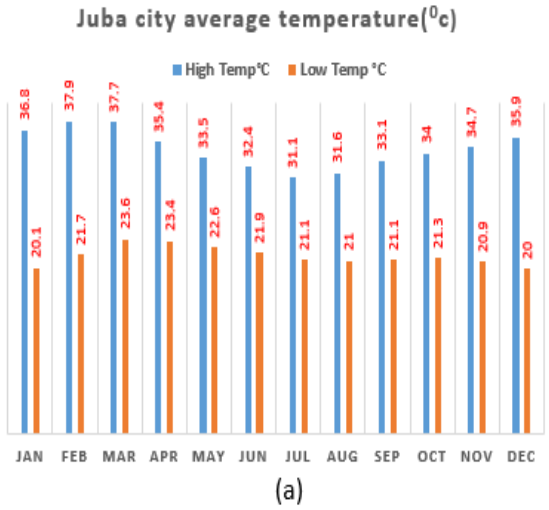

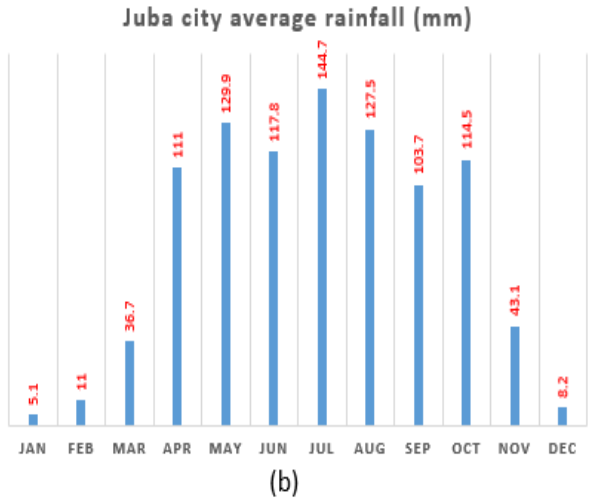

IV. Results

4.1.1 Drinking Water Sources in Juba city

The mains sources of water available for use by municipal water systems and the adequacy and reliability of each. Many municipal water systems use more than one type of water source as Impounding Reservoirs, Fresh-Water Lakes, Wells, Oceans, and Bays[15]. Water is an essential precious natural resource without which no form of livelihood is possible. Therefore, the quantity and quality of accessible water must be studied to make possible the concept of sustainable development[16].

South Sudan is rich with its surface water resources source gives a broad picture of its major surface water resources components[17]. An estimated approximately between 50-60 percent of the population has access to an improved water source, such as hand pumps shown in **Fig. (c)**, a protected well, or piped water supply that only benefits a minority. However, though the sections of the population with access to improve water sources often do not receive safe water. While those without access to an improved water source often fetch water from rivers, ponds, or open wells. Some buy water from vendors who use trucks to supply water to their customers. Only 13 percent of Juba city residents can access municipal water supplied mostly through a small piped network shown in **Fig. (a),** boreholes, and a single public water filling station on the river bank. Generally, the water system for the public has been complementing by the patchwork of small private water suppliers, which end up delivering relatively expensive and low-quality water in **Fig. (b)**. The residents of Juba city depend on unpurified water indicated[18]. There are about 300 registered trucks supplying water throughout Juba city[19].

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(a)

(b)

(c)

4.1.2 Drinking Water Supply System in Juba

The drinking water supply system on a tributary of the River Nile in Juba city, The screened feedwater drawn from the Juba channel River Nile with the help of a floating type intake supported by a bridge through which a flexible pipeline mounted by two pumps, each with a design capacity of 158 m^3/s and the third pump being on standby mode, the transported water to the raw water tank. The gravity water flows to the receiving raws water chamber, where aluminum sulfate is added and mixed by high energy dissipated, and the falling water through a weir facilitate the coagulation/flocculation process before entering the Sedimentation Tank. Then settled water is filtered through the rapid sand filtration technology, and the flocs are release to a maintenance hole where it finds its way for disposal into the river. At this treatment stage, chlorine is injected into the free gravity flowing water and finally stored in four underground tanks. Treated water has been lifted with the help of booster pumps to elevate tanks located in different areas. Then treated water is distributed to users as in **Fig. (a)** by a network of pipes or supplied by tankers to the unconnected regions [1].

Juba City is the national capital, the state capital of South Sudan, and a majority of the international, diplomatic, and regional hub. However, its water infrastructure is inadequate and requires urgent improvement. The water access coverage in the city is only about 20%[20]. And about 30-50 percent of water facilities are non-functional at any point due to weak water sector governance, limited funding and funding absorption capacity, human resource constraints[21]. Improving water supply, sanitation, hygiene, and management of water resources could prevent almost one-tenth of the global disease burden. In low-income countries, estimated that 80% of all illnesses are related to water. The primary cause of the waterborne disease is microbiological contamination[10]. The people in Juba obtain water through house connection or public tap of urban water corporation (UWC), public wells equipped with hand pumps, private vendors by water tanker or jerrycan vendors, and private wells. However, most of the people still use untreated river water or high salinity groundwater that has to be unhygienic and inadequate quality for human consumption[22]. The Juba city drinking water systems predominantly from surface water, boreholes, and public-wells not safe for drinking[23]. The vendors selling water to households or at collection points are common in many parts of the world where scarcity of water or fault in or lack of infrastructure limits access to suitable quantities of drinking water. Water vendors use a range of modes of transport to carry drinking-water for sale directly to the consumers, including tanker trucks and wheelbarrows or trolleys. There are several health concerns associated with water supplied to consumers by water vendors. These include access to adequate volumes and concern regarding inadequate treatment or transport in inappropriate containers, which can result in contamination[24].

In Juba city, most of the facilities have deteriorated and in an urgent need of rehabilitation or reconstruction to bring them to their normal condition of operation. However, there still exists a large gap between the current water demands and the water supply capacity. Besides, the water distribution network mostly composed of aged pipes asbestos causes high leakage. The water tankers truck of Juba is a daily feature of the city but at a higher cost, as overheads continue to rise, pushing up consumer charges. The lack of safe water shows residents at risk of the spread of sicknesses such as diarrhea and cholera, making children especially vulnerable to Water-Bornes disease. A water crisis, aggravated by political conflict, and a weakening economy, this is

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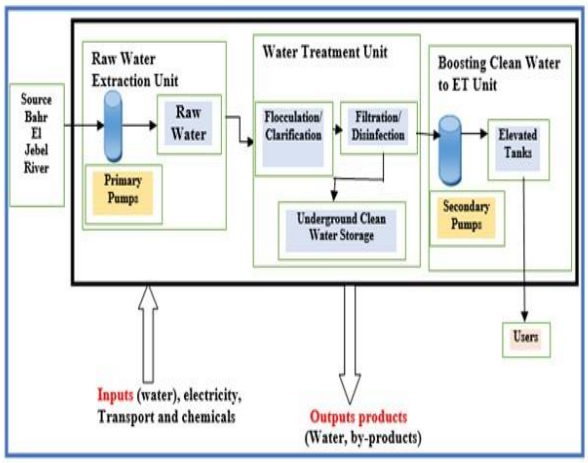
one of the more challenges in Juba city that families are facing daily. In 2015 estimated about 20% of Juba residents had municipal water access operated by South Sudan urban water corporation (SSUWC), the public water utility, mainly through a small piped network shown in fig.8 and boreholes. That likely has dropped the number further nationwide, for people without access to municipal drinking water. The water is givens by the private water trucking operators shown in **Fig. (b) and Fig. (c).** Often, water from these vendors is untreated, yet expensive, and the most source of hygiene-related diseases[25]. Water must undergo satisfactory treatment or disinfection that guarantees appropriate water quality[26].



(a)

(b)

(c)

4.1.3 The Specification of Drinking Water Quality Parameters.

The assessment of water quality mainly needs parameter identification. For every parameter, a standard being recognize. It encourages the understanding of water quality problems by integrating complex data and creating a score that defines water quality[27]. The drinking water quality guidelines for the tested parameters, which were proposed for Southern Sudan by UNICEF in October 2008, are summarized in Table 2[11].

Table 2 Southern Sudan draft proposal for water quality guideline (UNICEF, October 2008)[11].

Items	WHO Guideline value	S. Sudan Guideline value
pH	6.5 – 8.0	6 – 8.5
Electrical Conductivity (mS/m)	400	150

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TDS (mg/L)	600	1,000
Residual Chlorine(mg/L)	0.2	-

4.1.4 Drinking Water Treatment Process

Drinking water treatment typically includes coagulation, sedimentation, filtration, and disinfection. Coagulation is a critical step in water treatment processes, not only because it removes particles but because it also removes the microorganisms that are often attached to the particles[28]. In Juba city, the treated water is supply to only a small fraction of government offices and households. Most of the households rely on wells and water tankers. Since groundwater in most of the wells in Juba is high in salinity, and some wells are polluted, the use of groundwater becomes difficult for an urban water supply source. Also, the water tankers selling water to people are mainly raw river water that is not suitable for human consumption[29]. Water suppliers require information on the microbiological quality of their source water information on the contamination level of the source water is the basis for the design of an adequate treatment system. A water supplier also needs to know the efficiency of the treatment processes in eliminating microorganisms, initially in the designed phased to be able to design an adequate treatment system and subsequently in the production phase, to ensure its adequates operation. In the latter phase, detailed information on the microorganisms during the different operational phases may help to optimize the efficiency of treatment processes[30].

The two water clusters point taps install by UNICEF in Juba City, where water fetches from River Nile were treated with the aluminum sulfate and chlorine. Some 50,000 liters daily pumped out for private and commercial use. This small oasis offers a potable water source in a city where access to safe water isn't readily available. About 15 percent of Juba city residents only can access municipal water. A lot of the population is left vulnerable to waterborne diseases such as dysentery and cholera disease. According to an African Development Bank report, access to water supply service is among the lowest in Africa. And water scarcity affects more than 40 percent of the global population, according to the United Nations, and 1.8 billion people worldwide drinking water that is fecally contaminated. Some 1,000 children each day were dying from preventable water and sanitation-related diseases[31]. Despite available ground and surface water resources, evidence suggests that two in three people in the country South Sudan don’t have safe access and potable water supply services. More than six million people lack access to improve water supply services. Besides, 1,000 schools representing 50% of the total number of schools in South Sudan don't have access to water supply[32].[31]

The majority of the people in Juba city treat their water by using chlorine because chlorine tablets are the simple way of drinking water treatment and households trained in the areas on how to do filtration and sterilization of water since the cholera outbreak in Juba[23]. Chlorine is the most widely used disinfectant for the inactivation of waterborne pathogens in drinking water supplies historically has arguably contributed to the public health protection of the consumers. The post-treatment, primary disinfectant, and the level of the residual remain in the distribution water systems to ensure microbiological compliance can be a quality assured to consumer's taps in safeguarding against recontamination to the distributions system[33].

4.1.5 Biological Quality parameters

Biological parameters are the basics quality parameters for the control of diseases caused by pathogenic organisms, which have humans an origin. Pathogenic organisms found in surface water include bacteria, fungi, algae, protozoa, plants, animals, and viruses. These diseases, some caused organisms (algae, protozoa, bacteria, fungi, and viruses) were so difficult to identify and be observed microscopically only and may also be important in the changing of physical and chemical characteristics of water. The drinking water for cooking aims must be free from pathogens, greatly microbial risks connected with the consumption of contaminated water with human or animal feces[34].

Pollution by animal and human waste is the main factor for the majority of the microbiological degradation of surface water[35]. Unfortunately and regrettably, The Poor population of Juba city still directly depends on the River Nile water for drinking and all other domestic needs. The high fecal coliform presence concentration in the river water is a clear indication of the seriously municipal solids waste pollution in Juba. Also, it signifies the high percentage of both animal excreta and humans in the waste stream. Another majors source of this contamination is the discharge of direct illegal untreated sewage into the River Nile from the hotels along with it. Therefore, water contaminated with pathogens cause various waterborne diseases. It has being explains by the highest incidence of diseases such as typhoid, diarrhea, hepatitis A, and gastrointestinal infections in the city. Thus, the river water wasn't fit used for domestics purposes, except otherwise if treated: but it can use for recreational purposes, for example, swimming[36].

Table 3 Distribution of Coliform along the River Nile on the selected sample points[37].

Coliforms	Juba city (CFU/mL)	WHO Level (CFU/mL)
Total coliforms	20×10^4	100
Fecal coliforms	20×10^3	100
Escherichia coli (E. coli)	Is Present	100

4.1.6 Drinking Water quality in Juba city

Water quality is an important parameter, particularly in areas of severe water shortage, for urban development and ecological environment[38]. Water quality deterioration is the greatest challenge for the tradition of drinking water purification processes in achieving adequate removal of trace organic matters, toxic microbes such as Giardia lamblia and Cryptosporidium tyzzer, and the toxic organic halides produced chlorination[39].
Most developing and other developed countries use the WHO standards for drinking water quality measurement involves chemical, physical, and bacteriological analysis that determines

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the goodness of water for a particular aim. WHO guidelines reported that water quality effluents to test determinations for giving information concerning the water health and water qualities changing by applying water parameters such as temperature, pH, turbidity, salinity, nitrates, and phosphates, color, taste, odor, conductivity, chlorine, and the total dissolved solids. If the water is filtered to remove the suspended solids, the remaining solids in the water indicate TDS. If the dissolved solids in water exceed 300 mg/L, it adversely affects living organisms as well as industrial products[34, 40].

The Juba city four traditional water treatment plants haven't regularly monitored to the ascertain level. And the water quality trends have presented a high risk to increase water-related diseases connected with bad environmental sanitation practices exercised in most Southern Sudan parts, and the water supply facilities have been install over the years. Existing water supply facilities do not cater to the needs of entire towns and, this leads to the purchase of water from water tanks by the users. Most of these water tanks privately are owned, and these tanks filled up using water from the Rivers directly. While filling up the tanks, Liquid chlorine added to the tanks. However, no agency monitors the water quality supplied by these tanks. Water quality from these tanks should be monitor to avoid any outbreak of diseases[35].

4.1.7 Providing a Safe Drinking Water System in Juba city

Accessibility to safe drinking water always needs long, arduous hours of walking to the nearest borehole. Frequently many individuals resort to drinking dirty from surface water that has been used for bathing, washing clothes, and cleaning kitchen utensils[41]. Because of the lack of plans and policies for water resources management, both the water quantity and quality in these streams and River Nile has reached a terrible situation that doesn't allow its instant use[23]. The South Sudan water policy developed in 2009, and it represents a comprehensive framework for the sector. The keys principles are improved access to be a prioritized over-improved quality of water and water supply the requirement to provide technological options. The policy sees water as a human right and actively encourages community participation as well as through the involvement of the private sector in water service delivery[42].

Juba city residents have no clean and safe drinking water access. And since then, they have no other choices beyond the River Nile. They have to continue to consume raw water from the river. That has been saturating with the disease-causing microorganisms, inorganic and organic impurities that find themselves into the river either from domestic wastes or industrial wastes. As the population of Juba continues to grow, the water crisis in the city will continue to worsen, and if no appreciable measures have been taken and expeditiously so, the public health implications of this water crisis will soon become apparent to the government of South Sudan and the residents of Juba[43].

4.1.8 Drinking Water Quality Management in Juba city

The quality of water is a crucial issue to an assured safe consumption by the population. Water availability in sufficient quantity and quality is one of the mains focuses of the water resources management authorities[44]. Drinking water management must be able to satisfy the requirements of consumers regarding quantity and quality. The water has been transporting from the source to point distribution in a chain composed of six main links: adduction, storage, resource, capture, production, and distribution. The treatment link depends on the quality of the source water[45]. In Juba city, Water quality management and water distribution management focused on the maintenances and operations of the water supply system as the core value of water supply services. Also, strengthening customer services is primarily emphasized as the number of customers was planning to increase drastically toward the year 2015[29].

The communities in Juba city are thus eager for solutions to chronic issues such as dilapidated infrastructure, lack of investment, and unfair pricing. Ongoing safe access to potable water amid South Sudan's protracted crisis is fundamental to people's survival. It represents a step towards developing a situation of normality and the ultimate one in which the people can thrive. Partnership with the private sector has, however, demonstrated to communities that water treatment and distribution services can be better managed and has the potential to provide an extras source of income[46].

4.1.9 Drinking Water Responsibility in Juba city

The mandate of the South Sudan urban water corporation (SSUWC) is to provide the citizens with the drinking water. But the constraints of the resources-both financial and human continue to struggle to maintain services across the city. And cannot extend the service to underserved areas without external support. These have contributed to the dilapidation of existing service delivery systems, as well as due to a lack of clarity of sectoral roles and responsibilities leading to fragmentation and duplication exacerbated by weak accountability and oversight systems support[46].

Table 4 South Sudan Highlights based on Country Reported GLAAS 2016/2017 data[33].

SUSTAINABILITY MEASURES	EXISTENCE AND LEVEL OF IMPLEMENTATION	RESPONSIBILITY ASSIGNED TO
Improve reliability and continuity of urban water supply	Plans exist, but only moderate levels of implementation	South Sudan Urban Water Corporation (SSUWC), Local Government and Partners
Rehabilitate disused drinking-water hand Pumps	The planning exists, but only moderates levels of implementation	Local Water Departments, Water Users Committees
Ensure environmentally sustainability of water services	No plan or low levels of implementation	Ministry of Environment and Forestry (MEF), MWRI Directorate of Water Resources Management

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Ensure drinking-water quality meets national standards	Planning exists, but only moderate levels of implementation	Ministry of Health (MOH) Ministry of Water Resources and Irrigation (MWRI)

V. Discussion

5.1 Drinking Water System

The Juba city drinking water system predominantly from the Surface water and boreholes and public wells, which is not safe for drinking, unhygienic, and inadequate quality for human consumption. The water access coverage in the city is only about 20%. The water infrastructure under-investment has seriously impacted the drinking water system availability in Juba. The drinking water supply system is inadequate and requires urgent improvement. People used to source their drinking water from various places, never making sure whether it was safe or not? The vendor's water is untreated yet expensive and is the mains source of hygiene-related diseases.

5.2. Drinking-Water Supply

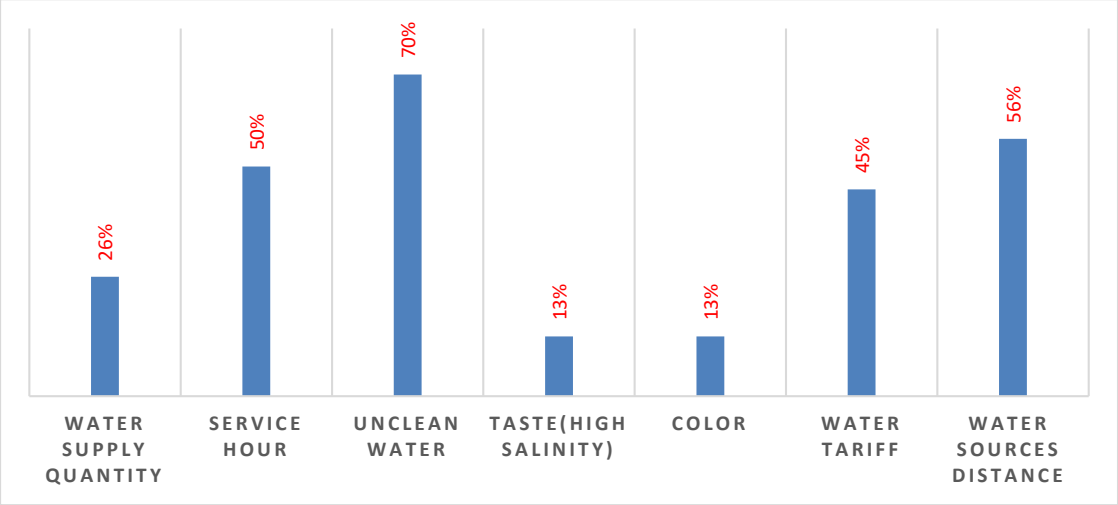

Fig.3. Showing the drinking water parameters in Juba city[29].

From **Fig.3,** the result shows that Juba city water supply quantity is 26%, the water doesn't cover the whole city, and the water supply quantity has just ended in a few areas. The majority of the people was relying on the water vendors or water tank truck to get water supply. Service hours are 50%, it's mainly due to the power issues, the electricity cannot operate the whole day, that's why it affects the service hours, and the water tariff is 45% due to the unavailability of the water supply quantity in the whole Juba city. However, 70% of the households have expressed their mains water sources are unclean because most of the Juba population used to obtain their drinking water from the Vendors and water tank truck, its water quality is not well treated. The water quality problems which the customer identified are color 13% and taste 13%. The watercolor and the taste appeared because of the less concentration on the water quality treatment. Over 90% of the households expressed dissatisfaction with the current water supply conditions of both mains and supplemental. And the distance for getting water source is 56%[29]. The water source points are very far from some residents and, it will take a half-hour to obtain drinking water and sometimes beyond this time.

The average time of the household's using urban water corporation UWC supplied water is 7 hours. The service hours of public tap and borehole with hand pumps are also restricted depending on the community. The average distance to water sources from the household is 281 minutes, and the average fetching time is 66 minutes. The water tanker's selling hour is also unscheduled, and the purchase of water may not be possible sometimes[29].

5.3. Treated Water Quality Parameters in Juba city 2018

The below table 5 are the results for the treated water quality parameters, the data composed of the following parameters such as water temperature, pH, conductivity, total dissolved solids (TDS), and residual chlorine.

Table 5 Treated Water Quality Parameters Results for Four Monthly
Chemical Parameters in Juba city 2018

Parameters	**Juba city, South Sudan**				**Specifications**	
	Jan	March	June	Aug	South Sudan GV	WHO GV
Water Temperature (˚C)	25.9	30.0	27.3	29.5	-	25
pH	7.9	7.3	7.3	7.9	6- 8.5	6.5 – 8.5
Conductivity (mS/m)	1420	132	138	131	150	400
TDS (mg/L)	719	482	590	572	1000	600

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Residual Chlorine	1.6	1.5	1.5	1.8	-	0.2

From the indicated Table 5, results show that water temperature for January, March, June, and August 25.9, 30.0, 27.3, 29.5˚C was above the WHO guideline value 25˚C. The water temperature could be higher due to the seasonal variation of temperatures, and the highest water temperature enhances the growth of microorganisms. And it may increase taste, odor, color, and corrosion problems[47]. The pH for January, March, June, and August 7.9, 7.3, 7.3, 7.9 was found to be normals in range with WHO recommended value (see Table 5). Therefore, pH was a measure of how acidic/basic water is-with the 7, beings neutral[48]. The water conductivity for January and August is 1420, 1331 mS/m is above the WHO guideline value 400 mS/m. It's because of the anthropogenic factors are thrown into the River Nile. However, for March and June 132,138, mS/m is below the WHO guideline value 400 mS/m. There was a significant change in the water conductivity in these mentioned four months January, March, June, and August. It could then be an indicator that less discharge or some other source of water pollution has entered River Nile during June, and August is the raining season in Juba city[49]. The TDS for January 719 mg/L is beyond the WHO guideline value 600 mg/L. that means the River Nile was exposures to some of the pollution substances. So the treated water quality for January is not well safe for drinking. The TDS for March, June, and August 482,590,572 mg/L found to be normals and in range with the WHO guideline value for the TDS 600 mg/L. Therefore, the treated water quality for March, June, and August is safe for drinking. The Residual chlorine for January, March, June, and August 1.6, 1.5, 1.5, 1.8 mg/L has a significant variation and above the WHO guideline standard 0.2 mg/L. The residual chlorine of 1.5 mg/L indicated that water is not well disinfected. Therefore, the water requires is 2.0 mg/L of recommended residual chlorine levels to destroy all organisms[50].

VI. Conclusion

The Juba city drinking water source is mostly from surface water, boreholes, water tank truck, and public-wells. That is not safe for drinking. The access to drinking water system coverage in Juba city is only about 20%. It has put the communities' drinking water in Juba city to source their drinking water from various places such as the River Nile that is dirty. The study results show the water temperature for January, June, March, August 25.9, 30.0, 27.3, 29.5˚C were above the WHO guideline value 25˚C. The highest water temperature has increase taste and color problems. Water conductivity for January, March, June, August 1420, 132, 138, 1331 mS/m were not in range with the WHO guideline 400 mS/cm. So the changing of water conductivity indicates that River Nile has received the discharge of pollution, especially in June and August are the raining seasons in Juba city. The residual chlorine 1.6, 1.5, 1.5, 1.8 mg/L were above the WHO guideline standard 0.2 mg/L. the residual chlorine of 1.5 mg/L indicated that water is not well disinfected. The pH for January, March, June, August 7.9, 7.3, 7.3, 7.9 mg/L was found to be normals with the WHO guideline value 6.5, 8.5 mg/L. And the TDS for January, March, June, 482,590, 572, mg/L were also found to be normals in range with the WHO guideline value 600 mg/L. Therefore, the treated water quality for March, June, and August is safe for drinking. While the TDS for August 719 mg/L is not in range with the WHO guideline value, it's due to the exposure of the waste into River Nile.

Therefore, the study has concluded that the under-investment in drinking water system infrastructure in Juba city has seriously affected the availability of the drinking water system. The treated water quality parameters for January are not well safe for the drinking, while for March, June and August were safe for drinking. Therefore, the study has recommended that Juba city should improve the development of the infrastructures for the drinking water systems and treat the water quality parameters in accordance to the WHO permissible level to meet the 2030 Sustainable Development Goals formulated in 2015 as the 2030 Agenda through the water as key to Sustainable Development.

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