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Evaluation of the Efficiency of Disc Filters used by Peri-Urban Farmers in Removing Impurities from Wastewater at Zagyuri Irrigation System in Sagnerigu Municipal of Northern Region of Ghana

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ABSTRACT

The results indicated that the study water was polluted and could only be suitable for drip and sprinkler irrigation if filtered at two levels: before and after storage to avoid blockage of emitters, since the water was highly turbid with high content of suspended particles. The physio-chemical parameters such as turbidity, Ph, conductivity and chlorine were within the World Health Organization standard for irrigation with wastewater. The trace metals such as copper, zinc, iron and manganese were below World Health Organization standard for irrigation with wastewater and also below the Environmental Protection Agency of Ghana standard. This indicates that the trace metals concentration in wastewater at Zagyuri has insignificant risk to soil and vegetable crops produced. Disc filtration can effectively reduce the concentration of suspended solids, colloidal matter, and certain dissolved constituents.

1.0 INTRODUCTION

1.1 Global Water Resources: Challenges and Opportunities

Water is a vital resource for life, and its availability and management have significant implications for human well-being, economic development, and environmental sustainability. However, the world is facing increasing challenges in terms of global water resources, including issues related to water scarcity, water quality degradation, and water management.

Water scarcity is a critical challenge that affects many regions around the world. As population growth, urbanization, and industrialization continue to rise, the demand for water for various purposes, such as agriculture, domestic use, and industry, is increasing. At the same time, climate change, including changing precipitation patterns and increased evaporation rates, is affecting water availability in many regions. According to the United Nations (UN), more than 2 billion people, or about one-fourth of the global population, currently live in countries facing high water stress, where water resources are scarce or overexploited (UN, 2021). This has severe implications for agriculture, livelihoods, and ecosystems.

Water quality degradation is another significant challenge in global water resources management. Pollution from various sources, including agricultural runoff, industrial discharge, and domestic waste, is contaminating water bodies, making them unfit for human consumption and damaging ecosystems. Water pollution not only affects human health but also has economic consequences, such as the cost of treating polluted water for safe use and the impact on industries that rely on clean water for production.

Water management is a crucial aspect of addressing the challenges of global water resources. Effective water management involves planning, development, allocation, and use of water resources in an integrated and sustainable manner. However, water management practices vary greatly around the world, and many regions face issues related to inadequate infrastructure, inefficient water use, and inadequate governance and policies. There are also opportunities for addressing the challenges of global water resources. Integrated Water Resources Management (IWRM), which promotes a holistic and participatory approach to water management, is gaining traction as a framework for addressing water challenges at the regional, national, and local levels (UNESCO, 2020). IWRM focuses on balancing the competing demands of various water users, ensuring social equity, economic efficiency, and environmental sustainability in water management. Another opportunity is the adoption of new technologies and innovative approaches for water resources management. For example, remote sensing, data analytics, and sensor-based technologies can provide valuable information for monitoring, modeling, and optimizing water use. Water-saving technologies, such as drip irrigation and precision agriculture, can improve water use efficiency in agriculture. Additionally, nature-based solutions, such as watershed restoration, wetland conservation, and green infrastructure, can help enhance water quality, increase water availability, and mitigate the impacts of climate change.

International cooperation and governance are critical for addressing global water challenges. Transboundary water resources, such as shared rivers and aquifers, often require cooperative management among multiple countries to ensure equitable and sustainable use. International organizations, such as the United Nations and its agencies, play a significant role in facilitating global cooperation on water resources management through policy advocacy, capacity building, and knowledge sharing. In conclusion, global water resources face significant challenges related to water scarcity, water quality degradation, and water management. However, there are also opportunity es for addressing these challenges through integrated water resources management, adoption of new technologies and innovative approaches, and international cooperation and governance. Sustainable and equitable management of global water resources is essential for ensuring human well-being, economic development, and environmental sustainability.

Global water resources are under increasing pressure due to various factors, including population growth, urbanization, industrialization, and climate change. These challenges are reflected in numerous facts and figures that highlight the magnitude of the global water crisis: Water scarcity: According to the World Wildlife Fund (WWF), around 2.2 billion people globally do not have access to safe drinking water, and over 4 billion people experience severe water scarcity for at least one month per year (WWF, 2021). Water scarcity affects not only human populations but also agriculture, industries, and ecosystems, leading to reduced crop yields, increased conflicts over water resources, and ecosystem degradation.

Water quality degradation: Water pollution is a significant issue that affects water resources worldwide. The World Health Organization (WHO) estimates that about 2 billion people globally use drinking water that is contaminated with feces, leading to waterborne diseases such as diarrhea, cholera, and typhoid (WHO, 2019). Water pollution also has economic consequences, with estimated costs of water treatment and healthcare associated with waterborne diseases amounting to billions of dollars annually.

Inefficient water use: Many regions around the world face challenges in terms of inefficient water use. In agriculture, which accounts for the largest share of global water consumption, inefficient irrigation practices can result in water wastage through runoff, evaporation, and inefficient distribution. According to the Food and Agriculture Organization (FAO), globally, only about 40% of the water withdrawn for agriculture is effectively used, while the rest is lost or wasted (FAO, 2020). Improving water use efficiency in agriculture through technologies such as drip irrigation and precision agriculture can help minimize water wastage. Climate change impacts: Climate change is exacerbating the challenges of global water resources. Changing precipitation patterns, increased evaporation rates, and more frequent and severe droughts and floods are affecting water availability and quality in many regions. According to the Intergovernmental Panel on Climate Change (IPCC), climate change is projected to increase the frequency and intensity of extreme weather events, leading to more uncertainty in water availability and impacting water resources management (IPCC, 2014). Transboundary water management: Transboundary water resources, such as shared rivers and aquifers, pose additional challenges for global water resources management. Approximately 60% of global freshwater flows in rivers that cross international boundaries, and about 90 countries share water resources with neighboring countries (UNESCO, 2019). Cooperation among countries is essential for managing transboundary water resources effectively and ensuring equitable and sustainable use. Water-related conflicts: Competition over water resources can also lead to conflicts at various scales, from local to international. Disputes over water allocation, access, and management can arise among different water users, such as farmers, industries, and urban populations. Water-related conflicts can have severe social, economic, and environmental consequences, exacerbating the challenges of global water resources. In light of these challenges and facts, addressing the issues related to global water resources requires concerted efforts at local, national, regional, and global levels. Sustainable water management practices, including integrated water resources management, adoption of water-saving technologies, nature-based solutions, and international cooperation and governance, are critical for ensuring the availability, accessibility, and quality of water resources for present and future generations.

1.2 Water Resources

Water, as a natural resource, holds immense importance in human daily activities. Its presence across the Earth is widespread, and its role within the natural ecosystem cannot be underestimated. According to Wikipedia (2012), water resources encompass sources of water that serve practical or potential purposes, ranging from agricultural and industrial to household, recreational, and environmental activities. Nearly all of these human applications necessitate the use of freshwater. Various studies by different authors have estimated the global water resource base differently, with figures such as 42,780 km^3/year (Shiklomanov, 2000), 44,540 km^3/year (Gleick, 2001), and 43,764.3 km^3/year (FAO, 2003) being reported. FAO (2003) similarly assesses the total worldwide water resources at approximately 43,764.3 km^3/year, distributed across the globe according to the diverse array of climates and geographic features. On a continental scale, the distribution of freshwater resources is characterized by America having the largest share, accounting for 45% of the world's total freshwater resources, followed by Asia with 28%, Europe with 15.5%, and Africa with 9%. When evaluating resources per inhabitant or per capita for each continent, America boasts 24,000 m^3/year, Europe 9,300 m^3/year, Africa 5,000 m^3/year, and Asia 3,400.1 m^3/year (FAO, 2003). According to Wikipedia (2012), the Earth's water resources encompass freshwater (3%) and saline water (oceans, 97%). Within the 3% freshwater category, surface water accounts for 0.3%, with freshwater surface sources, such as rivers making up 2% (swamps comprising 11% and lakes 87%), while the remaining 0.9% includes groundwater (30.1%) and ice caps and glaciers (68.7%). Global withdrawal of freshwater resources is on the rise, closely linked to population growth and the rapid industrialization of continents. This distribution of the Earth's water resources is visually represented in Figure 1 below, illustrating the global allocation of these resources (Peslier et al., 2017).

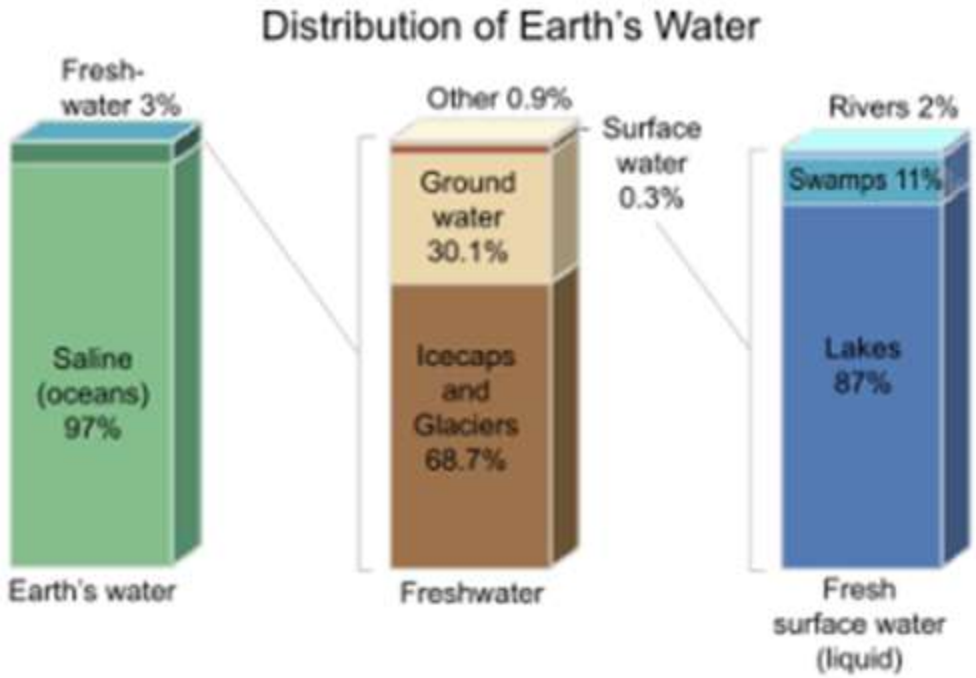

Figure 1.0 Distribution of the Earth's Water Resources. Source; (Peslier et al.,2017)

Shiklomanov (1998) recognized the importance of water especially freshwater as it was indicated that human life itself will be impossible without it as it has no substitution. According to recent studies, the utilization of water from various sources has become a critical global issue. In the past, man's impact on water resources was considered insignificant and localized. However, recent research shows that water supply variability is both spatial and temporal in nature, with significant fluctuations within months, years, and even decades, largely influenced by climate change (FAO, 2010). A study conducted by the FAO in 2010 revealed that the ten poorest countries in terms of water resources per inhabitant are Bahrain, Jordan, Kuwait, Libyan Arab Jamahiriya, Maldives, Malta, Qatar, Saudi Arabia, United Arab Emirates, and Yemen. These countries often face challenges due to uneven distribution of water resources in relation to their growing populations, and they are usually characterized by arid or island environments (FAO, 2010). Furthermore, global water withdrawal has increased significantly over the past few decades due to various factors such as expansion in irrigated areas, industrial and power engineering water consumption, and construction of reservoirs (Shiklomanov, 2010). This has led to a massive anthropogenic change in the hydrological cycle of rivers and lakes worldwide, affecting their water quality, potential as water resources, and the global water budget (Shiklomanov, 2010). The importance of large river systems in global water resources cannot be overstated. The Amazon, Ganges with the Brahmaputra, Congo, Yangtze, and Orinoco rivers together form 27% of the world's water resources, with the Amazon alone accounting for 16% of the annual global river runoff (Shiklomanov, 2010). However, many regions are facing depletion and contamination of water resources due to increasing demands and pollution, leading to adverse impacts on economic development and population growth (Shiklomanov, 2010). One notable concern is the arid regions, which have limited water resources, high water use, and rapid demographic growth (Shiklomanov, 2010). This exacerbates the challenges of water scarcity and calls for effective water management strategies to ensure sustainable utilization of this precious resource. In conclusion, the global distribution of freshwater resources is highly variable, with significant challenges faced by water-poor countries and regions with arid environments. The increasing demand for water, coupled with climate change impacts, has further exacerbated the variability of water supply. Sustainable water management practices are crucial to ensure equitable access to water resources and mitigate the adverse effects of water scarcity on economic development and population growth.

1.1.2 Water Resources Available for Irrigation in Sub-Saharan Africa

Water scarcity and its impact on food production in Sub-Saharan Africa continue to be critical challenges, as reported in various articles from 2010. With a growing global population, increasing demand for food, and ongoing industrialization, the availability and quality of water resources in Africa are crucial for socio-economic development. However, reports from the Economic Commission for Africa (ECA) indicate that freshwater scarcity is a pressing issue in Africa, with over 300 million people out of the estimated 800 million population living in water-scarce environments. Although Africa has ample water resources, with less than 4% of the continent's renewable water resources withdrawn for various uses including agriculture, domestic supply, sanitation, and industry, the potential of irrigated agriculture remains largely untapped in most African countries, including Sub-Saharan Africa. Barriers to the development of irrigated agriculture in Africa include lack of financial and human resources to build infrastructure and acquire technology. Sub-Saharan Africa and South Asia are the regions worst affected by food insecurity and malnutrition, home to 60% of the world's food-insecure people and 75% of its malnourished children. To address these challenges, the ECA recommends investing in the development of Africa's potential water resources, expanding irrigation areas to ensure food security, and effectively managing droughts, floods, and desertification to protect the gains of economic development. Despite the economic potential of water-scarce countries in Sub-Saharan Africa to meet their future water needs, many may lack the necessary investments to harness and utilize their water resources. Moreover, there are significant disparities in freshwater withdrawals among regions within countries, with less-developed regions relying heavily on agriculture for water abstraction. For example, the Ewaso Ng'iro North basin in Kenya is already facing serious physical water scarcity, highlighting the spatial variability of water resources within Sub-Saharan Africa. In conclusion, water scarcity remains a critical challenge for food production and socio-economic development in Sub-Saharan Africa, with ample water resources available but underutilized. Investments in infrastructure, technology, and effective water management are needed to unlock the potential of irrigated agriculture and address food insecurity in the region.

Furthermore, addressing water scarcity in Sub-Saharan Africa requires prioritizing access to safe water and adequate sanitation, particularly for communities that lack these basic services. This is crucial for improving public health, reducing waterborne diseases, and ensuring overall well-being of the population. Efforts towards achieving the water-related goals set within the framework of the Millennium Development Goals (MDGs) and the Africa Water Vision 2025 should be intensified, with a target of increasing the development of water resources potential by 5% by 2005, 10% by 2015, and 25% by 2025, as recommended by the 20 African Water Vision 2025. This will require adequate financial and human resources, as well as innovative technologies and sustainable management practices, to harness and utilize water resources effectively. In addition to agriculture, water resources in Sub-Saharan Africa also play a crucial role in other sectors such as hydropower, industry, tourism, and transportation. Therefore, integrated water resources management approaches that consider the multiple uses of water are essential for sustainable development in the region. It is important to recognize that water scarcity and its impacts are not uniform across Sub-Saharan Africa, with significant temporal and spatial differences. While some regions and river basins already face severe water scarcity, others may have untapped water resources. Therefore, context-specific solutions that consider the local socio-economic, environmental, and climatic conditions are necessary to effectively address water scarcity in Sub-Saharan Africa. In conclusion, addressing water scarcity in Sub-Saharan Africa is crucial for sustainable food production, economic development, and human well-being. Investments in infrastructure, technology, and sustainable management practices, as well as ensuring access to safe water and sanitation, are essential to unlock the potential of water resources and achieve water-related goals for the region's development. Table 2.1 indicates that per capita abstractions in developed countries are much higher than in developing countries and lowest in Africa.

Recent studies (Inocencio *et al*., 2010) highlight that low water withdrawals in Sub-Saharan Africa (SSA) serve as indicators of under-development and underscore the potential for further development of water resources in the region. With rapidly growing urban populations, there is an increasing competition between agriculture and urban (municipal and industrial) water needs. This often leads to reduced water allocations for agriculture in favor of higher-value urban uses, which can have adverse effects on food production. Given that food production in Africa already lags behind population growth, reduced allocations for agriculture may exacerbate the problem of food security (Inocencio *et al*., 2010).

In Sub-Saharan Africa (SSA), one pressing issue linked to water usage is the absence of wastewater treatment for irrigation purposes. Despite the potential of urban wastewater to serve as a stable water supply source, especially during droughts when urban water demands take precedence, a significant portion of wastewater used for irrigation in SSA remains untreated (Barry, 2010). Addressing this concern entails a focus on the participatory development of peri-urban agriculture, taking into consideration the needs of both peri-urban farmers and the urban populace. This approach involves the integration of government planning, investment, and extension efforts related to wastewater treatment, followed by its utilization by informal or private-sector farmers (Barry, 2010).

The distribution of water resources across Africa exhibits disparities, with an overall abundance of resources but varying accessibility across different agro-ecological zones (Svendsen *et al.,* 2010). Attempts to manage water resources and ensure availability in regions with the greatest need encounter numerous challenges. These include historical underinvestment in irrigation and the broader water sector, underdeveloped institutions for irrigation and water-resource management, and the prevalence of subsistence farming practices. Furthermore, despite the presence of abundant groundwater resources in many parts of the continent, with the exception of southern Africa, they remain largely untapped (Svendsen *et al.,* 2010). Sub-Saharan African nations have been observed to make relatively limited use of their plentiful water resources compared to other global regions. The extent of water utilization for purposes like irrigation can be evaluated through parameters such as total water withdrawals, agricultural water withdrawals, surface water storage capacity, and the exploitation of groundwater (Svendsen et al., 2010). Total water withdrawals across the region are very low, averaging just 3 % of available supply (Table 1).

Table 1 Indicators and Baseline Values of Water Resource Use in Africa, Sub-Saharan Africa the World

	Indicators (Percent)			
Region	Total Water Withdrawals as share of Total Renewable Water Resources	Agricultural Water Withdrawals as share of Total Renewable Water Resources	Dam Capacity as Share of Total Available Surface Water	Groundwater Pumped as a Percentage of Total Renewable Groundwater
Africa	3.8	3.3	14.6	-
SSA	1.5	1.3	11.2	-
Sudano-Sahelianbkc	28.3	27.3	9.8	3.3
Eastern	5.7	4.9	5.5	3.1
Gulf of Guinea	2.2	1.5	61.7	0
Central	0.1	0.1	0.9	0
Southern	9.1	5.8	47.8	21
Indian Ocean Islands	4.4	4.2	0.1	8.7
Asia	19.4	15.8	12	-
World	7.4	5.2	7.6	-

- *Indicates No Available Data.* ***Source:*** *FAO Aquastat Database; Global Groundwater Information System***:** *Adopted and Modified from Svendsen et al., 2008*

In contrast to the global landscape, Africa possesses a relatively minute proportion of its land equipped for irrigation. Moreover, the expansion of irrigated areas in the continent has experienced a marked slowdown since the year 2000. A mere 6% of Africa's cultivated land benefits from irrigation infrastructure, with the figure dropping even lower to 3.9% when considering a sample of 24 African countries. This stands in stark contrast to Asia, where 33.6% of cultivated land is under irrigation, and the global average of 17.7% (Table 2) (Svendsen *et al.,* 2008).

According to recent studies, lower utilization rates of water resources in sub-Saharan Africa can be attributed to various factors such as deteriorating facilities, insufficient water supply, and deficient management (Svendsen *et al*., 2008). The average utilization rate in the sample countries is reported to be 69.4%, which is comparable to the Asian average but falls well below the global average.

In order to meet targets for poverty alleviation and food security, substantial investments in agriculture are needed in sub-Saharan Africa. The Food and Agriculture Organization (FAO) of the United Nations estimates that around 75% of the required growth in crop production by 2030 will need to come from intensification, including yield increases and higher cropping intensities (FAO, 2002). Development of water resources will be crucial for achieving this intensification. Currently, only 24% of arable land in Africa is under cultivation, with a mere 0.5% under formal irrigation. However, it is estimated that annual renewable water resources in sub-Saharan Africa are abundant, though not evenly distributed, with only 2% of the annual renewable resource being abstracted for human use (FAO, 2002). In urban and peri-urban environments of Africa, another common practice is the use of wastewater for irrigation, which poses environmental and health risks. Studies have reported concerns such as salinization, eutrophication, and pollution of soils and drainage water with heavy metals and toxic substances associated with the use of wastewater for irrigation (Scott *et al*., 2004; Drechsel *et al*., 2006). However, wastewater can also serve as an important water and nutrient resource, improving socio-economic conditions for farmers and their families (Obuobie *et al*., 2006). For instance, in Ghana, irrigated urban and peri-urban vegetable farming using polluted water was found to generate significant incomes for farmers (Danso *et al*., 2002).

Table 2 Indicators and Baseline Values of Irrigation Area an Africa, Sub-Saharan Africa, Asia and the World

	Indicators (%)		
Region	Irrigation-equipped areas as share of cultivated area	Area actually irrigated as share of irrigation-equipped area	Water Managed area as share of cultivated area
Africa	5.8	81.6	6.7
SSA	3.5	71.0	4.5
Asia	33.6	66.9	34.3
World	17.7	92.4	17.6

***Sources** FAO Aquastat Database and Resource Stat Databases: Adopted and Modified from Svendsen, et al., 2008 and McCartney, et al., 2007*

1.1.3 Concept of Wastewater and Sewage

Wastewater and sewage are critical aspects of water management and sanitation, particularly in urban areas. Wastewater refers to water that has been used for various purposes, such as domestic, industrial, or agricultural activities, and contains contaminants that require treatment before being discharged or reused (UN-Water, 2013). Sewage, on the other hand, specifically refers to the wastewater generated from human activities, including toilet flushing, bathing, and laundry (WHO, 2012). The treatment of wastewater and sewage is crucial to protect public health and the environment. Untreated wastewater and sewage can contain harmful pathogens, chemicals, and pollutants that can contaminate water sources, leading to waterborne diseases and environmental degradation (UN-Water, 2013). Proper treatment of wastewater and sewage is essential to remove or reduce these contaminants to acceptable levels before discharge or reuse.

Wastewater and sewage treatment processes typically involve physical, chemical, and biological treatment methods, depending on the level of contamination and desired treatment goals. Common treatment processes include primary treatment, which involves physical removal of solids and floating debris; secondary treatment, which involves biological processes to remove organic matter; and tertiary treatment, which may involve additional processes such as chemical disinfection or nutrient removal (WHO, 2012).

Effective management of wastewater and sewage requires robust infrastructure, institutional frameworks, and policies to ensure proper collection, treatment, and disposal or reuse of wastewater and sewage. This includes the establishment of wastewater treatment plants, sewage collection networks, and regulatory mechanisms to monitor and enforce compliance with wastewater and sewage treatment standards (UN-Water, 2013). In conclusion, the proper treatment and management of wastewater and sewage are critical for protecting public health, preserving water resources, and promoting sustainable development. Efforts should be made to invest in adequate infrastructure, institutional capacity, and policies to ensure effective wastewater and sewage management in urban areas (WHO, 2012; UN-Water, 2013).

1.1.4 Wastewater Uses and Problems: Global Perspectives

According to recent studies, wastewater use in irrigated agriculture poses global perspectives, including both benefits and problems. Studies from 2010 onwards have highlighted the challenges and opportunities associated with wastewater use for irrigation (Scott *et al*., 2010; Drechsel *et al*., 2015). Wastewater irrigation has been found to be associated with various environmental and health risks, such as soil salinization, eutrophication, and pollution with heavy metals and toxic substances (Scott *et al*., 2010; Drechsel *et al*., 2015). On the other hand, wastewater can also serve as a valuable water and nutrient resource, improving socio-economic conditions for farmers and their families (Obuobie *et al*., 2010). In sub-Saharan Africa, where agriculture is a key driver for poverty alleviation and food security, wastewater use in urban and peri-urban environments has become a common practice (Scott *et al*., 2010; Drechsel *et al*., 2015). Studies have reported that this practice generates significant incomes for farmers, ranging from US$500-700 per year, depending on farm size, crop type, and cropping intensity (Danso *et al*., 2010). However, this practice also comes with associated risks, including potential contamination of crops and soils with heavy metals and toxic substances (Scott *et al*., 2010; Drechsel *et al*., 2015). Despite these challenges, wastewater irrigation has been recognized as an important strategy for improving water and nutrient availability in agriculture, particularly in regions with limited water resources (Obuobie *et al*., 2010). Table 3 below shows some characteristics of countries using wastewater for irrigation.

Table 3 Some Characteristics of Countries Using Wastewater for Irrigation

Use of Wastewater for Irrigation	Total Number of Countries	GDP per capita for 50% of the Countries (in US$)	Sanitation coverage for 50% of the Countries (%)
Untreated	23	880-4800	15-65
Treated and Untreated	20	1170-7800	41-91
Treated	20	4313-19800	87-100

Source: Jiménez *et al.* (2010a)

Jiménez *et al.* (2010a) have highlighted the absence of a comprehensive global inventory concerning the extent of untreated wastewater employed for irrigation, and even less information is available regarding treated wastewater. Estimated figures of over 4-6 million hectares of fields irrigated with wastewater or polluted water have been reported, drawing from data provided by countries disclosing information on irrigated areas, as reported by Jiménez and Asano (2008), Keraita *et al.* (2008), and UNHSP (2008). Within the developing world, Raschid-Sally and Jayakody (2008) have reported that four out of every five cities utilize untreated wastewater for irrigation purposes. However, the extent of wastewater use varies considerably from one country to another, often contingent on geographic location and the availability of freshwater resources. Developing countries, where 75% of the world's irrigated land is situated (UN, 2003), are noted for substantially higher quantities of wastewater utilization, in contrast to developed countries, where the practice is relatively limited (Jiménez and Asano, 2008). FAO (1992) has documented the historical practice of beneficial wastewater use in California dating back to the 1890s when raw sewage was employed in 'sewer farms.' By 1987, over 0.899 million m^3/d of municipal wastewater (equivalent to 7-8% of production) were being utilized for these purposes. While agricultural applications have historically dominated, the past decade has seen a growing trend of reclaimed wastewater use for urban landscape irrigation and groundwater recharge. Notably, 78% of reclaimed water is used in California's Central Valley and South Coastal regions, saving 0.759 million m3/d of freshwater (FAO, 1992). The utilization of wastewater in crop irrigation presents significant challenges, particularly concerning the presence of disease pathogens that can pose health risks. As noted by Jiménez *et al.* (2010a), the nature of these pathogens in wastewater varies locally and is linked to local public health patterns. Risks associated with wastewater use extend beyond just farmers and include agricultural workers and their families, crop handlers, consumers of crops and livestock products from animals grazing on contaminated fields, and residents living in or near areas where wastewater, sludge, or excreta is applied. Abaidoo *et al.* (2009) have emphasized that wastewater can be a source of elevated levels of heavy metals and toxic compounds. Contamination, as highlighted by Jiménez (2006), occurs through absorption from the soil, a process influenced by factors such as location, environmental conditions, bio-availability, plant types, and agricultural practices. Recommended levels of heavy metals in wastewater that crops and soil can be exposed to have been documented by Page and Chang (1994) and UNHSP (2008). Despite the potential for wastewater to serve as a source of crop fertilization in both developed and developing countries due to its lower levels of heavy metals (Jiménez and Wang, 2006; UNHSP, 2008), Abaidoo *et al.* (2009) caution against its use in proximity to tanneries and mining areas.

1.1.5 Utilisation of Wastewater in Developing Countries

The utilization of wastewater in developing countries has gained attention in recent years due to its potential for addressing water scarcity, enhancing food production, and improving livelihoods. Studies from the past decade have highlighted the status, challenges, and opportunities of wastewater utilization in developing countries (Jimenez *et al*., 2013; Qadir *et al*., 2018).

Wastewater is increasingly being used for agricultural irrigation in developing countries, particularly in urban and peri-urban areas where water resources are limited (Jimenez *et al*., 2013; Qadir *et al*., 2018). This practice has been found to have significant benefits, including increased crop yields, reduced reliance on freshwater sources, and improved livelihoods for farmers (Scott *et al*., 2010; Qadir *et al*., 2018). Additionally, wastewater can serve as a valuable source of nutrients for crops, contributing to improved soil fertility and reduced need for chemical fertilizers (Qadir *et al*., 2018). However, the utilization of wastewater in developing countries also poses challenges. One of the main concerns is the potential contamination of

crops and soils with pathogens, heavy metals, and other pollutants present in untreated or inadequately treated wastewater (Jimenez *et al*., 2013; Qadir *et al*., 2018). This can pose risks to human health, both for farmers and consumers of the crops, if proper safety measures are not followed (Scott *et al*., 2010; Qadir *et al*., 2018). Additionally, the lack of appropriate regulations, monitoring, and enforcement mechanisms for wastewater use in agriculture in many developing countries can further exacerbate the risks associated with this practice (Jimenez *et al*., 2013).

Despite these challenges, there is a growing recognition of the potential of wastewater utilization in developing countries as a sustainable water and nutrient management strategy. Efforts are being made to improve the safety and sustainability of wastewater use in agriculture through the development and implementation of guidelines, regulations, and best management practices (Scott *et al*., 2010; Qadir *et al*., 2018). Moreover, capacity building and awareness-raising activities are being conducted to promote safe and responsible wastewater use in agriculture in developing countries (Jimenez *et al*., 2013; Qadir *et al*., 2018).

1.1.6 Wastewater Generation and Utilization in Ghana

Wastewater generation and utilization in Ghana has been a topic of growing interest and concern in recent years. As a developing country in sub-Saharan Africa, Ghana faces significant challenges in managing its wastewater resources while also striving to achieve sustainable economic and social development. In this paper, we will examine the current status of wastewater generation and utilization in Ghana, including the challenges and opportunities associated with this practice. Wastewater generation in Ghana is mainly driven by rapid urbanization, population growth, and industrialization. The country has experienced significant urbanization in recent decades, with a large proportion of the population living in urban and peri-urban areas (Ghana Statistical Service, 2019). This has led to increased demand for water supply and sanitation services, resulting in a corresponding increase in wastewater generation (Amoah *et al*., 2010). Industrial activities, particularly in the manufacturing and mining sectors, also contribute to the generation of wastewater in Ghana (Ghana Environmental Protection Agency, 2019). Despite the increasing volume of wastewater generated in Ghana, the treatment and disposal infrastructure is inadequate, resulting in a significant portion of wastewater being discharged untreated or inadequately treated into the environment (Amoah *et al*., 2010; Obiri-Danso *et al*., 2011). This has raised concerns about the potential environmental and health risks associated with the discharge of untreated wastewater into rivers, lakes, and other water bodies, as well as the contamination of groundwater sources (Ghana Water Company Limited, 2018).

In recent years, there has been growing interest in the utilization of wastewater in Ghana for agricultural irrigation, particularly in urban and peri-urban areas where water resources are limited (Danso *et al*., 2002; Obuobie *et al*., 2006). Wastewater irrigation has been practiced in Ghana as a means of augmenting water supply for agriculture and improving livelihoods for farmers (Danso *et al*., 2002). Studies have shown that irrigated urban and peri-urban vegetable farming using wastewater can generate significant incomes for farmers, ranging from US$500 to US$700 per year, depending on farm size, crop type, and cropping intensity (Danso *et al*., 2002). The utilization of wastewater in agriculture in Ghana, however, is not without challenges. One of the main concerns is the potential contamination of crops and soils with pathogens, heavy metals, and other pollutants present in untreated or inadequately treated wastewater (Obiri-Danso *et al*., 2011; Drechsel *et al*., 2012). Studies have shown elevated levels of fecal coliforms, heavy metals, and other contaminants in crops irrigated with wastewater in Ghana, which can pose risks to human health if proper safety measures are not followed (Obiri-Danso *et al*., 2011; Drechsel *et al*., 2012).

Another challenge is the lack of appropriate regulations, guidelines, and enforcement mechanisms for wastewater use in agriculture in Ghana. The existing regulatory framework for wastewater management in Ghana is fragmented and lacks comprehensive guidelines and standards for the safe use of wastewater in agriculture (Ghana Water Company Limited, 2018). This has resulted in inconsistent practices and inadequate monitoring of wastewater use in agriculture, which further exacerbates the risks associated with this practice. Despite these challenges, there are opportunities for improving the management and utilization of wastewater in Ghana. Efforts are being made to develop and implement guidelines, regulations, and best management practices for safe wastewater use in agriculture (Ghana Water Company Limited, 2018). Capacity building and awareness-raising activities are also being conducted to promote safe and responsible wastewater use among farmers, extension agents, and other stakeholders (Obuobie *et al*., 2006). Moreover, there is potential for integrating wastewater treatment and

1.1.7 Composition and Characteristics of Wastewater

The physico-chemical and bacteriological qualities of wastewater are subsequently reviewed.

1.1.8 Physical Characteristics of Wastewater

Temperature

Temperature is an important physical characteristic of wastewater that can impact various aspects of wastewater management and treatment processes. The temperature of wastewater can vary depending on its source and ambient conditions, and it plays a significant role in influencing the efficiency and effectiveness of treatment processes (Wu *et al*., 2010). In wastewater treatment processes, temperature can affect the rate of biological and chemical reactions. Many biological processes, such as aerobic and anaerobic digestion, nitrification, and denitrification, are temperature-dependent, with optimal temperature ranges for their activity (Sundell *et al*., 2013). For example, higher temperatures can promote faster biological activity, leading to increased degradation of organic matter and nutrients, while lower temperatures may slow down or inhibit these processes (Kang *et al*., 2012). Temperature also impacts the performance of physical and chemical treatment processes. In sedimentation, for instance, higher temperatures can reduce the settling time and improve the settling efficiency of suspended solids, while lower temperatures may lead to reduced settling and increased solids carryover (Wang *et al*., 2017). Similarly, temperature can affect the efficiency of disinfection processes, such as chlorination or UV disinfection, as higher temperatures can enhance the disinfection effectiveness (Bachmann *et al*., 2016).

The temperature of wastewater can also impact the operational costs of treatment processes. Heating or cooling wastewater to achieve the desired temperature for optimal treatment can add energy costs to the treatment process. For example, in colder climates, additional energy may be required to maintain the optimal temperature range for biological processes, which can increase the overall operational costs of wastewater treatment (Drews *et al*., 2012). Furthermore, temperature can influence the release of greenhouse gases from wastewater treatment processes. Higher temperatures can increase the production of greenhouse gases, such as methane and nitrous oxide, during the biological treatment of wastewater, which can contribute to climate change (Keller *et al*., 2013). In conclusion, temperature is a critical parameter to consider in wastewater management and treatment processes. It affects the rate of biological and chemical reactions, performance of physical and chemical treatment processes, operational costs, and potential impacts on greenhouse gas emissions. Proper monitoring and management of wastewater temperature can help optimize treatment processes, minimize operational costs, and mitigate potential environmental impacts.

1.1.9 pH

The pH is another important physical characteristic of wastewater that can significantly impact its management and treatment processes. pH is a measure of the acidity or alkalinity of a solution and is expressed on a scale ranging from 0 to 14, with 7 being neutral, values below 7 indicating acidity, and values above 7 indicating alkalinity (Crites *et al*., 2006).

The pH of wastewater can affect various aspects of wastewater treatment processes. It can impact the performance of biological processes, such as microbial activity and nutrient removal. Many microorganisms responsible for biological treatment processes, such as aerobic and anaerobic bacteria, have specific pH ranges in which they are most active (Hernandez *et al*., 2012). For example, nitrification, which is the conversion of ammonia to nitrate in biological treatment processes, is most effective at a pH range of 7 to 8.5, while denitrification, which is the conversion of nitrate to nitrogen gas, is optimal at a pH range of 6.5 to 7.5 (Cheng *et al*., 2015). Deviations from these optimal pH ranges can lead to reduced microbial activity and decreased treatment efficiency. pH also influences the performance of chemical treatment processes. For example, coagulation and precipitation processes, which are commonly used to remove suspended solids and dissolved metals from wastewater, are pH-dependent. The optimal pH range for coagulation and precipitation processes varies depending on the type of coagulant or precipitant used (Gregory *et al*., 2010). Deviations from the optimal pH range can result in incomplete removal of pollutants and decreased treatment efficiency. In addition, pH can affect the stability and solubility of contaminants in wastewater. Some contaminants, such as heavy metals, can undergo changes in their solubility and speciation with changes in pH, which can influence their removal or release during wastewater treatment processes (Duan *et al*., 2014).

Proper pH control is essential in wastewater treatment to ensure optimal treatment performance. Monitoring and adjusting the pH of wastewater can be done through various methods, such as the addition of chemicals to adjust the pH, aeration, or the use of buffer systems. pH control is crucial to maintain optimal conditions for biological and chemical treatment processes, ensure efficient removal of pollutants, and comply with regulatory requirements. In conclusion, pH is a critical parameter in wastewater management and treatment processes. It affects the performance of biological and chemical treatment processes, stability and solubility of contaminants, and compliance with regulatory requirements. Proper pH control and monitoring are essential for effective wastewater treatment and pollution control.

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1.2.0 Heavy Metals in Wastewater Used for Irrigation

Plant toxicity and potential health risks for crop farmers can arise from excessive concentrations of certain trace elements, as highlighted by Jiménez et al. (2010a). These elevated concentrations often result from anthropogenic sources such as mining, incineration, plastic production, nuclear radiation, and the combustion of fossil fuels from vehicles and power plants, as noted by Maisto et al. (2003) and Nicola et al. (2003). When plants grow in soils contaminated with heavy metals, some of these metals are absorbed by their roots and subsequently stored in various parts of the plants. The concentration of these metals within different plant parts can vary depending on the plant species, as demonstrated by Chang et al. (1997) and Kulli et al. (1999). Interestingly, some metals and metalloids are essential for proper plant growth but can become toxic when present in elevated concentrations. provides Recommended Maximum Concentrations (RMC) for selected metals and metalloids in irrigation water, serving as guidelines to help mitigate the risk of plant toxicity and associated health concerns. Table 4 shows metals and their remarks.

The maximum concentration is based on a water application rate which is consistent with drip irrigation practices (10,000 m3 ha–1 yr–1). If the water application rate greatly exceeds this, the maximum concentrations should be adjusted downward accordingly. No adjustment should be made for application rates less than 10,000 m3 ha-1 y -1. The values given are for water used on a long-term basis at one site. Source: Ayers and Westcot (1985j); Pescod (1992).

TABLE 4

Elements	**RMC mgl^{-1}**	**Remarks**
Aluminium	5.00	Can cause non-productivity in acid soils (pH < 5.5), but more alkaline soils at pH > 7.0 will precipitate the ion and eliminate any toxicity.
Arsenic	0.10	Toxicity to plants varies widely, ranging from 12 mg/l for Sudan grass to less than 0.05 mg/l for rice.
Beryllium	0.10	Toxicity to plants varies widely, ranging from 5 mg/l for kale to 0.5 mg/l for bush beans.
Cadmium	0.01	Toxic at concentrations as low as 0.1 mg/l in nutrient solution for beans, beets and turnips. Conservative limits recommended.
Chromium	0.10	Not generally recognized as an essential plant growth element. Conservative limits recommended.
Cobalt	0.05	Toxic to tomato plants at 0.1 mg/l in nutrient solution. It tends to be inactivated by neutral and alkaline soils.
Copper	0.20	Toxic to a number of plants at 0.1 to 1.0 mg/l in nutrient solution.
Iron	5.00	Non-toxic to plants in aerated soils, but can contribute to soil acidification and loss of availability of phosphorus and molybdenum.
Lithium	2.50	Tolerated by most crops up to 5 mg/l. Mobile in soil. Toxic to citrus at low concentrations with recommended limit of < 0.075 mg/l.
Manganese	0.20	Toxic to a number of crops at few-tenths to a few mg/l in acidic soils.
Molybdenum	0.01	Non-toxic to plants at normal concentrations in soil and water. Can be toxic to livestock if forage is grown in soils with high concentrations of available molybdenum.
Nickel	0.20	Toxic to a number of plants at 0.5 to 1.0 mg/l; reduced toxicity at neutral or alkaline pH.
Lead	5.00	Can inhibit plant cell growth at very high concentrations.
Selenium	0.02	Toxic to plants at low concentrations and toxic to livestock if
Zinc	2.00	Forage is grown in soils with relatively high levels of selenium. Toxic to many plants at widely varying concentrations; reduced toxicity at pH ≥ 6.0 and in fine textured or organic soils

1.2.1 Copper

Copper (Cu) is a common heavy metal found in wastewater, and its presence can have significant implications for human health, agricultural productivity, and environmental sustainability when used for irrigation. Copper can enter wastewater from various sources, including industrial discharges, domestic sewage, stormwater runoff, and agricultural activities (Alloway, 2013). Copper is an essential element for plants and animals, but excessive concentrations of copper in wastewater used for irrigation can lead to toxicity and pose risks to crops, soils, and water resources.

Several studies have investigated the occurrence and impacts of copper in wastewater used for irrigation. For example, research conducted in different countries has reported elevated levels of copper in wastewater-irrigated soils and crops, including vegetables, fruits, and grains (Achiba *et al*., 2010; Khan *et al*., 2018). These studies have highlighted the potential for copper to accumulate in crops, leading to human exposure through consumption of contaminated food, and the potential for soil degradation and reduced agricultural productivity due to copper toxicity.

The risks associated with copper in wastewater used for irrigation have led to the development of regulations and guidelines in many countries to limit the concentrations of copper in wastewater and its use in agriculture. For example, regulatory agencies, such as the U.S. Environmental Protection Agency (EPA) and the European Union (EU), have established guidelines for the safe use of wastewater in agriculture, including maximum allowable concentrations for copper in irrigation water and food crops (EPA, 2012; EU, 2019). Compliance with these guidelines is critical to protect human health, ensure sustainable agriculture, and safeguard the environment.

To mitigate the risks associated with copper in wastewater used for irrigation, various treatment technologies can be employed, including physical, chemical, and biological methods. Physical methods, such as sedimentation and filtration, can be used to remove suspended solids, including copper-containing particles, from wastewater. Chemical methods, such as coagulation and precipitation, can be used to chemically remove copper from wastewater through the formation of insoluble copper precipitates. Biological methods, such as microbial remediation and phytoremediation, can involve the use of microorganisms or plants to degrade or accumulate copper in wastewater, respectively (Kabata-Pendias, 2010).

In conclusion, copper in wastewater used for irrigation can pose risks to human health, agricultural productivity, and environmental sustainability. Proper management of copper in wastewater through appropriate treatment processes and compliance with regulatory guidelines is essential to protect human health, ensure sustainable agriculture, and safeguard the environment.

1.2.2 Zinc

Zinc (Zn) is another common heavy metal that can be present in wastewater used for irrigation, and its presence can have significant implications for agriculture, human health, and environmental sustainability. Zinc can enter wastewater from various sources, including industrial discharges, domestic sewage, stormwater runoff, and agricultural activities (Alloway, 2013). While zinc is an essential element for plants and animals, excessive concentrations of zinc in wastewater used for irrigation can lead to toxicity and pose risks to crops, soils, and water resources.

Several studies have investigated the occurrence and impacts of zinc in wastewater used for irrigation. For example, research conducted in different countries has reported elevated levels of zinc in wastewater-irrigated soils and crops, including vegetables, fruits, and grains (Wuana & Okieimen, 2011; Singh *et al*., 2018). These studies have highlighted the potential for zinc to accumulate in crops, leading to human exposure through consumption of contaminated food, and the potential for soil degradation and reduced agricultural productivity due to zinc toxicity.

The risks associated with zinc in wastewater used for irrigation have led to the development of regulations and guidelines in many countries to limit the concentrations of zinc in wastewater and its use in agriculture. For example, regulatory agencies, such as the U.S. Environmental Protection Agency (EPA) and the European Union (EU), have established guidelines for the safe use of wastewater in agriculture, including maximum allowable concentrations for zinc in irrigation water and food crops (EPA, 2012; EU, 2019). Compliance with these guidelines is crucial to protect human health, ensure sustainable agriculture, and safeguard the environment.

To mitigate the risks associated with zinc in wastewater used for irrigation, various treatment technologies can be employed, similar to those used for copper. Physical, chemical, and biological methods can be used to remove or remediate zinc from wastewater, including sedimentation, filtration, coagulation, precipitation, microbial remediation, and phytoremediation (Kabata-Pendias, 2010; Wuana & Okieimen, 2011).

In conclusion, zinc in wastewater used for irrigation can pose risks to human health, agricultural productivity, and environmental sustainability. Proper management of zinc in wastewater through appropriate treatment processes and compliance with regulatory guidelines is essential to protect human health, ensure sustainable agriculture, and safeguard the environment.

1.2. 3 Aluminium

Aluminium (Al) is a commonly occurring metal that can also be found in wastewater used for irrigation, and its presence can have implications for agriculture, human health, and environmental sustainability. Aluminium can enter wastewater from various sources, including industrial discharges, domestic sewage, stormwater runoff, and agricultural activities (Das *et al*., 2019). While aluminium is not considered an essential element for plants or animals, excessive concentrations of aluminium in wastewater used for irrigation can lead to toxicity and pose risks to crops, soils, and water resources.

Several studies have investigated the occurrence and impacts of aluminium in wastewater used for irrigation. For example, research conducted in different countries has reported elevated levels of aluminium in wastewater-irrigated soils and crops, including vegetables, fruits, and grains (El-Nakhlawy *et al*., 2017; Das *et al*., 2019). These studies have highlighted the potential for aluminium to accumulate in crops, leading to human exposure through consumption of contaminated food, and the potential for soil degradation and reduced agricultural productivity due to aluminium toxicity.

The risks associated with aluminium in wastewater used for irrigation have led to the development of regulations and guidelines in many countries to limit the concentrations of aluminium in wastewater and its use in agriculture. For example, regulatory agencies, such as the U.S. Environmental Protection Agency (EPA) and the European Union (EU), have established guidelines for the safe use of wastewater in agriculture, including maximum allowable concentrations for aluminium in irrigation water and food crops (EPA, 2012; EU, 2019). Compliance with these guidelines is crucial to protect human health, ensure sustainable agriculture, and safeguard the environment.

To mitigate the risks associated with aluminium in wastewater used for irrigation, various treatment technologies can be employed. Physical, chemical, and biological methods can be used to remove or remediate aluminium from wastewater, including sedimentation, filtration, coagulation, precipitation, microbial remediation, and phytoremediation (Das *et al*., 2019; Kabata-Pendias, 2010).

In conclusion, aluminium in wastewater used for irrigation can pose risks to human health, agricultural productivity, and environmental sustainability. Proper management of aluminium in wastewater through appropriate treatment processes and compliance with regulatory guidelines is essential to protect human health, ensure sustainable agriculture, and safeguard the environment.

1.2.4 Manganese

Manganese (Mn) ranks as the eleventh most abundant element within the Earth's crust and is surpassed in abundance only by iron (Fe) when it comes to compounds found in the crust. The soil typically contains a total manganese content ranging from 20 to 3000 parts per million (ppm), with an average concentration of around 600 ppm. In the context of plant nutrition, the presence of divalent manganese ions (Mn2+) holds paramount importance, and these ions are absorbed by clay minerals and organic matter (Malakouti and Tehrani, 1999). Manganese exists in the soil in various forms, including exchangeable manganese, manganese oxide, organic manganese, and as a component of ferros-manganese silicate minerals. Notably, the manganese ion (Mn2+) shares a similar size with magnesium (Mg2+) and ferrous iron (Fe2+), allowing it to substitute for these elements within silicate minerals and iron oxides. The dynamics of manganese interactions within soils are notably intricate, with the availability of manganese being influenced by factors such as soil pH, organic matter content, moisture levels, and soil aeration (Schulte and Kelling, 1999). Manganese and iron (Fe) exhibit a complex relationship within plants, where high manganese concentrations in the soil can impact iron uptake by plants. Conversely, an excess of iron in the soil can lead to reduced manganese uptake by plants and the formation of manganese deposits, compounding issues related to manganese toxicity in plants (Michael and Beckg, 2001; Malakouti and Tehrani, 1999).

1.2.5 Iron

Iron (Fe) is a common element that can be found in wastewater used for irrigation, and its presence can have significant implications for agricultural productivity, environmental sustainability, and human health. Iron can enter wastewater from various sources, including industrial discharges, domestic sewage, stormwater runoff, and agricultural activities (Gupta *et al*., 2017). While iron is an essential nutrient for plant growth, excessive concentrations of iron in wastewater used for irrigation can lead to negative impacts on crops, soils, and water resources.

Several studies have investigated the occurrence and impacts of iron in wastewater used for irrigation. For example, research conducted in different regions has reported elevated levels of iron in wastewater-irrigated soils and crops, including vegetables, fruits, and grains (Iqbal *et al*., 2014; Gupta *et al*., 2017). These studies have highlighted the potential for iron to accumulate in crops, leading to reduced agricultural productivity and negative impacts on soil quality and water resources.

The risks associated with iron in wastewater used for irrigation have led to the development of regulations and guidelines in many countries to limit the concentrations of iron in wastewater and its use in agriculture. Regulatory agencies, such as the U.S. Environmental Protection Agency (EPA) and the European Union (EU), have established guidelines for the safe use of wastewater in agriculture, including maximum allowable concentrations for iron in irrigation water and food crops (EPA, 2012; EU, 2019). Compliance with these guidelines is crucial to protect agricultural productivity, environmental sustainability, and human health.

To mitigate the risks associated with iron in wastewater used for irrigation, various treatment technologies can be employed. Physical, chemical, and biological methods can be used to remove or remediate iron from wastewater, including sedimentation, filtration, coagulation, precipitation, microbial remediation, and phytoremediation (Gupta *et al*., 2017; Kabata-Pendias, 2010). In conclusion, iron in wastewater used for irrigation can have significant impacts on agricultural productivity, environmental sustainability, and human health. Proper management of iron in wastewater through appropriate treatment processes and compliance with regulatory guidelines is essential to protect agricultural crops, ensure sustainable agriculture, and safeguard the environment.

1.3.0 Soil and Heavy Metal Bioaccumulation

Heavy metal bioaccumulation refers to the process by which heavy metals accumulate in living organisms, such as plants and animals, over time. Heavy metals are toxic elements that can enter ecosystems through various pathways, including wastewater irrigation, agricultural runoff, atmospheric deposition, and industrial discharges. Once released into the environment, heavy metals can persist for long periods and can accumulate in biota, posing risks to both environmental and human health. Numerous studies have investigated the bioaccumulation of heavy metals in various organisms, including plants, animals, and microorganisms, in the context of wastewater irrigation. For instance, research has shown that heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), and arsenic (As) can accumulate in crops irrigated with wastewater, including vegetables, fruits, grains, and forage crops (EPA, 2012; Kabata-Pendias, 2010). These heavy metals can be taken up by plant roots and translocated to different plant parts, leading to their accumulation in edible plant tissues, which can pose risks to human health when consumed.

The bioaccumulation of heavy metals in aquatic organisms, such as fish and shellfish, can also occur when heavy metal-containing wastewater is discharged into water bodies used for aquaculture or other aquatic activities. Aquatic organisms can accumulate heavy metals through various mechanisms, including direct uptake from water, absorption through the gills or skin, and ingestion of contaminated food. As heavy metals accumulate in aquatic organisms, they can move up the food chain, leading to biomagnification, where the concentration of heavy metals increases at higher trophic levels. The bioaccumulation of heavy metals in living organisms can have detrimental effects on both the environment and human health. In the environment, heavy metals can disrupt ecosystems, affecting biodiversity, nutrient cycling, and ecological functions. In addition, heavy metals can persist in the environment for long periods, leading to potential long-term impacts.

From a human health perspective, consuming crops or aquatic organisms that have accumulated heavy metals can pose risks, especially for populations that heavily rely on wastewater-irrigated crops or fish from contaminated water bodies as a major food source. Heavy metals can accumulate in human tissues, leading to potential health effects, such as damage to the nervous system, liver, kidneys, and other organs.

To mitigate the risks of heavy metal bioaccumulation in the context of wastewater irrigation, appropriate management practices and regulations are essential. These may include regular monitoring of heavy metal concentrations in wastewater, soil, and crops; implementing treatment technologies to remove or remediate heavy metals from wastewater; and complying with regulatory guidelines for heavy metal concentrations in irrigation water and food crops (EPA, 2012; Kabata-Pendias, 2010). Additionally, promoting sustainable agriculture practices, such as integrated nutrient management, soil conservation, and crop rotation, can help reduce heavy metal bioaccumulation risks and promote environmental sustainability.

1.3.1 Biological Constituents of Wastewater

Biological constituents of wastewater refer to the various microorganisms and biological substances that are present in wastewater, including bacteria, viruses, protozoa, fungi, and organic matter. These biological constituents can have significant implications for wastewater treatment and management, as they can impact the efficiency of treatment processes, water quality, and environmental health.

Bacteria are one of the most common biological constituents of wastewater and play a crucial role in the decomposition of organic matter during wastewater treatment. Bacteria are responsible for the biodegradation of organic compounds through processes such as aerobic and anaerobic digestion, nitrification, denitrification, and phosphorus removal (Henze *et al*., 2008; Metcalf & Eddy, 2014). Bacterial populations in wastewater can vary in composition and abundance depending on factors such as the type of wastewater, temperature, pH, and oxygen availability. Viruses are another important biological constituent of wastewater, and they can pose risks to public health if not effectively managed. Viruses in wastewater can originate from human and animal waste and can survive in the environment for extended periods, making them potential sources of waterborne diseases. Wastewater treatment processes, such as disinfection, are often employed to reduce viral loads in treated wastewater before discharge or reuse (Ward, 2012). Protozoa are microorganisms that are commonly found in wastewater and can play a significant role in the removal of bacteria, viruses, and other organic matter during wastewater treatment. Protozoa are responsible for predation and grazing on bacteria, contributing to the reduction of bacterial populations and the improvement of wastewater treatment efficiency (Foladori *et al*., 2010). Fungi are also present in wastewater, albeit in lower abundance compared to bacteria and viruses. Fungi are known for their ability to degrade complex organic compounds, such as lignin and cellulose, and can play a role in the decomposition of organic matter in wastewater, especially in aerobic environments (Borja *et al*., 2011).

Organic matter, including particulate and dissolved organic matter, is a significant biological constituent of wastewater. Organic matter can come from various sources, including human and animal waste, food residues, and other organic compounds present in domestic, industrial, or agricultural wastewater. Organic matter can be biodegraded by microorganisms during wastewater treatment processes, and its removal is important for reducing the biological oxygen demand (BOD) and chemical oxygen demand (COD) of wastewater, which are important indicators of water quality and treatment efficiency (Metcalf & Eddy, 2014).

The presence of these biological constituents in wastewater necessitates proper management and treatment to protect public health and the environment. Wastewater treatment processes, such as activated sludge, trickling filters, oxidation ponds, and disinfection methods, are designed to effectively remove or reduce these biological constituents from wastewater to meet regulatory standards for discharge or reuse. Regular monitoring of the microbiological quality of wastewater and compliance with regulatory guidelines for wastewater treatment and disposal are essential to ensure effective management of biological constituents and protect human health and the environment.

1.3.2 Risk of Wastewater Utilisation and Tools for Risk Assessment of Wastewater

The utilization of wastewater in agriculture offers significant advantages, yet it also presents considerable threats to public health, particularly when untreated wastewater finds its way into crop irrigation. In many cases, farmers have little choice but to resort to untreated wastewater due to the absence of wastewater treatment facilities, coupled with the unavailability or high cost of freshwater (World Bank, 2010). Despite its undeniable benefits in terms of bolstering food supply, improving nutrition, generating employment, and alleviating poverty, urban vegetable production faces substantial human health and environmental risks. These challenges often hinder its official recognition and support, particularly in regions like Sub-Saharan Africa grappling with intricate urban sanitation issues (Drechsel *et al.,* 2006; Obuobie et al., 2006). The assessment of these risks primarily relies on data stemming from microbiological analyses, epidemiological investigations, and quantitative microbial risk assessments (QMRA). QMRA stands out as a prospective risk assessment tool, in contrast to extrapolations based on historical data. Although microbial analyses and epidemiological studies have long been employed to evaluate the risks associated with wastewater-irrigated agriculture, particularly among affected farmers, they have their limitations. These approaches are relatively costly and may not fulfill the need of the public, governments, and other stakeholders for health-risk estimates prior to project commencement. QMRA is gaining prominence as an alternative method that provides a forward-looking risk assessment tailored to the specific wastewater irrigation scenario in question (Hamilton et al., 2007).

1.3.3 Microbial Risks to Public Health

In low and middle-income nations, the primary concerns revolve around public health risks posed by microbial pathogens present in domestic wastewater, encompassing bacteria, viruses, protozoa, and helminths – disease-causing organisms. Extensive epidemiological investigations spanning the past four decades have established clear links between the unregulated utilization of untreated or partially treated wastewater for irrigating edible crops and the transmission of both endemic and epidemic diseases to farmers and consumers of these crops. The tangible consequences of employing untreated wastewater for irrigation include an elevated incidence of helminthic diseases, such as Ascariasis and Ancylostoma, among field workers and consumers of raw vegetables, as well as bacterial and viral infections, including diarrhea, typhoid, and cholera, particularly among those who consume salad crops and uncooked vegetables (World Bank, 2010).

1.3.4 Chemical Risks to Public Health

In middle and high-income nations, chemical hazards take on greater significance, often stemming from industrial wastewater discharge into public sewers, leading to contamination of municipal wastewater systems. These chemical risks to human health can arise from heavy metals like cadmium, lead, and mercury, as well as a multitude of organic compounds, including pesticides. Moreover, there is a growing concern in high-income countries surrounding a new category of "anthropogenic" chemical compounds, encompassing pharmaceuticals, hormones, endocrine disruptors, antibiotics, and personal care products, even though their long-term health implications remain somewhat unclear (World Bank, 2010).

1.3.5 Risks to Plant Health

Plants primarily face the risk of diminished crop yields when the physico-chemical quality of irrigation wastewater is inadequate, often due to issues like high salinity or elevated concentrations of substances like boron, heavy metals, industrial pollutants, nitrogen, or sodium. The extent of risk to plant health tends to decrease when the wastewater contains minimal industrial effluents. However, irrespective of the wastewater source, it's essential to monitor five key parameters throughout the irrigation season: electrical conductivity, sodium adsorption ratio, boron levels, total nitrogen content, and pH levels (World Bank, 2010).

1.3.6 Risks to Soil

The primary and frequently encountered issue associated with wastewater use in soils is salinization. This problem can arise even with freshwater if appropriate soil washing and adequate land drainage measures are not implemented. The utilization of wastewater exacerbates soil salinization due to its higher salt content. Salinization, in turn, leads to the deterioration of soil structure, resulting in the loss of pores and interconnections essential for water and air passage. Consequently (WHO, 2006b):

i. Lateral drainage is increased.
ii. Soils become more susceptible to erosion.
iii. Oxygenation of the soil is constrained.
iv. Root development is inhibited.
v. Plant growth is either stunted or halted.

Over the long term, the use of wastewater consistently raises soil and groundwater salinity levels, given its higher salt content compared to freshwater. Therefore, it becomes imperative to implement wastewater use practices in conjunction with salinization control measures (WHO, 2006b). Effectively managing chemical risks to human health, plant health, and the environment necessitates the establishment of robust industrial wastewater pre-treatment and control programs. It's important to note that such effective programs are not yet the standard in many developing countries, making it essential to pay special attention to chemical risks in these contexts (World Bank, 2010).

1.4.0 Methods and Benefits of Wastewater Irrigation

Microbial risks to public health are a significant concern associated with the utilization of wastewater. Wastewater can contain various microbial pathogens, including bacteria, viruses, protozoa, and helminth eggs, which can pose health risks to humans and animals when wastewater is used for irrigation or other purposes. In particular, the presence of fecal indicator bacteria, such as Escherichia coli (E. coli) and fecal coliforms, in wastewater can indicate the potential presence of fecal pathogens, which are known to cause gastrointestinal illnesses in humans, including diarrhea, gastroenteritis, and other waterborne diseases (Soller *et al*., 2010). Additionally, viral pathogens, such as rotavirus, norovirus, and hepatitis A virus, can also be present in wastewater and pose risks to public health, especially in areas where treated wastewater is used for agricultural irrigation or recreational purposes (Haramoto *et al*., 2008). Protozoan pathogens, such as Cryptosporidium and Giardia, are also of concern in wastewater as they are highly resistant to disinfection processes commonly used in wastewater treatment, and their cysts or oocysts can persist in the environment for extended periods, leading to potential transmission to humans and animals through water or food crops (Fayer, 2010). Similarly, helminth eggs, including those of Ascaris, Trichuris, and hookworms, can also be present in wastewater and pose health risks through ingestion or dermal contact during irrigation or other uses (Strande *et al*., 2014).

To mitigate microbial risks to public health associated with wastewater utilization, appropriate treatment processes, and risk management measures should be in place. This includes proper wastewater treatment, adherence to guidelines and regulations for wastewater reuse, and implementing best management practices in irrigation or other uses of wastewater. Regular monitoring and testing of wastewater and treated effluent for microbial pathogens can also be conducted to ensure compliance with standards and guidelines and to identify potential risks.

1.4.1 Wastewater Generation in the World and Ghana

According to a report by the United Nations, the world generates approximately 359 billion cubic meters of wastewater annually. This figure is expected to increase to 685 billion cubic meters by 2050 due to population growth, urbanization, and economic development (UN Water, 2017). In addition, it is estimated that only a small proportion of wastewater generated in developing countries is treated before being discharged into the environment, contributing to water pollution and associated health risks (UN Water, 2017). The management of wastewater is therefore an important global challenge that requires significant attention and investment to address. According to the World Bank, the amount of wastewater generated globally is increasing at an alarming rate and is projected to reach 82 trillion liters by 2025 (World Bank, 2019). This rapid increase in wastewater generation can be attributed to population growth, urbanization, industrialization, and changes in lifestyles. Furthermore, the majority of the wastewater generated is untreated or inadequately treated, which poses a significant threat to the environment and public health (United Nations, 2017). This untreated or inadequately treated wastewater is discharged into rivers, lakes, and oceans, causing pollution and eutrophication. The impact of wastewater on the environment and public health can be significant, especially in developing countries where access to clean water and adequate sanitation is limited. According to the World Health Organization (WHO), an estimated 2.2 million deaths occur annually due to diarrheal diseases caused by inadequate water, sanitation, and hygiene (WHO, 2018). Therefore, the need for sustainable wastewater management practices is crucial to protect public health and the environment. Sustainable wastewater management practices involve the safe and beneficial use of treated wastewater for irrigation, aquaculture, and other non-potable uses. According to a report by the Ghana Water Company Limited, Ghana generates about 200,000 m^3/day of wastewater (GWCL, 2017). This amount is projected to increase as the country's population and industrial activities continue to grow. Wastewater generation in urban areas is particularly high due to the concentration of human settlements and economic activities. However, the current capacity for treating wastewater in Ghana is limited, leading to the discharge of large amounts of untreated or inadequately treated wastewater into the environment, causing serious environmental and health concerns (Kortatsi *et al.,* 2010).

In Ghana, the amount of wastewater generated varies by region and is largely dependent on the level of urbanization and industrialization. According to a report by the Ghana Water Company Limited, the Greater

Accra Region, which includes the capital city of Accra, generates the highest amount of wastewater in the country, estimated at about 400,000 cubic meters per day (GWCL, 2019). Other major urban centers such as Kumasi, Takoradi, and Tamale also generate significant amounts of wastewater. In addition to domestic sources, industrial activities also contribute to the amount of wastewater generated in Ghana. The industrial sector, particularly the agro-processing, mining, and oil and gas industries, generate large volumes of wastewater that contain high levels of pollutants such as heavy metals, oil and grease, and toxic chemicals (EPA, 2010). Efforts have been made by the government of Ghana, in collaboration with development partners, to improve wastewater management in the country. One such initiative is the Greater Accra Metropolitan Area Sanitation and Water Project (GAMA-SWP), which seeks to improve sanitation and water supply in the Greater Accra Region, including the construction of new wastewater treatment plants and the rehabilitation of existing ones (GAMA-SWP, 2019). According to (Ghana Statistical Service, 2013), the most common method of liquid waste disposal in Sagnarigu is throwing onto the street/outside, accounting for 53.1% of the total liquid waste disposal methods. This is followed by throwing onto the compound (21.1%) and through drainage system into a gutter (7.0%). The least common method of liquid waste disposal is through the sewerage system, accounting for only 5.8% of the total liquid waste disposal methods. (Ghana Statistical Service, 2013).

2.0 MATERIALS AND METHOD

2.1 Study Area Map

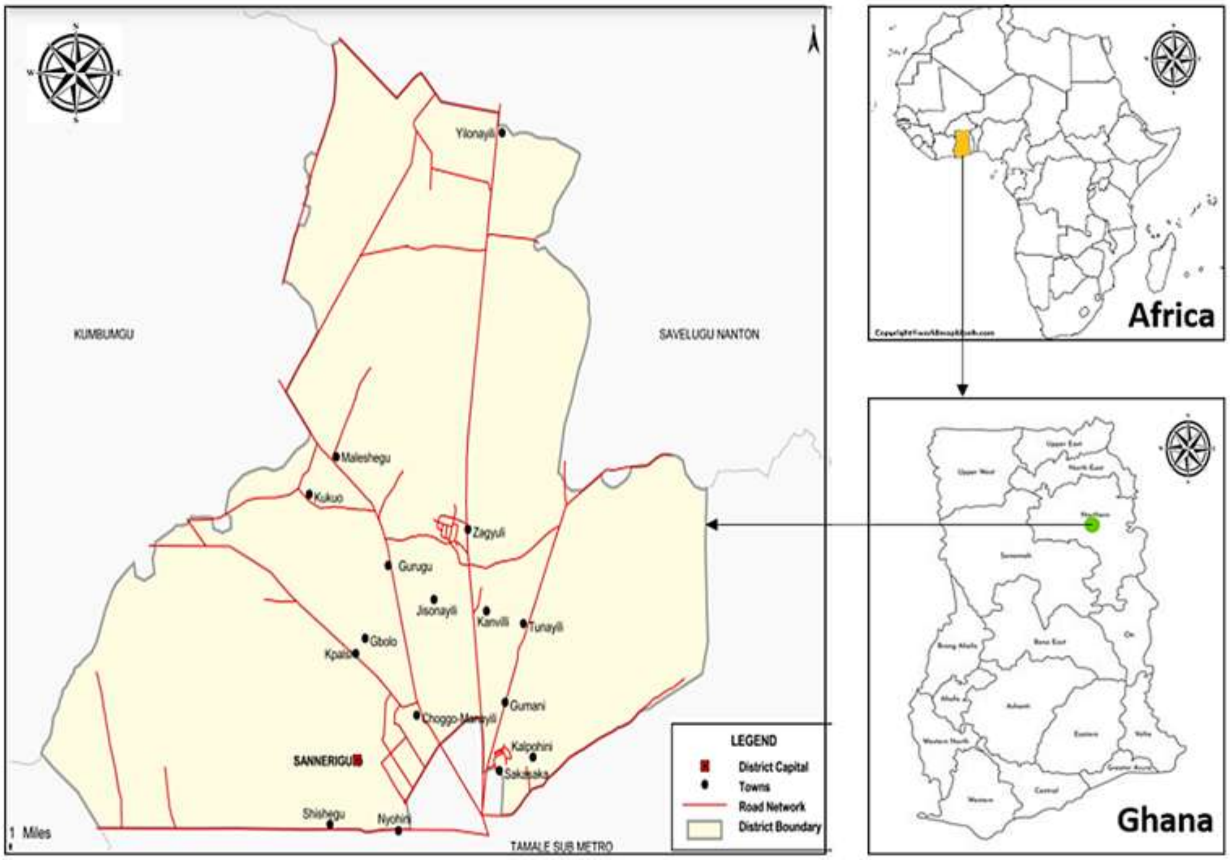

Figure 2. 1 Map of Sagnarigu Municipal Area (GSS, 2021)

The Sagnarigu Municipality, encompassing 79 communities, exhibits a diverse landscape with 20 urban, 6 peri-urban, and 53 rural areas. It spans a substantial land area, covering approximately 439.8 square kilometers, and shares its borders with neighboring regions - the Savelugu and Nanton Municipality to the north, the Tamale Metropolis to the south and east, Talon District to the west, and Kumbungu District to the north-west. Geographically, the municipality is situated between latitudes 9°16' and 9°34' North and longitudes 0°36' and 0°57' West. Climatically, the Municipal experiences a single rainy season commencing in April/May and extending through September/October, with its peak intensity observed in July/August.

2.2 Water Quality Analysis

Water samples were meticulously gathered from the site and subsequently transported to the Ghana Water Company laboratory located in Tamale for comprehensive physico-chemical and biological analyses. The analytical parameters encompassed various aspects, including color, turbidity, total dissolved solids, total suspended solids, total hardness, total alkalinity, calcium hardness, magnesium hardness, total coliform, and faecal coliform. In total, four distinct samples of both filtered and unfiltered wastewater were collected using an integrated sampling approach, involving the simultaneous collection of grab samples from different points. During the sampling process, great care was taken to ensure the integrity of the samples. Sampling bottles were employed, and measures were taken to avoid any inclusion of floating materials. The sample containers were securely sealed with stoppers to prevent any potential external contamination. Each container was meticulously labeled to provide essential information, including the name of the water body, date, time of sampling, sampling point, and specific conditions prevalent during the sampling process. To assess the color of the collected water samples, a visual comparison was conducted by juxtaposing the samples with distilled water. Additionally, the pH levels were determined using the electrometric method. Figure 2.2 visually depicts the Zagyuri wastewater stream, which serves as a crucial source for irrigation.

FIGURE 2.2 Zagyuri Wastewater Stream Used for Irrigation (Field STUDIES, 2023)

2.3 Filters

Water filters are essential devices designed to remove impurities from water by utilizing a finely structured physical barrier, often referred to as discs, stacked akin to a stack of poker chips. These discs act as a barrier through which irrigation water flows, and they effectively trap and retain impurities present in the water.

In this particular research, the filtration system employed disc filters, which are a specific type of water filter extensively used in irrigation. These filters share similarities with screen filters, but they are distinguished by their filter cartridge, composed of numerous plastic discs assembled in a stacked configuration, reminiscent of a stack of poker chips. Each of these discs boasts a surface textured with small grooves or bumps to enhance their filtration capabilities. The discs are designed with central holes, which collectively create a hollow cylinder at the core of the stacked arrangement. Consequently, as water traverses the minuscule passageways between the discs, any impurities are effectively captured and retained within the filter.

The effectiveness of filtration in terms of water quality hinges on factors such as the number and size of particles that the filtering element can successfully retain. In essence, higher-quality filtration equates to cleaner water. This effectiveness is intricately linked to the geometry of the channels within the filter, including attributes such as channel size, length, angle, and the quantity of intersection points generated. To denote the level of filtration, these discs are often color-coded. The filtration quality is quantified in microns, representing the smallest particle size that the filter can effectively remove. Mesh sizes, which span from 40 to 600, are typically used to gauge filtration quality, with 40 indicating the coarsest and 600 representing the finest or highest level of filtration. Disc filters are versatile and capable of addressing various contaminants, encompassing fine sand and organic matter. A regular cleaning regimen, conducted on a weekly basis, helps prevent clogging and ensures the sustained efficacy of these filters. To gain a visual understanding of the filtration system employed in the study, please refer to figure 2.3 which provides an illustrative depiction of the filters used at the research site.

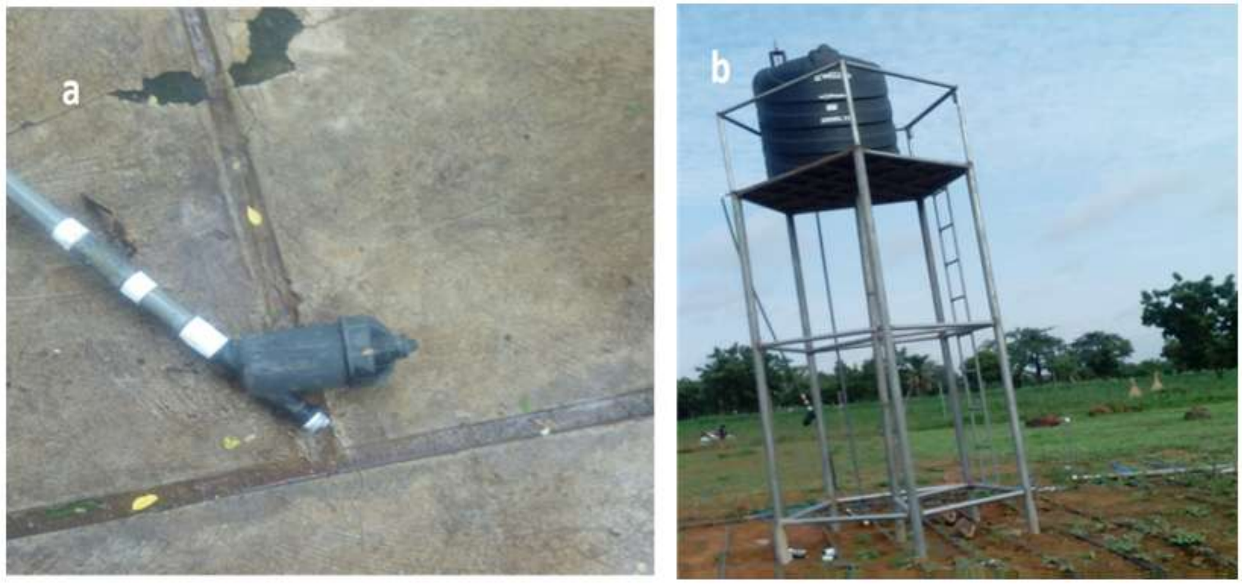

FIGURE 2.3 Filters Used for the Study Site (Field Studies, 2023)

3.0 RESULTS AND DISCUSSIONS

3.1 Water Quality Results.

The results indicated that the water was polluted and could only be suitable for drip and sprinkler irrigation if filtered at two levels: before and after storage to avoid blockage of emitters, since the water was highly turbid with high content of suspended particles. This finding is in line with the argument of Karlberg (2019), who indicated that competition for fresh water increases, water of lower quality, for example saline or polluted water, is often used for irrigation. Thus, in order to achieve long-term sustainability of these systems, appropriate management strategies are needed. The results of the analysis are presented in Table 5 (a) and Table 5 (b).

Table 5 (a) Water Quality Analysis Results

Parameter (In Mg/L Unless Otherwise Stated)			(WHO,2006a) Standard for Irrigation with Wastewater		Test Results before the use of Disc filter	Test Results after filtration
1.	Ph		6.5 – 8.5		7.50	7.50
2.	Color (Hazen Units)		NO SV		63.50	41.40
3.	Turbidity (NTU)		1000		308.0	201.0
4.	Conductivity (µS/cm)		7000		709.6	709.6
5.	Total Dissolved solids, (TDS)		2000		1543.8	1352.1
6.	Total Suspended Solids (TSS)		40.0		122.0	72.0
7.	Total Hardness (as mg/L $CaCO_3$)		>8.5		52.0	52.0
8.	Total Alkalinity (as mg/L CaCO3)		8.5		315.88	315.88
9.	Calcium Hardness (as mg/L $CaCO_3$)		NO SV		27.0	27.0
10.	Magnesium Hardness (as mg/L $MgCO_3$)		NO SV		27.0	27.0
11.	Calcium		9.0		12.0	12.0
12.	Magnesium		4.0		5.701	5.701
13.	Chloride		100.0		65.0	65.0
14.	Sulphate		10		51.67	51.67
15.	Nitrate – Nitrogen		>30		6.55	6.55
16.	Total Coliform (cfu/100ml)		400.0		TNTC	TNTC
17.	Faecal Coliform (MPN/100ml)		20.0		TNTC	TNTC

(Field studies, 2023)

***NOTE*: NO SV means, No Standard Value set**

TABLE 5 (b) Results of Trace Metals in Wastewater

Parameter (in mg/l)	WHO Standard for irrigation with wastewater (WHO,2006a)	EPA Ghana Limits (mg/l) (EPA,2012)	Test Results before filtration	Test Results after filtration
Zn	5.0	5.0	0.041	0.041
Mn	0.2	2.5	0.17	0.17
Al	5.0	5.0	0.11	0.11
Fe	5.0	-	0.73	0.73
Cu	0.2	2.5	0.08	0.08

From table 5 (b) above, all the trace metals such as Zn, Mn, Al, Fe and Cu were below the World Health Organization (WHO) standard for irrigation with wastewater. They were also below Environmental Protection Agency of Ghana limit for wastewater used for irrigation. This indicates that the trace metals concentration in wastewater at the study site had insignificant risks to the soil and vegetable crop produced by the peri-urban farmers.

3.1.2 Color

The color reduction of wastewater before and after filtration, as indicated by the values 63.50 and 41.40 respectively, signifies a significant improvement in water quality. This decrease in color levels highlights the effective removal of suspended particles, organic matter and other contaminants during the filtration process. This finding is in harmony with Smith *et al.,* (2018), particulate matter in wastewater can absorb and scatter light, resulting in the water appearing colored and turbid. Filtration mechanisms such as granular media filtration, disc filtration or membrane filtration, target these suspended particulates and help in achieving a reduction in color levels (Smith*, et al.,* 2018).

3.1.3 Turbidity

The turbidity of wastewater, is a crucial indicator of water quality and clarity, experienced a significant reduction from 308 NTU before filtration to 201 NTU after filtration. This improvement in turbidity levels highlights the efficiency of the filtration process in removing suspended particles and particulate matter from wastewater, enhancing the water visual clarity and overall quality. This finding is line with Smith *et al.* (2017), that effective filtration methods can lead to substantial reduction in turbidity levels. The findings of this study are consistent with the principles of water treatment discussed by Tchobanoglous *et al.* (2019). Thus, turbidity arises from the presence of colloidal and suspended particles in water, which can be effectively removed or reduced through physical processes like filtration. This finding is in harmony with Smith *et al.* (2022), thus effective filtration processes have been shown to signicantly reduce turbidity levels in wastewater.

3.1.4 Total Dissolved Solids (TDS)

The TDS value before filtration was found to be 1543.8 ppm, while the TDS value after filtration decreased to 1352.1 ppm. This reduction in TDS levels indicates that the filtration process effectively removed a certain number of dissolved solids from the wastewater. This finding is in harmony with (Wang *et al.,* 2020) thus, filtration can effectively reduce the concentration of suspended solids, colloidal matter, and certain dissolved constituents.

3.1.5 Total Suspended Solids (TSS)

The reduction in TSS from 122.0 mg /L before filtration to 72.0 mg/L after filtration is indicative of the efficiency of the filtration process. These findings agreed with Smith *et al.* (2018) that filtration processes are highly efficient in removing suspended solids from wastewater, leading to improved water clarity and quality.

3.1.6 pH

The Ph of wastewater before and after filtration remaining at 7.5 indicates that the filtration process did not significantly alter the acidity or alkalinity of the wastewater. This observation is consistent with the principle that filtration primarily removes solid particles and contaminants suspended in the water, rather than affecting its chemical composition, such as pH

The findings are in line with the study conducted by Johnson and Brown (2016), which reported that the Ph of wastewater remained relatively constant before and after filtration process, suggesting that the filtration method employed had no significant impact on pH. This results also strongly aligned with that of Smith *et al.* (2018), whose findings demonstrated that disc filtration does not alter pH values.

The analysis of the results indicated that disc filtration method did not significantly affect the conductivity value of the wastewater and this was in harmony with the result obtained by Smith *et al.* (2018) who observed that physical filtration methods such as disc filtration did not significantly affect conductivity value of the wastewater. The conductivity of wastewater before and after filtration remaining 709.6 Us/cm indicates that the disc filtration method used did not alter the conductivity of the wastewater. Also, the findings were in harmony with Jonson and Williams (2015) who indicated that while filtration can affectively remove suspended particles and contaminants, it might not always lead to a significant reduction in conductivity.

3.1.7 Total Hardness

The analysis of the results indicated that disc filtration method did not significantly affect the total hardness value of the wastewater and this was in harmony with the result obtained by Smith *et al.* (2018) who observed that physical filtration methods such as disc filtration did not significantly affect total hardness value of the wastewater. These findings also agreed with Jones and Brown (2016) who stated that traditional filtration methods such as sand or cartridge filters are generally designed to target larger particles and suspended solids. They might not be efficient in removing dissolved ions responsible for water hardness.

3.1.8 Total Alkalinity

The Total Alkalinity of wastewater before and after filtration remaining at 315.88 indicates that the filtration process did not significantly alter the alkalinity of the wastewater. This observation is consistent with the principle that filtration primarily removes solid particles and contaminants suspended in the water, rather than affecting its chemical composition, such total alkalinity. These finding is aligned to *Smith et al.* (2018), that physical filtration techniques may only remove suspended solids and not alter the chemical composition significantly.

3.1.9 Calcium Hardness

The results shown that the calcium hardness of wastewater before and after filtration remaining unchanged at 27.0 suggests that the disc filtration process did not effectively remove calcium ions from the water. This is consistent with the findings of Green *et al.* (2019), who concluded that solubility of calcium ions can be influenced by the pH of the water. In cases where the pH is not adjusted during the filtration process, calcium ions may remain in solution and not be effectively removed. This result also strongly aligned with that of Smith *et al.* (2018) whose findings demonstrated that certain filtration techniques were not effective in reducing calcium hardness. This finding is also aligned to Brown *et al.* (2019) who concluded that while filtration can be successful in removing certain contaminants, it may not significantly impact calcium hardness. The result was in harmony with Johnson *et al.* (2020) who indicated that even with variations in pH, calcium hardness levels remained relatively stable after filtration.

3.1.10 Magnesium Hardness

The findings of a magnesium hardness of 27.0 in wastewater both before and after filtration indicate that the filtration process did not effectively remove magnesium ions from the water. This lack of change in magnesium hardness suggests that the filtration method employed may not be suitable for reducing magnesium concentration in the wastewater. This result strongly aligned with that of Smith *et al.* (2018), who indicated that while disc filtration and sand filtration was effective at removing particulate matter, it had limited impact on the reduction of dissolved ions such as magnesium.

3.1.11 Calcium

The observation that the calcium concentration in wastewater remains the same before and after filtration, as indicated by a constant value of 12.0, suggests that the filtration process has not effectively removed calcium ions from the wastewater. This finding is also aligned to Brown *et al.* (2019) who concluded that while filtration can be successful in removing certain contaminants, it may not significantly impact calcium ions. The result was in harmony with Johnson *et al.* (2020) who indicated that even with variations in pH calcium levels remained relatively stable after filtration.

3.1.12 Magnesium

The results shown that the magnesium of wastewater before and after filtration remaining unchanged at 5.701 suggests that the disc filtration process did not effectively remove magnesium ions from the water. The result was noted to be similar to Jones *et al.* (2019), who reported that, if the primary source of the magnesium is from dissolved salts that remain in the solution, filtration may not be an effective means of removal. This is especially true if the magnesium compounds are highly soluble in water. This result is also in line with studies done by Smith *et al.* (2018), who concluded that filtration methods such as sand or microfiltration may not effectively remove dissolved magnesium ions

3.1.13 Sulphate

The sulphate of wastewater before and after filtration remaining at 51.67 Mg/L indicates that the filtration process did not significantly alter the sulphate of the wastewater. This observation is consistent with the principle that filtration primarily removes solid particles and contaminants suspended in the water, rather than affecting its chemical composition, such as sulphate level in the wastewater. Also, the sulphate level in the wastewater was above the World Health Organization (WHO) standard for irrigation with wastewater accepted value of 10 Mg/L.

3.1.14 Nitrate

The nitrate concentration in wastewater before and after filtration remains constant at 6.55, indicating that the filtration process did not significantly reduce the nitrate levels in the water. This result strongly aligned with that of Smith *et al.* (2018), who indicated that while disc filtration and sand filtration was effective at removing particulate matter, disc and sand filtration alone was not effective in reducing nitrate concentrations. This finding is also aligned to Johnson *et al.* (2017) who concluded that while disc filtration can be successful in removing certain contaminants, it was found to be less effective in nitrate removal.

All physico-chemical parameters analysed were within the WHO Standard for irrigation with wastewater. However, faecal contamination was too numerous to count. But for purposes of irrigation, water can safely be used.

4.0 CONCLUSION

According to a report by the Ghana Water Company Limited, Ghana generates about 200,000 m^3/day of wastewater (GWCL, 2017). This amount is projected to increase as the country's population and industrial activities continue to grow. Wastewater generation in urban areas is particularly high due to the concentration of human settlements and economic activities. The results indicated that the water was polluted and could only be suitable for drip and sprinkler irrigation if filtered at two levels: before and after storage to avoid blockage of emitters, since the water was highly turbid with high content of suspended particles. The physio-chemical parameters such as turbidity, Ph, conductivity and chlorine were within the World Health Organization standard for irrigation with wastewater. The trace metals such as copper, zinc, iron and manganese were below World Health Organization standard for irrigation with wastewater and also below the Environmental Protection Agency of Ghana standard. This indicates that the trace metals concentration in wastewater at Zagyuri has insignificant risk to soil and vegetable crops produced**.** Disc filtration can effectively reduce the concentration of suspended solids, colloidal matter, and certain dissolved constituents in wastewater. All physico-chemical parameters analysed were within the WHO Standard for irrigation with wastewater. However, faecal contamination was too numerous to count. But for purposes of irrigation, water can safely be used.

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