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Investigating Factors Contributing to Microbiological Quality in Handling Stored Water Among Residents of Sinazeze Compound in Sinazongwe District, Zambia

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Abstract: The deterioration of drinking water quality following the collection from a community water source such as boreholes and standpipes during storage in the home has been well documented. However, there is a view that the post-supply contamination is of little Public health consequence. This research explores the potential health risks from consuming contaminated drinking water at household level. A conceptual framework of principal factors that determine the pathogen load in household drinking water is proposed. Using this framework, a series of hypotheses are developed about the risk of disease transmission from contaminated water and examined the light of current literature and detailed field observation in rural Sinazeze communities. It is shown that considerable evidence of disease transmission from re-contaminated drinking water at the household level exists. In particular the type of storage container and hand contact with stored drinking water has been associated with increased incidences of diarrhoeal diseases. There is also circumstantial evidence linking such factors as sanitary conditions in the domestic environment, cultural norms, and poverty with the pathogen load of household stored drinking water and hence the risk of disease transmission. Mortalities and morbidities have proliferated due to continued consumption of contaminated water at household level. A study was undertaken to explore factors contributing to microbiological quality in handling stored water among residents of Sinazeze Compound in Sinazongwe District, Zambia

The study used qualitative analytical research approaches to collect and analyse data from 60 householders. The results show that the community had generalized knowledge about factors contributing to contamination of household water supply sources. Yet they overlooked individual factors contributing to contamination of household water supplies. This study found improper disposal of water agro-chemicals containers, faecal matter, pesticide and general household waste. Personal hygiene of water handlers, collectors and users, unconcern use of dirty utensils when dawning water from the storage constrainers including individual failures to secure water from contaminants, poor storage practices, type of storage vessel, transportation and sending children to draw water from storage containers contribute to the problem of contamination even if water was safe at the source or point of collection. In conclusion the quantity and quality of household water supplies should be given equal importance. Awareness related to 'water conservation' and 'safe drinking water' is extremely important and should be given a good thought to the people.

Keyword: *Safe Water Supplies, Water Quality, Hygiene and Environmental Sanitation.*

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I. INTRODUCTION

- *Background to the Study*

Water is one of the most important natural resources necessary for human survival after air. Access to clean and safe water, good sanitation and hygiene practices are necessary for healthy population (Nsubuga, 2014). Whereas the right to safe drinking water is a human right, one-sixth of the world's population cannot access safe drinking water, predisposing communities to the risk of water-borne Diseases (Chouhan, 2015).Globally, 700 million people lack access to safe drinking water and half of these are in sub-Saharan Africa, where WHO estimates that 1.8 billion people drink water contaminated with *Escherichia Coli*,

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which is an indicator of faecal contamination. In Zambia currently, over 80% of the health conditions presented at health institutions are communicable diseases related to poor environmental sanitation, with significant adverse impact on the poor, especially children. ((National Health Policy, 2013:11).

The availability of safe drinking water sources is a main concern in many countries around the world. Contamination of drinking water is one of the greatest public health problems worldwide particularly in developing countries and may be severe at the household level (Hossain et al., 2014). If public health measures for safe drinking water and adequate sanitation are not enforced, water-related diseases such as Cholera, dysentery, salmonellosis, and typhoid fever can erupt especially in developing countries where millions of lives are claimed every year. Globally, unsafe water coupled with poor sanitation kills at least 1.6 million children under the age of five years, 84% of whom live in rural areas (Raju, 2011).

Drinking water quality in the distribution network is paramount (Raiesia et al., 2017), and several studies have reported on the microbial safety of water sources (Chouhan, 2015). Such studies stimulate programs aimed at safe water supply to communities, thus improving public health and reducing water-borne disease burden. However, efforts by government and Non-governmental organizations to provide reliable sources of drinking water get jeopardized by poor handling and storage that contaminate the drinking water after it has been drawn from the source (Opio, 2012). Findings by Parker et al. (Parker, 2010) with similar studies by Amenu et al. and Schriewer et al (Schriewer, 2015) show that household water quality is compromised by storage methods after collection; thus increasing the proportion of people drinking unsafe water. In the study done by Raju et al. (Raju, 2011), household water showed progressive contamination during storage, and in this study, 73% stored household water samples were contaminated with enteric bacteria.

In September 2015 the United Nations (UN) set very ambitious goals for the developing countries around the world urging them to reduce the number of people without safe drinking water by half in the year 2015 (UN, 2000). By 2022 marginal progress has been made by some countries toward improving water supplies. Yet, making drinking water safe for human consumption has not been guaranteed at all times. A myriad of factors combines to contaminate water at various points (i.e., collection, transportation, storage vessels, individual and household hygiene among others). In common parlance, water for consumption is consider safe it is free from pathogens such as bacteria, viruses, and protozoan parasites, and when it meets the standard guidelines for taste, odour, appearance and chemical concentrations, and must be available in adequate quantities for domestic purposes (Kirkwood, 1998).

Globally, safe and readily available water is important for global public health, whether it is used for drinking, domestic use, food production or recreational purposes. The availability of this life precious resource in many settings is fraught with failure to meet the needs of the local people, high rate of disease and morbidity interlock with the current realties at household level that contribute to water contamination. The World Health Organization considers inadequate safe household water supplies as being the most pressing public health crises of our day with implications on public health responses to epidemic and pandemics as is the case for COVID-19 responses which demand high level of hygiene among its golden rules (WHO, 2020).

Currently, at least 2 billion people globally, use a drinking-water source that is contaminated with faeces (WHO, 2020). This is accounting to more 502 000 diarrhoeal deaths each year with nearly 1000 children dying every single day from drinking contaminated water. These deaths are so common among rural and urban slum duellers in developing countries, where people live in extreme poverty and face structural inequality. Diseases such as cholera, diarrhoea, dysentery, polio, typhoid are further, proliferated in sub–Saharan African countries are as a result of contaminated water. In other UN report 2003, every day 2 million tons of sewage, industrial and agricultural waste is discharged into the world's water (UN WWAP 2003).

The Zambia Demographic Health Survey (ZDH, 2018), estimates about 7 million Zambian without access to clean water out of a population slight around 17 million and ranking among countries with a highly poverty index and unequal access to social economic amenities. Only 90 percent of households in urban areas currently have access to safe water compared to only 53 percent of households in rural areas. In urban areas access to sanitation is at 70 percent, compared to rural populations, whose access is only at 25 percent. These figures project some very unequal population wide access to safe water supplies at household level and women and children bear the blunt of higher levels of contaminants in drinking water causing them seldom acute health effects. "Of course, it depends on individual susceptibility and mode of contact with the body" (Fawell and Nieuwenhuijsen 2003).

Nonetheless, for Zambia a "well-endowed country with an abundant natural freshwater body in most of its rural areas, it is, inexcusable for its government to deny their population in rural areas access to safe and readily available water supplies without barriers when government is able to pump treated water to urban cities located miles away from the rural water bodies. Safe water supplies are always important for public health, whether used for drinking, domestic use, food production or recreational purposes. However, the proliferation of the diseases liked to contaminated household water supplies mimic community and household failure to protect drinking water supplies from biological, inorganic radiologic, and organic contaminants beyond the point of supply, distribution, storage, persons factors, reuse, treatment technologies and indoor or outdoor interment among others (Kampata, Jonathan (6–8 December 2010).

To reduce the proliferation of diseases associated with consuming and using of contaminated water at household level, the Zambian Government has increased its investment in Water supplies across the country with rural areas getting more water mechanized boreholes that were drilled in rural areas to supplement other water supply sources. This is also part of government strategic position to recognize access to safe household water supplies as a human right issue and that it is governments role to mobilize resources and ensure that "every person' regardless of their ethical, social, economic status and gender or political affiliation, has the right to sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use" (UN, 2020).

In Sinazongwe district underground and surface water sources are the common supplies for the majority of residents. Residents of Sinazeze compounds on the other hand, access domestic water from the protected communal boreholes sunk by the Zambian Government with support from the International Development aid agencies and the local water utility companies who supply piped water from underground and river points. However, often, manmade factors such as by-products of industry, mining and agriculture, including heavy metals like mercury, copper, chromium, lead, and hazardous chemicals, dyes and compounds like insecticides and fertilizers, improper storing or disposing of household chemicals such as paints, synthetic detergents, solvents, oils, medicines, disinfectants, pool chemicals, pesticides, batteries, gasoline and diesel fuel and faecal matter can lead to ground and surface water contamination (Kass et al., 2005; Anwar, 2003).

Research studies in many sub-Saharan African countries and beyond, provide a myriad of causes for household water supply contamination. Nevertheless, there are contextualized differences when it comes to factors contributing to microbiological quality in handling stored water at the household level globally and in Africa, and within and among regions of a country. At the same time, there is a critical research roadblock and praxis-based knowledge in Sinazeze compound on factors contributing to contaminated household water supplies. To change the status quo, and no longer be outraged, taking corrective actions is needed.

It is against this background that this research is trying to investigate factors contributing to the contamination of Household Water Supplies among Residents of Sinazeze Township in Sinazongwe District

➢ *Statement of the Problem*

The rationale behind this study stems from the realization that, despite the availability of abundant natural and freshwater bodies in the Sinazongwe district of the Southern Province of Zambia and the Zambian government's continued investment in improved rural water and sanitation infrastructure, people have continued to consume contaminated water at household level. This is justified by the proliferation of waterborne diseases like Cholera that could have been prevented by taking appropriate measures at the household level. In comparison to the urban areas that have scored some positive achievements in addressing water and sanitation challenges. Additionally, the establishment of a devolution trust fund to focus donor support on poor peri-urban areas; and an increase in the access to water supply in rural areas, diseases and deaths related to drinking contaminated water, remain a public health threat for Zambia.

It is estimated that 82% of diarrhoeal disease in major townships like Sinazeze compound of Sinazongwe is caused by drinking contaminated household water supply, and inadequate sanitation and hygiene (WHO, 2004c). Therefore, defending the public health accountability mantra that says, 'Nothing for Us' 'Without Us' has prompted this study to investigate factors contributing to contamination of household water supply among the residents of Sinazeze compound in Sinazongwe District of Zambia.

➢ *Research Objectives*

- *General Objective*

The general objective of the study is to investigate factors contributing to microbiological quality in handling stored water among residents of Sinazeze compound, Sinazongwe district, Zambia.

- *Specific Objectives*

✓ To determine the microbiological quality of stored water in households of Sinazeze Compound.
✓ To establish methods of storage in households Sinazeze Compound.
✓ To ascertain the hygienic practices in handling stored water in households of Sinazeze Compound.

➢ *Research Questions*

The study will be predicated on the following research questions:

✓ What is the microbiological quality of stored water in households among residents?
✓ What are the available water storage methods in households among residents?
✓ What are the hygienic practices in the handling of stored water at the household level?

➢ *Significance of the Study*

The significance of this study is of high currency in that it will bring into being a spring of new empirical evidence other than abstract on the factors contributing to microbiological quality in handling stored water at household level in Sinazeze Compound of Sinazongwe District. The results can be extrapolated to similar settings and will help stir government, community, and individual actions. Several studies have focused on the socio-economic impact of consuming contaminated water, and epidemiological data of water bone related infection or outbreaks without exploring other factors in the web of contamination of water at the point of water collection, transportation, water storage vessels and practices at

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household level in rural districts such as Sinazongwe. The researcher, believes unless, there are evidence-based interventions, it will be difficult for the country's public health system to sustain current gains in reducing mortality and morbidity, related to contaminated water in several ways.

II. LITERATURE REVIEW

➢ *Literature Review at Global Perspective.*

Most developing countries fall short of meeting the United Nations (UN) set goal in their Millennium Declaration to reduce the amount of people without safe drinking water by half in the year 2015 (UN, 2000). The proliferation of diarrheal diseases, cholera, typhoid, dysentery among others causing morbidity and mortality is an indication that "Global water supplies are note spared form contamination. Thus, ensuring that safe drinking water is always readily available for human consumption and is free from faecal contamination and pathogens such as bacteria, viruses and protozoan parasites, meet the standard guidelines for taste, odour, appearance and chemical concentrations, and must be available in adequate quantities for domestic purposes remain a challenge facing most developing countries (Kirkwood, 1998).

Literature has demonstrated that people in different regions of the world are aware that, inadequate sanitation and persistent faecal contamination of water sources is responsible for a large percentage morbidity and mortality of peoples in developed or developing countries with limited or without access to microbiologically safe drinking water and suffering from diarrhoeal diseases (WHO, 2002a; Diarrhoeal diseases are responsible for approximately 2.5 million deaths annually in developing countries, affecting children younger than five years, especially those in areas devoid of access to potable water supply and sanitation (WHO, 2002b).

In a study done by Grabow, it was established that, water supplies in developing countries are devoid of treatment thus, the communities have no choice but to make use of the most convenient supply. Many of these water supplies are unprotected and susceptible to external contamination from surface runoff, windblown debris, human and animal faecal pollution and unsanitary collection methods. Detection of each pathogenic microorganism in water is technically difficult, time consuming and expensive and therefore not used for routine water testing procedures. Instead, indicator organisms are routinely used to assess the microbiological quality of water and provide an easy, rapid, and reliable indication of the microbiological quality of water supplies (Banda 2018).

Accordingly, the UN (2019) report revealed that the most vulnerable members of society, particularly women and children in contextual setting where social cultural, economic, and structural injustices overlap with the high risk of disease and mortality burden bear the blunt of diseases and infections. The complexities in household water collection, accesses, storage and use also overlap with communal and institutional factors such as faecal disposal methods, levels of hygiene and sanitation, water management and security, water treatment technologies and distribution, water, conservation policies, storage and use for households' purposes. However, institutional mechanisms for national policies implementation fall short of the vigour it takes to accelerate the attainment of Sustainable Development Goal (SDG) target 6.1 which call for "universal and equitable access to safe and affordable drinking water (UN 2010).

In the study conducted by Moyo et al., (2014) it was reported that, "the infectious disease risks from faecal contaminated and microbial unsafe water in developed countries is considered even greater in the water supplies of smaller communities than the larger ones. Small community water supplies are at greater risk than larger ones because they often lack the technical expertise and financial resources to adequately protect source waters, provide sufficient and technically reliable treatment and maintain the integrity of their distribution systems. For example, most waterborne outbreaks in the United States of America are due to systems with no or inadequate treatment, vulnerable watersheds and aquifers, distribution system deficiencies and serving smaller communities. Therefore, it should come as no surprise that, in communities throughout the world, improving household water quality by point-of-use treatment reduces risks of diarrheal disease and significantly improves microbial quality. In this review the candidate technologies and approaches for household water treatment and storage are examined based on their technical feasibility, practicality and availability, effectiveness in improving the microbiological quality of the water and reducing waterborne disease, cost, and potential for sustainability and dissemination (WHO, 2020).

Numerous studies have documented inadequate storage conditions and vulnerable water storage containers as factors contributing to increased microbial contamination and decreased microbial quality compared to either source waters or waters stored in improved vessels. Some studies also have documented increased risks of waterborne infectious diseases from inadequately stored water compared to water stored in an improved vessel (safe storage), treated in the home to improve microbial quality, or consumed from a quality source without storage (Farwell and Nieuwenhuijsan, 2003).

Higher levels of microbial contamination and decreased microbial quality are associated with storage vessels having wide openings (e.g., buckets and pots), vulnerability to introduction of hands, cups and dippers that can carry faecal contamination, and lack of a narrow opening for dispensing water. Some studies have noted the vulnerability of storage vessels with these undesirable characteristics to faecal and other contamination without having reported microbiological data on water quality or increased levels of diarrheal disease (Miller, 1984). Other factors contributing to greater risks of microbial contamination of stored water are higher temperatures, increased storage times, higher levels of airborne

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particulates (dust storms), inadequate hand washing and the use of stored water to prepare weanling and other foods that also become microbiologically contaminated and contribute to increased infectious disease risks (Luby et al., 2001,).

Most of the physical and chemical methods for on-site or point-of-use treatment of household water in developing countries are also employed in developed countries, either at point-of-use or in community (municipal) water treatment systems, using the same or similar technologies (LeChevallier and Au, 2000). In developed countries, a number of point-of-use treatment technologies not widely employed in community water systems also have been employed, including various filters, absorbents, ion exchange resins and softeners (Geldreich and Reasoner, 1990).

- *Literature Review at African Perspective.*

Recent studies in Africa amplified the way different countries are struggling to remove organic, non-organic biological and radiological contaminants in water. "Ensuring sustained supply of safe water require concerted efforts of all stake holders including the community and household members to explore the determinants of water contamination geological or anthropogenic (man-made)" (Farwell and Nieuwenhuijsan 2003). It is assumed that treated community water supplies in developed countries generally are of high microbiological quality and therefore safe with respect to waterborne microbial disease risks. However, significantly increased risks of waterborne gastrointestinal illness have been attributed to a centralized community water supply system in a large city of a developed country (Laval, Quebec, Canada) where water was extensively treated by modern methods and met all microbial quality requirements (Payment et al, 1991; 1996).

These findings suggest that pathogens at levels below detection but high enough to cause measurable gastrointestinal illness either penetrated the multiple treatment barriers or they entered the treated water subsequently in the community distribution system or within household plumbing. Hence, even extensively treated community drinking water of high microbiological quality and assumed to be of low risk in developed countries may still be contributing significantly to community diarrheal illness. It is noteworthy that the apparent risks of waterborne diarrheal illness from the treated community water delivered by the distribution system were significantly decreased either by point-of-use water treatment or by protecting the treated water from post-treatment contamination (i.e., bottling it at the treatment plant and delivering the bottles to consumers (Chidavaenzi et al., 1998).

Water since ancient times, water for household use is collected by a variety of physical methods ranging from manual (e.g., dipping), to passive (e.g., roof catchments and diversions) to mechanical (e.g., pumps), and it is stored in a variety container. In developing countries, many of the traditional types of water collection and storage methods employing vessels of various compositions and sizes are still widely used today (Mintz et al., 1995)

- *Water Storage Methods*

According to White et al., (1972), provided some traditional methods of water storage which include traditional pots or urns fashioned from natural materials (e.g., gourds or wood) or fabricated from clay, copper, brass and other impervious materials, and flexible bags or other vessels made of animal hides, other animal parts or fabrics treated to seal and prevent leakage. Today, other metals, including aluminium, steel and iron, as well as other materials, primarily plastics, have come into widespread use for water collection and storage in the form of buckets, jerry cans, picnic coolers and other vessel types and shapes. Cisterns and other basins are also still widely used for water collection and bulk storage near or adjacent to dwellings, as they have been since ancient times.

Some of the key factors influencing the impact of storage vessels and conditions on household water quality are: (1) portability and ease of use, based on capacity, size, shape, weight, presence of handles, (2) durability, weight and other properties related to resistance and longevity, (3) presence of a coverable (preferably screw-cap) opening for filling and cleaning access but small enough to reduce the potential for introducing contaminants by contaminated hands, dipping utensils and other vehicles (e.g., airborne dust), vectors, or other sources, (3) ability to withdraw water in a sanitary manner, such as via a tap, spigot, spout or other narrow orifice, and (4) presence and accessibility of documentation describing how to properly use the container for water treatment and sanitary storage (Mintz et al., 1995).

In most developing countries, women are responsible for the collection of water (Sobsey, 2002). The work involved in fetching the water may differ in each region, it may vary according to the specific season, it depends on the time spent queuing at the source, the distance of the household from the source and the number of household members for which the water must be collected (WHO, 1996b; WHO, 1996c). Water for domestic use is collected either by dipping the container inside the water supply, collecting rainwater from a roof catchment system or by using different types of pumps connected to the water supply system (Sobsey, 2002).

The transportation of the water from the source water supply could be either by a wheelbarrow, a donkey cart, a motor vehicle using a rolling system or by carrying the container by hand or on the head (CDC, 2001). A common practice often seen in rural areas was the use of leaves or branches with leaves to stop water slopping out during transit in wide-neck storage and transport containers (Sutton and Mubiana, 1989).

Consequently, a study by Sutton and Mubiana (1989) has showed that these leaves can be an additional source of coliform bacteria to the drinking water. In studies conducted in Malawi, Kenya, Uganda, and Tanzania (Lindskog and Lundqvist, 1989; White et al., 2002), it was found that if the water taps were situated closer to the dwelling, the amount of water collected/person/day increases from 9.7 to 15.5 litres.

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In Lesotho, Esrey and co-workers (1992) made a rough estimate of 10 litres of water/person/day based on direct observations of households in rural communities. In another studies conducted in the rural communities of Limpopo Province of South Africa showed that on average 11.4 litres of water/person/day was collected if the source was close to the household, compared to an average of 8.6 litre of water/person/day if the sources were more than 1 km from the household (Verweij et al., 1991).

Department of Water Affairs and Forestry in South Africa recommends 25 Chapter 2 34 litre/person/day from a source within 200 m from the dwelling (DWAF, 1994) and the WHO estimates a minimum of 20 litres of water/person/day is sufficient (WHO, 1996b), while Gleick (1998) recommends 50 litres of water/person/day is efficient. These studies indicated that more water was collected per person per day if the source was closer to the dwelling (White et al., 2002; Lindskog and Lundqvist, 1989; Verweij et al., 1991).

In another study in rural communities in South Africa (Verweij et al., 1991), water samples were taken immediately after collection from communal taps and unprotected borehole and springs. Special precautions were taken to prevent contamination during collection, which included rinsing of the container before filling, using a calabash to scoop water from the source and demarcation of a special area for water collection. The results from this study indicated no significant difference between faecal coliform counts at the source and immediately after collection of the water (Verweij et al., 1991).

- *Hygiene and Handling Practices in Relation to Microbiological Quality and Storage Methods*

A study carried out in a Malawi refugee camp has found that hands are primarily responsible for contamination of collected water because the women rinse the container with small amounts of water using their hands to rub around the container opening to clean it (Roberts et al., 2001).

In the study by Dunker (2001) concluded that rural communities in South Africa spent little time on proper cleaning of the collection containers, especially if water must be collected more than once a day. These studies have shown that although the microbiological quality of the source water could be classified as safe for domestic purposes, the water collected by the households from these sources, become contaminated after collection. The origin of the contamination includes transport and unhygienic collection and handling practices such as dirty utensils, dirty hands and unclean storage containers (Dunker, 2001; Sobsey, 2002).

Most of the methods or processes to purify water and make it safe for drinking and other potable purposes can be historically traced to ancient versions of them used since recorded history (Baker, 1948). According to the literature of Baker (1948), "the earliest written records of water treatment, dating from about 4000 B.C., mention filtration of water through charcoal or sand and gravel. Although several modifications have been made in the manner of application, filtration remains one of the fundamental technologies associated with water treatment." thus the practice of many of these water purification methods since ancient times has been documented by pictorial, written and archaeological records from a variety of original sources and recounted by scholars and historians of water treatment and water quality

Although the ancients may not have been aware of how such treatments improved the microbiological quality of water, they apparently were aware of and appreciated the benefits of these methods in making the water more healthful by reducing disease and improving its aesthetic qualities. Recorded in ancient history are the physical methods of sedimentation, filtration, boiling or heating, and exposure to sunlight (UV irradiation and heating), and the chemical methods of coagulation or adsorption with alum, lime, and plant extracts, absorption with carbon (charcoal), clay and plant materials, and exposure to germicidal metals such as silver and copper (Baker, 1948).

Key differences in the application of these technologies in developing countries compared to developed countries are in the availability and affordability of the materials and the need to adapt the technologies to local conditions and personal or community preferences. Furthermore, point-of-use or point-of-entry treatment devices or systems in developed countries are often being applied to waters already subjected to extensive treatment, including disinfection, or withdrawn from high quality water sources. Hence, such waters are already likely to be relatively safe or low risk with respect to microbial quality and waterborne disease risks without point of-use or point-of-entry treatment. In many developing countries as well as in many settings in developed countries, point-of-use, point-of-entry, and household treatment often must be applied to water that is microbiologically contaminated. Therefore, the treatment requirements to achieve acceptable microbiological quality can be substantial and only some technologies or unit process will be capable of meeting this objective (Geldreich and Reasoner, 1990).

Various intervention strategies to improve the water at the source have been described in the literature (Sobsey, 2002), pointed out there is improvements in water storage thus include the building of reservoirs, building protective structures around boreholes and fountains, providing communities with communal taps closer to the dwelling and the treatment of the water source with a disinfectant.

A study conducted in rural Malawi showed that communal piped water supplies situated within a distance of 400 m from a specific household, improved the microbiological water quality used for drinking because people collected water more often and did not store water which could have become contaminated during storage (Lindskog, 1988).

According to Ghannoum and co-workers (1981) showed that the installation of water treatment plants did

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reduce the incidence of bacillary and amoebic dysentery between 10% and 50%, but not Giardia infections. However, studies carried out in peri-urban communities in South Africa (Genthe et al., 1997; Jagals et al., 1999) have showed that although the households were supplied with good quality water complying with South African drinking water specifications the water in the household storage containers had increased levels of indicator microorganisms. This implied that secondary contamination was introduced after the water collection. Consequently, many of these studies have indicated that improvements at the water source are useless as water is contaminated during collection and storage in households due to poor sanitation practices (DWAF, 1996).

- *Point-Of-Use Water Resource in the Household (Microbiological Quality and Storage Methods).*

Source water contamination is likely to have a wide effect on the community because it can introduce new pathogens in the home environment (Sobsey, 2002). However, several studies have reported that the microbiological quality of the water deteriorate after collection, during transport and during storage at the point-of-use due to secondary contamination factors (Rajasekaren *et al*.,1977; El Attar *et al*.,1982; Simango et al., 1992; wright *et al.*, 2004).

Due to the distances and unavailability of piped water supplies on the dwelling or inside the households in many developing regions of the world, people are forced to store their drinking water (Sobsey, 2002). Transmission of microorganisms inside the household can occur through several routes (Briscoe, 1984; Roberts et al., 2001). The most important transmission routes include water, food, person-to-person contact, unhygienic behaviour (e.g., intra-household transmission of faeces), the storage conditions of the water storage containers at the point-of-use and the abstraction conditions of water from the storage container (Briscoe, 1984; Roberts et al., 2001). In addition, a number of studies (as shown in Table 2.2) suggested that inadequate storage conditions increased the risk of contamination, which can lead to infectious diseases.

Table 1 Summary of Studies Indicating Increased Microbiological Contamination of Stored Water and Associated Infectious Disease Risk Due to Inadequate Storage Conditions (Sobsey, 2002)

Study Area	**Storage Container**	**Storage time**	**Impact on Microbial quality**	**Disease impact**	**Reference**
Bangladesh	Water jars	1-2days	Increased Vibrio cholarea	Increased chorela rates	Spira et al., 1980
Bahrain	Capped plastic vessels, jars, pitchers	Not reported	Vibrio cholarea present in stored water and not in water source	Uncertain	Gunn et al., 1981
Sudan	Clay jars	2days to 1 month	Increased faecal indicator bacteria overtime, in summer nd durin dust events	Not measured	Hammad and Dirar 1982
Egypt	Clay jars	less than 1-3days	Algae growth and acculated sediments	Not detected	Miller, 1984
India	Wide mouth Vs narrow neck	Not reported	Not measured	Cholera infections four fold higher in wide mouth storage	Deb et al 1986
Burma	Buckets	Upto 2days	Higher levels of faecal coliforms	Not measured	Han et al., 1989
Liberia	Large containers, open or closed	Long time	High levels of enterobacteria in stored samples compared to sources	Not measured	Molbak et al., 1989
Sri Lanka	Earthen pots and others	Not reported	Higher levels of faecal coliforms in unboiled stored water	Not measured: no effect	Mertens et al., 1990
South Africa	Plastic containers	4 hours	Higher coliform levels overtime	Higher coliform levels over time	Verweij et al., 1991
Africa	Traditional and metal Jars	24 hours or more	High total and faecal coliform levels	Not measured	Empereur- Bisonette *et al.*, 1992
Malaysia	Variuous Containers	Not reported	Higher levels of facal coliforms in unboiled stored water	High diarrhea risks from water unboiled or stored in wide neck than narrow containers	Knight et al., 1992

Zimbabwe	Covered and Uncovered containers	12 hours and more	Higher E.coli and Aeromonas levels with storage and use	Not measured	Simango et al., 1992
Peru	Widemouth containers	Not reported	Higher coliform levels in stored waters than source waters	Increased cholera cases	Swedlow et al., 1992
Bangladesh	Traditional Pots	Not reported	Increased faecal coliforms and antibiotic resistance	Increased faecal coliforms and multiple antibiotic resistant flora	Shears et al 1995
Trinidad	Open drum, burrel, bucket vs tank or none	Not reported	Increased faecal bacteria lvels in open storage vessels than tank	Not measured	Welch et al 2000

- *Conceptual Framework*

The transmission of infectious disease is a complex process that cannot be predicted to a high degree of accuracy. There are many determinants of ill health, and a conceptual framework helps to understand which of these are important in disease transmission. The researcher has developed such a conceptual framework of factors that would be hypothesised and specific to the context of drinking water that have become contaminated between collection and consumption in households as shown in the table 1.

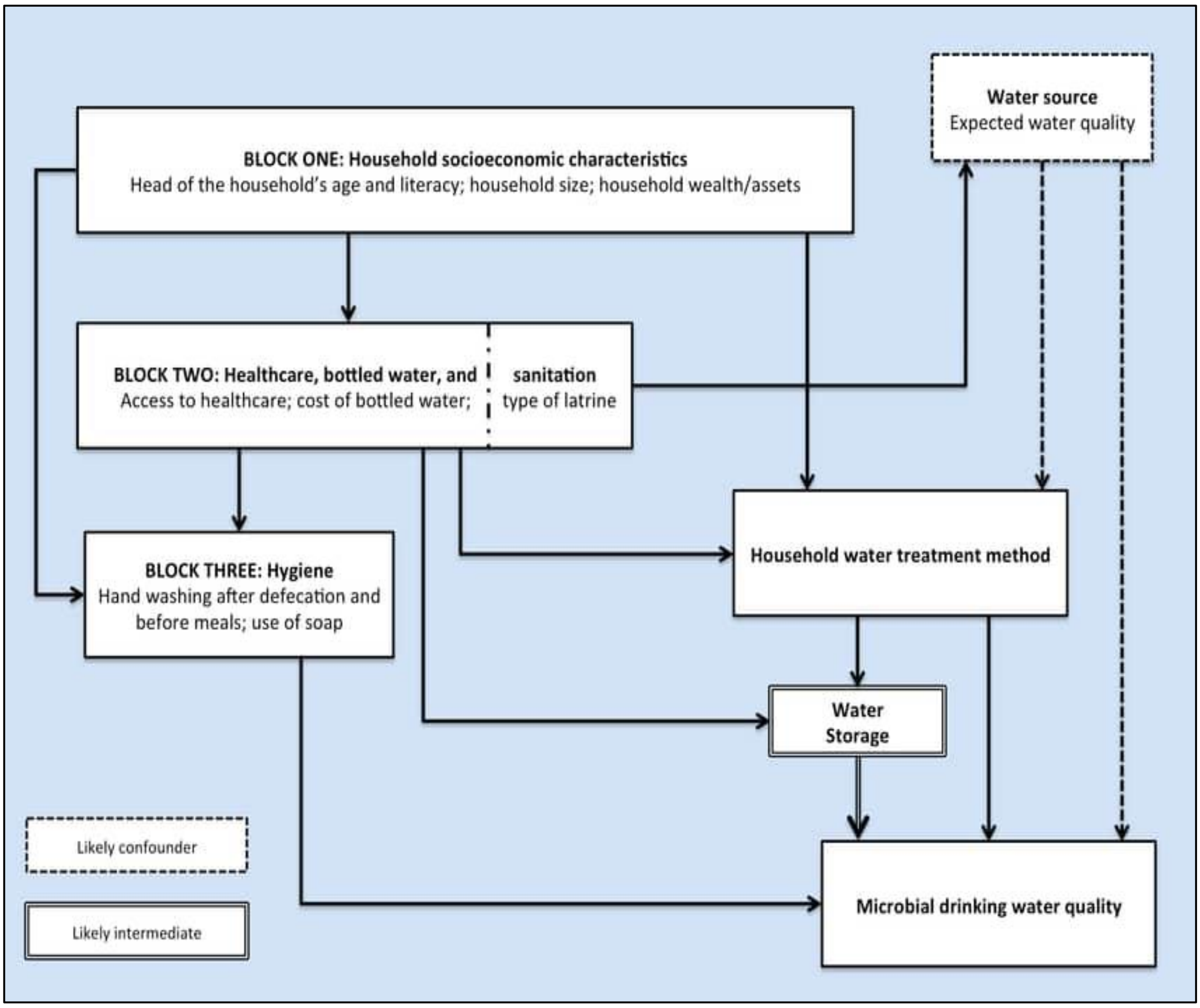

Fig 1 Conceptual Framework

The conceptual framework provides a starting point to develop a series of hypothesis that relate to the risk or actual occurrence of disease transmission through consumption of contaminated water in households. It is not the purpose of this research to produce an exhaustive list of hypotheses but instead to provide a few examples that can either be examined in the light of the existin literature or indicate areas of further research.

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Table 2 Examples of Hypotheses Relating to Disease Risk from the Consumption of Contaminated Drinking Water According to the Conceptual Framework Factors.

Primary/ Secondary Factor	Hypothesis
Handling	Improved storage containers maintain good water quality and lead to reduced disease incidence. Minimized handling can be linked to lower disease incidence.
Hygiene	Hand contact with drinking water can be linked to disease transmission. Improving hygiene/ hand washing behaviour leads to reduced water pollution in the home.
Environment	Improved sanitary quality of the environment leads to better water quality. Household's own excreta is implicated in disease incidence.
Anthropology	Communities exhibiting a high degree of social interaction experience greater incidence than those more ' closed' cultures
Socio-economic	Stored water quality is worse in the poorest households.

III. RESEARCH METHODOLOGY

➢ *Introduction*

This chapter focused on the methodology that the researcher utilized in carrying out the study. Areas of focus included the study design, study setting, population, sampling technique, sampling procedures, and research instruments. No research can be conducted without ethical considerations hence these will also be discussed. In this study, a cross-section study was employed.

➢ *Research Design*

A cross-sectional analytical study was carried out in Sinazeze Compound, Sinazongwe district between March to May 2024.

• *Study Variables*

A cross-section analytical study to answer the research questions employed observations and interviews to show the relationship in variables as shown in table 2.

Table 2 Showing the Variable

Variable	Description	Indicator	Scale of Measure
Dependent	Microbiological Quality.	Presence of Microorganisms.	Colour Change i. Black- Unsatisfactory ii. Brown- Satisfactory
Independent	Method of water storage.	Type of Water storage containers.	Storage Container. i. Storage Vessel having wide opening- Unsatisfactory ii. Storage Vessel with a narrow-necked opening with a lid-satisfactory
	Hygiene Practices/behaviour in handling stored water.	The presence of safe water and sanitary facilities.	Checklist/safe hygiene practices in handling stored water i.e i. Handling- Satisfactory/Unsatisfactory ii. Hygiene-Satisfactory/Unsatisfactory iii. Environmental Sanitation-satisfactory/ Unsatisfactory iv. Socio-economic- satisfactory/Unsatisfactory v. Household water treatment- Boiling, Chlorination, use of filter-Satisfactory; no treatment-Unsatisfactory. vi. Others- period of storage of stored water.

➢ *Study Setting*

The study was carried out in Sinazeze which is centrally located in Sinazongwe District. The study area was selected based on the dense population and health records from the servicing health facility (Sinazeze Rural Health Centre) which indicated higher cases of waterborne diseases. Households in Sinazeze Compound get their drinking water from a groundwater source (borehole with mechanized pump) through a pipeline and public tap.

➢ *Study Population*

The study population was selected among households of Sinazeze Compound in the Sinazongwe district of Zambia. Health providers at Sinazeze Rural Health Centre with vast knowledge of households with high incidence of diseases were also be selected as key informants.

➢ *Sample Size*

This study will apply Slovin's Formula to determine the sample for the study whose formula is shown below;

$$n= N/(1+Ne2)$$

Where;

n= sample size
N= population size
e= margin of error (at 5%)

Finally, the minimum sample size required for the study (60) was obtained.

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➢ *Sampling Technique*

A purposive sampling approach was used alongside snowballing. This means the samples were picked from the health facility registers by the researcher. This is a 'Fried Egg' approach that will be applied to randomize those residing within a 25-kilometer radius from the Health center until a desired sample size of 60 is achieved. Those beyond the 25-kilometer radius will be excluded from the sample unless there are exceptional cases. This reduced selection biases. Simple random sampling was used to select the participating villages and neighbourhood health zones.

- *Water Sampling Techniques*

The sample were collected by visiting the homesteads at random and taking a sample from any household container that had stored water from the common used water storage vessels.

Hydrogen sulphide test kits were used to ascertain the microbiological quality of water from selected Households. Sampling were aseptically done. Field test kits were used in which results were read at 24 hours and 48 hours in accordance to water sampling guidelines.

➢ *Data Collection*

Households visits made were made by the researcher to physically interview the households while observing the practices in water collection, transportation, storage, and collection vessels as well as other social economic challenges facing the community and households in particular. The data were collected using a structured and pretested questionnaire. Initially, it was developed in English, and then translated into the local language, Tonga; then it was translated back into English and administered to the mothers or caregivers by local language. The study questions included socio-demographic characteristics, type of water sources, housing and sanitation facilities, household water storage and handling practice, the hygienic practice of respondents and respondent's knowledge about the causes of drinking water contamination.

Water samples were collected from each household and their respective water source, one at a time, for bacteriological analysis. Sterile 20 ml glass bottles were used for sample collection i.e. Hydrogen sulphide test kit.

The drinking water in urban Sinazeze is distributed by a pipeline mainly from groundwater sources (boreholes with mechanized pumps). So water samples from all functional water sources and 60 households with at least one child under five years of age that had used these sources were selected randomly. A water sample was collected from each household's storage container using their drinking cup.

- *Operational Definition*

✓ *Improved Sanitation*

A sanitation facility that includes a flush/pour-flush toilet or latrine that flushes to a sewer, septic tank or pit, a ventilated improved pit (VIP) latrine, pit latrines with the pit well covered by a slab, or composting toilets and must not be shared.

✓ *Type of Water Source*

In this study, a piped water supply into the dwelling and piped water to a yard/plot is considered as an improved source whereas water supply from covered dug well with a hand pump and a public tap is considered as other improved sources.

✓ *Sanitary Disposal of Child Feces*

The management of a child's feces by putting or rinsing stools into sanitation facilities.

✓ *Household Water Treatment*

Are any of a range of devices or methods employed to treat water to remove or inactivate microbial pathogens in the home or at the point of use in other settings .

✓ *Hand Washing Facility*

The presence of any device or infrastructure that enables a resident to wash their hands effectively using running water, such as a sink with tap, water tank with tap, bucket with tap, tippy tap, or other similar device and both water and soap or detergent must be available at the hand washing facilities.

- *Domestic/ Household Water Storage Containers*

These are containers that are used to store water inside the houses for future use in domestic settings. This form of storage is common where the water supply is not constant and hence sources are not quite reliable.

In this study, therefore, all types of containers such as plastic buckets, bottles, Jerricans, and pots that were found to have water in them were sampled and the sample was classified as a household storage container.

- *Water Sampling Procedure*

Hands were thoughly washed with soap as first step before touching the Hydrogen Sulphide (H2S) test kit. The cap onto the bottle was removed and a water sample of 20 mls from the commonly used stored storage container was filled up to the mark indicated on the bottle. The bottle was then kept at an ambient temperature of between 25 to 35 degrees Celsius. Color change observations for 24 hours to 48 hours will be made at the nearest health facility laboratory. If the water turned black, it meant that the water was not safe for drinking (unsatisfactory result) and if it turned brown, then the water from that storage vessel was fit for drinking (satisfactory results). After the the sampling procedure was done, a few drops of disinfectant (i.e Detol, phenyl etc) was added and discarded the vial.

➢ *Data Analysis*

Data was collected, coded entered in the Epi Data Version 3.0, and exported to the Statistical Package for Social Sciences (SPSS) version 16.0. Quantitative data was analysed using STATA and presented in a tabular form using frequencies and percentages for easy interpretation. To establish relationships, bivariate robust Poisson

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regression analysis, and multivariate robust Poisson regression were done. The result is reported in terms of ratios 95% confidence interval and a P value of 0.05 was being considered significant. Thereafter, Analysed data was displayed by means of tables and figures to show the research findings

➢ *Ethical Considerations*

The following research ethics on human subjects will be upheld:

- *Ethical Considerations:*

Approval to conduct the study was obtained from the Lusaka Apex Medical University Bio-Medical Research Ethics Committee (LAMUBREC) and a request of permission from the District Health office in Sinazongwe District.

- *Informed Consent:*

Since the study area is a sensitive matter, consent forms were administered for the protection of both parties (Researcher and respondents), therefore participants will have to sign the consent form as a commitment that they have given the researcher permission to conduct the interview/observation or administer the questionnaire.

- *Confidentiality:*

The secrecy of respondents was taken into consideration, for no information written or obtained was not shared with anyone as it will be indicated in the respondent's approval form.

- *Anonymity:*

This was to identify the participant particulars i.e., names, residential location, church affiliated to, etc., but in this study, the names of the respondents were kept hidden to prevent participants from harassment.

- *Autonomy:*

The participant were assured of their right to withdraw from the study at any moment without any retribution.

➢ *Pretesting of Data Collection Tools*

Data collection tools were used in the Sinazeze compound of Sinazongwe District, Zambia. The pre-test will of data collection tools was done in Sinazongwe which was an area not where the study was being conducted to prevent contamination of data.

IV. PRESENTATION AND FINDINGS

➢ *Introduction*

This chapter presents the findings of the study whose research objective was to examine factors that contribute to the microbiological quality of handling stored water poor in the Sinazeze Compound of Sinazongwe District. The participation in the study was voluntary. Of n=60 individuals who started the survey and responded to the question - Do you agree to participate in the survey? n=60 (100%) agreed to do so. However, not all questions were answered by the 60 respondents. The respondents came from Sinazeze compound of the Sinazongwe District.

- *Section A: Social Demographic Characteristics of the Respondents*

- *Age Distribution*

The percentage distribution of the respondents by age group is given in table 1.

Table 3 Showing Responses of Respondent's Age

Variable n=60	**Frequency**	**Percentage**
How old were you at your last birthday?		
<25	6	10
26<35	12	20
36<45	19	32
46<55	16	27
56 and above	7	12
Total	60	100

Source; Field Survey 2024

The table 3 above show that majority of the respondents 19 (32%) were in the age category of 36<45 yrs. of age. These were followed by 16 (27%) in the age category of 46<55yrs and 12 (20%) in the age range of 26<35yrs. and 7 (12%) aged above 56 yrs. respectively, with the least being 6(10 %) in the age category of <25 respectively meaning that majority were between 26 and 55 years.

- *Respondents Gender*

Of the respondents (n=60; 100%) who provided demographic related information, 30 (30%) were males and 30 (50%) were females (see fig 2 below)

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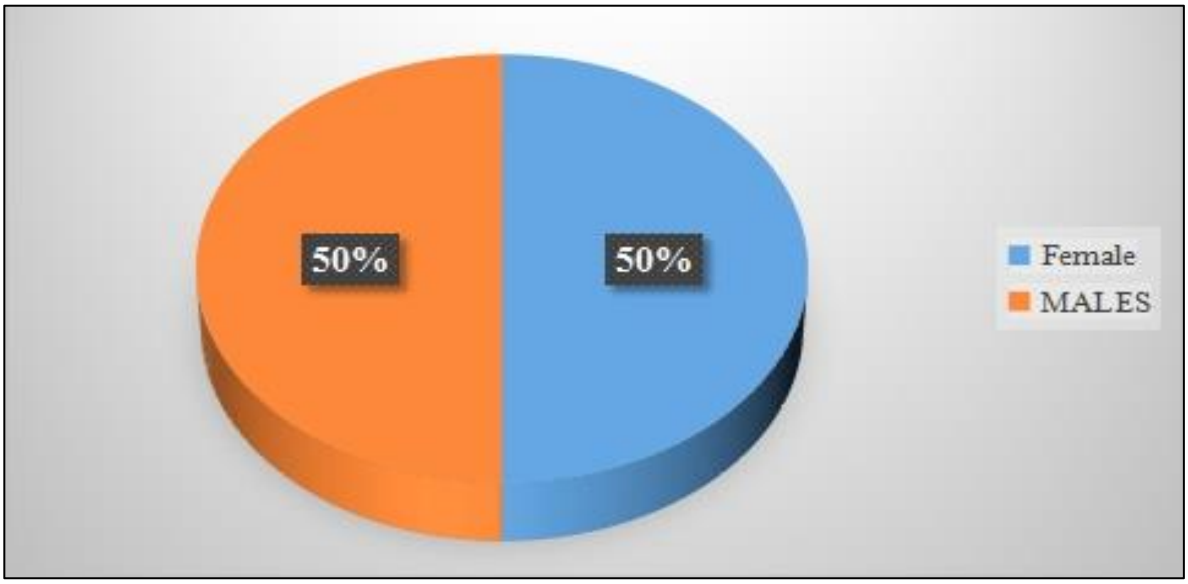

Fig 2 Responses on Respondents Gender
Source: field Survey 2024

- *Respondents Nationality*

Table 4 Showing Respondent Nationality

Variable n=60	Frequency	Percentage
What is your Nationality		
Zambian	53	88
Non-Zambian	7	12
Total	60	100

Source: Field Survey 2024

The percentage distribution of respondents' nationality given in table 5.1.2 below show that majority of the respondents 53(88%) were Zambians while minority 7(12%) were foreigners

- *Respondents Level of Highest Education Attained*

The highest education level of the respondents (n=60) included majority 25(42%) with junior secondary level education followed by 19 (32%) with primary schooling and the least were 9(15%) who had secondary school level education and 7(12%) tertiary education respectively.

- *Respondents Occupation That Best Describes Their Current Job*

Table 3 Showing Responses of Respondent's Occupation Strata that Best Describe their Current Job at Collumn Coal Mine in Nkandabbwe

Variable n=176	Frequency	Percentage
5. Which of the following occupation groups best describes you?		
Businessman/ trader	6	10
Unemployed	2	3
Self employed	16	27
Employed in an organization	10	17
Fisher man	8	13
Farmer	14	23
Others	4	7
Total	60	100

Source: Field Survey 2024

The 60 respondents came from a broad range of occupational backgrounds (as shown in table 3 above). Majority of the respondents were self-employed represented 16(27%) followed by farmers 14 (23%). Those who were employed in organizations only represented 10(17%) while 8 (13%) were fishermen alone, Business men or Traders represented 6 (10%) and the least being others 4 (7%) and unemployed 2 (3%) respectively.

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➢ *Main Drinking-Water Sources in Sinazeze Compound*

Table 4 Showing Responses on the Main Source of Water in Sinazeze Compound of Sinazongwe District as Reported by Majority

Variable n=60	**Frequency**	**Percentage**
What is the main source of water used by your household for other purposes, such as cooking and hand washing?		
Piped water into dwelling	5	8
Piped water to yard/plot	5	8
Public tap/standpipe	3	6
Tube well/borehole	35	58
Protected dug well	5	8
Unprotected dug well	5	8
Protected spring	0	0
Unprotected spring	0	0
Rainwater collection	1	2
Bottled water	0	0
Cart with small tank/drum	0	0
Tanker-truck	0	0
Surface water (river, pond, stream canal and irrigation channels)	6	10
Total	60	100

Source: Field Survey 2024

The majority reported use of surface water (n=18; 30%) and dug unprotected wells (n=35; 58%) whereas only n=6; 10% indicated accessing piped water into their dwelling places. Rains water source was reported only by the least (n=1; 2%). The other few who had access to different sources of water cited piped water to yard plot and public tap including borehole at (n=8; 5%) each respectively.

➢ *Residents Perception of Safe Householder Water Supplies in Sinazeze Compound*

Table 5 Showing Sinazeze Compounds Residents Perception of Safe Householder Water Supplies

n=60 Variable					
What does Safe water supplies mean to your facilities mean to you					
Safe	**Freq.**	**%**	**Contaminated**	**Freq.**	**%**
Piped water into dwelling, plot or yard	53	88	Public tap/standpipe	13	22
Tube well/borehole	60	100	Unprotected dug well	60	100
Protected dug well	34	57	Unprotected spring	60	100
Protected spring	12	20	Cart with small tank/drum	21	35
Rainwater collection	60	100	Others	-	-

Source: Field Survey 2024

The finding reviewed that the majority were able to distinguish between what safe and contaminated water supplies. However, the merit of their distinction was by and large informed by what they see and shared community experiences of each unique water supply source or infrastructure and not on laboratory analysis and conclusion of availability of microbiological, organic or inorganic contaminants. There varying views are as depicted in the table above where, 88% (n=53) said piped water in to dwelling or plot entail safe water and n=60 (100%) said Tube well/borehole and rainwater from collected from the roof was safe. On the other hand, unprotected dug wells and unprotected spring water were considered contaminated by majority n=60 (100%). The majority didn't, however, consider the possibility of water getting contaminated even during collection transporting and point of use at this point in time not after reflecting during the interviews.

➢ *Factors Contribution to Contamination of Household Water Supply Sources -a Generalized Perspective*

Table 6 Showing Generalized Factors Contributing to Contamination of Household Water Supply Sources Perceived by Respondents

Variable	**FX**	**Contaminated**	**Uncontaminated**	**Crude OR**	**95 % CI**	**Adjusted OR**	**95 % CI**	**P**
Nitrates found in fertilizers, manures and liquid waste coming from septic tanks and plumbing systems	Yes	412	27	2.81	1.57–5.00	1.49	0.75–2.94	0.25
	No	136	25	1.0		1.0		

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Arsenic substances found organically in small amounts within nature	Yea	31	15	0.15	0.07–0.30	0.32	0.14–0.75	0.01
	No	517	37	1.0		1.0		
Microorganisms, Bacteria, and Viruses	Yes	64	32	0.08	0.04–0.15	0.17	0.08–0.34	0.00
	No	484	20	1.0		1.0		
Aluminium elements present in the earth's soil, water and air	Poor	37	21	0.11	0.06–0.20	0.32	0.18–0.69	0.00
	Unimproved	511	31	1.0		1.0		
Fluoride	No	296	42	0.28	0.14–0.57	0.48	0.22–1.02	0.06
	Yes	252	10	1.0		1.0		

Source: Field Survey 2024

The results in table 6 show that the relationship of nitrates found in fertilizers, manures and liquid waste coming from septic tanks and plumbing systems at p values 0.25 and the arsenic substances found organically in small amounts within naturist at p value of 0.001 was statistically significant comparatively, community members were silent on microorganisms, Bacteria, and Viruses including Aluminium element present in the earth's soil, water and air as a source of contamination. This is mainly due to lack of sensitization on the subject matter and the use of physical eyes to judge or determine water safety than getting into the laboratory analysis. The rejection of the null hypotheses in favour of fluoride is another aspect indicating that more research was needed as communities did not see the need to be concern about fluoride as a contaminant of water.

- *Individual Household Practices Contributing to Contamination of Water Supply Sources in the Compound*

Table 7 Showing Individual Household Practices Contributing to the Contamination of Water Supply Sources in the Compound

Variance N=60	**Freq.**	**Perc. (%)**
Individual household practices contributing to contamination of water supply sources in the compound		
Improperly disposed of agro- chemicals, animal wastes, pesticides, faecal matter and household waste,	60	100
Dipping dirty utensils when drawing water from storage vessels	56	95
Sending children to draw water from the storage vessels	42	70
Individual negligence securing water from contaminants	51	80
Others (Personal hygiene, individual household vulnerability, age, gender, knowledge levels health risk …. etc	60	100

Source: Field Survey 2024

The findings in table 6 show that even though the individual factors contributing to contamination if household water supplies were myriads. This study found improper disposal water (agro-chemicals faecal matter, pesticide and general household waste) and other factors such as personal hygiene for water handlers, collectors and user, their knowledge about levels of health risk etc.), to be among the top four individual factors n-60(100%). this was followed by unconcern use of dirty utensils when dawning water from the storage constrainers (n=57; 95%) individual failures to secure water from contaminants (n=51;80%) and sending children to draw water from storage contains (n=42;70%) in that respective order.

- *Water Storage Practices Contributing to Microbiological Quality of Handling Stored Household Water Among Residents of Sinazeze Compound*

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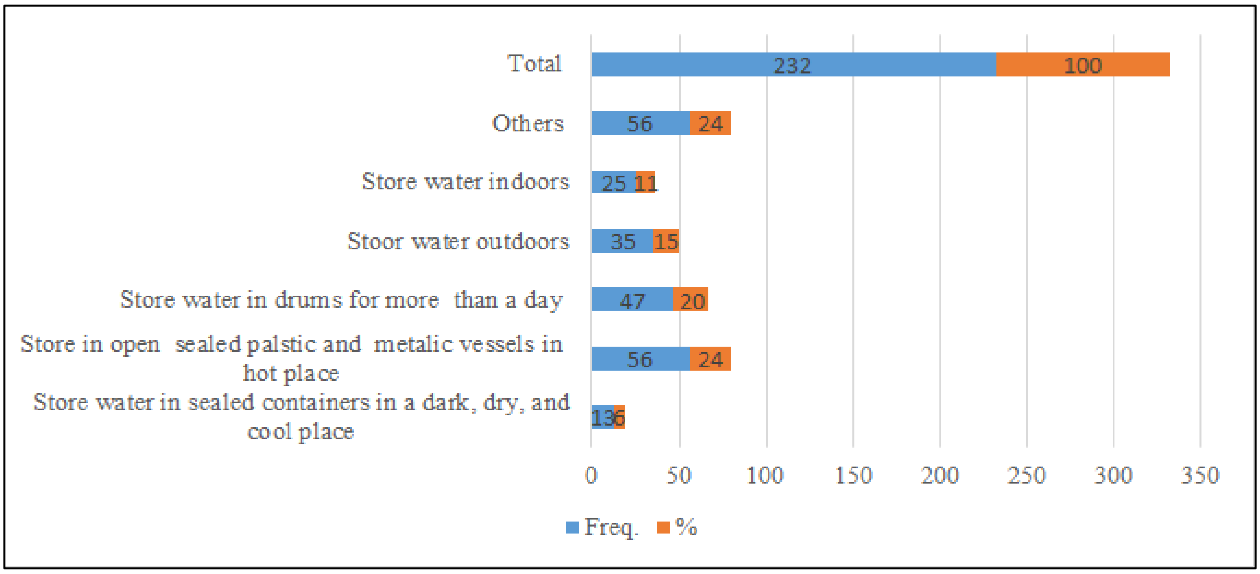

Fig 3 Showing Water Storage Practices
Source: Field Survey 2024

Majority of the household had reported unsafe water storage practices which included storing water in open plastics of metal containers, storing water outdoors and for a longer period in drums. This made their storage practice more vulnerable to bacteria, dust, and other microorganism and worse still rust for the water stored in metallic contenders.

➢ *What are the Water and Sanitation Challenges Contributing Contamination of Household Water Supplies in Sinazeze Compound*

Open defecation has reduced due to the implementation of sanitary improved toilets however, animal dung especially pigs around the boreholes and dug out wells as well as other ground water sources such as shallow wells which are the dominant source of contamination of household water supply most frequently used by the majority (n=42; 70 %) of the households. This is explained by the lack of fencing of the water sources. The resulting risks are well-known, and people are aware that the construction of fences around communicable wells or boreholes would be helpful to address the problem. The in-depth interviews did not reveal any cultural barriers to the use of latrines.

Waste is typically discharged into the surrounding environment by almost the entire household. Some of the households incinerate waste periodically. The almost total absence of controlled garbage dumps and the lack of garbage collection systems reflect the lack of attention to this problem, and waste management is a major concern in the municipality.

The finding in figure 3 reveals that majority of the respondents (n=60;100%) face the challenge of waste management in general and contribute to water pollution. this follows the same patterns of other challenges such as poorly managed household waste, (n=51 (85%) and agro-chemical containers (n=42; 70%). All the households surveyed lacked home dug refuse bins which are recommended by the Ministry of Health (MOH 2024) in Townships. Wastewater, as well as solid waste, is released untreated by 98.17 % of households. These practices pose a risk to water sources.

➢ *Water Treatment*

Table 7 below shows that of the majority respondents n= 13(100%) who said they treat water 100% mentioned that they boiled water while 62% added chlorine and 23 % said they also let it settle (see table 7 below). This result showed that majority did not treat water in any way 47(78%)

Table 8 Showing Responses on Water Treatment

Variable n=60	**Frequency**	**Percentage**
What do you usually do to make it safe to drink?		
Boil	3	23
Add bleach/chlorine	8	62
Strain it through a cloth	0	0
Use a water filter (ceramic, sand, composite)	0	0
Solar disinfection	0	0
Let it stand and settle	60	100

Source: Field Survey 2024

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➢ *Other Findings*

In-depth interviews with key informants were used to gain a better appreciation of their basic knowledge of factors contributing to poor water and environmental sanitation.

- *Water Uses*

Consumption of surface water was recognized by the community as having a health risk, with several making comments like:

✓ "*The water contains microbes and gives us diseases". Female respondent 1*

✓ *"The lack of improved water sources forces the households to use this water.* Male respondent

✓ *'The intermittent water supply in Sinazeze compound forces the household to draw water from streams- Sometimes water is not available for 2 days'' Female Respondent*

✓ *The inadequate supply of water to the residents which lead to households storing water for longer periods in big open plastic buckets'' Female respondent*

✓ "*It is paradoxical to note that the population generally does not use any home chemical water treatment method such as chlorine if there is no outbreak of disease such as: cholera, dysentery or typhoid"* One health workers remarked"

✓ *"They have always drunk water like that" or "We do not have chlorine".*

✓ "Transporting drinking water in non-covered basins was common because *we've always done it like that".* Female respondent 2

✓ *' Storing drinking water in re-used plastic buckets is common because they are durable and the Government and Non- Governmental organizations have stopped distributing standard 20litres containers that were being given at a subsidized price'. Female respondent 3*

✓ The risk associated with the disposal of leaves and plastic bags in drinking water is well known, with comments being made such as:

✓ "*It's because there was dirt on the leaves that we got sick*". Female respondent 3

V. MICROBIOLOGICAL QUALITY MONITORING

Table 9 Shows the Type of Water Storage Containers and Results from the Water Samples Collected During the Field Visits

Type of Storage Container	Total Number of Samples Collected	Number of Samples Satisfactory	Number of Samples Unsatisfactory	Percentage (Satisfactory/Safe).
Plastic Bucket –closed	5	2	3	40%
Plastic Bucket-open	5	1	4	25%
Plastic bottle-closed	5	1	4	25%
Plastic bottle-open	5	0	5	0
Plastic container, 20L-open	5	2	3	40%
Plastic Container, 20L-closed	5	3	2	60%
5 L container open	5	1	4	25%
5L container-closed	5	2	3	40%
Jerrican-closed	5	1	4	25%
Jerrican-open	5	1	4	25%
Pot-open	5	0	5	0
Pot-closed	5	1	4	25%
TOTAL	60	15	45	25%

➢ *Factors Associated with Domestic Water Contamination*

The main container used for the storage of drinking water was closed plastic bucket (re-used). Over 90% of the participants did not treat their drinking water, and the most popular method for treating was chlorination. The results showed that 41 (or 68%) of the community members did not wash their hands before handling stored water. Details of these findings are shown in Table 10.

Table 10 Showing Water and Sanitation Practice at the Household Level

Variable n=60	Frequency	Percentage
Common Water Storage Container		
Closed plastic bucket	24	40
Open Bucket	11	18.3
Pot	10	16.7
Closed bottle	15	25
Total	60	100

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Water Treatment		
Yes	53	88.7
No	7	11.3
Method of Water Treatment at Household Level		
Boiling	5	8
Chlorination	54	91
Filtration	1	1
Days of Water Storage		
One day	3	3.3
Two days	30	50
Three days	26	43.7
Four days	1	3
Washing Hands before Handling Stored Water		
Yes	19	32
No	41	68

VI. DISCUSSION

The findings of this study established that seventy five (75%) of the household water samples intended for drinking was not safe for drinking. The findings were preferably as a result of some community members using unprotected water sources which was found to be unsafe. The majority of the people, (88.7%) were reported not treating their household drinking water. The result were too close to Bidder, (2015) where faecal contamination and raw consumption assumed to be the primary route of exposure of contaminated water.

At the bivariate analysis, findings indicated that the most significant factors or practices associated with possible faecal contamination in household drinking water were education, occupation, water storage container, methods of water treatment, and days of water storage practices of drinking water that was stored in open bottles, and open water storage containers were highly contaminated (unsatisfactory) with a P=0.042 and P=0.01, respectively. Participants who used open storage containers without boiling, filtering or adding chlorine were approximately two times more likely to have their households water contaminated as those who used boiling method (cPR=2.17, P=0.05). This is quite different from the study by Fard et al. (2015).

Table 11 Bivariate Robust Poisson Regression Analysis of Total Microbiological Quality in Stored Water Among Households

Variable	Unsatisfactory (n=45)	Satisfactory (n=15)	cPR	95%CL	P Value
Water Storage Container					
Closed plastic bucket	38 (85.2)	2 (14.2)	1.0	-	-
Open bucket	37 (82.4)	2(17.6)	(1.12)	0.55-1.46	0.67
Pot	31(68.0)	5(32.0)	(2.16)	1.01-4.61	0.046
Closed bottle	28(62.3)	6(37.7)	(2.54)	1.26-5.13	0.009
Method of Water Treatment					
Boiling	25(56.3)	1(20.2)	1.0	-	-
Chlorination	35(79.8)	7(43)	2.17	1.18-3.99	0.013
Filtration	2(100)	0(0.0)	0.01	0.003-0.05	<0.001
Days of Water Storage					
One day	27(60)	6(40.0)	1.0	-	-
Three days	29(66.4)	5(33.6)	0.84	0.38-1.86	0.67
Four days	24(55.6)	7(44.4)	1.11	0.39-3.2	0.85
Hand Washing Practice					
Yes	31(69.1)	5(30.9)	1.0	-	-
No	40 (88.5)	2(11.5)	0.37	0.20-0.67	0.001

From observation, people stored drinking water in open plastic containers, jars, pots and buckets which were dirty and in poor housing and sanitation conditions. Studies from Uganda, (Nsubuga: 2015), shows that there is progressive contamination of water source to the point of consumption at the households mostly attributed to dirty collection or storage containers. The study findings also indicated that hand washing after using the toilet was 63% less likely to be associated with household drinking water contamination by total coliform (P=0.0010).

However, 68% of the people lacked the practice of hand washing. Lack of hygienic practices such as hand washing with soap after visiting the latrines is direct route to household contamination. Contamination of hands, utensils, food and clothing can also play a role, particularly when domestic water sanitation and hygiene are poor, leading to outbreak of water-borne diseases like cholera and Typhoid (deleye:2015). It is generally difficult to guarantee safe water quality beyond the water source, due to poor hygienic practices which result in significant deterioration of the quality of water from the time it was collected from the source to the time it is finally consumed. (Nsubuga 2014).

This study has categorically demonstrated that individual household practices were contributing to contamination of water supplies sources in the compound as well water storage practices, water collection methods and storage vessels contributing to contamination of household water supplies among residents of Sinazeze compound for household. In addition, the water and sanitation challenges contributing contamination of household water supplies were also enunciated.

In this study it was observed that residents in Sinazeze uses three sources of water for drinking purposes: borehole/piped, river and surface water. Generally, people had experience of using disinfection techniques such as chlorination, but did not implement them, for various reasons, probably the extra work or additional costs required. This study was not able to assess the functionality of boreholes throughout the year, nor did it investigate the quality of water from them.

In some localities of Sinazeze compound, there is no system for supplying improved water for the population. Households there use only unimproved water sources. The results from this study therefore show that 47.78 % of households use unimproved water (surface water and unprotected wells, river water) for drinking purposes. This proportion is higher than that in the WHO and UNICEF report published in 2013 on Zambia, which suggested that about 43 % of rural households had access to improved water sources.

VII. CONCLUSION

Zambia is facing turbulent water future. With the effects of climate change and growing economic challenges with the rising population, government efforts and investments in the water sector ought to be skewed towards encouraging communities to safeguard our domestic water supplies.

The result of this study revealed that the bacteriological quality of drinking water deteriorates from source to point of use. The overall results indicated that there is a strong linkage between microbiological water quality and water source contamination. High proportions of households' drinking water samples were contaminated or unsatisfactory. Furthermore, family wealth index, age, education level, occupation, water storage container, sharing the house with animals, type of sanitation facility, method of household water treatment and washing hands before water collection were associated factors of bacteriological quality of drinking water among households. Therefore, the District Health office should strengthen health education programs on water, sanitation, hygienic practice and proper storage and handling of drinking water to improve the quality of drinking water at the point of use. Additionally, the water supply and sewerage authority should also monitor the bacteriological quality of drinking water at the source, distribution, and household regularly. It is possible that community education, adoption, and promotion of appropriate water safety plans can reduce the increasing incidences of water borne diseases in the area.

➢ *Recommendation*

The researcher makes the following recommendations:

- Health education and promotion activities that address water supplies safety at household level need to be strengthened as water contamination happens at various levels
- There is need for community led initiatives to target unsanitary behaviours at household level particularly at disposal of faeces and other domestic and solid waste.
- There is need to support communities with basic water treatment methods that are cost effective.
- There is need to support household with standard storage containers
- The local authority must partner with the community members to see how best they can redirect piped water to all households including sanitation problems related to disposal of faecal matter.

➢ *Recommendation for Future Research*

The researcher has observed that there is need to:

- Conduct a further study to access the level of contamination of household water supplies including the specific contaminants of water sources.
- Also need to conduct a study to evaluate how behaviour and culture practices are impacting on water and sanitation in the compound.
- Another study being recommended is to examine how the current settlement plan is hindering the works related to improving water and sanitation services in the compound.

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