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RESEARCH ARTICLE

Community perceptions and practices on quality and safety of drinking water in Mbarara city, south western Uganda

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OPEN ACCESS

Citation: Catherine AN, Ayesiga S, Rukundo GZ, Lejju JB, Byarugaba F, Tamwesigire IK (2023) Community perceptions and practices on quality and safety of drinking water in Mbarara city, south western Uganda. *PLoS Water* 2(5): e0000075. <https://doi.org/10.1371/journal.pwat.0000075>

Editor: Eugene Appiah-Effah, Kwame Nkrumah University of Science and Technology, GHANA

Received: October 31, 2022

Accepted: April 29, 2023

Published: May 30, 2023

Peer Review History: PLOS recognizes the benefits of transparency in the peer review process; therefore, we enable the publication of all of the content of peer review and author responses alongside final, published articles. The editorial history of this article is available here: <https://doi.org/10.1371/journal.pwat.0000075>

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Data Availability Statement: To ensure confidentiality of participants' information as agreed up on during Ethical approval and Consent Process, qualitative interview transcripts' file is only

Abstract

Availability of clean drinking water is a universal human right. The quality of water differs across communities. When the quality is good, community members are the primary beneficiaries but they are also the first ones to experience the consequences of deteriorating quality of water. In most communities, the inhabitants are able to tell if their drinking water is safe and of quality basing on organoleptic properties. The community perceptions and practices about safety and quality of drinking water are informed by their attitudes and levels of knowledge about water quality. This study aimed to assess community perceptions and practices on quality and safety of drinking water in Mbarara city, south western Uganda. A qualitative study was conducted between May and July 2022. Six focus group discussions among community members and four Key informant interviews with stakeholders in the water service were conducted. Data was analysed basing on predetermined themes of: 1) perceived quality of water 2) perceived factors associated with water quality 3) practices related to water quality and 4) perceived solutions for improving water safety and quality. Drinking water safety and quality in Mbarara city is perceived as not good, dirty, salty and limited in supply and the water sources are shared with animals. The poor quality of drinking water is due to poor waste disposal, poor treatment, poor maintenance of systems, flooding, political interference, deficiency in city planning, increase in population growth and water hyacinth. Sensitizing the communities, community participation, proper water treatment and surveillance and monitoring are solutions to ensuring provision, use and maintenance of safe and quality drinking water in Mbarara city.

Introduction

Safe and quality water is defined as one free from any harmful chemicals and pathogenic agents such as Coliform bacteria, *Escherichia coli* and coliphages that affect its palatability as well as human livelihood [1, 2]. According to the United Nations Sustainable Development Goal 6, “water sustains life, but safe clean drinking water defines civilization” [3]. Drinking

visible to the direct research team or through Mbarara University of Science and Technology Research Ethics Committee, P.O. Box 1410 Mbarara, Tel: +256-48-543-3795, Fax: +256-48-542-0782, E-mail: irc@must.ac.ug, mustirb@gmail.com since they are not publically available.

Funding: The corresponding author who happens to be the PI for this study CNA received research support as part of Faculty Research Support from Faculty of Medicine, Mbarara University of Science and Technology (MUST). The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests: The authors have declared that no competing interests exist.

Abbreviations: NWSC, National Water and Sewerage Cooperation; NEMA, National Environment Management Authority; UBOS, Uganda Bureau of Statistics; WASH, Water, sanitation, and hygiene.

water should be adequate, reliable, clean, accessible and acceptable to communities as a human right to live healthy lives [4]. There is evidence that steps aimed at providing safe water services have fairly increased, but its safety is uncertain [5]. Most households in low and middle income countries lack sufficient safe and quality freshwater (physical scarcity). In other countries there is abundant freshwater of unknown quality hence communities supplement improved water supplies with unimproved water or multiple sources that may not be safe for human consumption because it is expensive to ensure adequate supply of safe and quality water [6, 7]. Safe drinking water” is water from an “improved water source,” that include household connections, public standpipes, boreholes, protected dug wells, protected springs and rainwater collections and it should not represent any significant risk to health over a lifetime of consumption [8, 9]. Assessment of water quality is subjective and is based on beliefs, cognition, geographic location of the water source, socio economic characteristics, the experience of the user and information provided by local media [10].

Community members are the primary beneficiaries of quality and safe water and they are the first to experience the consequences of the deteriorating water quality when known or suspected to be unsafe for human consumption due to regulatory problems and lack of support [11]. They evaluate the safety and quality of drinking water using its organoleptic properties like taste, smell, colour and clarity as well as presence of litter and sanitary conditions around the drinking water source [12]. These perceptions are however useful and help to complement scientific measurements hence supporting water management policies [13]. Community participation in water and sanitation is one of the prominent global indicators used to assess the achievement of water-related sustainable developmental goals [12]. In addition, public acceptability of drinking water is one of the world health organization guidelines for drinking water quality [14].

Communities’ perception of the quality of drinking water is informed by health risk perception, perceived control, past experience, trust on water service provider, influence of impersonal and interpersonal information like media and peers, contextual factors, colour, taste of the water, appearance and demographic variables [15, 16]. However, these perceptions are influenced by sociocultural, sociodemographic, and personal experiences and are shaped by service satisfaction, confidence in local and national authorities, selection of the water source as well as beliefs in human control of environment issues and formal and informal flow of information [17]. Community perceptions and practices of health risks related to drinking water are associated with drinking water, the persistence of these health problems and the level of awareness of the problem. Perception of the need for quality water drives the need to practice activities at the source, during transportation or storage and handling practices that will ensure the safety and quality of water as well as the use and storage of this God given resource [18]. Water quality concerns like water scarcity, lack of awareness and knowledge of ‘safe’ collection, handling and storage of water, inadequate sanitation services and/or unhygienic practices exist in communities. In addition; water quality attributes like taste, colour, smell, litter and presence of faecal matter in and around the water source as well as education, age, number of years a person has lived in the community, presence of visible aspects of water pollution and water source catchment area encroachment influence community members’ perception on the quality and safety of drinking water [19]. These water quality concerns when left unresolved for long may lead to community perceptions of health risk and prompt community practices that may be dangerous to their health like use of chemicals or using alternative sources of water such as unprotected open wells, use of unprotected buckets left outside on the ground [20]. Through a dialogue with government, drinking water service providers, and community members’ perceptions of the quality of drinking water and associated health benefits and risks inform community practices to maintain water quality [11]. Understanding community beliefs

and behaviours is critical for water resource management, monitoring, and creating drinking water quality standards [11]. Anecdotal evidence reveals that the quality and safety of drinking water in Mbarara city do not meet World Health Organization criteria for drinking water quality. Thus, the purpose of this study was to explore community members' perceptions and practices about the quality and safety of drinking water. Results of this study provides community members' perceptions, practices and perceived solutions to improve and maintain safe and quality drinking water in Mbarara City, South Western Uganda.

Materials and methods

Ethics statement

Administrative clearance was obtained from District, city, parish, National water and sewerage cooperation and Ministry of water, lands and Environment authorities. The protocol was reviewed and approved by Mbarara University of Science and Technology Institutional Review Committee (MUST-2021-39), and National Council of Science and Technology (HS1469ES). Permission was obtained from the district, local council leaders and household heads especially for water harvest tanks before commencement of data collection. Written informed consent was obtained from every participant before participating in the interviews and discussions.

Study area

This study was conducted in Mbarara city, south western Uganda. Mbarara city is the commercial and administrative capital of Mbarara district in south western Uganda. Mbarara city is located 270 kilometres, by road, southwest of the capital city, Kampala. Mbarara district lies between coordinates 00 36 48 S, 30 39 30 E and covers an area of 1,778.4 square kilometres. It has a population of 91867 [21]. Mbarara city receives an average annual rainfall of 1200 mm with two rainy seasons during the months of September-December and February-May. Temperature ranges between 17°C to 30°C, humidity of 80–90%. The topography is a mixture of fairly rolling and sharp hills and mountains, shallow valleys and flat land. Mbarara city is provided, operated and maintained with safe water supply technologies and sanitation facilities to all communities of the city. Mbarara district recorded an increase in access to safe and clean water from 45% in 2000 to about 63% in the villages and 65% for the municipality in 2007. The safe water coverage is 65.9% in the rural areas and 95.7% in the urban, while accessibility to safe water lies between 29% and 95% [22].

Participant recruitment and description

This study was a cross sectional study employing qualitative techniques. Purposive sampling was employed to recruit participants for the key informant interviews and focus group discussions. Four (4) key informants were recruited from the District water office, National Environment Management Authority (NEMA), Ministry of Water, Lands and environment and National water and sewerage cooperation (NWSC) based their knowledge, expertise and experience with water safety and quality in Mbarara city. The key informants were water quality control managers and policy makers. Eighty-four (84) community members from six (6) villages/cells (Kaburangiire, Nyarubanga, Rubiri, Lugazi, Katebe and Katukuru) of Mbarara city were recruited for focus group discussions (FGDs). FGDs participants were residents of the selected villages who were consumers of the water from various water sources. Evidence has shown that people who reside and work near water sources are more likely to be concerned about the quality and safety of drinking water [23]. Both male and females across the different age groups that met the inclusion criteria of being community members in the six selected

villages or water service providers in Mbarara city irrespective of their gender and socio economic status were recruited to gain a diversity of perceptives and variability within the community. We did not collect information on the years of residency. We assumed that persons who had lived in the neighborhood for a longer period of time were better knowledgeable about the safety and quality of water in Mbarara. The participants in the Focus Group Discussions were chosen by the local chairman of the village. The six focus group discussions were constituted by senior inhabitants of the neighborhood who owned homes and had lived in those homes with their families for a long time, also known as "abataka," which literally means "permanent residents of the village."

Data collection

Local leaders as gatekeepers to the community were used to recruit FGD participants and fix dates and time for the discussions. Written informed consent was obtained from all research participants. The consent forms, focus group discussion and Key Informant interview guides were translated into Runyankore-Rukiga the language spoken and well understood in the study area. Discussion / Interview guides were used to collect data from key informants and FGDs between May and June 2022. The key study questions included: 1. What is your perception of the quality and safety of drinking water from sources in your community. 2. In your own view, who/what do you think is responsible for the quality and safety of drinking water you have described? 4. At family and community level, what has been done to ensure that drinking water in your community is of quality and is safe? 5. At family, community level, district/ as stakeholders what you done to ensure quality and safety of drinking water from drinking water sources in the community? These questions were elaborated on with more probing questions. AC conducted the interviews together with NP as a note taker and AT did the recording of the interviews and discussion. Each focus group was comprised of 14 participants. Extra effort was made to ensure an equal number of males and females constituted the focus group discussions.

The interviews and focus group discussions with the participants were conducted at a private location at the convenience of the different participants at the time agreed upon with the study team. The interviews were recorded with a Sony audio recorder and field notes were taken. Participants were not paid for participating in the study but time was compensated as was stipulated in the consent form. The interviews lasted between 60 and 90 minutes. The interviews were transcribed and those in Runyankole-Rukiga translated into English and back translated to Runyankole-Rukiga to ensure that what was recorded in Runyankole-Rukiga is what was captured in the English version of the transcript. Interview data was supplemented with field notes captured during the different interview and discussion sessions. One interview/ focus group discussions was conducted per day.

Data analysis and interpretations

Data analysis started with listening to the audio recordings alongside the field notes at the end of each day's interview/ discussion session. They were transcribed sequentially on the daily basis by CA, NP and OJ which helped in giving a deeper insight into the inquiry during the data collection process in line with the study objectives. The data was transcribed by Research Assistant [24] and checked by CA and OJ. Data analysis was done through different stages of familiarization with data and dual coding was employed. CA, OJ and ACD independently read through the transcripts and identified emerging themes and manually identified corresponding quotes by highlighting them with different colors per theme. Data management from interviews and focus group discussions were analyzed differently and merged in one codebook by incorporating data from audio recordings, verbatim notes and nonverbal observations during

the interview and discussion processes. A codebook with sections for parent themes, sub themes, description and illustrative quotes was developed from emerging themes. Using the four predetermined themes, indicative thematic analysis was done by analyzing statements from participants, identifying commonalities and developing sub themes. The same data was entered into Atlas Ti 7.5. Using the themes, each transcript was re-analyzed to reveal the best corresponding quotes. The same process was done for key informant interviews and focus group discussions data.

Results

Findings from this study reveal the community perceptions and practices of community members and stakeholders on the quality of drinking water in Mbarara city, south western Uganda. The results are from Four (4) key informant interviews and six Focus Group Discussions from stakeholders and community members in Mbarara city. A total of 28 males and 56 females constituted the interviews and discussions. Participant quotes are presented to support the findings. Four themes were identified, Community perceptions on the quality and safety of drinking water, factors responsible for the quality of drinking water, community perceived solution for safe and quality drinking water and community practices for safe and quality drinking water as well as several subthemes as shown in [Table 1](#).

Community member's perception on the quality and safety of drinking water from sources in their community

We explored community members' perceptions on the quality and safety of drinking water in selected villages in Mbarara city. We asked the community members about their perception

Table 1. Themes and subthemes.

THEME	SUBTHEME
Community perceptions on the quality and safety of drinking water	Not good
	Dirty
	Salty
Community practices for safe and quality drinking water	Water rationing
	Legislation/permits
	Quality control
	Security
	Water treatment
	Alternative sources
	Sorting/recycling plastics
Community perceived factors responsible for poor quality of drinking water	Poor waste disposal
	Poor water treatment
	Poor maintenance of systems
	Political interference
	Population growth
	Water hyacinth
Community Perceived solution for safe and quality water	Sensitization
	Behavioural Change
	Community participation, water committees, catchment management committees,
	Water Treatment
	Surveillance and Monitoring

<https://doi.org/10.1371/journal.pwat.0000075.t001>

on the quality and safety of their drinking water from the different drinking water sources in their villages. They gave a wide range of perceptions regarding the different drinking water sources. Generally, they indicated that the drinking water from different drinking water sources is not good, dirty and tasted salty. They believe that the quality is generally lacking since it is contaminated with human waste, cow dung, always changes in colour, it sediments on settling and the water sources are communally used and shared in some cases shared with animals. The supply on taps is unpredictable while boreholes suffer serious mechanical problems and are usually out of use and for some long period of time.

To be honest, our water is bad since we share it with animals, dumping cow dung in it, and we also use it for cooking and bathing and the problem is that we do not know which water is fit for consumption and how it looks like because we think good water is pure white, which you may discover is not actually good, so we do not know which one is good and we cannot avoid water from the well even taps are few and used by a small number of people; most of us go to the well (FGD II).

We have a borehole, but the water cannot be used for cooking or bathing. Nothing good comes from that borehole, unless you wish to mix the soil for making bricks. Even when you wash your hands, they turn black. So in Kaburangire, we have a water problem, and even the rust they mentioned is there, so that is the type of water we have, and the borehole is now not operational (FGD III).

Similarly, a participant was noted to have said:

The safety and quality of drinking water is not all that bad because we follow world health drinking water standard regulations, but at times you find that the sources are contaminated when you are not aware, and we can face a challenge because this water that passes underground can be contaminated with anything, let us talk about boreholes, even a tap. Knowing that taps are sometimes passing through sewerage areas, someone can cut it and start getting water back flow (KII IV).

In addition, to the poor quality of drinking water, the participants reported that the supply is not constant

It comes and goes, and when it returns, it is different from what we had before it disappeared, and even when you put it in your mouth, you can feel the difference, and later, when it settles, a lot of sediments appear, which raises the concern on the quality (FGD IV).

Community member's perceived factors responsible for the quality and safety of water in their community

Communities attribute the poor quality and safety of drinking water from sources in their communities to the growing population in the city.

Mbarara's population is growing rapidly because, as a new city, there is scramble for resources. There are a lot of issues and of course as national water, we cannot meet the demands at the moment and people are opting for other sources (KII I).

Because of the rising population, garbage is deposited everywhere, rendering our water unfit for human consumption (FGD IV).

There is a lot of garbage volume and residents live in congested homesteads with no provision for waste disposal. They resort to throwing their waste in River Rwizi at night.

Waste management is poor, and everyone dumps wherever they please; laws are in place, but they are not followed; personnel exist to execute laws, but when you try to do what is right, they will claim that you are interfering with voters (KII II).

Sometimes you see someone on a boda boda (motorcycle) and you think that he is carrying luggage, and for those of us who walk at night, he reaches the bridge and stops for a while and dumps garbage into the river, thus we live by God's grace. For example, someone may have garbage in the house and when she wakes up in the morning, she goes with it and throws it in the river because she has nowhere to put it, but those ditches will undoubtedly help us, so in your research, you should coordinate with the government to put emphasis on landlords digging up ditches for their tenants (FGD I).

The toilet facilities are few and unhygienic making residents to resort to other options like open defecation, using polythene bags and plastic bottles for their excreta which is dumped /poured in the garbage bins or trenches. Some landlords open their toilets to empty directly in River Rwizi.

We have seen that pollution is from domestic wastes, people opening their latrines anyhow, so everything ends up in the system, which means you cannot rule out the drainage system, so we simply urge people to connect to national water because we know it is safe (KII I).

Participants believe that national water and sewerage cooperation is not treating the water they supply for use or does not treat the water properly. They believe that sometimes they use poor quality chemicals which remain as residues in the water as it is supplied.

You go to get water and find that it is really River Rwizi water that is very brown in color and I don't know what causes that because I believe they treat it and how come it is dirty as if it was not treated and even after boiling it and putting it down to settle, you find those brown things on the bottom so that water is not good and those who drink it without boiling it will get sick (FGD VI).

Other participants noted that drinking water is treated before it is availed for use but however attributed the poor quality of water accessed to the location of the consumer.

People who live in valleys have a higher chance of receiving dirty water because that is where settlement takes place and everything settles where there is a valley and you find that people who are in valleys have issues with water so the people at the end have a higher chance of receiving dirty water but we always put mitigation measures, for example, we encourage regular flashing of our systems. There are planned sessions every three months sometimes we conduct unplanned system flashing, which is done after getting complaints (KII III).

Participants believe that the safety and quality of drinking water is affected by poor maintenance of water systems. Once the water gets to the individual consumers, the overhead tanks are dirty since they are never or rarely cleaned. National water and sewerage cooperation is using old dysfunctional water systems (pipes) that have never been changed from the time they were installed and sometimes lack enough chemicals for treatment.

They are also not cleaning their tanks on a regular basis. Sincerely speaking, people do not wash their tanks for 3–4 years, the tank is just there, there are lizards, bird droppings, monkeys playing on it, and people are unaware of its effect, but people keep saying that national water gives us bad water because people are not sensitized, this is because our duty ends at your tap beyond your tap, it is your responsibility (KII III).

We have ancient pipes. I believe these pipes are 72 years old, making them incredibly old, and you can detect water pollution from those old pipes since they wear out over time. We might not recognize if the problem has occurred, but with this next project, we are replacing all of them (KII III).

Participants reported a deficiency in city planning. Most buildings are not built according to city authorities' plan. Factories and industries are constructed in water catchment areas with no permits and a provision for their waste disposal hence ending up in dumping their waste inappropriately that ends up in water catchment areas and water sources. These illegal developments are hard to regulate and monitor because of political interference.

We will not evict a factory near the river because there are so many industries along this river here, and when we look at the analysis we have been doing, we find that some samples taken at night have a different water quality than those taken during the day because we suspect that a lot of things are dumped there at night (KII III).

We no longer listen to technical experts; instead, we listen to politicians, which is driving our people to regress to the early 1960s. Let us prevent political involvement, and since there is a political hand somewhere, people construct factories anywhere even in water catchment areas, making it difficult for us to intervene. Hence, we consider our integrity, I believe there is much we can avoid (KII II).

River Rwizi which is the main source of drinking water in Mbarara city has been covered by water hyacinth. The weed has covered the biggest part of the river, it has led to reduction in water volume, it traps garbage deposited in the river and makes pumping of water for treatment hard and costly.

This weed in the River Rwizi called water hyacinth, it collects and traps polythene bags and bottles, and their contents slowly leak into the water, thus I believe they are to blame for the polluted water we drink these days, and you may find that some individuals use it the way it is (FGD I).

Community member's practices for safe and quality drinking water

Water rationing is employed where some areas receive water at night while others during the day to make sure that at least all communities have water per day. Communities are encouraged to have overhead tanks to ensure a continuous supply of water.

We practice water rationing, in which we decide to give water to one zone during the day and another during the night. We make sure everyone has access to water. We encourage people to get overhead tanks because residents in Mbarara get water via direct lines, so if there is no water on a certain day, overhead tanks might be of help (KII III).

Participants revealed that there are laws in place to ensure water catchment areas are protected and not encroached on for human activities. Any developments along water catchment

areas must be evaluated for impact assessment and must receive permission in form of permits that clearly stipulates what activity is going to take place and for how long and their waste disposal and environment protection and conservation plan.

We have legislation in place, such as the National Environmental Act, which serves as a foundation for all environmental concerns, including the preservation of all water resources. We have national wetland, river bank, and lake shores management in place for the preservation of water sources, and as part of our mandate, we aim to engage communities and stakeholders in the conservation of water sources, and the battle is still ongoing (KII IV).

Surface water abstraction permit, ground water abstraction permit, water discharge permit, construction permit, there are quite a few and for surface water permit, the main idea is that issuing a permit is to ensure that water is available for all not just some because they all need water so if we allow individuals, and you know individuals are selfish by nature, one can decide to take all the water excluding others so one needs to tell our department based on what they want (KII I).

Participants revealed that National water and Sewerage Corporation engages in both internal and external quality control measures to ensure that the drinking water supplied for human consumption is safe and of quality.

We sample together and then discuss the results. They also audit, and now we are going to audit so that if one group is not speaking the truth, another group will. I believe that with that level of transparency, we can perform those system checks and, at the end of the day, compare the data (KII III).

Community members have put in place security controls around water sources, the water sources are faced to stop animals from drinking from sources meant to supply drinking water for human consumption, they encourage community members not to send young children to fetch water hence minimising defecating and swimming in drinking water sources.

We have attempted to secure the water in our wetland so that when children go to get water from there, they do not defecate in the area surrounding our water and that cows that go to our water source do not go close the water that we fetch for drinking, which is what we do with our wetland. We make sure that when someone fetches, she/he ensures that the tap is properly closed and that children do not go there to play on the borehole/tap so that we can protect it (FGD III).

Water service providers ensure that drinking water supplied for use by communities is treated and is safe and of recommended quality of drinking water for supply to communities. The communities boil the water, sieve it, cover it, use clean water collection vessels, allow it to sediment, and use the supernatant and sometimes use safeguard to treat their drinking water before use.

For safety, I believe that for national water and sewerage cooperation, safety is maintained through treatment to address specific issues such as microbiology nuclei and all that, as well as disinfection, so the water is disinfected, and then there is the aspect of filtration to remove these other suspended materials, so there is this deliberate effort to treat the water so that it meets the standards that we require. So there is an effort in terms of personnel and resources,

and the entire site has the idea in mind that this water must be treated to this acceptable standard, so the safety is guaranteed (KII IV).

We boil water, especially when it comes to drinking, and then we filter it to limit the level of contamination since after boiling, there is some dirt that remains on the bottom (FGD II).

Communities have a vast number of alternative sources of drinking water that range from, open wells, protected springs, boreholes, gravity flow, and tap water and rain harvest tanks. They use an alternative source depending on what they want to use the water for and the availability, accessibility, safety and quality of water.

We can choose to utilize rain water since we have been spoiled by taps, and as a result, one can build a house without a gutter. Collecting rain water would also help, but the problem is that once collected, one person dips a cup to fetch water and another person brings a jug, making it unsafe, but it would be one of the best ways because that water is free, and I feel like if I could get a crest tank and put it on my house to harvest clean water, could it be a solution and once I get it, I get period to wash it and by the time water enters into that tank I make sure there is a sieve to prevent large things from entering the tank, and once the water is finished, you cleanse the tank and boil water from that tank for drinking (FGD II).

Community members have resorted to putting to use the overgrowing garbage and plastic volume to use. Garbage and plastics are being collected and used to make bricks. Plastics are collected and recycled into other accessories like beads and mats.

Organic and inorganic plastics are separated for possible recycling since we cannot do away with this because as a country, we still need jobs, so how can we have these jobs without damaging the environment and River Rwizi (FGD II).

For example, we make bricks from garbage, so if a person is aware that garbage is important and will benefit from it, he or she will take responsibility, and the responsible companies will come and pick it up. However, people should also be aware of which rubbish has value so that one knows the exact amount he is likely to receive (FGD VI).

Community member's perceived solutions to ensure safe and quality of water

Participants believe that engaging stakeholders in the catchment area on water source protection guidelines and the need to alert communities/stakeholders in case of contamination, and enforcing laws through political leaders can help ensure safe and quality water to the communities.

When the catchment is not proper, all of these will come down, so when we go to individuals, we must be aware that when certain things are not done correctly, one suffers, and when someone is not aware that chemicals for agriculture once sprayed, such chemicals will come back to me, so those people are not aware. So that is the information we are talking about, the safety of water and how this safety is important to all of us, not just you and me, but all of us, and even the people outside there, because otherwise, we would be treating the symptoms rather than the core cause of the problem (KII I).

Participants believe that community sensitisation on the need for safe and quality drinking water will help greatly in changing the mind set of communities.

Sensitization, that is it, the community may not be aware of pollutants rods and, major contaminants of water, so they need to come up with an approach of sensitization in our communities about the dangers of drinking contaminated water by informing the communities that if you use contaminated water, it affects them like getting water borne diseases, so that they can come to understand that they must protect the water sources (KII I).

When you go to the villages in these town councils, you will see what I mean, you will see everywhere is garbage and so on, so sometimes we apply law and sometimes you can find a leader in the village does not have a latrine, does not have anything to use for sanitation, you find somebody's compound is full of funny things and is a leader, so those are the things, but we will keep on community sensitization. Even if we lack resources, we will continue to educate the community, and those who wish to spread the word will go out and improve their surroundings (FGD II).

There is need to educate communities to create awareness and ensure that there are buffer zones in water catchment areas.

Awareness has been raised through educating communities and limiting development around waterways. NEMA regulates all projects where it is not possible; NEMA has not authorized any developments beside water resources, and when they are permitted, limitations are imposed. When we look at the River Rwizi, we tried to engage a number of stakeholders, including encroachers along the river basins, so that they can vacate and the buffer is well protected, and when the buffer is well protected, it means that the water is fine. We have also engaged industrialists in managing the effluents coming from their industries, so that the water released from the manufacturing processes is treated before it is discharged into the river, and even before it is discharged into the river (KII IV).

Participants believe that following guidelines set to ensure safe and quality drinking water is key to in maintaining safe and quality drinking water.

We must adhere to the drinking water guidelines. What is the distance from the latrine to the water source, sometimes people come and start cultivating near the water sources, so some meters are required from the water source, and even the water source itself has some meters' standard like 50 by 50 so that if there is run off, it should not filtrate easily into the water source, so after putting the measures at the source, we know that that source is ok (KII II).

Participants believe that most factors that affect the safety and quality of water in Mbarara city are due to the behaviour and mind set of community members. National water and sewerage cooperation tries its level best to supply safe and quality drinking water at the recommended standard for home use not at the bottled water standard. Most communities access this resource through illegal connections that makes the cost of supply and maintenance expensive for the service provider thereby making it expensive for the consumer. Communities are aware that the water available for use needs to be boiled before drinking it but for personal reasons like lack of firewood, ignorance and time, they resort to drinking it half boiled or unboiled. City authorities have put in place provisions for waste disposal but communities continue to dispose waste as they wish.

We have a lot of pollution from industrial developments, as well as problems with improper waste management, all of which end in our waters. Leaving that aside, we have a number of illegal construction and illegal activities that are taking place outside of the 100-meter zone

that is the protection zone along the river, thus ending up in the river, so the quality of water is not up to date due to poor waste disposal, population growth, and direct influent discharge from industries that is not even treated, and all of that ends up in our water sources (KII IV).

Individuals illegally connect to the water supply, and we have many such incidents in Mbarara, largely from private plumbers. Connection is also important since someone will connect you where the settlement is and where they do not encourage consumers to be connected, but you will find individuals connecting illegally (KI III).

We would be boiling the water, but most of the time we do not have enough money to buy charcoal because it is expensive, and sometimes you can have food but you cannot cook because you do not have charcoal, so there is no charcoal to boil water, so most people drink it without boiling it, which has caused typhoid infections. People have been talking about someone who just grabs a cup, pours directly from a jerrican, and drinks (FGD I).

To ensure safe and quality drinking water, there is need for collaboration between communities and water service providers. The community needs to be engaged and encouraged to participate in activities aimed at ensuring stable and sustainable supply and use of safe and quality drinking water. There is need to set up community water committees, catchment management committees and school sanitation committees through which information pertaining the use and maintenance of safe and quality water and practices to ensure proper use and maintenance of safe and quality water are shared between communities and water service providers.

we normally have the water user committees to check whoever gets water but they also have a challenge themselves. There is need to make committee on sanitation to ensure things like toilets, hand washing facility, abcd are introduced in the community so that they can reduce the risks and if someone comes from the toilet, there should be a jerrican and soap on the toilet to wash hands so those are the measures we are putting up but I told you that is a behavioural change strategy with its many challenges (K II IV).

We have not gone to the household level, but we have managed to get to catchment organizations, which are made up of many stakeholders, including local governments, so from local governments, we establish a committee of that catchment organization called the catchment management committee. The organization is comprised of structures that comprise the executive arm, which meets to address issues. There are many entities in that catchment management committee, such as district local government, which brings on board district water officials, chief administrative officers, and LC 5 (Local council) chairpersons (KII I).

Participants believe treating drinking water from drinking water sources in Mbarara city at supply system level with chemicals and at home with safeguard will greatly help in improving the quality and safety. This could be by providing chemicals to help in home treatment of drinking water and general treatment of water before it is supplied for use on the taps. There is need to mechanically remove the water weeds/plants, clear bushes around water sources and regularly cleaning the open wells.

Water, in my opinion, should be collected in tanks and then purified at various treatment stations before being released. But my heart continues telling me that maybe National Water and Sewerage Corporation obtains water from a source and store it in tanks, but they don't treat it before distributing it, or the tanks aren't washed on a regular basis, or the treatment

they use is insufficient. You are aware that in Uganda, less treatment can be used than is recommended, which cannot be sufficient for effective water treatment (FGD II).

For safety, I believe that national water and sewerage cooperation maintains safety through water treatment to address specific issues such as microbiological nuclei. Water is disinfected, and there is also the issue of filtration to remove these other suspended things, so there is a concerted effort to clean the water so that it meets the acceptable standards we require. There is constant monitoring to verify that these criteria are met, including the availability of persons and resources to ensure that this water is treated to appropriate levels and that safety is ensured (KII I).

Participants suggest that water service providers should ensure that the water they supply is safe and of quality. They should put provisions in place to ensure that the quality is maintained throughout the supply chain by routine monitoring and surveillance and ensuring that any pit-falls are addressed in a timely manner.

I believe that National Water and Sewerage Company should take the time to walk around and observe what is going on, not only to appear to collect their money but also to learn about the kind of water they supply. There is a need for communities to set aside time to meet with individuals and discuss what to do, like we are doing now, and we also know if the problem is here or there. They do not have that time they only come when they want their money but I think giving time to people is also crucial. They should visit different locations since the water may be polluted in some locations but clean in others (FGD II).

Participants believe that so many factors contribute to ensuring safe and quality drinking water supply. It is these same factors if not properly addressed that will lead to deterioration of water quality. By engaging stakeholders, it is a great step towards provision and sustaining clean, safe and quality water. Stakeholders should provide community with feasible solutions, keep the process in check and hence the safety and quality of drinking water is achieved and maintained.

We are executing a project in Rubanda, Kabale, Ntungamo, and Rukiga where they are attempting to engage with people to preserve water in their farmland in order to maintain it for a longer period of time. But when it is running, it runs a way with soil and they see that some diseases are becoming prevalent and they start asking themselves that they never used to get these diseases so where are they coming from not knowing that it is due to mishandling some aspects of the environment such as hormonal birth control measures and when we shared those things they understood (KII I).

We have national wetland, river bank, lake beaches management in place for water source protection, and as part of our mandate, we attempt to engage communities and stakeholders in water source conservation and protection, and the struggle is still ongoing (KII III).

Discussion

This study explored community perceptions and practices about drinking water quality and safety from various water sources in Mbarara, Uganda. We wanted to know what community members thought about the quality of water drawn from drinking water sources, what is responsible for the quality, what they do to ensure the drinking water is safe and of good

quality, and what possible solutions there are to ensure the water is safe and of good quality. The findings show that populations in Mbarara, south western Uganda, regard the quality of drinking water drawn for use as poor, dirty, tastes salty, and is generally unsafe for human use, as well as being limited in supply to communities.

Community member's perceptions of the quality and safety of drinking water

Based on the color, taste, and presence of physical pollutants, community members perceive the safety and quality of drinking water to be poor, dirty, and salty. This perspective was echoed by members of the community and key informants. They believe that the safety and quality of drinking water is poor and that it does not meet established standards for human consumption, yet they continue to consume it since it is the only water available to them. Similarly, a study by Apecu and co-authors on quality of water sources in South-western Uganda using the compartment bag test (CBT) found out that most of the water sources in the study areas were not fit for human consumption without prior treatment [25]. This is odd given that this is a city neighbourhood where social services should be of higher quality. This however is not unique to Mbarara city alone since the World Health Organization estimates that 2 billion people lack safely managed services, including 1.2 billion with basic services, 282 million with limited services, 367 million using unimproved sources, and 122 million drinking surface water, when the United Nations Sustainable Development Goal 6 is to ensure universal access to water and sanitation by 2030 [26]. In addition, without point-of-use treatment systems, at least four billion people worldwide do not have access to clean drinking water or are under the impression that it is unsafe to drink [27]. This is owing to increased water demand, reduced water supplies, and increased water pollution as a result of tremendous population and economic expansion. In many underdeveloped nations' urban areas, badly polluted little water sources are widely used [28]. Contamination concerns are considerable in urban areas due to increased population. Yet, because most populations in urban areas cannot afford the expense of a treated water system and lack access to infrastructure, their sense of quality relies on modest water systems or various sources to supply their drinking water demands [29]. In addition, perceptions of worsening water quality have been observed all across the world, in both rich and developing nations, and "Thousands have survived without love, not one without decent water quality [30]. It should be emphasized that the types, magnitudes, and extents of water quality concerns vary from country to country, and even from region to region within a country. This might be the result of uneven growth, accessibility, and water demands. Issues may be resolved via trust, political will, and social will, albeit the methods vary depending on the region of the country. It should be noted that; trust enables water delivery businesses to achieve both social and commercial benefits [31].

Community member's perceived factors responsible for safety and quality of water

According to the findings of this study, the poor drinking water quality in Mbarara city is mostly attributable to improper waste management, poor water treatment, poor system maintenance, political interference, population increase, and water hyacinth. Some variables do not remain constant throughout time. These factors are not static, but instead vary over time. Some of these factors are human made while others are beyond the communities' control. Issues such as flooding and water cost fluctuate between wet and dry seasons; changes in the water supply; changes in the community's/family's ability to maintain quality, household income, and level of awareness within a given community [32]. Similarly, to our study, the

decline in water quality is caused by increased demand for water, reduced water supplies, and increased water pollution as a result of dramatic population and economic growth [33]. This is due to the discharge of essential pollutants from anthropogenic activities such as industrial applications (solid/liquid wastes, chemical compounds, mining activities, spills, and leaks), urban development (municipal wastes, land use practices, and others), and agricultural practices (pesticides and fertilizers) that affect the safety and quality of water in urban communities [34]. There are other key pollutants emitted by natural processes that contribute to climate change, natural catastrophes, geological causes, soil matrix, and hyporheic exchange in the aquatic environment, all of which might have a detrimental impact (e.g. Endocrine disruptions, DNA damage, cancerogenicity). These elements, together with rising temperatures, accelerated remobilisation processes, and hormone pollution, have a greater impact and may disrupt natural environmental equilibrium. It should be noted that, as indicated in this study, greater population expansion frequently coincides with the demand for more food and food production, forcing communities to encroach on water catchment areas for agriculture [35]. Because of the requirement for improved yields on a short plot of land, fertilizers and crop insecticides are used indiscriminately. These changes in land-use/land-cover (LULC) pattern degrade water quality. This is due to the interdependence of population and economic growth, as well as water consumption, resources, and pollution, all of which contribute to water shortage [36]. Moreover, population growth leads to deforestation to support agricultural development and urban expansion in Mbarara city, necessitating the need for water quality protection to meet urgent human requirements while also ensuring the long-term quality of water resources. There is a lot of garbage produced in the midst of economic issues, making it hard to properly dispose of or pay for proper disposal through structured public services, resulting in waste buildup. Occasionally garbage is dumped in available water sources or catchment areas. This not only affects the quality of drinking water, but it also raises the cost of treated water since more sophisticated procedures are used to assure that the water supplied to communities is treated and of the required standard. A study to investigate the impact of drinking water quality and sanitation on child health: Evidence from rural Ethiopia demonstrated that uncontaminated stored drinking water and safe child stool disposal are related with 18 and 20 percentage point decreases in child diarrhoea rates, respectively [37].

Community member's practices for safe and quality drinking water

To ensure that drinking water from sources in Mbarara city is safe and of quality for use, as well as available and accessible in quantity, service providers use a holistic approach, water rationing, changing chemicals as often as possible depending on the quality of water available for treatment, and the water treatment process is quality controlled internally at National Water and Sewerage Corporation facility treatment centers and externally at Uganda National Bureau of Standards. National environment Management Authority issues permits for any developments that would result in waste to be dumped in River Rwizi or any developments close to the water catchment areas. This can be traced to the fact that, National water and sewerage cooperation, through their service accelerated program has created awareness for the need and maintenance of safe and quality water through radio talk shows, school health sanitation program and in churches. The communities, on the other hand, ensure that bushes are cleared around water sources, that adults and children in company of adults have access to these sources, that overhead tanks are installed and maintained, and that drinking water is boiled. This is crucial in increasing the availability, accessibility, and appropriate quantity of quality and safe drinking water since they are a primary measure for preventing different water-borne infections, poisoning, disease outbreaks, and human deaths in urban settings

[38]. A healthy population is critical for health and long-term socioeconomic growth. Clean drinking water is a crucial component of Primary health care and plays an important role in poverty alleviation, hence boosting economic growth [24]. Due to the exponential growth in water demand and the decrease in usable freshwater due to various climate, environmental, and anthropogenic events, rain water harvesting has become a useful practice because it is inexpensive and low risk if the roof catchment, collection system, and storage are well maintained [39]. Similar to the findings of this study, there is a need to better understand social factors such as governance and increased understanding of diverse physical and social influences that lead to a more comprehensive understanding, knowledge, and need for clean, safe, and quality water, as well as water security, which is defined as a reliable and adequate supply of safe and quality water to support humans and ecosystems at all times [40]. Furthermore, there is a need to raise awareness about the need of clean, safe, and high-quality drinking water, as well as the necessity for other government stakeholders to work together to enhance water quality for improved health [41]. As a result, there should be a continuous extensive water quality monitoring program of drinking water sources across urban areas and their adjacent settings to guarantee population health and environmental balance [42]. However, this requires policymakers and managers to use Artificial Neural Networks (ANNs) and risk analysis techniques to predict water quality because such predictions indicate the level of risk (low, moderate, or high) to the inhabitants, allowing for the implementation of preventive measures to avoid illness or disease outbreaks. This can be achieved through engaging in socio-hydrological research and data analysis to help improve the current understanding and management of the quantity and quality society dynamics for drinking water quality and safety [40].

Community member's perceived solutions for safe and quality of water

The participants in this study feel that stakeholder involvement, community awareness, establishing catchment plan rules and regulations, water treatment and maintenance, surveillance, and monitoring might all assist to improve and maintain the quality and safety of drinking water in Mbarara. This is due to an increasing number of people turning to alternative sources of drinking water, such as rainwater harvesting, to reduce their environmental footprint, because rainwater harvesting (RWH), while not economically feasible, provides protection against damage caused by increasing precipitation frequency and intensity [43]. Similarly, Anjana and colleagues in India advocated training people on drinking water treatment methods, sanitation, and hand washing habits since participants believed their drinking water was pure and didn't need any further treatment [44]. Furthermore, an Ochilova and colleagues study recommended the need for rational use and protection of water resources, as well as ensuring and guaranteeing citizens' right to a favorable natural environment, as well as helping to protect land, subsoil, forests, flora and fauna, atmospheric air, natural resources, and improving healthy family life [45]. There is a need to connect rural and urban areas. The two communities are mutually reliant. Water streams come from rural communities to feed water to urban cities; food production is mostly done in rural communities but is consumed in both rural and urban areas. The rural people should be given policy attention to the ecosystem services that rural areas provide, and the rural area's ecology should be conserved for long-term service delivery, reducing the need to farm in water catchment areas that exist in already overcrowded urban areas [46]. Most importantly, there is a need to invest in implementing sustainable technologies for future water supply and sanitation because the amount of time and money spent by developed, developing, and underdeveloped countries on water investments, operation, and maintenance has changed dramatically in recent decades [47].

Strengths and limitations of the study

The findings of this study represent the perspectives and opinions of community members and stakeholders in Mbarara City's water provision and maintenance. The study's main strength is the unanimity in their thoughts and beliefs. Our capacity to interact with communities and stakeholders in water service supply to investigate their perceptions and practices about the safety and quality of drinking water is our strength. Key informants in this study were water service providers; this may have worked against us since they were afraid to completely voice their ideas and opinions for fear of acting against the expectations of their employers. Nonetheless, we ensured all of our participants of anonymity and confidentiality during the informed consent procedure. We acknowledge that this study presents views and opinions of communities and stakeholders in the water service provision and maintenance in Mbarara city.

Conclusion

Residents in Mbarara perceive the quality of drinking water drawn for use as not good, dirty and salty, and generally unfit for human consumption and limited in supply to communities. Increased population expansion and accompanying human activities, political intervention, flooding, and deficiencies in water treatment, supply, and management are all contributing to poor quality of drinking water in Mbarara city. The service providers use water rationing, offer permits for developments in the city and most importantly in water catchment areas, the water is treated and the water supply system is quality controlled both internally and externally, water sources are protected from contamination by clearing bushes and fencing, and alternative sources are used to supply drinking water in the event of suspected contamination.

Perspective and recommendation

We recommend a comprehensive approach to the provision, use, and management of drinking water sources. Policymakers and stakeholders should collaborate to increase knowledge, sensitization, and practices aimed at providing, using, and maintaining safe and high-quality drinking water from drinking water sources in Mbarara, south-western Uganda.

Acknowledgments

We thank all those who participated in this research project. We acknowledge the study participants and the Alex Tumusiime (AT) and Patience Nabaasa the study Research Assistants and Owokuhaisa Judith(OJ) who read through the transcripts and coded We acknowledge the reviewers who are going to review and provide constructive comments that will help perfect this manuscript.

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