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Assessment of Toxic Chemicals Level in Water Supply Systems Operated by Ayateke Star Company Ltd in Kirehe District and Comparison with National and WHO Standards

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Abstract

Nowadays, one of the leading environmental pollutants is toxic chemicals. The safety and quality of drinking water are critical to public health, requiring routine monitoring of potential contaminants against national and World Health Organization (WHO) standards because they are toxic even at low concentrations. This study assessed the concentrations of Aluminium (Al^{3+}), Nitrate (NO_3^-), Ammonia nitrogen ($\text{NH}_3\text{-N}$), Copper (Cu^{2+}), Manganese (Mn^{2+}), Fluoride (F^-), Phosphate (PO_4^{3-}), and Iron ($\text{Fe}^{2+}/\text{Fe}^{3+}$) in Eight rural water supply systems include Kivogo, Rubona, Kirehe, Kigina, Muguruka, Mushikiri, Nyakagera and Cyanyiranyonza—located in Kirehe District in Rwanda operated by Ayateke Star Company Ltd. Water samples from each system were analyzed using Hach Digital Reactor 900 Portable Colorimeter. The results in (mg/L) showed the following concentration ranges: Aluminium: 0.024–0.062 (WHO limit: 0.2); Nitrate: 1.3–10.8 (WHO limit: 45), Nitrogen Ammonia: 0.00–0.09 (WHO limit: 0.5), Copper: 0.00–0.11 (WHO limit: 1.0), Manganese: 0.00–0.051 (WHO limit: 0.1); Fluoride: 0.19–1.34 (WHO limit: 1.5), Phosphate: 0.1–0.88 (no specific WHO health-based limit, Approx: 2.2); Iron: 0.011–0.60 (WHO aesthetic limit: 0.3) within safe limits in all water supply systems except iron concentration in Kirehe WSS exceeded the acceptable limit with 0.60 mg/l. Overall, 87.5% of the measured parameters complied with WHO guideline values. Therefore, the findings showed that the analysis of eight selected water supply systems managed by Ayateke Star Company Ltd, seven were within the permissible limits set by both the World Health Organization (WHO) and applicable national standards. These results indicate that the water supplied from the assessed systems is safe for human consumption with respect to the investigated parameters. Compliance with WHO guidelines reflects effective water treatment and monitoring practices, thereby minimizing the potential health risks associated with chemical contaminants. Nevertheless, continuous monitoring is recommended to ensure sustained water quality and safeguard public health.

Keywords: Toxic Chemicals, Pollutants, World Health Organization, Hach Digital Reactor 900 Portable Colorimeter, Water Supply Systems

Introduction

Access to safe drinking water is vital for human existence, and the water distribution system is a significant asset for human health and wellbeing, impacting various aspects such as material life, culture, society, politics, and the economy. Thus, ensuring the safety of the water distribution system (WDS) is strategically important

for protecting public health and fostering industrial development. Although water quality is monitored at treatment facilities, the WDS is susceptible to unintentional or purposeful attacks due to its accessibility, openness, and deteriorating infrastructure, which can result in contamination of drinking water during its delivery to consumers [1]. Nevertheless, gaining access to safe drinking water continues to be a major issue globally. Even with ongoing advancements in drinking water provision, approximately 884 million individuals, as referenced in still lack access to improved drinking water sources worldwide, according to WHO regulations [2].

The quality of water is characterized by its physical, chemical, biological, and aesthetic properties, which help assess its suitability for various uses, including safeguarding human health and supporting aquatic ecosystems. Many of these properties are affected by substances that are either dissolved or suspended in the water, and water quality can be impacted by both natural processes and human activities [3]. Water security refers to the ability of a population to maintain reliable access to sufficient amounts of water that meets acceptable quality standards, essential for sustaining human well-being and economic development. It also includes the need to protect against pollution and water-related disasters while conserving ecosystems in an environment of peace and political stability. The quality of water provided by municipal authorities should be evaluated according to the national drinking water standards established by federal governments and other pertinent organizations [3].

Enhancing the availability, quality, accessibility, and sustainability of water supply services in Rwanda is the sector's top priority. Rwanda has committed to meeting SDG targets by 2030 through various programs, including the NST1 and 7 Years Government Program, with the goal of achieving universal access to basic water and sanitation services by 2024. Access to safe drinking water is essential for people's health and well-being as well as for poverty reduction and economic development. A suitable institutional framework must exist in order to accomplish this goal. Private operators (POs) are required by Rwanda's public-private partnership contract for rural water supply systems to create their own operation and maintenance (O&M) manual for each individual water. A suitable institutional framework must exist in order to accomplish this goal. Private operators in Rwanda are required by the public-private partnership (PPP) contract for rural water supply systems to create their own operation and maintenance (O&M) manual for each and every water supply system.

RWASOM project also developed the "Training Module on Procedure of Operation and Maintenance for Rural Water Supply Systems focusing on operation, preventive maintenance and curative maintenance by facility to make POs easy to understand the procedure of O&M and help POs to develop their own manual by themselves [4].

To ensure that standards are acceptable to consumers, communities served, together with the major water users, should be involved in the standards-settings. Public health agencies may be closer to the community than those responsible for its drinking-water supply. At a local level, they also interact with other sectors (e.g. education), and their combined action is essential to ensure active community involvement [4].

Local environmental health authorities play a crucial role in the oversight of water resources and drinking-water supplies. This responsibility may involve inspecting catchments and approving activities within them that could affect the quality of source water. Additionally, they are tasked with verifying and auditing the management of official drinking-water systems. Local environmental health authorities also provide specific advice to communities and individuals on how to design and implement community and household drinking-water systems and address any issues that arise. Furthermore, they may oversee the monitoring of community and household drinking-water sources. Their educational role is vital in informing consumers about the need for household water treatment [5].

Ayateke Star Company Ltd is one of the private companies dedicated to advocating for the sustainable management of water and sanitation systems while facilitating access to adequate electricity, which enhances the quality of life in secure and inviting surroundings in rural regions. The quality of water has been associated with health outcomes globally. This research assessed the levels of toxic chemicals in the water supply systems managed by Ayateke Star Company Ltd in Kirehe District and compared them with national and WHO standards to evaluate the safety of the water provided to the community. The district and Private Operator's Manual for the Operation and Maintenance of Rural Water Supply Systems outlines drinking-water quality standards to guarantee that consumers have access to safe, adequate, and sustainable drinking water [4].

The document titled Water quality assessment and evaluation of human health risk of drinking water from source to point of use at Thulamela municipality, Limpopo Province emphasizes that social and economic development relies heavily on water sources. Access to safe and high-quality water is a basic human right, and providing clean water and sanitation to everyone is recognized as one of the objectives to be met by 2030 for sustainable development by the United Nations General Assembly (UNGA).

The World Health Organization (WHO) has put forth recommendations in to help manage the risks associated with hazards that could threaten the safety of drinking-water [4]. These recommendations should be viewed in the broader context of managing risks from various other exposure sources, including waste, air, food, and consumer goods. Enhancing access to safe drinking-water can lead to significant health improvements.

Every effort should be made to ensure that drinking-water is as safe as possible. According to, safe drinking-water poses no significant health risks over a lifetime of consumption, accommodating different sensitivities that may arise at different life stages [4]. Those most vulnerable to waterborne diseases include infants and young children, individuals with health challenges, and the elderly, particularly when they are living in certain conditions.

The health issues linked to chemical components in drinking water differ from those caused by microbial contamination and mainly stem from the potential of these chemicals to induce adverse health effects after extended exposure periods. Few toxic chemical substances in water can result in health issues from a single exposure, except in cases of significant accidental contamination of a drinking-water source. Nonetheless, a notable number of serious health risks can arise due to the chemical pollution of drinking water. In situations where, immediate exposure is unlikely to cause health problems, it is often more effective to focus available resources on locating and removing the source of contamination rather than investing in costly drinking-water treatment to eliminate the chemical substances [4].

One instance is the health-related guideline for fluoride levels in drinking water. A recommended value is 1.5 mg/l, accompanied by a note suggesting that "the quantity of water consumed and intake from other sources should be taken into account when establishing national standards." Therefore, in a country with consistently warm weather where piped water is the main source of drinking water, officials may opt for a health-based target for fluoride that is lower than this guideline value, given the expected higher water consumption. Similarly, the health-based target should be evaluated regarding its effects on the most vulnerable segments of the population. Several chemicals, both organic and inorganic, raise concerns about drinking water from a health standpoint because they can be harmful to humans or are believed to be carcinogenic. Additionally, some of these can influence the aesthetic quality of the water.

According to, the presence of chemicals in drinking water can be attributed to several factors: natural leaching from soils, rocks, and mineral deposits into water sources; land-use practices in catchment areas that intensify natural processes, such as the mobilization of salts; runoff from agricultural activities within drinking water catchments; biological activities including the growth of cyanobacteria and algae in water bodies and reservoirs; contamination of source water through discharged treated effluent and other point sources within the catchment; carry-over of small quantities of treatment chemicals; the deliberate addition of substances such as chlorine and fluoride; the formation of disinfection by-products resulting from reactions between organic and inorganic substances in water and disinfectants like chlorine; and the corrosion and leaching of metals and metalloids from pipes, fittings, and other plumbing materials that come into contact with drinking water. High level of Aluminium accumulation is particularly problematic for dialysis patients—linked with dialysis-related encephalopathy, osteomalacia, and anemia [6]. A safe threshold for dialysis water is below 0.01 mg/L. High level of Nitrogen Ammonia above ~0.5 mg/L can cause copper pipe corrosion, promote bacterial and algal growth, interfere with disinfection, and impair manganese removal.

High Nitrate levels exceeding 45 mg/L (or Nitrogen greater than 10 mg/L according to the US EPA) heighten the likelihood of methemoglobinemia, commonly referred to as "blue baby syndrome," in newborns. Furthermore, even concentrations as minimal as 5 mg/L may increase the risk of thyroid cancer in females; prolonged exposure over a decade or more is associated with a higher risk of colon cancer [7]. High concentrations of iron, while not an immediate health risk, lead to aesthetic concerns when they exceed approximately 0.2 mg/L, resulting in brown discoloration, turbidity, and staining of clothing and fixtures [7].

High manganese levels (exceeding 0.08–0.1 mg/L) are mainly a cosmetic issue, causing black stains and a metallic flavor. Nevertheless, recent research has also associated high manganese levels (greater than 0.1 mg/L) with developmental issues in children’s cognitive functions, including memory, attention, and learning capabilities [7]. When copper levels are high (EPA action level 1.3 mg/L; WHO approximately 2 mg/L), short-term effects can include gastrointestinal issues, while prolonged exposure may lead to liver or kidney damage; people with Wilson’s disease need to take precautions. Phosphate isn’t generally regulated in drinking water based on health risks; it’s commonly found due to corrosion control measures or agricultural runoff. There are no clearly defined upper or lower limits or direct health impacts identified by the WHO or significant regulatory agencies [7].

Ion/Chemical	Low-Level Effect	High-Level Effect
Aluminium	Acceptable, no health concern	Neurotoxicity in dialysis, possible neurodegeneration
Ammonia	Natural (<0.2 mg/L), safe	Corrosion, microbial growth, disinfection interference
Nitrate/Nitrite	Safe below limits	“Blue baby” in infants; long-term cancer and thyroid risks
Fluoride	Prevents cavities	Dental/skeletal fluorosis, neurocognitive effects
Iron	Safe, natural trace	Aesthetic issues (staining, color)
Manganese	Safe	Taste/color issues; possible cognitive harm in kids
Copper	Necessary trace mineral	GI distress; liver/kidney damage at chronic exposure
Phosphate	No significant health role	No established health-based limits

Table 1: Summary of The Effects at Low and High Limits of The Toxic Chemicals in Water(Guidelines for Drinking-Water Quality, 2011)

Understanding the concentration of contaminants is crucial to ensure that water complies with WHO and national safety standards, preventing both acute poisoning and chronic health issues. It aids in determining the necessary treatment methods, such as coagulation, ion exchange, and filtration. Staying compliant with drinking water regulations helps avoid legal repercussions and financial liabilities for suppliers. It minimizes issues like scaling, corrosion, and biofouling in pipes and distribution networks. Early identification of contamination sources allows for prompt corrective actions. Reliable monitoring fosters trust and acceptance regarding the quality of supplied water.

Numerous chemicals can be found in drinking water; however, only a limited number pose an immediate health risk in specific situations. The emphasis on both surveillance and corrective measures for chemical pollutants in drinking water should be organized to make sure that limited resources are not wasted on those that pose minimal or no health risks (refer to the supplementary document Chemical safety of drinking-water). There are very few substances for which the contribution from drinking water to total intake plays a significant role in disease prevention. One illustration is the role of fluoride in drinking water in helping to prevent dental cavities. The Guidelines do not aim to establish minimum desirable levels for chemicals in water [4].

As mentioned in earlier sections, most chemicals pose a risk primarily after prolonged exposure; however, certain hazardous substances found in drinking water are concerning due to the effects resulting from short-term exposure sequences. When the concentration of a specific chemical (such as nitrate/nitrite, linked to methemoglobinemia in bottle-fed infants) fluctuates significantly, even a series of test results may not adequately capture the public health risks involved. In managing such dangers, it is important to consider both the factors that cause these issues, like agricultural fertilizer use, and the trends in measured concentrations, as these can forecast potential significant problems in the future. Additional hazards might emerge sporadically, often tied to seasonal patterns or environmental conditions. An instance of this is the appearance of toxic cyanobacteria blooms in surface waters [4]. The characteristics and structure of drinking-water standards can differ from one country or region to another. There is no universally applicable method. When developing and enforcing standards, it is crucial to consider existing or planned legislation related to water, health, and local governance, as well as to evaluate the regulatory capacity in the country. Strategies that may be effective in one nation or region might not be suitable for another. Each country must assess its own requirements and capabilities when creating a regulatory framework [4].

Evaluating chemical priorities is essential since not all chemicals with established guideline values will be found in every water supply or country. If these chemicals are present, they might not necessarily be at levels that raise concerns. On the other hand, some substances that lack guideline values or are not mentioned in the Guidelines could still be relevant to local issues under certain conditions.

Risk management approaches, reflected in national regulations and monitoring efforts, should prioritize chemicals that threaten human health or significantly affect water acceptability. As indicated in the table1, certain toxic substances have been linked to widespread health issues in individuals when consumed in excessive amounts through drinking

water. Iron and manganese are particularly notable due to their impact on water acceptability, and thus, they should be factored into any prioritization process. In some instances, evaluations may reveal that there is no significant risk of exposure at the national, regional, or system level. Drinking water may only be a minor source of overall exposure to a specific chemical, and in some scenarios, regulating its levels in drinking water, which could incur substantial costs, may not significantly influence total exposure. Consequently, strategies for managing drinking water risks should be developed alongside considerations of other potential sources of human exposure [4].

Methods

This unit offers a reproducible methodology for field and laboratory settings to gather, preserve, analyze, and report the levels of Aluminium, Nitrate, Ammonia (expressed as N), Copper, Manganese, Fluoride, Phosphate, and Iron across eight different water supply systems: Kivogo, Rubona, Kirehe, Kigina, Muguruka, Mushikiri, Nyakagera, and Cyanyiranyonza. The Hach DR 900, referred to as the Hach Digital Reactor 900 Portable Colorimeter, is utilized for these measurements.

Study Design & Sampling Plan

- **Sampling sites:** Sample was taken from one of representative sampling point per water supply system (Kivogo, Rubona, Kirehe, Kigina, Muguruka, Mushikiri, Nyakagera and Cyanyiranyonza). The water sample was collected from the point of delivery (standpipe/tap) and where relevant, from raw source (intake) and treated output.
- **Number of samples:** triplicate samples at each site for precision were taken (3 × each parameter per site).
- **Sampling frequency:** Single baseline survey was used for seasonal assessment, sample once each in dry and wet seasons.

Sample Collection Materials & Bottles

Amber or clear glass sample bottles, typically 250 mL in size as suggested by the reagent manufacturer, were utilized for colorimetric analyses. Prior to filling, the bottles were rinsed three times with the sample water. For the analysis of trace metals (Al, Cu, Mn, Fe), acid-washed bottles were employed.

Preservation, Filtration and Holding Times

The targeted hazardous substances in water samples were analyzed promptly, and the DR900 method was applied to unfiltered water samples; the established procedures were adhered to by utilizing specific reagents corresponding to each toxic chemical tested, as outlined in the District and Private Operator's Manual for the Operation and Maintenance of Rural Water Supply Systems.

Reagents, Method Selection and Method Numbers (Dr900)

A compatible reagent for DR900 was prepared for each analyte. Hach supplies method IDs along with reagent packs (powder pillows, tablets, or liquid kits) specifically designed for DR900. Below are the method references from Hach for the analyzed toxic chemicals [8].

Parameter tested	Hach DR 900 Method	Set Programme	Testing Reagent
Nitrate (NO ₃ ⁻)	Cadmium reduction method ¹	355N, Nitrate HR PP.	Nitraver 5 Nitrate
Nitrogen-Ammonia	Salicylate method ²	385 N, Ammonia, Salic.	Ammonia Salicylate
Iron (Fe ²⁺)	USEPA1 FerroVer® Method ²	265 Iron, FerroVer	FerroVer Iron
Aluminium (Al ³⁺)	Aluminon Method ¹	10 Aluminum Alumin	AluVer3 Aluminum
Manganese (Mn ²⁺)	1-(2-Pyridylazo)-2-Naphthol PAN Method ¹	290 Manganese, LR PAN.	Alkaline Cyanide
Copper (Cu ²⁺)	USEPA1,2 Bicinchoninate Method ³	135 Copper, Bicin	PhosVer 3 Phosphate
Fluoride (F ⁻)	USEPA SPADNS Method ¹	190 Fluoride	SPADNS
Phosphate	USEPA1,2 PhosVer 3® (Ascorbic Acid) Method ³	490 P React. PP	PhosVer 3 Phosphate

Table 2: The Method, programme and reagents used test each parameter

Instrument Set-Up & Calibration (Dr900)

The DR900 was turned on, operated correctly, and had all required factory/user programs for each analyte loaded and updated. The appropriate DR900 method/program corresponding to the reagent pack was chosen from the instrument menu, and the reagent blank (reagent mixed with distilled water or blank as specified in the method) was prepared and set to zero/blank on the instrument when prompted, while the wavelength and cleanliness of the cuvettes were also confirmed. As a result, the matched cuvettes were utilized; those that were free of fingerprints and scratches were selected.

Field / Lab Test Procedure

- The various samples were allowed to reach room temperature while being tested in the field.
- The samples were mixed by inverting them; care was taken to avoid bubbles when filling the cuvette.

- **Zero/blank:** A clean cuvette was filled with the reagent blank, inserted into the instrument, and the "Blank/Zero" key was pressed as per the method's instructions.
- **Sample preparation:** The sample was prepared as follows: the appropriate volume was pipetted into the cuvette, specific reagents were added, and the color was allowed to develop for the duration specified by the method (incubation)
- Timing was executed with precision.
- Each prepared sample was placed into DR900 and the concentrations were read

Results and Discussion

Water samples from the six supply systems (Kivogo, Rubona, Kirehe, Kigina, Muguruka, Mushikiri, Nyakagera, and Cyanyiranyonza) underwent analysis for Aluminum, nitrate, Nitrogen-Ammonia, Copper, Manganese, Fluoride, Phosphate, and Iron. The analysis was conducted using the Hach DR 900 portable colorimeter, which stands for Hach Digital Reactor 900 Portable Colorimeter, and the results are presented in Table 3. The measured concentrations were compared to the WHO guideline values for drinking water quality as referenced in [4].

	Water Supply Systems (WSS) Concentration								
Parameters	Kirehe	Mushikiri	Rubona	Kivogo	Kigina	Muguruka	Nyakagera	Cyanyiranyonza	WHO Standard
Aluminium	0.037	0.041	0.03	0.028	0.043	0.03	0.024	0.062	0.2
Nitrate (NO3-)	3.00	5.3	5.4	2.2	1.3	5	10.8	3.3	45
Nitrogen-Ammonia	0.00	0.00	0.01	0.00	0.00	0.02	0.09	0.00	0.5
Phosphate	0.74	0.41	0.2	0.1	0.53	0.59	0.88	0.29	2.2
Iron	0.60	0.13	0.1	0.011	0.1	0.1	0.06	0.21	0.3
Manganese	0.02	0	0.012	0.051	0.026	0.015	0.032	0.009	0.1
Copper	0.11	0.02	0.06	0.04	0.03	0.00	0.00	0.05	1
Fluoride	0.22	0.34	0.19	0.22	0.35	1.34	0.31	0.26	1.5

Table 3: Toxic Chemicals Concentrations Results from Different Water Supply Systems (Wss)

Level of Aluminum ion Concentration in Water Supply Systems (WSS)

Figure 1 shows the concentration level of Aluminium found in each water supply system sample.

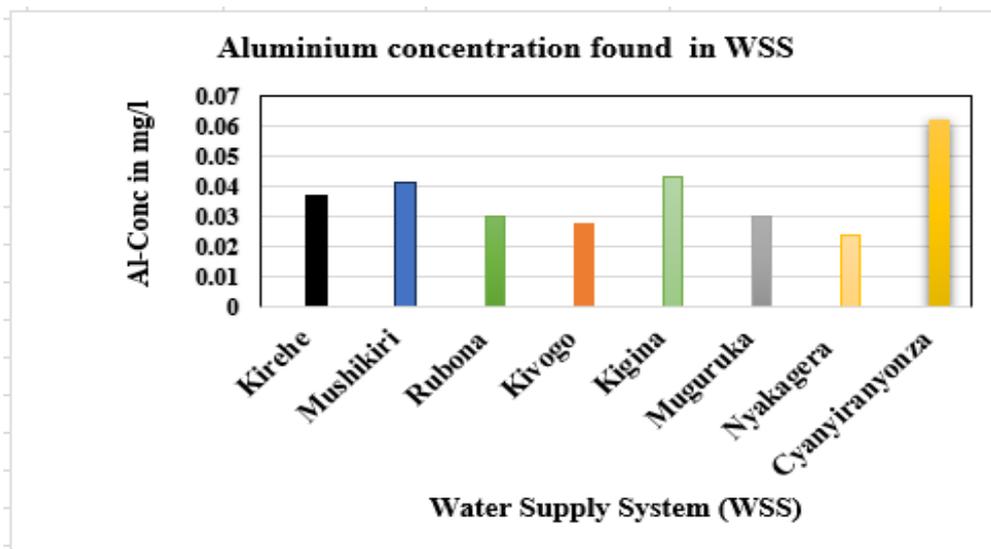


Figure 1: Aluminium Concentration in Water Supply System

Based on the findings presented in Figure 1, the Cyanyiranyonza water supply system exhibited the highest aluminium concentration at 0.062 mg/l, followed by Kigina with a concentration of 0.043 mg/l. The Mushikiri water supply system was third, recording a concentration of 0.041 mg/l, while the Kirehe system came in fourth with 0.037 mg/l. The fifth place was taken by both Muguruka and Rubona, which had equal concentrations of 0.03 mg/l. The sixth was the Kivogo system, showing a concentration of 0.028 mg/l, and the lowest concentration was found in the Nyakagera system at 0.024 mg/l. From the data on aluminium concentrations in the examined water supply systems, it was determined that the range was from 0.024 to 0.062 mg/g. According to the, all water supply systems had aluminium concentrations

within safe limits, given that the maximum allowable concentration in water is 0.2 mg/l [4].

Level of Nitrate Ion Concentration in Water Supply Systems (WSS)

Figure 2 shows the concentration level of Nitrate ion found in each water supply system sample.

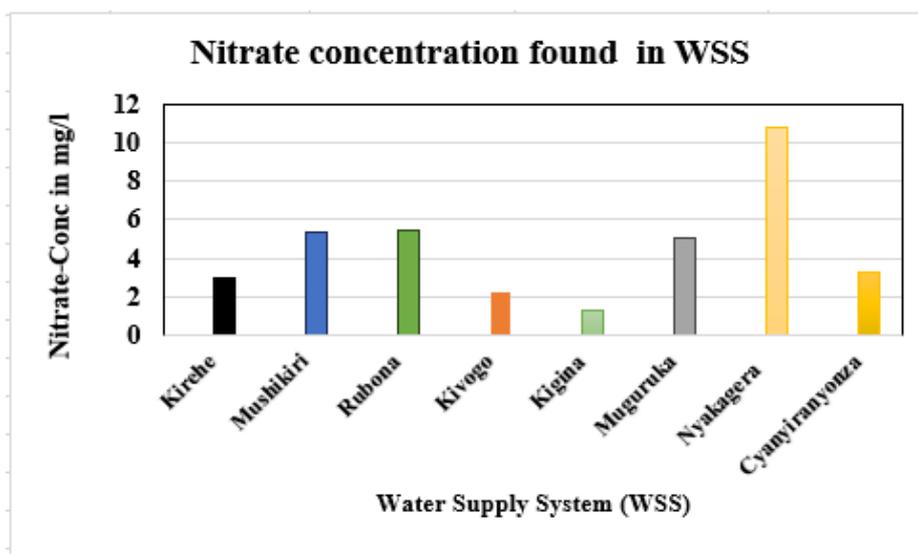


Figure 2: Concentration Level of Nitrate in WSS

All monitoring systems noted nitrate concentrations significantly under the WHO threshold of 45 mg/L, with measurements spanning from 1.3 mg/L in Kigina to 10.8 mg/L in Nyakagera. These figures indicate a low presence of agricultural or sewage pollution. High nitrate levels are particularly concerning for infants because of the potential risk of methemoglobinemia, commonly known as "blue baby syndrome." [7].

Level of Nitrogen-Ammonia Concentration in Water Supply Systems (WSS)

Figure 3 shows the concentration level of Nitrogen-Ammonia found in each water supply system sample.

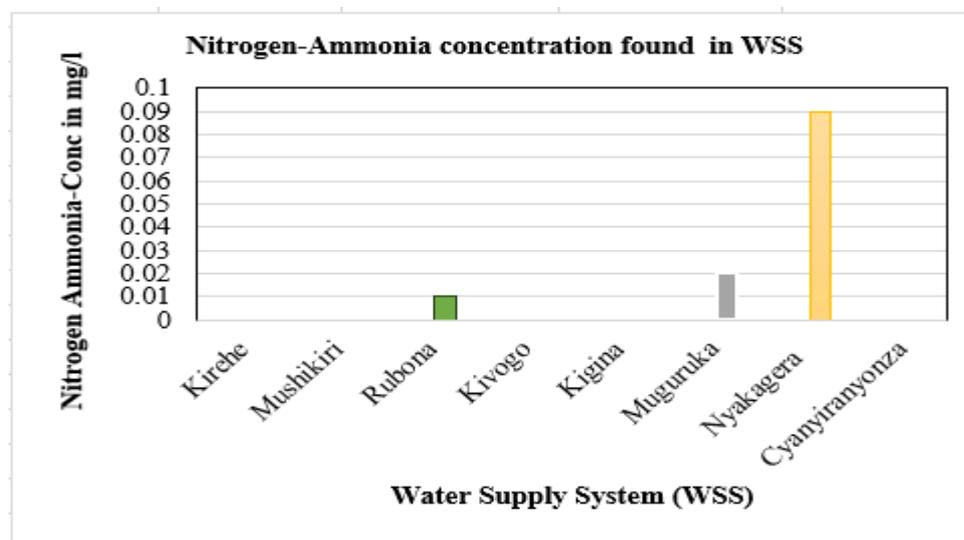


Figure 3: Nitrogen-Ammonia Concentration in WSS

According to the findings presented in Figure 3, the concentrations of Nitrogen-Ammonia ($N-NH_3$) were low, ranging from 0.00 mg/L to 0.09 mg/L, and remained within the WHO guideline of 0.5 mg/L, suggesting that there has been no considerable recent pollution from organic waste or livestock manure. Although ammonia itself does not pose a direct health risk, it can influence the effectiveness of chlorination and affect taste [4].

Level of Phosphate ion Concentration in Water Supply Systems (WSS)

Figure 4 showed the concentration level of phosphate ion found in each water supply system sample.

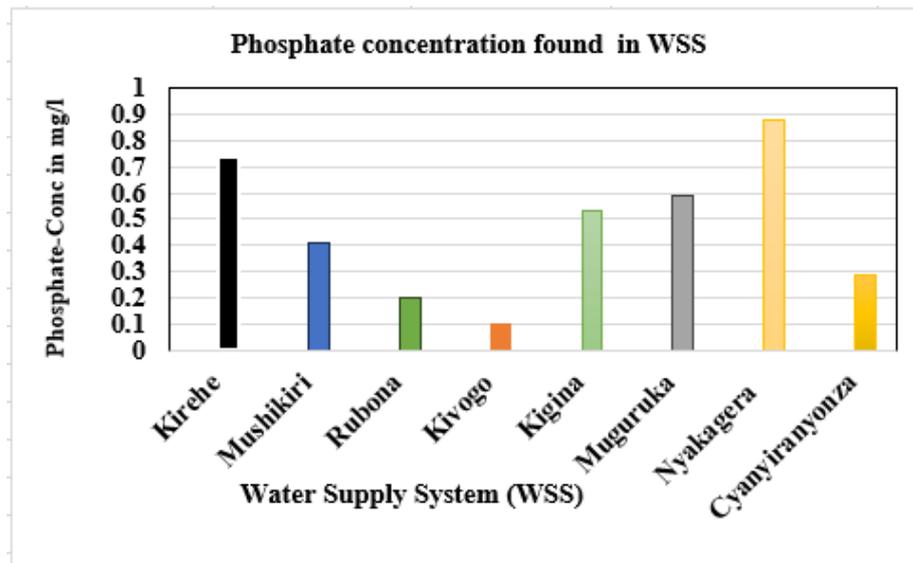


Figure 4: Phosphate Ion Concentration

The World Health Organization does not have a specific health-related limit for phosphate; however, the information shown in Figure 4 demonstrates that phosphate ion concentrations ranged from 0.1 to 0.88 mg/L, all falling below the WHO limit of 2.2 mg/L, indicating a low risk for eutrophication. Potential sources of phosphate can stem from the natural breakdown of minerals or residues left by detergents, as noted by (Guidelines for Drinking-Water Quality, 2011).

Level of Iron Ion Concentration in Water Supply Systems (WSS)

Figure 5 showed the concentration level of Iron ion found in each water supply system sample.

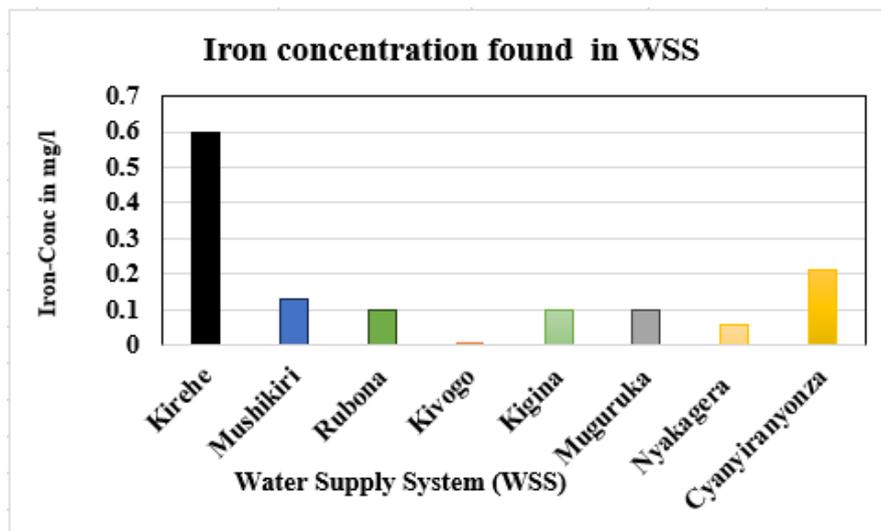


Figure 5: Iron Ion Concentration in WSS

The findings illustrated in figure 5 indicate that the iron levels in Kirehe WSS (0.60 mg/L) surpassed the aesthetic threshold of 0.3 mg/L. Although iron at these concentrations is not considered a health hazard, higher levels can lead to staining of clothing and plumbing fixtures, as well as impact taste [4].

Level of Manganese Ion Concentration in Water Supply Systems (WSS)

Figure 6 showed the concentration level of Manganese ion found in each water supply system sample.

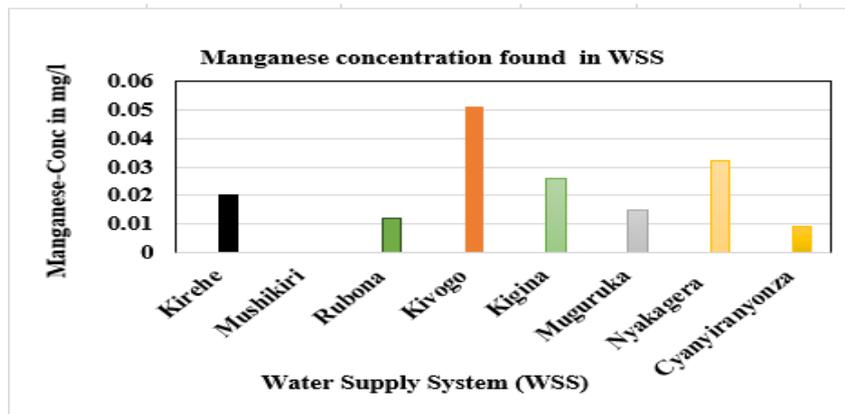


Figure 6: Manganese Ion Concentration in WSS

Based on the findings illustrated in Figure 6, all systems measured manganese concentrations significantly lower than the WHO threshold of 0.1 mg/L, with readings between 0.00 mg/L (Mushikiri) and 0.051 mg/L (Kivogo). High levels of manganese may occur naturally in groundwater or may be a result of leaching from distribution pipes. Prolonged exposure to elevated levels can lead to neurological issues and water discoloration [4].

Level of Copper Ion Concentration in Water Supply Systems (WSS)

Figure 7 showed the concentration level of copper ion found in each water supply system sample.

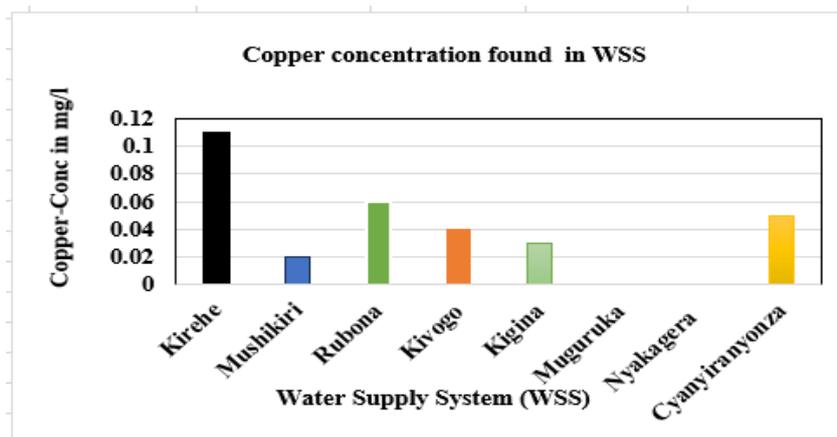


Figure 7: Copper Ion Concentration in WSS

The data presented in Figure 7 indicated that copper concentrations varied between 0.00 and 0.11 mg/L, significantly lower than the WHO threshold of 1.0 mg/L. These levels are not expected to present any health hazards or lead to aesthetic concerns such as changes in taste.

Level of Fluoride ion Concentration in Water Supply Systems (WSS)

Figure 8 showed the concentration level of Fluoride ion found in each water supply system sample.

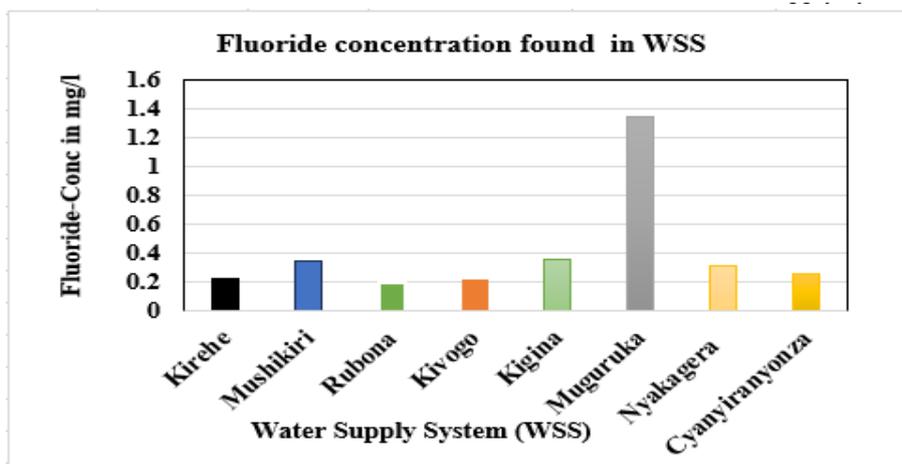


Figure 8: Fluoride Ion Concentration in WSS

Fluoride levels, as illustrated in figure 8, ranged from 0.19 mg/L (Rubona) to 1.34 mg/L (Muguruka). All measurements were within the WHO threshold of 1.5 mg/L. Prolonged intake of fluoride at or above this limit could result in dental fluorosis [7].

Conclusion

Consequently, the results revealed that out of the eight water supply systems managed by Ayateke Star Company Ltd, seven fell within the acceptable limits established by both the World Health Organization (WHO) and relevant national standards. These findings suggest that the water produced from the evaluated systems is safe for human consumption concerning the parameters assessed. Adherence to WHO criteria demonstrates effective water treatment and oversight practices, thereby reducing the potential health hazards linked to chemical pollutants. However, ongoing monitoring is advised to maintain water quality and protect public health.

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The Authors acknowledge that the public-private partnership (PPP) agreement for rural water supply systems in Rwanda requires private operators (POs) to create an operation and maintenance (O&M) manual for each water supply system, allowing my employee, Ayateke Star Company Ltd, to invest in rural water supply to ensure access to safe water for the community. The Authors also value the RWASOM project, which created the "Training Module on Procedure of Operation and Maintenance for Rural Water Supply Systems" aimed at making it easier for POs to understand O&M procedures, as well as assisting them in independently developing their own manuals.

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