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# MICROBIOLOGICAL QUALITY ANALYSIS OF WATER STORAGE CONTAINERS IN GOMA DISTRICT. SPECIFIC CASE OF THE MUGUNGA AND LAC VERT QUOTER

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## ABSTRACT

Water is an essential element for human life, having it in sufficient quantity and quality contributes to the maintenance of human health. The objective was to analyze microbiological quality of drinking water in Goma district. The design of this study includes experimental, qualitative and quantitative approaches. The sample size of this study was 396 adults and water analyses be done, for the total population estimated at 63492 in the Lac vert and mugunga neighborhoods. A survey was used to collect data from respondents. Collected data be processed with the SPSS version 20 software and analysed using the Chi-square test. Results were presented in tables. Results found were useful in reducing the diarrhea incidence in order to prevent health problems in our study environment. In view of the above, the following results were found: the samples taken in the two zones had presented turbidity, 47.8% before center training, 2.79% after training in the intervention zone, the control zone had presented 48.2% turbidity in phase 1 compared to 75.55% in phase 2, the majority of germs identified on gram staining in the intervention zone were gram negative bacilli (88.9% before training against 4.44% after training). On the other hand, the control zone revealed 84.4% in phase 1 against 90.55% in phase 2, the majority of germs identified on MacConkey in the intervention zone were positive (88.9% before training against 4.44% after training), the majority of bacteria identified before training were reduced to 100% after training in our area of intervention with LRV at least 3 which means reduction percentage of 99.9%. Conclusively, laboratory analyses showed that households containers used in the study area are not good for water storage consumption and susceptible to cause health problems.



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# INTRODUCTION

The health status of a population is closely dependent on drinking water quality. There are more than 3 million people who die worldwide per year or 7 people per minute because of poor water quality, the majority of victims are children under 5 years old. Waterborne disease caused by contaminated water consumption can affect numerous people in a short time (WHO, 2017). Microbiologically contaminated drinking water can transmit diseases such as diarrhea, cholera, dysentery, typhoid and polio and is estimated to cause 485 000 diarrheal deaths each year in the world. In 2022, over 2 billion people live in water-stressed countries, which is expected to be exacerbated in some regions as result of climate change and population growth. About 2.2 million deaths are attributed to diarrhea alone in India every year.

However, a large number of diarrheal cases may be avoided with proper sanitation and hygiene practices. Globally, at least 1.7 billion people use a drinking water source contaminated with feces. Microbial contamination of drinking-water as a result of contamination with feces poses the greatest risk to drinking-water safety (Madhulipika Giri *et al*., 2022). Diarrheal diseases kill 6,000 children per day (UNICEF, 2015). In 2016, there were an estimated 4.5 billion episodes of diarrhea worldwide. Diarrhea ranked eight among the leading causes of mortality globally, accounting for over 1.6 million deaths among all ages and fifth leading cause of death among children younger than five years with 446,000 deaths. Approximately 90% of these diarrheal deaths occurred in South Asia and sub-Saharan Africa (Global Burden Disease, 2016). It was noted that 58% of diarrheal deaths still occur in Low- and Middle-Income Countries due to inadequate water, sanitation and hygiene (Prüss-Ustün *et al.,* 2014, WHO. 2014). In sub-Saharan Africa, there are

over one billion diarrheal episodes and an estimated 606,024 diarrheal deaths annually with nearly half of the deaths occurring in children younger than five years. Unsafe water and unsafe sanitation are the leading risk factors for diarrheal mortality among children younger than five years while unsafe water and unsafe sanitation are the leading risk factors for diarrheal mortality among all ages (Global Burden Disease, 2016). Furthermore, unsafe water and sanitation as well as other risks associated with poverty and poor development have been projected to be major contributors to wide gaps in health outcomes in the sub-Saharan Africa region by 2040, if current trends persist (Foreman *et al.*, 2016). In Nigeria, there are an estimated 151,700 annual child deaths due to diarrhea with the prevalence of diarrhea ranging between 10% and 18.8% (UNICEF/WHO, 2017, Gebru *et al.*, 2014). In the Democratic Republic of Congo, Diarrheal diseases are one of the main public health concerns with over 1.45 million of people having the condition in 2019, and an extremely high death rate for under five years old. As of 2013, 119 deaths per 1,000 live births were reported, surpassed only by seven countries in which diarrheal diseases accounted for about 11% of child mortality (Chao Wang, 2019). According to UNICEF, 33 million people in rural areas did not have access to quality water in DRC, and only 52% of the population had access to adequate water sources (UNICEF, 2020).

Since 2014, attacks and abuses by armed men in the city of Beni in North Kivu province have forced thousands of people to abandon their villages and find a safer place to live in the cities. According to statistics, nearly 34,000 displaced families since 2022 often live in rudimentary mud or wooden plank constructions. In these precarious conditions, having access to water and meeting basic needs is a real headache. To hydrate, cook or do dishes, it is not uncommon for women to draw water from wells (Frédéric Joli, 2022). In 2018, MICS survey showed that, 68.4% of the population of North Kivu had access to water quality (running water, a standpipe, a natural spring and a water pumping point, a well drilled). This report also showed that 31.6% used an unprotected source. However, Regideso water is not drinkable in Butembo city. For drinking water, households must draw from water sources provided by humanitarians (Mukulu Vulotwa Hervé, 2020). Although diarrheal cases occur globally among all regions and populations, majority of cases occur in low resource settings and in places where access to health care, safe water and sanitation are limited. Understanding the contributions of households water hygiene practices, and microbiological quality of drinking water associated with diarrhea in poor resource settings would help inform policy makers on areas where specific interventions could improve diarrheal disease control and contribute towards achieving the Sustainable Development Goal which aims to ensure access to water and sanitation for all by 2030. The findings from this study would help guide policy formulation towards diarrhea prevention and control in the study area. To prevent diarrhea it is preferable to ensure a good way of hygienic elimination of stools (Good latrines cleaned regularly) and food hygiene (Eat well-cooked foods, Wash fruits and vegetables carefully, Wash plates and utensils well and do not place them on the ground, Always cover food and protect it from flies, Clean all surfaces used for food preparation). A good way to prevent water quality is to adopt a new urban planning and housing policy, so that households can access safe water by treating water at home, the containers used to store water should be protected from contamination and cleaned regularly, encourage handwashing in households with soap at crucial times (before breastfeeding, after changing sanitary napkins, before cooking, before eating and after using bathroom).

# MATERIEL AND MÉTHODS

***Study area: lac vert and mugunga quoter:*** This research will be done in the city of Goma. The city of Goma is located in the east of the Democratic of Congo, about 1500 meters above sea level in the Rift Valley. The city of Goma is the capital of North Kivu province. It extends over an area of 66.45 km2 covered with volcanic rocks with undulous relief at the foot of the Nyiragongo volcano. Geographically Goma city is located at an altitude of 1640m on the shores of Lake Kivu., 29°14' longitude East and 1° 45' South latitude (Appendix xxx). Its soil is volcanic. It is bordered in its southern part by Lake Kivu; it is not crossed by any river, or even a water body. It is boarder in the North by the territory of Nyiragongo; in the South by Lake Kivu to East by Rwandan border town of Gisenyi and to the West by the territory of Masisi. Its land area is 75,72Km². For relief, Goma city is located in the western part of Central Africa and overlooked in the northern part by an important range of Virunga volcanoes. It is covered by volcanic soil and very little by slightly sandy soil. It is influenced by the volcanic eruptions respectively of the years 1800, 1977, 2001 and 2021. The temperature is almost constant but often oscillates between 19.6 and 19.9 °C. The height of precipitation is hardly below 1300mm of water per year. The rain-thermal data of the Goma station relate to the existence of two wet seasons, one from March to May and the other from September to December, between which are also interspersed two less humid seasons from June to August, then from January to February. (Source : Goma Volcano Observatory, Department of Geophysics, September 2021.)


Source: Musée Royal de l'Afrique Centrale, Tervuren, 2016

***Data Collection:*** A pre-tested structured interviewer administered questionnaire consisting of the following sections: household hygiene water quality one-month weeks preceding the survey used to obtain information from community residents. diarrhea was defined as passage of loose or watery stool at least three times per day or more frequently than is normal for an individual at any time within the two weeks prior to the survey. The questionnaire that be conducted in the field allowed us to note details that have been possible if it had been asked by e-mail. The questionnaire was useful for us to ask several questions in order to know an opinion, on a given subject. Given that our respondents do not know the French language, the questionnaire was translated into Swahili to allow them to understand and answer it easily. We carried out a direct and structured interview with households, that is to say that the data collection agent, once arriving in the household, approached the head of household or his representative to obtain his consent and after the consent of the latter, it moved on to filling out the questionnaire. Each collection staff member had a unique identifier. We gave each team the list of all the households they were to visit. The list and cards made it possible to identify the precise numbers of each household to be visited, based on the questionnaire and at the end of each interview, the collection agent verified the veracity of the information as well as compliance with the sampling steps. Every evening, a briefing of the day's collection be done and the completed questionnaire be sent to the supervisors for checking. The questionnaires from each household be collected, packaged and transmitted to coordination during supervision for centralization. We defined the interview time which must not exceed 1 hour 30 minutes due to 10 minutes per question, we can therefore ask 6 to 8 questions on average without counting the introduction and conclusion part of the interview. The focus group allowed us to generate a group conversation around our research topic, we took representatives of our target population and have a meeting with them in a school to raise awareness of the relevance of the problem of diarrhea in their environments and the need and urgency to find an appropriate solution. We combined two methods to increase the effectiveness of collecting information from households, for example: a questionnaire be applied after or before an interview to collect quantitative and qualitative data; observation preceded

interviews individual, which served to clarify some of the aspects that have been observed; a documentary analysis may precede the individual or group interviews; a questionnaire may be sent to the respondents indicating that they be contacted by telephone at such time, which gave them time to prepare for the interview and allowed us to gather information to better interpret the meaning of their answers.

**Note:** All bacteriological analyzes were carried out using swab samples from water storage containers collected during the survey.

**Data Analysis**

After data extraction, editing, coding and cleaning, both descriptive and analytic statistical analysis be done. For the entry of data be used Word and Excel software and the data processing be done by SPSS version 26. After the encoding process, analyzes be calculated the frequencies translated as a percentage in order to characterize the sample and determine the phenomenon studied. Pearson Chi-square test be used test for difference in proportion or dependence variables while multiple analyze be used to test the association between independent and dependent variables.

For the quantification of fecal coliforms, the colonies were counted at the reference laboratory, after incubation and their total number was estimated from the formula below: CFU = Number of colonies counted / Volume of filtered sample (ml) × 100 ml. Where CFU = Colony Forming Unit per 100 ml.

# RESULTS

***Microbiological quality:*** Results reveals that the samples taken in the two zones had presented turbidity, 47.8% before center training, 2.79% after training in the intervention zone, the control zone had presented 48.2% turbidity in phase 1 compared to 75.55% in phase 2. Table 2.2. Showed that the majority of germs identified on gram staining in the intervention zone were gram negative bacilli (88.9% before training against 4.44% after training). On the other hand, the control zone revealed 84.4% in phase 1 against 90.55% in phase 2. Table 2.3. showed that the majority of germs identified on MacConkey in the intervention zone were positive (88.9% before training against 4.44% after training).

**Table 2.1. Identification of Germ count in the two zones during the two phases**

| | Before training | | After training | | Phase I | | Phase II | |
|---|---|---|---|---|---|---|---|---|
| | Intervention zone | | | | Control zone | | | |
| Germ count | Effectif/N=180 | % | Effectif/N=180 | % | Effectif/N=180 | % | Effectif/N=180 | % |
| 0 germ/ml | 20 | 11.1 | 172 | 95.55 | 28 | 15.5 | 10 | 5.56 |
| 1-10 germ /ml | 74 | 41.1 | 3 | 1.66 | 65 | 36.1 | 34 | 18.89 |
| 10-$10^2$germ/ml | 12 | 6.7 | 2 | 1.11 | 16 | 8.8 | 62 | 34.44 |
| 10-$10^3$germ/ml | 11 | 6.1 | 1 | 0.56 | 10 | 5.6 | 44 | 24.44 |
| 10-$10^4$germ/ml | 13 | 7.2 | 1 | 0.56 | 14 | 7.8 | 23 | 12.78 |
| >$10^4$germ/ml | 50 | 27.8 | 1 | 0.56 | 47 | 26.1 | 7 | 3.89 |
| Total | 180 | 100 | 180 | 100 | 180 | 100 | 180 | 100 |

**Table 2.2. Identification of total germs according to Gram coloration in the two zones during the two phases**

| Gram Coloration | Before training | | After training | | Phase I | | Phase II | |
|---|---|---|---|---|---|---|---|---|
| | Intervention zone | | | | Control zone | | | |
| | Effectif/N=180 | % | Effectif/N=180 | % | Effectif/N=180 | % | Effectif/N=180 | % |
| Gram negative bacilli | 160 | 88.9 | 8 | 4.44 | 152 | 84.4 | 163 | 90.55 |
| Negative Coloration | 20 | 11.1 | 172 | 95.56 | 28 | 15.6 | 7 | 3.89 |
| Gram positive Bacilli | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 10 | 5.56 |
| Total | 180 | 100 | 180 | 100 | 180 | 100 | 180 | 100 |

Legend:
Cb: concentration of bacteria in the intervention area before training
Ca: Concentration of bacteria in the intervention area after training

**Table 2.3. Identification of total germs according to Gram coloration in the two zones during the two phases**

| | Before training | | After training | | Phase I | | Phase II | |
|---|---|---|---|---|---|---|---|---|
| culture on | Intervention zone | | | | Control zone | | | |
| MacConkey | Effectif/N=180 | % | Effectif/N=180 | % | Effectif/N=180 | % | Effectif/N=180 | % |
| Positive | 160 | 88.9 | 8 | 4.44 | 152 | 84.4 | 170 | 94.44 |
| Sterile | 20 | 11.1 | 172 | 95.56 | 28 | 15.6 | 10 | 5.55 |
| Total | 180 | 100 | 180 | 100 | 180 | 100 | 180 | 100 |

**Table 2.4. Count of total germs before and after training in the intervention zone (lac vert district)**

| Intervention zone (Green Lake district) formed zone | | | | | |
|---|---|---|---|---|---|
| Germ Counts in Water Storage Containers | Before training(A) | After training(B) | WHO standards | % microbial reduction | LRV |
| *Salmonella thyphi* | 2100/100 ml | 200/100 ml | 0/100 ml | 90.48 | 1.02 |
| *Eschrichia coli* | 2900/100 ml | 300/100 ml | 0/100 ml | 89.90 | 0.98 |
| *Citrobacter freundi* | 1000/100 ml | 100/100 ml | 0/100 ml | 90 | 1.00 |
| *Shigella dysenteriae* | 3000/100 ml | 0/100 ml | 0/100 ml | 100 | 3.47 |
| *Enterobacter spp* | 1000/100 ml | 0/100 ml | 0/100 ml | 100 | 3.00 |
| *Salmonella parathyphi* | 2000/100 ml | 0/100 ml | 0/100 ml | 100 | 3.30 |
| *Aeromonas hydrophylia* | 1000/100 ml | 200/100 ml | 0/100 ml | 80 | 0.69 |
| *Shigella flexineri* | 1000/100 ml | 0/100 ml | 0/100 ml | 100 | 3 |
| *Seratia adorifera* | 700/100 ml | 0/100 ml | 0/100 ml | 100 | 2.84 |
| *Citrobacter diversus* | 1300/100 ml | 0/100 ml | 0/100ml | 100 | 3.11 |

All tests been two tailed a P-value of ≤ 0.05 be considered statistically significant. To test the significance of the variance of random intercept, likelihood ratio test be applied. Adjusted odds ratio with 95 % confidence level be used to show the strength of the association and its significance.

The table 2.4. shows that the majority of bacteria identified before training were reduced to 100% after training in our area of intervention with LRV e at least 3 which means reduction percentage of 99.9%.

**Table 2.5. Count of total germs before and after training in the control zone (mugunga district)**

| Control zone (mugunga district) untrained zone | | | | | |
|---|---|---|---|---|---|
| Germ Counts in Water Storage Containers | Phase A | Phase B | WHO standards | % microbial reduction | LRV |
| *Salmonella thyphi* | 4200/100ml | 4200/100ml | 0/100 ml | 0 | **0** |
| *Eschrichia coli* | 3800/100ml | 3800/100ml | 0/100 ml | 0 | 0 |
| *Citrobacter freundi* | 1400/100ml | 1600/100ml | 0/100 ml | -14.24 | -0.06 |
| *Shigella dysenteriae* | 1700/100ml | 2000/100ml | 0/100 ml | -17.64 | -0.08 |
| *Enterobacter spp* | 1200/100ml | 1600/100ml | 0/100 ml | -33.33 | -0.12 |
| *Salmonella parathyphi* | 1100/100ml | 1400/100ml | 0/100 ml | -27.27 | -0.10 |
| *Aeromonas hydrophylia* | 1800/100ml | 1800/100ml | 0/100 ml | 0 | 0 |
| *Shigella flexineri* | 2800/100ml | 2800/100ml | 0/100 ml | 0 | 0 |
| *Salmonella arizonae* | *3300/100 ml* | *3400/100 ml* | 0/100 ml | -3.03 | -0.01 |
| *Enterobacter cloaceae* | *2200/100ml* | *2400/100ml* | 0/100ml | -9.09 | -0.04 |
| *Klebsiella oxytoca* | *1700100ml* | 2000/100ml | 0/100 ml | -17.64 | -0.07 |
| *Bacillus sereus* | *1500100ml* | 1900/100ml | 0/100 ml | -26.67 | -0.10 |
| *Citrobacter diversus* | *1200100ml* | 1100/100ml | 0/100ml | 8.33 | 0.04 |

Legend :
Cb: concentration of bacteria in the intervention area before training
Ca: Concentration of bacteria in the intervention area after training

**Table 2.6. Distribution of respondents according to the frequency of cases of diarrhea in the two zones during the two phases**

| | Intervention zone Green Lake district | | | Control zone Mugunga district | | |
|---|---|---|---|---|---|---|
| Frequency | Before training | After training | Total | Phase I | Phase 2 | Total |
| 0-Once a year | 49(51.6%) | 46(48.4%) | 95(100.0%) | 15(51.7%) | 14(48.3%) | 29(100.0%) |
| 1-3 times a year | 40(69.0%) | 18(31.0%) | 58(100.0%) | 7(9.5%) | 67(90.5%) | 74(100.0%) |
| More than 3 times | 4(16.7%) | 20(83.3%) | 24(100.0%) | 0(0.0%) | 85(100.0%) | 85(100.0%) |
| Total | 93(52.5%) | 84(47.5%) | 177(100.0%) | 22(11.7%) | 166(88.3%) | 188(100.0%) |
| Tests | *Khi-deux= 18.67, dl=2 , P=0.001 ,* V de cramer=0.325 Décision : H1 | | | *Khi-deux= 56.581, dl=2, P=0.001, V de cramer=0.549* Décision : H1 | | |

$$P = 100\frac{Cb - Ca}{Cb}$$

P= Percentage reduction in germs
P=100x2100-200/2100= 90.48%

$$\text{LRV} = \log_{10}\left(\frac{A}{B}\right) \text{ ou } \text{LRV} = \log_{10}(A) - \log_{10}(B)$$

A = number of germs before formation;
B = number of germs after training (Hermione Amoukpo *et al*., 2018).
Example: LRV= log 10 (2100)-log10 (200) = 3.3222- 2.3010=1.02

The table 2.5. showed that there was no reduction in the phase I and phase of microbiology analyses with 0**%** microbial reduction and negative LRV.

$$P = 100\frac{Cb - Ca}{Cb}$$

P= Pourcentage de réduction des germes
P=100x4200-4200/4200= 0%

$$\text{LRV} = \log_{10}\left(\frac{A}{B}\right) \text{ ou } \text{LRV} = \log_{10}(A) - \log_{10}(B)$$

A = number of germs before formation;
B = number of germs after training. (Hermione Amoukpo,*et al.,*2018)
LRV: Reduction of germs has been shown in *Log Reduction Value* (LRV). (Hermione Amoukpo *et al.*, 2018)
Example: LRV= log 10 (4200)-log10 (4200)= 3.6232- 3.6232=**0**

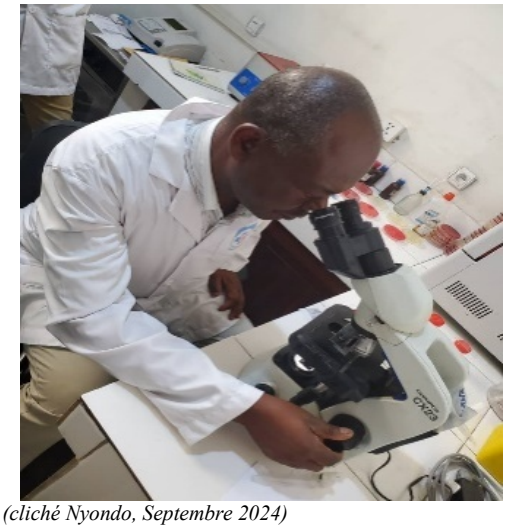
Table 2.6 presented the frequency of diarrhea episodes within two study areas, categorizing them into three intervals: 0-1 times per year, 1-3 times per year, and more than 3 times per year. We observed a significant increase in the number of individuals declaring more than 3 episodes of diarrhea per year before training, i.e. 16.7% compared to after training, i.e. 83.3% in the intervention zone compared to 0.0% in phase 1 and 100.0% in phase 2 in the control zone.

# DISCUSSION

This study showed that the samples taken in the two zones had presented turbidity, 47.8% before center training, 2.79% after training in the intervention zone, the control zone had presented 48.2% turbidity in phase 1 compared to 75.55% in phase 2. The results of this research are similar to those of Michel MAKOUTODE Edgard (2012) who revealed that 100% of the water samples taken from the well had presented turbidity and after enrichment with peptone water (Michel MAKOUTODE Edgard, 2012). Alongside the above, FAYZA DADAOU (2021) also showed that 80% of water conservation reservoirs showed turbidity (FAYZA DADAOU, 2021). Based on this laboratory result, we note that water storage equipment in households was contaminated before the water was stored there.

**Photo 1. samples taken in water containers storage before using in lac vert quoter *(cliché Nyondo , Septembre 2024)***

The results of bacteriological analyzes of containers used by the community for household water storage showed that the majority of germs identified on gram staining in the intervention zone were gram negative bacilli (88.9% before training against 4.44% after training). On the other hand, the control zone revealed 84.4% in phase 1 against 90.55% in phase 2.



*(cliché Nyondo, Septembre 2024)*

**Photo 2. Gram negative bacilli identified on gram staining**

The results of this research are almost consistent with those of HOUDA BUSENINA (2018) who found that out of 60 samples subjected to gram 46 staining, or 76.6%, were gram negative bacteria (HOUDA BUSENINA, 2018). Likewise, MBELLA MBONG ROSTAN (2022) also showed that storage materials contained 70.6% gram negative bacteria (MBELLA MBONG ROSTAN,2022). This situation was also noted by TOFFI DOSSOU Mathias (2015) who showed that out of 12 samples of water taken and analyzed, 7 were potable and 5 were contaminated by storage materials in households in terms of Escherichia coli 23.4% and fecal coliform 16.5% being the two bacteria that were revealed (TOFFI DOSSOU Mathias, 2015). Moreover, Julie Ghislaine Sackou Kouakou (2010) also noted similar results according to which Escherichia coli was the most found in water storage equipment with 42.5% and other total coliforms. And he founded a large presence of fecal coliforms on the containers (Julie Ghislaine Sackou Kouakou, 2010). Based on these results we note that water storage equipment is the reservoir of gram negative bacteria before drawing drinking water and therefore they are the cause of diarrhea in households in our study area. The work carried out by Moyes, R. B et al., (2009) corroborates with our results. Indeed, this author indicated that gram staining is a medical bacteriology technique, it ability to fix gentian violet (Gram +) or fuschine (Gram -). Its advantage is to provide quick and easy information on the bacteria present in a product or medium, both in terms of type and form (Moyes, R. B et al.,2009). The same observation was made by Kenneth Smith (2019) who showed that gram stainingis a very important step in a bacteriological analysis, because it allows the visualization of the morphology and the mode of grouping of the bacteria before continuing with the isolation of the bacteria on MacConkey medium. MacConkey agar is a selective and differential culture medium used in microbiology for the isolation and identification of Gram-negative bacilli (Kenneth Smith, 2019). We can say that the MacConkey culture medium grows gram negative bacteria because in its composition we have two inhibitory substances: bile salts and gentian violet which prevent the growth of gram-positive bacteria. Microbiological analyses of the collected samples revealed that, the majority of bacteria identified before training were reduced to 100% after training in our area of intervention with LRV e at least 3 which means reduction percentage of 99.9%. Alongside the above, the study conducted by Hermione Amoukpo et al. (2022), showed that all water samples taken from households before and after the implementation of the intervention were free of *Escherichia coli*. These samples were heavily contaminated with fecal enterococci, there was a reduction in total coliforms, fecal coliforms and fecal enterococci in water samples collected from households that used drinking water storage containers with taps. The percentages of reduction in germs responsible for the contamination of drinking water (total coliforms: 58.39% or LRV = 0.38; fecal coliforms: 86.07% or LRV = 0.85 and *fecal enterococci*: 82.18% or LRV = 0.74) are lower than the reductions in germs obtained with other methods of treating water at home (Hermione Amoukpo *et al*., 2022). As asserted by Mohamed *et* al.(2016), it is said that there was a reduction in fecal coliforms of 99.3% for boiling ( LRV = 2.2), 99.5% for the ceramic filter locally produced by Safe Water Ceramics of East Africa (LRV = 2.5) and 99.5% for Aquatabs (LRV = 2.5) (Mohamed *et al*., 2016). By making a comparison between the microbiological parameters obtained before and after the intervention we noted that there was a significant reduction in the germs responsible for fecal contamination of water storage containers in the Lac Vert district (intervention area). This reduction in pathogenic germs is explained by the method adopted by the community during the training, which is washing water storage containers using soap with hot water. However, this reduction is not complete and some cases of microbiological contamination are still observed. Given that the change in behavior of the study population is a process, we believe that these contaminations are surely produced during transport or when filling the storage containers, the user must avoid using unwashed materials in direct contact with the water coming from the water storage containers when he wants to use it to avoid contamination of it. The results of this investigation showed that the control area which did not benefit from our continued action recorded new species of bacteria and experienced a negative evolution, not noted negative percentages of microbial reduction and LRV.

The results of this investigation revealed that the frequency of diarrhea episodes within two study areas, categorizing them into three intervals: 0-1 times per year, 1-3 times per year, and more than 3 times per year. This situation was also noted by Nouhoum KOITA et al. (2016), who states that in the project intervention villages, 27.3% of children under 2 years old are suspected of having had diarrhea during the last 15 days before the survey compared to 30.1% in the control villages (Nouhoum KOITA et al.,2016). Sandrine Mesflé-Somps and Laure Pasquier-Doumer (2011) in the same vein, had underlined that the 1,900 children in the intervention zone, 8.8% suffered from diarrhea at least once during the month preceding the interview, around 170 children compared to 4% in the control zone (Sandrine Mesulé-Somps and Laure Pasquier-Doumer, 2011). Likewise, Dansiné DIARRA (2014**)** also said thatmore than three children under the age of two in ten (34.1%) suffered from diarrhea during the two weeks preceding the survey. The prevalence of diarrhea is particularly high in (34.5% in the intervention zone compared to 34.1% in the control zone) (Dansiné DIARRA, 2014). According to the WHO, diarrhea is a symptom of various infections caused by bacteria, viruses or parasites transmitted, for the most part, through water contaminated with fecal matter. These infections are more common when there are shortages of safe water for drinking, cooking, washing and cleaning. Rotavirus and Escherichia coli are the 2 most common etiological agents of moderate to severe diarrhea in low-income countries (WHO, 2017). Infant mortality due to diarrheal diseases is highest in developing countries and constitutes a public health problem. Diarrhea in children is sometimes considered a consequence of poor water hygiene practice, which is why many actions must be taken to control the scourge in both study settings.

# CONCLUSION

This work focuses on effect of household hygiene training on water quality to reduce incidence of diarrhea in Goma district. specific case of Mugunga and Lac Vert districts. Laboratory analyzes of water storage containers showed that some samples contained pathogenic germs before drawing water, which sufficiently proves that there is a permanent danger that awaits our study community when storing water before domestic use. Furthermore, the presence of isolated germs demonstrates an inadequacy of hygiene practices of these water

reservoirs in households which calls into question its good biological quality. Our bacteriological analyzes confirm our hypothesis because after isolation and identification we found fecal germs in particular: *shigella dysenteria, escherichia coli, salmonella typhi, citrobacter freundi, enterobacter spp, aeromonas hydrophila, seratia adorifera, citrobacter diversus.* These water storage tanks were therefore of poor bacteriological quality before the training in the intervention area. After the organization of training and popularization of hygiene practices by washing the storage containers with hot soapy water, our observation is that there was a 100% reduction in germs in the study area, which contributed to the significant reduction in the frequency of diarrhea in our intervention area.

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**Conflict of Interests:** We declare that there is no competing conflict of interest.

**Authors' Contributions**

BERNARD ABONG'O OMONDI contributed to the data collection, study methodology and data analysis sections, as well as to the writing of the manuscript; CAREENA OTIENA ODAWA contributed to the literature review and data analysis; and editing the manuscript. All authors read and approved the final manuscript.

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