Image: Gabrielle String, Tufts University

Safe Water Optimization Tool

SWOT CASE STUDY: KYAKA II WATER TRUCKING

Evaluating the SWOT on water trucking operations in Uganda

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DAHDALEH INSTITUTE FOR GLOBAL HEALTH RESEARCH

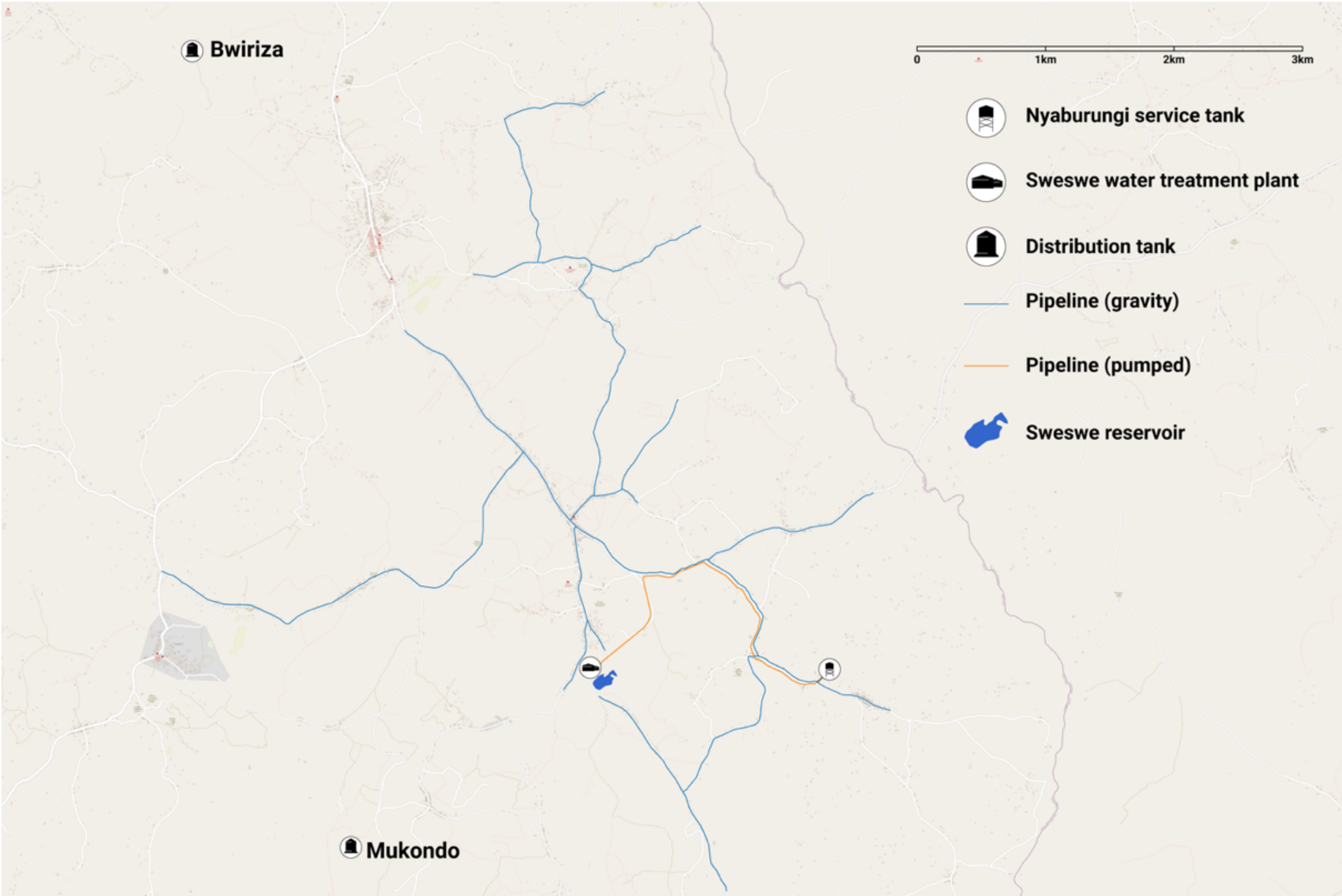
OXFAM

Tufts University | School of Engineering

HIF Humanitarian innovation fund | elrha

Location:	Kyaka II Refugee Settlement, Kyegegwa District, Western Uganda
Type of water system:	Surface water with pre-treatment and chlorination with distribution via water trucking
Data collection:	June - August 2022
Partner organisation(s):	Oxfam, Tufts University
Funding:	Humanitarian Innovation Fund/ELRHA

The data collection for this exercise was part of a larger evaluation study of the SWOT and so required additional considerations beyond what would typically be involved to use the SWOT. Because of this, the SWOT team supplied dedicated water quality monitoring tools and one person from Tufts University visited the site to carry out training for the data collection team. Additional data collection was also carried out to meet the needs of the evaluation, including a household survey and water sample collection for microbiological testing and testing for disinfection by-products. The pace of sampling was reduced by the additional data collection required as part of this study.



BACKGROUND

The Kyaka II refugee settlement in Kyegegwa District, Western Uganda is home to approximately 136,000 people. While the site was originally set up in 2005 to house refugees fleeing violence in neighbouring Rwanda, the population has evolved over the years, reflecting the different crises impacting the region. The general population trend had been steadily decreasing; however, in December 2017, the camp experienced a rapid influx of tens of thousands of people fleeing conflict in the Democratic Republic of Congo (DRC). The DRC is now the most common country of origin among the refugee population.

Kyaka II is managed by UNHCR (United Nations High Commissioner for Refugees) and the Ugandan Office of the Prime Minister (OPM). Oxfam is an implementing partner of UNHCR, responsible for construction and operation of many of the water supply systems servicing Kyaka II, including the Sweswe water treatment plant and the water trucking operations which were the focus of this case study. As UNHCR's partner responsible for operating the Sweswe water system, Oxfam was interested in understanding how effective their water treatment approach was, and in optimizing water safety as part of their commitment to quality assurance.

The Kyaka II site was selected for this case study because it would be the first time that the SWOT was used to optimize chlorination in a water trucking system (from any water source, in this case, surface water). Previously, the SWOT has mainly been used to optimize chlorination in piped water systems using groundwater sources.

SITE INFORMATION

he Kyaka II zones of Mukondo and Bwiriza hosted 35,000 individuals in 2021 and were not within the piped water network at the site. Water was supplied to these zones by water trucking to a 10m3 distribution tank location in each zone, from which people collected water at tapstands, which was then stored and used in their homes for several hours after collection.

This water trucking operation depends on the same source of surface water and treatment process that serves the piped network in the rest of Kyaka II. Water is pumped from the reservoir at Sweswe Dam and then treated at the Sweswe water treatment plant by flocculation-coagulation, sedimentation, and aeration to remove iron and reduce turbidity. Clarified water is then pumped into a water truck (either 8m^3 or 20m^3), which then transports the water to a holding tank in each of the two villages. HTH chlorine solution is added to the truck during filling. Waiting and travelling time accounted for 30-60 minutes between filling and delivery, providing sufficient contact time for chlorination.

Most people in these zones collect and store water in opaque 20L jerrycans. There is generally good knowledge about the importance of safe drinking water and hygienic water handling practices.

DATA COLLECTION

As this case study was embedded within a larger research project at Kyaka II, a local research team was assembled consisting of a research manager, eight data collectors, and members of Village Health Teams (VHT). For all surveys with water-users, a data collector was paired with a VHT member who helped translate consent forms and survey questions from English or Swahili to local languages as needed.

Data for this evaluation was collected in two rounds (baseline and endline). Baseline data was collected over 10 days in June 2022, with 208 paired water quality measurements recorded. A total of 213 paired samples were collected at endline over 9 days in August 2022.

Monitoring teams used digital chlorometers (with DPD1) to measure FRC levels and water temperature, conductivity and pH were measured using multi-meters. Results were recorded on phones or tablets using a survey set up in KoboToolbox.

Data was reviewed by the team daily and inconsistencies, such as improbable FRC changes or sampling times, were excluded from the analysis. The SWOT team used this baseline data to develop FRC target recommendations. Households where FRC was measured to be at least 0.2 mg/L in stored drinking water were defined as having 'safe' water. The Household Water Safety (HWS) score was then defined as the proportion of households meeting this criterion after specified storage times.

Water-users were selected at random at one of the two distribution tanks in each zone, and recruited using a standard consent form. Water quality measurements were taken while they filled their containers at the tapstands at the tanks, and then water-users were accompanied back to their households where a household survey was administered. The water containers used to collect water from tapstands were marked and the household was given a numbered card to identify them at follow-up. After 3 to 24 hours of household storage and use (after the start of the tapstand sample), the enumerator team returned to the household, checked whether the water had been used up or mixed, and if not, took a follow-up measure of FRC only.

SWOT RECOMMENDATION & IMPLEMENTATION RESULTS

The results of the first round of data collection show that the household water safety (HWS) score at baseline was only 8% in the two zones. This meant that for water that was stored in the home for between 3 and 24 hours, fewer than 1-in-10 household samples showed a protective level of FRC in stored drinking water. Without this protection, stored drinking water was at risk of recontamination by waterborne pathogens.

The SWOT generated a site-specific tapstand FRC target to replace the status quo target of 0.5mg/L, based on the baseline round of data collection. Initially, we modelled decay for a duration of protection of 12 hours, and generated a tapstand FRC target of 1.6 mg/L. However, due to concerns regarding the risk of taste and odour rejection at this FRC level raised by Oxfam, we modified the duration of protection to 9 hours. At this duration of protection, a target FRC of 0.9mg/L was required at the tapstand. While our survey results suggested that the majority of water users stored water for more than 9 hours, this duration of protection was selected to balance water safety with the risk of taste and odour-driven rejection.

Based on this recommendation, Oxfam conducted a series of Modified Horrock's jar tests to determine the HTH chlorine dose required to achieve this new target. FRC monitoring at the two distribution tanks continued as the chlorine dose was adjusted.

During the second round of data collection, the Oxfam team were able to achieve the target FRC of 0.9 mg/L, although there was still variability between the two zones and over time. The median tapstand FRC increased from 0.3 to 0.9 mg/L during endline data collection. Correspondingly, the HWS score improved from 8% to 42% for water stored for up to 24 hours. While this is a significant increase, it shows that over half of stored water sampled at the household remained unprotected from recontamination (note that this was at 24-hours instead of the modelled duration of protection of 9 hours)

We did not see evidence of increasing rejection of the supplied water due to taste or odour concerns, and so there is scope to gradually increase the chlorine dose and achieve higher HWS scores across the two zones. The second round of data collection, after Oxfam adjusted the chlorine dose, showed an increase in tapstand FRC and an improvement in the HWS score. However, water system operators found it challenging to reliably meet the new FRC target. The median tapstand FRC only increased from 0.2 to 0.4 mg/L after the SWOT recommendation was provided, below even the initial target of 0.5 mg/l or the SWOT-recommended target of 0.7-0.8 mg/L. The corresponding HWS score improved from 22% to 35%, showing that there remained significant risk of contamination of household water due to the partial implementation of the SWOT recommended target.

KEY TAKEAWAYS

The FRC target recommendation provided by the SWOT for the water trucking operation at Kyaka II was higher than that for the piped system using the same treated surface water supply. This implies a higher chlorine decay rate in the water trucking system, which may be linked to the elevated turbidity in the trucks. In parallel, we saw that water-users were storing water for longer periods. These factors resulted in a particularly high initial target FRC recommendation of 1.6 mg/L. Our initial reaction was that this target was too high, based on the taste and odour results from an earlier assessment in the piped water network at Kyaka II. However, later, when we carried out additional focus groups with water-users at Kyaka II, we found that increasing the target further to 1.4mg/L may not lead to increased rejection.

Ideally, the chlorine target would have been gradually increased from the 9-hour target of 0.9 mg/L to the 12-hour target of 1.6 mg/L over time, while continuing to engage with water-users to identify any concerns. Unfortunately, this was not possible within the timescale of the study and so we opted to recommend a more conservative chlorine dose increase that could guarantee 9-hours protection.

Water quality testing at tapstands showed a median turbidity of around 20 NTU across both data collection rounds. Elevated turbidity indicates high levels of suspended particles that will increase the chlorine demand, so sector guidance recommends pre-treatment to reduce turbidity to <5 NTU. Our previous work in the piped network showed turbidity of around 11 NTU at tapstands supplied by the piped water system, suggesting that the trucks and/or tanks themselves were contributing to the increased turbidity. Oxfam should ensure that trucks and tanks are cleaned and inspected regularly. In addition, further tuning of the clarification processes will be required to ensure turbidity is <5 NTU prior to chlorination.

NEXT STEPS

Field data collection for the study at Kyaka II has concluded, but we will continue to support Oxfam to maintain the use of the SWOT as a key component of their continuous water safety management plan in the area. As the study team progresses with data analysis from Kyaka II, we plan to disseminate further findings both to field partners and the broader WASH research community. The practical applications in the field at Kyaka II, along with feedback from our new users, are crucial for identifying and prioritizing enhancements to the SWOT web application. These improvements aim to enhance its relevance and utility for teams overseeing water supplies in emergency situations.

Overall, these findings indicate that to fully realize the goal of ensuring water safety in humanitarian settings, the SWOT must extend its support beyond just generating site-specific chlorination targets to also providing broad-based technical support to water system operators on all aspects of safe water supply including all relevant water treatment processes such as clarification and chlorination, managing dosing, water quality monitoring, and protecting the safe water chain during distribution.