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Safe Water Optimization Tool

SWOT CASE STUDY: KYAKA II PIPED WATER SYSTEM

Evaluating the SWOT on a surface water source in Uganda

December 2023

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 piped network
Data collection:	April - 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 that supplies almost a third of the total daily water needs of the settlement, through both the piped network and water trucking operations. As a UNHCR partner responsible for operating the Sweswe water system, Oxfam were interested in understanding how effective their water treatment approach was, and fine tuning this as part of their commitment to quality assurance.

The Kyaka II site was identified as an interesting case study for the SWOT because it is a large scale piped system that relies on a treated surface water source. Previously, the SWOT has mainly been used to in systems reliant on groundwater sources. We were interested to learn how the SWOT would cope with this different use case with surface water.

SITE INFORMATION

The water supply system at Kyaka II analysed in this case study is known as Cluster II. This piped water network extends over 18 km of gravity-fed distribution lines and 2.2km of pumped transmission lines and served villages in the Sweswe and Itambabiniga Zones with a combined population of 44,000 in 2021.

Cluster II is fed by surface water from a reservoir at Sweswe. This water is treated at the Sweswe water treatment plant through flocculation-coagulation, sedimentation, and aeration to eliminate solids and iron. Twice per day, clarified water is pumped to an elevated tank 2.2km away, from where it enters the gravity fed distribution network. HTH chlorine solution is added to the tank during filling and after 30-60 minutes of contact time the water is allowed to flow through into the main distribution lines.

Users collect water from one of 18 tapstands (each with two taps) or an automated water dispenser that works using prepaid cards.

DATA COLLECTION

As this case study was embedded within a larger research project at Kyaka II, a local research team was assembled in Kyaka II consisting of a research manager, 8 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 was collected in two rounds; baseline data was collected between 20 April and 18 May 2022. Endline data was collected between 19 July and 8 August 2022. A total of 439 paired samples were recorded over 27 days, an average of 16 paired samples per day.

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.

Water-users were recruited at random at the tapstand, where initial water quality measurements were taken. Water-users were then followed back to their households where a survey was administered. The water containers used to collect the water were marked and the users were given a numbered card to identify them at the follow-up. After 3 to 24 hours had elapsed following the tapstand sample, the enumerator team returned to the household and asked to check whether the water had been used up or mixed with new water, and if not, they took a follow-up measure of FRC. The enumerator teams each focused on a specific tapstand until completing the planned number of samples before moving on to the next tapstand.

Data was reviewed by the evaluation team daily and inconsistencies, such as improbable FRC changes or sampling times, were excluded from the analysis. The SWOT team used the baseline data to develop a FRC target recommendation.

For the purposes of this evaluation, 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.

SWOT RECOMMENDATION & IMPLEMENTATION RESULTS

The results of the first round of data collection show that the baseline HWS score was 22% across the study area (27% in Sweswe zone and 19% in Itambabiniga). This meant that for water that was stored for up to 12 hours, fewer than a quarter of household samples had a protective level of free residual chlorine. Without this protection, stored drinking water was at risk of recontamination by waterborne pathogens.

Our survey data showed that the majority of people reported storing water for up to 12 hours, and fewer that 1 in 10 stored water for longer than 24 hours. We also carried out a rapid assessment of taste and odour acceptance, which suggested that there was good acceptance of FRC levels up to about 0.8 mg/l, after which the taste and odour of chlorine becomes increasingly off-putting. Oxfam were initially targeting an FRC level at distribution points of 0.5 mg/L.

22%

Baseline household water safety score

We used the SWOT to create a site-specific tapstand FRC target to replace the status quo target of 0.5mg/L, based on this first round of data collection. Based on modelling chlorine decay over a storage time of 12 hours, the SWOT provided a tapstand FRC target of between 0.7 – 0.8 mg/L. The SWOT predicted that achieving this target at tapstands would mean an increase in the HWS score from 22% to 65% at 12 hours of storage. Our assessment of taste and odour rejection suggested that the increased chlorine does would not lead to more people rejecting the treated water.

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. We also looked closely at the tapstand data to identify four 'sentinel' tapstands that were broadly representative of the range of FRCs found across the system. FRC monitoring at these tapstands continued as the chlorine dose was adjusted.

0.7-0.8 mg/L

SWOT tapstand FRC target

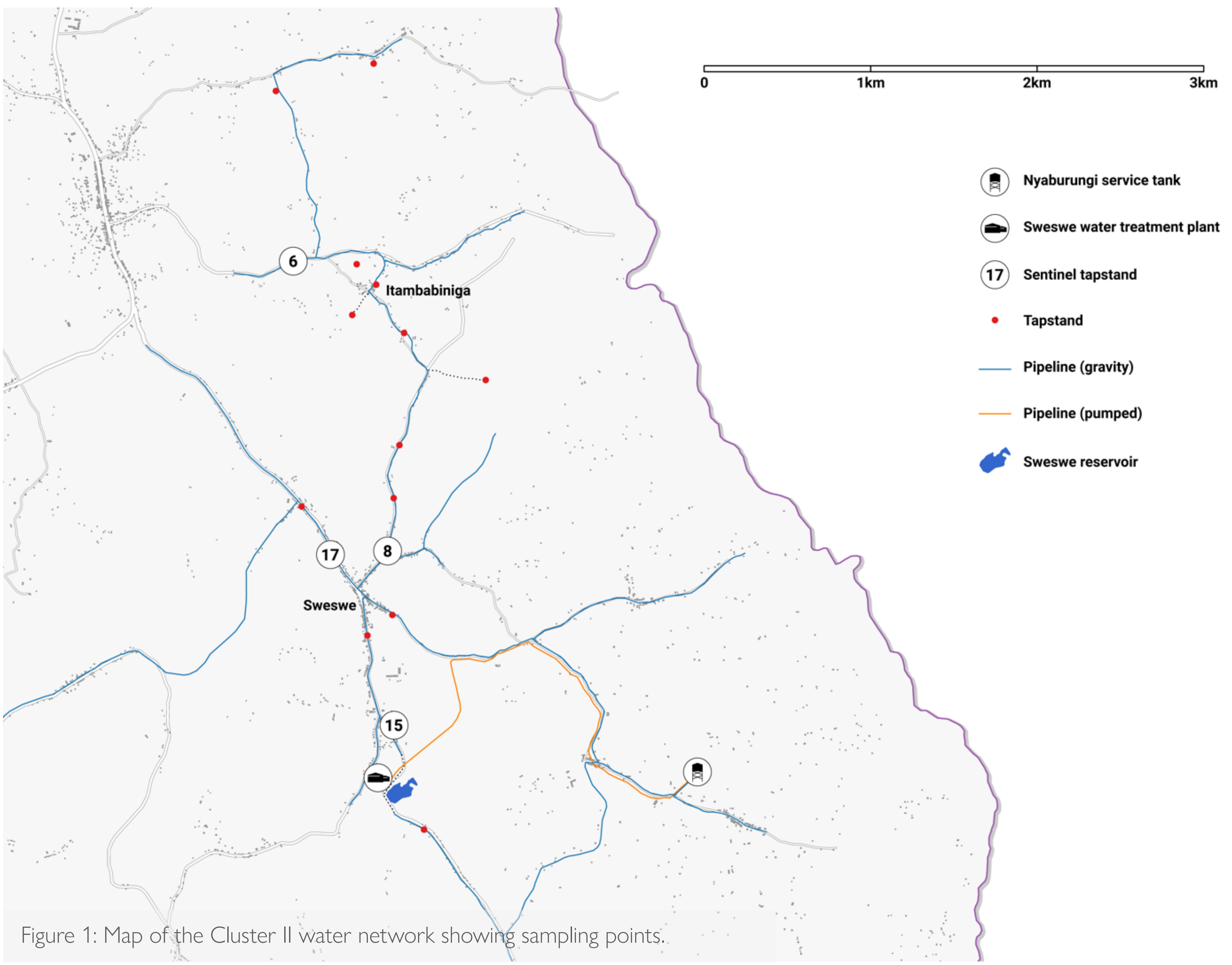

Figure 1: Map of the Cluster II water network showing sampling points.

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 scale of the Cluster II piped water network at Kyaka II posed several challenges to the implementation of the SWOT.

First, the extent of the network meant that travelling between tapstands was time consuming. The data collection team got around this by collecting all required samples from a single tapstand before moving on to the next. While this enabled the teams to collect all the required samples in a shorter time, it did make it more difficult to understand how the variability in chlorine dose at treatment from one day to the next affected FRC levels at the widely spaced tapstands in the piped network.

The scale of the network also made it challenging to provide a single chlorine dose that would result in an appropriate delivery FRC across all tapstands, which were located between 2.5 km and 7.8 km from the chlorination point. The use of sentinel tapstands as designated points for on-going monitoring made this simpler, but more data would be needed to confirm where these sampling points were the most representative of the system as a whole.

Monitoring at tapstands showed a wide variability in the measured FRC, over both time and distance. During the morning particularly, very high FRC levels (i.e., >3 mg/l) were recorded, suggesting that water was being distributed before the necessary 'contact time' was completed and chlorine decay was still in the early rapid phase. This may have arisen due to the pressure water system operators faced to open taps and get water flowing to the community in the morning and suggests that the water network is operating close to its maximum capacity. This was raised by the SWOT team during training with the water system operators.

Conversely, for tapstand samples taken in the early morning, enumerators faced the challenge of overnight water storage and associated chlorine decay. Often samples taken in the morning showed very low levels of FRC as it took some time for the water treated during the previous day to work through the network. To avoid this affecting our results, we instructed the monitoring team to wait for FRC levels to increase each morning before starting data collection to ensure testing was carried out on the most recently chlorinated 'batch' of water. However, this does not address the fact that, for the first people to collect water each morning, the water flowing from the taps would not have a protective FRC. The issues of chlorine decay and overnight water stagnation in the piped network are not as yet considered by the SWOT.

On an operations level, water system operators faced difficulties using the Modified Horrock's jar test to estimate the chlorine dose required to achieve the tapstand target FRC. In fact, the first round of data collection demonstrated that the status quo target of 0.5 mg/L was not being reliably achieved at baseline (median tapstand FRC was 0.2 mg/L, and the range was 0.01 to 3.84mg/L!). This may have arisen due to the surface water source and effectiveness of the clarification pre-treatment before chlorination. In fact, water quality testing at tapstands showed a median turbidity of 11 NTU across both data collection rounds. Elevated turbidity indicates high levels of suspended particles which will increase chlorine demand, which is why sector guidelines recommend pre-treatment to clarify water to <5 NTU prior to chlorination. Additional tuning of clarification processes is required to consistently achieve this.

In the initial round of data collection over 20% of the paired samples collected had to be removed from the dataset because of missing or inconsistent data. By the second round, as enumerators became more confident with the data collection and water quality testing tools, this dropped to less than 6% of paired samples. Additional time for training and conducting practice surveys would be useful for ensuring data quality.

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.