



With funding from the Conrad N. Hilton Foundation, the Aquaya Institute tested for chemicals and heavy metals in drinking water in Lira District, Uganda, in March 2024. Aquaya analyzed water samples from 69 water points serving schools and healthcare facilities. This testing was part of the WaterTRACS initiative.

WaterTRACS

(Testing, Research, and Capacity Strengthening) Initiative

CHEMICALS AND HEAVY METALS IN DRINKING WATER IN LIRA DISTRICT, UGANDA

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SUMMARY

➤ We tested water quality parameters at 69 water points from schools and healthcare facilities.

➤ Some water points exceeded drinking water standards for parameters with low health implications, like pH, turbidity, iron, chloride, and phosphate. These parameters do not directly affect health but may be unpleasant to users and can interfere with treatment efforts.

➤ Regarding parameters with high health implications, some water points exceeded drinking water standards for arsenic and lead. All samples met drinking water standards for fluoride and nitrates.

➤ Lead levels exceeded drinking water standards in one-tenth of water points, which may have severe health implications.

RECOMMENDATIONS

➤ Due to widespread acidic water and high levels of chloride, new water infrastructure should be constructed with corrosion-resistant materials, in line with national regulations.

To address lead in drinking water:

- Water suppliers should construct new infrastructure **using certified lead-free parts.**
- • Authorities should mandate **regular lead testing of drinking water and raise awareness about lead-contaminated supplies.**
- Consumers should flush water points for at least 30 seconds before collecting drinking water following multiple hours of non-use.

➤ While chemical contamination can be of great concern, most water-related health problems arise from microbial contamination;¹ therefore, **microbial surveillance should be prioritized.**



BACKGROUND

Globally, microbial drinking water quality remains a top health concern in low- and middle-income countries.¹ There are also health risks associated with chemicals like fluoride, arsenic, and nitrates, which may be present in drinking water.¹ Further, growing evidence indicates widespread lead contamination in drinking water supplies, often being introduced through lead-containing water system components.²

With funding from the Conrad N. Hilton Foundation, The Aquaya Institute is monitoring microbial water quality over time in two districts in Uganda (see prior [research briefs](#)). In March 2024, Aquaya also tested chemical water parameters at a subset of water points to get a more comprehensive picture of water quality, including contaminants with known health risks and physiochemical parameters affecting user acceptability.



A handpump at a school in Lira.

METHODS

Aquaya visited 61 institutions, which were randomly selected among all public schools and healthcare facilities in Lira district. We identified 79 drinking water points at these institutions – including both primary and secondary sources. Ten (13%) were unavailable for testing due to breakdown or other reasons. We collected drinking water samples from the remaining 69 water points – 53 at schools and 16 at healthcare facilities. A subset of these samples was analyzed for different water quality parameters.

DRINKING WATER SAMPLES TESTED IN LIRA DISTRICT



69 Water points tested,
including:



53 at Schools



16 at Healthcare facilities

Aquaya tested physicochemical parameters (pH, turbidity, and electrical conductivity) on site with portable meters and collected samples to be tested for other parameters at the Uganda Ministry of Water and Environment (MWE) Regional Laboratory in Lira or Central Laboratory in Entebbe. Anions (chloride, fluoride, nitrate, nitrite, phosphate as orthophosphate, and sulfate) were measured using ion chromatography following USEPA 300.1 Methods, hardness was measured by spectrophotometer or titrimetry following USPEA 130 Methods, and heavy metals (arsenic, iron, and lead) were measured using inductively-coupled plasma optical emission spectroscopy (ICP-OES) following USEPA 200.2 Methods. Samples for metals analysis were acidified with concentrated nitric acid.

For water points that could be shut off (e.g., piped systems, handpumps, rainwater collection), we asked operators to close water points overnight (for 8-18 hours³) and collect “first-draw” samples of the first water leaving the system in the morning. These samples were tested for lead, with the purpose of identifying whether excess lead may be leaching from water system components after a period of water stagnation. We tested 59 first-draw samples.



RESULTS

PARAMETERS WITH LOW HEALTH IMPLICATIONS

Most samples (93%) had pH below the Uganda National Bureau of Standards (UNBS) minimum requirement of 6.5, and one-third of samples (32%) had chloride levels above the standard of 250 mg/L; acidic water and elevated chloride may cause corrosion of metal parts in the water system. A quarter of samples (25%) had turbidity above the standard of 5 NTU, which may reduce chlorine’s treatment effectiveness and may be visually unpleasant to water consumers. Three-fifth of samples (62%) had iron levels above the standard of 0.3 mg/L, and one-third of samples (32%) had phosphate levels above the standard of 2.2 mg/L. Elevated iron and chloride do not represent a known health risk, but water consumers may not like the water’s taste or appearance.

All samples had electrical conductivity, total hardness, and sulfate within the standard range.

Table 1: Summary of drinking water standards and test results for parameters with low health implications

	Limit (Uganda National Bureau of Standards, UNBS ⁴)	% outside of limits (n=69)	Likely origin	Implication of being outside limits
pH	6.5 – 8.5	93% (all under)	pH is determined from source water characteristics and treatment processes, and may be influenced by human activities	Low pH may corrode water system hardware; high pH may reduce effectiveness of chlorine treatment
Turbidity	5 NTU, max	25%	Naturally suspended or dissolved materials	High turbidity may look unpleasant, indicate presence of other contaminants, and reduce effectiveness of chlorine treatment
Electrical Conductivity	1500 μ S/cm, max	0%	Dissolved salts, minerals, and metals	Water with high electrical conductivity may look or taste unpleasant (salty)
Iron	0.3 mg/L, max	62%	Naturally occurring in earth deposits; corrosion of iron-containing materials in water point components	High iron may look or taste unpleasant, and may reduce effectiveness of chlorine treatment
Chloride	250 mg/L, max	32%	Naturally occurring in earth deposits	High chloride may look or taste unpleasant and may promote corrosion in metal pipes
Hardness (total)	300 mg/L, max	0%	Naturally occurring in earth deposits	High hardness may taste unpleasant, may irritate skin, may leave scale on cooking pots, and makes soap less likely to lather
Phosphates (as ortho-phosphate)	2.2 mg/L, max	32%	Contamination from agricultural activities (fertilizers) or poorly-sited or maintained latrines or septic tanks. Also added to prevent corrosion of metals into drinking water	None known
Sulfate	400 mg/L, max	0%	Contamination from agricultural activities (fertilizers) or poorly-sited or maintained latrines or septic tanks	High sulfate may look or taste unpleasant



PARAMETERS WITH HIGH HEALTH IMPLICATIONS

We analyzed a set of chemicals (fluoride, nitrate, and nitrite) and heavy metals (arsenic and lead) with known negative health impacts. Fluoride and arsenic were included due to their recognition as priority chemicals by the international WHO/UNICEF Joint Monitoring Programme, nitrogen (nitrate and nitrite) was included due to its persistence in rural areas, and lead was included due to national and global interest to reduce lead exposure from drinking water.⁵

All samples met the UNBS drinking water standard for fluoride and nitrates. Few samples had arsenic (3%) concentrations above the UNBS standard.

Overall, **10% of samples had detectable lead levels** above 15 µg/L, or 15 parts per billion (ppb). Due to the severe health impacts of lead exposure, we include more information about lead in the following section.

Table 2: Summary of drinking water standards and test results for parameters with high health implications

	Limit (Uganda National Bureau of Standards, UNBS ⁴)	% outside of limits (n=69)	Likely origin	Implication of being outside limits
Fluoride	1.5 mg/L, max	0%	Naturally occurring in earth deposits	High fluoride may cause dental and skeletal fluorosis
Nitrite	3 µg/L, max	0%	Contamination from agricultural activities (fertilizers) or poorly-sited or maintained latrines or septic tanks	High nitrite may lead to negative blood or thyroid effects, especially in infants
Nitrate	45 mg/L, max	0%	Contamination from agricultural activities (fertilizers) or poorly-sited or maintained latrines or septic tanks	High nitrate may lead to negative blood or thyroid effects, especially in infants
Arsenic	10 µg/L, max	3%	Naturally occurring in earth deposits	High arsenic is carcinogenic and may lead to negative cardiovascular and neurodevelopmental effects
Lead	10 µg/L, max	10%*	Most commonly from lead-containing materials in water system components	High lead may lead to negative neurodevelopmental effects, particularly in children

* We report detectable lead as above 15 µg/L (ppb) due to the reporting limit of the analytical method used (ICP-OES, USEPA Method 200.2). Because the UNBS drinking water standard (10 ppb) is set at a lower level than we were able to detect (15 ppb), it is possible that a higher percentage of sampled exceeded the standard level.



SPOTLIGHT: LEAD IN DRINKING WATER

In some cases, lead is present in drinking water from naturally-occurring sources. However, in most cases, **lead contamination in drinking water comes from lead-containing components in water systems, such as pipes, faucets, and handpump components.** Exposure to lead in drinking water may lead to negative neurodevelopment effects, with infants and children being most vulnerable.²

There is no safe level of lead in drinking water.² In this brief, we define detectable lead as above 15 µg/L (ppb) due to the reporting limit of the analytical method used (ICP-OES, USEPA Method 200.2). This is less conservative than the maximum level allowed by the UNBS drinking water standard and the WHO provisional guideline value of 10 ppb. In other words, it is possible that more samples exceeded the 10 ppb standard than the percentage with detectable lead reported here.

One-tenth (10%) of drinking water samples had detectable lead (≥ 15 ppb), including **11% of school samples and 6% of healthcare facility samples.** All samples with detectable lead were taken from handpumps; no lead was detected in samples from piped taps or springs (Figure 1).

All samples with detectable lead had pH below 6.5; however there were few samples with pH above 6.5. Low pH promotes corrosion of water system components, which can release metals into the water, including lead if present.

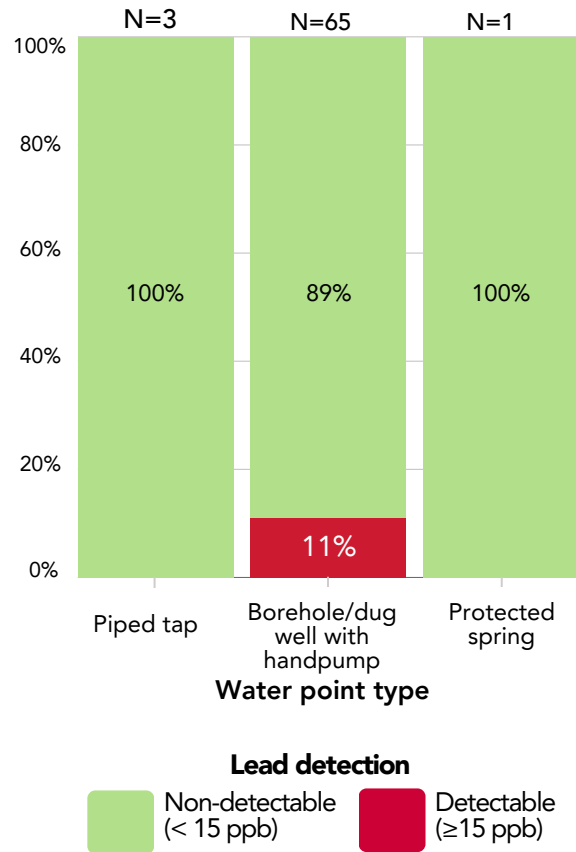


Figure 1: Lead concentrations by water point type. Water samples were collected during the daytime from a sample of institutional water points in Lira District.

FIRST DRAW SAMPLES

We tested 59 first-draw samples – two from piped system taps and 57 from boreholes with handpumps. There was **slightly more lead in first-draw samples compared to random daytime samples** among handpump samples. Among first-draw samples, 15% had detectable lead, which was slightly higher than the 8% found in matched random daytime samples.

Among first-draw samples, elevated lead levels may be attributable to leaching from handpump components, especially after sitting stagnant overnight.

DEFINITIONS

First draw samples refer to those taken from a water source after it has been turned off for a period of 8 to 18 hours.

Daytime samples are collected randomly during regular usage.



SUMMARY

PARAMETERS WITH LOW HEALTH IMPLICATIONS

Some water points did not meet the limits defined by the Uganda National Bureau of Standards. Most water points (93%) had acidic water (pH below 6.5); one-quarter were turbid (cloudy); over half had high iron; one-third had high chloride; and one-third had high phosphate. While these exceedances do not have direct negative health implications, they may be unpleasant to water users, may suggest presence of other contaminants, may interfere with treatment processes, and should continue to be monitored. All samples met drinking water standards for electrical conductivity, total hardness, and sulfate.

PARAMETERS WITH HIGH HEALTH IMPLICATIONS

All samples met drinking water standards for fluoride and nitrates, but some exceeded recommended levels of lead and arsenic, which may have severe health implications.

RECOMMENDATIONS

1 Given the widespread presence of acidic groundwater (pH is <6.5) and chloride, new water infrastructure should be constructed with corrosion-resistant materials such as stainless steel or PVC (rather than galvanized iron), in line with national regulations.

2 To address lead in drinking water:



Water suppliers should construct new infrastructure **using certified lead-free parts.**



National authorities should mandate **regular lead testing of drinking water.**



Piped water suppliers should consider maintaining pH above 7.5 and adding orthophosphate to minimize lead leaching from water system components.



Local authorities should **raise awareness about lead-contaminated supplies** and alternative water sources among consumers.



New research should identify low-cost and practical lead removal strategies.



Consumers should flush water points for at least 30 seconds before collecting drinking water following multiple hours of non-use.

3 While chemical contamination can be of great concern, most water-related health problems arise from microbial contamination;¹ therefore, **microbial surveillance should be prioritized.**



REFERENCES

1. WHO. *Guidelines for Drinking-water Quality: Fourth Edition Incorporating the First and Second Addenda.* (World Health Organization, 2022).
2. World Health Organization. *Lead in drinking-water: health risks, monitoring, and corrective actions.* (2022).
3. US EPA. *Lead Sample Collection Field Guide for Schools and Child Care Facilities.* (2022).
4. Uganda National Bureau of Standards (UNBS). *Uganda Standard, US EAS 12: 2014, Potable Water — Specification.* (2014).
5. Global Lead-Free Water: A global initiative. <https://www.globalleadfreewater.org/#>.

