With funding from the Conrad N. Hilton Foundation, the Aquaya Institute conducted chemical and heavy metal water quality testing in Wassa East District, Ghana, in June 2024. Aquaya tested water samples from 71 unique 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 WASSA EAST DISTRICT, GHANA

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SUMMARY

- We tested water quality parameters at 71 water points from schools and healthcare facilities.
- Some water points exceeded drinking water standards for parameters with low health implications like pH, turbidity, and iron. These do not directly affect health but may be unpleasant to users and can interfere with treatment efforts.
- All samples met drinking water standards for arsenic, cadmium, and cyanide, indicating no measurable negative impacts from mining activities. Fluoride and nitrogen were also within safe limits.
- Lead levels exceeded drinking water standards in one-tenth of water points, which may have severe health implications.

RECOMMENDATIONS

- 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.
  - Local authorities should raise awareness of lead-contaminated supplies and alternative water sources among consumers.
  - Users should flush water systems for 30 seconds before using the water if the system has sat unused for >8 hours.
- While chemical contamination can be of great concern, most water-related health problems arise from microbial contamination; 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] In southwestern Ghana, including Wassa East District, mining operations have also significantly contributed to environmental and drinking water contamination.[3]

With funding from the Conrad N. Hilton Foundation, The Aquaya Institute is monitoring microbial water quality over time in two districts in Ghana (see prior research briefs). In June 2024, Aquaya also tested chemical water parameters at a subset of the district's water points. The purpose of this analysis was to get a more comprehensive picture of water quality, including contaminants with known health risks, as well as physicochemical parameters affecting user acceptability.

A handpump with a yellow container placed nearby in Wassa East.

METHODS

In June 2024, Aquaya visited **70 institutions**, which were randomly selected among all public schools and healthcare facilities in Wassa East district. We identified primary and secondary drinking water points at each institution, for a total of 75 unique water points (where four water points served multiple institutions). Four (6%) were unavailable for testing due to breakdown or other reasons. We collected drinking water samples from the remaining **71 water points** – 52 at schools and 19 at healthcare facilities.

Aquaya tested physicochemical parameters (pH, turbidity, and electrical conductivity) on site with portable meters. Samples were collected to be tested for arsenic, cadmium, cyanide, fluoride, iron, lead, mercury, and total oxidized nitrogen (TON) by SGS Laboratory Services Ghana Limited in Tarkwa and Tema, Ghana. Cyanide, fluoride, and TON were measured using an ion-selective electrode following APHA 4500 Methods, and heavy metals (arsenic, cadmium, iron, lead, and mercury) were measured using inductively-coupled plasma mass spectroscopy (ICP-MS) following EPA 200.8 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 hours[4]) 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 lead concentrations in 60 first draw samples.

RESULTS

PARAMETERS WITH LOW HEALTH IMPLICATIONS

Over half of samples (54%) had pH below the Ghana drinking water standard minimum value of 6.5, which may cause corrosion of metal parts in the water system. One-fifth (19%) of samples had turbidity above the standard of 5 NTU, which may reduce chlorine treatment effectiveness and may be visually unpleasant to water consumers. One-quarter (23%) of samples had iron levels above the standard of 0.3 mg/L. Elevated iron does not represent a known health risk, but water consumers may not like the water's taste or appearance. All samples had electrical conductivity within the standard range.

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

	Limit (Ghana Standards Authority[5])	% outside of limits (n=71)	Likely origin	Implication of being outside limits
pH	6.5 – 8.5	**54%** (all below)	pH is determined from source water characteristics and treatment processes and may be influenced by human activities, such as mining	Low pH may corrode water system hardware; high pH may reduce effectiveness of chlorine treatment
Turbidity	5 NTU, max	**19%**	Naturally suspended or dissolved materials	High turbidity may be visually unpleasant, indicate presence of other contaminants, and reduce effectiveness of chlorine treatment
Electrical Conductivity	1500 µS/cm, max	0%	Dissolved salts, minerals, and metals	Water with high electrical conductivity may be visually unpleasant or may have an unpleasant (salty) taste
Iron	0.3 mg/L, max	**23%**	Naturally occurring in earth deposits; corrosion of iron-containing materials in water point components	High iron may be visually unpleasant, may taste unpleasant, and may reduce effectiveness of chlorine treatment

PARAMETERS WITH HIGH HEALTH IMPLICATIONS

We analyzed a set of chemicals (cyanide, fluoride, TON) and heavy metals (arsenic, cadmium, lead, mercury) that have known negative health impacts. Several of these may be introduced by gold mining activities in Wassa East District, including cyanide, arsenic, cadmium, lead, and mercury. Fluoride and arsenic were included due to their recognition as priority chemicals by the international WHO/UNICEF Joint Monitoring Programme, and nitrogen was included due to its persistence in rural areas.

All samples met the Ghana drinking water standard for cyanide, fluoride, TON, arsenic, cadmium, and mercury. This implies that gold mining operations have not negatively impacted drinking water supplies at the institutions included in our sample.

Overall, **11% of samples had lead levels above the Ghana standard** of 10 parts per billion (ppb). Because of its health impacts, 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 (Ghana Standards Authority[5])	% outside of limits (n=71)	Likely origin	Implication of being outside limits
Cyanide	0.07 mg/L max	0%	Contamination from mining activities	High cyanide may lead to negative neurological and thyroid effects
Fluoride	1.5 mg/L, max	0%	Naturally occurring in earth deposits	High fluoride may cause dental and skeletal fluorosis
Total Oxidized Nitrogen (TON)	50 mg/L, max	0%	Contamination from agricultural activities (fertilizers) or poorly-sited or maintained latrines or septic tanks	High TON may lead to negative blood or thyroid effects, especially in infants
Arsenic	0.01 mg/L, max	0%	Naturally occurring in earth deposits; contamination from mining activities	High arsenic is carcinogenic and may lead to negative cardiovascular and neurodevelopmental effects
Cadmium	0.003 mg/L, max	0%	Contamination from mining activities	High cadmium may lead to kidney and bone damage
Lead	0.01 mg/L, max (equal to 10 ppb)	**11%**	Most commonly from lead-containing materials in water system components	High lead may lead to negative neurodevelopmental effects, particularly in children
Mercury	0.001 mg/L, max	0%	Contamination from mining activities	High mercury may lead to neurological and behavioral disorders

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 plumbing fixtures.** 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 report detectable lead as above 5 ppb due to the reporting limit of the analytical method used (ICP-MS, USEPA Method 200.8). We also report lead values above 0.01 mg/L (10 ppb), which is the maximum level allowed by the Ghana Standards Authority and is the WHO provisional guideline value for lead in drinking water.

One-quarter (26%) of drinking water samples had detectable lead (>5 ppb) and 11% exceeded the Ghana drinking water standard limit of 10 ppb, including **one-tenth (8%) of school samples and one-fifth (21%) of healthcare facility samples.**

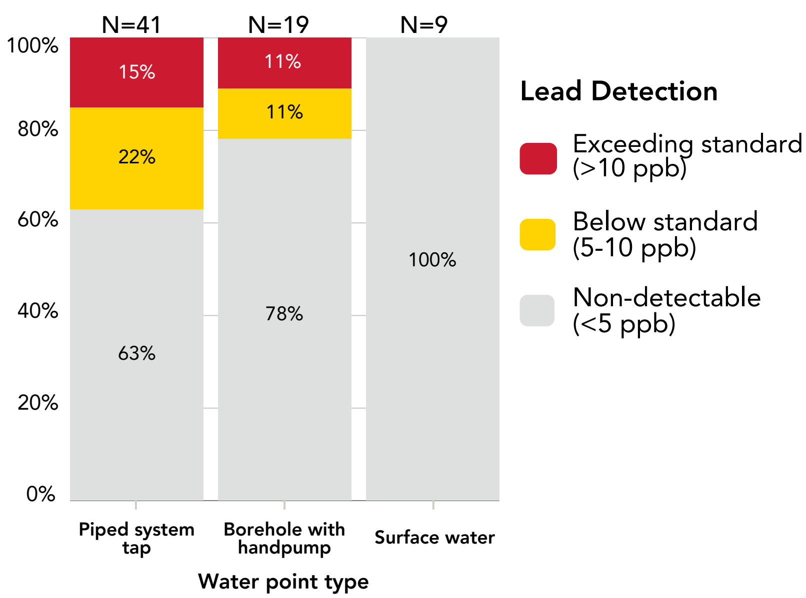

Figure 1: Lead concentrations by water point type (note: the borehole with handpump category includes one dug well with handpump). One rainwater sample and one unprotected dug well sample were omitted from the graph.

Lead was only detected in samples from piped system taps and boreholes with handpumps; no lead was detected in surface water, unprotected dug wells (n=1), or rainwater (n=1) (Figure 1).

Low pH was associated with elevated lead in drinking water. Among samples with pH below 6.5, 17% had lead concentrations exceeding 10 ppb, compared to 6% of 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.

FIRST DRAW SAMPLES

We tested 60 first draw samples – 40 from piped system taps, 18 from boreholes with handpumps, one from a protected dug well with handpump, and one from rainwater collection. Overall, 19% of first draw samples exceeded 10 ppb, compared to 11% of random daytime samples. Lead levels were not statistically different between first draw samples and daytime samples for any water point type, though sample sizes may have been too small for a robust comparison.

Piped systems had slightly higher lead in first draw samples than in random daytime samples. This suggests that more lead may be leaching from piped system taps after a period of stagnation when water has sat in contact with fixtures.

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 Ghana Standards Authority. Over half of water points had acidic water (below pH 6.5); about one-fifth were turbid, or cloudy; and one-quarter of samples had high iron. 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.

PARAMETERS WITH HIGH HEALTH IMPLICATIONS

All samples met drinking water standards for arsenic, cadmium, cyanide, and mercury, which implies limited impact from mining activities. Fluoride and nitrogen were also within health-based recommended limits, but one-tenth of samples exceeded recommended lead levels, which may have severe health implications. We found that elevated lead concentrations were associated with acidic water sources and water from piped system taps and handpumps.

RECOMMENDATIONS

1 To address lead in drinking water:

- Water suppliers should construct new infrastructure using certified lead-free parts and should consider adding orthophosphate and maintaining pH above 7.5[6] to minimize lead leaching from piped water system components.
- National authorities should mandate regular lead testing of drinking water.
- Local authorities should raise awareness of lead-contaminated supplies and alternative water sources among consumers.
- Users should flush water systems for 30 seconds before using the water if the system has sat unused for >8 hours.
- New research should identify low-cost and practical lead removal strategies.

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

REFERENCES

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