

Water Quality in Uganda

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Abstract

Drinking water quality monitoring is critical in the effort to improve health outcomes in developing countries. Poor waste management, rapid industrialization, agricultural activity, and soil erosion are examples of anthropogenic and natural processes that affect the concentrations of heavy metals, anions, nutrients, and bacterial concentrations in water. The purpose of this study was to investigate the concentrations of these contaminants in water from shallow wells, boreholes, rivers, and lakes in the southwestern region of Uganda. The water samples were analyzed in the field and in the laboratory at USD and at the U.S. Geological Survey in Boulder, Colorado to determine the concentrations of various anions and cations that may have long-term health impacts. Data presented here depict single sampling events at the various locations and provide a snapshot of the various water quality issues facing a developing country like Uganda.

Introduction

The issue of drinking water quality is one that is familiar to most developing countries. Although safe, acceptable, and affordable water has been deemed a human right by the United Nations General Assembly in 2010, according to the World Health Organization (WHO), 2.1 billion people lack access to safely managed drinking water services and 4.5 billion people lack safely managed sanitation services (7). Poor waste management, rapid industrialization, agricultural activity, rock weathering, soil erosion, and salt dissolution in water are examples of anthropogenic and natural processes that affect the chemistry and biology of drinking water sources (1). In Uganda, although efforts have been made by The Ministry of Water and Environment and the National Water and Sewerage Corporation to improve waste management and provide the people with “cost effective quality water and sewerage services”, most Ugandans who reside in rural neighborhoods especially, still rely on potentially hazardous sources such as boreholes, shallow wells, lakes and rivers (7,2,3,4). The country is also at an increased risk for contaminated water because of its profound population growth of three times the global average and limited sanitation (60.2 percent of Ugandans used an unimproved sanitation service in 2015) (5,6).



Results

Table 1. Concentrations of metals and anions in samples from various sites and sources.

Source	Site	Al (mg/L)	Cd (mg/L)	Cl (mg/L)	F (mg/L)	Fe (mg/L)	Mg (mg/L)	Mn (mg/L)	NO ₃ (mg/L)	Sb (mg/L)
Surface (N=9)	Holma	0.164	<0.002	-	-	0.151	16.5	0.166	-	<0.03
	Masindi	0.631	<0.002	-	-	3.17	3.56	0.26	-	0.036
	Fort Portal	0.527	<0.002	-	-	0.208	13.8	0.125	-	<0.03
	Mityana	0.395	<0.002	-	-	11.2	1.77	0.257	-	<0.03
	Masaka	0.125	<0.002	-	-	4.8	0.792	0.077	-	<0.03
	Kakoma	0.227	<0.002	-	-	0.134	7.95	1.71	-	<0.03
	Kyabirikwa Shallow Well	0.009	0.003	172	0.65	0.013	40.4	4.86	0.61	<0.03
	Kyabirikwa Road Side Swamp	<0.002	<0.002	431	0.67	<0.002	52.6	0.001	<0.05	<0.03
	Kyabirikwa Lake	0.173	<0.002	68.2	0.24	0.018	27.9	0.158	<0.05	<0.03
Borehole (N=6)	Buhungiro	0.028	<0.002	52.6	<0.05	0.015	5.63	0.007	31.1	<0.03
	Kyabirikwa	<0.002	<0.002	41.3	3.16	0.316	1.69	0.048	0.11	<0.03
	Kyabirikwa Farm	0.615	<0.002	2.0	0.07	0.013	0.304	0.002	4.95	<0.03
	Kyabirikwa South	<0.002	<0.002	167	0.37	1.23	16.8	0.049	73.4	<0.03
	Mubende	0.04	<0.002	-	-	0.003	11	0.003	-	<0.03
	Ruw	0.15	<0.002	-	-	0.403	1.69	0.044	-	<0.03
Tap (N=1)	Kyabirikwa Two	0.059	<0.002	-	-	0.006	16.9	0.158	-	<0.03
	Kyabirikwa GS Staff Tank	<0.002	<0.002	18.5	0.69	<0.002	4.11	0.005	2.50	<0.03

Table 2. Conductivity and concentrations of arsenic, iron, and copper in samples from various sites and sources.

Site	Source	Conductivity range (µS)	As (ppb)	Fe (mg/L)	Cu (µg/L)	
Rubindi (N=27)	Surface (N=5)	0-675.0	Average Range	0 -	1.22 ± 1.39 ^a 0-above scale	0.9 ± 1.9 0-4.3
	Borehole (N=1)	422.0	Average Range	0 -	3.3 -	0 -
	NWSC Tap (N=20)	0-179.5	Average Range	0.25 ± 0.79 0-3	0.08 ± 0.26 0-1.16	3.6 ± 10.0 0-43.2
	Rain Catchment (N=1)	36.8	Average Range	0 -	0.08 -	0 -
Butare (N=38)	Surface (N=17)	15.6-117.7	Average Range	-	6.16 ± 24.96 0-103	- ND-51.5
	Borehole (N=1)	24.6	Average Range	0 -	0.12 -	23 -
	NWSC Tap (N=4)	10.0-85.9	Average Range	-	0.07 ± 0.03 0.03-0.1	ND -
	Rain Catchment (N=2)	42.7-48.6	Average Range	0 -	0.06 ± 0.07 0.01-0.11	ND -
	Spring (N=14)	0-101.3	Average Range	-	0.07 ± 0.11 0-0.39	- 0-33.6
	Rubaya (N=29)	Surface (N=15)	54.5-751.0	Average Range	-	1.83 ± 0.96 0-3.30
Borehole (N=1)		573	Average Range	10 -	0.14 -	0 -
	NWSC Tap (N=3)	814.0-868.0	Average Range	-	0 ± 0.01 0-0.01	4.8 ± 4.1 0-7.2
	Rain Catchment (N=10)	0-148.7	Average Range	-	0.07 ± 0.16 0-0.45	0.3 ± 0.8 0-2.5



Table 3. Concentrations of fluoride, fecal coliform, and other coliforms in samples from various sites and sources.

Source	Site	Fluoride (mg/L)	Phosphate (mg/L)	Fecal/100 mL	Other/100 mL
Surface (N=5)	B44JC	0.089	0.05	24.22	1603.71
	B44	0.117	0.03	19.03	7997.79
	K34	0.515	0.19	314.86	125.43
	DS4	0.160	0.34	882.30	10587.60
	DS5	-	0.39	1781.90	16642.60
Rain Catchment (N=7)	Montfort	0.060	0.21	224.90	3228.18
	Butare Cement	0.046	0.11	0	302.75
	Butare Plastic	0.046	0.08	0	83.04
	R18	0.036	0.10	19.90	2143.47
	St. Joseph's	0.218	0.06	0	5.19
	RCCT	0.058	0.15	0	1134.88
NWSC Tap (N=1)	RCPT	0.041	0.11	44.98	245.66
	HICH	0.310	0.22	0	7319.63

[#]Averaged from N=4 because one of the values was above the scale of detection. Therefore, the true average is higher than reported average.
ND = Not Detectable
Highlight cells - Exceeds the WHO, Ugandan, and/or EPA standard

Discussion and Conclusions

- ✓ In surface water, such as wells, lakes, and rivers, the levels of magnesium and manganese in >50% of the samples exceeded the EPA standard of 0.05 mg, 4 of 9 samples had aluminum concentrations greater than the EPA standard of 0.2 mg, 46% of samples had arsenic concentrations at or greater than the WHO standard of 10 ppb, and 3 of 5 samples had fecal coliform concentrations higher than the Ugandan standard of 50 fecal coliform per 100 mL
- ✓ In boreholes, all of the samples had magnesium concentrations that exceeded the EPA standard, 4 of 9 samples had iron levels greater than the EPA standard of 0.3 mg/L, and 1 of 9 samples had an arsenic concentration equal to the WHO standard
- ✓ In rain catchments, all of the samples tested for magnesium had concentrations that exceeded the EPA standard, 2 of 15 samples had arsenic concentrations greater than the WHO standard, and 1 of 7 samples had a fecal coliform concentration greater than the Ugandan standard
- ✓ In NWSC tap sources, 4 of 28 samples had arsenic concentrations greater than the WHO standard and 6 of 28 samples had copper concentrations greater than the EPA standard of 1.3 mg/L
- ✓ In springs, 12 of 14 samples had arsenic concentrations that exceeded the WHO standard



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Methods

A YSI-85 meter, a color wheel, metal test strips, and SAM-probes were used in the field.

Hach powder pillows and a DR890 Pocket Colorimeter were used to analyze the concentrations of phosphate, nitrate, copper, and iron.

Fluoride was quantified using a Fluoride Ion Selective Electrode.

Winkler titrations were performed to determine dissolved oxygen concentrations.

Fecal coliform and enterococci were counted on plates containing m-Colibblue24 Broth or m-Enterococcus Azide Agar (Hach).

The concentrations of other elements in acidified samples were analyzed by the USGS.

Future Studies

Future studies may include utilizing the results from this study to link the health outcomes of Ugandans to their water sources to better understand the effects of toxins (or lack thereof) in drinking water.



References

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