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# Iodine in drinking water from East African groundwater sources


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## Background

The content of iodine in the diet has implications for human health. Chronic deficiency has long been associated with development of iodine-deficiency disorders (IDDs) including goitre. Drinking water, including groundwater, contributes to the dietary iodine intake so establishing the content and distribution in water improves the understanding of dietary sources. However, whilst the prevalence of IDDs is widely reported, iodine is rarely analysed during traditional groundwater health studies. There are also no regulations for either the minimum or maximum concentrations of iodine in drinking water.

This study aims to review the distribution of iodine in groundwater-sourced drinking water supplies in areas of Ethiopia, Uganda, Tanzania and Malawi (sample sites shown in **Figure 2**, summary statistics in **Table 1** and **2**). The study aims to deduce the sources and mechanisms controlling iodine concentrations in each region.

## Methods

Groundwater sources including, springs, shallow boreholes and hand dug wells have been sampled by the British Geological Survey across East Africa (examples of sampled drinking water sources shown in **Figure 1**). The hydrochemistry data have been compiled into a database for iodine in groundwater from East Africa. Variation in detection limits from the ICP-MS analysis method were accounted for. The preliminary results presented here are based on the iodine content of water from 196 shallow boreholes (BH), 38 hand dug wells (HDW), 18 springs (SP) and 10 rainfall samples.



***Figure 1*** *Examples of a shallow borehole (top left), hand dug well (top right) and spring drinking water source (bottom left) in Ethiopia (Bell, 2019).*

## Iodine content

The iodine content of groundwater varies both between source type (**Table 1**) and regionally (**Table 2**). Iodine concentrations are lowest in rainfall and springs, and greatest in boreholes and hand dug wells in two regions where data are available (also demonstrated in **Figure 3**).

| Water Source | Count | Min | Median | Mean | Max |
|---|---|---|---|---|---|
| Boreholes | 196 | 0.3 | 9.65 | 37.2 | 718 |
| Hand dug wells | 38 | 2.08 | 19.5 | 53.4 | 322 |
| Springs | 18 | 2.8 | 5.56 | 9.66 | 44 |
| Rainfall | 10 | 1.8 | 3.4 | 4.02 | 7 |

***Table 1*** *Summary statistics for iodine concentrations ($\mu g\ l^{-1}$) in drinking water sources across East Africa split by source type.*

| Region | Count | Min | Median | Mean | Max |
|---|---|---|---|---|---|
| Abeshege | 12 | 2 | 5.35 | 6.48 | 18 |
| Balaka | 12 | 3.2 | 20 | 40.1 | 165 |
| Budaka | 11 | 1.6 | 6 | 10.2 | 29 |
| Ejere | 8 | 2.5 | 7.1 | 16 | 57 |
| Kobo | 26 | 2.08 | 13.1 | 49.4 | 322 |
| Kumi | 16 | 1.2 | 32.5 | 43.2 | 115 |
| Lay Gayint | 27 | 2.8 | 8.58 | 11.2 | 62.8 |
| Lilongwe | 8 | 1.3 | 2.95 | 5.79 | 24 |
| Luwero | 10 | 8 | 12.5 | 43.9 | 313 |
| Machinga | 11 | 2.7 | 6.8 | 12 | 61 |
| Mecha | 12 | 0.35 | 0.92 | 0.884 | 1.9 |
| Nkhotakota | 16 | 2.2 | 3.75 | 5.64 | 16 |
| Oyam | 13 | 0.3 | 2.5 | 3.64 | 9.6 |
| Singida | 15 | 10 | 77 | 161 | 470 |
| Sodo | 12 | 0.77 | 5.8 | 9.23 | 30 |
| Tabora | 45 | 2.1 | 46 | 81.2 | 718 |

***Table 2*** *Summary statistics for iodine concentrations ($\mu g\ l^{-1}$) in drinking water sources in regions of Ethiopia, Uganda, Tanzania and Malawi.*

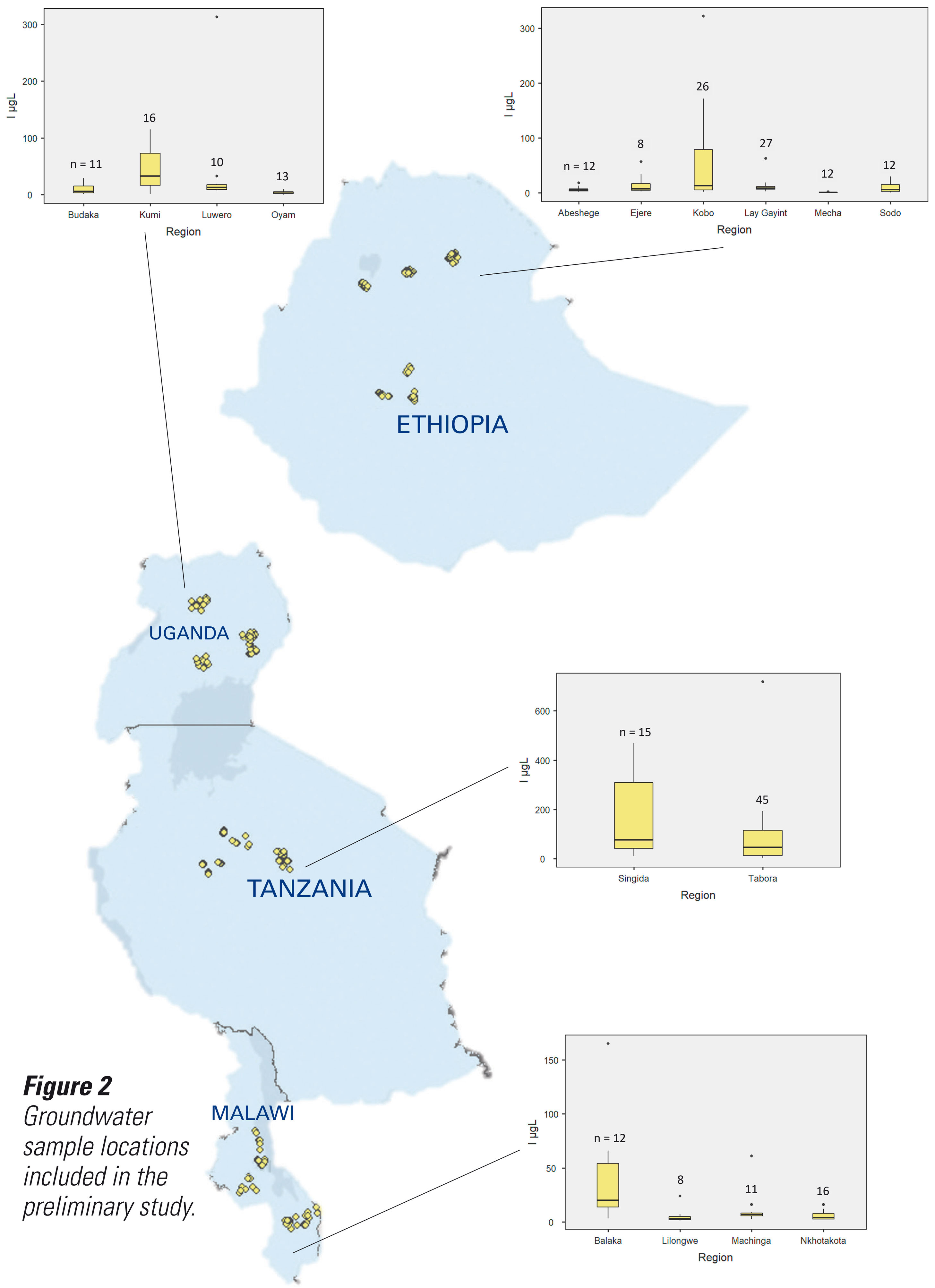


***Figure 2*** *Groundwater sample locations included in the preliminary study.*

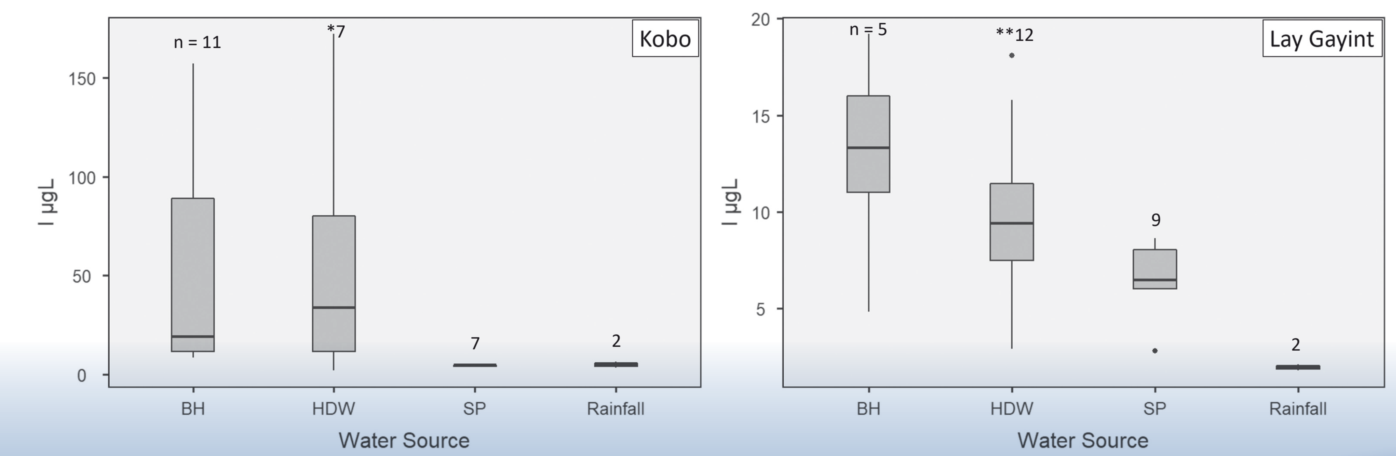


***Figure 3*** *Boxplots show the distribution of iodine occurring in natural waters in two regions of Ethiopia. * HDW with iodine concentration of 322 $\mu g\ l^{-1}$ excluded from plot, ** HDW with iodine concentration of 62.8 $\mu g\ l^{-1}$ excluded from plot.*

## Iodine and other elements in groundwater

An assessment of the relationships between iodine and other dissolved ions was conducted in order to deduce the processes contributing to iodine content. Preliminary results indicate that the concentration of iodine is related to other dissolved ions. Sulphate, uranium, strontium, sodium and fluoride show the strongest relationships with iodine (**Figure 4**), and are in line with the association between iodine and TDS.

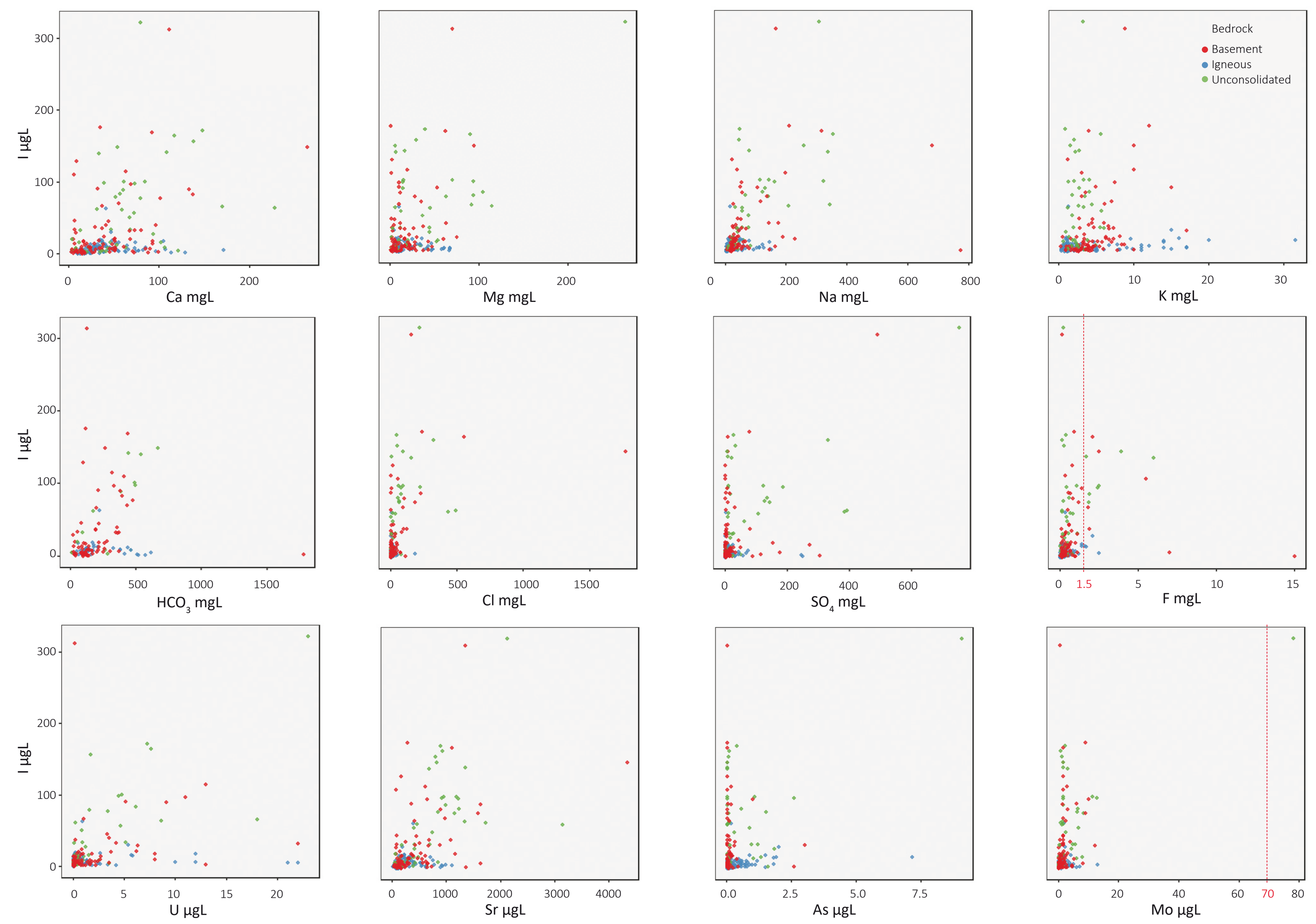


***Figure 4*** *Relationships are shown between iodine and other elements, grouped by bedrock type. WHO (2011) guideline values indicated, showing maximum recommended concentrations. There are no health-based guideline values for sodium, magnesium, calcium, chloride, sulphate, carbonate or strontium. All samples are below the WHO (2011) guideline value for arsenic (10 $\mu g\ l^{-1}$) and uranium (30 $\mu g\ l^{-1}$).*

## Implications

Iodine content is not simply controlled by the composition of rain water; increases occur in catchments through interactions with rocks and soils. The controls on iodine concentration in drinking water supplies have implications for the dietary intake of iodine and can be particularly marked in isolated populations, where low iodine in groundwater is reflected in crops and livestock of the local area.

## Next Steps

Work is ongoing to investigate the relationships between iodine and other solutes in the groundwater, and to build a database of groundwater in East Africa. The natural iodine concentrations of the groundwaters will be combined with additional rainfall and aquifer composition data. The results will provide information on the iodine intake of populations with groundwater-sourced drinking water. By characterising the environmental sources and processes behind the iodine content, the results will contribute to wider public health initiatives in the mitigation of iodine deficiency disorders.

## References


Bell, R. (2019). Impact of the 2015/16 El Niño on rural water security in Ethiopia.

World Health Organisation (2011). Guidelines for drinking-water quality, fourth edition.



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