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# Physical and Bacteriological Quality of Selected Water Sources in Wakiso District, Uganda

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**Abstract**

Poor water quality continues to pose a serious threat to human health, and is one of the major causes of morbidity and mortality in low income countries. The objective of the study was to assess the physical and bacteriological quality of selected water sources in Wakiso district, Uganda. Water samples were collected from 16 purposively selected water sources in 8 villages and analysed for pH, turbidity and selected bacteria (total coliforms and *E. coli*). Membrane filtration method was used for bacteriological analysis while portable meters were employed for pH and turbidity. During sample collection, physical inspection of the water sources was carried out to identify any potential risk factors for water source contamination. The majority of water sources, 14 (87.5%) were contaminated bacteriologically as they had total coliforms and *E. coli* count above zero; and 12 (75%) of them had pH that was not within the national recommended standards. Turbidity of all the sources (100%) was below 5 Nephelometric Turbidity Units (NTU) although 4 sources (25%) had NTU above 0. From the physical inspection, it was observed that some protected springs had poor drainage of waste water which accumulated in the collection area thereby increasing the risk of contamination of water being collected. Environmental Health practitioners and other concerned authorities need to ensure communities treat their water before drinking such as by boiling. Local authorities should also improve drainage at water sources to reduce the risk of water contamination.

**Qualité physique et bactériologique de certaines sources d'eau dans le district de Wakiso, en Ouganda**

**Résumé**

La mauvaise qualité de l'eau continue de poser une menace sérieuse pour la santé humaine, et est l'une des causes principales de morbidité et de mortalité dans les pays à faible revenu. L'objectif de l'étude était d'évaluer la qualité physique et bactériologique des sources d'eau sélectionnées dans le district de Wakiso, en Ouganda. Des échantillons d'eau ont été recueillis à partir de 16 sources d'eau choisis à dessein dans 8 villages et analysés pour le pH, la turbidité et des bactéries sélectionnées (coliformes totaux et de E. coli). La méthode de filtration membranaire a été utilisée pour l'analyse bactériologique alors que les compteurs portables ont été utilisés pour le pH et la turbidité. Lors de la collecte des échantillons, une inspection physique des sources d'eau a été effectuée pour identifier les facteurs de risque potentiels de contamination des sources d'eau. La plupart des sources d'eau, 14 (87,5%) ont été contaminés bactériologiquement les coliformes totaux comme ils avaient E. coli et au-dessus de comptage zéro ; et 12 (75%) d'entre eux avaient un pH qui ne respectait pas les normes nationales recommandées. Turbidité de toutes les sources (100%) était inférieure à 5 unités de turbidité néphélométriques (NTU), bien que 4 sources (25%) l'aient au-dessus de 0. De l'inspection physique, il a été observé que certaines sources protégées avaient un mauvais drainage des eaux usées qui s'accumulaient dans la zone de collecte, augmentant ainsi le risque de contamination de l'eau collectée. Les professionnels de la santé environnementale et les autres autorités concernées doivent s'assurer que les communautés traitent leur eau avant de la boire, par exemple en la faisant bouillir. Les autorités locales devraient également améliorer le drainage des sources d'eau afin de réduire le risque de contamination de l'eau.

## Introduction

Water related diseases are a leading cause of morbidity and mortality in developing countries. Over 2 million people die every year from diarrhoeal diseases with children under 5 years of age mostly in developing countries being most affected (WHO, 2017). According to estimates, 663million people, mostly the poor and marginalised living in sub-Saharan Africa, still lack access to an improved drinkingwater source (WHO and UNICEF, 2015). Evidence suggests that improved water supply can significantly reduce diarrhoea and related diseases' morbidity (Fewtrell *et al*, 2005). The importance of safe water to the general health and wellbeing of populations is well known. Indeed, water supply has direct effects on various facets of public health including maternal health (Benova *et al*, 2014), as well as other communicable diseases such as HIV/AIDS (Peletz *et al,* 2013). The millennium development goal (MDG) targets for drinking water were not met by least developed countries, Uganda inclusive (WHO and UNICEF, 2015). It is therefore evident that despite global progress in water supply in recent years, the situation is still worrying in developing countries including sub-Saharan Africa.

Uganda's access to safe water for urban and rural areas is 71% and 67% of the population respectively (MOWE, 2016). Although these figures have generally increased in the recent past, access to safe water remains a major public health challenge in the country particularly in rural areas where 75% of the population lives (UBOS, 2016). The prevalence of diarrhoeal diseases remains high in the country mainly affecting children under 5 years of age (MOH, 2015). The use of non-improved water sources in rural communities in Uganda such as unprotected springs, lakes, rivers and dams contribute to the high burden of diarrhoeal diseases. In addition, with piped water supplies majorly in urban settings (MOWE, 2016), rural communities can only access other available water sources. The risk of unimproved water sources being contaminated physically or bacteriologically is high. Indeed, studies done in Uganda and other parts of sub-Saharan Africa have shown that several water sources used by communities including springs are contaminated particularly bacteriologically (Haruna *et al,* 2005; Tsega *et al,* 2013; Palamuleni and Akoth, 2015;). Occurrence of diarrhoea and other faecal-oral diseases such as typhoid and cholera is directly associated with poor water, sanitation and hygiene including community practices (Caincross *et al,* 2010). Assessing the quality of water from various sources is therefore important to ascertain its status so as to put in place interventions to safeguard health of the public. The study was carried out to assess the physical and bacteriological quality of selected water sources in Wakiso district, Uganda.

## Methods

### *Study area*

The study was carried out in Nkumba and Bulwanyi parishes in Wakiso district located in the central region of Uganda (Figure I). Wakiso district has a population of 1,997,418 with 1,035,297 females and 814,517 rural inhabitants (UBOS, 2016). The district experiences heavy rain and moderate sunshine throughout the year with 2 rainy seasons (March to May, and September to November). Wakiso district is where Uganda's only international airport (Entebbe) is located as well as part of Lake Victoria, the biggest lake in East Africa. These parishes were involved in the study as they were taking part in a malaria prevention project that was being implemented by the research team. Each of the parishes provided 4 villages that were involved in the study as follows: Nkumba (Central, Bufulu, Bukolwa and Bendegere) and Bulwanyi (Lukose, Bulwanyi, Bumpenje and Kaama). All villages involved in the study were predominantly rural with agriculture as their main economic activity. Villages are the lowest administrative structure in Uganda with each having a local council leadership committee headed by a Chairperson.

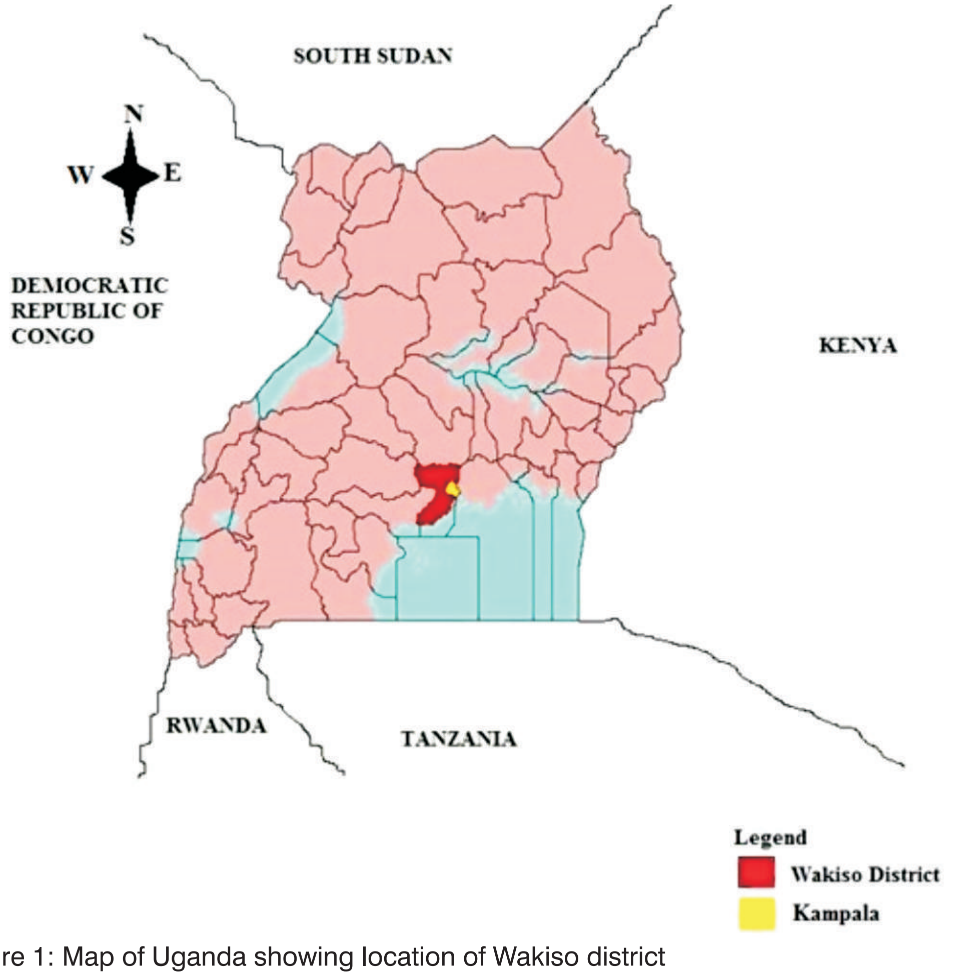


Figure 1: Map of Uganda showing location of Wakiso district

***Sampling and analysis***

Two water sources were purposively sampled from each of the 8 study villages based on the most usedsources in the respective communities to make a total of 16 sources. This was done in consultation with the village leaders including local council chairpersons and community mobilisers. The sampled water sources were: 7 protected springs, 2 boreholes, 2 rain water harvesting tanks, 1 unprotected spring, 1 lake, 1 water pond, 1 tap stand and 1 abandoned cattle dip (which was used to collect water for domestic use when it rained). The protected water sources (boreholes and protected springs were in a fairly good state at the time of data collection). However, the unprotected sources (such as lake and unprotected springs) were prone to contamination due to easy access of humans and animals to the water.

Analysis was carried out for 3 water parameters of pH, turbidity and bacteriological quality (total coliforms and *E. coli*). The samples were analysed bythe Government Analytical laboratory, Kampala which is an accredited laboratory in Uganda. Turbidity and pH were measured using portable meters in the field while membrane filtration method was used to measure bacteriological quality. The bacteriological samples were aseptically collected and taken for analysis immediately after sampling (within 2 hours). Samples were collected by an experienced environmental health scientist and transported in a lightproof insulated box that contained ice. Those carrying out bacteriological analysis were blinded of the sources of water by presenting samples for analysis with codes. During sample collection, physical inspection of the water sources was carried out to identify any potential risk factors for water source contamination. The potential risk factors that were looked out for during the inspection were conditions, devices and practices at each water source that posed an actual or potential danger to health of the consumer.

***Ethical considerations***

The study was carried out as part of the Presidential Initiative on Malaria Research projectwhich received approval from the Uganda National Council for Science and Technology. Village leaders were duly informed about the study. Before collecting samples, individuals responsible for the various water sources were clearly explained to, the purpose of the study.

## Results

Regarding bacteriological quality, the majority of water sources, 14 (87.5%) were contaminated as they had total coliforms and *E. coli* count above zero. The most contaminated sources were the water pond and lake with too numerous to count total coliforms and *E. coli*. The other sources including protected springs and boreholes were significantly contaminated. Most of the water sources, 12 (75%) had pH that was not within the national recommended standards of 6.5 – 8.5 including all the springs and boreholes. Among the water sources with pH not within the standards, the majority 11/12 (91.7%) had a pH of less than 6.5. Turbidity of all the sources (100%) was below 5 *Nephelometric* Turbidity Units (NTU) although 4 of them (25%) had a value above 0 (0 NTU being desirable). The sources with NTU above 0 were the water pond, lake, cattle dip and a protected spring which all had 1 NTU. With the exception of tap water and one rain water harvesting tank, the rest of the water sources 14 (87.5) did not meet all the required standards of bacteriology, pH and turbidity (Table 1).

Table 1: Physical and Bacteriological Quality of the Water Sources

| | Type of water source | pH | Turbidity (NTU) | *E. coli* (CFU/100ml) | Total coliforms (CFU/100ml) |
|---|---|---|---|---|---|
| 1. | Rain water harvesting tank 1 | **6.71** | **1** | **0** | 80 |
| 2. | Rain water harvesting tank 2 | **6.66** | **0** | **0** | **0** |
| 3. | Water pond | 5.67 | **1** | TNTC* | TNTC |
| 4. | Lake | 9.02 | **1** | TNTC | TNTC |
| 5. | Tapstand | **7.30** | **0** | **0** | **0** |
| 6. | Cattle dip | **7.18** | **1** | 100 | TNTC |
| 7. | Unprotected spring | 5.30 | **0** | 8 | 40 |
| 8. | Protected spring 1 | 4.85 | **0** | 32 | 128 |
| 9. | Protected spring 2 | 5.23 | **0** | 60 | 240 |
| 10. | Protected spring 3 | 5.10 | **0** | 20 | 220 |
| 11. | Protected spring 4 | 5.28 | **0** | **0** | 144 |
| 12. | Protected spring 5 | 5.65 | **0** | 28 | 104 |
| 13. | Protected spring 6 | 5.30 | **0** | **0** | 96 |
| 14. | Protected spring 7 | 5.76 | **1** | 4 | 120 |
| 15. | Borehole 1 | 5.80 | **0** | 32 | 56 |
| 16. | Borehole 2 | 5.46 | **0** | **0** | TNTC |

Bold values are those within the national recommended standards.
* TNTC – Too numerous to count

Of all the water quality parameters assessed in the study, only turbidity standards were met by all the water sources (Table 2).

Table 2: Summary of Water Analysis Results

| Standards | Within standards N=16 (%) |
|---|---|
| pH (6.5 – 8.5) | 2 (12.5) |
| Turbidity (<5 NTU) | 16 (100.0) |
| *E. coli* (0 CFU/100ml) | 6 (37.5) |
| Total coliforms (0 CFU/100ml) | 2(12.5) |

Inspection of the water sources revealed that many protected springs had poor drainage which led to accumulation of waste water in the collection area (Figures 2 and 3) whereas only a few had proper drainage (Figure 4). Human activities were found being carried out at the lake shore including washing clothes and swimming. The unprotected spring was surrounded by bush

Figures 2 and 3: Two protected springs with water stagnated in the collection chamber.

and could easily be contaminated by the water container, hands or feet during the collection process, and animals (Figure 5).

Figure 4: A protected spring with adequate drainage of waste water

Figure 5: The unprotected spring

## Discussion

Generally, the physical and bacteriological quality of water was poor. Indeed, only a few water sources met the recommended pH values, most were turbid, and majority were contaminated with *E. coli*. In addition, the drainage of wastewater from some of the springs was poor hence posing a threat to public health. pH is an important water quality parameter that should be routinely measured in supply systems. The majority of water sources had pH above or below the recommended national standards of 6.5 – 8.5. Since the majority of water samples analysed were from ground water courses, the low pH found in most of them could be due to the nature of geological formations in the study area.The extremely high pH (9.02) of the lake could have been contributed to by water hyacinth that has invaded Lake Victoria in recent years (Mwamburi, 2016). Exposure to water with extreme pH values can result in irritation of the eyes, skin and mucous membranes (WHO, 2003). Specifically, water with a low pH (acidic) can lead to redness and irritation of the eyes, the severity of which increases with decreasing pH. In addition, because pH can affect the degree of corrosion of metals as well as disinfection efficiency, it may also have an indirect effect on health. Indeed, for effective disinfection of water with chlorine, pH should preferably be less than 8 (WHO, 2011).Water sources with pH at either extreme should therefore be discouraged for use, particularly human consumption.

All water sources had turbidity below 5 NTU as required by national guidelines. However, 25% of the sources had turbidity of 1 NTU. Other than 1 protected spring, all the other water sources that had a pH of 1 were surface water sources including the lake and water pond. It is well-known that surface water sources are easier to contaminate than ground ones for example by human activity and surface run-off which could be the reason for the turbidity found in the study. Indeed, it is common to find people bathing and washing clothes as well as children playing in surface water sources in Uganda. A turbidity of 0 NTU is desired as presence of particles can affect the physical appearance of water hence affect its use. In addition, turbidity above 0 NTU can affect the efficiency of disinfection of water as the suspended matter increase demand for the disinfectant, protects microorganisms, and may stimulate bacterial growth (WHO, 2011). Since turbidity also affects the aesthetic quality of water, there is a risk of communities opting for water sources with no turbidity which could be more contaminated. It is therefore important for turbidity to also be considered as an important parameter while assessing water quality particularly in rural communities to protect public health.

The majority of water sources (87.5%) were bacteriologically contaminated. The most contaminated water sources were the lake and water pond which had too numerous to count *E.*

*coli* and total coliforms. Although the use of such surface water sources for domestic purposes is generally discouraged, it is unlikely to be ended in rural communities as in the study villages. This is because such water sources are many times the closest to households hence their use is inevitable under the circumstances. The treatment of water from such sources before drinking, for example by boiling, is therefore of paramount importance. Although surface water sources such as lakes and ponds are more likely to be contaminated, ground ones such as boreholes and protected springs are normally of better quality (Ritter *et al*, 2002). Indeed, most ground water sources if protected are categorised as improved by theWorld Health Organisation/UNICEFJoint Monitoring Program (JMP) for Water Supply and Sanitation (WHO and UNICEF, 2014). However, all the ground water sources (springs and boreholes) in this study were contaminated. The poor quality of water from the ground water sources could be due to contamination of aquifers by various sources particularly latrines. Latrines, which are the main form of human excreta disposal in rural communities in Uganda, have been shown to be a main polluter of ground water sources (Graham and Polizzotto, 2013). It is therefore important that communities treat all their drinking water irrespective of the source so as to prevent diarrhoea and other related diseases.

The study established that there was poor drainage at many protected springs leading to accumulation of waste water in the collection chamber sometimes to the level of the spring outlet. This situation poses a major public health concern and is likely to lead to contamination of water during collection from the springs. Water user communities, local authorities and other responsible community members including community health workers should ensure that drainage of waste water at protected springs is improved by unblocking the channels responsible draining the water. The activity of unblocking drainage channels should be done as frequently as the situation at each water source necessitates. Human activity in or near water sources such as washing clothes should be discouraged as it is a potential source of contamination (Pandey *et al*, 2014).

Interestingly, due to socio-economic reasons, it is common to find communities with piped water supplies opting to fetch lake water for domestic use. With such risks of potential water contamination, water for human consumption should be adequately treated for example by boiling or chlorination, and stored in clean containers.

One limitation of this study was that it involved a relatively small number of water sources hence the findings may not be generalised to a larger geographical location. Nevertheless, since the water sources were sampled based on those most used by the community, the findings give a good scenario of the quality of water used in rural Uganda which can inform improvement interventions as well as future research.

## Conclusion

The physical and bacteriological quality of most of the water sources was not within the required standards. Therefore, Environmental Health practitioners and other stakeholders concerned with water quality need to ensure the public treat their water before drinking such as by boiling or point of use chlorination. Local authorities (including water user committees) and the communities using water sources should also ensure protected springs have good drainage from the source to prevent waste water stagnating in the collection area which can lead to contamination of water and resultant burden of water borne diseases.

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