Water Quality Assessment in a Rural Setting; A Case Study of Budaka District

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Abstract. Pollution of improved water sources has been reported to be on the increase, especially in rural water sources, evidenced by the increasing outbreaks of waterborne diseases, despite the construction of many improved water sources. This raises doubt about the water quality in these sources. This paper presents the water quality, the factors that may impact water quality and the possible pollution mitigation interventions, in the case study of Budaka district, eastern Uganda.

Keywords: Pollution, Waterborne diseases, Mitigation

1. INTRODUCTION

The primary concern of people living in developing countries is that of obtaining safe drinking water. In Africa and Asia, most of the largest cities utilize surface water but many millions of people in peri-urban communities and rural areas are dependent on groundwater. Safe water supply access in the developing world is still very inadequate and in Africa, for example, more than 47% of urban households are without access to safe water; the conditions are even worse for rural areas. This situation is not different in Uganda, particularly in the rural areas with a national safe water access of only 65% and 60% for Budaka district as in 2011.This situation inevitably calls for interventions to increase safe water access with keen attention to quality compliance. Uganda, through the Ministry of Water and Environment, has already responded to the situation with different strategic interventions by collaborating with some Non-Governmental Organizations (NGOs) constructing deep boreholes, shallow wells and protection of springs all over the country. However, despite the increasing construction of new improved water sources, these efforts have not resulted in the desired water supply service level particularly in terms of quality of the water from these improved water sources. The trend of the national water quality of the protected rural point water sources is concerning, having declined from 63% in 2013 to only 53% in 2014 compliance to the national standards, With urban water quality compliance of nearly 100%, it is evident that rural water supply is not receiving adequate attention. The effects of this trend of poor water quality are evident in Budaka, manifesting itself through the continuous and increasing outbreaks of water borne diseases reported in the area.

The objectives of this study therefore, were: first, to assess water quality and the causes of pollution of the different water source types; second, to establish the most sustainable water supply source type with respect to water quality; and thirdly, to recommend appropriate measures that can be adopted for mitigation of the pollution of water sources in Budaka.

2.0 METHODOLOGY

A total of 50 water sources with thirty (30) deep boreholes, fifteen (15) protected spring wells and five (05) shallow wells were studied for microbiological, physical and chemical water quality properties. Under the microbiological assessment, thermo tolerant coliforms (*E.coli*) count was determined using water samples of 100ml collected from the different water sources.

Under chemical analysis, the parameters determined were: pH, nitrates, fluorides, chlorides, iron, hardness, total alkalinity, electrical conductivity and total dissolved salts (TDS). Testing for pH was done using a pH meter, turbidity using a turbidity tube, electrical conductivity and total dissolved solids using EC/TDS meter, feacal coliform using the filter membrane method. The analytical method involving titration was used to determine the alkalinity and hardness as $CaCO_3$ of the water, while the spectrophotometer was used to determine the concentrations in mg/l of iron, chloride, fluoride and dissolved oxygen in water. The physical water parameter determined was turbidity. A *Water Quality Index* was then determined for the water sources based on five test indicator parameters, that are most relevant to rural water quality monitoring. These are; feacal coliforms, pH, turbidity, nitrates and dissolved oxygen.

Sanitation assessment included the measurement of the proximity of latrines to the water sources and an assessment of the physical/structural condition and the surrounding sanitary conditions. The measured water quality parameters enabled us to determine a sanitation risk factor.

Linear and multiple regression analysis were done to assess the significances and correlations between the different variables. Significances of the correlation coefficients were determined using the t distribution.

3. RESULTS

The results of the testing of water quality parameters in compliance to World Health Organization (WHO) Water Quality Guidelines and UNBS Water Quality Guidelines are shown in Table 1, while Table 2 shows the water source compliance to UNBS and WHO microbiological, chemical and physical Water Quality Guidelines.

Results indicated the water quality compliance to Uganda National Bureau of Standards (UNBS) guidelines for biological quality as 97%, 73% and 63% for boreholes, protected springs and shallow wells respectively.

Table 1 Compliance to WHO and UNBS Water Quality Parameters

The chemical water quality of rural water supply in Budaka is quite satisfactory having an average compliance to UNBS guidelines of 99%, 100% & 100% for boreholes, springs and shallow wells respectively as shown in Table 2.

The main pollution factors identified were; poor operation and maintenance of water sources particularly in terms of poor sanitation at the sources especially for shallow well and spring water sources, which indicated linkage of 67% and 70% respectively to *E.coli* pollution compared to boreholes which had

linkage of only 4.5% to *E.coli* pollution due to sanitation factors. Analysis showed latrines, which in some cases were found constructed close to water points to have significant linkages to pollution with 64% and 72% of *E*.coli pollution in boreholes and shallow wells respectively, being linked to latrines.

Table 2 Water Source Compliance to UNBS and WHO Microbiological, Chemical and Physical Water Quality Guidelines

Average Compliance to Drinking Water Guidelines (Percentage)	UNBS			WHO		
	Boreholes	**Protected Springs**	**Shallow Wells**	**Boreholes**	**Protected Springs**	**Shallow Wells**
Microbiological Quality	97	73	63	53	0	0
Chemical Quality	99	100	100	100	100	100
Physical Quality	83	27	40	70	15	0
Average Water Source Compliance	**93**	**67**	**68**	**74**	**38**	**33**

Testing the significances of the independent variables of shallow well sanitation and latrine proximity in correlation to microbiological water quality using t- distribution test and Pearson's correlation indicated, that both factors are significant to *E.coli* pollution in the water sources. The results also indicate that shallow wells (as shown in Figure 1) and springs are very vulnerable to pollution as none of the two source types was found compliant to the WHO microbiological water quality guideline (0 *Ecoli*/1000ml).

Figure 1: A poorly maintained shallow well with a cracked apron

4. CONCLUSIONS

The general water quality of improved water sources in Budaka had an average *Water Quality Index* (WQI) of 63.4, 56.8 and 55.7 for boreholes, springs and shallow wells respectively and an overall WQI of 58.6 and thus can be classified as *medium water quality*.

The results also indicate that an improved water source, does not necessarily guarantee supply of safe water as a number of them, 3%, 27% and 37% of boreholes, springs and shallow wells respectively were non-compliant to the UNBS biological water quality guidelines as can be observed from Table 2.

The results show the most appropriate water supply technology, with respect to water quality in Budaka rural water supply, are boreholes, considering their high level of biological water quality compliance of 97% to the UNBS water quality guidelines as can be observed from Table 2.

The results indicated that microbiological (*E.coli*) water quality is the most significant with respect to human health and there is a strong linkage between microbiological water quality and water source sanitation, as well as latrines that are constructed close to the water sources.

5. RECOMMENDATIONS

Based on the conclusions of this study, the following are recommendations for addressing the water quality improvement of rural water supply in Budaka:

Deep borehole technology for water supply, where ground water potential permits, is recommended as being the most appropriate for rural water supply, considering their low level of vulnerability to pollution.

Protected springs, if well maintained, in terms of managing all the water source sanitation parameters that prevent pollution, are the next alternative water supply technology, where they exist and where borehole technology is not applicable, due to ground water potential limitations.

Shallow wells should be the least promoted for water supply in Budaka as the results indicated that they are heavily polluted by faecal coliform. The sources of pollution are sometimes unclear, which makes pollution control in shallow wells more complex and difficult to manage.

As long term water supply strategy, simple piped water supply systems for rural growth centers could be a better supply technological option, considering that in such centers there is a high pollution risk to point water sources from pit latrines in the vicinity and provided funding is available.

Water sources should not be constructed downhill existing pit latrines or after water source construction, no latrines should be constructed uphill the water source and WHO recommends a minimum latrine – water source proximity of 30 m.

Water for drinking should first be boiled before drinking to remove the feacal coliform.

There should be effective and regular operation and maintenance of point water sources, particularly in terms of improved water source sanitation, which can significantly serve as an interventional mitigation measure, which could be achieved and enhanced through the adoption and promotion and use of an appropriate *Water Safety Plan*.

These results are significant countrywide and can be used to improve the water supply and sanitation of improved water sources in other districts.

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