

Full Length Research Paper

Water quality assessment of various sources in Peri-urban areas of Malawi: A case of Bangwe township in Blantyre

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Water supports life at microscopic and macroscopic levels. Good quality water is essential to economic and social growth of a community and a nation at large. Bangwe township in Blantyre is one of the closest townships to the city and provides a reliable workforce and supply of consumables to the city. Due to its overcrowding, there are a lot of issues to do with illnesses that arise from contamination of portable water. They have water resource points that they share communally, apart from others that have their own individual source points. This work aimed at assessing the quality of the most communally shared water points in Lilaka, Mvula, Chikunda, Namiyango and Ntopwa 2 areas of the township. Three major water source points (tap water kiosks, boreholes and water wells) from each community were selected for the study and samples from these sources were analyzed for conductivity, pH levels, total dissolved solids, total suspended solids, turbidity, fecal coliforms, lead and iron. The results showed that the water from these communal water source points are highly contaminated with a *F. coliform* maximum record of 350.00 ± 0.03 cfu/100 ml in Chikunda area and of not pleasant organoleptic characteristics which risk the health of the consumers. This work recommends that authorities should plan to intensify monitoring of water from these sources, inspections and preventive maintenance of boreholes and tap water plumbing systems to check the quality and safety of the water and replace any damaged systems or parts thereof.

Key words: Water quality, water safety, contamination, water points, portable water.

INTRODUCTION

Bangwe township is one of the most important areas to the city of Blantyre. Due to its proximity to the city, it offers a reliable labor force and consumable resources for the city. Compromising the health of the township is

likely to have a huge economic and at worst, a health impact on city dwellers and workers. Clean and good quality portable water ensures a healthy citizenry that can contribute to community and/or national development,

without which, life falters and conflicts for good quality water arise. There is currently limited literature on the quality and safety of water being used in Bangwe and many other such Malawian townships.

Water is a fundamental basis of life both in the animal and the plant kingdoms. It is a valuable and finite resource that is central to the human well-being and socio-economic development. Poor quality water majorly threatens the health of millions of people worldwide (Adekunle et al., 2007). Poor quality of water retards development of people and states through health-related costs which reduce active participation of individuals in developmental activities. Research shows that about 80% of diseases are connected in some way to poor quality contaminated water (Adebayo et al., 2011; Sadallah and Al-Najar, 2015). This contamination is usually a public health concern when it comes from artificial pollution. Pollution of water sources in rural and urban areas remains a serious challenge worldwide especially in many developing countries like Malawi (Mwendera, 2006).

The major artificial pollutants include chemical composition of parent rocks from construction activities, the discharge of chemicals and hazardous materials from residential and industrial sites, agricultural activities and discharge of wastes into water sources from business places and individuals from residences as well as in transit. The sources that are most vulnerable are rivers, boreholes and piped water sources. A number of interventions have been put in place by various organizations and the government to improve the quality and safety of drinking water from these sources in order to meet the sustainable development goal 6 targets number 1 and 3 and Malawi vision 2020. Some of the interventions that have been made are construction of new boreholes, water kiosks, wastewater removal in rivers by city councils, formulation of water legislation and civic education of people in water management in rural and peri-urban areas. After the interventions, there is lack of attention amongst scientists to assess water quality levels of these sources that are now being used by households in the rural and peri-urban areas in Malawi.

Water quality and safety parameters

Naturally, water contains colloidal matter, minerals, gases, non-electrolytes and electrolytes, contributing to the overall pH of the water which helps to determine water power or ability to cause corrosion (WHO, 2007). Iron is one of the most important natural trace elements human bodies need to survive. Besides being a protein functional component, it activates and stabilizes enzymes

when at low concentrations (Tautkus et al., 2003). Above trace amounts of iron can lead to serious health problems including rapid, shallow respiration, depression, coma, cardiac arrest and convulsions (Alemdaroğlu et al., 2000; Bağ et al., 1998; Paleologos, Giokas et al., 2000). On the other hand, lead (Pb) is a seriously toxic heavy metal to many body organs even at low concentrations, reported to cause deficiency of mental ability in children (Talebi and Safigholi, 2007). High levels or prolonged low levels of Pb can also lead to slow fetal growth, premature birth, cardiovascular and reproductive problems, low IQ and anemia among others (EPA, 2017). A growing public health concern on the presence of lead in drinking and natural water made the Public Health Association reduce the maximum limit of the presence of lead in portable water, from which the European Community recommended 50 µg/L (Talebi and Safigholi, 2007). Metals are generally found in water pipe materials, paints and plastics pigments, acid battery, water treatment coagulants, solder and food colorings among other materials which easily contaminate water sources by discharge (Schock, 1989; Tautkus et al., 2003; WHO, 2009). Metal elements (Fe, Pb and others) are determined spectrometrically and gravimetrically. Gravimetry is considered cumbersome and less precise by some while spectrometry is fast with better precision and accuracy.

Total dissolved solids (TDS) and electric conductivity (EC) are essential parameters in the determination of the amounts of solids in a sample of water. Water EC indicates the amount of ionic solutes from impurities and other contaminants which enable the water to conduct an electric current (Tchnobanoglous and Kreiti, 2002).

Fecal coliforms in water indicate a possibility of serious contamination by pathogens. They can come from latrines and livestock dung (Kaonga et al., 2013). Fecal coliform in water microbiology (organisms that grow at 44 or 44.5°C) produces gas and acid from the fermentation of lactose. Although there are some organisms with same characteristics but being not of fecal origin (generally referred to as thermo-tolerant coliforms), it is almost always that thermo-tolerant coliforms indicate fecal contamination in water, more than 95% of which are *Escherichia coli* (UNEP/WHO, 1996). Fecal coliforms are used in studies as they indicate portable water quality to the effect that they influenced the development of the public health concept (Nikaeen et al., 2009).

Water vendors from Bangwe township sell water collected from different points in Bangwe to travelers and workers in various selling points, including bus terminals and schools. With limited literature on the quality and safety of water from Bangwe township, people from the area and far beyond could be at a risk of diseases from unsafe water. The aim of this study was to conduct a

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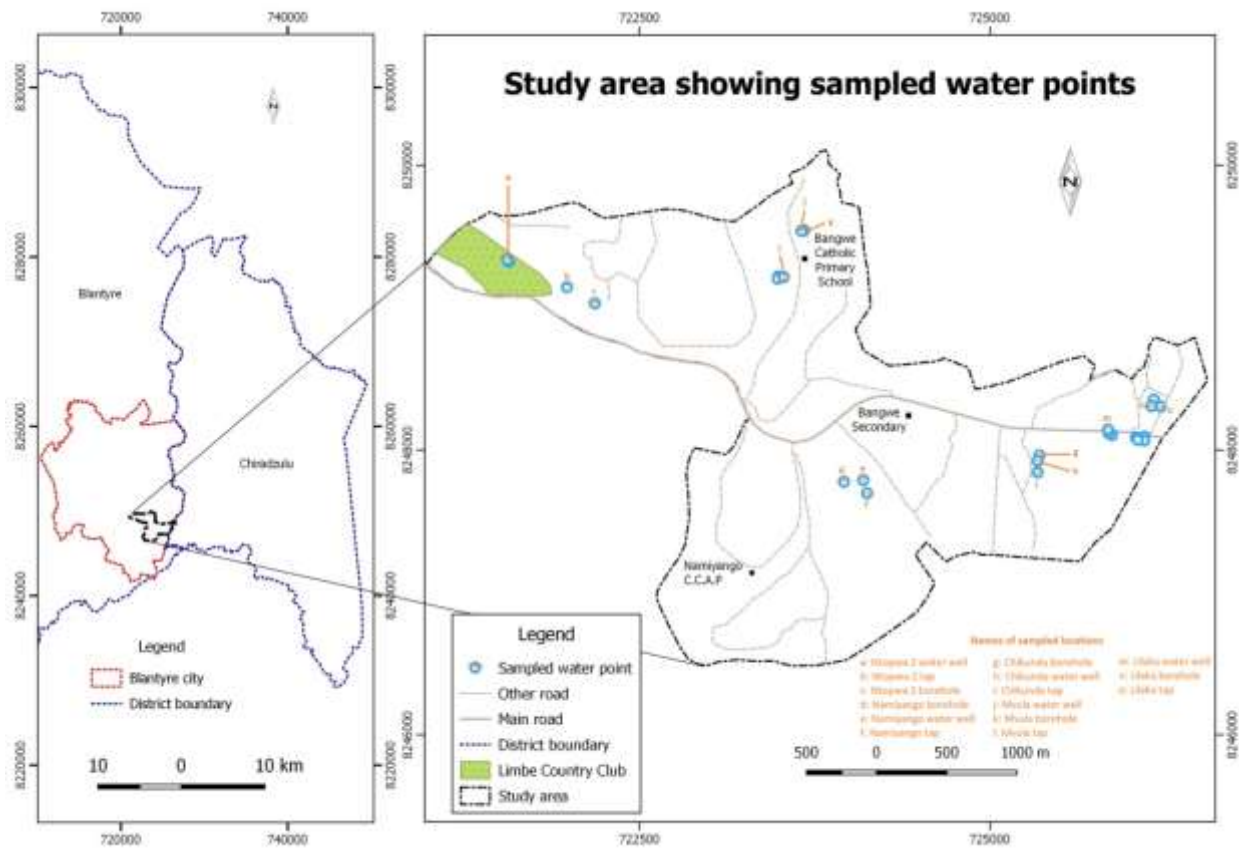


Figure 1. Location of Bangwe township relative to the economic city of Blantyre and to the right, details of sample collection points.

water quality and safety assessment of various water sources basically used by households in Bangwe, a peri-urban township of Blantyre, Malawi. The study will complement efforts of making sure that the country achieve sustainable development goals 6 and 3 which state that there should be equitable access to safe water and sanitation for all, and healthy lives and the well-being of all people of all ages by 2030 respectively. Therefore, the study will help to inform relevant authorities in advance about water quality of various areas and act accordingly. The undertaking of this research is justifiable because Bangwe township is a vitally important township to Malawi’s economic city of Blantyre.

MATERIALS AND METHODS

Sample collection

Samples were collected in Bangwe township from five large communities; Lilaka, Mvula, Chikunda, Namiyango and Ntopwa 2 areas. This research focused only on the most reliable sources of portable water that were being used communally in the area

as directed by community leaders. In each community, water was sampled in triplicates from common boreholes, water wells and water tap kiosks. Figure 1 is a map showing the location of Bangwe township in Blantyre city and a detailed locations of the sampling points within the township.

Sample collection was done in two consecutive days (2nd and 3rd of August, 2018) and samples were collected as described in literature (Uwidia and Ukulu, 2013). Immediately after drawing samples, TDS, pH and temperatures were determined electro-chemically using hand-held meters and samples were kept in a cooler box for further laboratory analyses to avoid biodegradation. All laboratory analyses were started on the same day of sample collection. At the laboratory, analyses started the same day of sampling. Physical and biological characteristics of the samples were determined. The analyses were performed to assess water contamination and quality for drinking.

Sample analysis

Standard methods from the American Public Health Association (APHA, 2005) were used to determine total dissolved solids (TDS), pH, electrical conductivity (EC), total soluble solids (TSS), turbidity, metal concentrations and fecal coliforms. Briefly, EC and TDS were determined using a hand-held EC/TDS meter. A refractometer (Atago) was used to determine TSS. A calibrated electrode pH

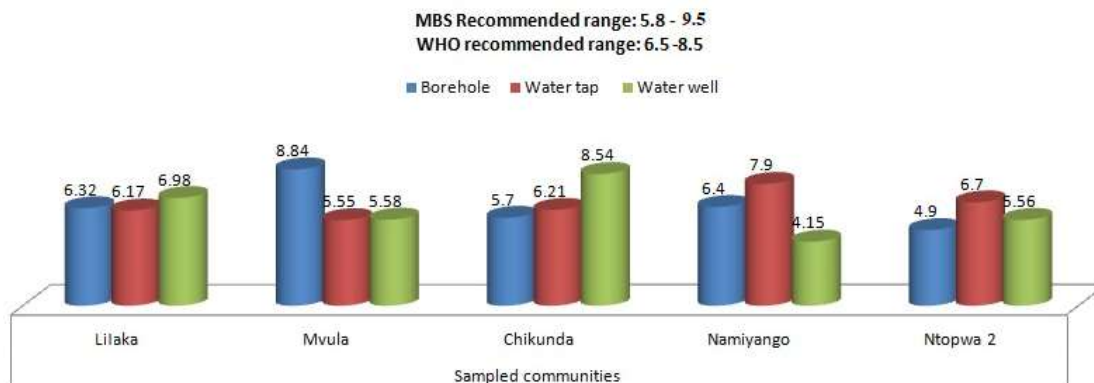


Figure 2. pH values of various water samples in the research communities.

meter was used to determine pH and a portable turbidity meter was used to determine turbidity. Iron and lead concentrations were determined using weight digestion where hydrochloric acid and nitric acid were used to free metals from water. An atomic absorption spectroscopy (AAS) was then used to determine the amounts of metals in the samples using flame atomic excitations (APHA, 2005; Twyman, 2005). For fecal coliform determination, a membrane filter (0.45 μm) was used to pass a water sample in order to retain coliform bacteria on the membrane. A broth (membrane lauryl sulphate) was used as nutrient and the bacteria were incubated in a petri dish at 37°C for 24 h. A microscope was then used to enumerate all yellow colonies and expressed the counts in colony forming units (cfu/ml) (APHA, 2005).

RESULTS AND DISCUSSION

All the results presented in this paper are the means of triplicate sample tests.

Water pH levels

The pH of tap water was within the Malawi Bureau of Standards recommended range of 5.8 to 9.5 for drinking water (MBS, 2005) except for Mvula area which could be due to acidic discharge from dissolved metals from plumbosolvency. The pH of borehole water had a maximum of 8.84 and minimum of 4.9 in Mvula and Ntopwa 2 areas respectively and maximum pH values for well water was 8.54 with a minimum of 4.15 in Chikunda and Namiyango areas respectively. The maximum and minimum values are observed to be way out of the recommended safe range of the Malawi Bureau of Standards which already is relaxed from the WHO recommendations. Figure 2 shows a summary of the results for pH in all the sample collection areas.

The pH variations for well and borehole water could be due to solvation of organic matter in the soil matrix surrounding and in contact with the water wells (Mtewa, 2017). These pH levels create a conducive environment for the proliferation of fecal coliforms that survive well

between pH of 5.8 and 8.4 (Kaonga et al., 2013; Lambert, 1974). It is difficult to control well and borehole water pH apart from checking the site before boring and buffering water using recommended acid-base buffers. The lower the pH levels of water get, the higher the potential corrosion levels of the water become (WHO, 2007).

Iron, turbidity and total suspended solids

The results for Iron, turbidity and total suspended solids are presented in Figure 3.

Amongst the four communities, only Mvula area showed better results (0.31 ppm), slightly higher than the maximum WHO allowable limit of 0.3 ppm. Lilaka (0.6 ppm), Chikunda (0.46 ppm), Namiyango (0.49 ppm) and Ntopwa 2 (0.71 ppm) put the users at the risk of iron toxicological complications. The presence of the metals in the water could largely be due to contamination from pre-contaminated water drawing materials, sawdust particles, organic materials decay with ligands in their structural formations, plumbosolvency for borehole due to low pH water levels and salvation from soil in contact with the water which comes up due to ionic completion in the water as a solution. Tap water and borehole plumbing systems could be too old and liable to corrosion with time, contaminating the water in turn. There was no mention of recent checks of water plumbing system in recent years which shows negligence of engineering inspections and preventive maintenance in the area which are required for the sustenance of quality assurance systems as recommended by Mtewa and Mtewa (2017).

Turbid water is unpleasant for consumers. High levels of turbidity were found in water wells which make scientific sense due to many materials that easily get into the water bodies. This can however be checked in the dry season better than in the rainy season by taking turns when drawing the water at given intervals to avoid agitation of the water.

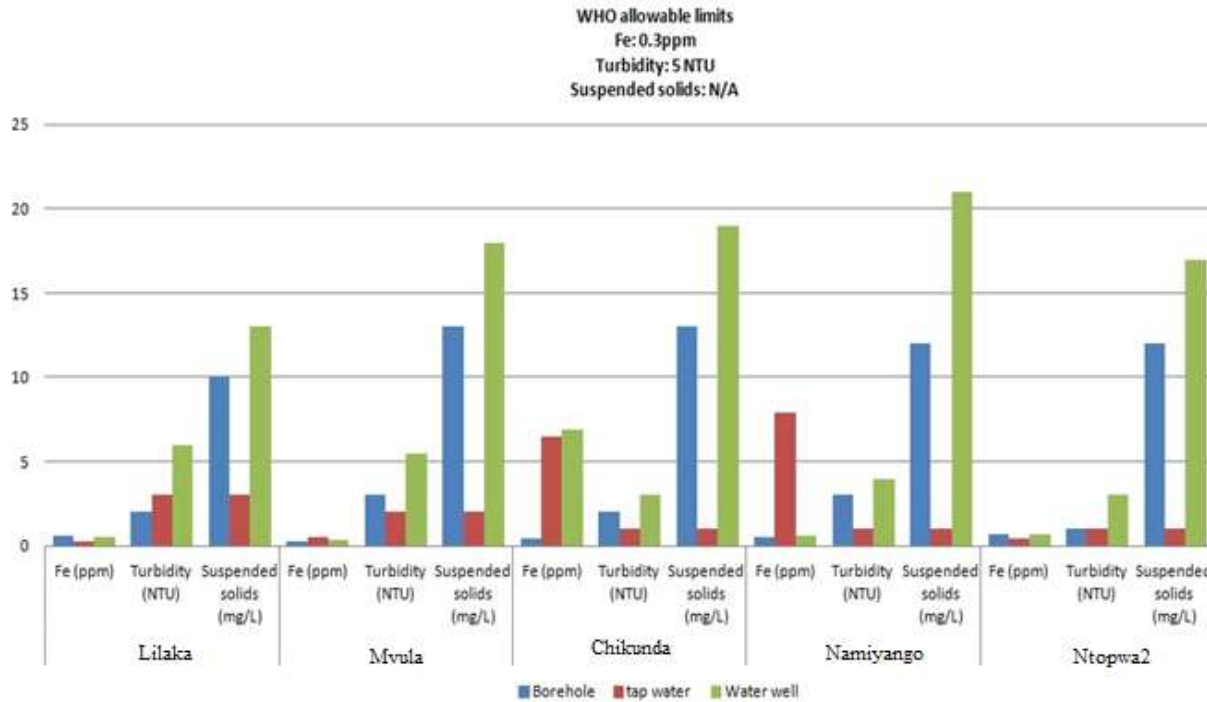


Figure 3. Comparative results for iron, turbidity and total suspended solids in the sampled communities.

Table 1. Results for lead (Pb) in water samples from all the research sites.

Sample name	Lead concentration (mg/L) for water source points		
	Tap water	Borehole water	Well water
Mvula	0.16±0.0014	0.09±0.0013	0.1±0.0004
Chikunda	0.1±0.0003	0.06±0.0003	0.1±0.0003
Namiyango	0.1±0.0001	0.08±0.0002	0.11±0.0002
Ntopwa2	0.07±0.0002	0.08±0.0004	0.11±0.0005
Lilaka	0.09±0.0002	0.1±0.0002	0.1±0.0003

The results are expressed as mean ± standard deviation, n=3.

Lead content in water samples

The presence of lead (Pb) in all water samples raises a serious concern to the safety of the water that people in Bangwe township are subjected to. With a maximum of 0.16 mg/L lead in Mvula area, frequent exposure to consumers may ultimately lead to lead toxicity in future. These results and those for pH indicate that the plumbing system in Mvula area could be worn out or have several points of possible contamination. It is prudent for authorities to develop a preventive maintenance program that needs to always be adhered to without fail as this is a matter of the life of real people which translates to the intended socio-economic development of the city of Blantyre. Table 1 presents results for lead content in water samples collected from all the five research sites.

Lead concentrations as for any other heavy metal in portable water, needs to be checked and managed to save consumers from detrimental effects of heavy metal toxicity.

Total dissolved solid and electrical conductivity

Table 2 shows the results of electrical conductivity and total dissolved solids in the water samples from the sampled communities.

The results in Table 2 show that there was high amount of matter in well and boreholes, with more resounding presence in the wells. This could be due to the contamination from dust particles and other materials that find their way into the wells at the time of use or

Table 2. Total dissolved solids and electrical conductivity of water samples.

Water source	Lilaka		Mvula		Namiyango		Ntopwa 2		Chikunda	
	TDS (mg/L)	EC (μ S/cm)	TDS (mg/L)	EC (μ S/cm)	TDS (mg/L)	EC (μ S/cm)	TDS (mg/L)	EC (μ S/cm)	TDS (mg/L)	EC (μ S/cm)
Borehole	188 \pm 1.25	282 \pm 0.00	694 \pm 7.25	1044 \pm 6.00	400 \pm 0.00	601 \pm 0.00	139 \pm 2.25	207 \pm 0.00	159 \pm 0.00	241 \pm 0.25
Water tap	94 \pm 0.00	143 \pm 2.25	129 \pm 0.00	190 \pm 0.00	146 \pm 2.25	218 \pm 5.45	130 \pm 2.25	199 \pm 0.00	127 \pm 0.00	191 \pm 5.00
Water well	180 \pm 1.25	198 \pm 3.77	834 \pm 1.00	1249 \pm 8.25	376 \pm 0.00	558 \pm 6.77	428 \pm 0.00	642 \pm 0.00	338 \pm 0.00	627 \pm 2.13

The results are expressed as mean \pm standard deviation, n=3.

Table 3. Results for fecal coliforms for the research sites.

Site	Fecal coliform (cfu/100ml) for water source points		
	Tap water	Borehole water	Well water
Mvula	0.00 \pm 0.00	9.00 \pm 0.00	12.00 \pm 0.00
Chikunda	0.00 \pm 0.00	0.10 \pm 0.01	350.00 \pm 0.03
Namiyango	0.00 \pm 0.00	0.00 \pm 0.00	0.00 \pm 0.00
Ntopwa2	0.00 \pm 0.00	0.00 \pm 0.00	28.00 \pm 0.02
Lilaka	0.00 \pm 0.00	0.00 \pm 0.00	0.00 \pm 0.00

The results are expressed as mean \pm standard deviation, n=3.

when the wells are left open for some time; waiting for next user. EC values were generally higher than the upper limit recommended by the Malawi Bureau of Standards (150 μ S/cm) (MBS, 2005) leading to a slightly salty taste of the water (Kaonga et al., 2013). As reported in literature (Uwidia and Ukulu, 2013), high EC values indicate that the water sources had a lot of inorganic ions which had influence on the conduction of electric currents such as Na⁺, K⁺, H⁺, Cl⁻, SO₄⁻, HCO³⁻ and others. Fe²⁺ and Pb²⁺ have been confirmed to be present in this study. High TDS values show that the water sources had high amounts of dissolved solid substances as solid matter, which usually include proteins, carbohydrates, esters and salts (Uwidia and Ukulu, 2013). This is risky as some of the materials into the water bodies could be highly

poisonous or infected, making the wells a health hazard to the community. This is the case with fecal coliform contamination which was higher (350 cfu/ml) than the WHO recommended safe maximum levels of 100 cfu/100mls. It should be noted that fecal contamination was mentioned to be one of the causes of diarrhea pathogens in less developed countries in previous studies (Kaonga et al., 2013). The risk of disease is even higher as the areas of Ntopwa 2, Lilaka and Mvula are highly populated. Overcrowding in the areas contributes to poor hygienic and sanitation practices (Osei and Duker, 2008). The findings show relatively better results on fecal coliforms than those that were reported by kaonga et al., (2013) in Ntopwa area and others. This is an indication of improved hygienic practices facilitated

probably by the dry weather as opposed to the rainy weather the previous study was carried out under.

Fecal coliforms

The results for fecal coliforms are presented in Table 3. 60% of the sampled well water and 40% of the sampled borehole water are microbiologically not safe for drinking. Despite the levels of care that the people in all sites visited expressed to be adhering to, like covering the wells every time after use, Mvula area, Ntopwa 2 and Chikunda wells still register high levels of poor water sanitation with Chikunda registering as high as 350.00 \pm 0.03 cfu/100 ml of *F. coliforms*

against a WHO maximum limit of absence for drinking water, totally unacceptable for drinking.

Note needs to be taken that consumers in these areas were confident about the sanitation of their water and they were still using the water for drinking and cooking during sample collection. The lack of knowledge of the people of the areas about the quality and safety of their water could be a general scenario with other areas where research of this kind has not yet been undertaken. Dissemination of such findings as these ones and enhanced surgical civic education on basic hygienic practices can help positively change the lifestyles of people in the areas to become more water quality and safety-conscious.

Conclusion and recommendations

Issues of water quality and safety are critical to health and national development. Citizens could be suffering from cancers and other unknown and untraceable diseases which could be linked to consuming contaminated water some time back. Water from wells are generally found to be not safe and of poor quality probably due to their open nature to the environment, relative to tap and borehole water. High levels of matter and metals in tap water for Mvula area suggest compromised plumbing systems, affecting the portability of the water thereof.

This work revealed no major differences between findings in the rainy season from those in the dry seasons. Perhaps the time it has taken to study some sources of water in the area have seen some practices previously recommended, being compromised with time. Generally, water sources close to market areas and well within overcrowded residential areas of Bangwe have less than pleasant water qualities to ensure safety for the consumer. There is a high risk of contamination with heavy metals and other inorganic and organic substances that could easily lead to human health complications with high or extended exposure. This risk is not only on the people from Bangwe township but also lies on unsuspecting travelers who buy plastic bag packaged water and cooked foods using water from the area.

There is still need to encourage safekeeping of water sources in Bangwe township by communities, starting from simple activities like covering the top openings of wells to regular sanitation talks and decontamination campaigns. There is also need for authorities to check the conditions of the borehole and tap plumbing systems which could likely be too old and easily get corroded, contaminating the water by consumers. There is need for institutions to be carrying out such monitoring projects to ensure right measures and interventions are carried out where necessary.

The results from this work are critical in addressing public health and environmental concerns for Bangwe

area, from which lessons can be drawn to work in other areas too. New knowledge about the quality and safety of water in Bangwe area in the dry season of the year has been added to the scientific database. These results will also be used as a baseline reference point for other subsequent studies to be conducted in the country and beyond. The results will effect meaningful interventions and life style changes on the part of various stakeholders in the water sector in Malawi and beyond.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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