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*Full Length Research*

# Quality of drinking tap water in semi urban areas of Malawi

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**The study on the water quality of the water from source and along the distribution pipe to the tap was conducted to assess its suitability for consumption. Water samples were collected in the wet and dry seasons to compare seasonal differences. The results showed that while most parameters were below the hazard limit, others such as lead were above the limit in the dry season although this element was not detected in the wet season. Total dissolved solids were much higher ($p<0.05$) in the wet season compared to the dry season. Fecal coliform was present in the water in both seasons although in the wet season this was only obtained at the source. The results suggest serious deficiencies in the treatment of the water at the treatment plant and this may be a health risk to the consumers. It is therefore recommended that the authorities should take appropriate steps to rectify the situation before unforeseen events take place.**

**Key words:** Chemical analysis, consumer, health risks piped water, pollution.

## INTRODUCTION

Water is a vital natural resource worldwide. The supply and consumption of safe portable water is being advocated in many developing countries where the majority of the population has relied on unsafe water from rivers or other sources. The misuse and mismanagement of water in many countries have resulted in rapid and widespread decline in source-water quality and supply (Watson and Lawrence, 2003). This is partly due to human activities that include indiscriminate disposal of sewage, industrial waste, agricultural activities and in some cases the direct discharge of human and livestock feces into water (Loomer *et al*., 2008; Hyland *et al*, 2003; Mishra *et al*., 2009; Goldar and Banerjee, 2002). The concern of all these activities is their impact on health and economic status of the people and the degradation of the aquatic ecosystems (Hayakawa *et al*., 2006; Akoto and Adijiah, 2007; Jameson *et al*., 2003; Mahvi *et al*., 2005). In addition, the mismanagement and poor conservation of the available water bodies and lack of adequate treatment of the drinking water result in outbreaks of epidemics (Fakayode, 2005). It is estimated that as many as four million children die every year as a result of diarrhea caused by water borne infection (Ongley, 1996).

In order for the water suppliers to achieve good drinking water quality, there is need to understand the system starting from the water source to the point of consumption. It is important to assess the capability of a treatment plant to treat and supply water that meets health-based targets, identify potential sources of contamination and how they can be controlled, employ valid control measures to control hazards, implement a system for monitoring the control measures within the water system, timely corrective actions to ensure that safe water is consistently supplied, and undertake verification of drinking-water quality.

Although the Malawi Government advocates for potable water to reach all urban and semi urban and even rural communities, water-related diseases including cholera and typhoid fever are still common throughout the country (Water for people, 2006). Cases of diarrhea among infants and children are high due to poor and low priority on the need for sanitation and improved hygiene practices. The major threat is the fact that only 36% of the population has access to safe sources of water (Malawi Government, 2003). Lack of knowledge on hygienic water handling practices at the water sources, during its

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transportation and use in the home also contribute to the recurrence of diseases among children.

The domestic water which is supplied to some parts of the semi urban areas comes from a dam which is situated in a catchment area. The dam itself is not fenced such that animals and humans use the water at will. People also catch fish from the dam for home use and for sale. The dam is also used for recreational purposes. In addition, the water from the same dam is piped to the house holds. Despite the water being treated at a treatment plant situated near the dam, questions are raised by the consumers on the quality of the water being supplied. The water running from taps is sometimes dirty and with brownish color. During rainy seasons the water also contains some suspended particles. Being the only source of domestic water to the communities, residents have no other alternative other than continuing to using it. The water of such quality has a potential to cause health problems to the consumers. There are possibilities of the water not being treated properly and as such, the water could be containing pathogens, chemicals, dissolved salts and some toxic metals that may be a health hazard to the consumers.

The objective of this work was therefore to assess the quality of the water from source and along the distribution pipe to the consumer point at the tap.

## MATERIALS AND METHODS

### Samples and sampling

The research was conducted from the source water dam in the capital city of Malawi and along the distribution pipe up to the consumer point or the tap. Five sampling sites were chosen at random. The first sampling point (Point 1) was at the source of water, before entry into treatment plant. The second sampling point (Point 2) was after the treatment plant. The third (Point 3) was the receiving/storage tank in the consumer area. The fourth (Point 4) and fifth (Point 5) sampling points were from two taps of the consumers. All samples from were then analyzed for the several parameters. Sampling was carried out in the dry season and the rainy season. In each season, sampling was done twice at each sampling point. At each point, two samples were obtained on each sampling day, making a total of four samples at that point.

### Chemical Analysis

**Sulfate:** This was determined by turbidimetric method (AOAC, 2002). To a 5 $cm^3$ solution of conditioning reagent (a mixture of glycerol (50 $cm^3$), HCl (30 $cm^3$), water (300 $cm^3$), ethanol (100 $cm^3$) and NaCl (75g) was added 100 $cm^3$ sample in a 250 $cm^3$ flask and mixed. While stirring, a spoonful of $BaCl_2$ was added and the mixture stirred for a further 1 minute. Some solution was then transferred into a cell and the absorbance measured at 420nm. The milligrams of sulphate were obtained from a standard curve and the concentration (in mg/ $dm^3$) calculated from the relation: mg $SO_4^{2-}$ / $dm^3$ = mg $SO_4^{2-}$ sulphate from the curve x 1000/$cm^3$ sample.

**Phosphate:** To a 50 $cm^3$ sample was added 8 $cm^3$ of combined reagent (a mixture of solutions of sulphuric acid, potassium antimony tartrate, ammonium molybdate and ascorbic acid), mixed and left to stand for 10 minutes. The absorbance of the solution was then measured at 880nm (AOAC, 2002) and the concentration of phosphate obtained from a calibration curve.

**Lead, Iron and Zinc:** The samples were treated with 5 $cm^3$ of $HNO_3$ and then boiled for ten minutes and allowed to cool. The metal concentrations were measured directly, on the Atomic Absorption Spectrophotometer (AAS).

**Suspended Solids:** The sample was thoroughly shaken and 100 $cm^3$ of sample was filtered through a weighed filter paper. The filter paper was then oven dried after which it was re-weighed to obtain new mass.

**Total dissolved solids:** The sample was let to settle all the sediments after which 250 $cm^3$ of the clear solution was filtered to secure perfectly clear liquid. A 100 $cm^3$ sample of the clear liquid was placed in a previously weighed Petri dish and evaporated to dryness in an oven. The Petri dish was then re-weighed to obtain new mass.

**pH:** The water pH was measured using a pH meter immediately after sample collection.

**Hardness:** This was obtained by titrimetric methods (AOAC, 2002). To a 50 $cm^3$ sample placed in a conical flask, was added 1ml of buffer (pH 10), 0.5 $cm^3$ of Mg-EDTA solution and 5 drops of indicator with stirring. The solution was then titrated with 0.01M EDTA to a blue end point. The hardness was obtained as mg $CaCO_3/dm^3$.

**Fecal Coliform:** A 200 $cm^3$ volume of the sample was filtered through a membrane filter. The latter was then placed on a pad saturated with media (culture) after which it was incubated at a temperature of 44.5°C for 24 hours. The colonies were then checked and quantified in relation to the volume of the initial sample used. Concentration was calculated in count/100 $cm^3$.

### Data Analysis

The data collected was analyzed using GenStat package. The Least Significant Difference (LSD) was used to assess the significance difference between the points and between the seasons.

**Table 1.** Mean Concentration of parameters obtained in the dry season.

| Parameter | Sampling points | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| pH | 7.4±0.26 | 7.44±0.27 | 7.71±0.07 | 7.79±0.04 | 7.76±0.04 |
| $SO_4^{2-}$ (mg/ $dm^3$) | 6.18±1.05 | 5.29±1.7 | 5.83±0.64 | 5.95±0.94 | 5.98±0.49 |
| $PO_4^{3-}$ (mg/ $dm^3$) | 0.023±0.01 | 0.021±0.01 | 0.023±0.06 | 0.022±0.01 | 0.022±0.01 |
| Hardness (mg/ $dm^3$) | 25±2.56 | 30±2.74 | 30.1±0.96 | 31.5±0.97 | 24.5±1.61 |
| Suspended solids (mg/ $dm^3$) | 17.2±2.99 | 9.5±3.4 | 14.5±3.4 | 10.5±1.92 | 9.5±1.7 |
| Total dissolved solids (mg/ $dm^3$) | 153±24.5 | 157±17.5 | 205±18.6 | 202±22.4 | 189±12.7 |
| Fe (mg/ $dm^3$) | 0.64±0.13 | 0.51±0.13 | 0.57±0.13 | 0.94±0.27 | 0.62±0.18 |
| Pb (mg/ $dm^3$) | 0.065±0.01 | 0.183±0.02 | 0.299±0.11 | 0.306±0.05 | 0.454±0.04 |
| Zn (mg/ $dm^3$) | 0.04±0.03 | 0.01±0.01 | 0.02±0.003 | 1.51±0.35 | 0.02±0.01 |
| Fecal coliform (counts/100$cm^3$) | 250 | 0 | 54 | 120 | 0 |

**Table 2.** Mean concentration of parameters obtained in the wet season.

| Parameter | Sampling points | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Ph | 6.32±0.21 | 6.45±0.05 | 6.65±0.4 | 6.61±0.13 | 6.6±0.3 |
| $SO_4^{2-}$ (mg/ $dm^3$) | 6.89±0.22 | 5.61±0.16 | 6.02±0.50 | 5.92±0.60 | 6.24±0.8 |
| $PO_4^{3-}$ (mg/ $dm^3$) | 0.052±0.01 | 0.033±0.01 | 0.043±0.003 | 0.045±0.002 | 0.043±0.004 |
| Hardness (mg/ $dm^3$) | 52±9.2 | 56.3±13.0 | 59.2±14.8 | 60.9±15.0 | 49.8±5.96 |
| Suspended solids (mg/ $dm^3$) | 48.8±24.2 | 23.0±7.9 | 37.5±15.7 | 33.8±17.8 | 25.2±10.3 |
| Total dissolved solids (mg/ $dm^3$) | 774±86.7 | 722±70.65 | 988±147.9 | 1211±324.5 | 948±262.7 |
| Fe (mg/ $dm^3$) | 2.0±1.3 | 1.69±1.3 | 1.71±0.02 | 2.55±1.14 | 1.08±0.5 |
| Pb (mg/ $dm^3$) | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 | 0.0±0.0 |
| Zn (mg/ $dm^3$) | 0.0±0.0 | 1.98±2.8 | 0.02±0.02 | 2.79±0.4 | 0.16±0.02 |
| Fecal coliform (counts/100 $cm^3$) | 500 | 2 | 0 | 0 | 0 |

## RESULTS AND DISCUSSION

The mean concentrations of parameters obtained in the dry and wet seasons are given in Tables 1 and 2 respectively. pH of the water in the dry season was higher ($p<0.05$) compared to the readings observed in the wet season. However, no significant difference was observed between points in each season. The values were within the minimum (6.5) and maximum (8.5) as set by the WHO. Sulphate did not vary significantly between points and seasons. In the wet season, the concentration in the reservoir was slightly higher than in the dry season and this was also reflected in the slightly higher level in the tap water in the wet season compared to the level in the dry season. The values in both seasons were below the hazard limit set by the Malawi bureau of Standards (400mg/ $dm^3$) in drinking water (MBS, 2000).

Phosphate concentration varied significantly ($p<0.05$) between the two seasons, the wet season having higher amounts compared to the dry season. In the dry season the concentrations did not vary from each other among the five sampling points. However, during the wet season there were some significant differences among the sampling points with the values in the dam being highest. This could be attributed to run off from the surrounding agricultural fields. The World Health Organization recommends a limit of 0.05-0.1mg/$dm^3$ of phosphate in drinking water. The values obtained in the wet season in the dam water and from the tap water were close to the hazard limit and this indicated a potential risk to the consumers.

The water hardness did not vary significantly at all the five points in the dry season. In the wet season, the water was relatively hard compared to the dry season. In both seasons though, the values were below the hazard limit set by the World Health Organization (500mg/$dm^3$) and the Malawi Bureau of Standards (500mg/$dm^3$), (MBS, 2000). Total dissolved solids did not vary significantly in the source water and after the filter in the dry season but the two values differed greatly from those in the reservoir tank and from tap water. The highest value was obtained in the reservoir water and this could reflect the higher values in the tap water. It is therefore possible that the reservoir is not cleaned frequently to remove the sediments that settle in. The values in the wet season were much higher ($p<0.05$) than those in the dry season. This could be attributed to the run-off and surface water that flow to the dam during this period. The higher values obtained in the reservoir and tap waters point to serious deficiencies in the filtering and subsequent treatment of the water at the treatment plant. Suspended solids were significantly higher ($p<0.05$) in the wet season compared to the dry season. High amounts of suspended particles make the water turbid and this agrees with the observation that in the wet season, consumers normally receive brownish water that is unpalatable. Since turbidity can indicate problems with treatment process, especially during filtration and flocculation this agrees with the earlier suggestion of serious deficiencies at the treatment plant. Consequently, this water may not be fit for consumption.

Iron was obtained in the wet season in amounts exceeding the hazard limit set by WHO (1mg/dm$^3$) compared to the dry season. This could be explained as due to run off from the fields. The soils around the source area are red indicating high concentrations of iron. As such, run off from the field flushes a lot of iron compounds to the dam. Lead was not detected in the wet season but significant amounts were observed in the dry season. In the latter case the amounts exceeded the hazard limits set by the WHO (0.05mg/dm$^3$) and the Malawi Bureau of Standards (0.05mg/dm$^3$). It is difficult to explain the source of the metal in the dry season but it is possible that evaporation of the water makes it more concentrated to point where it can be detected. Zinc was not detected in the source water in the wet season but was obtained at the other points. In the dry season this element was obtained at all points. Since the concentration of zinc in surface water is as low as 0.05mg/dm$^3$, the higher amounts of this element at all points other than in the dam in the wet season could probably be due to dissolution from pipes (WHO, 2006).

The fecal coliform was observed at the source, in the reservoir tank and in tap water in the dry season while in the wet season, this was only obtained at the source water and just after the treatment plant. There was no coliform in the reservoir or from tap water in the wet season. The higher incidence in the dry season could be attributed in part to the fact that during this period, a lot of fishing activities take place in the dam and this could result in direct defecations in the water. Also free range livestock graze in the area more than in the dry season resulting in animal feces going in the dam water. The dry season is also the time for recreational activities, such as partying, in the area. Most of the activities that occur in the dry season are not there in the wet season as such the fecal coliform observed could be coming from the few animals that graze in the area or run off from the upland. Trends of higher coliform in the dry season compared to the wet season have also been observed by other researchers (Hyland *et al*., 2003; Jamieson *et al*., 2003). What is of most significant though is the fact that fecal coliform is present in this drinking water from the source to the consumer tap. This suggests fecal contamination which might result into the introduction of pathogenic microorganisms in the water and this can present potential health risks to individuals using the water (Chigbu and Sobolev, 2007). This should be a concern to the authorities to take appropriate steps to properly treat the water before distributing it to the consumers.

## Conclusion

The results of the study have shown that although the supply and consumption of portable water is available, the water is not safe for consumption. The presence of toxic metals such as lead and the presence of fecal coliform are a sure indication that serious deficiencies in the treatment of the water exist at the treatment plant. Potable water is essential but at the same time it would be advisable for the authorities to take appropriate steps to ensure that safe water is distributed to the consumers.

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