Standard Scientific Research and Essays Vol2 (9): 396-400, September 2014 (ISSN: 2310-7502)
http://www.standresjournals.org/journals/SSRE

Research Article

Impact of soil chemical parameters on ground water quality in some parts of Malawi

[1]Tadala Sendezera, [1]Boyson H. Z Moyo and [*2]Peter P. Mumba

[1]Department of Natural Resources Management, Lilongwe University of Agriculture and Natural Resources, P.O. Box 219, Lilongwe, Malawi
[2]Department of Basic Sciences,
Lilongwe University of Agriculture and Natural Resources, P.O. Box 219, Lilongwe, Malawi

***Corresponding Author E-mail:** mumbap01@yahoo.com

Accepted 15 September 2014

Abstract

A study was carried out to determine the water quality of ground water in bore hole, protected well and unprotected well 1 and 2 in some parts of the central region of Malawi in the dry and rainy seasons in relation to wide spread fluorosis in the study area. The results showed that while hardness, alkalinity and sulphate were relatively high in the dry season fluoride was higher in the rainy season. In the dry season, for hardness, significant differences were observed between bore hole and the two unprotected wells ($p<0.05$). For sulphate differences were observed between the protected well and the other three sampling places. However, there was no significant difference in the concentration of fluoride at all four sampling places. In the rainy season, significant differences were only observed for sulphate in the sampling places, being highest ($p<0.05$) in the protected well. If ailments are to be avoided, continuous monitoring of these ground water sources need to be taken. This is especially true for fluoride since dental fluorosis is common in the study area.

Keywords: Ground water, pollution, chemical analysis, consumer, health risks

INTRODUCTION

Water is an essential natural resource for sustaining life and environment which we have always thought to be available in abundance and a free gift of nature. However, chemical composition of surface geothermal or non- thermal is one of the prime factors on which the suitability of the water for domestic, industrial and agricultural purpose depends. Groundwater forms a major source of drinking water in urban as well as in rural areas of the developing countries (Ullah et al., 2009, UNEP, 2003). Most of rural population in the society uses groundwater since it is readily available and is not usually subjected to multi annual or seasonal fluctuations. Urban dwellers too take another portion of groundwater consumption due to low income levels and its easiness in accessing to suffice their daily needs (Malawi Govt., 1996, 1998).

Ground water is the water located beneath the ground surface in soil pore spaces and fractures of rock formation. It makes about 20% of world's fresh water which is about 0.61% of the entire world's water (Meenakshi and Mehshwari, 2006). Ground water is often replenished by surface water from precipitation, streams and river seepages and lakes overlying and underlying aquifers and other means. Ground water sources are often prone to contamination with elements such as metals, liquid wastes from industrial sources, and chemical fertilizers in agricultural areas and septic and sewages treatment system discharges in communities, deposition of atmospheric volcanic particles and others (Adetunji and Odetokun, 2011; Abudullahi et al., 2011; Sandhyarani, 2013; Thole, 2013).

Groundwater quality problems have emerged in many geographical areas due to natural environmental processes and human intervention in the geosystems. As such water can be a serious source of environmental and health problems especially if the design of such water supply is not coupled and tied with appropriate sanitation measures (Adekunle et al., 2013; Akankpo and Igboekwe, 2011; Jumma et Al., 2012). It is unfortunate that many people in most rural areas have no access to safe drinking water and they are compelled to consume the untreated water which is easily accessible to them without knowing the ill effects of such consumption.

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. This is because most rural communities try to make a simple open water source in their village and obtain water from it. Such an open source is most of the times a shallow hole in the ground and as such, the water is easily contaminated and prone to collapsing from rain and animals because it is not protected or supported (Yamada, 2007). The consequences are that cases of diarrhoea 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 Govt, 1998). Lack of knowledge on hygienic water handling practices at the water sources, during its transportation and use in the home also contribute to the recurrence of diseases among children. In spite of the advocacy on the use of potable water, most of the population in Malawi, as in many other countries, ground water is still used in many ways. Although bole holes are common but equally most used are wells that are dug along rivers used mostly by the rural communities. In most parts of the country where such water is consumed, dental fluorosis is also prevalent (Thole, 2013). It is therefore important to carry out quality measurements for the safety of the population that use them.

The objective of this study was to assess the water quality of bole hole and some protected and unprotected wells. The specific objectives were to determine levels of fluoride, hardness, sulphate, and alkalinity in these water sources.

MATERIALS AND METHODS

Study Area

The study was conducted in the central region of Malawi, in an area where people draw water for domestic use from wells dug on shallow areas along rivers (also called dimba areas). Normally, these wells are not protected. Samples were collected from two such wells (unprotected well 1 and unprotected well 2). A second set of samples were collected from a protected well (also situated along a dimba area) and a third one from a bole hole from a neighbouring village.

Samples and sample collection

Three groundwater resources were identified and sampled purposely basing on their land usage thus residential, dambo and dimba areas and at a spacing of about 150m from each source with exception of the dimba wells. In each of the water source, five samples were collected in rainy and dry season respectively.

Chemical Analysis

Fluoride: Fluoride was determined by spectrophotometric methods (AOAC, 2002)

Hardness: This was obtained by titrimetric methods (AOAC, 2002). To a 50ml sample placed in a conical flask, was added 1ml of buffer (pH 10), 0.5ml 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 $CaCO_3$/L.

Alkalinity: This was determined by titrimetric methods. To 50 ml sample was added 3 drops of phenolphthalein indicator and titrated with 0.01M sulphuric acid until the solution became colourless.

Sulphate: This was determined by turbidimetric method (AOAC, 2002). To a 5ml solution of conditioning reagent (a mixture of glycerol (50ml), HCl (30ml), water (300ml), ethanol (100ml) and NaCl (75g)) was added 100ml sample in a 250ml 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/l) calculated from the relation: mg SO_4^{2-}/l = mg SO_4^{2-} sulphate from the curve x 1000/ml sample.

Data Analysis

Data was analysed by use of Microsoft excel to obtain the means. Chi-square was used to compare the observed results with those set aside by the World Health Organization (WHO) and the Malawi Bureau of Standards (MBS).

RESULTS AND DISCUSSION

The concentrations of the parameters obtained in the dry and wet seasons are given in Tables I and 2 respectively.

Table 1. Concentration of parameters in the Dry season

Parameter	**Location**			
	Protected Well	**Borehole**	**Unprotected well 1**	**Unprotected well 2**
Hardness (mg/l)	476	500	288	296
Alkalinity (mg/l)	476	448	240	254
SO_4^{2-} (mg/l)	270	12.8	20.8	21.6
F^- (mg/l)	0.98	0.87	0.68	0.73

Table 2. Concentration of parameters in the Rainy season

Parameter	**Location**			
	Protected Well	**Borehole**	**unprotected well 1**	**unprotected well 2**
Hardness (mg/l)	320	217.1	283.8	296
Alkalinity (mg/l)	154	180.07	126.03	124.06
SO_4^{2-} (mg/l)	60.28	5.23	5.88	5.75
F^- (mg/l)	0.99	1.05	1.07	0.99

In the dry season, water hardness ranged from 288-500 mg/l in all the sampling places. The highest value was observed in the bole hole and the least in the unprotected well $1_.$ In the rainy season, hardness was highest in the protected well and the least was in the bole hole. Dry season values were generally higher than wet season values. The mean hardness was higher in dry season (391.0 mg/l) compared to that in the wet season (292.5 mg/l). Higher hardness concentration in dry season could be as a result of fluctuations in water table. The water table is likely to be lower in this season hence there is no recharge due to precipitation, only seepages could contribute hence, it might be of insignificant amount. Withdrawing of water by people is another aspect and worse still evaporation due to higher temperatures can contribute to reducing water table. The lowering of water table makes it possible for the concentration of salts or ions to increase. However, the mean concentration of hardness in both seasons (dry and rainy) tended to be above the recommended set standards by the Malawi Bureau of Standards (MBS, 2000) whilst on the other the mean, range (285.5-400 mg/l) seemed to lay within the World Health Organization maximum set allowable value of 500mg/l (WHO, 2004). Reports have indicated that very hard water as was observed in this study may lead to increased incidence of utolithiasis and may possess laxative properties due to the association of magnesium with the sulphate ion (Ullah et al., 2009). Surprising, such cases were not reported in the study area.

In the dry season, alkalinity was high in water samples obtained from protected well which also had a relatively higher reading of hardness concentration. Borehole gave a second highest reading followed by unprotected $well_2$ and lastly a high least reading was obtained from unprotected $well_{1.}$ The concentration of alkalinity followed the same sequence with those of hardness being higher in the dry season (with a mean of 354.5 mg/l) compared to the rainy season (with a mean of 146.07 mg/l). Alkalinity is primarily a function of dissolution of carbon dioxide from the atmosphere as well as the geology of the location of the water source (Appelo and Postma, 1999). It has been observed that groundwater sources in areas with limestone formations are especially likely to have high hardness and alkalinity due to the dissolution of bicarbonates and carbonates (Timmons et al., 2002).

Alkalinity with regard to season was observed to give a maximum mean reading of the water samples obtained in dry season. It was observed that there was a significant difference in concentration with regards to season since the calculated value was greater than that of alpha value ($0.1 < p < 0.5$). The explanation for having higher alkalinity in dry season could be similar to that of hardness hence the terms are applied interchangeably. Alkalinity and hardness are related through common ions formed in aquatic systems. Specifically, the counter-ions associated with the bicarbonate and carbonate fraction of alkalinity are the principal ions responsible for hardness (usually Ca^{++} and Mg^{++}). As a result, the carbonate fraction of hardness (expressed as $CaCO_3$ equivalents) is chemically equivalent to the bicarbonates of alkalinity present in water in areas where water interacts with limestone (Timmons et al., 2002).

The concentration of sulphate was highest in the protected well regardless of season. In the dry season the lowest concentration was in the bole hole and the same was true in the rainy season. Rainy season values tended to be lower than dry season ones. This could be due to natural oxidation of sulphides and elemental sulphur transported from igneous rocks to form aqueous sulphate ions in the soil. It could also be due to dilution effects. The higher values in the dry season could be due to precipitation of the ion during this period as a result of evaporation making the water be more concentrated (Waziri, 2006). Contamination from agricultural activities could also contribute through deposits from fertilisers (Ullah et al., 2009). Sulphate is also related to water hardness in that, it contributes to water hardness by forming compounds such as calcium sulphates and magnesium sulphates. The concentration of sulphate in the protected well reached higher value than the allowable limit of 250 mg/l (WHO, 2004). This means that consumers of the water in this well should take precautions during this period to avoid ailments such as diarrhoea.

Hardness and alkalinity showed a negative relationship on the concentration of fluoride in all the four water sources. Thus, high concentration of fluoride was observed in rainy season when hardness and alkalinity were low. The salts of calcium and magnesium constitute hardness and these metal ions also precipitate fluoride as their respective fluorides, calcium fluoride and magnesium fluoride. The level of maximum possible calcium and magnesium with fluoride is governed by the solubility product principle. The solubility products (Ksp) of CaF_2 and MgF_2 are 3.9×10^{-11} and 6.4×10^{-9} respectively, imply that only when the product of ionic concentrations of calcium and fluoride in water exceeds 3.9×10^{-11} and that of magnesium and fluoride exceeds 6.4×10^{-9}, will salts of these precipitate out. Otherwise, when the level of fluoride increases, levels of calcium or magnesium decrease automatically. The observed results do agree with the above argument.

The concentration of fluoride in all the four groundwater sources was above the permissible range of 0.6-0.8 mg/l thus according to fluoridation of water suppliers regulations of 2007. According to WHO standards, the concentration is falling within the allowable range of 1.0-1.5 mg/l (WHO, 2004). At concentration of fluoride ranging from 0.5 mg/l to 1 mg/l dental fluorosis may be prevented. However, with concentrations higher than the set limit, dental fluorosis is possible. In the study area, due to inefficient defluoridation technologies or lack thereof, the incidence of dental fluorosis, including pitting and alteration of tooth enamel is quite high. This could be due to prolonged consumption of the water and consequent deposition of fluoride since this ion is non-degradable and has cumulative effect.

CONCLUSION

The study has shown that concentrations of hardness, alkalinity and sulphates were notably lower in the wet season and higher in the dry season and were negatively correlated with fluoride concentration. Although the concentration of fluoride was relatively low, the dental fluorosis observed in the area suggests that the concentrations are a threat to the communities continuously consuming the water in the study area. It may be recommended that communities in the area should use alternative water sources such as rainwater in rainy season when the concentrations are high.

ACKNOWLEDGEMENT

The authors would like to give special thanks to the Central Water Laboratory in Lilongwe, Malawi, for the use of their spectrophotometer to determine fluoride levels.

References

Abudullahi NK, Osazuwa IB, Sule PO(2011). Application of the integrated Geo-physical techniques in the investigation of ground water contamination. A case study of municipal solid waste. Ozean J. Appl. Sci. **4(1**): 7-25.

Adekunle AA, Badejo AO, Oyerinde AO(2013). Pollution studies on ground water contamination. Water quality of Abeokuta , Ogun State, South West Nigeria. J. Environ. Earth Sci. **3(5):** 161-166.

Adetunji VO, Odetokun IA(2011). Groundwater contamination in Agbowo community, Ibadan Nigeria: Impact of septic tanks distances to wells. Malaysian J. Microbiol. **7(3)**: 159-166.

Akankpo AO, Igboekwe MU(2011). Monitoring Groundwater Contamination Using Surface Electrical Resistivity and Geochemical Methods. J. Water Resource and Protection. **3**: 318-324.

AOAC(2002). Association of Official Analytical Chemists. (Maryland, USA:AOAC)

Appelo C, Postma R(1999). Chemical analysis of groundwater. In A. Balkema, *Geochemistry of groundwater and pollution.* (Rotterdam, Bookfield).

Jumma JA, Toriman ME, Hashim N(2012). Groundwater Pollution and Wastewater Management in Derna City, Libya. Environ. Res. J. 6(1): 50-54

Malawi Goverment Government (1996). National environmental Policy . Lilongwe: Ministry of Natural Resources and Environmental Affairs.

Malawi Government (1998). State of Environment Report for Malawi. Lilongwe: Ministry of Natural Resources and Environmental afffairs.

Meenakshi R(2006). Fluoride in drinking water and its removal. *J. Hazardous materials B. 137*: 456-463.

Sandhyarani N(2013). Ground water pollution. Retrieved on November 1, 2013 from: http://www.buzzle.com/articles/ground water pollution.html.

Thole B(2013). Ground water contamination with fluoride and potential fluoride removal technologies for East and Central Southern Africa. In

''Perspectives in water Pollution'' Ahmad I. and Ahmad M. (Eds) In tech Publishers. Pp. 65-95.

Timmons M, Ebeling J, Wheaton F, Summerfelt S, Vinci B(2002). *Recirculating Aquaculture Systems, 2nd ed.* Ithaca, N.Y: CAYUGA AQUA VENTURES.

Ullah R, Malik RN, Qadir A(2009). Assessment of groundwater contamination in an industrial city, Sialkot, Pakistan. Afr. J. Environ. Sci. Technol. **3 (12):** 429-446,

UNEP (2003). Groundwater and its susceptibility to degradation: *A global assessment of the problem and options for management.* UNEP, Nairobi. A report. Pp. 140.

Waziri M(2006). Physiochemical and Biological investigationof surface and groundwater of the Kumadugu- Yobe basin. *Unpublished PhD Thesis Department of chemistry of Maiduguri* . 24-186.

WHO (1994). International standards for drinking water from quality criterai and standards for industrial effluents by R.M. Santanello. In H. F. Lund, *Industrial pollution control handbook* (pp. 4/23-4/39). New York: Mc Graw Hill book. Co.

WHO(2004). Guidelines for drinking water quality. *3rd edn, vol. 1, Recommendations, World Health Organisation: Geneva* .

Yamada Y(2007). Treatment of drinking water in the rural villages in Malawi. Water for people country strategy report. Retrieved on October 16 from: http://repo.lib.ryukoku.ac.jp/jspui/bitstream/10519/305/1/rd-ho-kn_011_008.pdf