



Evaluation of groundwater quality in rural-areas of northern Malawi: Case of Zombwe Extension Planning Area in Mzimba



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ARTICLE INFO

Article history:

Received 26 March 2015

Received in revised form

21 October 2015

Accepted 17 March 2016

Available online 22 March 2016

Keywords:

Boreholes

Groundwater

Mzimba

Zombwe Extension Planning Area

Water quality

ABSTRACT

Many people in the Sub-Saharan region rely on groundwater for drinking and other household uses. Despite this significance, information on the chemical composition of the water in the boreholes and empirical data on groundwater quality is limited in some rural areas of Malawi. This study was conducted to evaluate the physico-chemical quality of water from boreholes ($n = 20$) in Zombwe Extension Planning Area (EPA), Mzimba in Northern Malawi to ascertain their safety. Desktop studies and participatory approaches were employed to assess the socio-economic activities and water supply regime in the study areas. The water samples were analysed for pH, conductivity (EC), turbidity, water temperature, nitrate (NO_3^-), magnesium (Mg), calcium (Ca), zinc (Zn), fluoride (F^-), and sulphate (SO_4^{2-}). In-situ and laboratory analyses were carried out using portable meters and standard procedures. The results were compared with national (Malawi Bureau of Standards – MBS) and international standards (World Health Organization – WHO) for drinking water. The following ranges were obtained: pH (6.00–7.80), EC (437–3128 $\mu\text{S}/\text{cm}$), turbidity (0.10–5.80 NTU), water temperature (27.0–30.60 °C), NO_3^- (0.30–30.00 mg/L), F^- (0.10–8.10 mg/L), Mg (31.00–91.00 mg/L), Ca (20.00–197.10 mg/L), SO_4^{2-} (10.20–190 mg/L), Fe (0.10–3.60 mg/L) and Zn (0.00–5.10 mg/L). Generally, some parameters tested at several sites ($>80\%$, $n = 20$) complied with both MBS and WHO limits. No significant differences ($p > 0.05$) was observed for most parameters ($>65\%$, $n = 11$). Groundwater contamination was not significant in the area despite some parameters like F^- , Ca and SO_4^{2-} showing higher levels at other sites. Some sites registered very hard water (244.60–757.80 mg/L CaCO_3) probably due to mineralization influenced by underground rock material. Further studies are needed to ascertain the groundwater quality of other parameters (like F^- , and SO_4^{2-}) which registered higher levels at some sites. Routine monitoring of the groundwater in the study area and entire Malawi is needed for spatio-temporal variation assessment and to ensure good public health.

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1. Introduction

1.1. Ground water sources

Water is essential to sustain human life and is at the centre of Sustainable Development Goals (SDGs) which target to ensure availability and sustainable management of water and sanitation for all by 2030 (UN, 2015). Lack of access to sufficient water supply of acceptable quality leads to incidences of waterborne and sanitation related diseases which affect public health and the country's

economic productivity (WHO, 2008; WHO/UNICEF, 2015). Water demand is a crucial concern in Southern Africa because of the increasing human population and the associated demands for resources. Many people in developing world, usually in the rural areas, are affected most due to inadequate resources to invest in water supply and sanitation (GWP, 2010). Nearly all the 748 million and 2.5 billion people who lack adequate water supply and sanitation services respectively live in rural and informal urban settlements in the developing countries (MDG Report, 2006; WHO/UNICEF, 2015).

The most important pools of water sources from human point of use are the surface and ground waters. Surface water comprises water that flows across the land in the form of rivulets, springs, streams and rivers or it collects to form ponds, lakes and seas. In

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contrast, groundwater is located in aquifers underground and relates to surface water through percolation, wells and springs (Manahan, 1993; Pierzynski et al., 2005). Due to challenges associated with surface water including natural seasonal and annual variations of river flows, groundwater has gained increasing attention as a source of water supply owing to its relatively large storage capacity and low susceptibility to pollution. Groundwater resources occur in natural formations or geological strata saturated with water of good hydraulic conductivity to supply economic quantities of water to a pumping well or spring (Freeze and Cherry, 1979). Groundwater is also considered the most abundant available reservoir of freshwater resources on earth representing about 97% (Freeze and Cherry, 1979; Schneider, 2014). However groundwater is susceptible to contamination if not properly protected from sources of contamination. The chemical, physical as well as microbiological quality of groundwater used for human consumption in developing countries is a significant, but neglected public health issue (WHO, 2008). While Malawi has generally made significant progress in provision of safe and potable water by about 67% proportion of the 2015 population (World Health Organization and UNICEF, 2015) and an estimated coverage of 81% (Government of Malawi (GoM), 2014), the country still faces challenges to address water supply in rural and informal settlements. Like many other countries in Africa, the country relies on groundwater as a major source of drinking water supply for its dispersed rural population (GoM, 2014).

Earlier studies in Malawi (Chilton and Smith-Carington, 1984a,b; Chiphambwa et al., 2009) reported that weathered basement aquifers are important for rural water supply as they cover most of the country. Although borehole supplies are used by a significant percentage of the population in Malawi, information on the chemical composition of the water in these boreholes is either scanty or non-existent (Bath, 1980; Chilton and Smith-Carington, 1984a,b; McFarlane and Bowden, 1992; Kanyerere et al., 2010; Palamuleni, 2002; Sajidu et al., 2008). Furthermore, empirical data on groundwater quality is absent in some rural and peri-urban areas of Malawi where use of boreholes is common. In an attempt to address this knowledge and information gap, a study was

conducted in Zombwe Extension Planning Area (EPA), Mzimba, northern Malawi to determine the groundwater quality. In the study, selected physico-chemical water quality analyses were undertaken for the sampled boreholes ($n = 20$) in order to determine their suitability for drinking and other domestic uses. Desktop study and participatory approaches were also conducted to understand the groundwater dynamics in the study area.

1.2. Description of the study area – Zombwe EPA, Mzimba

The study was conducted in Zombwe Extension Planning Areas (EPA) under Mzuzu Agriculture Development Division (ADD) in Mzimba, Malawi (Fig. 1). Mzimba is the largest district found in the Northern Region in Malawi. The district borders with Zambia to the West, Kasungu to the South, Nkhatabay to the East, Nkhosakota to the South East and Rumphi to the North (Fig. 1). The total land area of the district is estimated to be 10,430 Km². An average annual rainfall for the district is 3500 mm while the annual mean temperature varies from 15.5 to 19.8 °C (Mzimba District Socio-Economic Profile, 2008; NSO, 2008). According to the NSO (2008) Census, the total population of the district was estimated at 724,873 representing 5.5% of the country's total population of 13.1 million as of 2008. The intercensal population growth rate for the district is 3.8% per annum. Agriculture is the major economic activity, with much of the land being under subsistence farming. There are four major physical features in the district namely; Vipha highlands in the east, the plains in the west, the hill zones and natural forests (Mzimba District Socio-Economic Profile, 2008).

Mzimba is covered mainly with medium to light textured but moderately fertile eutric-fersialic soils (Mzimba District Socio-Economic Profile, 2008; MoWD, 2005). Mzimba district is reported to be underlain by a basement of Precambrian to Lower Palaeozoic low grade metamorphic gneisses. Earlier studies have also shown that the basement rocks, localized to the north western edge in the South Rukuru and Kasitu valleys, are Karoo sedimentary rocks (Carter and Bennet, 1973; Gaskell, 1973; Hopkins, 1973). A report by MoWD (2005) classified Mzimba north as high, moderate and low groundwater potential areas.

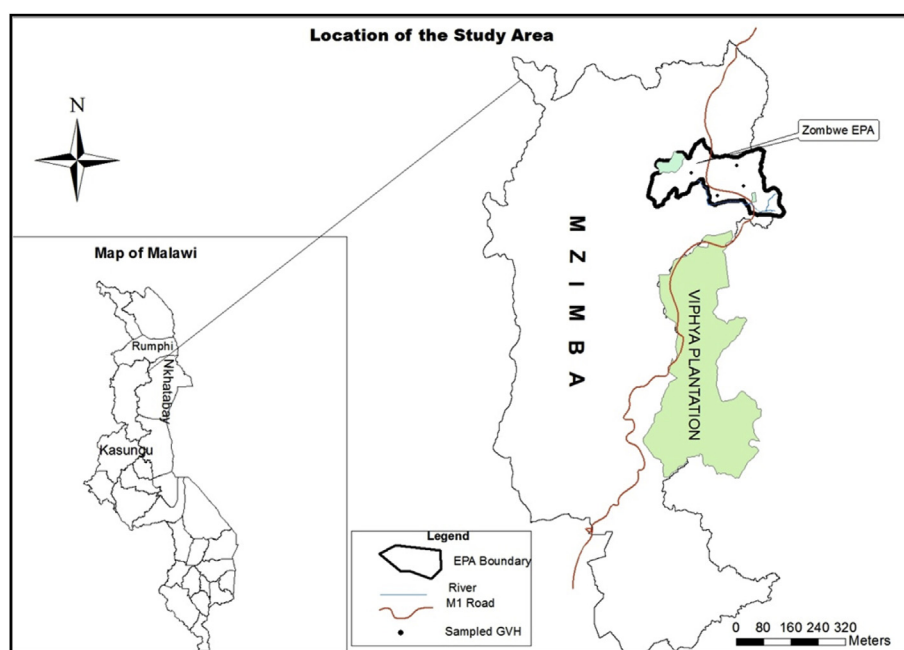


Fig. 1. Map of Zombwe EPA in Mzimba, Malawi.

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