Physics and Chemistry of the Earth 35 (2010) 823–827

Contents lists available at ScienceDirect

Physics and Chemistry of the Earth

journal homepage: www.elsevier.com/locate/pce

# The impact of water scarcity on environmental health in selected residential areas in Bulawayo City, Zimbabwe

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ARTICLE INFO

*Article history:*
Received 19 February 2010
Received in revised form 7 June 2010
Accepted 25 July 2010
Available online 8 August 2010

*Keywords:*
Water scarcity
Environmental health
Disease profile
Bulawayo
Zimbabwe

ABSTRACT

This paper assesses the extent of water scarcity at household level and the resultant environmental health impacts in Bulawayo, Zimbabwe's second largest city. The paper is based on two separate surveys that were undertaken in low and high income suburbs between June 2007 and January 2008. The first survey investigated the extent and impacts of water scarcity at household level. Data was collected by means of a household questionnaire, key informant interviews, review of clinic records and physical observation. The second survey assessed microbial levels in the main water sources and was complemented by examining water-related disease profiles. Water scarcity was found to be more severe in low income than in high income suburbs. This was a consequence of the city's skewed water distribution policy which favoured the former and failure by residents of the latter to invest in safer water alternatives. Per capita water consumption in both suburbs was below internationally recommended levels. Microbial assessment indicated presence of coliforms in water obtained from the tap and alternative sources at levels above WHO and Zimbabwean standards. Water scarcity resulted in an increase in the incidence of water-related diseases and environmental contamination. The evidence suggests that water scarcity in Bulawayo represents a huge cost to residents and the environment.



## 1. Introduction

Increasing urbanization throughout the world is putting a strain on the provision of basic social services such as safe clean water, and adequate sanitation in urban areas (Srinivas, 2009; UNEP, 1998). In 1950 there were less than 100 cities with a population in excess of 1 million compared to 2000 when some 23 cities, 18 of them in the developing world, were cited to have populations exceeding 10 million. This number is expected to rise to 650 by 2025. On a global scale, half of the world's people now live in urban areas, with the percentage projected to increase to 60% by 2030 (Richards, 2002). This implies that the current number of 500 million urban residents without appropriate access to safe water (USAID/PADCO, 2001) will increase substantially. Against this background it is no wonder that water scarcity is emerging as a big challenge in urban areas. Water scarcity is defined as the point at which aggregate impact of all users impinges on the supply or quality of water under prevailing institutional arrangements to the extent that the demand by all sectors, including the environment, cannot be satisfied fully (UN, 2006).

The problem of water scarcity is worse in regions like southern Africa, of which Zimbabwe is a part, where underdevelopment that is characterised by financial, human and institutional constraints, is widespread (Swatuk, 2008). The problem is not helped by a burgeoning population – the region experienced a population boom in the past 20 years especially in the urban areas where the population increased at a rate of 6.5% per annum, thanks to the cessation of civil and regional wars that raged between the 1970s and the 1990s. The rate of urbanization and general population growth has been found to exceed the capacities of local authorities to provide essential services. In Zimbabwe the problem has been compounded by weak governance systems (Musemwa, 2008).

Water problems that confront Bulawayo, Zimbabwe's second largest city, are well documented, and are mainly attributed to the poor rainfall that characterises its catchment (Mkandla et al., 2005; Taigbenu and Ncube, 2005; Gumbo, 1994; Binnie et al., 1993). Water scarcity in the city is severe and, in some cases, can be extreme. In September 2007, for example, only 46–48% of its daily water requirement was being met because the supply dams had been decommissioned due to small water inflows (The Chronicle, 2007). Despite the impressive documentation of water scarcity in Bulawayo, there are no known studies that deal with the extent and impacts of water scarcity on the human and physical environment at the local level. This is despite the fact that water scarcity is

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doi:10.1016/j.pce.2010.07.028

known to have negative impacts on physical, biological and socio-economic aspects of the environment (Davis, 1993).

This paper reports on the extent of water scarcity and the resultant environmental impacts in the city of Bulawayo at the household level. This is against a backdrop of residents being known to consume only a third of the globally accepted per capita water consumption of 50 l (Singizi, 2007; Gumbo, 2004; Gleick, 1999). The paper presents results of two separate surveys undertaken between June 2007 and January 2008. The main objective of the first survey was to assess the extent and environmental impacts of water scarcity at the household level while the second sought to assess the microbiological quality of the main and alternative water sources.

## 2. Methodology

### 2.1. Study area

The city of Bulawayo is located in south west Zimbabwe, in the drought prone and semi-arid Matebeleland region. It lies 1350 m above sea level on the apex of the watershed between the Zambezi and Limpopo rivers. The geographical and climatic conditions are such that Bulawayo receives low and unreliable rainfall. The average annual precipitation is 587 mm (Chenje et al., 1998). Mean annual runoff is also poor and falls within the 17–19 mm range. The rivers in the area are dry for the most part of the year. Storing water in large and deep reservoirs is difficult in most areas because of the flat terrain.

The population of Bulawayo is nearly 1 million (Mutengu et al., 2007). Residential areas in the city can be categorized into four, namely low-density areas, high-density areas, plots and inner city dwellings. High-density areas are located on the western part of the city, and are overcrowded. Generally less affluent people reside in these areas. Low-density areas are located in the eastern part of the city and are characterised by fewer people per unit land, and tend to be inhabited by relatively affluent people. Plot and inner city dwellings were regarded as low-density areas for purposes of this study.

The surveys were carried out in the low income suburbs of Mpopoma and Pumula, high income suburb of Khumalo, and the peri-urban suburb of Robert Sinyoka. In Mpopoma houses are arranged in blocks with about 32 houses per block. There are 96 blocks of such houses. More than one family lives at most of these premises. The average number of residents per house is 10. Mpopoma was included in the study because it is one of the oldest suburbs in the city (BCC, 1994). Robert Sinyoka and Pumula are located 14 km and 10.5 km respectively in a westerly direction from the city centre. Khumalo is a low-density area that was developed in the late 1980s.

The city is dependent on five major dams for its water supply, namely Insiza, Upper and Lower Ncema, Umzingwane, and Inyankuni dams, which have a combined capacity of 353 $Mm^3$ (Mkandla et al., 2005). Currently the water supply system serving the city is made up of two functional water treatment plants, namely Criterion and Ncema which have a combined water treatment capacity of 265,000 $m^3$/day. Water is pumped from Criterion water works, the city's main reservoir, to any of the other five reservoirs, which are Tuli Hill, 6 J, Rifle Range, Hillside, and Criterion. From there it is either pumped to several water towers or supplied directly to consumers. Water destined for the eastern suburbs, which include Khumalo, Saurcetown, and Hillside is pumped to consumers straight from the Hillside Works. Water destined for the western areas, which include Magwegwe, Mpopoma and Lobengula, is pumped to Magwegwe tower from where it is distributed to households mainly by gravity (Ndlovu-BCC, personal communication, 2008).

### 2.2. Data collection

#### 2.2.1. Water scarcity and environmental impacts in Mpopoma and Khumalo

Data was collected by administering a questionnaire to 25 respondents in Mpopoma and Khumalo respectively. This was complemented by interviews held with key informants, and physical observation of environmental contamination. In Mpopoma 25 houses were randomly selected from houses numbered B1–B96. In Khumalo stratified sampling was used in order to get a representative sample since the suburb has both high and low lying areas. The suburb was divided into five strata demarcated by major roads. Random sampling was used to select households within the stratum.

The questionnaire was designed to find answers to the following: general household characteristics; nature of water supply; water use patterns; alternative water sources; impacts of water shortages on human health; water conservation/coping strategies; and effects of water scarcity on the social and physical environment. Water rationing schedules, from the city, which gave an indication as to the number of days that the city council was supposed to be supplying water to the two areas, were studied. These were used to triangulate data obtained from the questionnaire. Interviews were held with the secretary of the residents' committee, a senior water engineer at Criterion water works, and the nursing sister in charge at Mpopoma clinic in order to get insight on the nature and magnitude of the problem. Data was analysed using Statistical Package for Social Scientists (Version 10) to obtain descriptive statistics such as percentages and frequencies.

#### 2.2.2. Microbial assessment of groundwater quality in Pumula and Robert Sinyoka

Water quality sampling was undertaken in Pumula (Old, North and South), and Robert Sinyoka suburbs. Coordinates of sampling sites were determined using a Global Positioning Systems (GPS) device. Three samples were collected per sampling point starting from December 2007 through to January 2008. Samples were collected in 300 ml sterilized glass bottles, and stored in an ice packed cooler box or refrigerator at ±4 °C to minimize microbial population fluctuations. When collecting tap water samples, the tap was heated with an open flame using butane gas cylinder so as to induce aseptic conditions.

Analysis for coliform bacteria (total coliforms, faecal coliforms, *Escherichia coli* and faecal streptococci) was undertaken using the membrane filter method (Standard Methods, 1998). Inoculum from the BGBB tubes from the total coliform confirmatory test was plated on MacConkey agar plates. Pink/red colonies were isolated and examined for the following characteristics; glucose utilization, indole test, lactose fermentation (negative) and urea hydrolysis (negative) to test for *Salmonella*. Data on waterborne diseases, such as dysentery and diarrhoea, were obtained from the local clinic in Pumula. The clinic serves both Pumula and Robert Sinyoka.

Trends in the data were analysed using MINITAB statistical package to determine spatial variance between sites, effects of microbes on water quality, and interaction between organism type and water source. Analysis of variance package (ANOVA) was used to assess statistical differences.

## 3. Results and discussion

### 3.1. Water scarcity and environmental impacts

#### 3.1.1. Water supply/availability

The majority of households in Mpopoma received tap water only 2 days per week whereas in Khumalo they received water for longer