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Compliance to Bacteriological Standards for Bottled Drinking Water Sold in Lusaka District Zambia

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DEDICATION

This work is dedicated to my family; Dad and Mum; Mr and Mrs Wallace and Christine Meki and all my siblings; Coretta, Charity, Wallace, Linda, Webster, Bruno and Ben for their encouragement.

DECLARATION

I, the undersigned declare that this dissertation entitled 'Compliance to Bacteriological Standards for Bottled Drinking Water Sold in Lusaka District Zambia' presents my own work that it has not previously been submitted for the degree at the university of Zambia or at any other university and that it does not incorporate any published work or material from other thesis.

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APPROVAL

The University of Zambia approves this dissertation by Chisala D. Meki as fulfilling part of the requirements of Master Degree in Public Health (Environmental Health)

EXAMINERS' NAMES AND SIGNATURES

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Above all, I give 'all the glory to my heavenly father God for giving me the grace to live to the completion of the report.'

LIST OF ABBREVIATIONS

CAC : Codex Alimentarius Commission

CFU : Coliform Forming Unit

E. coli : Escherichia coli

FC : Faecal Coliform

FDA : Food and Drugs Act

FSA : Food Safety Agency

LCC : Lusaka City Council

PHA : Public Health Act

SDWF : Safe Drinking Water Foundation

TC : Total Coliform

TNTC: Too Numerous to Count

UNICEF: United Nations International Children's Emergency Fund

WHO : World Health Organisation

ZABS : Zambia Bureau of Standards

ABSTRACT

Many people in Zambia and world over perceive bottled water as safe for consumption. However, studies have indicated that not all bottled water is up to standards. This study aimed at establishing compliance to bacteriological quality standards of bottled drinking water sold in Lusaka district and also at establishing factors associated with compliance to standards by water bottling companies.

A cross sectional study was conducted in Lusaka district from December 2013 to July 2014. The study population consisted of 14 selected water bottling companies and a total of 116 workers. Data was collected through water sampling and oral guided interviews with regular workers and supervisors including observations for triangulation purposes. Interviews were used to obtain information about the factors associated with compliance with standards and water samples to get information about the bacteriological quality of water and level of compliance. Water was sampled from selected companies and at the market (supermarkets, grocery shops and other distribution centres). A total of 56 samples of bottled water were collected, four for each brand of which two were drawn from the companies and two from the market at a 10 to 14 days interval. Water was tested for total and faecal coliform using membrane filtration technique. Data was entered in EPI data version 3 and analysed using Stata version 11 to get summary statistics, p-values, odds ratios and 95% confidence intervals.

A total of 112 water bacteriological testing were conducted consisting of 56 tests for faecal coliform and 56 for total coliform. The study revealed 8.90 percent of analysed samples positive for both faecal and total coliforms in every 100ml of water. The level of faecal and total coliforms contamination ranged from two coliform forming units (cfu) to too numerous to count (TNTC) and nine cfu to TNTC for faecal and total coliforms respectively. The study also revealed that out of 14 companies sampled, five (35.7 percent) companies were not complying with standards. Knowledge on standards was the only factor associated with compliance with a p - value of 0.016 and adjusted odds ratio of 0.139.

The study revealed that not all water sold in Lusaka district was of good quality and only 64% of the companies complied with standards. It is therefore, important that all stakeholders involved in bottled water in Zambia work together to ensure water sold to the public is up to standards.

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CHAPTER ONE: INTRODUCTION

1.1 Background Information

It is reported that over 1 billion people in the world lack potable water (UNICEF, 2006). Potable water is water of high quality that could be consumed without risk of acute or chronic harm or injury free from chemical, biological and physical contaminates. One of World Health Organization (WHO) primary goals is access to adequate supply of safe drinking water for all. However, this goal is far from achievement in most developing countries especially in the rural and peri-urban areas as over 5 million people die annually of water-borne diseases such as; cholera, typhoid, diarrhoea, polio and meningitis (Taiwo *et al*., 2010).

Despite the abundance of water covering 71% of the earth surface, people spend billions of dollars per year to buy purified water that has been pre-bottled. Most people around the world regard bottled water as that which needs no further treatment, as it is processed into a wholesome state before being put on the shelf. Consumers have various reasons for purchasing bottled drinking water such as taste, convenience or fashion, but for many consumers' safety and potential health benefits are important considerations (Nyundu *et al*, 2012). However, in reality there is no guarantee that processed and packed bottle water is absolutely safe. This is because studies that have been conducted indicate the presence of contaminants in bottled water sold for human consumption.

Studies conducted by various scholars indicate that not all companies in Zambia are complying with the set recommended standards, especially for bacteriological parameters such as *Escherichia coli (E. coli),* total coliforms and faecal coliform. The compliance levels were as low as 40% and this is as opposed to non-compliance which was as high as 60% (ZABS, 2000: Nyundu *et al*., 2012 and LCC, 2012).

In Zambia, it is the responsibility of Zambia bureau of standards (ZABS) and the Lusaka city council (LCC) supported by various laws and regulations such as food and drugs act and Zambia Bureau of Standards (ZABS) regulations, to ensure that bottled drinking water is up to the recommended standards. Water bottling companies also have a role to play in ensuring that standards are followed by making sure that they adhere to all hygiene standards in handling and use of appropriate methods in processing the products.

1.2 Problem Statement

Despite the laid down laws and regulations that guide water quality, most companies in Zambia do not meet the standards for bottled drinking water qualities (LCC, 2012). For example, assessment of water qualities in Lusaka by the LCC in the Public Health Department revealed that most of the companies dealing in bottled water did not meet the bacteriological standards related to water quality. To this effect LCC recommended for the closure of nine companies which treated and packaged bottled water not fit for human consumption contrary to standards as stipulated in Food and Drugs Act Chapter 303 of the Laws of Zambia (Times of Zambia, 30th June, 2012 and LCC, 2012). Among the fifteen (15) water bottling companies in Lusaka, only six were producing a commodity that was fit for human consumption representing 40% and the other nine (60%) companies were producing a commodity not absolutely fit for human consumption.

In addition, a study conducted by Nyundu et al., (2012) on bottled drinking water in Zambia established that bottled water was not absolutely safe for direct drinking and potentially posed a risk to human health. The study established that out of 233 of bottled water sampled, 68% were found to be safe as opposed to 32% which was unsafe. This is because the majority of the water samples had unacceptable levels of bacteriological parameters i.e. *E. coli,* total coliform count and other microbial. Out of the 39 brands sampled only 15(38%) complied with the microbiological standards of zero fecal coliforms per 100ml. A total of 24 brands (62%) out of 39 had at least 1cfu/100ml contrary to WHO standards that were employed as standards in the study.

It is therefore undeniable that if the bottled water being sold is not up to standards, consumers are prone to diseases and water poisoning. This could be one of the main contributing factors to high cases of diarrhea and other water related diseases. The fact that consumers are at risk calls for further investigation.

Studies that have been conducted on water safety and its quality in Zambia show that little is known on bacteriological standards of bottled water and factors that are associated with compliance to bacteriological standards by water bottling companies. This poses a gap that this study seeks to fill. This study will therefore aim at establishing the level of compliance to

bacteriological standards and look at factors associated with compliance to standards by water bottling companies in Lusaka district.

1.3 Study Justification

Despite various laws and policies that guide water standards such as the Public Health Act and statutory regulatory organisations such as ZABS, available literature indicates that most companies in Zambia do not comply with standards (LCC, 2012). While most of the studies have ended at acknowledging the fact that most companies do not comply with the recommended standards, investigations have not been carried out to find out compliance to standards of bottled drinking water and factors associated with compliance to bacteriological standards. It is therefore hoped that this study will bring out information on the bacteriological standards of bottled drinking water and the factors that are associated with compliance to standards.

By investigating the level of compliance and factors associated with compliance to bacteriological standards of bottled drinking water in Lusaka, this study may provide valuable insights into what remains to be done in this area. This study may also help policy makers and other agencies concerned with standards of bottled water such as the LCC and ZABS to make relevant decisions on bottled water in Zambia, thereby improving the health of the public.

The findings may also be useful to other stakeholders especially, the general public in the sense that they will be able to know whether the water they are drinking is safe or not. Members of the public may also use the findings of the research to make informed decision on the water they decide to buy and drink and seek for good quality.

In addition to the benefits stated above, the study will add to the existing body of knowledge on standards of bottled water and factors affecting compliance to bacteriological standards.

The points listed above, warrant that this study is conducted.

1.4 Research Question

What is the level of compliance to bacteriological quality standards of bottled drinking water sold in Lusaka district and factors associated with compliance to bacteriological standards of bottled drinking water in Lusaka district?

1.5 Objectives

1.5.1 General Objective

To establish compliance to bacteriological quality standards of bottled drinking water sold in Lusaka district and factors associated with compliance to standards by water bottling companies.

1.5.2 Specific Objectives

1. To determine the bacteriological quality standards of bottled drinking water sold in Lusaka district.
2. To determine level of compliance to bacteriological standards of bottled drinking water by water bottling companies in Lusaka district.
3. To assess factors associated with compliance to bacteriological standards of bottled drinking water by water bottling companies in Lusaka district.

1.6 Operational Definition of Concepts

Compliance: means adherence to set bacteriological standards of water by WHO, FDA and ZABS i.e. zero cfu in every 100ml for total and faecal coliform.

Standards: refers to minimum acceptable limit levels for bacteria in bottled drinking water.

Bottled Water: refers to drinking water packaged in plastic or glass water bottles for sale.

Regular worker: refers to a worker involved in handling water at filling and or sealing stages other than the supervisor.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter presents the information gathered from various scholars on the subject of bottled drinking water in Zambia and around the world. The information reviewed is presented under the following headings; overview/general perspectives of bottled water around the world, bottled drinking water in Zambia, dangers associated with contaminated water, standards of bottled drinking water and level of compliance, factors associated with compliance to standards and legal support of bottled drinking water standards.

2.2 General Perspective of Bottled Water

Bottled drinking water has been a growing industry around the world. The water is packed either in glass or plastic bottles. The sizes of the bottle range from small to large containers. Bottled water appears clear to the human eye, is conveniently packaged and marketed. Many people tend to assume that bottled water is treated, clean and safe for drinking. However consumers should be aware of the fact that bottled water is not necessarily safer than tap water. This is because bottled and municipal (tap) water may contain the same microorganism since both originate from the same source (Nyundu *et al*., 2012).

2.3 Bottled Drinking Water in Zambia

Bottled water has been a growing industry in Zambia and most people in Zambia perceive bottled water to be better than tap water in terms of quality. In addition the prevalence of cholera, dysentery and other waterborne diseases in many parts of Zambia coupled with perceived poor quality of municipal tap water has tremendously increased the consumption of bottled drinking water (Nyundu *et al*., 2012).

According to Zambian law, all companies that deal in bottled water must register with the local authority and ZABS in order to ensure qualitative production of potable water for the populace. These authorities are mandated to conduct random sampling or checking of the standards of bottled drinking on water four times in a year and general operation requirements every quarter in a year. Despite these inspections or random checks by the authorities , there is presence of counterfeit brands of bottled water on the market, which in

one way or the other has been posing threat to people's health (LCC, 2012). Analysis of these bottled water is therefore pertinent for qualitative examinations since water from various sources (groundwater, spring, distilled and tap) is bottled, packaged and sold to the vulnerable masses. Lusaka remains one of the biggest markets for many brands of bottled water in Zambia. The demand for bottled drinking water applies mostly to the middle and high income social classes due to its relative high cost.

A number of parameters must be considered or analysed in ensuring that water consumed by people is of high standard. These parameters include microbial organism(s), chemicals such as nitrite and pesticides, metals such as lead and copper, and how it looks, tastes and so on. Besides being important, water can be a source of infections and a medium for transmission of diseases. It is therefore important to ensure that water that the public consumes is of recommended standards (GRZ, 1995).

2.4 Dangers Associated with Contaminated Water

A wide variety of pathogens such as viruses, protozoa and bacteria are found in water. These micro-organisms cause diseases such as gastroenteritis, giardiasis, hepatitis, typhoid fever, cholera, salmonellosis and dysentery (SDWF, 2005). Although disease outbreaks due to contaminated bottled water are rare, any contamination may pose a unique hazard because of the widespread distribution.

Common microorganisms (bacteria) common in water that are dangerous to health include:

- Total coliform bacteria: primarily used as a practical indicator of the general hygienic quality of water and mainly used in routine monitoring of drinking water supplies.
- Fecal coliform bacteria: primarily used as a practical indicator of fecal pollution; which is more specific for fecal pollution than total coliforms; mainly used for assessment of fecal pollution of wastewater, raw water supplies and natural water environments used for recreational purposes.
- *Escherichia coli*: Highly specific indicator of fecal pollution which originates from humans and warm-blooded animals (Taiwo *et al*., 2010).

There have been multiple waterborne disease outbreaks from contaminated bottled water. The Centre for Diseases Control documented a cholera outbreak in the 1970s in Portugal. The contaminated water source of a bottled water company resulted in 2,467 hospitalized cases of cholera and 48 deaths. In 1994, a cholera outbreak occurred in a United States territory in the Marianas Islands. Approximately one-third of the residents on the island drank the brand of bottled water, which was contaminated with *Vibrio cholera.* Thousands of the consumers may have been exposed to the bacteria, but at least 11 became ill four of whom had to be hospitalized (SDWF, 2005). In the same line *Vibrio cholera* was isolated in drinking water which led to a cholera outbreak which led to a number of deaths (Blake *et al*, 1977).

2.5 Standards of Bottled Water and Levels of Compliance

In Zambia not much literature exists on the standards of bottled water. Little research has been done on the topic especially, in areas related to factors that affect or are associated with compliance to standards. However, according to available literature a study on bottled water established that not all the companies dealing in water are providing a wholesome product especially in the area of bacteriological standards (Nyundu *et al*., 2012). Further, an assessment done by the LCC revealed that most of the companies did not comply with bacteriological standards. In particular companies more than 60% did not comply to total coliform counts standard of not more than zero per 100ml of water of the brands contaminated with faecal coliforms and *E.coli,* which are supposed to be zero per 100ml in water (LCC, 2012).

A study conducted in Tanzania on the microbiological quality of bottled drinking water sold in Da. res salaam revealed that out of 130 samples representing 13 brands of water tested, 4.6% and 3.6% were contaminated with total and faecal coliform respectively (Kassenga, 2007). A study in Zimbabwe that involved sampling 60 samples of water from three companies, different batches and at different storage conditions revealed 11.7% of water tested exceeding the total coliform count Okagbue *et al,* (2002). Another study conducted in Ghana by Addo *et al* in 2009 which looked at bacteriological quality of bottled water sold on the Ghanaian market revealed sampled water being in compliance with WHO standards. Seven brands and 70 of bottled water were sampled tested over a period of 10 weeks. The water was tested for the presence of fecal and total coliforms and *E. coli*. The results revealed that all tested water was in compliance with the world health organization standards.

In most developed countries like the United States of America (USA) bottled water is seen as unsafe due to a number of recorded incidences of diarrhoea related diseases after consumption. It is for this reason that most of people trust and prefer tap water to bottled water (Muriithi, 2008). Stringent measures have been put up in most developed countries to ensure that the manufactures of water follow the standard of drinking water.

In Canada, the Canadian Food Inspection Agency visits a water bottling plant once in a 12 to 18 months period. In the United States, water bottling plants must test the source of water and finished products at least once per week for microbiological contaminants and at least once per year for physical, chemical and radiological contaminants (SDWF, 2005).

2.6 Factors Affecting Compliance to Standards

Limited studies have been conducted on factors affecting compliance to bacteriological standards of bottled drinking water. However, a few studies were found. Some factors have been drawn from studies conducted in relation to food safety. The main factors that have been found to be associated with compliance include: enforcement visits, frequency of water testing, knowledge, and training.

2.6.1 Enforcement Visits and Monitoring

According to Semerjian, (2011) and Muriithi, (2008), inadequate enforcement by health inspectors or enforcement officers' visits to monitor the way the company is running affects compliance. The studies have revealed that companies that are frequently visited by enforcement officers were more compliant than those that were not frequently visited. Another study conducted by Yapp and Fairman, (2004) revealed similar findings, indicating that inadequate enforcement visits contribute negatively to compliance as most of the companies that were visited during the study indicated association between compliance to standards and enforcement visits by the officers. According to legal requirements, enforcement visits must be conducted quarterly (four times in a year).

2.6.2 Frequency of Water Testing

In developed countries like the USA and United Kingdom, every water bottling company is mandated to have a laboratory and an officer in charge of water quality. This helps to easy testing of water before and after packaging. This is also important to ensure production of a

wholesome product. Research indicates that the companies that have their own laboratory were more complying with the standards than those without a laboratory. In addition, the frequency of water testing also contribute to the level of compliance as most companies that take water for testing frequently i.e. once in a week are likely to comply as they are able to detect the contamination in good time. The issue of inadequate frequency in testing is caused by lack of officers and laboratory facilities for testing (SDWF, 2005).

2.6.3 Knowledge on Standards

Ilyai *et al*, (2011) in his study revealed that knowledge on standards was a significant factor that was associated with compliance to standards. These findings are also in line with those by Muriithl (2008). Lack of knowledge can be attributed mainly to lack of legal and regulatory framework and guidelines (information). The studies concluded that the presence of guidelines help the manufacturer to produce a wholesome product if all precautions are put in place as indicated in the guidelines. A study conducted by Yapp and Fairman in 2004 on Factors affecting food safety compliance within small and Medium-sized enterprises: implications for regulatory and enforcement strategies in United Kingdom also revealed that knowledge was associated with compliance with standards in food establishments.

2.6.4 Training on Hygiene

Training on hygiene has been found to be another factor affecting compliance with set standards. Studies have revealed that companies that have trained personnel in food safety and hygiene are more likely to produce food that is of the required standards (FSA, 2006).

2.6.5 Legal Support on Bottled Water Standards

There are various laws and regulations that guide bottled drinking water. In Zambia, the law that govern bottled drinking water is the Food and Drugs Act Cap 303 (FDA). ZABS is a statutory organization established under the Act of Parliament; the Standards Acts Cap 416 of 1994 for preparation and promulgation of Zambian standards include bottled water standards. The following are the bacteriological standards of bottled water: according to Food and Drugs Act and ZABS the *E. coli* must be zero in every 100ml of water, total coliform bacteria must be less than 10 in every 100 ml and faecal coliforms must be zero in every 100 ml of water (ZABS, 2000). ZABS also specifies the description, treatment, testing, packaging and

labelling of bottled water for human consumption. Under the Food and Drugs Act, the standards of total, faecal coliforms and E. coli coliform forming units are supposed to be zero per 100ml.

According to the Public Health Act Cap 295 (2005) of the laws of Zambia, every person who wishes to open a water manufacturing plant must obtain a permit from the Local Authority authorising to run a water manufacturing company.

A sufficient supply of pure water, free from risk of contamination must be packaged or provided at the premises. The place at all times must be maintained in a clean state with adequate ventilation. The place should also be fly screened to prevent presence of flies in the area. In the same line, dust must be adequately catered in the manufacturing plant. The bottles used to package the water must be in a clean state. In addition, bottles in which the water is to be sold must be marked with a description of the contents and a clear indication of the name and address of the manufacturer (GRZ, 1995).

In terms of personnel, all staff handling water must be free from any infectious or contagious disease to ensure that they do not contaminate the water with the infections. By law every worker or water handler must be medically examined after every six months. It is also important to note that the medical officer of health and the health inspector have the right by law to enter any water manufacturing premises for inspection to check for compliance to the regulations (GRZ, 1995).

In addition, the shelf life of bottled water should be six months. The source of water must also be protected and a sample of water must be collected at the source during the rain and dry season to check for its standards (GRZ, 1995 and ZABS, 2000).

There are other regulations that exist that addresses bottled water. The inter-governmental body for the development of internationally recognised standards for food including bottled water is the Codex Alimentarius Commission (CAC) and WHO. Most countries around the world including Zambia have adopted the standards. The CAC has developed a codex standard for natural water and an associated code of practice. The codex standard describes the product and its labelling, compositional and quality factors, including limits for certain chemicals, hygiene, packaging and labelling. The codex code of practice for collecting,

processing and marketing of natural mineral water provides guidance to the industry on a range of good manufacturing practice matters (WHO, 2000).

Conceptual Framework

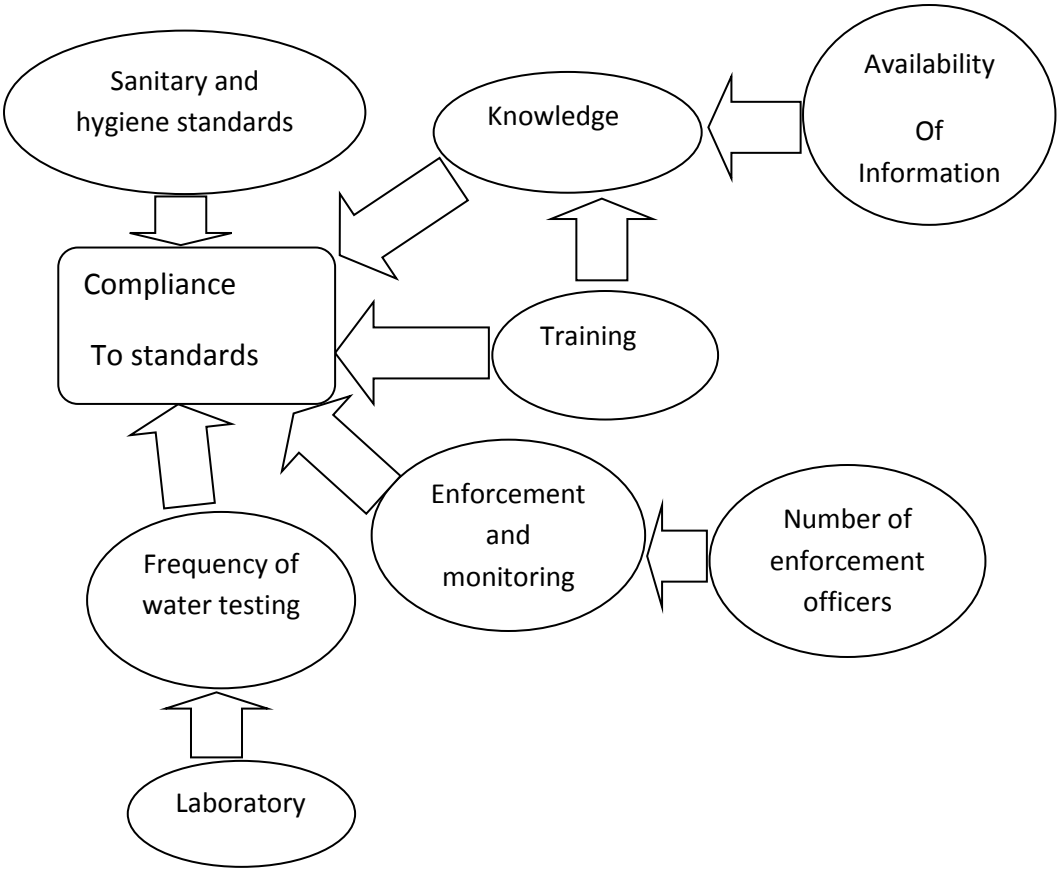

Figure 1: Conceptual Framework

The figure 1 portrays a conceptual framework that shows the factors associated with compliance. This model was borrowed from different scholars i.e. ((Semerjian (2011), Muriithi (2008), Yapp and Fairman, (2004), SDWF (2005) and Food Safety Agency (FSA - 2006)) and extended to suit the research. The major factors associated with compliance included in the model are: knowledge on standards, training on standards, enforcement and monitoring visits, frequency of water testing and sanitary and hygiene standards.

CHAPTER THREE: STUDY METHODOLOGY

This chapter describes the methodology of study. To achieve this, the chapter will cover the following: study design, study variables, study setting, target population including the inclusion and exclusion criteria, study population, sample size and sampling procedure, data collection management and quality control, data processing and analysis, water analysis, ethical considerations, disposal of data collection tools, pretesting of data collection tools and administration, monitoring and utilization of results.

3.1 Study Design

The study design was a cross – sectional study conducted from December 2013 to July 2014. It involved getting a snap shot situation of the prevailing bacteriological standards of bottled water and factors associated with compliance to bacteriological standards of bottled water.

3.2 Study Variables: Dependent and Independent Variables

The study employed different types of variables including the dependent variable, independent variables and other background variables. The dependent variable is compliance to bacteriological standards and the independents variable includes: knowledge on standards, training, frequency of enforcement visits, frequency of water testing, medical examination, size of the company and mode of certification. Other variables included the position of the worker and sex. The variables are described in detail in table 8 annex 1.

3.3 Study Setting

The study was carried out in Lusaka district which is also the capital city of Zambia. Being the largest city in Zambia, it is considered one of the fastest growing cities in the region (CSO, 2010). The level of unemployment in Zambia stands at 13% and in particular the majority of the unemployed are the youths standing at 16% in Lusaka province and 25.1% national (CSO, 2010). This high level of unemployment may be one of the contributing factors to the mushrooming of private companies. One stream of these private companies is water manufacturing companies.

There were 78 bottled drinking water companies in Zambia (ZABS, 2013), of which 26 were in Lusaka. These companies were divided into classes, according to sizes and the shares they

owned on the market which were large, middle and small. The companies were further classified according to certification status which can be either by certification or by permit. Those that were classified as large companies supply water mostly to the high class of consumers i.e. in hotels and established work places or organization. In contrast the middle and the small companies mostly supply water to the low classes of the population i.e. in peri-urban areas and other low class markets (ZABS, 2013).

3.4 Target Population

The target population consisted of all the 26 water bottling companies registered with ZABS and LCC.

3.5 Study Population

The study population included 14 water bottling companies in Lusaka district selected to take part in the study.

3.5.1 Inclusion Criteria: All water bottling companies in Lusaka district registered with ZABS and LCC that consented to the study.

3.5.2 Exclusion Criteria: All the water bottling companies registered with ZABS and LCC that were not picked to participate in the study and those picked who refused to give consent to the study. Including water bottling companies that operated outside Lusaka.

3.6 Sample Size and Sampling Procedure

The study targeted 54% of water bottling companies registered in Lusaka district, this was because of limited funds and time to cover the companies all companies were located in different locations around the city of Lusaka. In addition, the number was reasonably large as a representative sample.

The companies were sampled by firstly categorizing them into sizes i.e. small nine, medium 11 and large six. The number of companies to be picked in each category was determined using ratios or probability sampling proportional to size. This was done as follows:

Number of companies to be sampled in each category = Total Number of companies in each category / Total Number of companies x Total sample size required

For small companies	=	9/26	x	14	=	5
For medium companies	=	11/26	x	14	=	6
For large companies	=	6/26	x	14	=	3

A total of 14 companies were included in the study as determined from the calculations above.

The companies included in the study were picked using simple random sampling lottery for each category. In an event that the company picked did not give consent another company was picked to participate in study.

The overall size of the sample for the participants i.e. supervisors and regular workers as determined using the formula below was as follows:

The sample was calculated at 95% (1.96) confidence interval with predicted 60% (0.6%) as per companies not complying with bacteriological standards according to LCC (2012) and standard error set at 10% (0.1%). Using the formula below:

$$n_1 = \frac{Z^2\, p\,(1-p)}{e^2} = \frac{1.96^2\, 0.6\,(1 - 0.6)}{0.01} = 92 \text{ participants}$$

Where:

Z^2 = Z score at 95% (1.96)

P = predicted value as per companies complying to standards

e^2 = predicted standard error

The sample size was multiplied with a factor 2 to consider the design effect since the study units i.e. companies where categorised (stratified) according to size in the process of selection. The number of participants were therefore be 92 x 2 = 184.

Two sets of participants were included in the study at each company. These were regular workers and supervisors. A total of 14 supervisors were proposed to be asked to participate in the study one from each company. In terms of regular workers a total of 170 participants were proposed to be asked to participate in the study. The breakdown of these was as follows:

61 from the small companies, 73 from the medium companies and 36 from the large companies these numbers were calculated or determined using probability sampling proportional to category of the company. Twelve (12) regular workers were proposed to be picked at each company to participate in the study. In an event that the company had a total number of workers less than the target number of 12 regular workers, all workers were asked to participate in the interviews. The supervisors were chosen to participate in the study considering their role in the company and the fact that they were custodians of the basic information about the company. The regular workers were picked as they were the ones involved in the actual processes in the production of bottled water. Information from the two parties was compared and used for triangulation purposes.

Systematic sampling was used to select participants (regular workers) at each company. Firstly a sampling frame i.e. employee register was created at each company, with names arranged in alphabetical order. The K^{th} or sampling interval (SI) was determined by dividing the required sample size at each company i.e. 12, by the total number of regular workers at each company. The sampling starting point was determined by selecting a number using a probability random sampling lottery i.e. writing numbers on papers from 1 to the maximum number (total sample size) at each company. The numbers were then put in a box and pick one by one randomly.

In an event that the worker picked to participate was not in condition to answer the questions due to not consenting, absenteeism and other reasons, the data collectors asked the next worker on the sampling frame to participant in the study.

Only two companies had the complete number of participants i.e. 13 the rest of the companies had less than 13 participants. The number of participants therefore reduced to 116.

3.7 Data Collection, Management and Quality Control

The data was collected by the Principal Investigator with the help of three Research Assistants trained in data collection procedure and techniques. The study employed three techniques of data collection including water sampling of bottled water, oral guided interviews and observations.

- **Water Sampling:** Laboratory testing was employed to determine bacteriological standards of bottled drinking water. The following water parameters were considered: Total Coliform bacteria and Faecal Coliform using a method known as membrane filtration. A total of four samples of bottled water were picked four for each brand of which four of the samples were from the company and another two from the market. One sample at two different times for each brand and point was drawn after about 10 to 14 days intervals. Water from the companies was sampled at the packaging stage from the batches of water ready for distribution. In terms of the market water was purchased from the grocery shops, supermarkets and distribution centres randomly. The water was clearly marketed for identification. The study sampled four samples from each company as Food and Drugs Act cap 303 of the laws of Zambia recommends taking more than one sample of the product when determining compliance. The study used sampling procedures as specified by the WHO and or Food and Drugs Act lot sampling technique for quality control in industrial production which involved taking a small random sample from a set of bottled water at each company and from the market. The sampled bottled water was then tested to determine whether the sample met the bacteriological quality of bottled water as recommended by the regulations. A total of 56 bottles of water were collected i.e. four samples for each brand. In particular, two samples from the market and two samples from each water bottling company plant were collected. A total of 112 tests were carried out, 56 for fecal coliforms and 56 for total coliforms. The water collected was stored in a cooler box to maintain the temperature in order to avoid reactions that can result when the water is exposed to sunlight and high temperatures that can affect the samples. The sampled water was delivered to the laboratory within 24 hours of collection. Water samples collected were 500 or 750 millilitres in capacity.

- **Water analysis:** Analysis of water samples was done by the University of Zambia Environmental and Engineering laboratory. Water was tested for presence of total coliform and faecal coliform using membrane filtration method. For each sample, a measured volume 100ml of water was filtered through a membrane of pores of 0.45microns. The membrane made of cellulose compound. After filtration the membrane was incubated on a suitable selective medium. The coliform bacteria were then left to reproduce and form colonies for 24 hours on the medium. The number of

colonies produced at 35 degrees celsius gave the total coliform of the water sample. In terms of faecal coliform the membranes were incubated at 44.5 degrees celsius on membrane faecal coliform agar medium the colonies formed on the medium after 24 hours represented the faecal coliforms of the sample. The numbers of colonies were counted using a low power microscope. If the total number of colonies on the culture media were too indistinct for accurate counting, the results were reported as "Too Numerous to Count" (TNTC).

- **Oral Guided Interviews:** The questionnaires were orally administered to the supervisors and regular workers. Questionnaires assessed levels of knowledge on standards, frequency of inspections, frequency of water testing, training and medical examination of workers. The questionnaires are presented in annex under annex 4 and 5.

- **Observations:** This technique was used mostly for triangulation purposes i.e. using the checklist, the availability of laboratory, evidence of valid medical examination certificates and documentation of training was determined. Checklist is presented in the annex as annex 6.

3.8 Data Processing and Analysis

The collected data was entered into EPI data version 3 and thereafter exported to Stata versions 11 for processing and analysis. The data processing and analysis was done as follows. Firstly the results from the laboratory were checked and analysed manually to get the frequencies and percentage in relation to the sample results in determining bacteriological water quality and compliance to standards. The analysed data from the laboratory on compliance to standards was then combined with the data collected through interviews and observations. The analysis was conducted on two levels the company and workers level. At company level, the variables that were included were the size of the company, presence of laboratory facility, mode of certification, frequency of supervisory visits and water testing. At individual or workers level sex, position, training, medical examination and level of knowledge were assessed.

Univariate analysis was done for each variable to obtain descriptive statistics such as frequencies and proportions. Chi-square test of association and fisher's exact test were then

done to determine the association between the dependant variable compliance to bacteriological standards and the independent variables including: knowledge on standards, training, frequency of enforcement visits, and frequency of water testing, medical examination, and size of the company, presence of laboratory and mode of certificate to determine factors associated with compliance. The significance was assessed using chi - square and fishers exact p value at less than 0.05 significant level. Fisher's exact tests were employed for some variables which had less than five observations cell counts.

Bivariate logistic regression was also conducted to determine the strength of association between the dependant variable (compliance to bacteriological standards) and three independent variables i.e. knowledge, training and medical examination obtaining odds ratios with 95% confidence intervals. Multiple logistic regression was conducted to come up with the final model getting adjusted outcome parameters i.e. odds ratios and p-values. The three independent variables included in logistic regression were chosen as they made up the group were knowledge the only variables that was significant belonged during the chi-square and fishers exact tests. In addition the variables included in the logistic regression models had a reasonable number of observations that is 116 observations to conduct logistic regression analysis.

The data analysed using Stata was presented in form of frequency tables, cross tabulations and other presentation patterns.

3.10 Ethical Considerations

Before proceeding to collect research data from companies, permission was obtained from Lusaka City Council and study approval from Excellence in research ethics and science (ERES) Coverage Research Ethics Committee. At each company, the researcher asked for permission from the owner/ supervisor to collect data. The participants were approached with informed consents explaining to them exactly what they were supposed to expect and whether they wanted to participate in the study or not. Participants who refused to participate were excluded. Those who accepted to take part were given the information sheet and asked to sign the consent form. The researcher explained the purpose of the study to participants. The researcher assured participants that all data collected was going to be used purely for academic purposes and information collected was going to be treated with the strictest

confidence. Participant's names were not indicated on the questionnaires instead they were given identification (ID) numbers for identification. The labels at each water bottle were removed and replaced by ID numbers. No direct benefits or incentives were offered to participants. Consent from company owners and participants were sought on the same day the interviews took place.

3.11 Disposal of Data Collection Tools: The study data collection tools (questionnaires and checklists) were destroyed six months after the study was completed.

3.12 Pre-Testing of Data Collection Tools

The data collection tools (questionnaires) were pre-tested before being administered. The pretesting was conducted at one of the water bottling companies outside Lusaka. One supervisor and five regular workers were included in the pilot study. The following information was collected during the pre-test: The time it took to interview and complete the questionnaire, clarity of the instructions, if any questions were unclear or ambiguous, any objectives to answering any question(s), layout clarity and attractiveness of the collection tools and any other comments. To ensure validity and reliability of the study tool after pretesting, the tools were then refined in line with the necessary information that was obtained during the pre-test.

3.13 Administration, Monitoring and Utilization of Results

The data was collected by the Principal Investigator with the help of three Research Assistants. Before commencing data collection, research instruments were pretested at one of the water bottling companies outside Lusaka. Research Assistants were trained to get familiar with the tools and data collection techniques. The data collected was organized by the principal Investigator. The information gathered during data collection was checked after every visit for accuracy and completeness by the Principal Investigator. The research supervisors were briefed at each stage of excursion and checked the final research report before being disseminated to the various stakeholders. The analysed data and the conclusion drawn in form of recommendations will be disseminated to relevant stakeholders to take necessary action.

CHAPTER FOUR: RESULTS

4.1 Characteristics of water bottling Companies in Lusaka district

Table1: Characteristics of Companies n = 14

Variable	Frequency	Proportions (%)
Size of Company		
Small	5	35.71
Medium	6	42.86
Large	3	21.43
Laboratory		
Present	3	21.43
Absent	11	78.57
Mode of Certification		
Possession of a Permit	10	71.43
Possession of a Certificate	4	28.57
Supervisory Visits		
Adequate	1	7.14
Inadequate	13	92.86
Water Quality Control (Testing)		
Adequate	3	21.43
Inadequate	11	78.57

Table 1 presents the characteristics of the company included in the study. A total of 14 companies were included in the study majority of the companies six (42.86 %) were medium. The majority of companies 11(78.57%) had no laboratory facilities. The majority of companies 10 (71.43%) had permits. Only one company representing 7.14% had adequate visits by enforcement officers every after three months. The Majority of the companies 11 (78.75%) did not test their water adequately a minimum of at least once per week. The average number of workers at the 14 companies was eight. The number of workers ranged from five to 26. The small companies had the least number of workers compared to the medium and large companies.

4.2 Characteristics of Participants at the Water Companies Bottling Companies in Lusaka District

Table 2: Characteristics of Participants n = 116

Variable	Frequency	Proportion (%)
Sex		
Male	86	74.1
Female	30	25.9
Position of Worker		
Supervisor	14	12.1
Regular	102	87.9
Training on Standards		
Attended (Trained)	46	39.7
Did not attend (not trained	70	60.3
Medical Examination		
Attended	87	75.0
Not attended	29	25.0

Level of Knowledge on Set Standards		
High	20	17.2
Low	96	82.8

Table 2 shows characteristics of participants. A total of 116 workers participated in the study. 30 (25.9 %) participants were female and the majority 86 (74.1 %) were male. These consisted of 14 (12.1 %) supervisors and 102 (87.9 %) regular workers. The majority of workers interviewed did not have any form of training in water handling 70 (60.3 %). The study also revealed that the majority 87 (75.0 %) workers were medically examined the past six months with valid medical certificate. In terms of knowledge levels, the study established that the majority of the workers 96 (82.8 %) had low knowledge levels on standards of water as opposed to 20 (17.2 %) with high knowledge level on standards.

4.3 Bacteriological Quality of Bottled Drinking Water

Table 3: Laboratory Test Results for Total and Faecal Coliforms in Bottled Water

Company Number	First Test Company		Second Test Company		First Test Market		Second Test Market	
	TC # per 100ml	FC # per 100ml	TC # per 100ml	FC # per 100ml	TC # per 100ml	FC # per 100ml	TC # per 100ml	FC# per 100ml
1	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	12	10
8	0	0	0	0	0	0	9	2
9	0	0	0	0	0	0	TNTC	TNTC

10	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	14	8	0	0	0	0	0	0
14	0	0	0	0	TNTC	TNTC	0	0

Key: TNTC = Too Numerous to Count, TC = Total Coliform, FC = Faecal Coliform

Table 3 shows the laboratory results. A total of 112 water bacteriological testing were conducted consisting of 56 tests for faecal coliform and 56 for total coliform. Out of the 56 bottles sampled, five tests were positive for both faecal and total coliforms and giving the total number of contaminated tests to be 10 out of 112 samples. The overall positive tests represented 8.9 % of the analysed samples. The level of contamination of faecal and total coliforms ranged from two cfu to TNTC and nine cfu to TNTC respectively. The majority of the positive tests were from the water that was collected from the market which were eight tests representing 7.1 % of the total samples and this is as opposed to two tests from the company representing 1.9 % of the samples. In terms of collection time, the first samples from the company collected recorded two positive tests while of the second samples from the company none of the samples were contaminated. At the market the first group of sample reported two contaminated samples. The last and second samples from the market reported six samples that were contaminated. Majority of the contaminated samples 8 (80.0 %) were from the market as opposed to only two (20.0 %) sample from the companies. Four tests from the market indicated coliform forming units that were too numerous to count.

4.4 Level of Compliance to Bacteriological Standards of Bottled Drinking Water by Water Bottling Companies

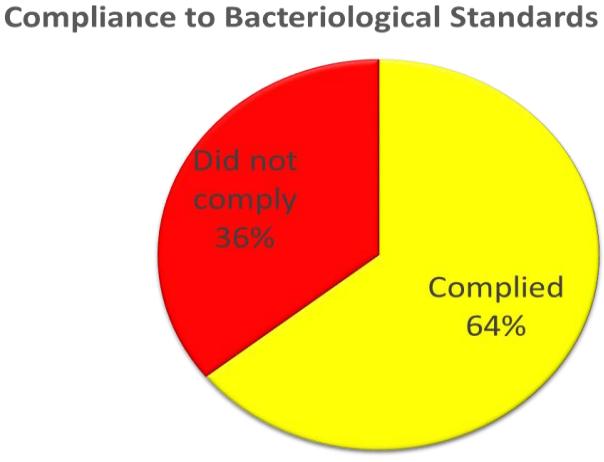

Figure 2: Level of Compliance with Bacteriological Standards by water bottling companies.

Figure 2 shows level of compliance to bacteriological standards by water bottling companies. The study revealed that out of the 14 companies sampled, nine (64.3%) of the companies were complying to faecal and total coliform standards of bottled water of zero cfu /100ml, as opposed to five (35.7%) of the companies that were not complying to the standards.

4.5 Socio-economic and service factors associated with compliance to bacteriological standards of bottled drinking water

Table 4: Factors Associated with Compliance to Bacteriological Standards for Bottled Drinking Water

Variable	Compliance to standards				Total		Fishers Exact
	Complied		Not complied				
	Frequency	%	Frequency	%	Frequency	%	
Laboratory Facility							
Present	2	14.3	1	7	3	21.4	
Absent	7	50	4	28.6	11	78.6	1.000
Total	9	64.3	5	35.7	14	100.0	

Size of the Company							
Small	4	28.6	1	7.1	5	35.7	
Medium	3	21.4	3	21.4	6	42.9	0.775
Large	2	14	1	7.1	3	21.4	
Total	9	64.0	5	35.6	14	100.0	
Type of Certification							
Certified	2	14.3	2	14.3	4	28.6	
Permit	7	50	3	21.4	10	71.4	0.580
Total	9	64.3	5	35.7	14	100.0	
Frequency of Visitation							
Adequate	1	7.1	0	0	1	7.1	1.000
Inadequate	8	57.1	5	35.7	13	92.9	
Total	9	64.2	5	35.7	14	100.0	
Water Quality Control (Testing)							
Adequate	3	21.4	0	0	3	21.4	
Inadequate	6	42.9	5	35.7	11	78.6	0.258
Total	9	64.3	5	35.7	14	100.0	

Table 5: Factors Associated with Compliance to Bacteriological Standards for Bottled Drinking Water

Variable	**Compliance to Standards**				**Total**		**Fishers Exact/ Chi - Square**
	Complied		**Not Complied**				
	Frequency	**%**	**Frequency**	**%**	**Frequency**	**%**	
Level of Knowledge							
High	18	15.5	2	1.7	20	17.2	Fishers exact
Low	50	43.1	46	39.7	96	82.8	p-Value 0.002
Total	68	58.6	48	41.4	116	100.0	

Training on Standards							
Yes	32	27.6	14	29.2	46	39.7	Chi-square
No	36	31.0	34	29.3	70	60.3	3.754
Total	68	58.6	48	41.4	116	100.0	p-Value 0.052
Medical Examination							
Attended	52	44.8	35	30.2	87	75.0	Chi-Square
Not attended	16	13.8	13	11.2	29	25.0	0.190
Total	68	58.6	48	41.4	116	100.0	p-Value 0.663

Tables 4 and 5 shows chi-square and fishers exact test results used to determine factors associated with compliance to standard. Knowledge on standards was the only factor that was associated with compliance to standards with fishers exact p value of 0.002. The rest of the factors had chi square and fishers exact p-values of more than 0.05 cut off point for significance of this study.

4.6 Logistic Regression

To test for strength of association, logistic regression was carried out taking compliance to standards as the dependant variable and three variables i.e. knowledge, training and medical examination as independent variables.

Table 6: Bivariate Logistic Regression Factors Associated With Compliance to Bacteriological Standards for Bottled Drinking Water

Compliance to Standards	Odds Ratio	Standard Error	P - Value	95% CI
Knowledge on Standards	0.121	0.093	0.006	0.027 - 0.549
Training on Standards	2.159	0.863	0.054	0.986 - 4.726
Medical Examination	1.207	0.522	0.664	0.517 - 2.819

CI: **Confidence Interval**

The bivariate logistic analysis conducted taking compliance to standards as dependent variable and knowledge, training and medical examination as independent variable. The results revealed knowledge as the only independent variable that was significantly associated

with compliance to standard with p-value of 0.006 and odds ratio of 0.121 with 95% CI 0.027 to 0.549 as shown in table 6.

Table 7: Multiple Logistic Regression Analysis, Adjusted for Training on Standards and Medical Examination

Compliance to Standards	Adjusted Odds Ratio	Standard Error	P-Value	95%CI
Level of knowledge	0.139	0.114	0.016	0.028-0.690
Training on Standards	1.294	0.589	0.572	0.530-3.160
Medical Examination	0.918	0.421	0.852	0.373-2.256

CI: Confidence Interval

Multiple logistic regression analysis was conducted taking Compliance with standards as dependent variable and knowledge, training on standards, and medical examination as independent variables. The results of multiple logistic regression analysis revealed the final model significant with p-value of 0.008. Knowledge on standards remained significant with p-value of 0.016 and adjusted odds ratio of 0.139 and confidence Interval of 0.028 to 0.690 as shown in table 7. Training on standards and medical examination remained non-significant in the final model. The results therefore indicated association between compliance to standards and knowledge on standards. Companies whose workers had low knowledge on standards had a 0.139 reduced chance of complying with set standards than companies whose workers had high knowledge.

CHAPTER FIVE: DISCUSSION

5.1 Characteristics of Companies

The study managed to include the total number of 14 companies as proposed. The study revealed that majority of the companies had no laboratory and took water for testing to other laboratories such as UNZA and ZABS. This is an indication of the challenge faced by these companies to keep up with standards as they have to go out of the company for quality assurance at least once per week as recommended. Having a laboratory is important as it helps in detecting contamination in good time before the water is distributed to the market. In terms of certification, all the companies that were visited had some form of certification including operating certificates and permits. All the companies were operating legally. The company certificates were checked and found to be up to date. The issue of enforcement visits was critical in this study. The study revealed that only one of the companies visited had adequate number of enforcement visits by the health inspectors - every after three months, this company was complying with standards and was one of the best companies in terms of standards. Some company personnel claimed that they were never visited by any health officers in the past one year. Some companies complained that the officers did not give any feedback after the visits. This finding is an indication of a problem as the health inspectors visit are vital for the companies to be operating according to standards through information provision. It is also important to note that these results are contrary with the Zambian laws Food and Drugs Act and Public Health Act that indicates that health officers must conduct enforcement visits regularly to promote compliance to standards.

5.2 Characteristics of Participants

The majority of participants were male in all companies included in the study. This is a typical Zambian workplace as majority of the workers in most workplaces in Zambia are male. According to literature training of workers is an important component in ensuring compliance to standards (FSA, 2006). However, the current study revealed that majority workers did not have any form of training before they started work. The workers just received simple orientation on how to pack the water and operate certain machines if appropriate for their work. No training on how to prevent contamination of water and set water standards was given to the workers. This fact is a threat to the quality of water as people with little or no

knowledge on hygiene standards are involved in the production of the commodity for public consumption. This argument is in line with FSA (2006) that indicates that lack of training is a threat to quality.

Medical examination of workers is another factor that is important in production of food. This is because workers who are infected and allowed to handle water are likely to contaminate the water especially those with infectious diseases. The study revealed that majority of the workers were medically examined. This is a good indication of the importance and the awareness of the employee/employers on importance of medical examinations to ensure quality. However, there was still a proportion (25%) of individuals who did not undergone medical examinations contrary to the Food and Drugs Act chapter 295 of the laws of Zambia that states that all food handling workers are to be medically examined every after six months. This can affect the quality of water as there is a possibility that the handlers carry infectious agents that can contaminate the water.

The study revealed that knowledge levels were low among most participants. Supervisors had more knowledge on standards compared to the regular workers. This might be because most of the supervisors had worked in the companies for a long time and were mostly involved in taking water to the laboratory thus being able to have some knowledge on standards. However, some of the supervisors could not interpret the water tests results in company records. This is an Indication of limited knowledge on the standards and what those standards meant.

5.3 Bacteriological Quality of Bottled Drinking Water

The study revealed that not all bottled drinking water sold in Lusaka district was safe. 8.9% of water tested was found to be contaminated with both faecal and total coliform. These results are in line with the study conducted by Nyundu et al. in 2012 under UNZA and assessment by LCC in 2012 that revealed that water sold in Lusaka was not totally safe. However these results are lower compared to the ones from LCC and UNZA. The study by UNZA revealed 32% of water tested not complying with microbiological standards of zero coliform or other growths per 100ml. An assessment by LCC revealed 60% of the tested samples contaminated. The difference in contamination among the studies might be attributed to the number of water samples tested, more samples were tested in the UNZA and LCC

assessment than this study. For example, 233 samples representing 39 brands were collected in the UNZA study compared to the 112 samples representing 14 brands included in this study. In addition, the other studies extended their sample to water companies outside of Lusaka and Zambia. Additionally, other bacteriological parameters were considered in the other studies like *E. coil* and other growths.

In terms of studies conducted outside Zambia, the current study findings are in line with findings by Okagbue et al, 2002 who looked at microbiological quality of water processed and bottled in Zimbabwe. The study revealed that out of the 60 samples of water from three companies tested seven (11.7%) samples were contaminated with total coliforms. In addition study findings in a study conducted in Tanzania by Kassenga, 2007 on microbiological quality of bottled drinking water sold in Da res salaam were also in line with the finding of this study. The study revealed that out of 130 samples representing 13 brands of water 4.6% and 3.6% were contaminated with total and fecal coliform respectively. On the other hand findings of a study conducted in Ghana, 2009 by Addo et al were not in agreement with the findings of the current study, as all the 70 water samples tested for fecal and total coliform and E. coli were in accordance with the WHO standards. In general, the majority of the studies and assessments conducted in Zambia and outside Zambia show similar results, an indication that the problem of the quality of bottled drinking water is not only a problem in Zambia but other countries as well.

The current study also established that the majority of the contaminated water was from the market. This is an indication that contamination may also be attributed to factors after the treatment and bottling processes such as transportation and storage and also the possibility of counterfeit products. The second set of water tested at the second visit from companies revealed no contaminated samples compared to two samples contaminated in the first set. This might be as a result of improvement after the first samples were collected. The companies might have been applying all the advice that was given to them during the first visit. The information given to them was still new and applied easily considering the time difference between the two sampling intervals which was 10 to 14 days. Some companies had high levels of water contamination too numerous to count under the light microscope. These results indicate a serious threat to the health of consumers as this can result to serious intoxication if water is consumed.

5.4 Level of Compliance to Bacteriological Standards by Water Bottling Companies

The study revealed that not all the companies that were sampled were complying with bacteriological standards of zero cfu for total and fecal coliform in every 100mls of water. A total of 14 companies were sampled of these companies nine were complying with standards and the rest five were not complying with standards. In short nine (64.3%) of the company were complying with standards as opposed to five (35.7%) not complying with standards. These results are in line with the assessment by the LCC and UNZA that indicate that not all the companies complied with bacteriological standards of bottled water. Assessment by the LCC revealed that among 15 water bottling companies included in the assessment, nine (60%) were producing a commodity that was unfit for human consumption contrary to the laws of Zambia. The UNZA study by Nyundu *et al*. also revealed that 24 brands representing (62%) out of 39 brands sampled had at least one cfu/100ml. These results are a threat to safety and health of consumers because most people in Zambia prefer and trust bottled drinking water as being absolutely safe (Nyundu *et al*., 2012).

5.5 Social-Economic and Service Factors Associated with Compliance to standards

The study went on to determine the factors associated with compliance. The main factors that were tested included the presence of laboratory facility, size of company, mode of certification, frequency of enforcement visitation, water quality control (testing), continuous development training and medical examination. The only factor that was associated with compliance to standards in this study was knowledge with fisher exact p value of 0.002. These finding are in line with Studies by Ilyai *et al,* (2011), Muriithi (2008) and Yapp and Fairman (2004) who indicated that knowledge was associated with compliance to standards. In terms of strength of association the final model multiple logistic regression revealed knowledge as the only factor associated with compliance. The results therefore indicates that companies whose workers had low knowledge on standards had a 0.139 reduced chance of complying with set standards than companies whose workers had high knowledge.

The other factors not associated with compliance included enforcement visitation, water testing, presence of laboratory facility, medical certification of workers and training on standards. In terms of enforcement visits, findings of this study were not in line with Semerjian, (2011) and Murithl, (2008) and Yapp and Fairman, (2004) who indicated that

visits are associated with compliance to standards. The findings in literature indicated that companies that were frequently visited by health officers more than four times in a year were more likely to comply with standards, compared to the ones that were not visited regularly. In terms of water quality control (testing) the results revealed no association between water testing and compliance with standards. These results are not in agreement with finding by SDWF (2005) who indicated that testing water more than once per week is likely to result to compliance to standards as the manufacturers are able to detect the contamination in good time.

The presence of the laboratory was another factor that was found to be associated with compliance with standards in literature. SDWF (2005) reported that having a laboratory encourages the water bottling companies to test water regularly resulting to lower levels of contamination as the quality will be determined before it is dispatched for sale. However the results obtained from this study revealed no association between compliance and presence of laboratory. Training on standards was another factor that was tested to determine association with compliance to standards. The chi square was found to be 3.750 with p value of 0.052 meaning that there was no association between training and compliance with standards. These results are not in line with findings by FSA (2006) that indicated an association between training in hygiene in food establishments and compliance with standards. In terms of medical examination, there was no association between compliance with standards and workers being medically examined. Other factors such as the size of the company and mode of certification that the researcher thought would affect compliance with standards were found not to be associated with compliance.

5.6 Limitations, Discussion of Methods, Bias and Validity of the Study

The majority of the factors that were found in literature as being associated with compliance were not associated with compliance. This might be attributed to the sample size as results might have been different if the sample was larger than the sample in this study. A study covering more companies and participants is required to be conducted in line with this study that will consider regression analysis controlling for potential confounder would be recommended to assess the strengths and direction of association. The current study

considered few studies in literature that looked at factors associated with compliance to standards. This is because few studies have been published on the subject. In addition, the results of the available studies were positive that is significant association between compliance to standards and studied factors was found. There is possibility of studies with negative results that have not published due to publication bias.

The other limitation of this study is that only companies that were registered with LCC and ZABs were included in the study. There was a possibility of leaving out some of the companies that were not registered with these institutions leading to some form of selection bias, as some companies in Zambia operate illegally without being registered with ZABS and LCC. However, the companies that were included in the study were selected at random to make sure that they were representative of the target population. In terms of external validity results obtained in this study can therefore only apply or be generalised to the target population of water bottling companies in Lusaka district registered with LCC and ZABs. The results of the current study might also give indications of the overall situation of water sold in Lusaka and other parts of Zambia considering that some companies included in the study have branches in other parts of the country. In addition most of the water bottled in Lusaka is supplied and sold in other provinces of Zambia. The target number of workers (participants) was not reached as most of the companies had very few numbers of workers. While the study aimed at 184 workers to take part in the study, only 116 participated in the study. To deal with this problem all the worker at the companies that did not reach the target were asked to participate in the study. All the workers that were approached agreed to participate, thus being enough to come up with a comprehensive conclusion.

The study did not consider all the bacteriological parameters that are important in making a comprehensive conclusion of the water quality due to financial limitation. Only two parameters were included in this study. However, the researcher included total and faecal coliform the two most important parameters used as practical indicators of the general hygienic quality of water and mainly used in routine monitoring of drinking water supplies and indications of faecal contamination of water. These two parameters are also used in determining the effectiveness of water treatment methods. In addition, only one laboratory was used for all the tests carried. It would have been better to use another independent laboratory for comparison but resources could not allow.

The questionnaires and checklists used in the current study were not standardised. This might have affected the quality of information acquired in this study. However, to ensure internal validity, the tools were pretested before admission. The principal investigator trained the data collectors on the best ways to collect the data. The data was also check for completeness every after a day's work. Triangulation of findings was also applied as some information were collected through both interviews and observations, For example the presence of laboratory facilities, presence of laboratory results to check for frequency of water testing, medical examination of worker and evidence of training were obtained from both interviews and observation. The conclusions were drawn by the researcher based on the two sets of information. Triangulation of findings also helped to deal with information bias in this study.

The study design was a cross sectional type which involved collection of data on water parameters and factors that affects compliance within a short period of time. This might have affected the reliability of the results. Thus it is important that the water results and other information gathered are interpreted with caution. In addition more studies such as longitudinal studies have to be conducted to make a comprehensive conclusion in the same setting.

Further Studies

- A study to assess the hygiene aspect of the water bottling companies and water treatment methods applied.
- A study to assess physical and chemical standards of bottled water.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study revealed that not all the water sold in Lusaka district was of good quality as perceived by the buyers. The level of contamination of faecal and total coliforms ranged from two cfu to TNTC and nine cfu to TNTC respectively. Five representing 8.9% out of 56 of water sampled and tested was contaminated with both faecal and total coliforms. Among the 14 companies that were included in the study nine (64.3%) of the companies were complying with faecal and total coliform standards of bottled water of zero cfu /100ml. Among the various factors tested for association with compliance to bacteriological standards, only knowledge among other factors was found to be associated with compliance. Other factors including size of company, mode of certification, frequency of water testing, medical examination of workers and enforcement visit and presence of the laboratory were found not to be associated with compliance.

The study was an indication of the risk related to consumption of bottled drinking water. Although disease outbreaks due to contaminated bottled water are rare or never been reported in Zambia, any contamination may pose a unique hazard because of the widespread distribution. Almost every person including the vulnerable populations such as babies and pregnant women are subjected to bottled drinking water. Thus it is important that all the stakeholders involved in bottled water in Zambia such as ZABs, Ministry of Health, Lusaka City Council, water bottling companies, applied laboratories such as food and drug laboratory and UNZA laboratory, distributors, shops and super markets work together to ensure that the water sold to the public is up to standards.

Recommendations

Water Bottling Companies

- Ensure that all workers are medically examined before handling water every after six months as advised in the law.
- Test water at least twice a week to check its bacteriological quality and make appropriate measures if the water is found to be contaminated i.e. check from the

sources of contamination by conducting hazard analysis (Hazard Analysis Critical Control Points (HACCP).

- Make arrangements to build up a laboratory for the company and employ laboratory technicians to be in charge of the quality assurance.
- Conduct training on water handling for all workers to increase their knowledge on how to treat and handle water.

Lusaka City Council

- Conduct regular inspection or visits of the water bottling companies to assess the water quality sold to the public every three months.
- Conduct random sampling of water on the markets to check for quality.
- Conduct education on water handing in the water bottling companies.

Water Distributors

- Ensure that the water sold out to the public is bought from the companies or reputable suppliers.
- Ensure that water is stored in clean vessels to ensure that it does not get contaminated during transportation and storage.

REFERENCES

Addo K. K., Mensah G. I., Donkor B., Bonsu C. and Akyeh M.L. (2009). **Bacteriological Quality Of Bottled Water Sold On The Ghanaian Market**. Bacteriology Department, Noguchi Memorial Institute for Medical Research, University of Ghana. Legon-Accra, Ghana. African Journal of Food Agriculture Nutrition and Development, Volume. 9, No. 6. pp 1378-1387.

Blake, P. A., Rosenberg, M.L., Florencia, J., Costa, J.B., Prado, Q. L. and Gangarose, E. J. (1977) **Cholera in Portugal, 1974 Transmission by Bottled Mineral Water. American Journal of Epidemiology.** p105 (4):344-8.

Central Statistics Office, (2010). **Population Census Report** .Lusaka. Zambia.

Department of Health (2012). **Bottled Water Design For Processing And Bottling Of Bottled Drinking Water Standards**. West Virginia State, USA.

Department of Water Affairs (1996). **South African Water Quality Guidelines, Domestic Water Use**. 2nd edition, South Africa.

Drinking Water Inspectorate (2010)**. Guardians of Drinking Water Quality.** Ergon house, Horse ferry road, London, UK.

Fairman, R. and Yapp, C. (2003). **Education or enforcement: improving standards in food SMEs**, Environmental Health Journal, 111, 1, 16-19.

Food Safety Agency (2006). **Food Hygiene: A Guide for Businesses.** United Kingdom.

Gleick, P. H. (2010)**. Bottled and Sold: The story behind our obsession with bottled water.** Island Press, DC.

Government of the Republic of Zambia (1995). **Food and Drugs Act Chapter 303 of the Laws of Zambia.** Government printers. Lusaka, Zambia.

Ilyia, N. A. R., Rosli, S., Suhaimi, A. R. and Dzulkifly, M. H. (2011). **Factors Contributing to Non-Compliance of the Halal Standard among Restaurant Operators in Malaysia**.

Halal Products Research Institute, University of Putra Malaysia, Malaysia Faculty of Economics Management, Malaysia.

Kassenga G.R. (2007). **The Health – Related Microbiological Quality Of Bottled Drinking Water Sold In Dar es Salaam, Tanzania.** Department of Environmental Engineering, University College of Lands and Architectural Studies, Dar es Salaam, Tanzania. Journal of water and health. pp 175-185.

LCC (2012). **Data on Assessment of Water Quality Program Water Policy and Samples; Routine Inspections.** Lusaka, Zambia.

MoH (2011). **Health Management information systems.**

Muriithl, B. W. (2008). **The Study to Assess Awareness of the Eurepgap Standards among Smallholder.** University of Egerton.

Nyundu K. Silembo O. Simumba F. S. (2012). **Bottled Drinking Water in Zambia- Does It Pose Any Threat To Human Safety And Health**. Integrated water resources management center. University of Zambia. Lusaka, Zambia.

Okagbue R. N. Dlamini N. R. Siwela M. and Mpofu F. (2002). **Microbiological Quality of Water Processed and Bottled In Zimbabwe.** Department of applied biology and biochemistry. National university of science and technology. Bulawayo, Zimbabwe. African journal of health sciences. Volume 9. pp 99-103.

Safe Drinking Water Foundation (2005). **Bottled Water, Food and Drugs Administration.** USA.

Semerjian, L. (2011). **Quality Assessment of Various Bottled Waters Marketed In Lebanon**. Environmental Monitoring and Assessment, p 172, pp 275–285.

Sulaiman, G., Lawen, S. E. and Shelear, H. H. (2002). **Effects of storage temperature and sunlight exposure on the physicochemical properties of bottled water in Kurdistan region-Iraq.** Kurdistan, Iraq**.**

Svagzdiene, R. (2009). **Microbiological quality of bottled water brands sold in New Zealand.** London, United Kingdom.

Taiwo, A. M., Gbadebo, A. M. and Awomeso, J. A. *(*2010). **Portability Assessment of Selected Brands of Bottled Water in Abeokuta, Nigeria**. Ogun State, Nigeria.

Times of Zambia (2012). **Nine Bottled Water Firms Face Closure in Lusaka.** June 2012.

UNICEF (2006). **Progress for Children**, News and notes. www.unicef.org/publication. Accessed on 05/07/2014.

WHO (1988). **Codex Standard For Natural Mineral Water And Edible Ices Mixes. Volume 12**. Food standards program codex alimentary commission.

WHO (1996). **Guidelines for Drinking Water Quality, Volume 2,** 2nd Edition**,** Geneva.

Yapp, C. and Fairman R. (2004). **Factors affecting food safety compliance within small and medium – sized enterprises: Implications for regulatory and enforcement strategies**. London, UK.

ZABS (2000). **Zambian Standards Bottled Drinking Water: Specifications**. Lusaka, Zambia.

ZABS (2013). **List of Water Bottling Companies Information File**. Lusaka, Zambia.

ANNEXES

Annex 1: Study Variables

Table 8: Variables

Type of Variable	Variable	Indicator	Measuring Scale
Dependent	Compliance to bacteriological standard of bottled water	Number of companies complying to standard i.e. Faecal coliform 0 in 100mls Total coliform 0 in 100mls	• Yes = 1 • No = 2 Nominal
Independent	**Service Factors**		
	• Frequency of inspections by health inspectors for enforcement	Number of health visits by health inspectors	• Adequate: 1 and above visits per 3months = 1 • Inadequate: 0 visits per 3 months = 2 Nominal
	• Frequency of water testing	Number of water testing conducted	• Adequate: once and above testing conducted per week = 1 • Inadequate 0 testing per week = 2 Nominal
	• Training in hygiene and food safety	Evidence of documentation or minutes of training or certificates	• Trained Yes = 1 • Not trained No = 2 Nominal
	• Medical examination	Evidence of valid medical examinations certificates in	• Present Yes = 1

	of workers	the last 6 months	• Absent No = 2 Nominal
	Socio-Economic Factors		
	• Knowledge on standards	Number of right responses to questions asked	• High: 3 – 4 = 1 • Low: 2 and below = 2 Ordinal
	• Size of company	Size of the company	• Large = 1 • Medium = 2 • Small = 3 Ordinal
	• Type of certification	The type of certificate owned by the company	• Certified = 1 • Permit = 2 Nominal
	• Sex	Sex of the participant	• Male = 1 • Female = 2 Nominal
	• Position	Position of worker	• Supervisor = 1 • Regular worker = 2 Nominal
	• Training	Evidence of training on standards	• Evidence present yes = 1 • Evidence absent no = 2 Nominal

	• laboratory	Evidence of a laboratory	• Present = 1 • Absent = 2 Nominal

Annex 2: Information Sheet and Consent Form

Information Sheet

- **Introduction**

I am a student at the University of Zambia School Of Medicine studying Master of Public Health. We are carrying out a research on bacteriological standards of bottled drinking water produced and sold in Lusaka district. You have been selected to take part in the research. Your voluntary participation is requested so we may learn more about the bacteriological standards of water and factors associated with compliance to standards.

- **Procedures**

The study will involve collecting water sample from your presences and take it for bacteriological analysis at the University of Zambia laboratory. The study will also involve asking you a number of questions that will help us to establish the factors that are associated with compliance to standards. The questions on the questionnaire will be read to you and your responses will be recorded on the questionnaire. The interview will take approximately 10minutes.

- **Risk Factors and Discomfort**

The study will not generate any concrete risk to our knowledge however there is loss of work time during the interviews and when guiding us for sample water collection.

- **Confidentiality**

Your name will not be recorded on the questioner instead you will be given identity number for identification purposes only. The information revealed will be used purely for academic purposes and treated with the strictest confidentiality possible. In addition all the labels will be removed from the water samples to prevent identification of the samples by the other people.

- **Benefits**

This study will not offer direct benefit for you as a participant. However, the information that will be generated will be used to give advice to you as a company, to improve standards so that you improve on the quality of product being a direct benefit to the business. The information will also be used to improve the health of the public as it will ensure they get a quality product that is beneficial for health.

- **Voluntary Participation**

Your participation is voluntary and you may choose not to answer all of the questions that you are not comfortable with even after signing the consent form. You are also allowed to withdraw from the study at any time you feel like.

- **Results or New Findings**

The results of the sampled water and data will be made available after the study by the PI, in case you want to refer to them in any way or enter them in your laboratory and other company files**.** In addition, the laboratory will be asked to keep samples in case you wish to check and or confirm the results with what will be reported by the Principal Inspection.

Yours Faithfully,

Chisala .D. Meki

Date.....

University of Zambia School of medicine P. O. Box 50110 Lusaka Cell number: 0966526445 Email chisalameki@yahoo.com.

The Chairperson ERES Converge IRB 33 Joseph Mwilwa Road Rhodes Park, Lusaka.

Consent Form

Study Title: Compliance to Bacteriological Standards of Bottled Drinking Water in Lusaka Urban District

The main purpose of the study has been explained to me, including the benefits and the issue of confidentiality.

I am willing to participate in this study and am well informed that I can withdraw at any time from the study or answering any question if am not comfortable.

Signature of participant: .....

Date: .....

Students Name: Chisala Deborah Meki

Sponsors of study: University of Zambia

Chisala D. Meki. C/o University of Zambia, School of medicine P.O. Box 50110 Lusaka

Cell number 0966526445. Email chisalameki@yahoo.com

The Chairperson ERES Converge IRB 33 Joseph Mwilwa Road Rhodes Park Lusaka.

Annex 3: Water Sampling Form

REPUBLIC OF ZAMBIA

MINISTRY OF HEALTH

SAMPLING FORM

FOOD AND DRUGS ACT CAP 303 OF THE LAWS OF ZAMBIA

<table>
<tr><td colspan="2">1. Sample No.</td><td colspan="2">2. Date Collected:</td></tr>
<tr><td colspan="4">3. (a) Product name and description:……
(b) Method of collection: …….
(c) Collector’s identity on package and seal: ……...</td></tr>
<tr><td colspan="4">4. Reasons for collection:</td></tr>
<tr><td colspan="2">5. Manufacturer:</td><td colspan="2">6. Dealer:</td></tr>
<tr><td colspan="2">7. Size of lot sampled:</td><td colspan="2">8. Date dispatched:</td></tr>
<tr><td>9. Delivered to:</td><td>10. Date:</td><td colspan="2">11. Laboratory:</td></tr>
<tr><td rowspan="2">12. Records obtained</td><td colspan="2">(a) Invoice No. and date</td><td></td></tr>
<tr><td colspan="3">(c) Other documents:</td></tr>
<tr><td colspan="2">14. Sample cost:</td><td colspan="2">15. Collector (Print Name & Signature)</td></tr>
</table>

Source: Food and Drugs Act Cap 303 of the laws of Zambia.

Annex 4: Questionnaire for Supervisors

- Company Location: _____
- Date of interview: _____
- Interviewers' name:_____

Instruction to the Interviewer

- Greet the interviewee
- Introduce yourself
- Explain why you are conducting the interview
- Assure the interviewee that the information collected will be treated with confidence
- Get consent
- Carry out the interview
- At the end of interview thank the interviewee
- TICK (√) AND FILL APPROPRIATE OPINIONS IN SPACES PROVIDED

A. Basic Information

1. Sex of supervisor/ Regular worker

    a. Male ( )

    b. Female ( )

2. Number of workers ( )

    a. Female ( )

    b. Male ( )

3. Type of certification

a. Certified ( ) b. Permit ( )

4. Size of company

a. Small ( ) b. Medium ( ) c. Large ( )

Knowledge on Standards

5. Which of the following bacteriological standards are important in bottled water?

a. PH ( ) b. Total solid ( ) c. E. coli ( )

d. Total coliform ( ) e. Fecal coliform ( )

6. What is the recommended standard of E. coli in water according to FDA and ZABs?

a. 0 in every 100mls of water ( )

b. 10 coliforms forming units in every 100mls ( )

c. 20 coliforms forming units in every 100mls ( )

7. What is the recommended standards of total coli forms in water?

a. 30 in every 100mls ( )

b. 40 in every 100mls ( )

c. 90 in every 100mls ( )

d. 0 in every 100mls ( )

8. What is the recommended standard of fecal coliform according to the laws i.e. Food and Drugs Act and Zambia Bureau of standards?

a. 20 in every 100mls of water ( )

b. 30 in every 100mls of water ( )

c. 0 in every 100mls of water ( )

d. 50 in every 100mls of water ( )

Frequency of Enforcement Visits per Year

9. How often are you visited by health inspectors or enforcement officers in a year?

a. Once a year ( )

b. Twice per year ( )

c. 3 times per year ( )

d. 4 time a year ( )

e. Others specify.....

Frequency of Water Testing

10. How often do you take your water for testing?

a. Once per month ( ) b. Twice a month ( )

c. Twice a week ( ) d. Once a week ( )

e. Other specify.....

Training on Hygiene.

11. Have you received any formal training on how to handle water as workers i.e. hygiene package?

a. Yes ( ) b. No ( )

12. Are you medically examined?

a. Yes ( ) b. No ( )

13. If yes to the above question, when last were you medically examined?

a. 6months ago ( ) b. 1 year ago ( )

b. Others specify.....

14. Do you have a laboratory as a company?

a. Yes ( ) b. No ( )

15. If yes ask for evidence

a. Present ( ) b. Absent ( )

16. If no to the answer where do you take your water for testing?

a. UNZA lab ( ) b. ZABS ( )

c. Others specify.....

17. Ask for evidence available of documentation

a. Available ( ) b. Not available ( )

Annex 5: Questionnaire for Regular Workers

- Company Location: _____
- Date Of Interview: _____
- Interviewers' Name:_____

Instruction to the Interviewer

- Greet the interviewee
- Introduce yourself
- Explain why you are conducting the interview
- Assure the interviewee that the information collected will be treated with confidence
- Get consent
- Carry out the interview
- At the end of interview thank the interviewee
- TICK (√) AND FILL APPROPRIATE OPINIONS IN SPACES PROVIDED

Basic Information

1. Sex of supervisor/ Regular worker
    - Male ( )
    - Female ( )
2. Number of workers ( )
    - Female ( )
    - Male ( )

Level of Knowledge

3. Which of the following bacteriological standards are important in bottled water?

   - PH ( )
   - Total solid ( )
   - E. coli ( )
   - Total coliform ( )
   - Fecal coliform ( )

4. What is the recommended standard of E. coli in water according to FDA and ZABs?

   - 0 in every 100mls of water ( )
   - 10 coliforms forming units in every 100mls ( )
   - 20 coliforms forming units in every 100mls ( )

5. What is the recommended standards of total coli forms in water?

   - 30 in every 100mls ( )
   - 40 in every 100mls ( )
   - 90 in every 100mls ( )
   - 0 in every 100mls ( )

6. What is the recommended standard of fecal coliform according to the laws i.e. Food and Drugs Act (FDA) and Zambia Bureau of Standards (ZABS)

   - 20 in every 100mls of water ( )
   - 30 in every 100mls of water ( )
   - 0 in every 100mls of water ( )

- 50 in every 100mls of water ( )

Training on Hygiene

7. Have you received any formal training on water standards and how to handle water as workers i.e. hygiene package?

   - Yes ( )
   - No ( )

8. Are you medically examined?

   - Yes ( )
   - No ( )

8.1 If yes to the above question, when last were you medically examined?

- 6months ago ( )
- 1 year ago ( )
- Others specify.....

Annex 6: Check List

- Checklist Number:_____
- Company Location:_____
- Date:_____
- Data Collector:_____

Instruction

Tick (√) where appropriate

EVIDENCE	**Present**	**Absent**	**Other Information**
Valid Medical Examination Certificates for all Workers			
Documentation for Training			
Evidence of Laboratory Reports			
Evidence of a Laboratory			
Documentation of Last Visit by Enforcement Officers			
Documentation on Frequency of Water Testing			

Annex 7: Permission Letter from Assistant Dean Post Graduate Studies

THE UNIVERSITY OF ZAMBIA
SCHOOL OF MEDICINE

Telephone: 252641
Telegram: UNZA, Lusaka
Telex: UNZALU ZA 44370
Email: selestinenzala@yahoo.com

P.O. Box 50110
Lusaka, Zambia

==========

12th July, 2013

Ms Chisala D. Meki (51289063)
Department of Public Health
School of Medicine
LUSAKA

Dear Ms Meki,

RE: GRADUATES PROPOSAL PRESENTATION FORUM (GPPF)

Having assessed your dissertation entitled **"Compliance to Bacteriological Standards for Bottled Drinking Water in Lusaka District".** We are satisfied that all the corrections to your research proposal have been done. The proposal meets the standard as laid down by the Board of Graduate Studies.

You can proceed and present to the Research Ethics.

Yours faithfully,

Dr. S. H. Nzala
ASSISTANT DEAN, POSTGRADUATE

CC: HOD – Public Health

UNIVERSITY OF ZAMBIA
SCHOOL OF MEDICINE
12 JUL 2013
ASSISTANT DEAN (PG)
P.O. BOX 50110, LUSAKA

Annex 8: Permission Letter from Lusaka City Council

LUSAKA CITY COUNCIL
MEMORANDUM

TO : Director of Public Health

FROM : The Acting Director of Human Resource & Administration

REF : LM/lm
TCD/7/58/10

DATE : 18th July, 2013

REQUEST FOR INFORMATION - MEKI CHISALA

The above mentioned is student from the University of Zambian and is conducting a research on **"Compliance to Bacteriological Standards for Bottled Drinking Water in Lusaka District".** The research is being conducted in partial fulfillment for the award of her Masters Degree in Public Health (MPH). She has since paid the research fee of KR60.50 on receipt number BX27608.

Kindly therefore, provide her with the necessary information to enable her carry out the research.

for **RABECCA C. BANDA**

Annex 9: Ethical Approval Letter

33 Joseph Mwilwa Road
Rhodes Park, Lusaka
Tel: +260 955 155 633
+260 955 155 634
Cell: +260 966 765 503
Email: eresconverge@yahoo.co.uk

I.R.B. No. 00005948
F.W.A. No. 00011697

23rd October, 2013

Ref. No. 2013-July-004

The Principal Investigator
Ms. Meki Deborah Chisala
C/o The University of Zambia
School of Medicine
Dept. of Public Health
P.O. Box 50110,
LUSAKA.

Dear Ms. Chisala,

RE: Compliance to Bacteriology standards of bottled drinking water sold in Lusaka District by 2013.

Reference is made to your corrections dated 21st October, 2013. Noting that you addressed all concerns raised the IRB resolved to approve this study and your participation as Principal Investigator for a period of one year.

Review Type	Ordinary	Approval No. **2013-July-004**
Approval and Expiry Date	Approval Date: 23rd October, 2013	Expiry Date: 22nd October, 2014
Protocol Version and Date	Version-Nil	22nd October, 2014
Information Sheet, Consent Forms and Dates	• English.	22nd October, 2014
Consent form ID and Date	Version-Nil	22nd October, 2014
Recruitment Materials	Nil	22nd October, 2014
Other Study Documents	Sampling Tool, Questionnaire for Supervisors/Regular Workers and Check list.	22nd October, 2014
Number of participants approved for study	184.	22nd October, 2014

Specific conditions will apply to this approval. As Principal Investigator it is your responsibility to ensure that the contents of this letter are adhered to. If these are not adhered to, the approval may be suspended. Should the study be suspended, study sponsors and other regulatory authorities will be informed.

Conditions of Approval

- No participant may be involved in any study procedure prior to the study approval or after the expiration date.
- All unanticipated or Serious Adverse Events (SAEs) must be reported to the IRB within 5 days.
- All protocol modifications must be IRB approved prior to implementation unless they are intended to reduce risk (but must still be reported for approval). Modifications will include any change of investigator/s or site address.
- All protocol deviations must be reported to the IRB within 5 working days.
- All recruitment materials must be approved by the IRB prior to being used.
- Principal investigators are responsible for initiating Continuing Review proceedings. Documents must be received by the IRB at least 30 days before the expiry date. This is for the purpose of facilitating the review process. Any documents received less than 30 days before expiry will be labelled "late submissions" and will incur a penalty.
- Every 6 (six) months a progress report form supplied by ERES IRB must be filled in and submitted to us.
- ERES Converge IRB does not "stamp" approval letters, consent forms or study documents unless requested for in writing. This is because the approval letter clearly indicates the documents approved by the IRB as well as other elements and conditions of approval.

Should you have any questions regarding anything indicated in this letter, please do not hesitate to get in touch with us at the above indicated address.

On behalf of ERES Converge IRB, we would like to wish you all the success as you carry out your study.

Yours faithfully,
ERES CONVERGE IRB

Mrs. M.M Mbewe
RNM, DNE, BSc., M.Ed.
ACTING CHAIRPERSON

Annex 10: Laboratory Results

SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
ENVIRONMENTAL ENGINEERING LABORATORY

P.O Box 32379, Lusaka
Direct Telefax: 260-1-290962
Telegram: UNZA LUSAKA
Telex: ZA44370

BACTERIOLOGICAL EXAMINATION OF WATER

Reference : MEKI CHISALA
Attn : SCHOOL OF MEDICINE

Sampled by : Client
Sampling date : 17.12.2013
Report date : 19.12.2013

Laboratory Results

Sample Number:	Sample ID	Total coliforms (#/100ml)	Feacal coliforms (#/100ml)
131700	**SAMPLE 1**	0	0
131701	**SAMPLE2**	0	0
131702	**SAMPLE 3**	0	0
131703	**SAMPLE 4**	0	0
131704	**SAMPLE 5**	0	0
131705	**SAMPLE 6**	0	0
131706	**SAMPLE 7**	0	0
131707	**SAMPLE 8**	0	0
131708	**SAMPLE 9**	0	0
131709	**SAMPLE 10**	0	0
131710	**SAMPLE 11**	0	0
131711	**SAMPLE 12**	0	0
131712	**SAMPLE 13**	14	8
131713	**SAMPLE 14**	0	0

Tests carried out in conformity with " Standard Methods for the Examination of water and Wastewater APHA, 1998".

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
19 DEC 2013
CIVIL ENGINEERING
P.O. BOX 32379 LUSAKA

J. Kabika
Co-ordinator- Environmental Engineering Laboratory

SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
ENVIRONMENTAL ENGINEERING LABORATORY

P.O Box 32379, Lusaka
Direct Telefax: 260-1-290962
Telegram: UNZA LUSAKA
Telex: ZA44370

BACTERIOLOGICAL EXAMINATION OF WATER

Reference : MEKI CHISALA
Attn : SCHOOL OF MEDICINE

Sampled by : Client
Sampling date : 26.12.2013
Report date : 30.12.2013

Laboratory Results

Sample Number:	Sample ID	Total coliforms (#/100ml)	Feacal coliforms (#/100ml)
131741	**SAMPLE 1**	0	0
131742	**SAMPLE2**	0	0
131743	**SAMPLE 3**	0	0
131744	**SAMPLE 4**	0	0
131745	**SAMPLE 5**	0	0
131746	**SAMPLE 6**	0	0
131747	**SAMPLE 7**	0	0
131748	**SAMPLE 8**	0	0
131749	**SAMPLE 9**	0	0
131750	**SAMPLE 10**	0	0
131751	**SAMPLE 11**	0	0
131752	**SAMPLE 12**	0	0
131753	**SAMPLE 13**	0	0
131754	**SAMPLE 14**	TNTC	TNTC

Tests carried out in conformity with " Standard Methods for the Examination of water and Wastewater APHA, 1998".

TNTC: Too Numerous To Count

J.Kabika
Co-ordinator- Environmental Engineering Laboratory

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
10 DEC 2013
P. ENGINEERING
32379 LUSAKA

SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
ENVIRONMENTAL ENGINEERING LABORATORY

P.O Box 32379, Lusaka
Direct Telefax: 260-1-290962
Telegram: UNZA LUSAKA
Telex: ZA44370

BACTERIOLOGICAL EXAMINATION OF WATER

Reference : MEKI CHISALA
Attn : SCHOOL OF MEDICINE

Sampled by : Client
Sampling date : 27.12.2013
Report date : 31.12.2013

Laboratory Results

Sample Number:	Sample ID	Total coliforms (#/100ml)	Feacal coliforms (#/100ml)
131790	**SAMPLE 1**	0	0
131791	**SAMPLE2**	0	0
131792	**SAMPLE 3**	0	0
131793	**SAMPLE 4**	0	0
131794	**SAMPLE 5**	0	0
131795	**SAMPLE 6**	0	0
131796	**SAMPLE 7**	0	0
131797	**SAMPLE 8**	0	0
131798	**SAMPLE 9**	0	0
131799	**SAMPLE 10**	0	0
131800	**SAMPLE 11**	0	0
138001	**SAMPLE 12**	0	0
138002	**SAMPLE 13**	0	0
138003	**SAMPLE 14**	0	0

Tests carried out in conformity with " Standard Methods for the Examination of water and Wastewater APHA, 1998".

UNIVERSITY OF ZAMBIA
SCHOOL OF ENGINEERING
31 DEC 2013
DEPT. OF CIVIL ENGINEERING
P.O.BOX 32379 LUSAKA

J.Kabika
Co-ordinator- Environmental Engineering Laboratory

SCHOOL OF ENGINEERING
CIVIL ENGINEERING DEPARTMENT
ENVIRONMENTAL ENGINEERING LABORATORY

P.O Box 32379, Lusaka
Direct Telefax: 260-1-290962
Telegram: UNZA LUSAKA
Telex: ZA44370

BACTERIOLOGICAL EXAMINATION OF WATER

Reference : MEKI CHISALA
Attn : SCHOOL OF MEDICINE

Sampled by : Client
Sampling date : 03.01.2014
Report date : 07.01.2014

Laboratory Results

Sample Number:	Sample ID	Total coliforms (#/100ml)	Feacal coliforms (#/100ml)
140012	**SAMPLE 1**	0	0
140013	**SAMPLE2**	0	0
140014	**SAMPLE 3**	0	0
140015	**SAMPLE 4**	0	0
140016	**SAMPLE 5**	0	0
140017	**SAMPLE 6**	0	0
140018	**SAMPLE 7**	12	10
140019	**SAMPLE 8**	9	2
140020	**SAMPLE 9**	TNTC	TNTC
140021	**SAMPLE 10**	0	0
140022	**SAMPLE 11**	0	0
140023	**SAMPLE 12**	0	0
140024	**SAMPLE 13**	0	0
140025	**SAMPLE 14**	0	0

Tests carried out in conformity with " Standard Methods for the Examination of water and Wastewater APHA, 1998".

TNTC : Too Numerous To Count

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