# PROPOSED EDUCATIONAL ACTIVITIES FOR UNIVERSITY OF ZAMBIA WATER USERS ARISING FROM AN ENVIRONMENTAL WATER AUDIT OF THE INSTITUTION

**By**

**Flaviour Sisala Chanda**



**A dissertation submitted to the University of Zambia in Partial Fulfilment of the degree of Master of Education (Environmental Education).**

**University of Zambia**

**Lusaka**

**2007**

## TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

## LIST OF APPENDICES

## ACKNOWLEDGEMENTS

I would like to thank Dr C.M Namafe, my supervisor, for the untiring support and effort he rendered in ensuring that this dissertation was completed and also wish to thank the late Dr A. Tembo (Manager of ESU- ZESCO) for his insights and many corrections on this study. I also wish to thank Mr Ian Banda (past resident engineer for UNZA) for his detailed and broad assistance in the data collection stages of this report.

I would also like to extend my sincere gratitude to my husband and friend Osward M. Chanda for his expert input on water issues. He helped with many issues that related to this research. He facilitated my research in many aspects too

I would also like to thank Mr Chikubula (past resident engineer) for the help he rendered on many aspects of data collection.

## DECLARATION

I, Flaviour Sisala Chanda, hereby declare that this dissertation represents my own work, and that it has not previously been submitted for a degree at this or any other university.

**Signature:**.....

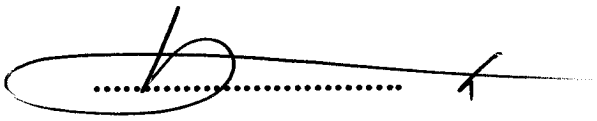
**Date:**.....

## DEDICATION

*This dissertation is dedicated to my parents Mr and Mrs P. Sisala who have encouraged me throughout my academic life and to my husband who by believing in me so much encouraged me to complete my work.*

## APPROVAL

**The University of Zambia has approved this dissertation of Flaviour Sisala Chanda as partial fulfilment of the requirements for the award of the Master of Education Degree in Environmental Education.**

| Signature of Examiner | Date of Approval |
| --- | --- |
| CMAfe | 27th June, 2007 |
|  | 27th June, 2007 |
| | |
| | |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| AWWA | American Water Works Association |
| BATNEEC | Best Available Techniques Not Entailing Excessive Costs |
| BOD | Biochemical Oxygen Demand |
| EAL | Environmental Action Learning |
| ECZ | Environmental Council of Zambia |
| EE | Environmental Education |
| EU | European Union |
| GRZ | Government of the Republic of Zambia |
| LWSC | Lusaka Water and Sewerage Company |
| MANOVA | Multiple Analysis Of Variance |
| NWASCO | National Water Supply and Sanitation Council |
| SPSS | Statistical Package for Social Sciences |
| UNEP | United Nations Environmental Programme |
| UNZA-GER | University of Zambia - Great East Road Campus |
| UK | United Kingdom |
| UK's NRA | United Kingdom's National Rivers Authority |

## ABSTRACT

Water supply management and wastewater disposal is a widespread problem, which can have significant impacts on an individual's daily life, health and the general environment. This study explored the situation of water management and wastewater disposal at the University of Zambia Great East Road Campus (UNZA-GER) located in Lusaka, Zambia. The study used the theoretical model of hydrosocial cycle in order to understand and explain the interconnected systems of UNZA-GER fresh or portable water supply management and its wastewater disposal system. Fresh/ portable water and wastewater are collectively referred to as water in this study.

The process of the research involved three main connected stages, with one stage leading into the other. The first stage involved conducting an environmental water audit at UNZA-GER using the theoretical concept of the hydrosocial cycle. In the second stage, the findings of the study were presented and analysed. In the third and final stage the analysed findings of the water audit were used as a basis for proposing environmental education (EE) activities, which UNZA-GER Administration could effect. This last stage incorporated a process called Environmental Action Learning (EAL).

The study adopted a qualitative research design, although few quantitative aspects were also utilized. Interviews were conducted and both non-structured and structured questionnaires were used depending on the theme. Observations as well as document review were also used as data collection techniques.

The study results indicated that quite a significant amount of portable water, at the time of this study, was being lost between the points of abstraction and the points of use

especially in the old residences, with old defective fittings, thereby inflating the amount of portable water consumed. The state of affairs was attributed to inadequate finances, old water infrastructures and unsustainable values and attitudes of water users coupled with increased student population and vandalism.

The concept of Environmental Action Learning (EAL) has been proposed in this study, which involves an action orientation on the part of the various water users at UNZA-GER campus to solve the problem.

For sustainable environmental management of UNZA-GER water resource it is required that the portable water flow is measured, the old corroded distribution galvanised iron (GI) pipes are replaced with PVC pipes and the metal potable water storage tanks on rooftops replaced with PVC tanks of much bigger capacity.

The dissertation also looked at wastewater management at UNZA-GER and it was noted that there is no treatment of wastewater as it is discharged into the LWSC sewer lines. However, there are numerous processes used to clean up wastewater depending on the type and quantity of contaminants that UNZA-GER can benefit from. Wastewater can be highly treated and reused as reclaimed water and some treatment facilities are capable of producing useful by-products such as methane and organic fertilisers from sewage sludge. Wastewater if not properly handled can have adverse impacts such as odour and breeding of mosquitoes, responsible for the spread of malaria.

UNZA-GER should introduce Environmental Education in form of Environmental Action Learning (EAL) among the various water users, particularly in the curricula of students for improved and sustainable water management. For administrators, the University stands to benefit greatly if it introduced the EAL which could be informal, formal and non-formal. This suggestion would lead to making informed decisions and

actions. The university would greatly cut down on the cost of water, chemicals and energy if it introduced EAL. Through EAL, the university also needed to embark on vigorous campaigns against vandalism and water wastage, coupled with measures to protect the water facilities. The Rubber trees near water lines should also be replaced.

With these proposed measures in place, the university could significantly cut down on portable water losses and the cost of providing it, thereby being able to manage its water sustainably.

# CHAPTER 1: INTRODUCTION

## 1.1 Background to the Research Problem

In terms of the scale of human suffering, inadequate sanitation and clean water provision remains the most serious of all environmental problems (World Bank 1992). Water conservation is, therefore, very important even in a country with sufficient water resources like Zambia. Water conservation and management is not just a question of conserving the raw water but there are other considerations involved, such as, that:

- Safe drinking water is treated with costly chemicals and should, therefore, only be used for purposes where treated water is necessary for hygienic reasons and not for watering plants.
- In the process of water distribution, electricity is required to pump water.
- A lot of other resources, mainly capital and labour, are used in water supply and sanitation services (NWASCO, 2005).

This research addressed the general issue at the UNZA-GER of portable water supply and wastewater disposal management. UNZA-GER has been losing a lot of water in the distribution process of its hydrosocial cycle and several factors which will be explored in detail later have contributed to this state of affairs.

The Government of the Republic of Zambia (GRZ) built UNZA-GER campus in the late 1960's as the first national university. When the university was built, it was initially planned as a residential campus and it was envisaged that over 95% of the student population would reside on campus.

## 1.2 Portable Water Supply

Water is a critical requisite that supports daily life in any place where people reside and UNZA-GER is no exception. Its uses include human consumption, washing, cooking, as an aid during cleaning of the environment, irrigation of the grounds and sports fields, as well as for use during laboratory experiments. Water at UNZA-GER also acts as a medium to facilitate the removal of human waste through a piped network for eventual disposal at the main Manchinchi sewerage treatment in Lusaka.

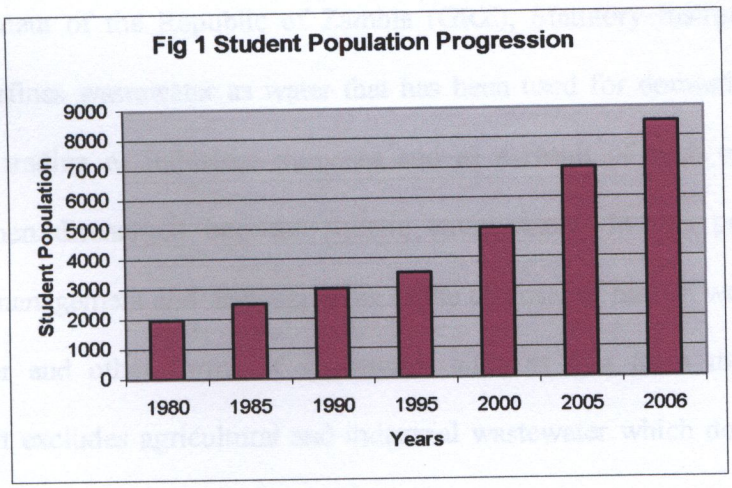
During its time of construction, UNZA-GER obtained water for construction purposes from a borehole that is located close to the mid-western boundary of the UNZA-GER transport yard. The institution was also obtaining portable water for its other uses from the Lusaka City Council, which was the then licensed provider for portable water supply in the whole city of Lusaka. The City Council water was metered and the university had to pay for this water.

At the time of writing this report in the year 2006, UNZA-GER campus had two main sources of water namely, the Lusaka Water and Sewerage Company (LWSC) as well as a network of six boreholes all located on UNZA GER campus.

According to UNZA (2005), at the time of writing this report, LWSC was the main source of water as 12,000 cubic meters of water was drawn when the campus was in session. Session here refers to the period when full time students are resident on campus. The bills for the main UNZA-GER campus were over K50 million per month for both water and sewer disposal charges. Cumulative bills over the years had been difficult to settle. The report noted above stated that the average consumption of water over the period February to May 2005 was 11.7 million litres per month.

Three of the local boreholes that supplied water to the campus were operational but the amount of water drawn was not metered. It was estimated by the resident engineer that more than 7million litres of water per month was pumped out when all six pumps were fully functional.

When the then water supply system was built, it was originally intended for only about 20% of the total population, which was there at the time of writing this dissertation. However, student population has been on the increase, as shown in figure 1 below.




Source: Registrar (Admissions) -UNZA

A network of galvanized pipes was laid beneath the ground level to service the various buildings on campus. Galvanised pipes are iron pipes, which are coated with zinc to avoid rusting. However, with time, these pipes start to corrode and after a number of years (about 20 years) the pipes eventually burst, as they will have outlived their lifespan to an extent that it is not feasible to effect repair on them, implying that replacement is the only remedy. When these pipes burst they start to leak, resulting in severe water losses. The picture in figure 9 depicts a corroded pipe at UNZA-GER campus.

The water pipes at the UNZA-GER campus have been in existence for over 30 years and, therefore, it can safely be deduced that most of these pipes were then laced with excessive corrosion levels. A large majority of these corroded pipes around campus had burst and so there were heavy water leakages around campus at the time of this report in the year 2006, leading to severe losses of water and, ultimately huge financial implications.

## 1.3 Wastewater Management

The Government of the Republic of Zambia (GRZ), Statutory Instrument No.72 of 1994: 258 defines wastewater as water that has been used for domestic, commercial, agricultural, trading or industrial purposes and as a result of such uses may cause pollution when discharged into the aquatic environment. In this particular study, wastewater management and disposal refers to the disposal of human waste through the use of water and other forms of wastewater such as that from the kitchens and bathrooms. It excludes agricultural and industrial wastewater which does not apply in this case.

When UNZA-GER was built, there was a sewer treatment plant, which was built, and this is located near the transport yard of UNZA-GER campus. The system is such that all wastewater from the campus is collected through an array of pipes laid at a gradient, leading to the sewer treatment plant next to the transport yard. When this treatment plant was built it was only half of the original plant that was supposed to be built, and plans to complete this plant have never been realised to date. Until 1992/3 UNZA-GER campus wastewater was treated at this plant, and then it would flow through what is today known as Arcades under the Great East Road, to Ngwerere stream where it was discharged.

The UNZA-GER campus wastewater treatment plant became mal-functional due to lack of spares as the technology was outdated and the manufacturers of this particular type of equipment who were in the Republic of South Africa had stopped manufacturing it. An appraisal was conducted in 1993 to try and assess the cost of replacing this whole system and it was found that it was way beyond what the UNZA-GER could afford and so it was decided in October 1994 to connect the UNZA-GER sewer system to the Lusaka City sewer system, the closest point being near National Assembly Motel. At the time of writing this report in the year 2006, UNZA-GER wastewater was not being treated and so the Lusaka City Council borehole that is located near Arcades and which supplies water to Kalundu, Olympia and Roma areas was being threatened with contamination. There was also a foul smell that one could get around Arcades area. This smell was threatening contamination of the general environment around that area.

Another problem that had been associated with the wastewater disposal and management at the UNZA-GER. campus had been that the type of waste that this sewer system was originally designed for had changed so much. This was worsened by the cooking by students in the hostels, which produced so much grease that accumulated in the pipes, leading to many blockages.

The rubber trees that are in the area between the October car park and the natural sciences car park were also not ideal for the area as their roots entered into the sewage system and caused blockages in the system. This resulted in more leakages of sewer from burst pipes.

## 1.4 The Research Problem

This researcher saw the need to investigate the water mismanagement experienced at the various components of UNZA-GER hydrosocial cycle as well as the unsustainable attitudes of the various water users at the UNZA-GER.

Part of the problem was that, there were no systematic studies done so far to investigate the major factors that had contributed to severe portable water losses at UNZA-GER. It was, therefore, worthwhile for this particular study to investigate the major factors that had contributed to this problem and also to identify possible ways of reducing this problem through the medium of education. In other words, the general research problem addressed by this study was double-pronged, namely;

- how prevalent was the problem of water loss at UNZA-GER, and what factors contributed to this problem if found to be prevalent?
- what form of educational measures would be proposed in the event that the problem of water loss at UNZA-GER was prevalent?

## 1.5 Research Questions

In order to tackle the double-prolonged above noted general problem, the study was guided by the following specific research questions:

- Did the university have a well-defined water policy and, if not, what are the implications of lacking one in managing campus water?
- What was the impact of increased water losses from the UNZA-GER hydrosocial cycle, if any, on the water environment of the campus?

- How much portable water was being consumed or wasted within UNZA-GER and what were the cost implications?
- With reference to a hydrosocial cycle, how best could the results of an environmental water audit benefit the university management and the general water users at the campus so as to effectively manage their water resources?

## 1.6 Purpose of the Study

This study had two main aims. Firstly, as part of the water audit, the study sought to describe in detail the nature of the portable water losses and the management of wastewater in the university's hydrosocial cycle, as well as to determine the impact of this on the human and non-human environment of the UNZA-GER campus. This knowledge was expected to be used to design relevant educational activities for various UNZA-GER water users as the target audience. Such water users included students, faculty members including library staff, as well as other support staff that worked around campus.

## 1.7 Specific Objectives

The following were the specific objectives of the study:-

1. To conduct an environmental water audit of UNZA-GER hydrosocial cycle.
2. Arising from item 1 above, it was hoped to :
    - suggest some possible direction on how to minimize negative environmental impacts in the university in the event that there was some ineffective water management at the campus.
    - propose educational activities for targeted UNZA-GER water users as a way of sustainably managing water resources at the institution. As part

of this process, the study would propose educational measures which were hoped would enlighten the water users on how best they could effectively reduce the problem of water loss at the institution.

## 1.8 Operational Definition of Terms

For the purpose of this dissertation, the following terms had the meaning ascribed to them hereunder:

- Environmental Audit is a tool used to understand and analyse the environmental effects of the operations of an institution.
- The hydrosocial cycle basically illustrates the flow of water from the point where it is abstracted to the point of distribution or consumption through to the collection and disposal of wastewater.
- Environmental Impact is an effect, either positive or negative, of an operation on the environment.
- Water management is looked at in terms of portable water supply, usage, and wastewater disposal or management
- Environmental Policy is a commitment of an institution to care for the land, water, air, and other external influences and conditions that affect the development and life of all organisms, including humans.
- Campus water users were all the people at UNZA-GER who benefited from using water resources at the campus, and these included students, faculty members, administrators, as well as support staff.

## 1.9 Significance of the Study

This study may help to identify areas of risk reduction, performance improvement and cost reduction in the management of the hydrosocial cycle of the UNZA-GER campus. It further may help the university to effectively manage its water supply by reducing the water losses that are encountered through its hydrosocial cycle thereby cutting down the cost of water management at the campus.

- Environmental policy at UNZA-GER

The issue of an environmental policy in any place where there are several actors interacting with the environment becomes very cardinal. An environmental policy would help to direct the conduct of the actors towards the environment, in conserving it and nurturing it to the enjoyment and benefit of all. Once a sound environmental policy is in place and implemented at UNZA-GER, it would lead to improved life and living conditions for all actors, but a lack of one, results in lack of care and deteriorated environmental condition, which greatly affects the quality of life.

- Environmental Education among UNZA-GER water users

Introducing EE in any community is very important, particularly in a community like UNZA-GER with a very high concentration of people. EE is very important in maintaining good attitudes towards the environment, thereby minimising waste of resources.

- Sustainable water management among UNZA-GER water users

Introducing sustainable water management is not a matter of choice in a situation where water supply is limited, and the costs of providing it is rising and the demand through increased population is rising as well. Sustainable water management among UNZA-GER water users is a must, as it will help in effective use of the limited resources and reduce the need of huge capital outlay to correct the situation.

# CHAPTER 2: LITERATURE REVIEW

This chapter provides an insight into studies of water supply management that have been carried out by various authors. The chapter is divided into four sections. The first section reviews some of the previous researches done on water use/ supply management, as well as some literature on water resources management in general. Secondly, the chapter looks at literature on wastewater management and disposal, and, thirdly, reviews have been made of literature on environmental audits that have been conducted in other universities with specific reference to water, and finally the last section of this chapter looks at the importance of environmental education in the management of water resources.

A wide range of books and periodicals dealing with water supply management and wastewater disposal were reviewed. This literature allowed the researcher to understand the research problem better, in terms of its historical background, theoretical framework, current research developments and trends in water management. All these forms of literature were critically applied to the water situation of UNZA-GER in one-way or the other.

## 2.1 Water Use/ supply Management

National Water Supply and Sanitation Council (NWASCO 2005) points out that proper water management is crucial in the protection of the environment. The environment has to be protected for the use of future generations. There are mainly two ways in which water supply and sanitation can have a negative impact on the environment; firstly the excessive use of underground water has to be avoided in order to prevent a permanent decline of the underground water level. This can mainly be achieved by conservation of

water and adequate monitoring. Secondly, sewage treatment has to be adequate before being released into the environment.

The World Water Council (2003) affirms that water is a driving force for sustainable development, including environmental integrity and the eradication of poverty and hunger. Water is also indispensable for human health and welfare. Prioritising water issues is an urgent global requirement as reflected in the declaration of the Millennium Development Goals (UN 2000) and so each country has the primary responsibility to act. Whilst effort being undertaken in different parts of the world so far on water resources development and management should be continued and strengthened, it is important to recognise that good governance, capacity building and financing are of utmost importance in these efforts. The point of prioritising and setting targets for improvement of water supply and water resources management is relevant to the current study, as UNZA-GER at the time of this study seemed not to have any documented targets or priority for water issues. It is very important for the university to have documented targets and priority as such documentation indicates the Management's commitment to improving water supply and water resources management at the institution.

Future domestic water demands in the world are calculated from projected population growth and unit consumption rates. With the ever-increasing population, it is evident that water demands will also increase significantly across the countries, and so there is a serious need to properly manage our water resources.

*Environmental Council of Zambia (ECZ 2001) affirms that water resources are very* critical in any nation, and that conservation of the resource should be a priority in any

nation. Zambia is endowed with sufficient water resources to meet the present and the foreseeable future demand for water. Both surface and underground water resources have been used in meeting this water demand. Unless these water resources are utilised in a sustainable manner, it will be difficult to ensure the continued availability of the resource in terms of both quality and quantity. Therefore there is need for a well-developed water management strategy to support sustainable water use. The point of sustainably using water applies to the present investigation because UNZA-GER campus appeared, at the time of writing, to lack a comprehensive water management policy which could have informed the researcher how much water needed to be used sustainably.

According to the ECZ (2001), in Zambia, groundwater is fairly evenly distributed and most areas depend on it while surface water is unevenly distributed, which results in some areas experiencing shortages. To meet future demand, the water resources in Zambia need to be developed, conserved and protected.

Cheryl le Roux (2005) states that in a large number of rural communities in South Africa where water is provided through local or governmental projects, water wastage is considerable and this contributes to significant environmental problems that need to be addressed. Further, Cheryl le Roux found that many residents of these villages have negative attitudes towards the process and principles on which the provision and management of water has taken and continues to take place. Given the fact that water is essential to life, and that it is a scarce resource and consequently that communities are obliged to manage and use the resource sustainably, the possibility of, and need for trying to influence community members' attitudes positively towards the sustainable

use of water, becomes prominent. This study is relevant to the current study because UNZA-GER campus, at the time of this study, lacked demonstrable efforts at water conservation attitudes and values.

Significant water loss constitutes not only an urgent challenge for the management of water resources, but also a problem which can have significant impact on an individual's daily life, health, and the general environment. Studies exploring challenges in water supply and wastewater disposal management indicate that severe water loss is quite common in water resources management (Stephen 1997), and UNZA-GER as an institution as well as a social community of water users is not an exception to this problem as shown in figures 10 and 11, which this researcher found during the course of investigations in physical inspection of UNZA-GER buildings and review of unpublished reports of the Resident Engineer's office.

In many countries, the loss of water as a result of leakage, mainly occurring between the points of abstraction and the points of consumption as well as on the consumer's property, is considered to be of great importance. The significance of such losses is that for a given level of consumption the capacity of a water system in terms of abstraction, storage, freshwater treatment and distribution must be correspondingly higher to compensate for such leakages, with all the financial and environmental costs thereby implied. Losses are a function in part, of the total distance over which water is distributed. For that reason they are often expressed in terms of cubic metres per day lost per kilometre of the mains supply. But burst pipes and the rate of leakage also vary directly with water pressure, which is higher, for example in distribution to consumers in hilly areas and in densely populated areas. The latter may also suffer losses because

their pipes are old. Losses are also exacerbated in areas where ground conditions are unstable or corrosive. The movements in the ground lead to fracturing of pipes, while corrosive soils wear out the pipes until they puncture. In this study, though water losses are of great significance there seemed to be no urgency on the part of UNZA-GER administrators to resolve the problem.

Infrastructure renewal aimed at reducing losses takes several forms, such as leakage control targets defined in litres per property per hour, pressure reduction measures and the active location and repair of both bursts and corroded mains. Loss control can be advantageous for a given demand forecast, a lower leakage rate permits a lower capacity construction; for an existing system in which supply exceeds demand, it reduces operating costs in abstraction, treatment and distribution for an existing system in which demand exceeds supply it allows for more modest or no additions to capacity to meet that excess demand than would otherwise be the case (Stephen 1997).

To complete this review of fresh water distribution management, it is worth noting that leakages are usually treated as a demand size issue in current technical literature. For example industry forecasts of the growth in demand include unaccounted for water; lost water is treated as a use, and it is suggested that the control of distribution losses is a form of demand management. This does not seem helpful. The key argument for regarding water losses as part of supply analysis is that they occur prior to consumer use. The exact scale of leakage is not known because of the imprecision of flow monitoring and metering and this is why the term 'unaccounted for water' is to be found in the literature, however it is believed that most losses occur in the mains supply, the distribution systems and company communication pipes rather than from the supply

pipes located on the users property. In this study, identification of where major losses take place is important in instituting control measures within the system. UNZA-GER did not have water flow meters at the time of this study, to be able to identify places of highest losses. There where also no written plans of installing water flow metres in the system, which could have informed the researcher that water supply was being managed efficiently.

## 2.2 Wastewater Management

Wastewater is generally any water that has been adversely affected in quality by anthropogenic influence. It comprises liquid waste discharged by domestic residences, commercial properties, industry, and/or agriculture and can encompass a wide range of potential contaminants and concentrations. In the most common usage, it refers to the municipal wastewater that contains a broad spectrum of contaminants resulting from the mixing of wastewaters from different sources (Tchobanoglous et al, 2003).

Sewage is correctly the subset of wastewater that is contaminated with faeces or urine, but is often used to mean any wastewater. "Sewage" includes domestic, municipal, or industrial liquid waste products disposed off, usually via a pipe or sewer or similar structure. The physical infrastructure, including pipes, pumps screens, and channels used to convey sewage from its origin to the point of eventual treatment or disposal is termed as sewerage (Tchobanoglous et al, 2003).

ECZ (2001), states that, in Zambia management of wastewater and sewage through levies is only possible in the planned and more developed settlements. In the peri-urban and rural areas, communal type facilities, if they exist, are usually provided at no or minimal fee. In most cases, water supply facilities are provided without sanitation facilities.

**Treatment**

There are numerous processes that can be used to clean up wastewater depending on the type and extent of contamination. Most wastewater is treated in industrial-scale wastewater treatment plants (WWTPs) which may include physical, chemical and biological treatment processes (Tchobanoglous et al, 2003). However, the use of septic tanks and other on-site sewage facilities is widespread in areas with smaller populations. Some wastewater may be highly treated and reused as reclaimed water. Modern systems include tertiary treatment by micro filtration or synthetic membranes. After membrane filtration, the treated wastewater is indistinguishable from waters of natural origin of drinking quality. Nitrates can be removed from wastewater by microbialdenitrification, for which a small amount of methanol is typically added to provide the bacteria with a source of carbon.

The nature of the treatment process is determined by the quality of the wastewater received at the sewage treatment works and the targeted quality of the effluent that leaves the works. Effluent limit may be decided on a case-by-case basis depending on the river into which it is discharged and its use (Heidebrecht and Hewitt 1994).

Wastewater that is neither internally nor externally re-used may be recycled, that is to say, released into the fresh water network, where it supplements the natural flows down stream from its point of disposal. A special case of recycling is the artificial recharge of aquifers.

Some local authorities, and Water and Sewerage companies in Zambia do treat and dispose off sewage, however, they require major repairs and rehabilitation. According to ECZ (2001), there are only 35-sewer schemes countrywide-Zambia, but growth is expected, though at a much lower rate compared to water schemes. Some treatment

facilities are capable of producing methane and organic fertilizer from sewage sludge. Unfortunately, these opportunities are not being utilized at all in Zambia.

Waste stabilization ponds are the most common facility for sewage treatment in urban areas. These ponds are often overgrown with aquatic weeds. The major adverse impacts are odour and breeding of mosquitoes, responsible for the spread of malaria

**Sewage disposal**

In some urban areas, sewage is carried separately in sanitary sewers and runoff from streets is carried in storm drains. Access to either of these is typically through a manhole. During high precipitation periods a sanitary sewer overflow can occur, causing potential public health and ecological damage.

Sewage may drain directly into major watersheds with minimal or no treatment. When untreated, sewage can have serious impacts on the quality of an environment and on the health of people. Pathogens can cause a variety of illnesses. Some chemicals pose risks even at very low concentrations and can remain a threat for long periods of time because of bioaccumulation in animal or human tissue (Tchobanoglous et al, 2003).

In many countries, including Zambia all discharges require government consent whether they are into rivers, estuaries or the sea. If sewage sludge has not been re-used as a fertilizer or soil conditioner, it may be incinerated, buried in landfill sites or dumped into the sea. Rivers have the power to assimilate organic waste. This requires a minimum acceptable flow to make possible the process of effluent dilution and break down. Minimum acceptable flows are in any case necessary to protect riverine environments. Stephens (1997) states the four major indicators of high overall quality as being: high dissolved oxygen, low biochemical oxygen demand (BOD), low ammoniac

nitrogen and –other than in times of flood – low suspended solids. The UNZA-GER would need to prepare to comply with the discharge requirements from the Environmental Council of Zambia.

**Reuse**

Treated wastewater can be reused as drinking water as is the case in Singapore, in industry for cooling towers, in artificial recharge of aquifers, in agriculture for instance 70% of Israel's irrigated agriculture is based on highly purified wastewater and in the rehabilitation of natural ecosystems e.g. in the USA-the Florida's Everglades (Tchobanoglous et al, 2003). According to Stephens (1967), Governments in developing countries exalt sewage works to use the best available techniques not entailing excessive cost (BATNEEC) some of these wastes may then be externally reused. For example, treated wastewater may be used for irrigation purposes. Internal and external reuse both contribute to the dual supply uses, of course, external reuse may generate extra distribution cost. Even though there are many benefits from wastewater treatment through reuse or use of generated solid waste to offset costs, this may not currently apply to UNZA-GER as no treatment currently takes place there. However, UNZA-GER would benefit greatly from treating its own wastewater through use of solid waste to offset costs of disposing it off. The UNZA-GER can also reuse the treated wastewater for toilet flushing, clothes washing as well as watering of gardens. This would result in savings of potable water of up to sixty percent. This, according to Del Porto and Steinfield (1999), is because toilets, clothes washing and watering of gardens are the biggest users of water in most learning institutions and accounts for between fifty and seventy percent of the water used in an institution.

## 2.3 Water Management and Audits in Other Universities

California State University-Northridge has had an active water conservation programme since 1986.The Campus had taken steps, which resulted in a 24% reduction in water usage. Some of these measures included retrofitting all shower, flush vales and faucets with water saving devices as well as reducing and changing their irrigation systems, placing water conservation stickers in various rooms, and distributing educational materials on water conservation. (Www.csun.edu/audit)

Brown University in the United States of America began its water conservation efforts in 1991. The university uses approximately 300million gallons of water a year according to Kurt Teichert. If Brown can reduce its water consumption, in addition to saving water on the supply side, it will also reduce the amount of wastewater, which must be treated, thereby minimizing its impact on the local environment.

There are also valid economic arguments to conserve water. Brown uses an average of eight hundred thousand gallons of water a day. During fiscal year 1991 for example, Brown used 480 million gallons of water. The university has retrofitted all shower heads with low flow utilities, has taken steps to improve process cooling systems for laboratory equipment resulting in reduced water consumption and, finally, a water audit had been undertaken that revealed that by continuing these water conservation measures, the university could save up to 120million gallons of water annually, saving approximately $300,000/year (Fetter and Mudd 1993).

Princeton University a private institution located in New Jersey, with a total campus population of 10,571 and a residential population of about 6,220, has considerable environmental impacts associated with its operations. For example, for the year 1994, 3000 tons of solid waste was disposed off at a cost of $409,000, 64,000lb of hazardous waste were generated, $6.5 million was spent on the campus energy bill, and 55.5 million sheets of copier paper were used. At such a large scale, waste was inevitable and every effort needed to be made to increase efficiency and environmental consciousness at the University.

In order to improve Princeton University's relationship with the environment, the Princeton Environmental Reform Committee (PERC) conducted an environmental audit. This audit represented a year of research on campus energy use, solid waste recycling, water use, food procurement and disposal, and construction of new facilities at the campus. The status of each issue was reported and recommendations made for ways to mitigate the university's environmental impact and to operate more efficiently. In Most cases these recommendations are accompanied by significant cost-saving opportunities for the university.

PERC's Water use Task force conducted three investigations of water conservation options for the university to reduce the amount of water used on campus. The survey was limited to residential water use, although the total water used by the university was divided into categories and the usage calculated in each. Findings show that residential areas consumed the highest percentage of water during the time period examined. For this reason, the analysis on water use was confined to this area. Princeton has for the past two to three years been replacing broken showerheads and toilet fixtures with

water-efficient models, with these and other efforts, the savings in the water bill multiply each year (PERC 1995).

Some African universities that have undertaken similar water conservation measures include the Rhodes University in South Africa and the University of Zimbabwe. The results from other universities have clearly shown that they could reduce costs of water by as much as one third by performing environmental audits, which helped to determine the break down of total usage, identifying leaks and so on. Clearly UNZA-GER campus has a lot to gain economically as well as environmentally, by performing an environmental water audit.

### 2.4.1 The Importance of Environmental Education (EE) in Addressing Water Management

According to Van Rensburg (1999), environmental research focuses on environmental issues, but not issues necessarily limited to aspects of the natural environment but also human and cultural aspects, which constitute the social environment. This implies that environmental research encompasses studies of natural and social systems and their interactions. This, by deduction, involves research, which would be classified as environmental education research. Van Rensburg looked at EE as a label for a range of educational processes and initiatives that may differ, at least to some extent, from the usual orientation of education. Some of the reasons noted for the difference were as follows:

- Firstly, she notes that EE happens in a context of an urgent imperative for individuals and groups of people to act differently today towards the

environment from how previous and indeed the current generations of people do. For instance the notion of 'ecological sustainability' that EE aims to promote draws us to start farming our land, boosting our economy and dealing with our garbage in a different way.

- Secondly, she notes that developing durable solutions to complex environmental issues requires combined efforts from diverse ways of thinking about those issues from ethical, experiential, indigenous, and scientific perspectives, implying that with issues of the environment we are all educators and learners and so there is need to have an open minded approach in dealing with environmental issues. All forms of knowledge whether traditional or modern scientific is therefore important and has a role to play in EE.
- Thirdly, Van Rensburg notes that in the light of the rapid technological and cultural change of our time the world of tomorrow, for which today's children are being educated, will feature socio-ecological issues beyond the imagination of today's educators and book writers. What this means is that EE should have an open approach to issues, leaving room for additional knowledge at any time as opposed to education, which normally follows a prescribed curriculum.

From the above view, it is very clear that EE is participatory in nature and it incorporates various fields of study using various approaches. EE should therefore be able to provide the learners with an opportunity to acquire awareness of and concern for the planet and its people the knowledge, skills, attitudes and values needed to protect and improve the environment. EE will also enable the learner to acquire new patterns of behaviour in both the personal lifestyle choices and informed social action that reflects this care.

According to Kim le Roux (2001) to ensure sustainability of any environmental resource it is very important to modify or adapt present patterns of use. This means that it is necessary to design, implement and monitor environmentally focussed education programmes to assist communities to view and use environmental resources in a sustainable and equitable way. Seen within the context of contemporary education processes it is expedient that programmes aimed at the management of any environmental resource should be economically efficient socially appropriate and just, and presented within clearly defined parameters based on an approach of full community participation. Based on these observations the need to investigate the communities' attitudes towards water as a scarce environmental resource and to investigate the role education could play in encouraging the sustainable use of water, becomes compelling.

**Guiding Principles of Environmental Education**

Some of the guiding aims and principles of Environmental Education as developed at the UNESCO/UNEP conference held at Tbilisi in 1977 were as follows:

- EE should consider the environment in its totality
- EE should be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages.
- EE must be interdisciplinary in its approach, drawing on the specific context of each discipline in making possible a holistic and balanced perspective.

- Examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas.
- Focus on current and potential environmental situation while taking into account the historical perspective.
- Promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems.
- Explicitly consider environmental aspects in plans for development and growth.
- Enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences
- Help learners discover the symptoms and real causes of environmental problems
- Emphasise the complexity of environmental problems and thus need to develop critical thinking and problem-solving skills
- Utilize diverse learning environments and a broad array of education approaches to teaching/learning about and from the environment with due stress on practical activities and first experience.

(UNEP 2004:34)

The Tbilisi principles and objectives above define the nature of EE and what it is intended to achieve. EE according to these principles is recognised as a lifelong process based on an interdisciplinary approach and diverse methods. Intrinsic to this process of education is the acquisition of knowledge, skills and attitudes that individuals apply to

and incorporate in everyday life. Ultimately, education shapes perceptions of the world at large. In the context of an individual's personal environment, how much one knows about the elements and resources in ones environment, and what one's attitudes towards these elements and resources are, are largely determined by the extent to which one is knowledgeable about those aspects within that environment. Put differently, the way in which environmental resources are used is largely determined by one's knowledge of and attitude towards those resources. Therefore, influencing attitudes through knowledge acquisition is very important in conservation and management of any resource.

It can also be deduced from these principles that EE is very important as it enables learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences. Through action learning the students are involved in analysing their own problems, understanding the consequences or implications of those problems and also making decisions to resolve those problems. This is a great achievement where changing the attitudes and values of water users is concerned. EE is important as it involves emphasising the complexity of environmental problems and thus calls for a need to develop critical thinking and problem-solving skills. This coupled with utilization of diverse learning environments and a broad array of education approaches to teaching/learning about and from the environment with due stress on practical activities and first experience will enable the learners to change their views and attitudes about the natural resources and this will consequently affect the way they care for the environment.

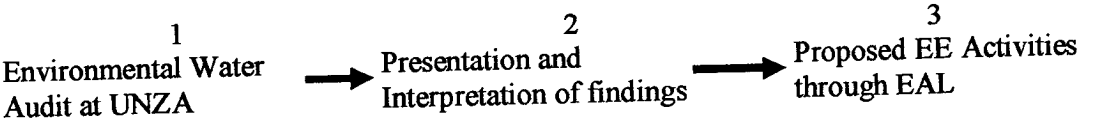
EE is therefore very important in addressing issues of water resources management and especially in changing the way people perceive things, thereby changing ones values and attitudes.

The Tbilisi principles bring out important aspects that would greatly benefit UNZA-GER if applied. For instance the holistic and continuous approach to awareness and knowledge acquisition would need to be applied to the UNZA-GER water users in their curricula, and all other activities offering an opportunity. The water users would come out with better attitudes, values and well equipped with the skills for identifying and solving environmental problems. They would be more willing to participate in working towards the resolution of environmental problems at UNZA-GER.

# CHAPTER 3: RESEARCH METHODOLOGY

The nature of this study had a dual intention: the investigation of an environmental issue as well as an educational one. The former led to the later. What this means is that on one part, the method addressed the environmental water audit using the theoretical framework of the hydrosocial cycle, and on the other part issues arising from the water audit formed a basis of the proposed environmental education activities.

**Fig 2. The Process of the Research**




Such types of enquiry are uncommon to environmental research as many researchers simply end up with collecting data and then presenting them in form of research results, as well as interpreting the results.

## 3.1 Research Design

The study mainly employed qualitative research designs. For the first phase of the study involving the water audit, a survey method was chosen as it involved the collection of data on a wide range of cases, each being investigated only on a particular aspect under consideration.

## 3.2 Population of the Study

For phase two of the study involving proposed educational activities, the target population comprised all water users at UNZA-GER campus in Lusaka. The population from which the sample was drawn were ranked into various categories: undergraduate

students, postgraduate students, faculty members, library staff, and other support staff at campus.

Students included only the full time students at UNZA-GER campus. Part-time students who included those that come in the evenings were not included as well as those that are distance education students.

### 3.3 Sample and Sampling Method Procedure

Selection of the sample was done using purposive sampling and stratified random sampling procedure. UNZA has eight schools at the GER campus: these are Agriculture, Education, Engineering, Humanities and Social Sciences, Law, Veterinary Medicine, Natural Sciences and Mines. In this study the schools were defined as the strata or sampling units, and the students as the actual units.

In the selecting of the strata or sampling units, the purposive method was employed, but in selecting actual units from each stratum, stratified random sampling method was used. Stratified sampling was chosen as a refinement of simple random sampling since; in addition to randomness stratification introduced a secondary element of control as a means of increasing precision and representativeness. Gender representation was also considered during the selection process.

Lists of students: both undergraduates and postgraduates were obtained from the Registrars (Admissions) office and Directorate of Graduate studies respectively. The list of names for the academic faculty was obtained from the Registrar (Administration) office, while a list of library staff was obtained from the deputy librarian's office.

## 3.4 Research Instruments and their Administration

The following techniques were used to generate data for this research.

### *3.4.1 Structured and Non- Structured Questionnaires*

This was used to generate data for both the first and second phases of the study (the environmental audit of UNZA-GER hydrosocial cycle and the proposed educational activities). The structured questionnaire consisted of definite, concrete and directed questions whereas the non-structured questionnaire consisted of partially completed questions and statements. This was used as a guide for the interviewer, which was non-directive. The interviewer posed only a blueprint of the enquiries and was largely free to arrange the form and statements of the questions. The enquiries framed in a general form beforehand were given a specific form during the actual process of interviewing.

### *3.4.2 Interviews*

This was used for the second phase of the study to generate data for the proposed environmental educational activities. Various people were interviewed and these included the resident engineer, some faculty members, library staff, students and some support staff. This helped the researcher to be able to probe further into causal factors, determine attitudes, discover the origin of the problem, involve the interviewee in an analysis of the problems and secured the interviewee's cooperation in the analysis of the problems.

### *3.4.3 Direct Observation*

On-site observations were made and pictures taken at various points. This natural way of collecting data was used in generating data for the hydrosocial cycle at UNZA, and it helped the researcher to overcome some of the restrictions encountered in both the questionnaires and the interview. The problem of artificiality and formality that was encountered in the first two methods above was replaced with reality and informality in this method of gathering data.

### *3.4.4 Analysis of Various Relevant Campus Records*

To generate more data for the hydrosocial cycle, the researcher reviewed some background information to gain familiarity with the project site and also gain knowledge of the operational information. The following documents were reviewed:

- The site layout plans of both the water supply and wastewater disposal networks at campus.
- Site history, use and activities of the area under study
- Blueprints/ as built drawings
- Organisational structure of the area under study
- Internal policies, procedures and guidelines

## 3.5 Data Processing and Analysis

Interview notes from the field were transcribed by re-writing them into readable and meaningful information and were also given some interpretations. Exploring the dimensions of each category (stages of the hydrosocial cycle) did this and how each category linked to others, using concepts of 'process' and 'change' as guiding

principles. Whilst in the field clarifications and missing information from respondents were sought through the preliminary analysis of data, which was done whilst in the field.

## 3.6 Ethical Concerns

Ethical issues were highly considered in this study. Permission was sought from the school administration and library administration to enable the students and library staff to participate in this study respectively. Also from the resident engineer's office, permission was sought to do a conducted tour of the entire campus to observe and investigate the situation of water supply and wastewater management on campus.

## 3.7 Scope and Limitations

This study was carried out at the UNZA-GER and involved sampling students, academic faculty, and staff from the resident engineer's office. Due to financial resources and time constraints it was not possible for the researcher to conduct personal observations on water supply management and waste water disposal in other higher institutions for comparative study. Owing to the same reasons, it was not possible to survey the water use habits of the distance education students. However, in spite of these limitations the researcher is fully convinced that the results of this study will be valid to the UNZA-GER.

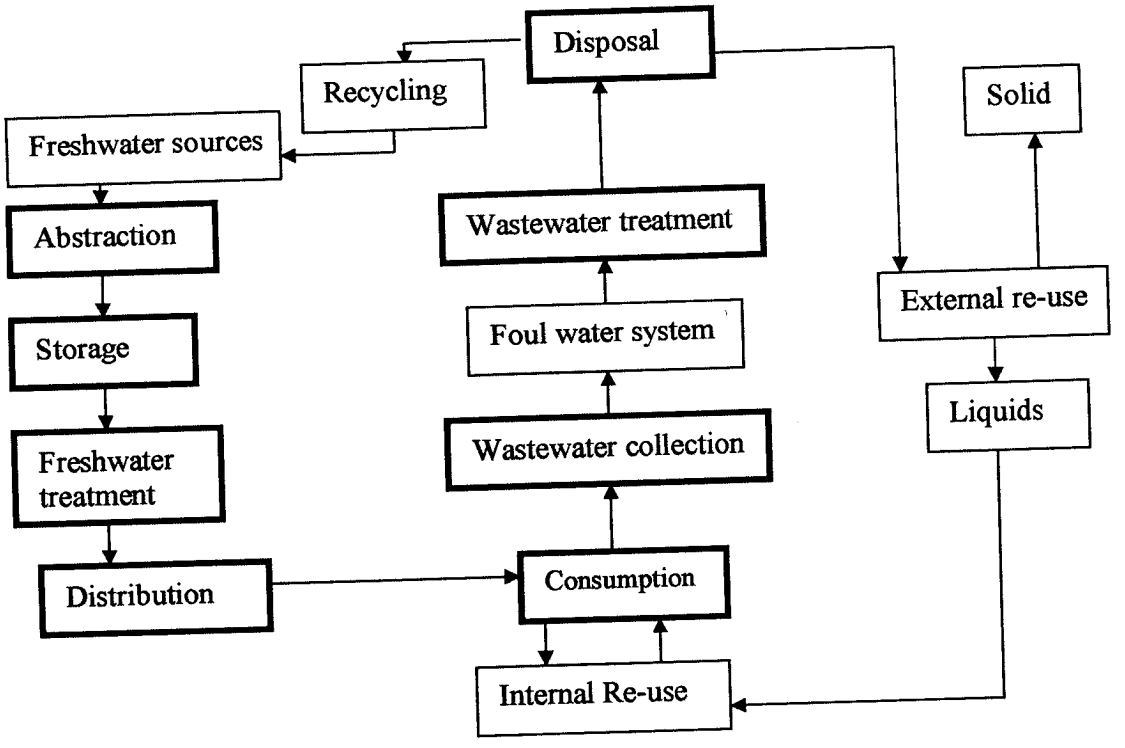
# CHAPTER 4: ENVIRONMENTAL WATER AUDIT OF UNZA-GER USING THE THEORETICAL MODEL OF HYDROSOCIAL CYCLE

## 4.1 Descriptive Features of the Model

As already pointed out, this study aimed amongst other ways, to conduct an environmental water audit of UNZA-GER's hydrosocial cycle. The concept of "Hydrosocial cycle" requires to be clarified now because it formed a theoretical means of addressing the issue of water loss at UNZA-GER. Moreover, the process of environmental water audit touched or addressed elements of the same hydrosocial cycle. A hydrosocial cycle basically involves the supply of fresh and wastewater services. The cycle demonstrates the flow of water from the point where it is abstracted to the point of distribution or consumption through to the collection and disposal of wastewater. The hydrosocial cycle has a number of boxes that are of special importance and these include: abstraction, fresh water storage and treatment, distribution and consumption, wastewater collection and treatment, and wastewater disposal (Stephen 1997).

Such a cycle contrasts with a hydrological cycle because of the emphasis given to society or human beings in the process, whereas the hydrological cycle largely focuses on natural elements. This model is known as hydrosocial because once water is abstracted it changes from being a natural resource to a social product. In this research the university community is considered as making a small social community of people whose water supply and consumption constitutes a "hydrosocial cycle".

**Fig. 3: A Simple Model of the hydro social cycle**




(Source: Stephen M, 1997:6)

This research attempted to survey water losses occurring at the various components of the cycle, the major factors that contributed to these losses and attempts to address these issues or factors by the UNZA-GER community of water users at that time. This aspect constitutes what this study is referring to as a "water audit". The issues generated from the water audit themselves formed a basis for the proposed educational activities which appear in chapter 5 of this dissertation.

The 'hydrosocial' cycle as applied to UNZA-GER, has five fundamental processes and these are described below:

### 4.1.1 Abstraction

Abstraction takes place from groundwater or from fresh water surface sources. It may be directly by the user; or it may be by a water company, which supplies the water as a service. In the European Union for example direct users as well as water companies must have an abstraction licence, which defines the maximum flow, which it is permissible to take.

Abstraction requires source works, in the case of groundwater, boreholes are driven down into the aquifers and pumping equipment is installed to get the water to the starting point of the hydrosocial network. Accessing surface water is easier but still requires source infrastructures.

In the case of UNZA-GER, abstraction occurs from its network of boreholes, as well as from Lusaka Water network. The water source data collected using a qualitative method revealed that water used at UNZA-GER is extracted from boreholes located within the campus grounds and this accounts for approximately 80% of the total volume of water consumed. This is done using submersible pumps which deliver the extracted water under pressure through dedicated pipelines into the main underground storage tank located adjacent to the Great East Road. These pumps operate for 22 hours on average per day and are manually operated by pump attendants working in 12-hour shift cycles per day. According to this researcher, this is a cheaper source of water for UNZA-GER as

only energy and direct labour and maintenance costs are incurred (Chikubula 2005).

The qualitative data collected further revealed that UNZA-GER procured water from the LWSC via a 375mm diameter supply pipe that delivers water to the north-eastern suburbs of the City of Lusaka. The LWSC supply acts mainly as a "back-up" to the borehole supply and accounts for about 20% of the total water consumption on campus. The water collected from LWSC is initially stored in the main underground storage tank located adjacent to Great East Road where it is mixed with that collected from the boreholes. All the water from the storage tank is delivered to the campus community through piped-mains, with pressure provided by a pumping unit installed in a pump room located above the underground tank. The researcher found out that water bills have accumulated over time and these have been difficult to settle. The researcher feels that this is a more expensive source of water though it is necessary for backup.

### *4.1.2 Storage and Treatment*

Storage is the second stage in fresh and wastewater supply systems of the seven fundamental processes.

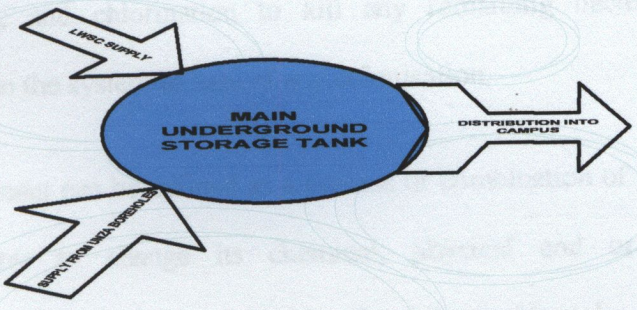
The inevitable variation in effective rainfall within the year and between years makes the natural supply of water inconstant. In dry spells and in droughts, this has the effect of reducing actual abstractions precisely when more water is needed for consumption. Water level also fluctuates with the levels of economic activity. Without some buffering device, the effect of this variance in supply and demand would be to create local water shortages, sometimes with disastrous consequences.

Water storage moderates these difficulties by providing a stock of water for times when it is low. Storage takes the form of reservoirs and water tanks.

The main storage facility at UNZA-GER is an underground concrete reservoir having a full capacity of approximately six hundred and fifty cubic meters, located adjacent to the great east road close to the main bust stop. The tank was located here because of the close proximity of this location to the LWSC trunk mains delivering water to the north-eastern suburbs of the City of Lusaka.

The tank is supplied via two sources namely the borehole supply and from LWSC. The diagram below schematically illustrates the inflow and outflow of water into the storage tank;

**Fig 4: Main Underground Storage Tank and its Main Supplies of Water**




Source: Self derived (2006)

The extraction of water from the main underground storage tank is effected by means of a ground level mounted manually operated pumping unit. This pumping unit provides the energy required to deliver the water to the high level buildings on campus. Each multi-storied building is supplied with water through a "mini"

storage steel tank mounted on the concrete rooftop having an average capacity of about one thousand litres. The main purposes of these tanks are:

- to provide a buffer storage capacity for each building block; and
- to assure water pressure for the users in the building.

*Treatment*

Fresh water treatment takes place in what is in effect a special type of chemical plant. The installation and operation of these raise the costs of water services provision; such costs are greater according to the range of pollutants dealt with and the degree of purification in respect of any single pollutant. Modern or advanced treatment was not an issue before the 1970's. Traditional treatments consisted and still consist of sand filtration to remove suspended particulate matter such as dirt, dust, clays, rust, colloids, mineral matter and algae, vegetable matter and bacteria, and chlorination to kill any remaining bacteria and provide prophylaxis in the system in case of any colonisation.

Water Treatment can be defined as a process or combination of processes applied to raw water to change its chemical, physical and or microbiological characteristics with the prime objective of making it safe and palatable for public use (AWWA, 1995). The following are the main rationale behind water treatment:

- to remove impurities that can have an adverse effect on public health;
- to improve the water's aesthetic qualities; and
- to ensure compliance with statutory drinking water regulations and standards.

Borehole water is normally not subjected to treatment as the ground water undergoes filtration as it percolates through the different underground soil strata. The main exception is when the water has a high prevalence of dissolved iron and manganese which if not removed will appear as a brown to very dark brown colour. This will normally stain clothing and result in many complaints from the users.

The main threat to sustenance of good quality borehole water at UNZA-GER can arise from the following:

i) poor solid waste disposal, which if left unabated can lead to infiltration of hazardous chemicals and substances into the underground water body from which the water is extracted; and
ii) poor transportation of the raw sewage discharged from the different buildings on campus.

Water supplied by LWSC is subjected to treatment at the main treatment plant located 55kms south of Lusaka at the intake point along the Kafue River. The water undergoes the main conventional methods of treatment outlined below:

i) Screening to remove floating debris such as branches, weeds, leaves etc;
ii) Coagulation and Flocculation-Sedimentation where a chemical known as Aluminium Sulphate is added to coagulate the small floating particles into bigger sizes to facilitate settlement and draining thereafter. The water after this process is clear and visibly attractive;
iii) Filtration where the very small suspended particles are removed by forcing the water through a bed of granular material (gravel and sand) called filter media;

iv) Chlorination where chlorine in gas form is added to the water to destroy any pathogens (disease causing organisms).

The water is then ready for consumption and is pumped to the City of Lusaka's storage facilities.

From a theoretical perspective, it is not necessary to treat the water procured from both sources due to reasons stated above. However, it is possible that there could be existent contamination in the storage tank and or the borehole water could be contaminated due to underground infiltration of sewage from leaking sewer pipes due to wear and tear and or root overgrowth, which has in many instances damaged the sewer lines.

To minimise risk of delivering contaminated water, UNZA-GER enforces a strict policy of manual chlorination into the tank using "HTH" Granular Chlorine Powder. The chlorine powder is administered directly into the tank by the pump attendant on duty using dosage rates prescribed by the UNZA-GER department of Environmental and Civil Engineering which currently stands at 900 grams per dose four times daily. This translates to a monthly chlorine usage of 108 kilograms.

The UNZA-GER Environmental Engineering lab, to check for presence of disease causing pathogenic material, tests the water regularly. The three criteria used to check the quality are, physical, bacteriological, and chemical.

i) Physical tests: these ascertain the colour and turbidity of water. The findings so far indicate that the water conforms to the acceptable WHO standards.

ii) Bacteriological tests ascertain the presence of faecal coliforms and any other harmful organism that may be present in water. The findings indicate that the water conforms to the set standards as per WHO guidelines.

iii) Chemical tests; looks at any metals or nitrates that may be present in the water UNZA-GER (2005).

### *4.1.3 Distribution and Consumption*

The definition of consumption is that it begins at the point where the water flow is put to use for the various purposes where feasible. The global water balance equation is stated as follows:

Water consumption = water production – water losses, (Rees and Williams 1993:23)

The distribution of water embraces both bulk transmission and retail networks to individual consumers. Bulk flows from abstraction and storage locations almost always require pumping facilities. In water supply, the more forceful the pumping action, the greater the water pressure and the faster the rate of flow. The Longman dictionary (1986), defines pressure as the force exerted per unit area at the base of a column of water of defined height for example 60 metres.

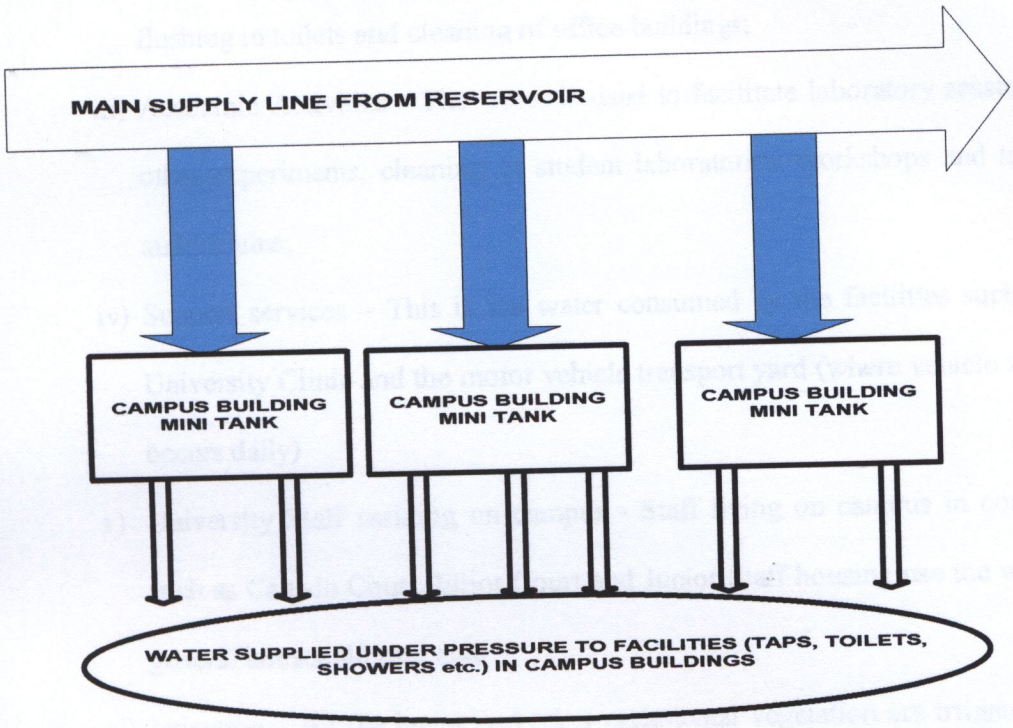
It is important to note that fresh water is usually pumped at pressure, whereas storm and wastewater sewers operate under gravity.

*Distribution*

The water is distributed to the entire campus from the main storage tank through a 200mm diameter mains pipe under pressure from the ground mounted booster pump. Secondary distribution pipes with diameters ranging between 100mm to 50mm tap off from the main line to transport the water to specific facilities that

require water such as ablution blocks, laboratories and fire hydrants. The secondary distribution pipes are made from asbestos-cement, PVC or galvanised steel. Water flow into the secondary lines is regulated at the junctions using a fixture known as a sluice valve. The distribution process at UNZA-GER is depicted in the figure 5.

**Fig 5: Water distribution Process at UNZA-GER**




Source: Self derived (2006)

*Consumption*

The water consumption at UNZA-GER was grouped into the following main categories:

i) Student Populace – The water is used for cooking, washing of utensils, clothes, bathing, waste flushing in toilets and general cleaning of the student hostels;

ii) University Staff – The water is used for "on-campus" catering services, waste flushing in toilets and cleaning of office buildings;

iii) Academic Activities - The water is used to facilitate laboratory sessions and other experiments, cleaning of student laboratories, workshops and teaching auditoriums;

iv) Support services – This is the water consumed by the facilities such as the University Clinic and the motor vehicle transport yard (where vehicle washing occurs daily)

v) University Staff residing on campus - Staff living on campus in complexes such as Canada Court, Elliot Court and Junior Staff housing use the water for general household use; and

vi) Irrigation – All the lawns and other ornamental vegetation are irrigated using water supplied through the campus water supply system

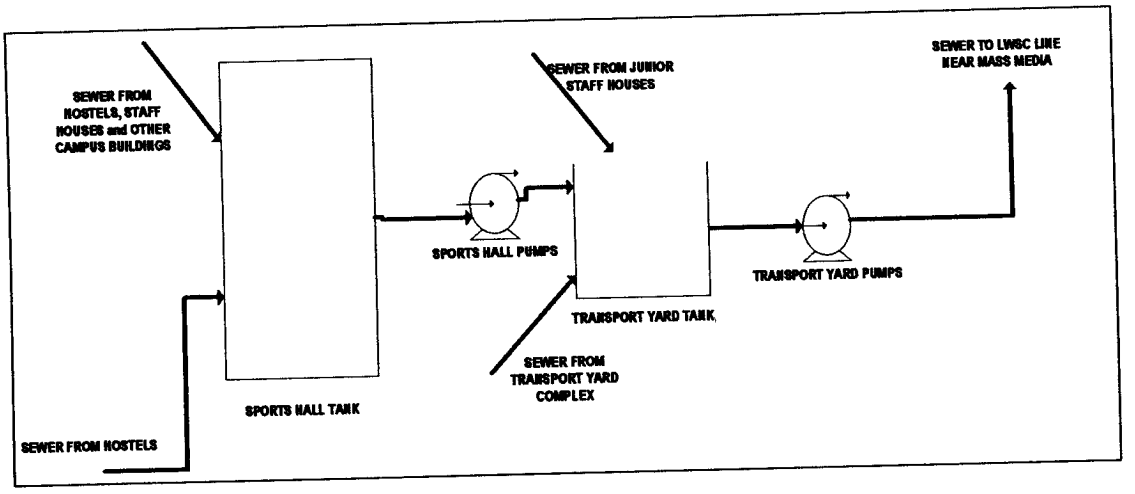
### *4.1.4 Wastewater Collection and Treatment*

Because of the physical character of the consumption process some users of water use up almost or all of the water they receive and return little or none of the water into the rivers or seas. Other users exhaust little of the flows they receive and discharge the bulk after use but the water they return may be degraded.

In some cases most significantly in the industrial sector consumers that do not exhaust all the water supplied to them are able to reuse that supply for themselves over and over again, although water treatment may be required as part of this loop. The advantage to the consumer and the environment is that such internal reuse necessitates less primary abstraction to meet consumption requirements. Where water is not used up in the process of consumption or internally reused it leaves the consumption sector as wastewater. Most wastewater then requires collection for treatment in specially designed plants. In the case of domestic wastewater the collection of sewage is through pipes connected to a main sewer and thence to a sewage works.

The disposal of all sewerage generated from the UNZA-GER is effected through a complex network of pipes and storage tanks aided by accessory equipment called sewage pumping units. The sewer flows by gravity from all the points of generation namely cafeterias, laboratories (a small percentage from the laboratories is discharged directly into the drainage channels), hostels and office ablution blocks into the sports hall underground storage tanks. It is then pumped to the transport yard open collection tanks where effluent from the transport yard and junior staff houses is added. It is then pumped for a distance of close to two kilometres into the LWSC network system entering through the sewer line adjacent to the Mass Media complex and Parliament Motel complexes. The sewage is then transported for treatment by LWSC at the Manchinchi Sewerage Treatment Plant in Garden Compound Lusaka before eventual discharge of effluent into the Ngwerere Stream located north east of Lusaka City. The flow diagram shown in fig. 6 below shows the sewer reticulation arrangement at UNZA-GER.

**Fig 6: Sewer flow from the UNZA-GER to the LWSC Network**




Source: Self derived (2006)

The carrying capacity of the sewer system is currently well over the initially designed capacity. The UNZA-GER sewer system was designed for a total populace of about four thousand persons. It is currently serving about double the design figure and extra loading also arising due to waste generated from individual cooking of meals being done by students who dispose off the cooking waste matter into the drainage channel connected to the sewer network.

### *4.1.5 Wastewater Disposal*

Wastewater that is neither internally nor externally re-used may be recycled, that is to say, released into the fresh water network, where it supplements the natural flows down stream from its point of disposal. A special case of recycling is the artificial recharge of aquifers. In the case of UNZA-GER an array of pipes laid around the Campus collect wastewater from the student hostels, staff housing on campus (Canada court and Elliot court), academic and administration buildings which then flows directly into the Goma lakes and the overflow eventually flows

into Ngwerere river via a stream running between Roma and Olympia park, to Kabanana then to Ngwerere. This wastewater does not contain human waste from toilets, whose collection has been described in the paragraphs above.

# CHAPTER 5: PRESENTATION AND INTERPRETATION OF FINDINGS

## 5.1 Introduction

This section is divided in two parts: interpretation of results of the water audit and suggested educational activities arising from the interpretation of results. The suggested educational activities represent a means by which to increase awareness among students and other water users at UNZA-GER regarding water conservation issues. The findings of the study are presented in this section to establish the prevalence level and nature of water losses at campus. The findings are presented according to the variables identified in the hydrosocial cycle. In other words, there are two main headings in this section, namely:

- Water mismanagement in UNZA-GER's hydrosocial cycle which consist of; water abstraction, storage, treatment, distribution and consumption; wastewater collection and treatment, and finally wastewater disposal
- Proposed EE activities using Environmental Action Learning

## 5.2 Water Mismanagement

### *5.2.1 Abstraction*

Stephen (1997) suggested that abstraction takes place from groundwater or from fresh water surface sources. It may be directly by the user; or it may be by a water company, which supplies the water as a service.

Abstraction requires source works, in the case of groundwater, boreholes are driven down into the aquifers and pumping equipment is installed to get the water to the starting point of the hydrosocial network. Accessing surface water is easier but still requires source infrastructures.

In the case of UNZA-GER, the results of the study revealed that abstraction occurs from its network of boreholes, as well as from LWSC. UNZA-GER uses submersible pumps to abstract its water, however most of these pumps are now very old and this greatly contributes to water losses at the institution. Other defective fixtures used in this process like valves are also very old, and result in leaks at this point. It was further noted that there is also a lot of leaking at the point where the water from LWSC is mixed with water from the boreholes.

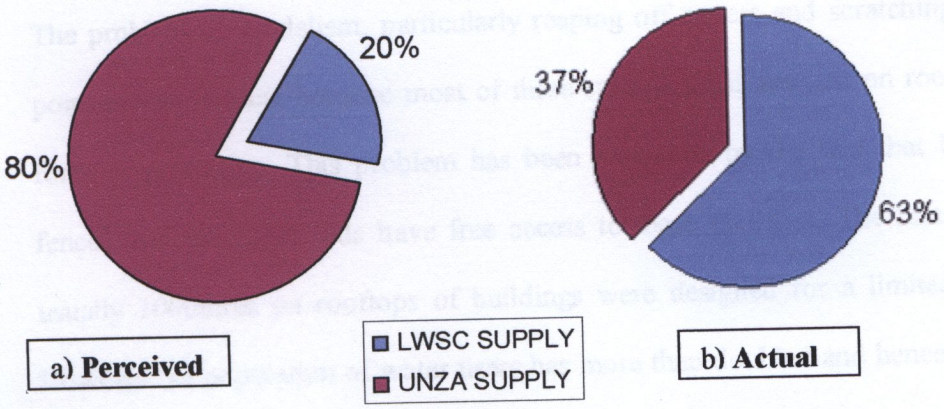
Water from boreholes at UNZA-GER is not metered and so it was difficult to get the exact amount of water pumped out, however, since the capacity of boreholes average 5litres per second (5l/s), the researcher estimated that about 12,960,000 litres of water could be pumped out per month. UNZA-GER uses about 12,000 cubic meters of LWSC water per month when students are on campus. The research also revealed that bills for both water and sewer charges at the campus were over fifty million kwacha and cumulative figures over the years had become difficult to settle.

It is very important for UNZA-GER to measure the quantity of water that it produces to be able to know how much chlorine to add but also to better understand the performance of the equipment and their capacities. For sustainable environmental management of the water resource, the production of water must be known. It is also important to know the production cost of the UNZA-GER generated water.

The researcher argued that the quantity of water procured from LWSC could be minimised once the full capacity of UNZA-GER's own supply was measured and understood. The figures of the amounts of water totalling 19,000$m^3$ being generated by the two main sources of LWSC at 12,000$m^3$ and UNZA-GER's own supply at 7,000$m^3$ (when all six pumps are operational) are different from the perception of management that UNZA-GER only uses about 20% of LWSC water of its entire total requirement. This was attributed to lack of

measurements of supply. These water source figures given to the researcher translates to 63% (12000/19000* 100 %) LWSC and 37% (7000/19000*100 %) of UNZA-GER source. Even though UNZA-GER has an estimated borehole capacity of 12,900 $m^3$ per month it continues to draw more water from LWSC than its own source, which could be attributed to the failure of the submersible pumps in some boreholes. With proper management and maintenance of its network of boreholes, UNZA-GER can drastically reduce the amount of water it draws from LWSC.

**Fig 7: Proportion of water supplied by the UNZA-GER system and LWSC**




### *5.2.2 Water Storage*

Rees and Williams (1993) as cited in Stephen (1997) suggested that water storage and treatment is a very important process in the hydro social cycle and that without some buffering device, the effect of this variance in supply and demand would be to create local water shortages, sometimes with disastrous consequences. Water storage moderates these difficulties by providing a stock of water for times when it is low. Storage takes the form of reservoirs and water tanks.

The results of this study confirmed this perspective as UNZA-GER, has both underground and overhead storage tanks. Findings of the study indicated that a lot of water is lost at the storage stage due to a number of factors. Some of these included the old storage tanks; especially the overhead tanks which are meant to boost the pressure. The storage facilities at UNZA-GER have been in existence for a long time over 30 years for most of them, and most of them have not been renovated or replaced, leading to severe losses of water. The research found that, among other factors, financial constraints as well as vandalism have greatly contributed to this state of the storage facilities at the institution.

The problem of vandalism, particularly reaping off covers and scratching the tanks, at this point is very critical because most of these storage tanks are just on roof tops without any form of protection. This problem has been worsened by the fact that UNZA-GER is not fenced and the street kids have free access to these facilities. The metal storage tanks of usually 1000litres on rooftops of buildings were designed for a limited number of users. However the population of water users has more than doubled and hence the capacity of the storage tanks has been outstripped. These tanks can only provide water for a limited period and in order to provide continued supply, there has to be continued pumping, this greatly contributes to raising the energy bill. The problem of storage is further compounded by the fact that the tanks are corroded and leak thereby reducing the holding time of water in the tanks, which would also require continuous pumping for water to be available to users at the tops.

**Fig 8: An Overhead storage tank at UNZA-GER**

(Source: Personal pictures by this Researcher)

It has become necessary to replace the metal water storage tanks on rooftops with PVC tanks of a much bigger capacity because these are not adversely affected by chlorine in the water. Bigger capacity storage tanks will minimise the pumping and ensure availability of water to users. There is also an urgent need to embark on a program of replacing the old corroded distribution G I pipes with PVC pipes which have a lot of water leakages. This programme should take into account the increased population and hence demand for water so that bigger diameter pipes are used for the main distribution lines. This programme should significantly help to reduce the water losses in the distribution network, thereby bringing down the cost of pumping, chemicals used for treatment and amounts of water produced.

### *5.2.3 Distribution and Consumption*

Rees and Williams (1993) suggested that the "Supply or Demand" question is not pedantic. To include losses on the consumption side misleadingly inflates the estimated demand for

water. In countries where losses run at 30 to 50% or even up to 85% in some cases the over statement of demand is enormous. It also deflects attention from the appropriate supply-side responses. If for example 50% of water abstracted is lost between the point of abstraction and the point of use then the reduction of these losses should be a prime option for action. This does not mean that loss reduction is cost free or that zero losses are neither feasible nor in economic terms desirable. What it does imply is that raising consumption by means of increased delivery rates can rank equally along abstraction capacity increases as engineering and economic responses worthy of investigation. The results of this study partly confirm the above perspective, because in the case under study it was observed that quite a significant amount of water at the time of this study was being lost between the point of abstraction and the point of use, through the defective fixtures like valves, leaking pipes, taps and showerheads in the bathrooms especially in the old residences, thereby inflating the amount of water consumed. Several factors identified to be contributing to this state of affairs have been analysed and found that most of these could be prevented in one way or another.

The university would greatly cut down on the cost of water, chemicals and energy by attending to the defective fittings at the point of use. The university also needs to embark on vigorous campaigns against vandalism.

**Fig 9: Corroded Pipes at UNZA-GER campus**

(Source: Personal pictures by this researcher)

At the time of this research, in the year 2006, a few examples of places that were leading to severe water losses around the campus included the following:

- Behind Africa hall where there was a leakage due to a defective 150mm dia cast iron sluice valve;
- Booster pump area where there was a leakage due to the 150mm cast iron sluice valve;
- The Supply line near the booster pump also had a leakage from the 150mm asbestos cement pipelines due to pressure from roots;

- Other leakages that had been detected included the chemistry building where there were leakages due to the corroded 75mm galvanised iron supply pipeline caused by growth of roots and;
- The chemistry top floor water tank, which had been leaking due to a defective ball valve

(UNZA 2005). These leakages verifies in intensity and ranged from five to fifteen litres per minute (5-12ltr/min).

From the above examples it was evident that water loss was quite prominent around UNZA-GER. Water losses noted at this stage of distribution is termed as Network water losses, which were caused by leakages due to defective infrastructure.

Terminal losses that were caused by leaking pipes, taps and showers, was noted as the major type of water loss at this stage of distribution and consumption. Most of the fixtures were not functioning properly and as can be noted from figure 10, a lot of treated water was being lost at this stage. Another major problem that the researcher noted was the unsustainable water values and attitude of most of the water users at UNZA-GER. Mostly the taps were left running without being closed for long hours, and the taps that had become lose and could not close were not reported early enough to the responsible authority. At times when these faults were reported, most students talked to, indicated that even when they reported these problems they were not attended to quickly due to lack of materials.

**Fig 10:Water leakages from a shower mixer at UNZA-GER**

(Source: Personal pictures by this Researcher)

A lot of water is lost at consumption stage due to many factors. Some of the factors identified by the researcher included the following:

- UNZA-GER was a government institution, which was almost entirely dependant on government for funding. However, with the budgetary constraints that the country had been experiencing, the university had not been receiving much funding from the government and so it had not been able to refurbish or even maintain its infrastructure, including its water supply system, which had not been maintained or refurbished in a long time (Chikubula Pers com, 2005).
- The deteriorating equipment such as the pumps, valves and overhead storage tanks for the hostels. This equipment was not maintained or even replaced frequently and

therefore much water was being lost through these pieces of equipment, which had greatly deteriorated.

- The small components on most of these fixtures such as taps, shower mixers, toilet cisterns, and geysers are worn out and this leads to a lot of water being lost, through these worn out fixtures.
- Pilfering and vandalism has been another major problem because UNZA-GER campus is not fenced and so people from kalingalinga and other nearby squatter settlements easily have access inside the campus and even the hostels to steal pieces of these fixtures and equipment, especially during vacations when the students are closed. This also leads to severe water losses.
- The increase in student population on campus has also greatly contributed to the problem of water supply management.
- Unsustainable values and attitudes of the water users at campus, most users do not bother to ensure that a tap is tightly closed before leaving the bathroom.

***Fig 11:Treated water being lost due to unsustainable attitudes of water users***

(Source: Personal Pictures by this Researcher)

This study also investigated action oriented educational methods by which to increase student awareness of water conservation issues and to ascertain the values, attitudes and lifestyles of water users with regards to water use at UNZA-GER. A number of hostels were randomly selected. On average most of these hostels are five storey undergraduate hostels housing about 120 students per hostel. There are two showers, one bathtub, four hand wash basins, a kitchenette and a laundry facility per floor. The kitchenette and laundry are just on the first floor. Fifty water users from different hostels completed a survey and the results revealed that 40% of the people interviewed responded that they do not think about how much water they are using when in the bathroom. 25% responded that they sometimes think about the amount of water they are using when they are in the bathroom, while the remaining 35% indicated that they do think about how much water they are using. It is evident from the results that most water users at UNZA-GER have unsustainable values and attitudes towards water resources management. The attitudes of water users were also revealed to the researcher by the Resident Engineer who confirmed findings of the study, which, tarried with the observations from their report. In this vein it was stated that most of the water users at UNZA-GER have unsustainable water values and attitudes. The attitudes of the water users largely determine the degree to which the water bill can be lowered. The percentage indicating people that don't think about how much water they use in the bathroom is indicative of a certain attitude and lack of awareness of water conservation issues.

## 5.3 Wastewater Management

### *5.3.1 Collection and Transportation*

Heidebrecht and Hewitt (1994) suggest that most wastewater requires collection for treatment in specially designed plants. In the case of domestic wastewater the collection of sewage is through pipes connected to a main sewer and thence to a sewage works.

The nature of the treatment process is determined by the quality of the wastewater received at the sewage treatment works and the targeted quality of the effluent that leaves the works. Effluent limit may be decided on a case-by-case basis depending on the river into which it is discharged and its use. The results of this study indicated that UNZA-GER collects its wastewater through an array of pipes laid around campus connecting all the different hostels around the campus.

The wastewater collection network at UNZA-GER is extensive and adequate at the moment. However the network is in dire need of rehabilitation particularly on lines that are near the rubber trees, because these trees greatly contribute to bursting the pipes. Most of these wastewater pipes are also corroded and eventually just burst. Another major problem that was noted at this point as contributing to the blocking of sewer pipes was cooking in the hostels by students. This leads to an accumulation of oil and bits of foodstuffs in the pipes leading to blockages. This problem has been worsened by the fact that these pipes were not originally designed for such a function. The university should not wait for the pipes to be completely blocked before acting because unlike water pipes, sewer pipes when blocked can, have very serious health hazards on both the environment and the water users. The increasing wastewater generation may soon require that the pumping capacity at the sports hall and the transport yard be increased particularly for the peak period to avoid flooding.

### 5.3.2 *Treatment and Disposal*

Stephens (1967) suggested that if sewage sludge has not been re-used as a fertilizer or soil conditioner, it may be incinerated, buried in landfill sites or dumped into the sea. Rivers have the power to assimilate organic waste. This requires a minimum acceptable flow to make possible the process of effluent dilution and break down. Minimum acceptable flows are in any case necessary to protect riverine environments. The results of this study indicated that UNZA-GER just transported its wastewater to join in the main network for LWSC for disposal. There were, therefore, no major issues that were noted at this point because UNZA-GER did not treat or even dispose off its own treated wastewater.

## 5.4 Proposed Environmental Education Activities through Environmental Action Learning

This section of the dissertation now tackles the following general question: - What type of educational activities could the above mentioned categories of water users be invited to undertake as individuals or in a group in order to solve the issues identified under the various stages of the hydrosocial cycle?

The section presents suggested educational activities arising from the interpretation of results of the environmental water audit of UNZA-GER by using the hydrosocial cycle (i.e. pages 33-46). In other words, the proposed educational activities presented here are creatively pulled from chapter 4 and 5 together. Table 1 summarises the identified issues at the different stages of the hydrosocial cycle of UNZA-GER, namely Abstraction, Storage and Treatment, Distribution and Consumption, Wastewater Collection and Treatment and finally Wastewater Disposal as related to the proposed educational activities which could be implemented by different water user categories of students, faculty members, UNZA-GER administrators and the support staff.

This study proposes educational activities, which are based on the idea of Environmental Action Learning (EAL). This is basically environmental learning which is action oriented, aimed at providing a framework for support of good practices of environmental learning processes that addresses the levels of poverty and environmental degradation in Southern and Eastern Africa (UNEP 2004). In EAL action orientation is designed to provide knowledge and learning through taking action to solve problems. This framework caters for formal (school curricula), non-formal (professional development and training) and informal (media and awareness) levels, hence extending to community learning, colleges, university, private sector, public sector and civil society. In the case of UNZA-GER, the formal framework would include an actual incorporation of environmental issues in the school curriculum, while the non-formal would include workshops and round table discussions to be organised for the lecturers and other members of staff at the institution, to be done every so often, such as quarterly. The informal aspect would include environmental awareness through the media and public awareness, such as publication of environmental/water related issues in the UNZA-GER newsletter, water conservation programmes on UNZA-GER radio, made more interesting by inviting different water experts to discuss water related issues. Sticking water conservation and wastewater management posters in the hostels would be another way of public environmental awareness at the institution.

EAL will be good for UNZA-GER as it will lead to having a population that makes environmentally informed decisions and that considers the fitness of the planet's resources in the actions that are taken. EAL will help facilitate the change in attitudes of UNZA-GER water users and reflexivity in the values of the UNZA-GER community. The development of the UNZA-GER Environmental Policy needs to be vigorously pursued and implemented, as this will help in directing the conduct of the actors towards the environment, in conserving it *and nurturing it to the enjoyment* and benefit of all. Once an environmental policy is

implemented, it will lead to improved life and living conditions of all water users at UNZA-GER. A lack of one will lead to lack of care and deteriorated water supply at the institution and this would greatly affect the quality of life and may result in ill health among the water users. The lack of appropriate policies and inefficient enforcement gives room for social irresponsibility and exploitation of natural resources. To address such issues good governance and appropriate legislation should be promoted and strengthened. The World Summit on Sustainable Development (WSSD 2002) noted that good governance is essential for sustainable development and this includes development of sound policies.

Agenda 21, a mechanism to promote sustainable development and address environmental issues produced at the 1992 United Nations Conference on Environment and Development (UNCED) known as the Earth Summit, also stated that the means to achieving sustainable development include education, public awareness and training as outlined in chapter 36 of Agenda 21. This chapter calls for the setting up of training programs that encourage public participation, recognise indigenous knowledge and the reorientation of education towards sustainable development. As applied to this study a need to reorganise the process of acquiring, transmitting, and applying environmental knowledge at UNZA-GER with specific reference to water use management, is essential for social transformation at the institution.

The UNZA-GER should mainstream Environmental Action Learning in all its curricula and programmes. This would be putting environment at the centre of learning which could yield benefits through improved curriculum, increased environmental awareness and empowerment of both the learners and decision makers at UNZA-GER. This process could also lead to improved campus environment, increased involvement of the community of water users at UNZA-GER and financial savings for the institution.

The Civil and Environmental Engineering Department at UNZA-GER would be expected to take leadership in carrying out research and proposing solutions to the challenges being faced in the hydrosocial cycle of the institution. This has not been the case as no research has been conducted nor have they presented any paper outlining proposed solutions to the UNZA-GER administration.

**Table 1. Summary of Proposed Educational Actions for UNZA-GER Water Users**

| Water Themes | Issues Warranting Educational Measures | Category of Water User and Suggested Educational Action Points | | | |
|---|---|---|---|---|---|
| | | **Students** | **Faculty Members** | **UNZA Administrators** | **Support Staff** |
| **Environmental Water Audit Through the Hydro social cycle (ref Chapter 4)** | **Abstraction**<br>-Defective Abstraction equipment e.g. pumps<br>-Lack of measurement of water abstracted | **Use Student Newsletter:**<br>-Water puzzles<br>-Water conservation articles and tips<br>-UNZASU to engage relevant government and NGOs to help abstract clean water<br>-Use of stickers as another form of communication | **Hold staff Departmental seminars:**<br>-Environmental and economic benefits of water conservation<br>-Status of water abstraction at UNZA-GER amidst increased water users<br>-Use of UNZA radio to disseminate water management | **Hold Training Workshops:**<br>-Significance of measuring of quantity of water produced<br>-Environmental impacts of over-abstraction of water<br>-UNZA radio programmes to disseminate water management | **Memo to Deans**<br>-Reporting of any defective equipment<br>-Environmental and economic benefits of water conservation |
| | **Storage and Treatment**<br>-Non protection of the storage equipment<br>Vandalism of equipment by street kids<br>-Old storage tanks | -Importance of safeguarding their equipment<br>-Value equipment as direct beneficiaries<br>-Report any defective equipment<br>-UNZASU to demand clean water supply | **Talk to UNZA-GER staff by invited water experts:**<br>-Value of proper water storage<br>-High capital costs of equipment<br>-Use radio as other media | **Sensitization Workshop:**<br>-Value of proper water storage<br>-High capital costs of equipment<br>-Use student environmental association to disseminate information | **Sensitization Workshop:**<br>-Importance of safeguarding their equipment<br>-Report any defective equipment |

| | | | | | |
|---|---|---|---|---|---|
| | **Distribution and Consumption**<br>-Defective fixtures and other pieces of equipment<br>-Outstripped capacity of most of these equipments<br>-Unsustainable values and attitudes of water users<br>-Corroded distribution pipes | **Sensitise UNZASU members:**<br>-Students should not destroy water infrastructure when they riot<br>-Student right to clean water and reflection of this in the UNZASU Action Plan (2007)<br>-Appreciation of increased student population and low capacity of water equipment<br>-Need for investments to improve capacity of water equipment<br>-Use UNZA radio to broadcast water conservation messages | **Use medium of UNZA-GER mid week fliers at public relations office**<br>-Water conservation tips<br>-Implications of ageing equipment and increased population of water users<br>-Student right to clean and safe water and reflection of this into lessons | -Develop UNZA-GER water conservation strategy which focuses on Table 1 of this study<br>-Implications of ageing equipment and increased population of water users<br>-Need to plan for rehabilitation and new investments<br>-Make use of relevant water researchers from UNZA-GER's various faculties (e.g School of Mines and Education) to sensitize water users | **Sensitization Workshop:**<br>-Talk to cleaners by resource persons<br>-Water conservation tips<br>-Report any leakages in the system |
| | **Wastewater collection and Treatment**<br>-Outstripped capacity of the sewer system<br>-Cooking of students in the hostels<br>-Rubber trees planted around Campus | **Small-scale individual student research projects:**<br>-Minimising wastewater generation through water conservation<br>-Fund a student competition which focuses on best wastewater management options on campus<br>-Use UNZA radio to announce results of research projects | **Long term research projects:**<br>-Wastewater treatment methods<br>-Recycling methods of wastewater<br>-Uses of wastewater<br>-Engage School of Mines in water research | -long-term benefits of wastewater recycling<br>-Use of wastewater treatment products as resources<br>-Horticultural department to engage consultant to advise on way forward with the Rubber trees on campus | Minimising wastewater generation through water conservation |

| | | | | | |
|---|---|---|---|---|---|
| | **Wastewater Disposal**<br>-Lack of funds<br>-Lack of water policy | -Research on disposal methods and uses of the generated waste<br>-Use of stickers with messages on benefits of wastewater reuse | -Appeal to sponsors to fund research into wastewater disposal<br>-Problems of operating without an environmental policy and the advantages of having one | -Communicate through press to sponsors to fund wastewater disposal<br>-Engage School of Education Environmental Education Unit to highlight problems of operating without an environmental policy | -Talk to cleaners by resource person about benefits of improved wastewatermanagement |
| **Water Mismanagement as well as Unsustainable water values and attitudes (ref. item 5.2)** | **Abstraction**<br>-Lack of measurement of abstracted water<br>Over-abstraction | **Hostel Competitions**<br>-Install water flow measuring devices in hostels<br>-Amounts of water consumed per hostel per month<br>-Publish the amount of water used per hostel with prizes for most efficient hostel | **Exchange visits between UNZA-GER selected staff and LWSC staff**<br>-Availing water journals and other literature on water<br>-Share through UNZA radio good abstraction practice | **UNZA-GER water open day**<br>-Importance of measuring water abstracted<br>-Cost implications of water over-abstraction | -Open day on water blues at UNZA-GER hosted by cleaners |
| | **Water storage and treatment**<br>-Lack of maintenance<br>-No protection | -Award for best maintained and protected storage facilities<br>-UNZASU to make supply of clean and safe water to its members as number one priority | -Student essay assignments<br>-Presentations to UNZA-GER administrators for best practices in water treatment and storage | -Develop a strategy in water management<br>-Marching for sponsored walks<br>-Create mutually beneficial networks with outside water professionals | -Sensitise to value of awesome water treatment and storage<br>-Alert to vandalism of equipment |

| | | | | | |
|---|---|---|---|---|---|
| | **Distribution and Consumption**<br>-Leaving running taps in bathrooms<br>-Not reporting leakages<br>-Lack of routine maintenance of equipment | -Include in regular school curricular<br>-Essay competitions on best practices in water use management<br>-Introduce awards for the most water efficient hostels<br>- Introduce the use of falcon waterfree urinals<br>-Replace taps with more efficient electrofit type. | -Devising water conservation posters<br>-Presentations to UNZA-GER administrators for best water use practices<br>-Engage in more research on best distribution and consumption options for UNZA-GER | -Regular contribution of articles to the UNZA-GER newsletters on water use and management<br>-Devising water conservation posters<br>-Awards for the most water efficient faculty and hostel | -Sensitisation on good water use habits<br>-Alert to vandalism of equipment and water wastage |
| | **Wastewater collection and treatment**<br>-Pouring of cooking oil and left over foodstuffs in wastewater drainages | -Formation of student Water Boards on Campus<br>-Importance of separating solid waste from the wastewater to be disposed off<br>-Replace standard urinals with the water free type | -Various methods of wastewater disposal and treatment to be investigated through research | -Develop a strategy in wastewater management<br>-Devise an environmental policy for UNZA-GER | -Sensitization about wastewater recycling |
| | **Wastewater Disposal**<br>-High wastewater disposal costs | -Research on disposal methods and uses of the generated waste | -Appeal to sponsors to fund research into wastewater disposal | -Support research in faculty wastewater reuse<br>-Promote wastewater reuse | Awareness about the value of wastewater |

The next paragraphs describe aspects of Table 1 in a little detail, that is, the issues identified for each stage of the hydrosocial cycle of UNZA-GER and the embedded educational activities linked to each identified issue.

### 5.4.1 Proposed Educational Activities to Address Issues from the Water Audit

This subsection focuses its attention on issues identified from the water audit, reported in chapter 4 of this study and the proposed educational activities. It elaborates what is briefly contained in table 1.

***Abstraction***

Some of the main challenges that were observed here included lack of measurement of abstracted water and over-abstraction of water. The implication of both of these issues is that UNZA-GER spends more money than what is actually needed. By measuring the amount of water that the university abstracts from its own network of boreholes as well as from LWSC, UNZA-GER would be in a better position to manage supply and demand and thus save on a lot of money. Some of the educational activities proposed to address the two identified issues include water puzzles and articles on water conservation tips using the student newsletter as a means of communicating this to students. For faculty members, holding staff departmental seminars through which environmental and economic benefits of water conservation could be discussed. Use of UNZA radio could be another mode of reaching faculty staff with water management messages. Seminars for UNZA-GER administration staff that targets increasing understanding of benefits of water conservation and the management of supply and demand of water, with the view to supporting initiatives aimed at increased water use efficiency.

***Storage and Treatment***

The main issue of concern in storage and treatment which somewhat affects the whole UNZA-GER is that of security. The water storage facilities were not protected from

vandalism. Access to the storage tanks, which were on rooftops, was open to anyone who enters the university grounds. This had in the past led to theft of fittings on storage tanks particularly by street kids, resulting in water wastage. The situation was further compounded by the fact that the storage tanks were old and of limited capacity compared to the current population they were serving. The water treatment at UNZA-GER was limited to disinfection with chlorine. The disinfection was not regular as there was no flow-regulating device for consistency and continuous disinfection of water. In both of these issues the students needed to be targeted in raising their awareness about the importance of safeguarding the water storage facilities in question. The students would need to appreciate the equipment, as they are the ones that directly benefit from their use, and be able to report any defective equipment and suspicious characters.

The UNZA-GER staff, through organised presentations and discussions with invited water experts from LWSC or NWASCO, would need to be helped to understand the value of proper water storage and effective treatment of water. The capital cost of the equipment is yet another awareness lesson that required to be raised with the UNZA-GER staff in order for them to realise the need to have strategies aimed at infrastructure improvement. The administrative staff required appreciating the importance of proper water storage and the capital cost implication of neglecting regular equipment maintenance, for which UNZA-GER student environmental association could be used to reach out. Education campaigns could be devised among the support staff to inculcate the importance of safeguarding UNZA-GER equipment and being alert to any person that might be vandalising UNZA-GER water equipment. These campaigns should also help to raise the importance of reporting any defective equipment.

***Distribution and Consumption***

The biggest challenge in the management of water and wastewater in the hydrosocial cycle at UNZA-GER was at the distribution and consumption stage. The research

revealed that users were in the habit of leaving taps running in bathrooms. Cisterns did not hold water but run continuously and the type of urinals that UNZA-GER has are the type that run water continuously. Leakages in the distribution network and halls of residence were not attended to timely. Further, limited funds hampered routine maintenance of equipment, which resulted in very high water losses, which translated into huge financial losses. The repair works were limited to emergency works and preventive maintenance was non-existent. Proposed environmental actions to address these challenges among the different user groups include a specific focus on water conservation in the regular educational curricular at UNZA-GER. Awareness campaigns through essay competitions on best practices in water use management and introducing awards for the most water efficient hostels could also be implemented. Other campaigns could be aired on the UNZA-GER radio station. Other avenues such as use of UNZA radio, posters with water conservation messages could be tried to educate the student population.

UNZA-GER administrators would themselves require presentations on the prevailing water situation on campus and the gravity of the matter by water experts from the resident engineer's office. The same water experts, including those from among the academic staff such as the school of mines, could make regular contribution of articles to the UNZA-GER newsletters on water use and management, devising water conservation posters to be stuck in halls of residences especially in kitchenettes and shower rooms. Awards for the most water efficient faculty and hostel could also be devised. The support staff need some workshop trainings in alertness to vandalism of equipment and water wastage around UNZA-GER.

*Wastewater collection and treatment*

The major issues of concern in this aspect of the hydrosocial cycle included the outstripped capacity of the sewer system, cooking by students in their hostels and the Rubber trees planted around Campus. Some of the educational activities proposed to address these issues include small-scale individual student research projects on minimising wastewater generation through good and efficient water conservation practices. The results of these projects could be announced on UNZA-GER radio as way of raising awareness. The faculty members should be encouraged to undertake long term research projects on wastewater treatment and recycling methods, as well as uses of wastewater and its products among other things. The good research papers could be funded to demonstrate the outcomes. This would be a double cost saving measure for the university as it would not only save on wastewater treatment costs but it would also greatly benefit from using the wastewater and its products like solid waste which makes very good manure for the loans. For the UNZA-GER administrators, as a way of addressing the identified concerns, long-term benefits of wastewater recycling and use of wastewater treatment products as resources could be discussed through organised workshops and round table discussions. Finally, for the support staff, training in minimising wastewater generation through good water conservation practices could also be introduced.

*Wastewater Disposal*

The research revealed that UNZA-GER did not dispose off its own wastewater but instead it was connected to the LWSC network, which disposed its water at Ngwerere stream. Major challenges identified in this category included lack of funds and lack of a water policy by UNZA-GER management. A number of educational activities are being

proposed to address the identified problems. Among students it is suggested that research on disposal methods and uses of the generated waste could enhance wastewater disposal at UNZA-GER. Stickers with messages of benefits of wastewater reuse. Among the faculty members, it is hereby proposed that appeal to sponsors to fund research into wastewater disposal and problems of operating without a policy would help with these identified concerns. UNZA administrators could appeal, through the press, to sponsors to fund wastewater disposal to enable UNZA-GER to dispose off its own wastewater effectively and efficiently. Support staff could also be targeted with talks with messages on benefits of improved wastewater management.

### 5.4.2 Proposed Educational Activities to Address Unsustainable Water Values and Attitudes on Campus

This subsection addresses itself to educational activities that could be implemented in order to tackle the intangible issues of unsustainable water values and attitudes which together often result in water mismanagement. As in previous subsections, key elements of the hydrosocial cycle will form the basis of this discussion.

***Abstraction***

Lack of measurement and over-abstraction of water were noted as major challenges relating to water mismanagement as well as unsustainable water values and attitudes of UNZA-GER water users. Hostel Competitions by first installing water flow measuring devices in hostels and then monitoring the amounts of water consumed per hostel per month among the students. This could be complimented with winning prizes to encourage the water users. The result of the hostel competition could be announced on

UNZA radio. Exchange visits between UNZA-GER selected staff and LWSC staff should be encouraged among the UNZA-GER faculty members and through this, journals and other literature on water should be availed to the UNZA-GER water users.

***Water Storage and Treatment***

The mismanagement and unsustainable water values is manifest in the manner in which the infrastructure is maintained. Clearly there is lack of maintenance of water infrastructure which often is blamed on the lack of financial resources but the lack of values and a bad attitude to public infrastructure is very apparent in the water users at UNZA-GER. Lack of protection of these facilities is one such testimony to the unsustainable water values of UNZA-GER water users. Concerted efforts to address the attitude problem need to be made in order to inculcate new values and attitude among the users to the public infrastructure. The following environmental education actions are proposed to the various water user groups at UNZA-GER: a competition could be introduced for the best maintained and protected storage facilities. The competition could come with a little incentive of a financial token but largely the incentive will be emotional. Student essay assignments are yet another effective approach that could be used. The faculty members could be encouraged to give these assignments as a way of raising awareness to the problem of water mismanagement and low water values; continued discussions through presentations and seminars to UNZA-GER administrators by various experts on best practices in water management with financial cost benefit analysis should be encouraged. The UNZA-GER administrators should be encouraged to develop a strategy in water management with the participation of the different user groups. The strategy should contain the various principles and values for the sustainable management of water and; awareness of water issues could also be

raised through sponsored walks and using national and international commemorations such as the World Water Day to bring out water conservation messages to the users. Regular talks targeted at the support staff should be encouraged to sensitise them on the value of awesome water management. This way the support staff will learn to conserve water and report any defects in the storage and treatment facilities at UNZA-GER. The talks should include awareness to the issues of vandalism of water facilities.

***Distribution and Consumption***

The mismanagement of water and unsustainable water values and attitude is most apparent in the manner in which water distribution and consumption are managed. A number of water faucets are left running continuously. This is most pronounced in the bathrooms and other water conveniences. The taps and urinals should be replaced with the more efficient electrofitted types. Leaking pipes, which remain for very long periods without being attended to, are a common sight at UNZA-GER. The Resident Engineers office at the time of writing this report did not have a routine maintenance schedule and has not had one in a long time, which indicates the level of mismanagement and attitude to maintenance. The environmental education actions proposed to the various user groups follow. The regular school curricular for students needs to be reviewed to include aspects of environmental education to impart knowledge in the students. Essay competitions among the students on best practices in water use management are another awareness programme that can help in minimising the mismanagement and the unsustainable values. An incentive to becoming more water wise is to introduce awards for the most water efficient hostels. Some criteria could be developed that includes the specific problem areas in mismanagement of water.

Environmental awareness to faculty members could include devising of water conservation posters with messages addressing water mismanagement and the unsustainable values and habits. Water experts could also be invited to make presentations to UNZA-GER administrators for best water use practices; this will enable them to appreciate the impact of some of their actions/practices. Administration staff could make regular contribution of articles to the UNZA-GER newsletters on water use and management to enlighten UNZA-GER water users but also as away of advancing their own knowledge on water issues.

Support staff should be sensitised on good water use habits and being alert to vandalism of equipment and water wastage in the university and reporting them to security.

***Wastewater collection and treatment***

With the advent of students cooking in the hostels wastewater management poses a serious challenge. Students dispose left over cooking oil and other foodstuffs into wastewater drainages. This has resulted in blocked sewer lines and makes treatment of the wastewater using conventional methods almost impossible. It is important that advocacy messages aimed at correcting the unsustainable habits are intensified. The standard urinals could also be replaced with the waterfree type, which could result in water saving of $151m^3$ of water per year (*Falcon Waterfree Technologies, 2006*). Environmental education to students could begin with mobilising their support through the formation of Student Water Boards on Campus, so that they can police themselves and have a defined channel of communication. Using the student boards, messages, which could include importance of separating solid waste from the wastewater before disposing off, could be communicated.

Faculty Members could also be targeted with messages on various methods of wastewater disposal and treatment. They could be encouraged to undertake research and disseminate the outcome at departmental meetings and workshops. The Administrative Staff need to be prodded into developing a strategy in wastewater management. The strategy could outline the measures to better manage wastewater. Issues of recycling of waste could be included and encouraging all the other users to participate with recognition of the ones that excel. Support Staff require to be sensitised to waste recycling. The support staff would better appreciate waste as a resource and improve on the habits of using toilets as solid waste bins.

***Wastewater Disposal***

Without a wastewater treatment policy of its own UNZA-GER is constrained in its initiatives to dispose off wastewater. This limits the opportunities for recycling also. The high wastewater disposal costs call for a need to improve the wastewater management. Some of the educational activities to encourage sustainable values and attitudes among students with regard to wastewater management are to encourage research on disposal methods and uses of the generated waste. Similarly faculty members should be helped to secure sponsorship to fund their research into wastewater disposal. This, other than bringing about new disposal methods will also greatly contribute to changing their values and attitudes towards wastewater disposal and management.

Administrative Staff need intensified education through presentations by relevant water experts invited from say LWSC and NWASCO, to better appreciate the need and benefits for better wastewater disposal and reuse at UNZA-GER. This will facilitate and enlist the much-needed support for research in facilities for wastewater reuse.

Support Staff require awareness to the benefits of better waste management through some organised workshops or seminars. This will also greatly help in changing their values and attitudes towards the wastewater.

# CHAPTER 6: SUMMARY, CONCLUSION AND RECOMMENDATIONS

## 6.1 Summary of Findings

The aim of this study was to conduct an environmental water audit of UNZA-GER: by exploring the situation of water losses in the hydrosocial cycle of UNZA-GER, the wastewater management of the same, factors that have contributed to severe water losses at the institution and finally how UNZA-GER management has attempted to address this situation. The sample in this qualitative study consisted of the UNZA-GER hydrosocial cycle looking at the water losses in this cycle. Thus the findings of the study only described aspects of this particular cycle and may not apply to other hydrosocial cycles with severe water losses. The findings brought out the current water situation in terms of water losses as well as wastewater management at the institution. It has been observed and noted from this study that the need for sufficient water in any place where people live is critical. The loss of water greatly inflates the amount of water used at the institution, contributing to water shortages, and also huge financial implications. The results show that several factors including social, economical and psychological factors have all contributed to the severe water losses at UNZA-GER and demonstrate in what way severe water losses can have an impact on daily life. These three factors are very relevant to this study even though this dissertation did not look at psychological factors in detail. The water losses at campus are mainly of two types: network losses and terminal losses. The network losses are due to leakages caused by defective infrastructure, while terminal losses are due to leaking pipes, taps and showers. The institution currently suffers a lot in water losses in the rain season, as weak cracked pipes carrying water at high pressure cannot sustain this pressure, the weak corroded, rusted pipes burst with high pressure, and finally the defective fixtures in buildings. The case under study has 60 blocks of hostels representing about 170

floors comprising an average of two toilets, two showers, one kitchen facility, one laundry facility, six hand wash basins, in addition there are garden taps and water hydrants per block, the campus also has eight schools with lecture and laboratory facilities with several floors and offices. There are at least four water closets, one urinal, and two hand washbasins in academic ablutions. If there are 200 floors with one leaking fitting losing about 200litres of water per day, the water loss is 40,000 litres costing at K76,000 per day or K2.3 million per month or K27.4 million per year.

The above loss is enough to buy a 25hp submersible pump and supply the community. The solution obviously lies in an aggressive approach of all parties concerned. The Resident Engineer, the Bursar, and the Department of Civil and Environmental Engineering on one hand, for technical inputs, and on the other hand the general water users at campus for a consistent and workable solutions.

## 6.2 Conclusion

The UNZA-GER currently suffers significant water losses resulting from aged infrastructure, lack of vigorous maintenance works mostly due to inadequate funding, and bad water use habits. The losses are not quantified making it difficult to see trends in water losses over the years. There is great opportunity to make huge savings on campus from better water management and use practices. The savings would come in terms of reduced pumping hours, reduced water treatment chemicals, less water procurement and of course the generated wastewater will also be less. The population on campus is growing yearly, and so there is need to upgrade the water and wastewater infrastructure and to secure it before the problem reaches a crisis stage. The unsustainable water values and attitudes of water users and easy access to the water

fittings by the public are also a major contributor to the water losses and vandalism of the fittings. This is a double cost to the institution in the replacement cost and water losses. Without an Environmental Water policy and an explicit water management plan of the hydrosocial cycle at UNZA-GER, these losses are likely to continue and cost the institution greatly.

## 6.3 Recommendations

This subsection provides recommendations to UNZA-GER administration on how water and wastewater management could be enhanced. The subsection also discusses additional ways of conserving water at the institution thereby enhancing effective management of the resource. Further there is a need to get other key departments such as the civil and environmental engineering department involved in finding lasting solutions to the challenges in water management.

- UNZA-GER should measure the quantity of water that it produces daily from its network of boreholes to be able to determine how much additional water is needed from LWSC. This is important in determining the quantity of chemicals for disinfection required on a daily basis. Measurement of the quantities of water would allow for better planning and forecasting of costs.
- The metal water storage tanks on rooftops that are now corroded and of low capacity should be replaced with PVC tanks of larger capacity that are not so easily affected by chlorine in the water. This will further help in rationalising the water pumping while ensuring water is available to users at all times. The storage tanks should be secured and be out of reach of students and the general public particularly the street kids.

- The corroded water distribution iron pipes need to be replaced with much bigger PVC pipes to address the demand resulting from increased population. This replacement exercise should include the defective valves in the distribution network.
- The rubber trees located near the October car park should be replaced with other trees to avoid any further blockages of pipes by the roots, which lead to bursting the pipes.
- Aggressive educational campaigns should be embarked on, using multidimensional educational approaches such as newsletters on water use at campus, posters around the campus and in ablution blocks on water conservation practices; this can greatly help in improving the water values and attitudes of water users at UNZA-GER.
- Developing a policy and strategy on water management at UNZA-GER, which should clearly address how to deal with problems of vandalism, water wastage at point of use and wastewater management. This will ensure the UNZA-GER administration staff adhere to the priorities that have been set out in the strategy.
- UNZA radio as a channel of communicating messages on better water management to the users should be fully exploited.

## REFERENCES


Adams G.R and Schvaneveldt J.D *Understanding Research methods.* New York, Longman

AWWA (1995), *Water Treatment: Principles and Practices of Water Supply Operations.* 2nd Ed., American Water Works Association, Denver, Colorado, U.S.A

Brooks B.D (1997) *Management of water Demand in Africa and the Middle East. Current practices and Future Needs.* IDRC (International Development Research Centre). Canada

Cheryl Le Roux (ed) (2005) *Our Environment our stories, The Sustainable use of Water: Rural Communities Perspectives and Attitudes Towards Water.* NEEP-GET, Sharenet, Howick, R.S.A

Chikubula P (2005) *UNZA Past Resident Engineer*. Personal Communication, Lusaka

Department of Education (1993) *Environmental education Curriculum guide*. DOE, Queensland

Del Porto D and Steinfield C, 1999, *The composting Toilet System Book –A Practical Guide to Choosing Planning and Maintaining Composting Toilet Systems, A Water Saving, Pollution Preventing Alternative.*

Centre for Ecological Pollution Prevention (CEPP), Massachusetts

ECZ (2001) *State of Environment in Zambia 2000*, ECZ, Lusaka

Falcon Waterfree Technologies (2006) www.falconwaterfree.com

Fetter and Mudd (1993) *An Environmental Audit of Brown University*, University Publication, U.S.A

GRZ (1994), *The National Water Policy*, Government Printers, Lusaka

Heidebrecht R and Hewitt N (1994) *Environmental Management of Water.* International Council for Local Environmental Initiatives

Isaac and Michael W (Eds) (1982) *Handbook in Research and Evaluation* (2nd Ed) San Diego

Jans Van Rensburg E. (1999) *The Educational Response to the Environmental Crisis.* Rhodes University. London

JICA (1995) *The Study on the National Water Resources Master Plan In the Republic of Zambia*, Lusaka, Zambia

Kelly M. J (1999) *Origins and Development of Education in Zambia from pre-colonial times to 1996.* Image Publishers, Lusaka

Kim le Roux (2001) *Environmental Education Process: Active Learning Guide,* University of Natal Press, Petermaritzburg

Namafe C.M (2006) *Environmental Education in Zambia: A Critical Approach to Change and Transformation.* UNZA Press, Lusaka, Zambia.

NWASCO (2005), *Reaching the Millennium Development Goals for Water Supply and Sanitation in Zambia –The Urban Perspective,* NWASCO, Lusaka

PERC 1995 *2000 Environmental Audit of Princeton University.* Princeton Environmental Reform Committee

Stephen M (1997) *Introduction to the Economics of Water Resources.* UCL Press Ltd, London

Stephens J.H (1967) *Water and Waste,* Macmillan and Company, Melbourne Australia

Tchobanoglous, G., Burton, F.L., and Stensel, H.D. (2003) *Wastewater Engineering (Treatment Disposal Reuse)* Metcalf & Eddy, Inc., 4th Edition, McGraw-Hill Book Company, England

UNEP (2004) *Environmental Action Learning in Eastern and Southern Africa.* Share-Net, Howick, R.S.A

UNZA (2005) *Environment and Engineering department Report, April,* UNZA, Lusaka

World Water Council (2003), *Third World Water Forum Report,* Kyoto

Www.csun.edu/audit

www.unza.zm

# APPENDICES

## Appendix A: Campus Water Use Survey

Dear respondent,

Iam a postgraduate student at the University of Zambia pursuing a Master of Education Degree in Environmental Education. Iam carrying out a research on the values and attitudes of water users at UNZA-GER, in partial fulfilment of my programme. In this regard you have been randomly selected as one the respondents. This is purely an academic exercise and all the information availed will be handled with the highest confidence that it deserves and will be used only for academic purposes.

I thank you most sincerely in advance,

Flaviour Sisala Chanda.

**University of Zambia**

**Questionnaire for Selected UNZA-GER Water Users**

**Instructions for answering the Questionnaire**

1. **Tick the correct answer where options are provided**
2. **Where there are no options provided write appropriate answers in the space provided.**

**Questions**

1. What is your gender? (a) M (b) F

2. What is your age? (a) 19-24 (b) 25-30 (c) 30-35 (d) over 35

3. What is your marital status? (a) Married (b) Single (c) divorced (d) Widowed

4. When did you first come to this institution? .....

5. Which school are you in? .....

6. Which year of study are you in? .....

7. Do you encounter any water problems at this institution? If you do, explain or give details.....

.....

8. What is your average shower time in minutes per day?

(a) 0-5 (b) 6-10 (c) 11-15 (d) 16-20

9. When using bathroom facilities, are you conscious of the amount of water you are using? (a) Yes (b) No

10. Do you turn off the tap at the sink during activities such as brushing your teeth?

(a) Always (b) Never (c) Sometimes

**End of questionnaire.**

**Thank you**

University of Zambia

**Appendix B: Key Informants Interview Guide**

**Resident Engineer's Office**

**Position of Person Interviewed:** Resident Engineer

**A. Water use management**

1. Where does UNZA-GER's water supply originate from?
2. Where is campus water treated?
3. What kind of treatment does it receive?
4. How much water did the university consume last year
5. How has the population figure changed over the past five years?
6. What percentage of water is used indoors as compared to outdoor?
7. How does UNZA-GER manage it's out door water usage?
8. What were the water utility costs for the university for the past year?
9. How have these costs changed over the past five years and why?
10. Does the campus have a water conservation programme?
11. If so what measures does it include?
12. Is there any difference in water use between the wet and dry seasons?
13. Are there any estimates of water savings from such programmes?
14. If so how much?

**B. Waste water management**

1. How much wastewater does the campus generate annually?
2. Where is campus wastewater treated?
3. Where is this treated wastewater discharged?
4. What percentage of the community's wastewater treatment facility is used to process campus-generated wastewater?
5. What kind of treatment does it receive?
6. What costs if any are associated with treating campus wastewater?
7. Has UNZA-GER initiated any programmes to reduce wastewater volume and /or toxicity? If so please describe
8. Does UNZA-GER use any reclaimed water in its facilities or on landscaping? If so how much?
9. What is the source of this water?

**End of questionnaire**

**Thank you**

## Appendix C: Observation Checklist for UNZA-GER's Hydrosocial Cycle

1. What stages or characteristics constitute UNZA-GER's hydrosocial cycle?
2. What problems are experienced at each stage of the cycle?
3. What are the major causes of these problems?
4. Which stage of the hydrosocial cycle experiences the most problems of water loss? And why?
5. Are the storage tanks big enough for the population that they cater for?
6. Is the material used for the storage tanks ideal for the purposes of these storage tanks?
7. What sort of treatment does the UNZA-GER water undergo? Is it adequate to treat the water to acceptable standards?
8. Material and size of distribution pipes.
9. Presence or absence of certain facilities.
10. Are taps left running after use by water users?
11. Is wastewater transported and disposed off in an ideal manner?