Management of Fluorescent Lamps in Public Schools within the Johannesburg Metropolitan Area

By

WELLINGTON SIZIBA

A dissertation submitted as partial fulfilment for the

MASTERS DEGREE IN TECHNOLOGY

in

Environmental Health

in the

Faculty of Health Sciences

at the

University of Johannesburg

Supervisor: Prof. A. Swart

Co-Supervisor: Ms. B. Allies

2011

DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Technology at the University of Johannesburg, Johannesburg. It has not been submitted before for any degree or examination at any other University.

15-03-2012

ABSTRACT

Fluorescent lamps, because of their mercury content, are regarded as hazardous waste and fall under the category of electrical waste. This is due to mercury's toxicological, physical, and chemical or persistence properties, which may have acute or chronic detrimental impact on human health and the environment. This study adopted a quantitative research approach, which aimed at determining how fluorescent lamps are managed in selected public schools. The investigation followed an exploratory design.This research was done under the umbrella of the World Health Organisation Collaborating Centre for Urban Health's Health, Environment and Development study. The sample population included 22 public schools, and proportionate purposive sampling was used and data was collected through the use of structured questionnaires and observation checklist. There were no formal guidelines available for the management of fluorescent lamps in schools as a result improper handling, storage or disposal thereof, poses a health risk to the learners, employees and the environment. The outcome of this study indicated the need of formal guidelines for the management of fluorescent lamps in public schools to the Department of Education, and to produce guidelines for operational procedures.

DEDICATION

This research is dedicated to Mr Clever Ncube for playing a pivotal role in my life as a father figure and a role model in the field of Environmental Health.

ACKNOWLEDGEMENTS

Throughout the study I was advised, assisted, encouraged, motivated and supported by various people in numerous ways. My appreciation and acknowledgements goes to:

1. My supervisor, Prof. A. Swart for his patience, tireless guidance and encouragement throughout the study.
2. My co-supervisor, Ms B. Allies for the incredible support and encouragement she gave me during the study.
3. Mrs T. Haman (HOD) for all the administrative support she rendered during the course of the study.
4. The University of Johannesburg for awarding me with a Next Generation Scholarship.
5. The University of Johannesburg Post Graduate Centre for funding support, information services and research capacity development provided during the course of the study.
6. Ms R. VanWyk for her significant contribution she made during the early stages of this study.
7. My uncle Shepherd Siziba for his assistance and support during data collection.
8. Helena Pietersen for her support, advice and assistance she made during the course of the study.
9. My wife to be Sandra Sibanda for her unfailing motivation and encouragement she provided during the compilation of this document.
10. Last, but not least, to God is the glory, for giving me the strength to endure till the end of this study and for surrounding me with such wonderful people during the study.

TABLE OF CONTENTS

CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

LIST OF FIGURES

LIST OF TABLES

NOMENCLATURE

E-Waste:	Electrical and electronic waste
FL:	Fluorescent lamps
CFL:	Compact fluorescent lamps
EPA:	Environmental Protection Agency of the United States
Hg:	Mercury
UNEP:	United Nations Environment Programme
LED:	Light emitting diodes
SECO:	Swiss Secretariat for Economic Affairs
EMPA:	Federal Laboratories for Material Testing and Research
eWASA:	e-Waste Association of South Africa
WHO:	World Health Organisation
WHOCCUH:	World Health Organisation Collaborating Centre for Urban Health's Health
UV:	Ultraviolet
HID:	High-Intensity discharge
OHSA:	Occupational Health and Safety Act (South Africa, 1993)
ECA:	Environmental Conservation Act (South Africa, 1989)
DWAF:	Department of Water Affairs and Forestry
NWMS:	National Waste Management Strategy
DEAT:	Department of Environmental Affairs and Tourism
W:	Watts
WEEE:	Waste electrical and electronic equipment
pH:	Measure of the strength of acidity or alkalinity
NEWMOA:	Northeast Waste Management Officials' Association (United States)
TWA:	Time-weighted average

CHAPTER 1
INTRODUCTION AND BACKGROUND

1.1 INTRODUCTION

This Chapter provides an introduction to and outline of the entire study; furthermore, it discusses fluorescent lamps and their hazardous nature. As the use of fluorescent lamps becomes widespread so too are the concerns relating to their mercury content and the associated hazards. Despite the hazards associated with fluorescent lamps, these lamps are being embraced internationally and nationally because of their energy-saving properties. The following section will provide a background to fluorescent lamps and their management.

1.2 BACKGROUND

Fluorescent lamps, because of their mercury content, are regarded as hazardous waste and fall under the category electrical waste (e-waste) according to Lombard and Webb (2008).

Finley and Liechti (2008) state that e-waste embraces all types of waste containing electrically powered components and are categorised as hazardous waste by international convention. They further state that electrical waste, regarded as hazardous waste, is an increasing global concern because it poses a risk to human health and the environment directly or indirectly. This is due to its persistent properties (chemical, physical, and toxicological) which might have an acute or chronic detrimental impact on human health as well the environment.

The problems associated with management of solid waste in today's society are complex because of the quality and the nature of waste. According to Krikkle (2008) the world produces about 40 million tons every year of:

- personal computers;
- cathode ray tubes;
- screens;
- facsimile machines;
- game consoles;
- mobile phones; and other electrical waste including
- fluorescent lamps.

In most office buildings, stores and schools fluorescent lamps are used to provide lighting. The North Carolina Division of Pollution Prevention and Environmental Assistance (2009) states that in schools fluorescent lamps are found in areas such as science labs, art rooms, maintenance areas, home economics rooms and others. However, mercury is a key element in most energy-efficient lamps, which may pose a health risk because of their toxic, flammable or reactive properties (North Carolina Division of Pollution Prevention and Environmental Assistance, 2009).

1.2.1 Efficiency of Fluorescent lamps

Gale (2001) states that fluorescent light is the most common type of electrical light found in the United States, where it is used for practically all commercial lighting, i.e. offices, factories, stores and schools, adding up to an estimated 1.5 billion fluorescent lamps in use nationwide. It is indicated that fluorescent lighting is popular due to its high efficiency, as it produces between three to five times more light than an incandescent lamp consuming the same electrical power. The main reason for its high efficacy is that a fluorescent lamp employs a phosphor, which converts non-visible light produced by the lamp into visible light, whereas a large fraction of the output from incandescent lamp is infra-red light, which escapes as heat (Gale, 2001).

Kennedy (2008) also compared the two types of lamps and stated that compact fluorescent lamps (CFL's) are (about 75%) more energy-efficient compared to incandescent light bulbs. As a result they last 10 times longer, and thus have quickly become a modem-day environmental icon. However, he agrees that these CFL's do have one dim spot on their otherwise bright green image: the mercury that makes the bulbs' inner phosphor coating to fluoresce and produce light. The U.S. Environmental Protection Agency (EPA) estimates that about 290 million CFL's were sold in 2007 (Kennedy, 2008).

Although Becquerel in the 1860s referred to fluorescent lamp, Gale (2001) notes that it was not until 1938 that fluorescent lamps became available (commercially) due to the introduction of phosphors that endured the rigours of operation over a period of time. Since then fluorescent lamps have been improved in all aspects as follows:

- electrodes;
- phosphors;
- gas mixtures; and
- control circuitry.

These improvements are most essential given that there are various lamps available.

1.2.2 Classification of mercury containing lamps

According to Jang *et al.* (2005) fluorescent lamps rely on mercury as the source of radiation for the production of visible light. Reclite (2008) also notes that mercury is the key element in most energy-efficient lamps and the popular mercury containing lamps are as follows:

- **Fluorescent linear tubes** - (range between 5 and 15mg of mercury (Hg) depending on type, manufacturer and when it was manufactured).
- **Compact fluorescent lamps** - energy savers (range between 4 and 6mg of Hg).

- **High-intensity discharge (HID) lamps** - (range between 13 and 80 mg of Hg and between 10 and 170 mg of metal halide).
- **Sodium lamps** - (range between 15 and 30 mg of Hg).
- **Automotive Mercury** - Xenon lamps.

Figure 1.1 illustrates that inert gas is filled in a typical fluorescent lamp and a small quantity of mercury turn to vapour. Producing fluorescent light happens in two phases. Firstly, cathodes emit electrons creating an electrical arc generated by mercury vapour. Secondly, ultraviolet radiation produced strikes phosphor coating thereby releasing visible light (Henkenius and Thompson, undated). Although a single fluorescent tube has a small amount of mercury, collectively large numbers of them contribute to the total amount of mercury that is released into the environment (Reclite, 2008).

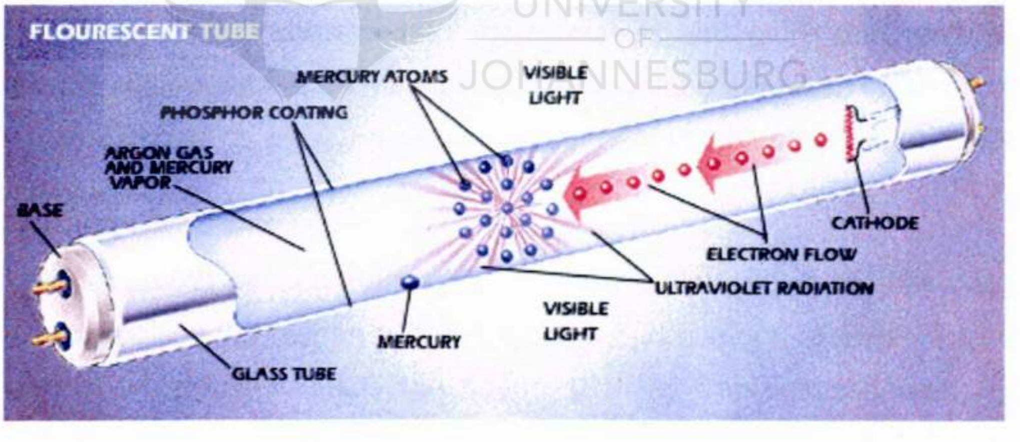

Figure 1.1: Fluorescent tube lamp (Source: Henkenius and Thompson, undated)

1.2.3 Mercury and its forms

The World Health Organisation states that mercury is an element that occurs naturally and is found in soil, water, and air. It is also found in different inorganic and organic forms and is persistent in the environment (WHO, 2008). The three predominant forms include:

- elemental mercury (Hg0);
- ionic mercury (known as inorganic mercury, Hg2+), which exists in nature as complexes in solution or mercuric compounds; and
- organic mercury with methyl mercury (MeHg).

Weathering of rocks that contain mercury ore leads to the release of mercury into the air and water. Mercury can also be released through human activities such as mining, industrial processes, burning of forest fires, burning of fossil fuels (coal) and waste incineration, including a number of products that contain mercury such as dental amalgam, electrical applications, laboratory and medical instruments (South Africa, 2011).

Bellinger (2002) describes mercury as a fascinating substance, a metal that is liquid at room temperature and which expands and contracts in direct relation to temperature and pressure. He also states that mercury is a commonly used substance in thermometers and other temperature-sensing equipment like thermostats and temperature detectors in ovens. It is also common in pressure-sensing equipment like blood pressure cuffs and barometers.

Bellinger (2002) defines mercury as a heavy metal, a type of substance that can poison the human nervous system. Furthermore, mercury is also used in tilt switches inside the hoods of motor vehicles and washing machines to turn the light on when the lid is open, and off when it closes. Since mercury is a good conductor of electricity, it is used extensively in batteries and in the switches of fluorescent light bulbs. Some of these uses of mercury, like batteries, are being phased out because of mercury's poisonous effects (Bellinger, 2002).

1.2.4 United Nations' initiatives to address effects of mercury

Due to the harmful effects of mercury there are initiatives being undertaken by the United Nations Environment Programme (UNEP) to address the global problem of mercury (South Africa, 2011:1-3). UNEP's Global Mercury Assessment Report noted that there is enough proof for immediate intervention to protect the environment and human health from the release of mercury and its compounds. This action should be facilitated by technical assistance and capacity building from UNEP, governments, and relevant international organisations. UNEP concluded that further long-term international action was required to reduce such risks, and decided to assess the need for further action on mercury, including the possibility of a legally binding instrument, partnerships, and other actions (South Africa, 2011:1-3).

At its 25th Session, held during 2008 in Nairobi, the UNEP Governing Council (GC) agreed to formulate a legally binding instrument on mercury, and requested UNEP to convene an Intergovernmental Negotiating Committee (INC), with the mandate to prepare for such an instrument (South Africa, 2011:1-3). South Africa also participated in the 2nd INC in Japan from 24-28 January 2011, which sought to prepare an instrument on mercury. The meeting discussed mainly the substantive elements to be contained in a treaty on mercury. These proposed elements include the following:

- to specify the objectives of the instrument;
- to reduce the supply of mercury and enhance the capacity for its environmentally sound storage;
- to reduce the demand for mercury in products and processes;
- to reduce international trade in mercury;
- to reduce atmospheric emissions of mercury;
- to address mercury-containing waste and remediation of contaminated sites;
- to increase knowledge through awareness raising and scientific information exchange; and
- to specify arrangements for capacity-building and technical assistance. (South Africa, 2011:1-3).

1.3 INTERNATIONAL CONTEXT

Mercury continues to be used in a variety of products, in spite of its potential risks (e.g. fluorescent lamps) and processes globally because of its unique properties (WHO, 2008). Starting with Australia, governments are now promoting and even mandating the use of compact fluorescent lamps (CFL's) and other energy-efficient light bulbs to address concerns about rising energy costs and climate change (Herro, 2007). It is also stated that lighting absorbs nearly one-fifth of global electricity generation, which is more than what is produced by hydroelectric or nuclear power stations. Lawmakers in California, New Jersey, United Kingdom, Canada and a growing number of other states hope to follow Australia's lead.

In Europe, lighting manufacturers have agreed to work together to promote energy-efficient lighting, including light emitting diodes, or LED's, which can save even more energy than CFL's (Herro, 2007). It is also indicated that the European Lamp Companies Federation, which includes General Electric, Siemens, and Royal Philips Electronics, plans to promote public incentives for consumers to buy more efficient products and to set performance standards that will eliminate less efficient products from the market. Herro (2007) points out that even Russia, a country with huge oil and gas reserves, is beginning to promote CFL's, though it's all about conserving energy supplies and limited consideration for the environment. Herro (2007) further agrees that a worldwide step to efficient lighting systems could reduce the electricity bill globally by nearly one-tenth.

According to Galbraith (2009) tougher energy-efficiency requirements were announced by President Obama in the U.S. for specific types of incandescent and fluorescent lighting as a move by the administration to reduce the country's energy use. Galbraith (2009) furlher states that this new rule, scheduled to take effect in 2012, will cut the amount of electricity used by affected lamps by 15 to 25% and save $1 billion to $4 billion a year for consumers in America.

India has also taken some steps by seeking to replace 400 million inefficient, incandescent light bulbs with energy-saving compact fluorescent lamp (CFL) bulbs. This is being done at noticeably reduced cost to the consumer and simultaneously it is expected to avoid the release of 40 million tons of carbon dioxide (Singh, 2010). The Bachat Lamp Yojana (BLY) project ("Savings Program through Lamps") promises to lower the price of CFL's to 15 rupees (about R2.50) each, instead of the current market price of 100 rupees (about R16.75). According to Singh (2010) it is expected that half the households in India will immediately benefit from this project.

The BLY project taps a unique public-private partnership linking the government of India, private-sector CFL suppliers, and state-level electricity distribution companies (Singh, 2010). Under the scheme, Singh (2010) notes that 60 watt and 100 watt incandescent lamps will be replaced with 11 to 15 watt and 20 or 25 watt CFL's, respectively. In 2008, 734 million incandescent lamps were sold in India, whereas CFL sales were only 199 million. The combined penetration share of incandescent lamps for lighting in the commercial and residential sectors was nearly 80% (Singh, 2010).

Compact fluorescent light bulbs (CFL) are being embraced worldwide as an energy-efficient alternative than the incandescent bulbs that have reigned supreme for 125 years, however, there are some concerns that have arisen about the potential for mercury contamination from the newer bulbs (Scheer, 2008). While each CFL contains only a trace amount of mercury, Scheer (2008) states that landfill managers are concerned that large volumes of them disposed of in their facilities could pose problems for employees, not to mention the surrounding communities.

Scheer (2008) further states that the Environmental Protection Agency of the U.S. recommends switching over to the bulbs for the energy and greenhouse gas emissions savings; however, it also acknowledges that the newer bulbs pose a contamination problem when they break. Scheer (2008) indicates that currently only seven states of the U.S. ban putting CFL's in the regular landfill-bound garbage, and there are still very few CFL recycling centres.

According to Scheer (2008), CFL manufacturers are working hard to minimise the amount of mercury in their bulbs while simultaneously utilising other high-efficiency bulbs that do not contain toxic elements (such as light-emitting diode bulbs and high-efficiency incandescent). A solution is needed urgently, as Australia, China and now the U.S. have made big commitments to CFL's in order to lower their carbon footprints.

1.4 NATIONAL CONTEXT

Considering that fluorescent lamps are part of electrical waste streams, Osibanjo (2007) states that developing countries face challenges in electrical waste management. These challenges include the lack of appropriate infrastructure for waste management; specific legislation dealing with electrical waste; implementation of extended producer responsibility; or any framework for end-of-life product take-back. It is further stated that many developed countries, including Switzerland and Netherlands, have taken steps to develop policy guidelines and legislation for developing electrical waste management systems.

Finley and Liechti (2008) also agree that developing countries, including South Africa, still require numerous interventions along such lines, and most of the electrical waste processing is done by the private sector, which responded instinctively to the profit potential in recycling discarded technology. In 2004 South Africa, together with India and China (as part of the interventions to address challenges of e-waste), became part of a global e-waste knowledge-sharing programme initiated by the Swiss State Secretariat for Economic Affairs (SECO) and implemented by the Federal Laboratories for Material Testing and Research (EMPA). This support catalysed the formation of e-Waste Association of South Africa (eWASA) (Finley and Liechti, 2008).

According to Finley and Liechti (2008) volumes of e-waste are expected to rise considerably also in South Africa in the near future. Yet there are still challenges of consumer awareness, collection, recycling processes, and the disposal of electrical waste. They further note that collective action is needed for dealing with electrical waste challenges in South Africa, including developing frame work policy and legislation, and a practical electrical waste management solution that involves all stakeholders. Krikkle (2008) states that only 20% of this highly toxic waste is properly disposed of and recycled. Some electrical waste is stripped of precious metal and unusable components are dumped in landfills, poisoning the soil and precious water resources. Therefore, this means that failure or inability to salvage and reuse such materials economically results in the unnecessary waste and depletion of natural resources.

According to Finley and Liechti (2008) South Africa faces a number of recycling challenges when it comes to e-waste. They further state that health and safety policies are loosely enforced whereas basic environmental precautions are not available at some recyclers. While the cost of logistics (transport) is an on-going challenge (faced by recyclers) e-waste projects currently piloted demonstrate that at least a minimum wage is possible through the manual dismantling of discarded technology. The assessment suggests that recycling of e-waste creates job opportunities and promotes economic development. However, the assessment also indicates that informal e-waste recycling includes mostly the early stages of recycling, collection, crude dismantling and sorting. Due to these activities informal recyclers are vulnerable and often deal with e-waste in a hazardous way and are open to exploitation.

Fluorescent lamps in South Africa are supposed to be landfilled in permitted hazardous waste disposal sites according to the South African

Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste (South Africa, 1998a:2-3). The client is then issued with a certificate of safe disposal; however, most of the times these lamps are disposed of in the municipal waste stream and are landfilled in the local general waste disposal site (Reclite, 2008).

A study was conducted as a result of concern about mercury absorption amongst residents of a peri-urban area in Cape Town, South Africa, in close proximity to waste disposal sites and an industrial area (Dalvie & Ehrlich, 2006). The two samples were comparable with respect to background and potential confounding variables. The prevalence of urinary mercury levels greater or equal than the WHO reference range in the exposure area was higher than that in the control area (13% and 0% respectively). Dalvie and Ehrlich (2006) notes that this was the first study of community inorganic mercury absorption in a developing country setting, and where airborne mercury exposure was of concern. It was concluded that the health risk associated with the urinary mercury levels of residents in the exposure area was very low. However, low-level environmental exposure in the area of concern could not be excluded.

1.5 CONCEPTUALISATION OF THE PROBLEM

Reclite (2008) states that millions of spent lamps countrywide, which contain mercury, are disposed together with municipal waste every year. Since most of these lamps are commingled with general waste, breakages are inevitable. This practise results in mercury being released into the environment, instead of encouraging recycling and controlled crushing.

The general public is not well-informed in terms of the hazards of lamps that contain mercury and what to do in the event that a lamp breaks (Reclite, 2008). It is also stated that currently such products are not regulated in terms of domestic disposal, some industries are not disposing of them at hazardous landfill sites, and the transportation of fluorescent lamps is not regulated, and neither is the crushing or disposal of lamps.

WHO (2008) states that the primary targets for mercury and mercury compounds are the nervous system, the kidneys, and the cardiovascular system. Effects on the nervous system (especially the developing nervous system) appear to be the most sensitive toxicological endpoint observed following exposure to elemental mercury. WHO (2008) further states that mercury vapour's effects are also seen, depending on dose, in the oral mucosa.

The effects on the nervous system appear to be the most sensitive toxicological endpoint observed following exposure to elemental mercury. Symptoms associated with elemental mercury-induced neurotoxicity include the following: tremors, initially affecting the hands and sometimes spreading to other parts of the body; emotional liability, often referred to as "erythrism" and characterised by irritability, excessive shyness, confidence loss, and nervousness; insomnia; neuromuscular changes (e.g., weakness, muscle atrophy, muscle twitching); headaches; polyneuropathy (e.g., paresthesia, stocking glove sensory loss, hyperactive tendon reflexes, slowed sensory and motor nerve conduction velocities); and memory loss and performance deficits in test of cognitive function. At higher concentrations, adverse renal effects and pulmonary dysfunction may also be observed. A few studies have provided suggestive evidence for potential reproductive toxicity associated with exposure to elemental mercury (NEWMOA, 2010).

A case study was conducted in Sweden to (1) reduce the risk of potential mercury exposure of students and school staff, (2) minimise releases of mercury to the environment by eliminating mercury from schools, and (3) educate students and staff about the dangers of mercury. The results showed that use of mercury-detecting dogs is both a cost-effective way to find mercury and an excellent tool for teaching students about the dangers of mercury. In 1999, two specially trained dogs checked 1,100 schools in Sweden. As a result, about 1.4 tonnes of mercury were removed from these schools (Hubbard, 2009). This indicates that employees and learners are exposed to mercury at schools and there is a great need to take action on raising awareness and to safeguard public health.

Therefore, employees and learners (in public schools) may be exposed to elemental or inorganic mercury through inhalation of ambient air in classrooms when fluorescent lamp(s) are broken, or when fluorescent lamps are being handled, stored or disposed of improperly in schools leading to the release of mercury to the environment.

1.6 RESEARCH STRATEGY

The study adopted a quantitative research approach which aimed at determining how fluorescent lamps, as a hazardous waste stream, are managed in public schools. The investigation therefore followed an exploratory study design since little research has been done on mercury exposure from fluorescent lamps in South Africa. This study design is essential whenever the researcher is breaking new ground, and it can always yield new insights into a topic for research. Exploratory study design also indicates the viability of undertaking further investigation and the methods to be used (Babbie, 2006:76).

Data was collected through the use of structured questionnaires during interviews. The most suitable respondents during interviews were the school principals, as they are answerable to all matters arising from school (and they are also responsible for the enforcement of any guidelines if available). Data was also collected through the use of a checklist during observation. Designing and pre-testing data-collection tools – i.e. structured questionnaires and observation check list – were done before the actual study to ensure that only the information required is addressed in a reliable and consistence manner. A pilot study included three public schools and where necessary corrections were made on data-collection tools, as discussed in Chapter 3. A clear explanation of the aim of the study was provided and the research commenced only when permission was granted by the Gauteng Department of Education. Informed consent was sought from principals at selected public schools, and ethical clearance was granted by the University of Johannesburg (refer to appendix 4 and 6).

This study was carried out under the umbrella of the World Health Organisation Collaborating Centre for Urban Health's (WHOCCUH) Health, Environment and Development (HEAD) study, which aims to monitor changes in living conditions and health status, alongside government development initiatives (WHOCCUH, 2007). The sample population included public schools from within and around each of the five selected HEAD study geographic locations within Johannesburg. These geographical locations included Hillbrow, Bertrams, Riverlea, Braamfischerville and Hospital Hill.

The City of Johannesburg has grown rapidly especially when compared with other surrounding urban centres such as Ekurhuleni and Pretoria (WHOCCUH, 2007). The effects of the rapid increase in population (where it has exceeded the pace of delivery of housing and health infrastructure to meet the demand) may be noticed in areas such as informal settlements, degraded inner-city areas and certain mass-based low-cost housing developments (WHOCCUH, 2007).

The WHOCCUH is committed to community participation, sustainable development, addressing inequities in access to resources and services. The well-being and health needs of the most vulnerable low-income urban populations are at the heart of the centre. Although located in South Africa, the WHOCCUH recognises that similar urban health challenges face many African countries, and aims to contribute to finding solutions of relevance to the entire continent (WHOCCUH, 2007).

1.7 PROBLEM STATEMENT

Employees and learners at schools may be exposed to elemental or inorganic mercury through inhalation of ambient air in classrooms when fluorescent lamps are broken, or when fluorescent lamps are being handled, stored or disposed of improperly in schools, leading to the release of mercury into the environment. It is in this regard that the study intended to determine the management of fluorescent lamps in selected public schools within the Johannesburg Metropolitan Area.

1.8 AIM AND OBJECTIVES

The following aim and objectives are applicable to this study.

1.8.1 AIM

The aim is to determine how fluorescent lamps as a hazardous waste stream are managed at selected public schools in the Johannesburg Metropolitan Area.

1.8.2 OBJECTIVES

To achieve the abovementioned aim the objectives of the study are to:

- Determine the awareness levels of staff at selected public schools regarding the hazardous nature of fluorescent lamps.
- Identify if any guidelines exist whether formal or informal for fluorescent lamps management in selected public schools.
- Assess possible routes of exposure related to employees and learners and possible environmental exposure to mercury.
- Compare the effectiveness of available operational procedure guidelines in selected public schools on fluorescent lamps management (whether formal or informal) to minimum national requirements and international guidelines.
- Propose possible guidelines for operational procedures.

1.9 WAY FORWARD

Fluorescent lamps (FL's) have played a key role in energy-efficiency campaigns locally and internationally. Their energy-saving properties present a simple but effective measure against ever-increasing global energy constraints, raising energy costs and concerns about climate change (Venter and Van Der Walt, 2008). However, as the use of FL's becomes increasingly widespread so too are the concerns relating to their mercury content and the associated hazards. Using fluorescent lamps makes economic sense, because their cost is significantly lower than incandescent lighting. At the same time, fluorescent lamps need to be handled very carefully because they contain mercury at an average of 5 mg mercury per lamp (Venter and Van Der Walt, 2008).

As a consequence, if fluorescent-lamp management is to be accomplished in an efficient and orderly manner, the fundamental aspects and relationships involved must be identified – that is, activities from the point of generation to final disposal. Inefficient and improper methods of handling, storage and disposal of fluorescent lamps create serious hazards to public health (human and environment). It is in this regard that the anticipated outcome of the study would be to depict the need for general guidelines for the management of fluorescent lamps in public schools to the Department of Education, and a possible model for operational procedures.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

The prominence of climate change concerns and energy constraints globally have prompted an intensified focus on energy efficiency measures, resulting in a significant increase in the usage of fluorescent lamps (Hex *et al.*, 2009). According to the White Paper on Integrated Pollution and Waste Management (South Africa, 2000:3) South Africa has extensive environment, pollution and waste management legislation, and responsibility for its implementation is scattered over a number of departments and institutions.

Chapter 1 gave the background and an outline of the entire study, however, this Chapter discusses the literature reviewed in order to understand the hazardous nature and the management of fluorescent lamps. This literature is discussed under the following topics: mercury-containing lamps, hazardous waste legislation in South Africa, management of hazardous waste, management of fluorescent lamps and CFL waste stream, environmental impact, health effects, mercury in schools, World Health Organisation guidelines and threshold levels, routes of exposure to mercury and susceptible populations.

2.2 MERCURY-CONTAINING LAMPS

The looming energy crisis, electricity load-shedding and frequent power outages became a reality in South Africa in early 2008 (Lombard and Webb, 2008). Eskom has since embarked on a concentrated national campaign to raise awareness of the need to conserve electricity and to fast-track alternative energy sources.

Lombard and Webb (2008) further states that significant savings can be made by changing the type of electricity lights used. Traditional incandescent lamps are less efficient than fluorescent lighting and therefore, over the past year, millions of fluorescent lamps have been handed out by Eskom to increase awareness and to encourage the changeover to fluorescent lamps.

Lombard and Webb (2008) further allude that the South African market is currently serviced with imported fluorescent lamps only. Since 2004 to 2007, Eskom alone purchased 12 million CFL's and in 2008 this increased to 20 million in the quest to make lighting more efficient and thus reduce the demand for electricity. Table 2.1 shows the volumes that have been imported into South Africa in 2005/2006 are reported by Eskom as follows (Lombard and Webb, 2008):

Table 2.1 Volumes of lamps imported into South Africa: 2005/6 (Source: Lombard and Webb, 2008)

Type of lamp	No. Imported in 2005/6
Incandescent	92,421,000
Tungsten Halogen	3,321,000
Dichroic	4,821,000
High-Intensity Discharge (HID)	1,869,000
Linear Fluorescent	16,330,000
Compact Fluorescent	19,095,000
Total Lamps	**137,857,000**

Lombard and Webb (2008) notes that the traditionally used incandescent lamps emit light from a tungsten filament that heats up and glows white hot. In contrast, gas-discharge lamps, such as fluorescent tubes and CFL's, do not generate light by heating a metal filament but instead use an electric current through special gas which either emits light directly or causes other chemicals to fluoresce and emit light.

Furthermore, Lombard and Webb (2008) states that a typical fluorescent lamp is composed of a phosphor-coated glass tube, with electrodes located at either end. The tube contains mercury (Hg), of which only a very small amount is in vapour form. When a voltage is applied, the electrodes energise the mercury vapour, causing it to emit ultraviolet (UV) energy. The phosphor coating absorbs the UV energy, causing the phosphor to fluoresce and emit visible light. Without the mercury vapour to produce the UV energy, there would be no light. There are variations in the structure of gas-discharge lamps, but generally the average lamp life and efficiencies of different types of fluorescent and High-Intensity Discharge (HID) lamps are far higher than incandescent lamps, as shown in Table 2.2. HID lamps include metal halide, sodium and mercury vapour lamps (Lombard and Webb, 2008).

Table 2.2 Relative efficiencies and lamp life (Source: Lombard and Webb, 2008)

Type of lamp	**Lamp life (hours)**	**Efficiency (lumens per watt)**
100 W Incandescent	750	20
Linear Fluorescent	12,000-20,000	100
Compact Fluorescent	10,000	80
Metal Halide	7,500-20,000	90
Mercury Vapour	24,000	50
High-Pressure Sodium	24,000+	95
Low-Pressure Sodium (no mercury)	18,000	125

2.3 HAZARDOUS WASTE LEGISLATION IN SOUTH AFRICA

According to Brice *et al.* (2006) there are many legislative requirements that regulate the management of waste in South Africa. These include international conventions, national acts and regulations, provincial regulations, and local municipal by-laws. This section therefore discusses related hazardous waste legislation in South Africa that applies in the management of fluorescent lamps as a hazardous waste stream.

In South Africa, fluorescent lamps because of their mercury content are classified in terms of the Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste (South Africa, 1998a:A6-6) as a corrosive chemical Class 8 (III), with a hazard rating 1 (highly hazardous), because mercury is corrosive. Mercury is also carcinogenic (Class C&D carcinogen) and has mutagenic and teratogenic properties. Regarding the disposal of fluorescent lamps, the Department of Water Affairs and Forestry (South Africa, undated) states that no fluorescent tubes collected in large quantities from the premises of industries or commercial activities may be disposed of under any circumstances in a general waste disposal site. Lombard and Webb (2008) states that the incineration of mercury-containing wastes is prohibited because burning will release mercury emissions.

The South African Constitution (South Africa, 1996:7/8) establishes basic environmental rights, including the right to an environment that is not detrimental to one's health; just administrative action and access to information. These form the basis for the country's environmental and waste legislation. The Occupational Health and Safety Act (OHSA) (South Africa, 1993:3-17) provides for the health and safety of persons at work and specific regulations that deal with waste management is considered as a background to specific legislation dealing with e-waste management.

The primary objective of the Environment Conservation Act (ECA) (South Africa, 1989:12/13) is to provide for the effective protection and controlled utilisation of the environment. The ECA makes specific reference to waste disposal, and Section 20 of the ECA defines the role of the Department of Water Affairs and Forestry (DWAF) in permitting waste disposal sites. This responsibility is addressed through the formulation of the "Minimum Requirements" documents guiding the disposal of waste by landfill. These minimum requirements state the requirements, standards and procedures that apply in waste disposal and handling facilities.

The White Paper on Integrated Pollution and Waste Management (South Africa, 2000:10-12) outlines the principles for the allocation of environmental and waste management functions as well as powers for national, provincial and local governments. The National Waste Management Strategy (NWMS) and action plans followed, through a joint venture between the Department of Environmental Affairs and Tourism (DEAT) and the Department of Water Affairs and Forestry (DWAF) in an initiative supported by the Danish donor agency. The action plans developed under the NWMS initiative focuses on the following:

- Integrated waste management planning;
- Waste information system;
- General waste collection;
- Waste treatment and disposal; and
- Capacity building, education, awareness and communication.

South Africa currently does not have any specific legislation dealing with fluorescent lamps and as a result are treated as part of electrical and electronic waste (e-waste). However, the National Environmental Management Act (South Africa, 1998b:2) states that it is the duty of the state, businesses and all citizens to prevent pollution and other damage to the environment, and to promote conservation and sustainable development.

All levels of government, whether national, provincial, or local, have a duty to take reasonable steps in their current functions as well as future plans to prevent pollution, promote conservation, and ensure sustainable development (South Africa, 1998b:2). In addition, DWAF has developed a number of policies that relate to specific waste streams and to disposal site authorisations.

The Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste (South Africa, 1998a:1-1) is the most applicable document that aims to ensure the sustained fitness for use of South

Africa's water sources and to protect both the public and the environment from harmful effects of incorrect waste management without impairing the economic development that is essential to South Africa.

The National Environmental Management: Waste Act (South Africa, 2008:24) makes provision for a municipality in terms of a by-law to identify requirements for the management of waste, including requirements in respect of the avoidance of the generation of waste and the recovery, re-use and recycling of waste. The municipality has powers to ensure that waste management services are provided within the municipality in a manner that prioritises the recovery, re-use or recycling of waste and provides for the treatment and safe disposal of waste as a last resort. However, it also specifies the extended producer responsibility to be taken in respect of a product or class of products, or person or category of persons who must implement waste management services and their responsibility.

The requirements in respect of the implementation and operation of an extended producer responsibility programme include the requirements for reduction, re-use, recycling, recovery, treatment and disposal of waste (South Africa, 2008:34). In accordance with the cradle-to-grave principle, it is the generator of fluorescent lamps who is responsible for the management of fluorescent lamps from their inception to their final disposal. In this case, it is the responsibility of public schools to ensure the proper management of fluorescent lamps in their institutions until they are finally disposed of in a safe manner. Hence, the need to determine how fluorescent lamps as a hazardous waste stream, are managed at selected public schools and to make recommendations accordingly.

2.4 MANAGEMENT OF HAZARDOUS WASTE: HANDLING, STORAGE AND DISPOSAL

This section discusses the management of hazardous waste at sources of generation until final disposal.

2.4.1 Handling and storage at source

According to the Minimum Requirements for Handling, Classification and Disposal of Hazardous Waste (South Africa, 1998a:2-7), hazardous waste must be securely contained during handling, storage and transportation to prevent risk to the environment. It is essential that all waste generated should be accumulated at its point of origin and should not be allowed to remain at the source for any length of time or mixed with other wastes of a different nature or composition. The waste generator may be an individual, an industry or any other party whose activities result in the production of waste (South Africa, 1998a:2-4).

In terms of storage, once the waste has been accumulated in a suitable container, the waste container itself must be clearly marked during temporary storage to prevent any risk of incorrect classification resulting in environmental pollution. This area must be clearly demarcated and should not be accessible to unauthorised persons (South Africa, 1998a:10-3). Table 2.3 indicates the quantities of hazardous waste that can be kept at source for a period not exceeding 90 days, depending on the nature and toxicity of the waste generated, unless if the generator is licensed to keep such waste.

Table 2.3 Quantities of hazardous waste that can be stored on site (Source: South Africa, 1998a:10-3)

Hazard	Risk	Quantity (kgs)
Hazard 1	Extreme	10
Hazard 2	High	100
Hazard 3	Moderate	1000
Hazard 4	Low	10000

On-site processing of spent fluorescent lamps reduces storage space requirements and prevents mercury-containing lamp contents from entering the municipal waste stream, but such processing activities are typically not carried out in facilities specifically designed for the operation. This circumstance is of particular concern because lamp-handling and crushing operations can release mercury vapours and aerosols that constitute an occupational exposure risk. Lucas and Emery (2006) reported that sampling for airborne mercury was performed during the processing of fluorescent lamps in an enclosed work area and in an open, outdoor work environment. In both enclosed and open work environments, exposures in excess of the established mercury exposure limit were detected.

Kennedy (2008) notes that the research group of the Institute for Molecular and Nanoscale Innovation broke a series of new and used CFL's to measure the release of mercury vapour into the air. In the hour immediately after each breakage, the team recorded mercury gas concentrations near the bulb shards between 200-800µg [micro-grams]. For comparison, the average eight-hour occupational exposure limit allowed was 100µg. Within four days a new 13-W CFL released about 30% of its mercury, with the remainder appearing to remain trapped in the bulb debris; picking up the glass shards after breakage reduced mercury release by 67%. Used bulbs followed similar patterns but with lower rates (Kennedy, 2008).

The study, which was funded by the NIEHS Superfund Basic Research Program, was reported on in the 1 August 2008 issue of Environmental Science and Technology (Kennedy, 2008). This kind of information could help regulators provide better information on how to handle broken CFL's. In 2007, the Maine Department of Environmental Protection performed one of the only other studies evaluating mercury exposure from broken CFL's. The EPA's current recommendation to leave the room for at least 15 minutes immediately after breaking a CFL is derived from that study. The EPA also recommends that broken CFL pieces be scooped up and placed in a plastic bag. However, Hurt's research as quoted by Kennedy (2008) suggests that the peak for escaping mercury vapour lasts a few hours and that plastic bags leaked mercury vapour. Hurt's group has therefore developed prototype packaging and disposal bags that can act as a barrier to neutralise as well as to prevent mercury from escaping.

2.4.2 Disposal

Fluorescent lamps in South Africa are supposed to be landfilled in permitted hazardous waste disposal sites, according to the South African Minimum Requirements for Handling, Classification, and Disposal of Hazardous Waste (South Africa, 1998a:9-2/3). The client is then issued with a certificate of safe disposal; however, most of the time these lamps are simply disposed of in the municipal waste stream and are landfilled in the local general waste disposal site (South Africa, 1998a).

The general public is not educated in terms of the dangers of mercury containing lamps, how to handle them or what to do in case of breakage (Reclite, 2008; Lombard and Webb, 2008). It is also stated that currently there are no regulations in terms of domestic disposal, some industries are not disposing at a hazardous landfill site, and the transportation of fluorescent lamps and the crushing, or disposal of them are not regulated.

Reclite (2008) as well as Lombard and Webb (2008) remark that, nationwide, millions of mercury-containing lamps are discarded each year and most of these are discarded with municipal waste. All mercury-containing fluorescent lamps will release mercury into the environment through breakage or leakage, outside a controlled crushing and recycling process.

Lombard and Webb (2008) also notes that improper disposal methods could lead to release of elemental mercury, which can be converted into an organic form that accumulates in living organisms and can contaminate the food chain. The combined action of heat and soil bacteria under anaerobic conditions transforms it into the highly toxic and more volatile methyl mercury, which can be released from the soil. Hence the best-practice hazardous landfill with a high-integrity lining may seem a fitting disposal site, since anaerobic micro-organisms fix mercury as mercuric sulphide, which remains as an immobile precipitate within the landfill. As long as conditions remain stable within the landfill and with a pH just above neutral, the presence of mercury should not be problematic; however, there is always the risk of such mercury being mobilised if the landfill is opened up or mismanaged (Lombard and Webb, 2008). Lombard and Webb (2008) also states that there are reportedly elevated levels of mercury in air over landfills where untreated mercury-containing lamps are disposed of. Therefore it is safer not to dispose of mercury-containing wastes in a landfill as far as possible.

2.5 MANAGEMENT OF FLUORESCENT LAMPS AND CFL WASTE STREAM

Throughout Europe and the USA the regulations governing the handling of electronic waste have become so strict that landfills are no longer a viable option for disposal (Lombard and Webb, 2008). The European Directive on Waste Electrical and Electronic Equipment (WEEE) as quoted by Lombard and Webb (2008) has also paved the way for mandatory and comprehensive recycling of used electronic equipment. The international trend is to move away from the landfilling of lighting lamp waste that contains mercury towards recycling. Lamp recycling started in the mid-1990s in the UK. California, for example, has banned the disposal of fluorescent tubes in landfills, as its recycling facilities are fully operational. South Africa is also considering recycling lighting lamp waste as electronic waste (e-waste) becomes a bigger challenge (Lombard and Webb, 2008).

Lombard and Webb (2008) further state that recycling is the best environmental alternative, as, nationwide, millions of mercury-containing lamps are discarded each year and most of these are discarded with municipal waste. This will result in all mercury-containing lamps releasing mercury into the environment through breakage or leakage, outside a

controlled crushing and recycling process. Recycling also reduces landfill volumes, since all the components of fluorescent lamps can be recovered and recycled, thus avoiding the wastage of valuable resources.
These components are:

- glass;
- plastic;
- fluorescent powder;
- aluminium;
- ferro metal; and
- mercury.

Recycling also creates employment and the opportunity for skills training. The need for an environmentally acceptable, yet cost-effective, spent-lamp management programme has become one of the environmental priorities in South Africa. The National Health Act (South Africa, 2003:15-22) makes provision for the foundational structure of the National, Provincial, and District healthcare system. Hex *et al.* (2008) indicates the role played by the government to encourage best practice to ensure compliance with relevant legislative requirements for the responsible handling of spent lamps.

Lombard and Webb (2008) outline the recycling process as follows:

- Collection

  Spent lamps are to be kept whole where possible and stored in a dry locked area, which minimises lamp breakage. Any broken lamps must be stored separately in a sealed container or drum that prevents mercury vapour emissions.

  Collection centres are to be introduced throughout South Africa, these being: wholesaler facilities, retailers (Pick 'n Pay and Woolworths' initiative, already launched), garden centres, and landfill sites, large industries can allocate collection areas.
- Delivery to recycling facility

- Processing (recycling)
- Re-using recycled products

2.5.1 National and Provincial Government Responsibility

Hex *et al.* (2008) suggest that national government support for a nationwide CFL recovery mechanism is critical to the success of the guidelines initiative. The Department of Environmental Affairs and Tourism's involvement is governed by the national legislation framework, including the Constitution (South Africa, 1996), and the National Environmental Management: Waste Act (South Africa, 2008). The main objective is to encourage thorough legislation and regulations and to enforce separation at source of all recyclable and particularly hazardous waste. It is stated that emphasis should be placed on the importance of appropriate handling of hazardous waste among all role players and every entity is under legal obligation to comply.

2.5.2 Local Authority / Municipal Responsibility

Hex *et al.* (2008) further state that the municipalities should proactively encourage separation at source of all recyclable and hazardous household waste, including specifically CFL's. Waste separation is an important step in the government drive for waste minimisation and key to achieving the waste hierarchy: Reduce, Re-use, and Recycle (Hex *et al.*, 2008).

According to Hex *et al.* (2008) it is the duty of municipalities to educate and create awareness among the public regarding the need for waste separation and specifically the need for separating CFLs and other hazardous waste from the waste stream. The role played by the Department of Environmental Health cannot go unnoticed, as it is responsible for promoting the proper handling and disposal of hazardous substances (such as fluorescent lamps), at both local and provincial level.

2.6 ENVIRONMENTAL IMPACT

The use of energy-efficient lamps rather than incandescent lamps has environmental benefits, according to Lombard and Webb (2008). Furthermore, lamp life has an effect on the waste generation rate, while the efficiency determines how much energy is consumed. The longer the lamp life, the less frequently lamps have to be discarded as waste, while the more efficiently a lamp can convert energy into visible light, the less electricity it will consume. A reduced power demand, in turn, helps reduce mercury vapour, and greenhouse gas and acid gas emissions from power plants.

Lombard and Webb (2008) argues that no mercury is released when the fluorescent lamps are unbroken or in use. Exposure is only possible when a lamp has been broken, but it is well known that these lamps are fragile and can break easily. Mercury can also be released into the air when the lamps break as a result of improper disposal such as inclusion in the domestic waste stream, or being discarded into skips and other general waste containers (Lombard and Webb, 2008).

The cumulative impact of the mercury present in each lamp, even though small, could result in adverse environmental impacts if broken or used fluorescent lamps are not properly treated or disposed of (Lombard and Webb, 2008). Furthermore, all over the world it is continuing to contaminate forests and water, resulting in severe damage to ecosystems. Mercury bio-accumulates in the tissues of animals and humans that eat contaminated food and the symptoms of mercury poisoning will become evident over time. Mercury contamination in water supplies poses a similar serious threat to humans and animals and is almost impossible to remove (Lombard and Webb, 2008).

Davidson *et al.* (2004) states that mercury is naturally present in the environment: it is part of the composition of the earth's crust and can be found in the air, water, soil, aquatic sediments, and living plants and animals. He further states that it occurs in several chemical forms, including elemental mercury (pure mercury) and both inorganic and organic mercury compounds. Davidson *et al.* (2004) also indicates that of the approximately 3400 metric tons per year of elementary mercury released into the global environment, 95% resides in terrestrial soils, 3% in ocean surface waters, and the remaining 2% in the atmosphere. He further states that in these three forms, mercury remains in the environment indefinitely.

Harris *et al.* (2007) states that mercury concentrations in many regions of the globe have increased as a result of industrial activities. Mercury contamination can occur as a localised issue near points of release and as a long-range transboundary issue arising from atmospheric emissions, transport, and deposition. Most of the mercury released into the environment is inorganic, but a small fraction is converted by bacteria into methyl mercury, a toxic organic compound. This is important because methyl mercury bio-accumulates through aquatic food webs so effectively that most of the mercury in fish is methyl mercury and fish consumption is the primary exposure pathway for methyl mercury in humans and many wildlife species (Harris *et al.*, 2007).

Regulations controlling mercury release have been proposed or put in place for major sectors of the U.S. economy releasing mercury to the environment, including a recent rule to control emissions of mercury from coal-fired boilers (Harris *et al.*, 2007). Harris *et al.* (2007) states that many scientists and policy-makers are concerned, however, that existing monitoring programmes do not provide an adequate baseline of mercury concentrations in the environment to compare against future trends or evaluate the effectiveness of emission controls. Local watershed and site conditions can exert large influences on mercury concentrations, as year-to-year, seasonal, and even daily variations in meteorology. Large-scale environmental changes such as acid deposition, land use, or climate change also have the potential to enhance methyl mercury production and contribute to higher fish mercury concentrations (Harris *et al.*, 2007).

2.7 HEALTH EFFECTS

Mercury is a powerful poison and neurotoxin, as stated by Williams (2005). Even in small amounts it is more toxic than lead, cadmium, and arsenic. Symptoms of toxicity are extensive. Serious health risks may include retardation, seizures, cerebral palsy, attention and sensory deficit, and learning disability in children. Psychological symptoms may include anger, irritability, nervousness, anxiety, poor self-control, fatigue, drowsiness, depression, intellect decline, memory loss, timidity, and insomnia. Neurological effects include headaches, tremors, weakness, tinnitus (ringing in the ears), impaired vision, and paraethesia (abnormal).

Williams (2005) also states that cardiovascular / respiratory symptoms may include tachyarrhythmia (irregular heart beat), chest pain, change in blood pressure, persistent cough, emphysema, shallow or irregular breathing. Endocrinological symptoms may include chronic fatigue, subnormal temperature, excessive perspiration, edema, weight loss, cold clammy hands and feet, muscle weakness, hypoxia (oxygen deficiency in the tissues), appetite loss, joint gums, thyroid dysfunction, and infertility. Oral cavity symptoms may include excessive salivation, metallic taste, and swollen tongue with scalloped edges, periodontal disease, bleeding gums, losing of teeth, and bone loss around teeth (Williams, 2005).

Davidson *et al.* (2004) states that children are seldom exposed to high levels of vapour, which occur mainly in occupational settings, but under such circumstances, they may exhibit a syndrome known as acrodynia (painful limbs) or pink disease. Davidson *et al.* (2004) further states that during the first half of the 20th century, children were often treated with teething powder that contained inorganic mercury in the form of calomel, and acrodynia was common. Clinically, it consisted of irritability, photophobia, erythema of the hands and feet, hypertension, and failure to thrive while death sometimes occurred (Davidson *et al.*, 2004).

Wedam (2010) states that, although the luminance appears consistent to the human eye, much more time is actually spent in near-darkness under fluorescent lighting than with incandescent lighting. The eye and the body must accommodate continuous rapid gradations in brightness. Incandescent light produces steady light with a low and consistent energy field compared with fluorescent lighting with its changes in lumens and electromagnetic fields. Processing these light-intensity and electromagnetic-field changes may confuse both the human eye and the brain. Fluorescent light is a pulsating energy source that produces measurable resonant frequencies capable of interacting with the human body on a variety of levels. The effect of the strength of the energy field can be described in terms of the duration of the exposure, and the intensity of and the proximity to the source (Wedam, 2010).

Wedam (2010) indicates that since the eye is another receptor organ for light, just as the skin, fluorescent lighting contracts the 100 million receptors in the retina. Visual information is then preprocessed and transmitted directly to the brain via the 1.2 million nerve fibres of the optic nerve. Thus, photoreceptor cells activate neuronal circuitry to regulate metabolic response. As incandescent lighting is phased out, prolonged exposure to fluorescent lighting will increase. Fluorescent lighting will become the dominant source of illumination. Energy-saving technology is now making it possible to extend the use of fluorescent lighting into the body's personal space, increasing the intensity due to proximity (Wedam, 2010).

All humans are exposed to some level of mercury, according to the WHO (2008). The primary targets for toxicity of mercury and mercury compounds are the nervous system, the kidneys, and the cardiovascular system. Effects on the nervous system (especially the developing nervous system) appear to be the most sensitive toxicological endpoint observed following exposure to elemental mercury (WHO, 2008).

Effects on the nervous system appear to be the most sensitive toxicological endpoint observed following exposure to elemental mercury. A few studies have provided suggestive evidence for potential reproductive toxicity associated with exposure to elemental mercury. Data from two studies in rats demonstrate developmental effects of elemental mercury exposure. These were behavioural changes associated with both in utero and prenatal exposure (NEWMOA, 2010).

Table 2.4 shows a comparison of health effects due to exposure of humans to mercury through inhalation, ingestion of or bodily contact with mercury, whether in its elemental form or combined with an inorganic element or compound (NEWMOA, 2010).

Table 2.4: Human health effects from exposure to mercury. Source: Northeast Waste Management Officials' Association (NEWMOA, 2010)

Inorganic and Elemental Mercury	**Methyl mercury**
Renal toxicity	Neonatal brain damage
Skeletal muscle degeneration	Nephritis – inflammation of the kidney
Gastrointestinal irritation	Paresthesia – tingling sensation of the skin
Pulmonary edema – fluid in the lungs	Muscle fasciculation – twitching muscles
Elevated blood pressure	Abnormal heart rhythms
Low-grade or intermittent fevers	Chromosomal aberrations
Flushing of palms and soles	Dermatitis – skin inflammation

2.8 MERCURY IN SCHOOLS

Sarikaya *et al.* (2001) recorded a case study of a 36-year-old woman who presented to the emergency department with a three-day history of abdominal pain, diarrhoea and fever, one week before this her daughter had brought mercury in liquid form from school without permission from her teacher. She had played with the mercury, and then put it on the heating stove and watched its vaporisation. Meanwhile, her mother breast-fed her 14-month old sister; 24 hours after this event the baby got fever and died before admission to the hospital without any specific diagnosis. The autopsy report disclosed suspected mercury poisoning, which might have led to cardiorespiration collapse resulting in the death of the infant.

Sarikaya *et al.* (2001) further state that acute inhalations of mercury vapours can cause pneumonia, adult respiratory distress syndrome, progressive pulmonary fibrosis and death. Also elemental (metallic) mercury can readily pass into systemic circulation via alveoli or directly through the skin. Elementary mercury can pass directly from nursing mothers to infants via breast milk. The predominance of gastrointestinal symptoms and historical findings suggest intoxication with elemental mercury in the case investigated here.

Sarikaya *et al.* (2001) states that historical findings played a critical role in this case. Tests for additional acid, alkali, and arsenic, phosphorous or iron ingestion did not yield any suspicious findings. History of exposure to mercury, gastrointestinal symptoms and the suspicious death of a breast-fed baby led to the presumptive diagnosis of acute mercury poisoning. Since brain maturation is not complete in young children and foetuses, even a small exposure can be fatal. The death of the previously healthy baby in 24 hours prompts consideration of necrotising bronchitis, pneumonia or respiratory distress syndrome. Inhalation of mercury by the baby can be thought to be the main reason of death. This case emphasises the importance of public education on poisoning and, specifically, the potential hazards of mercury for preventive community health. Training on poisoning with heavy compounds is recommended for school children and teachers (Sarikaya *et al.*, 2001).

In a case study, White and Smolinske (2001) describe the actions taken by a regional poison centre in response to the accidental elemental mercury contamination of a school. The regional poison centre was contacted shortly after a spillage of elementary mercury in a science classroom. Mercury beads were noted throughout the school. Many children played with the mercury and had already returned home. The appropriate authorities were mobilised and recommended the retrieval of students' personal items, many of which later found to be highly contaminated.

The regional poison centre then responded to the school's wish to offer medical screening to potentially impacted children by (1) developing medical screening forms; (2) developing a strategic plan for medical staffing/equipment acquisition; (3) creating a tracking system; and (4) providing risk communication to the public through media releases, fact sheets, and parent meetings. The regional poison centre also co-ordinated laboratory results interpretation and medical follow-up (White and Smolinske, 2001).

Finally, the regional poison centre spearheaded the formation of a Mercury Reduction in Schools Taskforce, which coordinated the following agencies: local public schools; country school systems; state science teachers' association; the United States Environmental Protection Agency; local, country and state health departments; department of environmental quality; hospitals; media relations; and other interested agencies. Teacher workshops highlighting chemical safety in schools and mercury risk to the community and environment have been sponsored by this task force and had reached over 150 schools by 2001. Regional poison centre can potentially play a key role in mitigating the effects of hazardous materials incidents through early mobilisation of appropriate agencies, coordination of medical response, and sponsorship of activities designed to prevent future occurrences (White and Smolinske, 2001).

Williams (2005) states that mercury spillages in schools are seriously considered and dealt with now than in the past. A certain school in Baltimore was closed for 35 days in 2003, and clean-up costs for the mercury contamination amounted to US$1.5 million. Besides disrupting classes, mercury spills in schools pose a danger to students, staff and environment. The National Science Teachers' Association and the US Environmental Protection Agency (EPA) are encouraging schools to remove mercury compounds and mercury-containing equipment. So far, nine states have created programmes to hasten mercury removal from schools (Williams, 2005).

2.9 WORLD HEALTH ORGANISATION GUIDELINES AND THRESHOLD LEVELS

In most cases the adverse human health effects caused by elemental mercury are due to inhalation of mercury vapour. Elemental mercury exposure is triggered by the spillage of mercury-containing products, such as breakage of fluorescent lamps. Elemental mercury spilled by these accidents becomes mercury vapour at normal room temperature because of its chemical property. Approximately 80% of mercury vapour crosses the alveolar membrane and is rapidly absorbed into the blood (WHO, 2008). Absorbed elemental mercury is rapidly distributed to all tissues, although it accumulates to the greatest extent in the kidney.

An acute exposure (>0.1 mg·mercury/m^3) to mercury vapour causes respiratory effects such as cough, dyspnoea and chest tightness as well as bronchitis and bronchiolitis with interstitial pneumonitis, airway obstruction, and decreased pulmonary function. The WHO air quality guideline for mercury is 1 µg·Hg/m^3 (annual average). The recommended health-based exposure limit for metallic mercury is 25 µg·Hg/m^3 for long-term exposure as the time-weighted average (TWA), which is the time-weighted average concentration for a normal eight-hour day and 40-hour work week to which nearly all workers can be repeatedly exposed without adverse effect (WHO, 2008).

2.10 ROUTES OF EXPOSURE TO MERCURY

The factors that determine the occurrence and severity of adverse health effects include: the chemical form of mercury, the dose, the age or developmental stage of the person exposed, the duration of exposure, and the route of exposure (inhalation, ingestion, and dermal contact) (WHO, 2008). Staff and learners may be exposed to elemental or inorganic mercury through inhalation of ambient air in classrooms when fluorescent lamps are broken, or when fluorescent lamps are being handled, stored or disposed of improperly in schools, leading to the release of mercury into the environment.

2.11 SUSCEPTIBLE POPULATION

A susceptible population is a group that may experience more severe adverse effects at comparable exposure levels or adverse effects at lower exposure levels than the general population (WHO, 2008). The greater response of these sensitive subpopulations may be a result of a variety of intrinsic or extrinsic factors. It is stated that, for mercury, the most sensitive subpopulations may be developing organisms. Data is also available indicating that other factors may be associated with the identification of sensitive subpopulations; these include age and gender. Generally there are two susceptible subpopulations, namely, those who are more sensitive to the effects of mercury and those who are exposed to higher levels of mercury. The foetus, the newborn and children are especially susceptible to mercury exposure because of the sensitivity of the developing nervous system (WHO, 2008).

Wedam (2010) states that some individuals are more sensitive and susceptible to the harmful effects of fluorescent lighting than others due to their general health and generic, hereditary, lifestyle, and environment factors. The type, condition, and age of the fluorescent lighting cause physical impairment in intolerant individuals. Such a disability marginalises certain people socially, restricts their activities, and limits their choice of employment (Wedam, 2010).

However, Al-Saleh (2009) states that each of the mercury forms pose a different risk to human health. Mercury can be transferred prenatally to the developing foetus via the placenta from breast milk to the nursing infant. It is further stated that children are potentially more susceptible to mercury than adults due to differences in the stages of brain development and organ growth that occur during the foetal, infant and childhood development periods.

2.12 CONCLUSION

Most people are ignorant of the hazards associated with fluorescent lamps once they break (Lombard and Webb, 2008). Hence it is vital that public schools become better informed about the danger that mercury-containing lamps can pose and how important it is to manage them safely when they become waste. The literature reviewed demonstrated the availability of mercury and mercury-containing substances (including fluorescent lamps) in schools. It has also revealed that children are not only fascinated by mercury but actually like playing with it, and at the same time they are the highly susceptible group because their nervous system is still developing.

The case studies also pointed out the necessity of taking a holistic approach to properly manage and where possible remove mercury and mercury-containing substances in schools. The exposure of learners, employees and the environment to mercury is inevitable if fluorescent lamps are improperly handled, stored and disposed of in schools.

Chapter 3 explains the methodology and the logic behind research methods and techniques used in this study in order to determine the management of fluorescent lamps, as a hazardous waste stream, in selected public schools.

CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

In Chapter 2 literature was reviewed in an endeavour to understand the hazardous nature of fluorescent lamps and the management thereof. This Chapter explains the activities and procedures undertaken during the course of the study. These activities and procedures include the research approach that was adopted, the study design followed, the research population used, how the sample was selected, and how the data was collected and analysed. According to Welman *et al.* (2005:2) research methodology considers and explains the logic behind research methods and techniques.

The study was done under the umbrella of the World Health Organisation Collaborating Centre for Urban Health's (WHOCCUH) Health, Environment and Development (HEAD) study, which aims to monitor changes in living conditions and health status, alongside government development initiatives (WHOCCUH, 2007). The sample population included public schools from within and around each of the five selected HEAD study geographic locations in the Johannesburg Metropolitan Area.

3.2 RESEARCH APPROACH

According to Welman *et al.* (2005:6) there are two main research approaches to research namely: quantitative, also known as the positivist approach, and qualitative, known as the anti-positivists. Welman *et al.* (2005:6) states that the purpose of quantitative research is to evaluate objective data consisting of numbers; as a result, the quantitative approach uses a process of analysis that is based on complex structured methods to confirm or disprove hypotheses. Welman *et al.* (2005:6-7) further states that, in quantitative research, flexibility is limited to prevent any form of bias in presenting the results, and this approach tries to understand the facts of a research investigation from an outsider's perspective. Furthermore, it is believed that detaching and objectively viewing the facts will keep the research process free from bias. On the other hand, De Vos *et al.* (2005:357) agree that the quantitative approach is more highly formalised, as well as more explicitly controlled than the qualitative, with a range that is more *exactly* defined, and that is relatively close to the physical sciences.

In contrast, the purpose of qualitative research is to deal with subjective data that is produced by the minds of respondents or interviewees and data is presented in language instead of numbers (Welman *at al.*, 2005:8). Furthermore, the qualitative approach emphasises processes and meanings that are not rigorously examined, or measured, in terms of the following:

- Quantity;
- Amount;
- Intensity; or
- Frequency.

However, qualitative research methods aim to establish the socially contracted nature of reality, in order to stress the relationship between the researcher and the object of study. Welman *et al.* (2005:8) also states that qualitative research is flexible and enables data to change as it tries to achieve an insider's view by talking to subjects or observing their behaviour in a subjective way. Nevertheless, De Vos *et al.* (2005: 357) describes tha qualitative approach as those procedures that are not strictly formalised. The scope is also more likely to be undefined, and a more philosophical mode of operation is adopted.

Given the aim of the study, it therefore adopted a quantitative research approach. The study aimed at determining how fluorescent lamps as a hazardous waste stream are managed at selected public schools. Therefore the quantitative approach was most appropriate for describing human behaviour in this phenomenon, unlike the qualitative approach, which describes the experiences of humans as a phenomenon. According to Welman *et al.* (2005:188) quantitative research approaches are more useful for hypothesis testing. In this study the quantitative research approach provided appropriate data to prove or disprove the hypothesis that employees, learners, and the environment might be exposed to elementary mercury if fluorescent lamps are improperly managed in public schools.

3.3 STUDY DESIGN

De Vos *et al.* (2005:132) states that research design is the plan, recipe or blueprint for the investigation, and as such provides a guideline according to which a selection can be made of which data collection method(s) will be most appropriate. However, Babbie (2006:72) indicates that a research design is a strategy for finding out something, as it helps to specify clearly what the researcher wants to find out and the way to do it. There are different kinds of research designs as listed below:

- Exploratory;
- Explanatory;
- Descriptive; and
- Experimental.

Babbie (2006:79) states that an exploratory study explores a research question about which little is known - in other words, it uncovers generalisations and develops hypotheses that can be tested later. This study design is essential whenever the researcher is breaking new ground, and it can always yield new insights into a topic for research (Babbie, 2006:79). Exploratory research designs also indicate the viability of undertaking further investigation and the methods to be used, whereas De Vos *et al.* (2005:106) states that exploratory designs arise out of a lack of information on a new area of interest, or in order to get acquainted with a situation so as to formulate a problem or develop a hypothesis.

De Vos *et al.* (2006:106) argues that a descriptive design begins with a well-defined subject and research is conducted to describe it accurately, whereas in exploratory studies, the research is conducted in order for the researcher to become more conversant with basic facts and to create a general picture of conditions. In an explanatory design a study is conducted on an issue that is already known and has been described; however, the study probes questions concerning why things happen the way they are happening – therefore such a study builds on exploratory and descriptive research (De Vos *et al.*, 2006:106). The last study design is defined as the correlational research design (experimental design), which helps to demonstrate causal relationships between the intervention and the behaviours and related conditions targeted for change (De Vos *et al.*, 2006:106).

The study therefore followed an exploratory research design since there is little or limited research that has been conducted on the subject of mercury exposure in public schools, or on employees, learners, and the environment, resulting from the improper management of fluorescent lamps in South Africa. Therefore the results of this study will contribute towards a sequence of studies that may follow.

3.4 TYPE OF RESEARCH

Welman *et al.* (2005:25) lists four types of research: historical research, case study research, action research, and applied research. In this study, applied or intervention research was used. This kind of research applies the research in practice and seeks to extend knowledge of human behaviour relating to human service intervention. It is directed towards shedding light on, or providing possible solutions to, practical problems (Welman *et al.*, 2005:26). Therefore, applied research is relevant to this study, as the knowledge gained through this study can be utilised to:

- plan possible interventions to redress the problem;
- create awareness on proper management of fluorescent lamps in public schools;
- promote recycling; and
- formulate a possible model for operational procedures in public schools.

3.5 PILOT STUDY

A pilot study was conducted before the major research endeavour was attempted. De Vos *et al.* (2005:206) state that a pilot study can be viewed as the "dress rehearsal" for the main investigation: it is a small-scale implementation of the planned investigation in an attempt to bring possible deficiencies to the fore timeously. Furthermore, De Vos *et al.* (2005:206) defines a pilot study as a small study conducted prior to a larger piece of research to determine whether the methodology, sampling, instruments and analysis are adequate and appropriate. According to De Vos *et al.* (2005:207) a literature study is important not only to formulate the problem, but also to execute the planning and actual implementation of the investigation. Babbie (2006:244) states that no matter how carefully a data-collection instrument is designed, there is always the possibility of error, and the surest protection against such error is pre-testing the instrument. For example, it may emerge from the pilot study that a significant number of respondents skip a certain question or interpret it incorrectly.

Literature was reviewed during the pilot study (as discussed in both Chapters 1 and 2) on electrical waste, and specifically fluorescent lamps, to try to understand the following aspects:

- the hazardous nature of fluorescent lamps;
- fluorescent lamp management, including recycling;
- the existence of guidelines on the management of fluorescent lamps;

- the most susceptible populations and routes of exposure;
- the environmental impact; and
- awareness in public schools.

This was done for orientation purposes and to ascertain whether literature on fluorescent lamps exists, and what kind of literature it is. Experts from the Electrical Waste Association of South Africa (eWASA) were also consulted during the literature review in an endeavour to learn more about the challenges posed by spent lamps in the field.

Three public schools, which were not part of the sample population but complied with the inclusion criteria, were used for the pilot study, and the respondents were the school principals or any respondent who represented the school management. The information collected and analysed during the pilot study revealed that:

- during data collection the researcher should not be present while the respondent completes the questionnaire, as he or she is likely to ask the researcher for assistance in completing some of the questions; in fact, in order to save time it is better to do some observations while they complete the questionnaire;
- the researcher should be prepared to collect the completed questionnaire some other time suitable for the respondent in cases were the respondents could not complete the questionnaire during the interview.
- it is better for the researcher to be escorted specifically by someone who is responsible for handling and disposing of fluorescent lamps during observations as they are more acquainted with storage and disposal area;
- it is necessary to develop an introductory statement that ensures consistency, and for every important aspect to be covered in the briefing process during introduction in each school; and

- it is necessary always to phone the schools a day before the appointment to remind them lest they forget; in some cases they rescheduled the appointment, and this avoids disappointment and saves time and transport costs.

The structured questionnaire and the observation checklist were developed and pre-tested during the pilot study to identify any ambiguity in the data-collection tools. Limited number of changes was made to enhance the effectiveness of both the questionnaire and the checklist.

Quantitative data analysis was used to process data collected during the pilot study to ensure that the responses reflect sufficient variables to test the hypothesis of the study, and to ascertain that the analysis of data ensures that the study is able to achieve its intended objectives. De Vos *et al.* (2005:15) states that it is possible that unforeseen problems may crop up only during the data analysis phase. Data was analysed, presented and interpreted in simple statistical analysis (Microsoft Excel). Frequency of responses was converted into percentages, and tables and figures were used to present data.

3.6 RESEARCH POPULATION

Welman *et al.* (2005:52/3) defines population as the study objects, and these consist of individuals, groups, organisations, human products and events, or the conditions to which they are exposed. Population also encompasses the total collection of all units of analysis about which the researcher wishes to make specific conclusions. However, De Vos *et al.* (2005:193/4) defines population as the total set from which the individuals or units of the study are chosen; as the set of elements that the research focuses upon and to which the obtained results should be generalised; as the sampling frame; and as the totality of persons, events, organisational units, case records or other sampling units with which the research problem is concerned. Therefore, in this study, the population consisted of the public schools within the five selected HEAD study geographic locations in the Johannesburg Metropolitan Area. These locations are regarded as relatively impoverished settlements that cover a range of formal areas, namely Hillbrow, Bertrams, Riverlea, Braamfischerville, and Hospital Hill as the only informal area according to WHOCCUH (2007).

3.7 SAMPLING

According to De Vos *et al.* (2005:194) a complete coverage of the total population is seldom possible, as all the members of a population of interest cannot possibly be reached. A sample thus comprises elements of the population considered for actual inclusion in the study, or can be viewed as a subset of measurements drawn from a population in which we are interested. Therefore we study the sample in an effort to understand the population from which it was drawn.

The sample population included a total number of 13 primary schools out of 21 and a total of 9 secondary schools out of 17 were sampled. Table 3.1 highlighted the selection and distribution of the schools selected for the study. Proportionate purposive sampling was used to select a total sample of 22 out of 38 public schools. De Vos *et al.* (2005:202) states that purposive sample is based entirely on the judgment of the researcher, in that a sample is composed of elements that contain the most characteristic, representative or typical attributes of the population.

Table 3.1 Sample population of public schools

Area	**Primary School**	**Secondary School**	**Total**
Bertrams	3	1	**4**
Braamfischerville	3	1	**4**
Hillbrow	2	2	**4**
Hospital Hill	3	2	**5**
Riverlea	2	3	**5**
Total	**13**	**9**	**22**

3.8 DATA COLLECTION

Morris (2006:41) states that a well-designed questionnaire should meet the objectives of the research, obtain the most complete and accurate information possible, and do this within the limits of available time and resources. Two data-collection instruments were designed – namely, a structured questionnaire and an observation checklist. Data was collected through the use of structured questionnaires during interviews (refer to Appendix 1). Questionnaires were hand-delivered to the respondents and each respondent determined how much time he/she needed to complete the questionnaire. The questionnaire was used to determine:

- the awareness levels in public schools regarding the hazardous nature of fluorescent lamps;
- if any guidelines existed, whether formal or informal, for fluorescent lamp management, including handling, storage and disposal;
- handling of fluorescent lamps before use in public schools; and
- storage and disposal of spent lamps in public schools.

The most suitable respondents for the interviews were the school principals, as they are responsible for all matters arising at school, and are also responsible for the enforcement of any guidelines available in the school. All completed questionnaires were hand-collected, either the same day (after the observations), or at some other time that was suitable for the respondent.

Data was collected using a checklist during observation to assess possible routes of exposure related to employees, learners, and possible environmental exposure to mercury from storage to final disposal of fluorescent lamps in public schools (refer to Appendix 2). The investigation observed the effectiveness of available operational procedure guidelines on fluorescent lamp management, whether formal or informal. Observations were carried out to investigate the:

- storage area of fluorescent lamps before use;
- availability of guidelines (formal or informal);
- crushing area, where practised; and
- receptacles used for spent lamps before collection for disposal.

The details of the questionnaire and the observation checklist are discussed in Chapter 4. Telephonic appointments were made with the schools in advance, to book the school principals or respondents who represented the school management, to present the questionnaire and to carry out observations. An introductory statement was designed to ensure consistency (in sampled schools) and to ensure that every important aspect was covered in the briefing process during introduction (refer to Appendix 3).

3.9 RELIABILITY AND VALIDITY

According to De Vos *et al.* (2005:162) and Welman *et al.* (2005:9) the reliability of a measurement procedure is the stability or consistency of the measurement. If the same variable is measured under the same conditions, a reliable measurement procedure will produce identical measurements. Furthermore, reliability refers to a measuring instrument's ability to yield consistent numerical results each time it is applied; it does not fluctuate unless there are variations in the variable being measured.

Designing and pre-testing data-collection tools was done for reliability purposes – i.e. structured questionnaires and observation checklists were tested in three different schools before the actual study was carried out. Some changes were made to the data-collection tools as discussed under the pilot study section 3.5. During the pilot study three public schools were sampled to ensure that the questionnaire and the observation checklist collected the intended information and also to verify consistency. The consistency of data collection tools (questionnaire and observation checklist) meant that the study could be carried out by a different researcher altogether using the same techniques to produce the same results, unless if there had been changes in the management of fluorescent lamps in the schools selected.

Babbie (2006:122) states that validity ensures that only information collected and processed accurately reflects the concept it was intended to measure. De Vos *et al.* (2005:160) also state that validity, therefore, has two aspects: that the instrument actually measures the concept in question, and that the concept is measured accurately. The content of the research instruments extensively covered the stages involved in the management of fluorescent lamps from storage before use to the final disposal method practised in public schools. Content validity indicated that, during the pilot study, the data-collection tools collected correct and adequate data that was intended to be collected during the actual study.

On the other hand face validity ensured that the questionnaire and the observation checklist were the appropriate tools to be used for the collection of data in public schools. Therefore, content validity and face validity were both used and the data-collection instruments were defined to determine how well the sample depicted the management of fluorescent lamps in public schools. The study will generalised the results or outcome of the study to other public schools within the Johannesburg Metropolitan Area.

3.10 DATA ANALYSIS

De Vos *et al.* (2005:218) state that quantitative data, in professional research, can be analysed either manually or by computer. If the sample is relatively small, some statistical analyses can be performed manually with calculators. In this study quantitative data analysis was used to determine the management of fluorescent lamps by public schools as a hazardous waste stream. Determining awareness levels (very low, low, moderate, high and very high) at public schools regarding the hazardous nature of fluorescent lamps was depicted by their practices (whether it was due to a lack of awareness or not). This was achieved by respondents' answers to questions being rated in the likert-type scale (refer to table 3.2).

Table 3.2 Level of awareness at selected public schools

Levels of Awareness	**Percentage (%)**
Very High	80 – 100
High	65 – 79
Moderate	50 – 64
Low	30 – 49
Very Low	1 – 29

Identifying the existence of available guidelines (whether formal or informal) will assist in adopting them as formal in public schools, adjusting them, or demonstrating the need for new guidelines. These options were based on the effectiveness of available guidelines, taking into consideration all stages of fluorescent lamp management from storage to final disposal, as well as measures to be taken in cases of mercury spillages due to fluorescent lamp breakages. Assessment of possible exposure (levels and routes) of employees and learners to mercury was conducted througb probing questions on when replacement of spent lamps was done, how lamps were being stored before and after use, and how lamps were disposed of. The level of exposure was determined by the quantity of spent lamps being replaced and the frequency of disposal. Assessment of the environmental exposure considered the storage and disposal of spent lamps in relation to underground water and air pollution.

Data was collected (through the questionnaire and checklist) from the selected public schools and was presented, analysed and interpreted in simple statistical analysis. This data was coded and captured on a Microsoft Excel statistical package and analysed by applying statistical techniques. The responses were then converted into percentages, and presented in tables and figures.

3.11 ETHICAL CONSIDERATIONS

De Vos *et al.* (2005:57) define ethics as a set of moral principles which is suggested by an individual or group, is subsequently widely accepted, and which offers rules and behavioural expectations about the most correct conduct towards experimental subjects and respondents, employers, sponsors, other researchers, assistants and students. It is further stated that ethical guidelines also serve as standards, and a basis upon which each researcher ought to evaluate his own conduct. De Vos *et al.* (2005:57) go on to emphasise the point by stating that ethical principles should thus be internalised in the personality of the researcher to such an extent that ethically guided decision-making becomes part of his total lifestyle.

3.11.1 Informed Consent

In this study, a clear explanation of the aim of the study was provided to the respondents beforehand, and the respondents were informed that they could withdraw their consent and refuse to participate in the study at any given time. The procedures, possibilities and disadvantages as well as the dangers that may arise were explained to the respondents to enable them to make informed decisions. The respondents were made aware that this study will raise their awareness related to the proper management of fluorescent lamps in public schools, thereby minimising the exposure of employees and learners from hazards associated with handling and disposal of fluorescent lamps. However, they were also made aware that data collection might take about an hour of their time. Informed written consent was obtained from the principals of the respective schools (refer to Appendix 4). Approval was sought with and granted by the Faculty of Health Sciences Higher Degrees Committee and Academic Ethics Committee from the University (refer to Appendix 6). However, the research commenced only when permission was granted by the Department of Education (refer to Appendix 5).

3.11.2 Privacy and Voluntary Participation

The privacy of the persons concerned and the confidentiality of their personal information were respected, to such extent that the information obtained shall not be disclosed for purposes other than for which it was collected. Individual responses were presented in a generalised manner and the results of the study will be disclosed only to the schools that were involved in the study, the Gauteng Department of Education and for academic discussions e.g. conferences and publications. All respondents' rights were respected by treating everyone equally with respect and dignity. The rights to freedom of choice (e.g. to discontinue with interviews), expression and access to information of persons involved were respected. In order to ensure this, respondents (prior interviews) were fully informed of their rights as far as the interviews were concerned. The respondents in this study were encouraged to participate voluntarily (refer to Appendices 3 and 4).

3.12 CONCLUSION

This Chapter explained the methodology used in capturing the data – i.e. the activities and procedures undertaken during the course of the study. The study adopted a quantitative research approach because it such an approach would be most helpful in depicting or describing the situation in selected public schools without considering someone's opinion, beliefs or past experiences as far as fluorescent lamps management in public schools was concerned. The investigation therefore followed an exploratory study design, since there is very little research conducted on the subject of mercury exposure in public schools. In this study, applied or intervention research was used, which is based more on addressing the application of research in practice and extending the knowledge of human behaviour relating to human service intervention.

A pilot study was conducted before the major research endeavour was attempted. During the pilot study the literature on electrical waste, and specifically fluorescent lamps, was reviewed. This was done for orientation purposes and to find out whether literature on fluorescent lamps existed, and, if so, what kind of literature it was. Experts from the Electrical Waste Association of South Africa (eWASA) were also consulted during the literature review in an endeavour to leam more about challenges posed by spent lamps in the field. Three public schools, which were not part of the sample population, were used in the pilot study and the respondents were the school principals or any respondent who represented the school management.

Therefore, in this study, the population consisted of the school principals or respondents who could represent the school management, fluorescent lamp storage areas before and after use, receptacles used for spent lamps, and crushing areas. The sample population included public schools from within and around each of the five selected HEAD study geographic locations in Johannesburg Metropolitan Area. These locations were Hillbrow, Bertrams, Riverlea, Braamfischerville and Hospital Hill. Proportionate purposive sampling was used to select a total sample of 22 out of 38 public schools.

Two data-collection instruments were used, namely, a structured questionnaire and an observation checklist. Designing and pre-testing the data-collection tools was done for reliability purposes – i.e. the structured questionnaire and observation checklist were tested in three different schools before the actual study was carried out. Some changes were made to the data-collection tools as discussed under pilot study section 3.5. Content validity and face validity were used, and the data-collection instruments were precisely defined to determine how well the sample depicted the management of fluorescent lamps in public schools.

In this study, a clear explanation of the purpose of the study was provided to the respondents beforehand, and the respondents were informed that they could withdraw their consent and refuse to participate in the study at any given time. The privacy of the persons concerned and the confidentiality of their personal information were respected, in that the information obtained shall not be disclosed for purposes other than those for which it was collected. Quantitative data analysis was used to determine the management of fluorescent lamps as a hazardous waste stream in public schools, and this is discussed in detail in Chapter 4.

CHAPTER 4
DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

Chapter 3 focused on the methodology used in capturing data, including activities and procedures undertaken during the course of the study. These activities and procedures included the research approach that was adopted, study design followed, research population used, how the sample was selected, and data collection and analysis. This Chapter, however, further elaborates on data collection, analysis and interpretation regarding the management of fluorescent lamps in selected public schools within the Johannesburg Metropolitan Area. The questionnaire was used to determine the awareness levels of selected public schools regarding the hazardous nature of fluorescent lamps, and to identify if any guidelines existed, whether formal or informal, for fluorescent lamp management on handling, storage and disposal. The structured questionnaire and the observation checklist were designed to collect the following data, respectively. The questionnaire was divided into four sections, namely:

- Awareness in selected public schools regarding the hazardous nature of fluorescent lamps.
- Existence of guidelines (formal or informal) for fluorescent lamp management in selected public schools.
- Handling of fluorescent lamps in selected public schools.
- Storage and disposal of spent lamps in selected public schools.

A checklist was used during the observations to assess the levels and possible routes of exposure of employees and learners to mercury, and its impact on the environment, in selected public schools. The observation checklist was divided into four categories (refer to Appendix 2) namely:

- Storage of fluorescent lamps before and after use.
- Handling of spent lamps.
- Availability of written guidelines, whether formal or informal.
- Crushing of spent lamps if practised at source.

Data collected from the selected public schools was captured and interpreted in simple statistical analysis. This data was coded and captured on a Microsoft Excel statistical package before it was analysed. The responses were converted into percentages, and tables and figures were used to present data.

4.2 AWARENESS OF SELECTED PUBLIC SCHOOLS REGARDING THE HAZARDOUS NATURE OF FLUORESCENT LAMPS

This section analyses the awareness of selected public schools regarding the hazardous nature of fluorescent lamps.

Table 4.1 shows that 77% of the selected public schools were aware that fluorescent lamps contain mercury vapour. It also indicates that 68% of the schools were aware that fluorescent lamps should be regarded as hazardous waste because of mercury vapour. The Table also shows that 91% of the schools were aware that fluorescent lamps (mercury emissions) due to breakages in class pose a health risk to employees and learners. The schools were also aware that fluorescent lamps should be stored separately from other waste stream.

Concerning the storage of fluorescent lamps, 86% of the selected public schools were aware that fluorescent lamps should be stored separately in a dry lockable area to control unauthorised access and, preferably in a closable container and in their original packaging material to minimise lamp breakage. Only 45% of the schools were aware that these fluorescent lamps can be recycled.

Table 4.1: Awareness levels of selected public schools

Question. Are you awere that fluorescent lamps:	Response True	 False	True Response %
a) contain mercury vapour?	17	5	77
b) are regarded as hazardous waste because of mercury vapour?	15	7	68
c) release emissions due to breakages in classrooms that pose a health risk to staff and leamers.	20	2	91
d) should be stored separately from other waste stream at the school?	20	2	91
e) should be kept in a dry lockable area to control unauthorised access and to minimise lamp breakage?	19	3	86
f) can be recycled?	10	12	45

Figure 4.1 indicates the total percentage distribution regarding the awareness levels of selected public schools: 77% represents the awareness level of schools on the hazardous nature of fluorescent lamps, while 23% represents the unknown hazardous nature of fluorescent lamps.

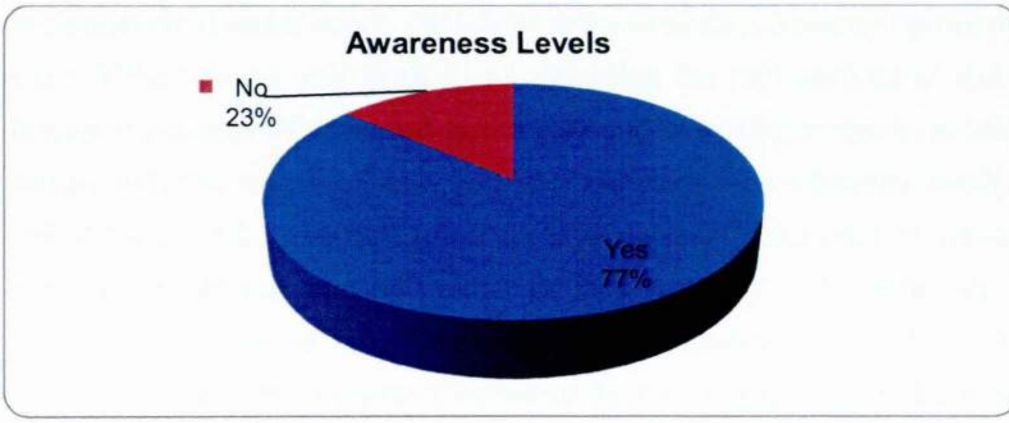

Figure 4.1 Total percentage distribution of awareness levels on hazardous nature of fluorescent lamps in selected public schools

A likert-type scale (refer to Table 3.2) was used to determine the levels of awareness in selected public schools. According to a likert-type scale it means that the awareness level of selected public schools regarding the hazardous nature of fluorescent lamps is high.

4.3 EXISTENCE OF GUIDELINES FOR FLUORESCENT LAMP MANAGEMENT

This section depicts the existence of guidelines (whether formal or informal) in selected public schools as well as the need for formal guidelines.

4.3.1 Existence of guidelines

In Table 4.2, 18% of the selected public schools had guidelines regarding storage of fluorescent lamps before use; however, all of these guidelines were informal. In contrast, another 18% of the schools were not sure of the availability of guidelines relating to storage of fluorescent lamps at schools. However, 64% of the selected schools had no guidelines at all on the storage of fluorescent lamps before use. On the guidelines regarding the replacement of spent fluorescent lamps, 14% of the schools had informal guidelines and only 9% of the schools were not sure if replacement of spent lamps guidelines were available. Seventy seven per cent (77%) had no guidelines at all regarding the replacement of spent lamps at schools. With regard to the cleaning of spillages due to broken lamps, only 9% of the schools had informal guidelines, whereas another 9% of the schools were not sure of the availability of guidelines. However, 82% of the schools had no guidelines at all relating to the cleaning of spillages in cases of lamp breakage. The existence of guidelines for fluorescent lamp management (whether formal or informal) in selected schools is indicated in Table 4.2.

Table 4.2: Existence of guidelines in selected public schools for fluorescent lamp management

Question. **Are there any guidelines, formal or informal, in terms of the following:-**	**Response**				
	Yes		**No**	**Not Sure**	**Total No. of schools**
	Formal	**Informal**			
a) storage before use?		4	14	4	22
b) replacement of spent lamps?		3	17	2	22
c) cleaning of spillages (broken lamps)?		2	18	2	22
d) storage after use?		2	18	2	22
e) disposal?		3	17	2	22

Concerning storage of fluorescent lamps after usage, 9% of the schools had informal guidelines and another 9% were not sure of the availability of guidelines. On the other hand, 82% of the schools had no guidelines, whether formal or informal, pertaining to the storage of fluorescent lamps after use. Regarding the disposal of spent lamps, 14% of the schools had informal guidelines, 77% of the schools had no guidelines at all relating to disposal of spent lamps and 9% of the schools were not sure if guidelines for disposal of spent lamps were available at school.

Table 4.3 shows the total average distribution of responses regarding the availability of guidelines from storage before use to final disposal of fluorescent lamps in selected public schools. On average only three schools had informal guidelines, while 17 schools had no guidelines at all, and two schools were not sure of the availability of guidelines for fluorescent lamp management.

Table 4.3: Total average distribution of responses indicating the existence of guidelines

Response	Yes (informal)	No	Not Sure
Total number of responses	3	17	2

As shown in Table 4.3 as well as Figure 4.2, a total of 3 responses indicated the availability of informal guidelines, which represents only 14% of the selected public schools. A total of 17 responses (77%) indicated that guidelines regarding the management of fluorescent lamps at schools were not available at all, whereas there were 2 responses (9%) indicating that they were not aware whether there were guidelines on the management of fluorescent lamps at public schools. Table 4.3 also indicates that the existing guidelines are all informal.

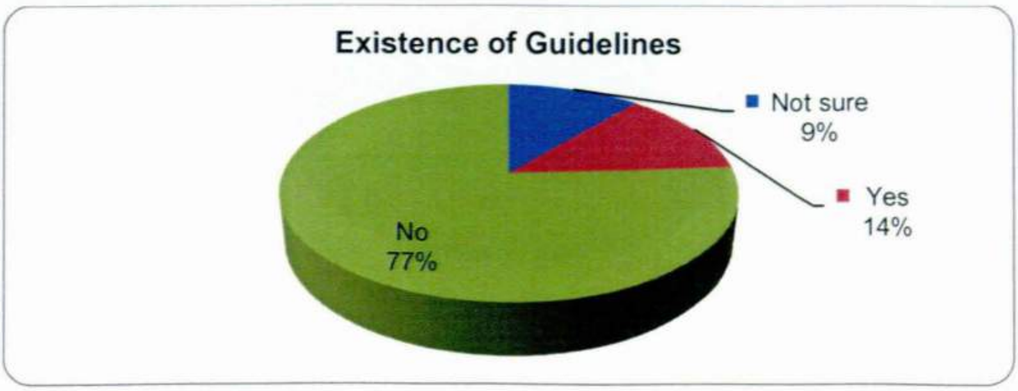

Figure 4.2: Percentage distribution of the existence of guidelines

4.3.2 The need of formal guidelines

The need of formal guidelines in selected schools is indicated in Table 4.4 and in Figure 4.3 respectively. Table 4.4 shows the total responses of public schools pertaining to the need of formal guidelines. Nineteen (19) of the selected public schools expressed a need for formal guidelines, while the other three felt that there was no need for formal guidelines.

Table 4.4: Indication of the need for formal guidelines

Question	Selected Public schools	
	Yes	No
Is there a need for Formal guidelines?	19	3

The percentage distribution on the need for formal guidelines is given in Figure 4.3: 86% of the selected public schools indicated a need for formal guidelines while 14% did not think that there was a need.

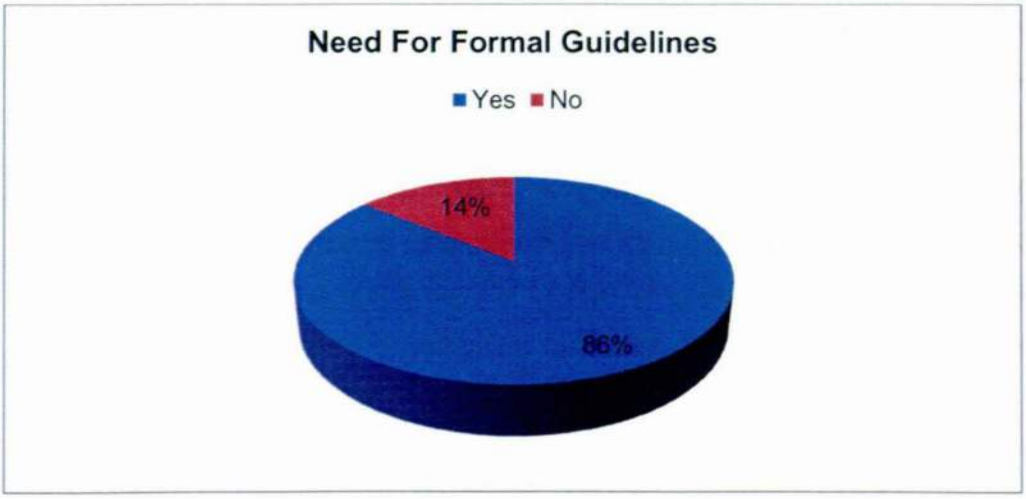

Figure 4.3: Percentage distribution on the need of formal guidelines in selected public schools

4.4 HANDLING OF FLUORESCENT LAMPS

The information in table 4.5 shows that 95% of the schools stored the fluorescent lamps in the storeroom. The remaining 5% of the schools kept fluorescent lamps before use in the maintenance department located elsewhere outside of the school premises.

Table 4.5: Storage of fluorescent lamps before use

Question	**Response**	**Number of Schools**	**Percentage**
Where do you store fluorescent lamps before use?	Storeroom	21	95
	Office	0	0
	Other	1	5
Total		**22**	**100**

Figure 4.4 indicates that 86% of the schools had access control to the storerooms and 14% did not have access control to the storerooms. The school rules or policies were the control measures available in schools. These control measures specified employees responsible for keeping the keys, persons with access, and stipulated that the storeroom should be locked at all times. The principal and the janitors had greater access to the storeroom than any other employees; however, this varied from school to school.

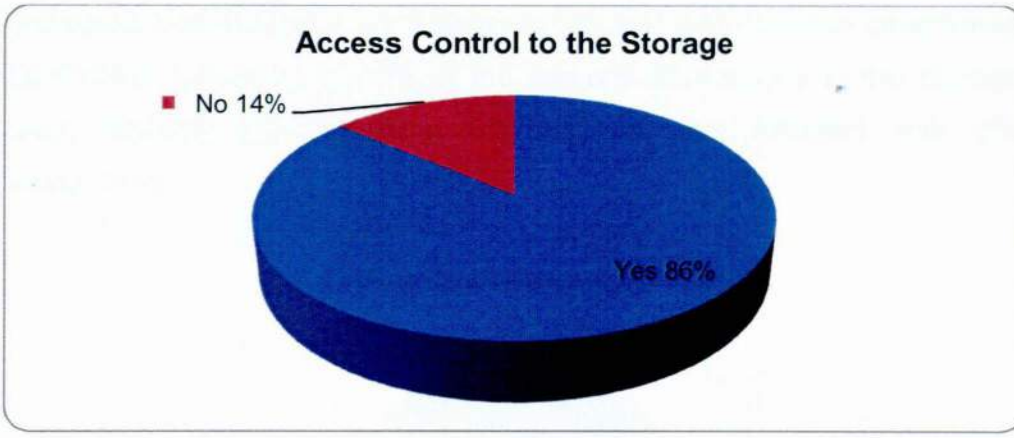

Figure 4.4: Percentage distribution of access control to the storeroom where fluorescent lamps are kept

Figure 4.5 illustrates that janitors are the persons who mostly have access to the storage area. This was the case in 16 schools, then principals in 13 schools, followed by other (administration and maintenance department staff) having access to the storage area in five schools. Security and teachers were three and two respectively, while no learners had access to the storerooms.

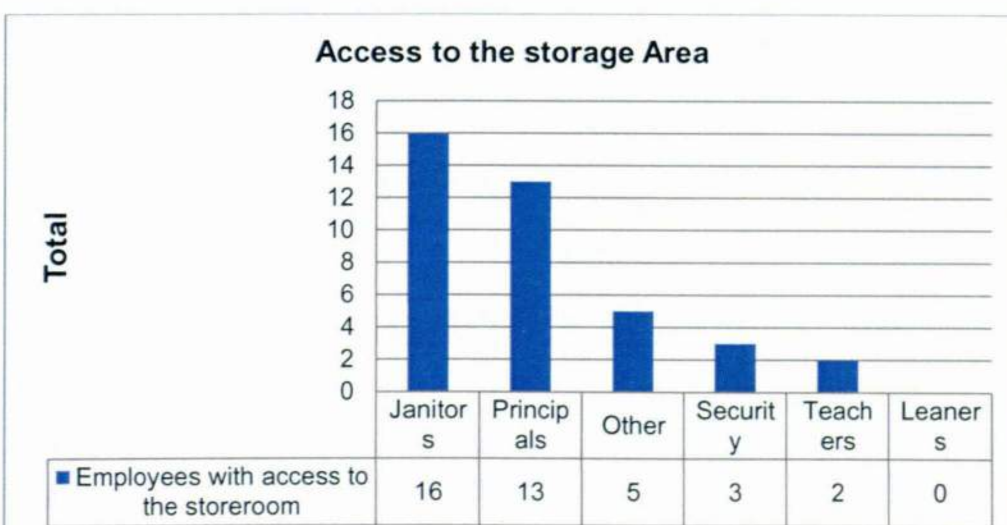

Figure 4.5: Access control distribution of respondents to the storage area

The information in Figure 4.6 shows that janitors constitute 41% of the persons with access to the storage area, whereas 33% comprise principals, followed by other administration and maintenance department staff which makes up to 13% of the persons with access to the storage area. Security 8%, teachers 5% and learners followed with 0% respectively.

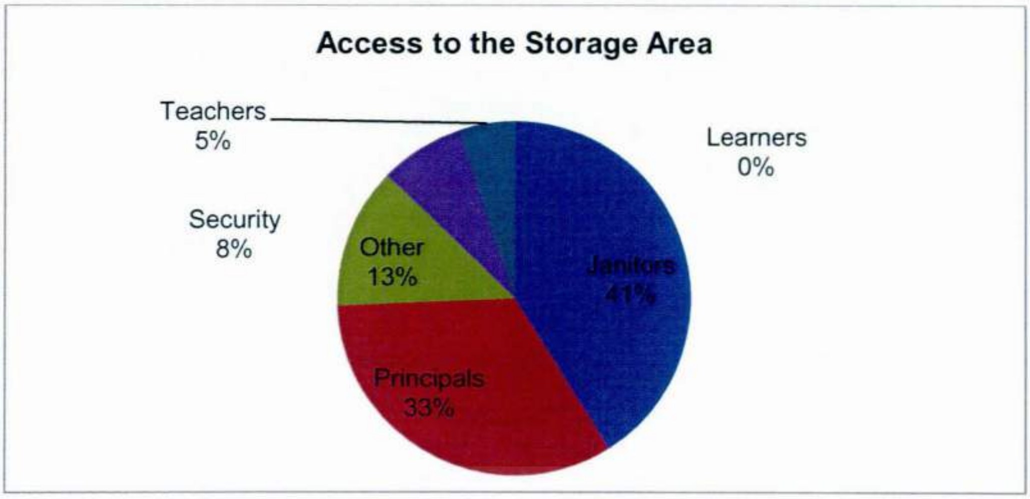

Figure 4.6: Percentage distribution of persons with access to the storage area

Table 4.6 indicates that 100% of the selected public schools kept their fluorescent lamps in their packaging material before use.

Table 4.6: Packaging material

Question	**Response**	**Number of Schools**	**Percentage**
How are fluorescent lamps stored before use?	With packaging material	22	100
	Without packaging material	0	0
Total		**22**	**100**

Figure 4.8 illustrates that 77% of the schools replaced their spent lamps after classes. However, 14% of the schools replaced during class periods, whereas 9% were replaced during break time.

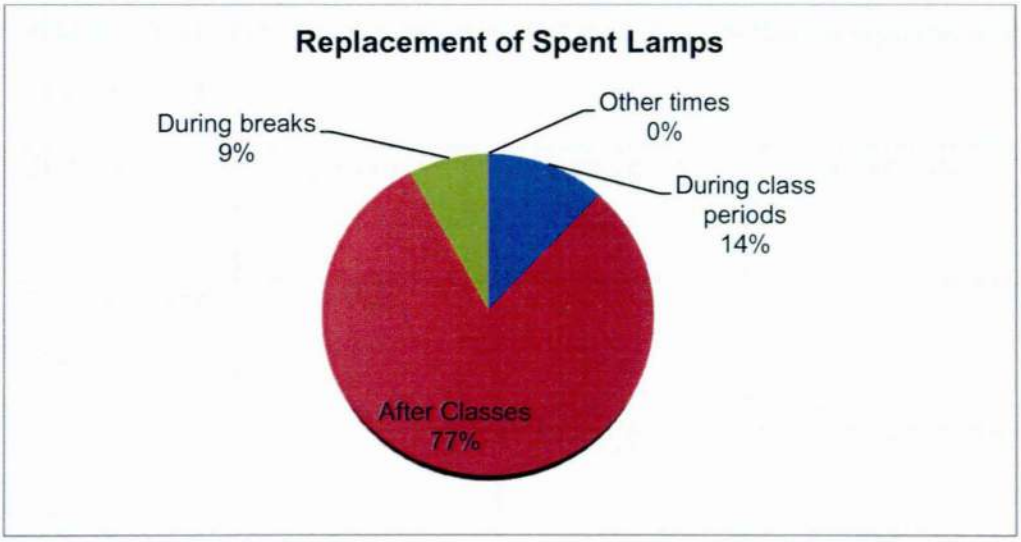

Figure 4.7: Percentage distribution on replacement of spent lamps

Table 4.7 shows that 82% of the persons responsible for replacing spent lamps were the janitors. These were followed by maintenance department with (14%) and security personnel with the remaining 4%.

Table 4.7: Persons responsible for replacing spent lamps in selected public schools

Question	Response	Number of Schools	Percentage
Who replaces spent lamps in selected public schools?	Janitors	18	82
	Security	1	4
	Maintenance department	3	14
Total		**22**	**100**

The information in Table 4.8 shows that 27% of the schools replaced the spent lamps in the presence of learners and staff, whereas 73% replaced spent lamps in the absence of learners and staff.

Table 4.8 Availability of learners and staff in classroom during replacement of spent lamps

Question	Response	Number of Schools	Percentage
If replacement occurs during class periods do learners or staff remains in class?	Yes	6	27
	No	16	73
Total		**22**	**100**

Figure 4.8 indicates that only 50% of the persons responsible for cleaning spillages in the event that lamps break use protective clothing, e.g. gloves and masks.

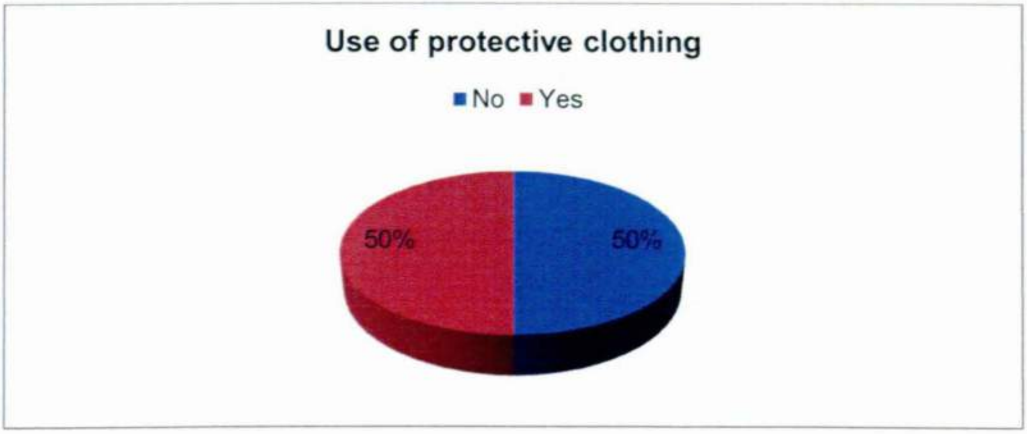

Figure 4.8: Percentage distribution on the use of protective clothing in selected public schools

Figure 4.9 indicates that 79% of the persons responsible for cleaning spillages of lamps due to breakages in schools were the janitors. Other responsible persons, who constitute 13%, were from the maintenance department. Security staffs, which are also responsible for cleaning spillages in some schools, constitute 8% of the total percentage of persons responsible for cleaning.

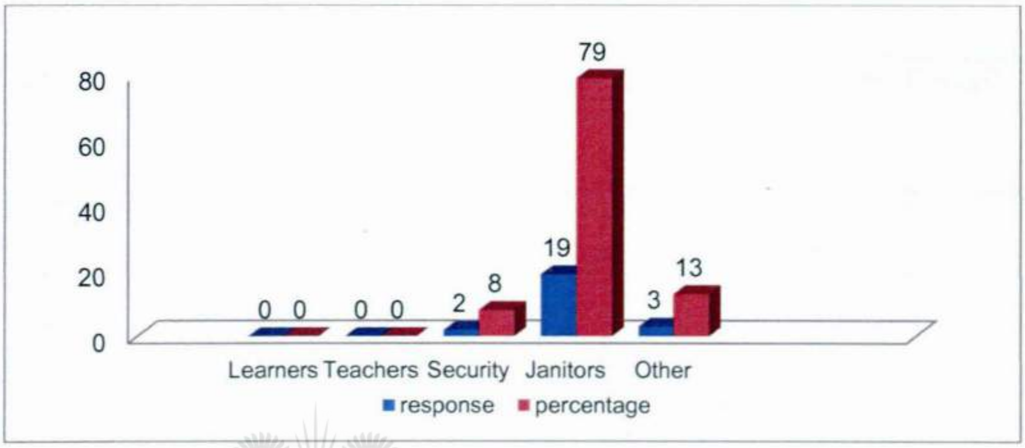

Figure 4.9: Persons responsible for cleaning spillages in selected public schools

The information in Figure 4.10 illustrates that 56% of the schools sweep and collect after lamp breakages or spillages in class, while 35% of the schools sweep collect and wash the affected areas and 9% use vacuum cleaners.

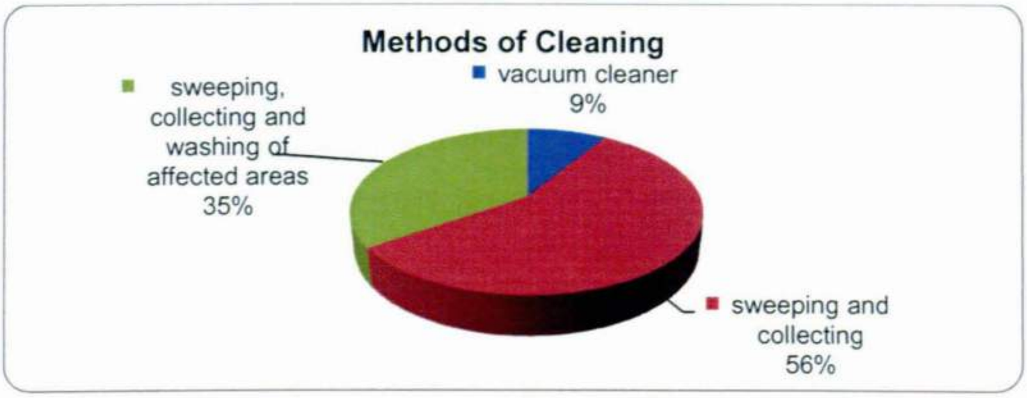

Figure 4.10: Cleaning methods used after breakage/spillage in selected public schools

4.5 STORAGE AND DISPOSAL OF SPENT LAMPS

Table 4.9 points out that 50% of the schools separated spent lamps from other solid waste stream during storage, whereas the other 50% did not separate spent lamps from other solid waste stream during storage.

Table 4.9: Separation of spent lamps during storage in selected public schools

Question	Response	Number of Schools	Percentage
Do you store spent lamps separate from other solid waste?	Yes	11	50
	No	11	50
Total		**22**	**100**

Figure 4.11 depicts that 59% of spent lamps was stored for collection by refuse collectors to be disposed of in general landfill sites. Twenty-seven per cent (27%) of schools crushed their lamps at source before collection for disposal. This crushing happened mostly in bulk containers of $6m^3$. Fourteen per cent (14%) of the schools dumped spent lamps in open spaces, and some buried them in sand within the school grounds. None of these spent lamps were recycled, as indicated in the figure below.

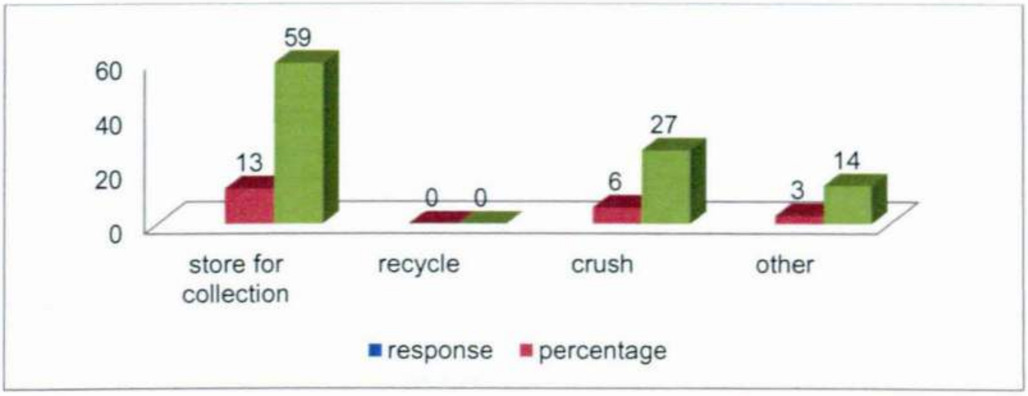

Figure 4.11: Handling of spent lamps in selected public schools

The information in Table 4.10 shows that 55% of the schools stored their spent lamps in wheelie bins before collection for final disposal, while 14% of the schools also used galvanised metal bins. However, 27% of the schools also used bulk storage containers. It is in these bulk storage containers that crushing was practised. Four per cent (4%) of the schools used other means for the storage of spent lamps before they are disposed of. Rubber bins and refuse bags were not used in any of the selected public schools.

Table 4.10: Receptacles used for disposing of spent lamps in selected public schools

Question	Response	Number of Schools	Percentage
What kind of receptacles do you use for disposing of spent lamps?	Wheelie bins (210ltrs)	12	55
	Galvanised bins (85ltrs)	3	14
	Rubber bins (75ltrs)	0	0
	Refuse bags	0	0
	Bulk storage ($6m^3$)	6	27
	Other (bury)	1	4
Total		**22**	**100**

Table 4.11 shows that 32% of the schools indicated that their spent lamps were collected on a weekly basis, while 23% said their lamps were collected monthly and another 23% indicated that their lamps were

collected every three months. Four per cent (4%) of the schools have their lamps collected after six months and about 18% were not sure about the frequency of spent lamp collection from their school.

Table 4.11: Collection frequency of spent lamps in selected public schools

Question	Response	Number of Schools	Percentage
How often are spent lamps collected for disposal?	Weekly	7	32
	Monthly	5	23
	Three monthly	5	23
	Six monthly	1	4
	Other (not sure)	4	18
Total		**22**	**100**

The information in Table 4.12 shows that there were no recycling companies that were recycling spent lamps in any of the selected public schools.

Table 4.12: Availability of recycling companies in selected public schools

Question	Response	Number of Schools	Percentage
Are there any companies that are already recycling your spent lamps?	Yes	0	0
	No	22	100
Total		**22**	**100**

Table 4.13 depicts that 77% of spent lamps was collected together with other solid waste stream for final disposal. This indicates that spent lamps became commingled with other solid waste during collection and are disposed of in general landfill site. However, 23% of the schools said that their spent lamps were collected separately from other waste stream; some of these schools were the ones that ended up burying, dumping spent lamps in open spaces, or leaving them lying in storerooms. There were variations in the way selected public schools managed their fluorescent lamps from handling, storage to final disposal of the spent lamps.

Table 4.13: Collection of spent lamps in selected public schools

Question	Response	Number of Schools	Percentage
How are spent lamps collected?	Together with other solid waste stream	17	77
	Separate from other solid waste stream	5	23
Total		**22**	**100**

4.6 OBSERVATIONS ON FLUORESCENT LAMP MANAGEMENT

This section observes the practises on storage of fluorescent lamps before use, handling of spent lamps and crushing of spent lamps observed during the school visits. Observations were done to substantiate data collected through the use of a structured questionnaire and significant variations were noted.

4.6.1 Storage of fluorescent lamps before use

Figure 4.12 illustrates that 91% of the selected public schools stored fluorescent lamps in the storeroom before use together with other goods such as stationary, teaching material and equipment. However, 9% stored their lamps in the workshop or maintenance department outside of the school premises.

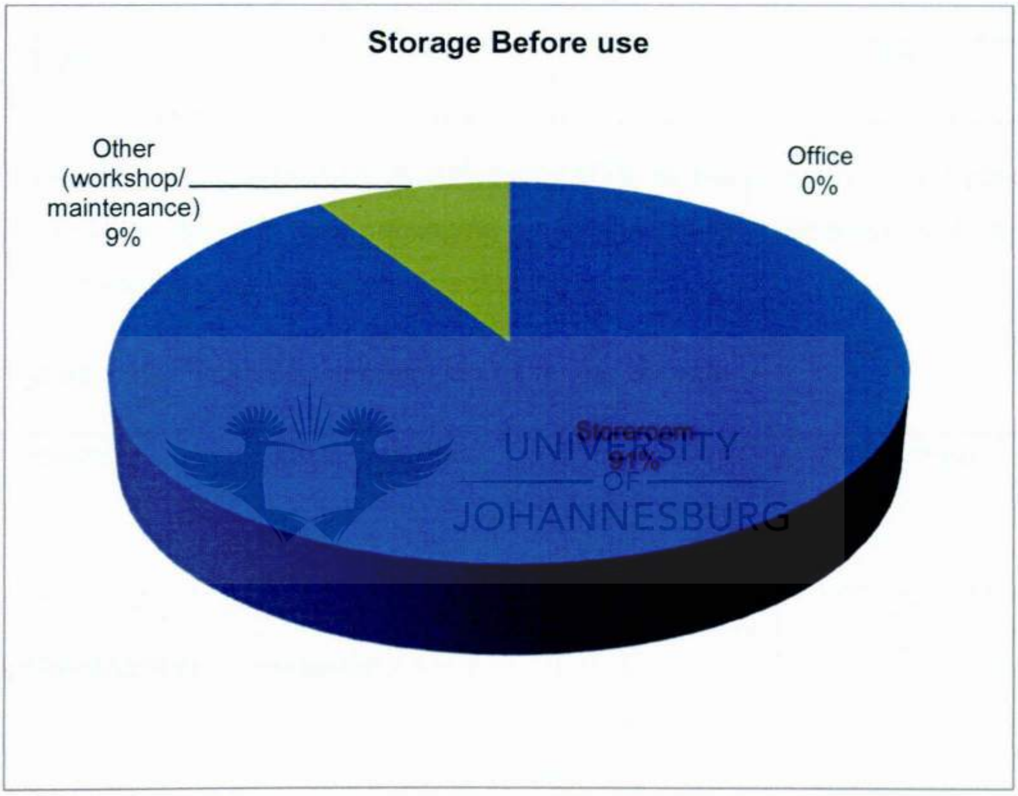

Figure 4.12: Storage before use

Table 4.14 indicates that 86% of the selected public schools observed had access control to their storerooms and 14% did not have access control to their storerooms where they stored their lamps before use. The school rules or policies were the control measures available in schools. These control measures specified employees responsible for keeping the keys, persons with access, and stipulated that the storeroom should be locked at all times.

Table 4.14: Access control in the storage area

Enquiry	Observation	Number of Schools	Percentage
Access control in the storage area.	Yes	19	86
	No	3	14
Total		**22**	**100**

In Table 4.15 observation revealed that 91% of the schools stored their lamps before use in their packaging material and 9% of the schools stored their lamps before use without packaging material.

Table 4.15: Packaging of spent lamps during storage

Enquiry	Observation	Number of Schools	Percentage
Packaging of spent lamps	With packaging material	20	91
	Without packaging material	2	9
Total		**22**	**100**

Table 4.16 shows that 18% of the schools separated their spent lamps from other waste during storage. However, it was observed that 82% of the schools did not separate their spent lamps during storage.

Table 4.16: Separation of spent lamps from other waste

Enquiry	Observation	Number of Schools	Percentage
Separation of spent lamps	Yes	4	18
	No	18	82
Total		**22**	**100**

Figure 4.13 illustrates the mixture of spent lamps with other solid waste. The picture below shows some broken spent lamps being kept together with other general waste stream in a wheelie bin.

Figure 4.13: Mixture of spent lamps with other solid waste

4.6.2 Handling of spent lamps

As Table 4.17 indicates, observation revealed that 64% of the schools stored their spent lamps for collection, while 27% of the schools crushed their lamps in bulk storage containers before it was collected for disposal.

Table 4.17: Handling of spent lamps

Enquiry	Observation	Number of Schools	Percentage
Handling of spent lamps	Store for collection	14	64
	Recycle	0	0
	Crush	6	27
	Other	2	9
Total		**22**	**100**

Figure 4.14 shows crushed spent lamps stored in bulk containers at school before being collected for final disposal.

Figure 4.14: Crushed spent lamps mixed with other solid waste in a $6m^3$ container

The other 9% of the schools dumped spent lamps in open spaces within the school grounds or buried them in the ground. See Figure 4.15 for an illustration of open-space dumping.

Figure 4.15: Dumping of spent lamps in open spaces within the school grounds

The information in table 4.18 indicates that 64% of the schools stored their spent lamps in wheelie bins. It was also observed that 27% of the schools stored their spent lamps in bulk containers before collection. The remaining 9% of the schools stored their spent lamps in the storeroom without packaging material before they were disposed of.

Table 4.18: Receptacles used for storage of spent lamps

Enquiry	Observation	Number of Schools	Percentage
Receptacles used for storage	Wheelie bins (210ltrs)	14	64
	Galvanised bins (85ltrs)	0	0
	Rubber bins (75ltrs)	0	0
	Refuse bags	0	0
	Bulk storage (6m3)	6	27
	Other	2	9
Total		**22**	**100**

Figure 4.16 shows some of the spent lamps being kept on the floor in the storeroom without packaging material before being disposed of.

Figure 4.16: Spent lamps being kept in storeroom without packaging material

4.6.3 Availability of written guidelines

Table 4.19 shows that none of the schools had written (formal) guidelines as far as the management of fluorescent lamps was concerned.

Table 4.19: Existence of written Guidelines

Enquiry	**Observation**	**Number of Schools**	**Percentage**
Existence of written guidelines	Yes	0	0
	No	22	100
Total		**22**	**100**

4.6.4 Crushing of spent lamps

Out of the 22 public schools selected for this study, six practised the crushing of spent lamps, which means 27% of the selected public schools crushed their spent lamps in bulk containers, which were not sealed. This is depicted in Table 4.20.

Table 4.20: Crushing area

Enquiry	**Observation**	**Number of Schools**	**Percentage**
Crushing area	In sealed containers	0	0
	In unsealed containers	6	100
Total		**6**	**100**

A metal, liquid-filled lensatic compass was used to detect direction during observations in crushing areas. Six of the selected public schools practised the crushing of spent lamps. In three of these schools the wind was blowing towards the playing grounds, in two schools it was blowing towards houses and in one school it was blowing towards the offices. This is illustrated by Table 21 and Figure 18 respectively.

Table 4.21: Wind direction

Enquiry	**Observation**	**Number of Schools**
Wind direction	Towards the classroom	0
	Surrounding parks	0
	Playing grounds	3
	Offices	1
	Houses	2
	Other	0
Total		**6**

Figure 4.17 shows the south-easterly winds blowing towards the playing grounds from the crushing area. Wind play a great role in dispersing mercury vapour from crushing points to the environment thereby contaminating the atmosphere and the ground.

Figure 4.17: Illustration of wind direction from the crushing area

Table 4.22 indicates that in all six schools that practiced crushing there was a possible impact of mercury on the surrounding environment. Considering that wind was blowing towards the school playing grounds, the nearby houses and the school offices. Air, land and underground water was at risk of being polluted as a result of improper crushing of spent lamps in public schools.

Table 4.22: Possible impact of mercury on the surrounding environment

Enquiry	**Observation**	**Number of Schools**	**Percentage**
Possible impact of mercury on the surrounding environment	Yes	6	100
	No	0	0
Total		**6**	**100**

Figure 4.18 illustrates the wind direction from the open spaces within the school grounds where crushing of spent lamps took place. The wind is blowing towards the nearby informal settlements along the school security fence (a distance of about 15m separates the crushing area from the informal settlements).

Figure 4.18: Shacks built along the school security fence in the direction of wind.

4.7 CONCLUSION

This Chapter focused on how data was collected, analysed and interpreted. Through the use of a structured questionnaire and the observation checklist, data collected during the study revealed that awareness of selected public schools as to the hazardous nature of fluorescent lamps was high. The study also showed that the available guidelines were all informal; however, 86% of the selected schools expressed a need for formal guidelines. Handling before use, storage and disposal of spent lamps in the schools varied significantly from school to school regardless of whether it is a primary or a secondary school. There were no recycling companies collecting spent lamps in any of the schools, and as a result some schools have resorted to crushing spent lamps in bulk storage containers before they are disposed of. Data collected during interviews and observation showed that although the selected schools knew about the hazardous nature of fluorescent lamps, these lamps were not treated accordingly to minimise the exposure of employees, learners and the environment from mercury vapour. Further discussion on the results of the study is undertaken in Chapter 5.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 INTRODUCTION

Chapter 4 explained how data on the management of fluorescent lamps as a hazardous waste stream in selected public schools within the Johannesburg Metropolitan Area was collected, analysed and interpreted. In this Chapter, the goal and objectives of the study are discussed in relation to the empirical findings, and conclusions are drawn from the facts deduced during data analysis. The results of this study are discussed in the following sections:

- Awareness in selected public schools regarding the hazardous nature of fluorescent lamps;
- Existence of guidelines (formal or informal) for fluorescent lamps management in selected public schools;
- Handling of fluorescent lamps in selected public schools;
- Storage and disposal of spent lamps in selected public schools;

5.2 AWARENESS IN SELECTED PUBLIC SCHOOLS REGARDING THE HAZARDOUS NATURE OF FLUORESCENT LAMPS

The findings revealed that 77% of the schools were aware that fluorescent lamps contain mercury vapour. However, only 68% knew that spent lamps are regarded as hazardous waste because of this vapour. This means that 32% of the schools were not aware that spent lamps must be regarded as hazardous waste because of mercury vapour. As a consequence, 32% of the schools were likely, due to a lack of knowledge, to be exposed to mercury vapour in cases where fluorescent lamps break in the presence of employees and learners. Therefore, it is important that public schools be educated about the health risks posed specifically by mercury, as it is a deleterious substance that is of concern in the management of fluorescent lamps. According to Hex *et al.* (2009) it is the duty of the municipalities to educate and create awareness among the public regarding the need for waste separation specifically the need for separating CFL's and other hazardous waste at sources of generation.

Eighty-six per cent (86%) of the schools were aware that fluorescent lamps should be kept in a dry lockable area in order to control unauthorised access and to minimise lamp breakage. This referred specifically to the storage of fluorescent lamps before use – and in this respect there was no access control in 14% of the schools. This means that there is a chance that some employees and learners, in 14% of the schools, would be exposed to mercury vapour – i.e. if fluorescent lamp(s) break in the storeroom.

A significant number (91%) of the schools were aware that fluorescent lamp emissions due to breakages in classrooms pose a health risk to employees and learners. However, this was not enough, as 32% of the schools were not aware that fluorescent lamps were regarded as hazardous waste because of mercury vapour. It was noticed during observation that (of the 91%) most of the schools were more concerned about broken glass as a health hazard to learners, as learners could get injuries if they played with broken fluorescent lamps, than it was with inhaling mercury vapour or getting into contact with mercury. If public schools could be educated about mercury vapour, susceptible populations, routes of exposure and the health effects of mercury in both humans and environment, this would encourage public schools to practise the proper management of fluorescent lamps at school level responsibly, and thereby prevent the exposure of employees, learners and the environment as far as is reasonably practicable.

It was noted that 91% of the schools were aware that spent lamps should be stored separately from other waste, yet only 18% (during observation) were found to be separating spent lamps from other waste. This means that even if the schools were aware of separating spent lamps from other waste, before disposal, certainly they were not aware of either its significance or how spent lamps should be disposed of. This was evidenced by the fact that only 45% of the schools were aware that spent lamps can be recycled. Yet even among those that were aware, none of the schools practised recycling or safe disposal of spent lamps. According to Hex *et al.* (2009) waste separation is an important step in the government drive for waste minimisation and the key to achieving the waste hierarchy: Reduce, Re-use and Recycle.

Therefore, the total average percentage of awareness at the schools as to the hazardous nature of fluorescent lamps was 77% (high), while 23% were not aware of this. The Likert-type scale in Table 5.1 shows that the level of awareness at schools regarding the hazardous nature of fluorescent lamps was high.

Table 5.1 Level of awareness at schools

Levels of Awareness	**Percentage (%)**
Very High	80 – 100
High	65 – 79
Moderate	50 – 64
Low	30 – 49
Very Low	1 – 29

5.3 EXISTENCE OF AND THE NEED FOR FORMAL GUIDELINES

The insights gained during data analysis were that only 18% of the schools had guidelines on the storage of fluorescent lamps before use; however, all of these guidelines were informal. On the other hand, 18% of the schools were not sure about the availability of guidelines relating to the storage of fluorescent lamps at school. In 64% of the schools guidelines on the storage of fluorescent lamps before use at school, whether formal or informal, were not available at all. This further emphasises the point that schools did not regard the management of fluorescent lamps as important, and the improper management thereof could pose health threats to humans and the environment.

As regards guidelines on the replacement of spent lamps, 14% of the schools had informal guidelines, while 9% of the schools were not sure about the availability of such guidelines. In 77% of the schools there were no guidelines available at all regarding the replacement of spent lamps. The absence of formal guidelines for the replacement of spent lamps meant that each school replaced spent lamps differently (in terms of how and when spent lamps were replaced). According to the guidelines in the Southern African Power Pool (SAPP, 2010) care should be taken when a bulb is removed from its packaging, and when it is installed and/or replaced. These guidelines also state that the lamp would always be screwed or unscrewed by its base (not the glass) and the CFL should never be pushed into a light socket with force.

With regard to cleaning of spillages from broken lamps, only 9% of the schools had informal guidelines, whereas another 9% of the schools were not sure as to the availability of such guidelines. This meant that in 82% of the schools, guidelines relating to cleaning of spillages were not available at all. As a result, schools varied greatly in the way how the cleaning of spillages was done, and this included vacuum cleaning, sweeping and collecting, to sweeping, collecting and washing of affected areas. In cases where lamp(s) break, the following precautions should be taken, according to SAPP (2010) guidelines:

- Open a window and leave the room for 15 or more minutes.
- Use a wet rag to clean it up and put all the pieces and the rag into a plastic bag.
- Place all material in a second sealed plastic bag and send it to modem municipal landfill as hazardous waste.

- Spent lamps should not be sent to an incinerator, which would disperse the mercury into the atmosphere.
- Spent CFL's should be collected and be sent to facilities capable of treating, recovering or recycling them.
- Carefully scoop up glass fragments and powder using stiff paper or cardboard and place them in a glass jar with metal lid (such as canning jar) or in sealed plastic bag.
- Use sticky tape, such as duct tape; to pick up any remaining small glass fragments and powder.
- Wipe the area clean with damp paper towels or disposable wet wipes and place them in a plastic bag.
- Do not use a vacuum or broom to clean up broken bulbs on hard surfaces.
- If clothing materials come into direct contact with broken glass or mercury-containing powder from inside the bulb that may stick to the fabric, the clothing should be discarded.
- Do not wash such clothing because mercury fragments in the clothing may contaminate the machine or pollute the sewage.

Concerning the storage of spent lamps, 9% of the schools had informal guidelines, while another 9% of the schools were not sure of the availability of guidelines. In 82% of the schools no guidelines, whether formal or informal, were available pertaining to the storage of fluorescent lamps after use. According to the CFL Recovery, Recycling and Disposal Implementation Guidelines (Hex *et al.*, 2009) CFL's are not supposed to be thrown away with domestic (general) waste; instead they should be kept separate until they are safely taken to drop-off/collection points. Hex *et al.* (2009) advise that spent CFL's should be taken to the nearest participating retailer. At present, Woolworths and Pick 'n Pay stores offer

CFL collection points. It is further stated that spent CFL's should ideally arrive at a drop-off point unbroken.

As for the disposal of spent lamps, in 14% of the schools only informal guidelines were available, in 77% of the schools no guidelines were available at all, and 9% of the schools were not sure of the availability of such guidelines. This indicates that most of the spent lamps were disposed of with general waste; as a result, spent lamps end up in general landfill sites. General landfill sites are not designed to accommodate the release of mercury (SAPP, 2010). Mercury needs to be treated (encapsulated in concrete or similar) to prevent leaching and release into the environment. Spent CFL's should be disposed at licensed hazardous landfill sites, and containers in which CFL's are treated and transported to the landfill site may not be opened and should be labelled according to their contents (SAPP, 2010).

Observation showed that there were no formal guidelines available in any of the schools across all stages of fluorescent lamp management. The existing informal guidelines were not written down anywhere and each school managed spent lamps differently. As discussed in Chapter 4 (refer to section 4.4), this is evidenced by variations in per centages showing the inconsistency in the way public schools handled fluorescent lamps. The informal guidelines that existed were incomplete in each school. This means that a particular school will have informal guidelines on the storage of fluorescent lamps before use and will have no other guidelines for replacement of spent lamps, cleaning of spillages, storage of spent lamps and disposal thereof. In this regard, the available informal guidelines did not address all the stages in the management of fluorescent lamps from storage before use up to final disposal.

Eighty-six per cent (86%) of the schools indicated the need for formal guidelines, while 14% did not feel that there was a need for formal guidelines. Hex *et al.* (2009) indicate that the need for an environmentally acceptable, yet cost-effective, spent lamp management programme has become one of the environmental priorities in South Africa. They further state that this includes steps and activities for the safe management of fluorescent lamp waste, from separation at source to ultimate disposal at a hazardous landfill site or to a recycling facility. As a result an overview of the best practice to ensure compliance with relevant legislative requirements for the responsible handling of spent lamps has been initiated (Hex *et al.*, 2009). This initiative demonstrates the need for formal guidelines, which can commit public schools to be accountable and responsible for the proper management of fluorescent lamps at source. Without formal guidelines for fluorescent lamp management at public schools, exposure of employees, learners and the environment to mercury will remain inevitable.

5.4 HANDLING OF FLUORESCENT LAMPS

It was revealed during interviews that 95% of the schools stored fluorescent lamps before use in the storeroom. However, during observations, only 91% stored fluorescent lamps before use in the storeroom. This discrepancy was caused by the fact that 9% of the schools used workshops or maintenance departments as the storage area for fluorescent lamps before use, some of which were located off the school premises. For example, the maintenance department would come with new fluorescent lamps and replace spent lamps as per request by the school. Nevertheless, 86% of the schools must be commended for having access control to the storerooms, and thereby minimising the chances of lamp breakages during storage. However, the use of a storeroom for keeping fluorescent lamps in schools seemed to be widely practised for security reasons (to prevent theft, in other words), rather than for the health safety of employees and learners. Hence, health education of public schools is necessary to create awareness about the hazardous nature of fluorescent lamps in case fluorescent lamps break during storage.

All (100%) of the schools stored fluorescent lamps before use with packaging material; observation showed that only 91% of the schools stored fluorescent lamps with packaging material before use. This means that in the 9% of schools that stored fluorescent lamps without packaging material, lamps were more likely to break during storage than in schools that stored fluorescent lamps with packaging material. As a consequence, the employees (janitors, principals and others) who have access to the storeroom (refer to Figure 4.7) in schools that stored fluorescent lamps without packaging material were more likely to be exposed to mercury vapour than in schools that stored fluorescent lamps with packaging material before use. It was also noticed that the persons who are most likely to be exposed to mercury vapour in the event of fluorescent lamp breakage during storage were the janitors and principals because they had more access to the storeroom than any other employees in the schools.

The results showed that 77% of the schools replaced spent lamps after class periods. However, 14% of the schools replaced spent lamps during class periods, while 9% of the schools replaced them during breaks. It was also revealed that 27% of the schools replaced spent lamps in the presence of learners and employees, whereas 73% of the schools replaced spent lamps in the absence of learners and employees. This means that in 27% of the schools there were chances of employees and learners being exposed to mercury vapour in cases where a fluorescent lamp breaks during replacement. Having noticed that 91% of the schools, as indicated in section 4.2 in Chapter 4, were aware that fluorescent lamp emissions due to breakages in classroom pose a health risk to employees and learners, it is therefore a cause for concern that 27% of the schools still replaced spent lamps in the presence of learners and employees. The janitors constituted 82% of the persons responsible for the replacement of spent lamps and were once again likely to be exposed to mercury vapour during replacement of spent lamps. This further indicates that there is a need for formal guidelines that will commit public schools to replace spent lamps in a manner that will minimise, as far as is reasonable possible, the exposure of employees and learners to mercury vapour.

Of the persons responsible for cleaning spillages due to lamp breakages in schools, only 50% used protective clothing. Janitors constituted 79% of the persons responsible for cleaning; however, they had inadequate protective clothing i.e. face masks and gloves. These are very important to avoid inhalation of mercury vapour during cleaning and being in direct contact with mercury. Data analysis showed that schools varied in the cleaning of breakages or spillages of fluorescent lamps: 56% of the schools swept and collected; on the other hand, 35% of the schools swept, collected, and washed the affected areas and only 9% used a vacuum cleaner for cleaning spillages. Great care should be taken when cleaning mercury spillages: using vacuum cleaners or brooms to clean up broken lamps on hard surfaces is strongly discouraged, as it can blow mercury into the air, exposing the persons responsible for cleaning to mercury vapour inhalation or being in contact with mercury (SAPP, 2010).

5.5 STORAGE AND DISPOSAL OF SPENT LAMPS

Fifty per cent (50%) of the schools did not separate their spent lamps from other waste. It was noted during observation that only 18% of the schools separated spent lamps from other waste, and 82% did not do so. It was also learnt that, in 82% of the schools, spent lamps were broken during storage in bulk storage containers (e.g. $6m^3$) as well as in wheelie bins (210ltrs). This was practised to avoid children from salvaging spent fluorescent lamp tubes, and also to ensure that spent lamps fitted into the wheelie bins. It was observed that none of the schools labelled the receptacles used (during storage) to indicate the contents, the hazardous nature thereof and the date from which it was stored for disposal, as required by the Minimum Requirement for Handling, Classification and Disposal of Hazardous Waste (South Africa, 1998a:10-3). As a result, breakages of spent lamps during storage would mean that most of the mercury vapour would escape into the environment at this stage, while the remaining mercury would find its way into a general landfill site together with commingled waste.

The results of the interviews indicated that 59% of the schools stored spent lamps for collection, while 27% of the schools crushed spent lamps at source before these were collected for disposal. However, during observations, it was noted that 64% of the schools stored spent lamps for collection and 27% of schools crushed spent lamps at source before collection. The remaining 9% of the schools dumped spent lamps within the school grounds, buried spent lamps, and also burnt spent lamps together with other solid waste in open spaces (refer to Figure 4.19). This practice, though done by few schools, poses threats to public health and the environment. Dumped and buried spent lamps are most likely to release mercury into the ground and thereby contaminate underground water sources, while burning spent lamps will result in air pollution.

The crushing of spent lamps, which was the practice in 27% of the schools, took place in bulk storage open containers. These open containers are placed where the refuse collectors have easy access to the container and minimal consideration is given to human and environmental health impact. During crushing, learners, the nearby residents, and employees might be exposed to mercury vapour, which is most likely to be blown towards the playing grounds, houses, and offices respectively, as shown in Table 4.21.

None of the spent lamps were recycled at any of the schools. Lombard and Webb (2008) states that recycling is the best environmental alternative, as, nationwide, millions of mercury-containing lamps are discarded each year, and most of these are discarded with municipal waste. As a result all mercury-containing lamps will release mercury into the environment through breakage or leakage outside a controlled crushing and recycling process (Lombard and Webb, 2008). Recycling also reduces the volume of landfills, since all the components of fluorescent lamps can be recovered and recycled, thus avoiding the wastage of valuable resources. The recycling of spent lamps will therefore significantly reduce the amount of mercury being disposed of in general landfill sites and that is lost into the environment. According to Reclite (2008) Pick n' Pay and Woolworth stores are already collecting spent lamps for safe disposal. Therefore, there is a need to raise awareness on storage, transportation and recycling, and safe disposal of spent lamps at public schools in and around the Johannesburg Metropolitan Area.

5.6 CONCLUSION

The study determined that the awareness levels of schools regarding the hazardous nature of fluorescent lamps were high. However, it is evident that a lot of effort is needed to specifically address mercury as a hazardous substance that is of concern during fluorescent lamp management in public schools. If public schools were educated about the handling, storage and disposal of fluorescent lamps, cleaning of spillages, mercury vapour, susceptible population, routes of exposure and the health effects of mercury in both humans and environment, this would encourage public schools to practise the proper management of fluorescent lamps at public schools responsibly and thereby prevent the exposure of employees, learners and the environment as far as is reasonably practicable.

The study also revealed during observations that there were no formal guidelines available in any of the schools that covered all stages of fluorescent lamp management. Moreover, in the 13% of the schools that did have guidelines, these were informal, were not written down anywhere, and each of the schools managed spent lamps differently. Health risks and environmental and underground water pollution are inevitable considering that there are no guidelines in place to commit public schools to be accountable and responsible for the proper management of fluorescent lamps at school level.

It is commendable that most of the schools stored fluorescent lamps in lockable storerooms, and with original packaging, as this minimises the chances of fluorescent lamp breakages during storage, before use. However, access control to the storage area, replacement of spent lamps, and use of protective clothing during cleaning and methods of cleaning remain a challenge as far as the handling of fluorescent lamps in public schools is concemed.

It was noted during observations that 82% did not separate spent lamps from other waste, which meant that most of these spent lamps are disposed of in general landfill sites. The crushing of spent lamps, in 27% of the schools, took place in bulk storage open containers e.g. $6m^3$. These open containers are placed where the refuse collectors have easy access to them, and minimal consideration is given to the human and environmental health impact. In cases where spent lamps are dumped, burnt and buried in open spaces (which occurred in 9% of the schools), air and underground water sources are exposed to mercury contamination.

None of the spent lamps was recycled at any of the schools. Recycling is regarded as the best environmental altemative. Recycling is regarded as the best environmental altemative, as, nationwide, millions of mercury-containing lamps are discarded each year. Most of these lamps are discarded with municipal waste, and this result in all mercury-containing lamps releasing mercury into the environment through breakage or leakage outside a controlled crushing and recycling process (Lombard and Webb, 2008). Therefore, it is of paramount importance to promote recycling and the safe disposal of spent lamps in public schools.

CHAPTER 6
CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

Chapter 5 provided the overview of the findings, and this final chapter draws conclusions and recommendations for possible interventions that can be used to redress the anomalies in the management of fluorescent lamps at public schools. The study set out to test the hypothesis that employees and learners may be exposed to elementary mercury through inhalation of ambient air in classrooms when a fluorescent lamp breaks, or when fluorescent lamps are handled, stored, or disposed of improperly in schools, leading to the release of mercury into the environment. To prove or disprove this hypothesis, the study aimed at determining how fluorescent lamps, as hazardous waste stream, are managed at selected public schools within the Johannesburg Metropolitan Area. To answer the study aim, specific objectives were met, as discussed in the conclusion section below.

6.2 CONCLUSIONS

The findings of the study were that 77% of the selected public schools were aware that fluorescent lamps contain mercury vapour. This indicated that the level of awareness at these schools regarding the hazardous nature of fluorescent lamps was high. However, only 68% of the schools knew that spent lamps are regarded as hazardous waste because of mercury vapour. This means that 32% of the schools were not aware that spent lamps must be regarded as hazardous waste (specifically) because of mercury content. As a consequence, due to lack of awareness, 32% of the schools were likely to be exposed to mercury vapour, in the event that a fluorescent lamp breaks in the presence of employees and learners.

It was noted that of the 91% schools that were aware that lamp breakages in class pose a health risk, most schools were more concerned about broken glasses as a health hazard to learners, as learners could get cut injuries if they played with broken fluorescent lamps, than it was with inhaling mercury vapour or coming into contact with mercury. Therefore, it was evident that a lot of effort is needed to address mercury vapour as a hazardous substance that is of more concern than broken glass in fluorescent lamp management in public schools. Only 45% of the schools were aware that spent lamps can be recycled, yet even in those that were aware, none of them practised recycling or safe disposal of spent lamps.

Observation revealed that there were no formal guidelines covering all stages of fluorescent lamp management in any of the schools. Only 14% of the schools had guidelines, and these were all informal. In other words, they were not formalised and documented anywhere, and as a result, each school managed spent lamps differently. Moreover, the informal guidelines that existed were incomplete in each school. This meant, for example, that a particular school had informal guidelines on the storage of fluorescent lamps before use, but had no guidelines for the replacement of spent lamps, for the cleaning of spillages, or for the storage and disposal of spent lamps. Thus, the informal guidelines that did exist in a small minority of the schools did not address all the stages of fluorescent lamp management from storage before use up to final disposal.

Eighty-sixty per cent (86%) of the schools indicated the need for formal guidelines, while 14% did not feel there was a need for formal guidelines. This indicates that there is indeed a need for formal guidelines that would commit public schools to be accountable and responsible for the proper management of fluorescent lamps at schools. Without formal guidelines for fluorescent lamp management at public schools, the exposure of employees, learners and the environment to mercury will remain inevitable.

It is commendable that 91% of the selected public schools stored fluorescent lamps in lockable storerooms, and with original packaging, as this minimises the chances of fluorescent lamp breakage during storage, before use. However, the use of a storeroom for keeping fluorescent lamps before use seemed to be widely practised for security reasons (to prevent theft) rather than for the health safety of employees and learners. Hence, health education of public schools is necessary to create awareness about the hazardous nature of fluorescent lamps in case fluorescent lamps break during storage.

The study also revealed that 27% of the schools replaced spent lamps in the presence of learners and employees, whereas 73% of the schools replaced spent lamps in the absence of learners and employees. This meant that in 27% of the schools there were chances of employees and learners being exposed to mercury vapour in cases where fluorescent lamps break during replacement.

Of the persons responsible for cleaning spillages due to lamp breakages in schools, 50% used protective clothing while the other 50% did not. Janitors (comprising 79%) were the persons most commonly responsible for cleaning; however, they had inadequate protective clothing – i.e. facemasks and gloves. These are very important to avoid the inhalation of mercury vapour during cleaning and coming into direct contact with mercury. Janitors were likely to be exposed to mercury vapour during cleaning because of the incorrect cleaning methods used.

The study also showed that in the schools examined there was variation in the cleaning of breakages or spillages of fluorescent lamps: 56% of the schools swept and collected; 35% swept, collected, and washed the affected areas and only 9% used vacuum cleaners for cleaning spillages. Great care should be taken when cleaning mercury spillages. Using vacuum cleaners or brooms to clean up broken lamps on hard surfaces is strongly discouraged as it can blow mercury into the air. This may expose the persons responsible for cleaning to mercury vapour inhalation or causing them to come into skin contact with mercury. Therefore, persons responsible for cleaning in the schools surveyed were more likely to be exposed to mercury vapour during cleaning of mercury spillages.

Moreover, access control to the storage area, replacement of spent lamps, and the use of protective clothing during cleaning and methods of cleaning remain a challenge as far as the handling of fluorescent lamps in public schools is concerned.

It was noted that 82% of the schools did not separate spent lamps from other waste stream during storage after use and this meant that most of these spent lamps are disposed of in general landfill sites. As a result, breakages of spent lamps during storage would mean that most of the mercury vapour would escape into the environment at this stage, while the remaining mercury would find its way to a general landfill site together with commingled waste. Separation is an important step in the management of spent lamps in public schools in order to: reduce spent lamps disposed of with general waste, promote safe disposal (in hazardous landfill sites) and recycling of spent lamps. The crushing of spent lamps, in 27% of the selected public schools, took place in bulk storage open containers. Open containers were put strategically for the refuse collectors to have easy access to them, and minimal consideration was made to the human and environmental health impact. In cases where there was dumping, burning and burying of spent lamps in open spaces (9% of the schools), air, and underground water sources was exposed to mercury contamination.

None of the spent lamps was recycled at any of the schools. This meant that spent lamps were broken and crushed during storage (before disposal) thereby releasing mercury into the environment. Recycling reduces volume to landfill sites, since all the components of fluorescent lamps can be recovered and recycled, thus avoiding the wastage of valuable resources. This therefore means that the recycling of spent lamps will significantly reduce the amount of mercury being disposed of in general landfill sites and lost into the environment. Therefore, it is of paramount importance to promote recycling and the safe disposal of spent lamps in public schools.

6.3 RECOMMENDATIONS

This section outlines the key recommendations based on the findings of the study. The recommendations are discussed under the following sections: health education, need of formal guidelines, handling of fluorescent lamps and recycling.

6.3.1 Health education

The responsibility of health education at public schools regarding fluorescent lamp management requires a collaborative approach. However, the Department of Education plays a major role to oversee that schools have certain policies in place including (formulation and adherence) fluorescent lamps management guidelines at public schools. This holistic approach of raising awareness should cover handling, storage, and disposal of fluorescent lamps, cleaning of spillages, mercury vapour, susceptible populations, and routes of exposure and impacts of mercury in both humans and the environment.

6.3.2 Need of formal guidelines

The study drew attention to the need for formal guidelines on fluorescent lamp management at public schools within the Johannesburg Metropolitan Area. Therefore, the Department of Education should provide formal guidelines and ensure compliance with regard to the following aspects:

- **Storage of fluorescent lamps before use**: a specific place separate from other goods stored within the storeroom should be provided. Preferable, fluorescent lamps must be stored in their original packaging material in a container, or a shelf or a cupboard that provides a secure storage area and where there is access control so as to minimise lamp breakages during storage before use.

- **Replacement of spent lamps**: fluorescent lamps must be replaced after school classes in the absence of employees and learners. Care must be exercised when removing a bulb from its packaging, installing and/or replacing it, making sure always to screw the lamp by its base (not the glass) and never to twist the bulb into a light socket with force.
- **Handling of spent lamps**: spent lamps should be stored separately from other waste stream in a closable container in the storeroom where access thereof is controlled, preferably spent lamps should be kept in their original packaging material when put in the container, to minimise breakages and for safe disposal purposes.
- **Cleaning of spillages**: using brooms and vacuum cleaners for cleaning spent lamp spillages or breakages should be avoided (refer to the handling of spent lamps in sub-section 6.3.3 below).
- **Storage of spent lamps**: spent lamps should not be stored at school for a period of more than 90 days, because of mercury content; spent lamps are regarded as highly hazardous waste. The receptacles used during the storage of spent lamps should therefore be labelled accordingly (contents and the date of storage) to prevent any risk of wrong identification resulting in environmental pollution.
- **Disposal of spent lamps**: spent lamps must be taken to collection points for recycling purposes or for the safe disposal thereof at hazardous landfill sites.

6.3.3 Handling of fluorescent lamps

The Southern African Power Pool (SAPP, 2010) recommended guidelines to be used in the management of fluorescent lamps at household (domestic) level; however, a similar approach to the management of fluorescent lamps at institutions such as public schools can be adopted. According to these guidelines (SAPP, 2010):

- Care should be taken when removing a bulb from its packaging, installing and or replacing it.
- Always screw or unscrew the lamp by its base (not the glass) and never twist the CFL into a light socket with force.

In cases where lamps break, precautionary measures as mentioned to in section 5.3 should be taken.

6.3.4 Recycling

Recycling or safe disposal of spent lamps was not practised in any of the selected public schools. Therefore, it is recommended that public schools should keep their spent lamps separately until they are safely taken to the nearest collection points – at present, participating retailers that are collecting spent lamps for safe disposal are Woolworths and Pick 'n Pay stores.

6.4 FURTHER STUDIES

This study set out to explore the exposure of employees, learners and the environment to elementary mercury, and the findings suggested that employees, learners and the environment were exposed to elementary mercury during the management of fluorescent lamps at selected public schools.

Further studies are recommended to investigate the following:

- The level of mercury toxicity in the environment due to fluorescent lamp exposure.
- Compliance of public schools pertaining to fluorescent lamp management including recycling / safe disposal methods as may be stated by lamp manufacturer.

- To design an operational procedure model that can be used by public schools for the efficient and effective management of fluorescent lamps in South Africa.

6.5 SUMMARY

The findings of the study indicates that employees, learners and the environment are exposed to elementary mercury during the management of fluorescent lamps at selected public schools within the Johannesburg Metropolitan Area. This was due to the improper management of fluorescent lamps, especially from the replacement of spent lamps to final disposal. The findings revealed that there is a need for formal guidelines and a possible model for operational procedures in fluorescent lamp management at school level. These operational procedures include the safekeeping of spent lamps until they are taken to a collection point for recycling or safe disposal in a hazardous landfill site, since there was no recycling or safe disposal of spent lamps practised in any of the selected public schools. The findings of this study can be generalised to be a reflection of the situation in public schools within the Johannesburg Metropolitan Area as far as fluorescent lamp management is concerned. As a result, the recommendations of this study, though not limited to, must be applied to public schools within the Johannesburg Metropolitan Area.

REFERENCES

Al-Saleh, I.A. (2009). *Health implications of mercury exposure in children. (Author abstract) (Report)* Page 22.

Babbie, E.R. (2006). *The Practice of Social Research*. 11th Edition, Oxford University Press Southern Africa. Cape Town. Pages 72, 76, 79, 122 and 244.

Bellinger, D. and White, R. (2002). *30. Mercury. (PART II. THE ENVIRONMENT) (health and environmental effects)*. Pages 247(8).

Brice, J., Sevitz, J. and Cornelius, J. 2006, "*Waste management principles, policy and legislation in South Africa" in Water Research Commission* [WRC], pp. 5-13.

Dalvie, M.A. and Ehrlich, R. (2006). Community mercury levels in the vicinity of peri-urban waste disposal sites and fossil fuel burning operations. *Environment international*, 32(4). Pages 493-499.

Davidson, P.W., Myers, G.J. and Weiss, B. (2004). *Mercury exposure and child development outcomes* Pages S1023 (7).

De Vos, A. S., Strydom, H., Fouché, C. B., and Delport, C. S. L. (2005). *Research at Grass Roots, For The Social Sciences and Human Service Professions*.3rd Edition. Van Schaik Publishers. Hatfield, Pretoria. Pages 15, 57, 106, 132, 162, 193/4, 202, 206/7, 218 and 357.

Finley, A. and Liechti, D. (2008). *E-Waste Assessment South Africa*. eWaste Association of South Africa (eWASA). Pages 4/5.

Galbraith, K. (2009). *Obama Toughens Rules for Some Lighting (Business/Financial Desk) (Barack Obama)* Pages B3 (L).

Gale, T. (2001)."Fluorescent light." *Gale Encyclopedia of Science. Academic One File*. Web. 27 Jan. 2011.

Harris, R., Krabbenhoft, D., Mason, R., Murray, M.W., Reash, R., and Saltman, T. (2007). *Ecosystem Responses to Mercury Contamination.* Indicators of Change. Taylor and Francis Group, LLC. Pages 1- 4.

Henkenius, M. and Thompson, E. Fluorescent Lamp. Undated. Available from: http://www.ustr.net/electronics/fluorescent.shtml. (Accessed on 2011/02/24).

Herro, A. (2007). *World governments adopting bright idea. (EYE ON EARTH) (using fluorescent lamps to cut energy costs)* Pages 6(1).

Hex, J., Barnard, E., Ball, J. and Bredenhenn, L. (2009). CFL Recovery, Recycling and Disposal Implementation Guideline. Available from: http://www.capetown.gov.za/en/solidwaste/Documents/CLF/Min/require/brochure.pdf. (Accessed on 16/03/2011).

Hubbard, C. (2009). *Mercury Free-Zone – Minnesota Pollution Control Agency.* Available from: http//www.pca.state.mn.us/programs/mercury-free/index.html. (Accessed on 2009/08/25).

Jang, M., Hong, S.M. and Park, J.K. (2005). Characterization and recovery of mercury from spent fluorescent lamps. *Waste management,* 25(1). Pages 5 – 14.

Kennedy, J.F. (2008). *Cleanup for broken CFL's: our problems are man-made, therefore they may be solved (MERCURY) (Compact fluorescent lamps)* Pages A378 (1).

Krikkle, J. (2008). *Trends, Recycling e-waste: Sky is the limit.* Available from: http//www.ita.org.za. IEEE Computer Society. (Accessed on 2008/01/15).

Lombard, J. E. and Webb, P.S. (2008). *What Happens When The Lights Go Out?* The 9th Waste Management Conference of the Institute of Waste

Management of Southern Africa [IWMSA]. 6-10th October 2008. Durban. Pages 439- 449.

Lucas, A. and Emery, R. (2006). Assessing occupational mercury exposures during the on-site processing of spent fluorescent lamps. *Journal of environmental health*, 68(7):30-34.

Morris, T. (2006). *Social Work Research Methods. For Alternative Paradigms*. Sage Publications, California. Page 41.

North Carolina Division of Pollution Prevention and Environmental Assistance. (2009). *Fluorescent Lamps and Mercury.* Available from: http://www.p2pays.org/mercury/lights.asp. (Accessed on 2009/08/25).

Northeast Waste Management Officials' Association. (2010). *Mercury: Health effects*. Available from: http//www.newmoa.org/prevention. F:\NEWMOA - P2Rx™ Topic Hubs™.mht. (Accessed on 2010/05/28).

Osibanjo, O. (2007). *Waste Management and Research*. International Solid Waste Association (ISWA), London. UK. Pages 25(6).

Reclite. (2008). *E-Waste in South Africa. Lighting Lamps*. Available from: www.ita.org.za/.../EWASTE/IN/SOUTH/AFRICA/Pres.pdf. (Accessed on 2009/08/25).

Sarikaya, S., Karcioglu, O., Ay, D., Cetin, A., Aktas, C. & Serinken, M. (2010). *Acute mercury poisoning: a case report. (Case study)*Pages 7.

Scheer, R. (2008). *The dark side of CFLs. (THIS WEEK) (compact fluorescent light bulbs) (Brief article)* Pages NA.

Singh, D. (2010). *India lights future with efficient lamps. (Bachat Lamp Yojana project or Savings Program through Lamps) (Brief article)* Pages 3(1).

South Africa. (1989). *Environment Conservation Act 73 of 1989*. Government Printer. Pretoria

South Africa. (1993). *Occupational Health and Safety Act 85 of 1993*. Government Printer. Pretoria

South Africa. (1996). *Constitution Act, 108 of 1996*. Government Printer. Pretoria

South Africa. (2003). *National Health Act 61 of 2003*. Government Gazette. (No. 26595).

South Africa. Department of Environmental Affairs and Tourism. (*2011). Draft South Africa Position Paper For the Second Intergovernmental Negotiating Committee (INC) To Prepare a Global Legally Binding Instrument on Mercury*. Government Printer. Pretoria

South Africa. Department of Environmental Affairs and Tourism. (*1998b). National Environmental Management Act, 107 of 1998*. Government Gazette. (No. 19519).

South Africa. Department of Environmental Affairs and Tourism. (2008). *National Environmental Management Waste Act 59 of 2008*. Government Gazette. (No. 32000).

South Africa. Department of Environmental Affairs and Tourism. (2000). *White Paper on Integrated Pollution and Waste Management*. Government Gazette. (No. 20978).

South Africa. Department of Water Affairs and Forestry. (DWAF, Undated). *Policy on Disposal of Fluorescent Tubes in Large Quantities. Available from:* www.dwaf.gov.za/Documents/Policies/WDD/FluorescentTubes.pdf. (Accessed on 09/03/2011).

South Africa. Department of Water Affairs and Forestry. (1998a). *Minimum Requirement for Handling, Classification and Disposal of Hazardous Waste*, Second Edition, CTP book Printers, Cape Town.

Southern African Power Pool [SAPP]. (2010). *Guidelines On The Use And Disposal Of Compact Fluorescent Lamps (CFL's) in The SAPP Region.* Available from: www.sapp.co.zw/SAPP/Guidelines/on/the/Use/and/Disposal/of/Fluorescent/Tubes.pdf. (Accessed on 16/03/2011).

Venter, L. and Van Der Walt, M. (2008). *Recovery of Compact Fluorescent lamps from general household stream.* E-Waste Association of South Africa (eWASA). Pages 1 – 13.

Wedam, N.F. (2010). *Fluorescent lighting and physiology.* Pages 66(3).

Welman, C., Kruger, F. and Mitchell, B. (2005). *Research Methodology.* Third Edition; Oxford University Press Southern Africa. Pages 52/3.

White, S. and Smolinske, S. (2001). *Mercury Spill In A School: The Role Of The Poison Centre.* Pages 223.

Williams, R.M. (2005). *Mercury rising. (Health Risks and Environmental Issues)*Pages 34(3).

World Health Organisation Collaborating Centre for Urban Health. (2007). *WHOCCUH Annual Report* 2007. WHOCCUH, Johannesburg. Pages 4-7.

World Health Organisation, 2008. *Guidance for Identifying Populations on risk from Mercury Exposure.* Available from: http://www.chem.unep.ch/mercury/IdentifyingPopnatRiskExposuretoMercuryFinalAugust08.pdf. (Accessed on 2009/10/22). Pages 2-4.

Appendix 1

QUESTIONNAIRE FOR MANAGEMENT OF FLUORESCENT LAMPS IN PUBLIC SCHOOL

SCHOOL NUMBER: ____________________

DATE OF INTERVIEW: ____________________

NAME OF INTERVIEWER: ____________________

1. Thank you for completing this questionnaire; your time and effort are much appreciated.

2. Please indicate your correct response by an **X** on the applicable column, as indicated by the example below.

   Example: Do you know that prevention is better than cure?

Yes	No
X	

3. Where applicable if you are not sure indicate not sure as in example below

   Example: Do you think health education is one of the important strategies in curbing the spread of HIV?

Yes	No	Not sure
		X

---

1. Below is a set of statements about fluorescent lamps; please choose the response you think is correct.

   Fluorescent lamps:-

	True	False
a) contain mercury vapour?		
b) are regarded as hazardous waste because of mercury vapour?		
c) emissions due to breakages in classrooms pose a health risk to staff and learners?		
d) should be stored separately from other waste stream at the school?		
e) should be kept in a dry lockable area to control unauthorised access and to minimise lamp breakage?		
f) can be recycled?		

2. Are there any written guidelines available for fluorescent lamps management in the school, in terms of the following:

	Yes	No	Not sure
a) storage before use			
b) replacement of spent lamps			
c) cleaning of spillages (broken lamps)			
d) storage after use			
e) disposal			

2.1 Is there a need for formal guidelines related to the criteria mentioned in question 2?

Yes	
No	

3. If you have more than one option in the same question, please indicate all those options accordingly.

3.1 Where do you store fluorescent lamps before use?	Storeroom	
	Office	
	Other (specify)	
3.2 Is there any control to prevent unauthorised access to the storage area as per 3.1?	Yes	
	No	
3.2(a) If, Yes what is the control measure?		
3.2(b) Who has access to the storage area?	Principal	
	Teachers	
	learners	
	Security	
	Genitors	
	Other(specify)	
3.3 How are fluorescent lamps stored before use?	With packaging material	
	Without packaging material	
3.4 When are fluorescent lamps replaced?	During class periods	
	After classes	
	During breaks	
	Other times (specify)	
3.5 Who replaces spent lamps?		
3.6 If replacement occurs during class periods do learners or staff remains in class?	Yes	
	No	
3.7 In the event of fluorescent lamp breakages are persons responsible for cleaning using protective clothing? E.g. gloves and face mask.	Yes	
	No	
3.8 Who is responsible for cleaning?	Teachers	
	learners	
	Security	

	Genitors	
	Other(specify)	
3.9 What cleaning methods are used after breakage/spillage?	Vacuum cleaner	
	Sweeping and collecting	
	Sweeping, collecting and washing of affected area	
	Other (specify)	

4. If you have more than one option in the same question, please indicate all those options accordingly.

4.1 Do you store spent fluorescent lamps separately from other solid waste?	Yes	
	No	
4.2 What do you do with spent lamps?	Store for collection	
	Recycle	
	Crush	
	Other (specify)	
4.3 What kind of receptacles do you use for disposing of spent lamps?	 Wheelie bins (210ltrs)	
	 Galvanised bins (85ltrs)	
	 Rubber bins 75lrs	
	 Refuse bags	
	Other (specify)	
4.4 How often are spent lamps collected for disposal?	Weekly	
	Monthly	
	Three monthly	
	Six monthly	
	Other (specify)	
4.5 Are there any companies that are already recycling your spent lamps?	Yes	
	No	

4.6 How are spent fluorescent lamps collected?	Together with other solid waste	
	Separate from other solid waste	

Thank you for your time. It is much appreciated.

Appendix 2

OBSERVATION CHECKLIST FOR FLUORESCENT LAMP STORAGE FACILITIES IN PUBLIC SCHOOLS

SCHOOL NUMBER:____________________________________

DATE OF OBSERVATION:__________________________________

NAME OF OBSERVOR:___________________________________

The observation checklist shall be administered by the researcher during school visits.

Relevant observation will be indicated by an **X** in the applicable column.

1. Storage

1.1 Storage before use.	Storeroom	
	Office	
	Other(specify)	
1.2 Access control in the storage area to keep out unauthorised access.	Yes	
	No	
1.2(a) If, Yes what is the control measure?		
1.3 Packaging during stored before use.	With packaging material	
	Without packaging material	
1.4 Separation of spent lamps with other waste stream.	Yes	
	No	

2 Handling

2.1 Handling of spent lamps.	Store for collection	
	Recycle	
	Crush	
	Other	
2.2 Receptacles used for spent lamps.	 Wheelie bins (210ltrs)	
	 Galvanised bins (85ltrs)	
	 Rubber bins (75-85ltrs)	

	 Refuse bags	
	Other (specify)	
2.3. Labelling of receptacles. e.g. "hazardous waste".	Yes	
	No	
2.4 Recycling measures in place.	Yes	
	No	

3 Written Guidelines

3. Are there any written guidelines?	Yes	
	No	
3. (a) If Yes do they control accordingly?	Yes	
	No	
3. (b) If Yes are they approved? (signatories, and stamp / letter head)	Yes	
	No	
3. (c) If Yes by which body are they approved?		

4 Crushing (if it is practised)

4.1 Crushing area.	In sealed containers	
	Non-sealed containers	
4.2 Direction of the wind.	Towards the classrooms	
	Surrounding parks	
	Playing grounds	
	Offices	
	Houses	
	Other (specify)	
4.3 Possible impact on areas referred to in 4.2 above.	Yes	
	No	

INTRODUCTORY STATEMENT

Introduction

My name is Wellington Siziba. I am a student at the University of Johannesburg registered for the Master's Degree in Environmental Health, and am conducting research in selected public schools to determine the management of fluorescent lamps which form part of the solid waste stream. It is envisaged that this study will raise awareness related to the proper management of fluorescent lamps in public schools, thereby minimising the exposure of employees and learners to the hazards associated with the handling and disposal of fluorescent lamps. The interview will not exceed an hour.

Issuing of approval letters

These are the approval letters (one from the Gauteng Department of Education and the other one is an ethical clearance from the University of Johannesburg) approving this research project. Two data-collection instruments will be used, namely a questionnaire and an observation check list. The questionnaire will be completed by the principal or any other respondent representing school management, while the observation checklist will be completed by me.

Brief explanation of the process (Issuing of a Consent form)

For the respondents to participate they need to sign a consent form to show their understanding and willingness to be involved in this study. Having said that, I would like to draw your attention to the following issues. As a respondent

1. your privacy and the confidentiality of your personal information shall be respected;
2. your responses shall be presented in a generalised manner and the results of the study shall only be disclosed to schools that were

involved in the study, the Department of Education and for academic discussions; and

3. your rights to freedom of choice, expression and access to information will be respected e.g. to discontinue with interviews or refuse to participate in this study.

Question

Are you willing to participate in this study? ***If yes!***

Thank you very much for your willingness to participate, please sign the consent form. *(collect consent form)*

Issuing of questionnaire

The study will require you to answer all questions as indicated in the questionnaire. Meanwhile I will also complete the observation checklist and would request the person responsible for handling and disposing fluorescent lamps to escort me as I do the observations. The observations will not interfere with the learning process in any way, as it shall be done in the office, storeroom, crushing area or storage area before disposal.

Collection of a completed questionnaire

Is it fine with you if I collect the completed questionnaire after the observations or alternatively come and collect it some other day? If it's another day when do you think it will be ready for collection? I am sure there is no need to make an appointment; I will collect the questionnaire from the reception if you don't mind.

Once again thank you so much for your participation. Have a good day.

Appendix 4

CONSENT FORM

I,.., hereby acknowledge that, in relation to the study entitled "**MANAGEMENT OF FLUORESCENT LAMPS IN PUBLIC SCHOOLS WITHIN THE JOHANNESBURG METROPOLITAN AREA**", I have:

- Received a full explanation regarding the aims, procedures and protocol of the study.
- Agreed to be part of this study and accept the conditions of the study when I sign this consent form.
- Am aware that I am free to withdraw my consent and refuse participation in the study at any given time.
- Given permission that the results of this study can be made public, provided that any personal details will be kept strictly confidential.

Signature ______________________________

Date: __________________________________

The contact details of the researcher and the supervisors are indicated below.

Wellington Siziba
Tel: 011 559 6339
Email: 200711612@student.uj.ac.za

Prof A. Swart
Supervisor
Tel: 011 559 6225
Email: andres@uj.ac.za

Ms B. Allies
Co-Supervisor
Tel: 011 559 6521
Email: ballies@uj.ac.za

UMnyango WezeMfundo
Department of Education

Lefapha la Thuto
Departement van Onderwys

Enquiries: Nomvula Ubisi (011)3550488

Date:	23 June 2010
Name of Researcher:	Siziba Wellington
Address of Researcher:	PO Box 53361
	Troyeville
	Johannesburg 2134
Telephone Number:	076 761 8379
Fax Number:	None
Research Topic:	Management of fluorescent lamps in public schools within the Johannesburg Metropolitan Area
Number and type of schools:	Twenty three [23]; Primary and Secondary
District/s/HD	Johannesburg East,-North and -South

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

Permission has been granted to proceed with the above study subject to the conditions listed below being met, and may be withdrawn should any of these conditions be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*

Office of the Chief Director: Information and Knowledge Management
Room 501, 111 Commissioner Street, Johannesburg, 2000 P.O.Box 7710, Johannesburg, 2000
Tel: (011) 355-0809 Fax: (011) 355-0734

4. *A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher must supply the Director: Knowledge Management & Research with one Hard Cover bound and one Ring bound copy of the final, approved research report. The researcher would also provide the said manager with an electronic copy of the research abstract/summary and/or annotation.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

2010-06-23

Shadrack Phele MIRMSA
CHIEF EDUCATION SPECIALIST: RESEARCH COORDINATION

The contents of this letter has been read and understood by the researcher.	
Signature of Researcher:	
Date:	2010-06-24

Appendix 6

UNIVERSITY OF JOHANNESBURG

FACULTY OF HEALTH SCIENCES

ACADEMIC ETHICS COMMITTEE

AEC22/02-2010

26 May 2010

TITLE OF RESEARCH PROPOSAL:	**Management of fluorescent lamps in public schools within the Johannesburg Metropolitan area**
DEPARTMENT OR PROGRAMME:	**M.TECH : Environmental Health**

RESEARCHER:	**SIZIBA, W**	**STUDENT NO.**	**200711612**
SUPERVISOR:	**Prof A Swart**		
CO-SUPERVISOR:	**Ms R van Wyk**		

The Faculty Academic Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the University of Johannesburg.

The attached recommendations were made by the committee which will improve the quality of your proposal.

Please make these changes and corrections to the satisfaction of the supervisor/s

The AEC would like to extend their good wishes to you in your endeavour of your research project.

Yours sincerely,

Prof. Karien Jooste
Chair: Faculty of Health Sciences: Academic Ethics Committee