Dental Laboratory waste management in respect of reusing and recycling in KwaZulu-Natal

Yonela Ngombane

B-Tech: Dental Technology

Student Number: 20300390

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APPROVED FOR EXAMINATION

_____	_____
SUPERVISOR	**CO-SUPERVISOR**
Mr Gregory H Bass	**Prof. Ashley H A Ross**
M.Ed (Higher Education) (UKZN), B. Comm (UN)	D. Tech: Hom (DUT), M.Tech: Hom (TN)
NHD (Status): Dent Tech (TN)	PGDip Health ResEth *cum laude* (SU)
	B. Mus. cum laude (UCT)

DECLARATION

This dissertation is my own work and has not been submitted in part, or in full, to any other university for any purpose. I have not plagiarised the work of anyone else in completing the requirements for this task. The research was conducted in KwaZulu-Natal in fulfilment of the requirements of the degree of Master of Health Sciences: Dental Technology in the Faculty of Health Sciences at the Durban University of Technology under the supervision of Mr. G H Bass and Prof A H A Ross.

Date:	16 January 2018
Place:	Durban
Student:	Yonela Ngombane
Signature:	
Supervisor:	G H Bass M.Ed (Higher Education) (UKZN), B.Comm (UN), NHD (Status): Dent Tech (TN)
Signature:	
Co Supervisor:	A H A Ross D. Tech: Hom (DUT), M.Tech: Hom (TN) PGDip Health ResEth *cum laude* (SU) B. Mus. *cum laude* (UCT)
Signature:	

ABSTRACT

This qualitative study explored the management of waste in commercial and training dental laboratories in order to determine the practices and attitudes of dental technology practitioners and academics towards reusing and recycling dental laboratory waste products, and alert them to the benefits of waste management on the environment.

The research objectives were to establish and report on the extent of waste management that entails waste reduction through reusing and recycling, to uncover alternative uses for dental laboratory waste and the possible economic benefits thereof and to influence dental technology industry on environmental sustainability.

The research project was conducted in the interpretive paradigm. In the course of this study dental laboratory owners, dental technicians/technologists and academics from the dental technology programme at a training institution were interviewed. Waste handling in dental laboratories was observed in order to gain greater insight as to current practices in laboratories. Thematic content analysis was employed to analyse the qualitative data. This study found that waste management was poorly understood and practiced amongst the dental laboratory owners, dental technicians/technologists and academics. The study adopted a waste management hierarchy conceptual framework which was influenced by the Waste Act (Act No. 59 of 2008).

The negative attitudes towards responsible waste management practices and the poor understanding of waste management by dental laboratory owners, dental technicians/technologists were found to be as a result of the poor understanding of the possible impact that waste from dental laboratories can impose on the environment. The perceived lack of participation in constructive waste management legislation by the South African Dental Technicians Council was also seen to be a contributing factor to the negative attitudes towards responsible waste management practices within the industry. This finding reinforced the finding that the dental industry has no knowledge, understanding and desire to understand waste management and, more importantly, to understand that one does not practice things solely for legislative reasons but that there are economic as well as environmental reasons to practice constructive waste management. On the other hand, this study found that the industry was not averse to

engaging in environmental friendly practices provided there is financial gain. This was established after the benefits of waste management practices were explained to the industry.

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LIST OF ABBREVIATIONS

Abbreviations

B.Tech	Bachelor's Degree in Technology
CPD	Continuing Professional Development
DENTASA	Dental Technology Association of South Africa
DLW	Dental Laboratory Waste
KZN	KwaZulu-Natal
SADTC	South African Dental Technicians Council
SAWIS	South African Waste Information Centre
UK	United Kingdom

DEFINITION OF TERMS

1. A landfill site, also known as a tip, dump, rubbish dump or dumping ground, is a site for the disposal of waste materials by burial and is the oldest form of waste treatment (Ethekwini online 2013).

2. Waste management refers to practices and procedures that relate to how waste is handled or dealt with, including reusing, recycling and disposal (Jee and Shagufta 2010).

3. Environmental impact refers to the possible adverse effects caused by a development, industrial, - or infrastructural project, or by the release of a toxic substances into the environment (Jee and Shagufta 2010).

4. To reuse is to recover value from a discarded resource without reprocessing or remanufacture (Jee and Shagufta 2010). This can be simply exemplified by a glass jar that used to contain jam being later used as a pencil holder.

5. Recycling is the process of collecting and sorting substances from waste which may require reprocessing and/or reforming and even remanufacturing into new goods (Gregorich 2001).

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CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION

Waste management in South Africa is a concern requiring attention dating back to the early 1960s. Currently, there exists an even greater need to manage waste production as a consequence of the increased volumes of processed goods. In a report issued by the Department of Environmental Affairs and Tourism (2005) in South Africa, saving of resources and reduction of environmental impact from waste by minimizing the amount of waste disposed at landfills were highlighted as objectives of recycling to which South Africans must aspire to.

This study explored the management of waste in commercial and training dental laboratories in KwaZulu-Natal (KZN), in order to determine the perspectives and attitudes of dental technology practitioners and academics towards reusing and recycling dental laboratory waste products and the benefits thereof.

This study was conducted in two phases. The first phase was the observation of waste management in different dental laboratories paying special attention to reuse and recycling of dental laboratory waste materials. The second phase consisted of semi-structured interviews with dental laboratory owners, dental technicians/technologists and dental technology lecturers at the Durban University of Technology (DUT). The aforementioned data collection methods placed the proposed study within the interpretive paradigm, a qualitative research paradigm which emphasises words as data for analysis (Black 2006).

1.2 UNDERSTANDING WASTE MANAGEMENT

Nairn (1997), denotes waste management as an industry with its own language. Therefore, it was sought to define waste and waste management to promote understanding of the context of this study. Jee and Shagufta (2010), define *waste* as any material that is produced by domestic households and commercial, institutional, municipal or industrial organisations, and which is regarded to have no further use. *Solid waste* is defined as general waste materials that currently go to landfills including those materials that are potentially recyclable. In the context of this study *dental laboratory waste* refers to any material (liquid or solid) produced by dental laboratories which is regarded as having no value, and generally discarded.

Waste management refers to practices and procedures that relate to how waste is dealt with. This includes reusing, recycling and disposal of waste (Jee and Shagufta 2010). In South Africa, general waste management models for municipal solid waste comprise provision of waste receptacles by the local municipality. These are used for storage of solid waste at the waste production sites. The accumulated waste is then transported by the municipality to a transfer station for separation or treatment and eventually disposed at designated landfills (Tworeck 1979). Landfills are sites where the controlled deposition of waste takes place in an environmentally responsible manner. Notwithstanding the positive attributes of landfills, they are expensive to maintain and develop. Insufficient land space for landfills also becomes a consideration in the reduction of the volumes of waste at landfill sites (Ethekwini online 2013).

In South Africa, the National Environmental Management Waste Act No. 59 of 2008 consists of regulations on waste management standards. These standards are required to promote the effectiveness of the Constitution of the Republic of South Africa of 1996 concerning waste management and environmental protection (Molewa 2011). The constitution clearly states that:

> All South African citizens have a right:
>
> 1. To an environment that is not harmful to their health or well-being; and
> 2. To have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that -
>
> (i) Prevent pollution and ecological degradation;
>
> (ii) Promote conservation; and
>
> (iii) Secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development
>
> (Department of Justice and Constitutional Development 1996:15).

Irrefutably, acceptable solid waste management standards are applicable to all producers and handlers of municipal solid waste.

1.3 DENTAL TECHNOLOGY AS PRACTICED IN SOUTH AFRICA

Dental Technology is a branch of restorative dentistry specialising in preparing, fabricating and repairing of dental prostheses. This includes dental appliances that are required for restoring or correcting the function and aesthetics of the upper and lower jaws as well as the patient's face (Rudd, Morrow and Rhoads 1986). Such fabrications or constructions are carried out in a dental laboratory (Martinelli 1970).

In order for dental appliances to be manufactured in a dental laboratory, instructions are received from a dentist. The instruction ordinarily includes the dentist sending a negative impression of the mouth to the laboratory. The laboratory will then produce a replica model of the oral structures on which the final prosthesis is eventually produced. The completed prosthesis accompanied by an invoice will then be returned to the dentist, who will in turn fit the prosthetic restoration to the patient and charge relevant fees including the dental laboratory fee.

Dental laboratories are profitable businesses and are, in this study, referred to as commercial dental laboratories. Given the variety and volumes of waste generated in laboratories, it was necessary to investigate the economic benefits of recycling. Dental laboratories where student dental technicians are trained are, in this study, referred to as training dental laboratories. Training dental laboratories are of no exception when it comes to consideration of economic benefits of recycling due to monetary requirements for operation and maintenance.

1.4 WASTE MANAGEMENT REGULATIONS IN DENTAL TECHNOLOGY

Dental laboratories in South Africa are regulated by Act 19 of 1979 under the control of South African Dental Technicians Council. The Act makes provision for proper waste disposal, but only for occupational health reasons. However, it is largely silent on issues of waste management and the environmental damage that dental laboratory waste may cause. Harris (2012), deems it crucial for influential policy-makers to understand the human relationship with the environment and the potential means of mitigating the deleterious impact on the planet.

It has been noted that dental laboratory solid waste has been mistaken for building debris due to it containing plaster and stone models, metal scraps and gypsum from

plaster traps (2015, pers.comm.15 January)[1]. In that case the laboratory is left to find other means to discard their waste. This highlights the lack of direct regulation of dental laboratory waste. In the United Kingdom disposal of gypsum waste from dental laboratories is strictly regulated by the Environmental Agency for Legal and Duty of Care In Europe, disposal of gypsum waste from dental laboratories is strictly regulated by Environmental Protection Agencies (Wessex Dental Laboratory 2007).

This study will also investigate the awareness of waste policies and regulations in the dental technology industry. The possible negative impacts of dental laboratory waste will be discussed in the next chapter.

1.5 BACKGROUND AND CONTEXT OF THE STUDY

Materials used for the production of dental prostheses are the materials that generate potential recyclable waste in dental laboratories. Some materials are solely used in the preparation and some dental materials go to waste after serving their purpose. Consequently, potentially large volumes of different waste products are produced in dental laboratories and are generally disposed of in municipal landfill sites (Komilis *et al.* 2008).

Notwithstanding the large volumes of waste generated in laboratories, it is often a general practice to reuse certain materials. These include waxes and metals. Some dental materials may not be reusable as their properties change making them unsuitable for future dental laboratory procedures (Powers and Wataha 2013).

The volume of work produced in a laboratory is dependent on the size of a dental laboratory and the type of work done. A dental technology programme at a University of Technology can train up to 130 students in all four disciplines at a given year of study. Consequently, such a dental laboratory will produce more waste compared to an average commercial dental laboratory. In South Africa, an average dental laboratory consists of 1 to 2 dental technicians (Pillay 2013). The question arises as to what happens to these volumes of waste that are produced in the manufacturing processes?

[1] The identity of the reference individual is withheld on request of the respective dental technician.

Kwa-Zulu Natal, the area of this study, comprises one training dental laboratory and approximately 96 registered commercial dental laboratories. At the training institution under study, a communal skip for hard waste and garden waste is provided by the municipality. This is in line with the waste regulation standards as outlined by Molewa (2011). Commercial dental laboratories in South Africa do not have such provisions.

Taking into consideration the large volumes of dental laboratory waste produced and disposed, a study that will explore the phenomenon of waste management is necessary in order to understand how the dental technology industry is currently managing its waste and the opportunities and benefits of recycling. An in-depth discussion on waste management, reusing and recycling will be found in the next chapter of this dissertation.

1.6 THE AIM OF THE STUDY AND RESEARCH OBJECTIVES

1.6.1 Research aim

The aim of this study is to explore the management of waste in commercial and training dental laboratories in order to determine the perceptions of dental technology practitioners and academics towards reusing and recycling dental laboratory waste products, and the benefits thereof.

1.6.2 Research objectives

1. To establish and report on the extent of waste management that entails waste reduction through reusing and recycling.

2. To uncover alternative uses for dental laboratory waste and the possible economic benefits thereof.

3. To influence dental technology industry on environmental sustainability as a benefit of recycling and reusing.

1.7 KEY RESEARCH QUESTIONS

1. How is the waste managed in dental laboratories?

2. What are the perceptions and attitudes of dental technicians/technologists and academics towards waste management systems that value and employ recycling?

3. What are the benefits and opportunities of reusing and recycling dental laboratory waste?

1.8 RATIONALE FOR THE STUDY

Dental laboratories manufacture various dental restorations and appliances that require use of various dental materials for both commercial and training purposes (Mikael 2006). The value of recycling in the dental technology industry has been noted. Manappallil (2003), wrote that the earth is the home for all its living creatures. He carries on saying, human beings must not destroy forests, pollute the environment but consider consuming less and recycle more. Saving the earth's resources and reducing the environmental impact of waste by minimizing the amount of waste disposed at landfills are the known objectives of recycling. In addition, recycling may offer economic benefits to those generating the waste. Recycling is also a viable way to reduce informal salvaging at landfills, which is undesirable due to the associated health and safety problems (Department of Environmental Affairs and Tourism 2005). In the context of dental laboratory waste, informal salvagers may not benefit lest they are aware of its commercial value but stand a possibility of being harmed by hazardous substances which may have been improperly disposed of by dental laboratories in landfill sites.

To date no record could be found that identifies discussions about dental laboratory waste management in South Africa. But, an international study was confined to the composition, classification and production rate of dental laboratory solid waste (Komilis *et al.* 2008). Notwithstanding the paucity of research of dental laboratory waste management, South Africa has hosted a number of waste summits, albeit not in the dental technology field, to design and implement waste management systems which will contribute to sustainable development and a measurable improvement in the quality of life (Wiechers, Borland and Matsabu 2002). In the same context, this research may uncover alternative uses for dental laboratory waste and the possible benefits thereof as well as report on attitudes of dental technology practitioners and academics towards recycling. In addition, a study on dental laboratory waste management (reusing and recycling) may influence the consciousness of the dental technology industry towards environmental sustainability as well as health problems related to waste management.

In order for the results of this study to be relevant and applicable to the industry being researched, it was necessary to interview dental laboratory owners, dental

technicians/technologists and academics from the dental technology programme at a training institution. Observations of waste handling in dental laboratories to gain greater insight as opposed to solely relying on data from interviews were also employed (Bailey 2007).

1.9 ASSUMPTIONS AND DELIMITATIONS

1.9.1 Assumptions

In this study, it is assumed that:

- Data collected from interviews of various participants reflects their true and honest perceptions towards waste management.
- Participating in this study will trigger environmental awareness and reflection in the current practices of waste management in dental laboratories.
- Observation of dental laboratories in terms of how waste is handled will influence sharing of best practices.

1.9.2 Delimitations

This study is limited to:

- Waste management practices and not the volumes of waste production.
- Exploring dental laboratory waste recycling and or reusing practices, and not the feasibility of recycling.
- Sharing information on existing recycling opportunities and not testing the validity of recycling dental laboratory waste materials.

1.10 OVERVIEW OF THE DISSERTATION

The dissertation is comprised of five chapters.

This chapter provides a background to the study through a brief overview of dental technology and a reflection on the current status of waste management that triggered the need to conduct the research at hand. Furthermore, the aim of the study, key research questions and the rationale of this study are outlined.

Chapter two of the dissertation focusses on the status quo of waste management generally and in dental laboratories, reporting on existing initiatives and opportunities

of recycling and reusing by reviewing related literature. The first section of this chapter will explore common practices of waste management and the relationship of such to deleterious impacts on the environment. Subsequently, it will examine reusing and recycling specifically focusing on motivation and general perceptions. The second section will then examine and discuss current practices of waste management in dental laboratories. The key areas will be the type of waste produced in dental laboratories and acts of reusing and recycling.

Chapter three offers the reader a detailed description of the research design adopted and a detailed report of how the inquiry was developed to answer the key research areas, from sampling, data collection to data analysis. In addition, ethical considerations and trustworthiness are discussed.

Chapter four details analysis of results collected from observations of waste handling in dental laboratories and interviews with dental technicians/technologists, dental laboratory owners and academic staff members lecturing in the dental technology programme.

The fifth and last chapter discusses conclusions and recommendations drawn from the aforementioned results. In this chapter, the reader will find out the extent and willingness of dental technology practitioners towards reusing and recycling. Also, areas of future research will be identified.

CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

In this chapter, this study reviews the literature related to waste management and recycling in general, within the specific context of dental laboratories. The first section of the chapter will explore common practices of waste management and its impact on the environment, where after issues of reusing and recycling with a specific focus on motivations and general perceptions will be examined. The second section will examine and discuss current practices of waste management within the specific research context of dental laboratories.

2.2 WASTE MANAGEMENT

As denoted in the previous chapter, waste management refers to practices and procedures that relate to how waste is handled or dealt with, including reusing, recycling and disposal (Jee and Shagufta 2010). Within the broader context of global warming and ecosystem thinking, the disposal of waste has become an important consideration within societies in general. Waste management is presented with challenges which are recognised by government officials globally (Harris 2012). A thirteen-year old, Severn Suzuki, speaking for Environmental Children's Organisation (ECO) at the United Nations Earth Summit in Rio, Brazil in 1992 vehemently expressed her concerns on the future of the environment:

"I'm only a child and I don't have all the solutions, but I want you to realise, neither do you! You don't know how to fix the holes in our ozone layer. You don't know how to bring salmon back up a dead stream. You don't know how to bring back an animal now extinct. And you can't bring back forests that once grew where there is now desert. If you don't know how to fix it, please stop breaking it!"

(Suzuki 2007)

South Africa has also been involved in several environmental summits. The first National Waste Summit to address the challenges facing waste management in South Africa in general was held in September 2001 (Wiechers, Borland and Matsabu 2002). This summit was held in recognition that waste management should be a priority for all South Africans and that there is an urgent need to reduce, reuse and recycle waste

to protect the environment. According to the Department of Environmental Affairs and Tourism (2005), the vision of the Summit was to implement a waste management system which contributes to sustainable development and a measurable improvement in the quality of life, by harnessing the energy and commitment of all South Africans for the effective reduction of waste generation and disposal by 50% and 25% respectively by 2012 and develop a plan for zero waste by 2022.

One of the attempts to improve on current practices of waste management was the endorsement of the Waste Act (Act No. 59 of 2008). This Waste Act adopts the waste management hierarchy approach illustrated in Figure 1, to dealing with and addressing waste issues in the current waste management model in South Africa (Department of Environmental Affairs 2013).

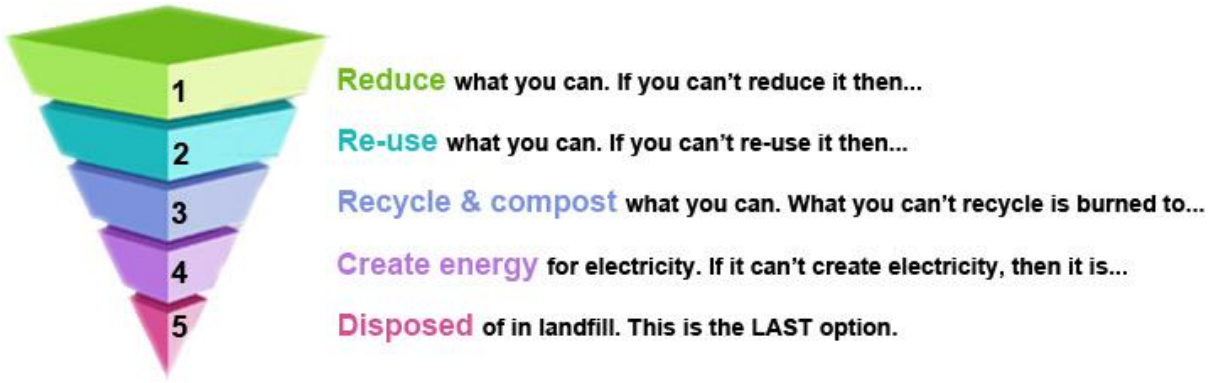

***Figure 1**: Hierarchy of waste management (Department of Environmental Affairs 2015)*

In South Africa, landfills are the core of waste management (Tworeck 1979). Since their development, waste has primarily been classified for landfill disposal, which does not support the principles of the waste hierarchy presented in *Figure 1* (Department of Environmental Affairs 2013). The waste hierarchy emphasises the reduction of waste production as the primary objective, with re-use and recycling as secondary emphases, as opposed to the landfill first approach. In the landfill first approach, waste generators pay little attention to re-use and recycling, they store the waste for the municipality to collect and have little to do with the end point of their waste.

In KwaZulu-Natal (KZN), Durban has three permitted landfill sites, namely: Bisasar Landfill Site, La Mercy Landfill Site and Marianhill Landfill Site. The Durban city municipality has reported that it has become very expensive to develop and manage

landfills. In addition to cost, there exists a challenge of siting new landfills sites due to what is referred to as 'NIMBY (not in my back yard) syndrome' where residents and businesses will object to landfills being located in their proximity, because of their association with air and noise pollution and possible negative health impact (Ethekwini online 2013). According to Bond and Sharife (2012), the Bisasar Road landfill is Africa's largest landfill site and processes 3 000 to 5 000 tonnes of waste daily. Such volumes of waste may be attributed to the landfill-first approach model of waste management.

It has been observed that as South Africa entered a new political era in the previous decade, accelerated economic growth and development were inevitable (Larney 2010). Consequently, a renewed onslaught on the environment may be observed, as increased demands are made on resources. More waste is being generated, with an increase in the need for solid waste disposal sites, which poses a severe problem considering the declining number of landfills and exploding landfill costs (Larney 2010). A change in approach, towards one which regards a landfill as the last option, would greatly reduce the problems of space and costs.

2.2.1 Classification of waste

The current waste management model employed by South Africa has been noted to place the responsibility for classifying waste in the hands of the landfill operators. The waste generators are often left with little or no understanding, and consequently implement no interventions to reduce waste volumes or to recycle. According to the South African Department of Environmental Affairs (2013), waste is currently classified into *General waste* and *Hazardous waste*, as seen in *Table 1* in the next page. This classification is made according to the South African National Standard Globally Harmonized System of Classification and Labelling of Chemicals (GHS – SANS 10234).

Table 1: *Classification of waste*

General waste – 2a	**Hazardous waste 2b**
• Domestic waste • Business waste not containing hazardous waste or chemicals • Uncontaminated building and demolition waste • Waste tyres • Garden waste • Post consumer packaging • Non-infectious animal carcasses • Uncontaminated, excavated earth	• Asbestos waste • PCB waste or PCB containing waste • Expired, spoilt or unusable hazardous products • General waste (excluding domestic waste) which contains hazardous waste or hazardous chemicals • Mixed hazardous chemical waste from analytical or academic laboratories in containers less than 100 litres • Health care risk waste

From the table, above, it is to be noted that business waste is listed under general waste, provided that it does not contain hazardous waste chemicals. If businesses, as waste generators, are not aware and responsible for classifying the waste they produce, there is a potential for business waste inadvertently to fall under category 2b. Consequently, there is a need for businesses to become aware of the nature of their waste, and to reduce, reuse and recycle their waste as far as is reasonable.

2.2.2 Environmental impact

The importance of setting good waste management standards has been made evident by the discussions above. Failure to do so would lead to a legacy of a hopeless deterioration or even unnecessary loss of resources, as well as remarkably adverse impact being exerted on the environment and on the physical and mental wellbeing of the affected inhabitants (Eggerth, Diaz and Savage 1993). In this study, environmental impact is viewed in reference to the surroundings within which humans exist and that are made of the land, water and atmosphere, micro-organisms, plant

and animal life. The importance of policy-makers to understand the human relationship with the environment has been previously mooted by Harris (2012). Consequently, it is important to explore the existing environmental impacts associated with the current waste management model.

Ethekwini online (2013), reported that despite sanitary landfills being a more environmentally responsible option, leaching of contaminants to ground-water and gas generation are two of the major problems associated with their use. Such problems are generally associated with incorrect landfill site selection, design, preparation or operation and may persist long after the landfill site has been closed (Department of Water Affairs & Forestry 2005). The main sources of leachate are water and other liquids already present in the waste, liquid by-products of microbial action during the anaerobic degradation of waste, and precipitation. As the water passes through the landfill, it picks up soluble portions of the decomposing waste. When the leachate leaves the landfill, it may contaminate either groundwater or surface water, thus acting as a vehicle for carrying potentially toxic materials from the landfill to water sources used for human activities (Ethekwini online 2013).

In addition to ground-water pollution, landfills have been reported to affect the health and safety of those who live in close proximity, and those who partake in acts of salvaging waste at landfills (Department of Environmental Affairs and Tourism 2005). An example of this would be the informal settlement on Kennedy Road, Claire Estate which is located four kilometres from the borders of the Bisasar landfill in Durban. There is no buffer zone between the landfill and the settlement. A buffer zone is an area of land designated for environmental protection. Such a zone may, for example, be in the form of farming land to stand between the residential area and the landfill site (Şener 2010). The lack of environmental protection, such as is in evidence in the Kennedy Road informal settlement, has been described as a toxic *cancer hotspot* where residents are like animals involved in a biological experiment (Albrecht as cited in Bond and Sharife 2012).

Health workers at a clinic near the Bisasar landfill confirmed that Kennedy Road residents suffer severely from asthma, sinusitis, pneumonia and even tuberculosis. A recent study concluded that, informal waste pickers at the New England road landfill site in Pietermaritzburg are at risk of increased adverse respiratory outcomes which may be attributed to their daily environmental exposure to the site and that this was

related to their exposure to high levels of particulate matter ($PM_{2.5}$), which may exacerbate respiratory ill-health (Dalasile 2014). In addition to health problems, safety is also a real issue. An illustrative example is an incident in which an informal salvager was buried alive by a dump truck offloading and died on the site (Bond and Sharife 2012).

2.2.3 General perceptions on reusing and recycling

Recycling has been recognized for its potential to save resources and to reduce the negative environmental impact, by reducing the amount of waste disposed at landfills. Baarschers (2013), describes recycling as following nature's example in which the waste of one species becomes food for another, and so without recycling nature would come to a halt. In a study on economic instruments for solid waste management in South Africa, it was also proposed that increasing landfill charges to reflect operational costs would go a long way towards providing an incentive to seek alternative options, making recycling and re-use a naturally attractive alternative (Nahmana and Godfrey 2010). Thereafter, if necessary, external costs could be addressed, perhaps by means of an environmental tax on landfill disposal. However, such an approach needs to be accompanied by education and awareness campaigns, as well as increased monitoring, to mitigate the resultant risk of increased illegal dumping.

2.3 DENTAL LABORATORY WASTE AND WASTE MANAGEMENT

2.3.1 Dental Technology disciplines

In understanding waste management in general, the focus of the discussion now turns to dental technology. There are four main disciplines existing in the dental technology industry. These are discussed below with the types of materials that are involved in the manufacturing processes. Dental materials listed under each discipline give an indication of the types of waste that are produced in dental laboratories which may be potentially recyclable, notwithstanding packaging materials.

2.3.1.1 Chrome-Cobalt

Chrome-Cobalt is a division of dental technology practice that deals with the manufacturing of metal denture frameworks for removable partial dentures as depicted in *Figure 2.*

Figure 2: *A removable partial denture with a palatal cobalt-chromium framework (Dentcaredental.com 2015).*

The manufacturing process requires the use of high temperature furnaces for burning out wax and heating up investment moulds (Johnson 2011). There is also melting of chrome-cobalt alloys using high temperature air/gas torches. The finishing procedures require stone burs, cutting discs, rubber wheels and some liquid electrolyte. All materials used in the production generate waste, the main waste being gypsum models, phosphate and gypsum bonded investment materials with silica content and cobalt-chromium metal alloys.

2.3.1.2 Prosthetics

Prosthetics is a branch of dental technology that deals with the manufacturing of partial or full acrylic dentures *Figure 3*.

Figure 3*: Upper and lower full dentures (Denturecare.com 2015)*

Here the manufacturing process requires the use of dental plaster, wax, preformed acrylic teeth and acrylic denture resins. These types of prostheses may be fixed or removable (Johnson 2011). Prosthetics may also include the manufacture of maxillo-facial prostheses. Significant volumes of gypsum and wax waste are produced in the production of prostheses.

2.3.1.3 Orthodontics

Orthodontics is a branch of dentistry that specializes in treating patients with improper positioning of teeth. A condition that usually results in an improper bite, speech and/or poor facial appearance (Luther and Nelson-Moon 2013). Therefore, Orthodontics includes treating and controlling various aspects of facial growth, shape and development of the jaw. The image in *Figure 4* is a good example of an appliance that provides realignment of teeth, improvement of bite and facial appearance (Tan 1984).

Figure 4: *An orthodontic appliance for the correction of teeth alignment, jaw repositioning and enhancement of oral functions (Aso-inter.co.jp 2015).*

In a dental laboratory, sets of study models are analysed and an appropriate orthodontic appliance is fabricated. The materials involved here include dental plaster, stainless steel wires, solders and orthodontic acrylic resins. Orthodontics also includes the manufacture of oral mouth guards using a thermoplastic material. Waste generated in this process is generally limited to gypsum products, small amounts of stainless steel wires, acrylic and thermoplastic material.

2.3.1.4 Crown and Bridge

The process of manufacturing crowns and bridges involves casting of metal substructures, posts as well as ceramic building up materials. These types of restorations are referred to as fixed restorations because they get cemented in the patient's mouth (Shillingburg and Sather 2012). Crowns and bridges may consist of a metal core and the rest of the tooth structure built up in porcelain material, *Figure 5(a)* and *Figure 5(b).*

Figure 5(a): *Porcelain Fused to Metal 3 Unit Bridge (Moderndentalusa.com 2015)*

Figure 5(b): *Metal-free 3 Unit Bridge (Moderndentalusa.com 2015)*

The manufacturing processes discussed above will yield waste consisting of gypsum products and investments, metal residues, porcelain, wax and impression materials.

In South Africa, dental laboratories are classified according to which of the four disciplines are practiced. A dental laboratory that does not practice all four disciplines

is referred to as a *specialist laboratory* and that which all four disciplines are practiced is referred to as a *genera*l dental laboratory.

2.3.2 Waste generated in dental laboratories

When humans developed manufacturing industries they mainly used stone and biodegradable materials such as wood and leather, and these naturally recycling materials mitigated against any negative environmental impacts (Baarschers 2013). A challenge emerged when the manufacturing industries began to include metals, minerals and other non-biodegradable materials. Waste (as a discrete entity) was then produced by the manufacturing process itself, and these by-products increasingly came to be perceived as worthless (Nairn 1997).

In restorative dentistry, the dentist produces an impression of the patient's oral cavity using rubberised impression materials to reproduce landmarks required for the fabrication of a dental prosthesis or appliance. The set impression material on an impression tray will be disinfected and wrapped in plasticized paper enclosed with a wet tissue or cotton pad to maintain moisture during transportation to a designated dental laboratory. These impressions form part of the solid waste from the dental laboratory. At the receiving area of the lab, the impression is disinfected, and a plaster model is then cast by the dental technician around the impression material.

The cast model will have the shape and size of the patient's alveolar ridge, teeth, mucosa, and will be further disinfected by the technician to receive different dental materials specific to restorations and appliances to be fabricated. The building up; processing; finishing and polishing steps after the model has been cast result in the production of several types of waste which are usually disposed of in municipal general waste bins (Haralur *et al* 2015).

Some dental laboratory solid waste is retrieved from solid waste traps installed under the sinks whilst other waste is disposed of into the sewerage system (Troendle and Troendle 1991). The materials that are usually trapped in this manner are gypsum from model grinders and excess mixing over the sink, investment materials, pumice, sand, and wax that has been boiled out from denture flasks or working models. However, no information on chemical waste that could be found in plaster traps could be found. It would be worthwhile to find this out, in order to determine whether toxic

liquids washed down the sink get trapped and mixed up in the plaster or go straight into the sewerage system (Troendle and Troendle 1991). Within this context, a particular point of interest would be the evident generation of a large number of gypsum models, which are routinely disposed of in municipal waste bins (Komilis *et al.* 2008). Dental laboratory solid waste has been reported to exist in three different categories as shown in *Table 2* below.

Table 2: Dental laboratory waste categories (Komilis *et al.* 2008).

Infectious and potentially infectious waste	**Non-infectious toxic waste**	**Household waste**
Waste that has come into contact with human saliva and possibly blood. An example would be impression materials.	Consists mostly of casting alloys such as chromium (Cr), nickel (Ni), silver (Ag) and other metals. These metals are discarded either as dust from grinding or as buttons left over from casting.	Gypsum products and different wax types are included alongside office and domestic waste.

Waste categories in columns 1 and 2 of Table 2 in the previous page, may fall under ‘hazardous waste’, which is defined as any waste that contains organic or inorganic elements or compounds that may, owing to its inherent physical, chemical, toxicological or infectious characteristics, have a detrimental impact on health and the environment. Hazardous waste may consist of substances that are explosive, corrosive, chemically reactive, poisonous, and bio-hazardous i.e. containing infectious bacteria (Wiechers 2014).

In a dental laboratory, there are laboratory finishing procedures that require use of corrosive liquids. Corrosive materials are so powerful that they damage or destroy metal. In humans, they can chemically destroy body tissues as soon as they touch the skin, eyes or lungs. A good example of a corrosive in a dental laboratory is the electrolyte liquid used for electro-polishing cobalt-chromium denture frameworks. The brass rod that technicians use to suspend the metal being polished becomes thinner with repeated use. The electropolishing process results in the removal of a thin layer of metal to produce a bright and smooth surface (Rodrigues and Shetty 2013).

Methylmethacrylate, the liquid monomer component of the powder-liquid type of acrylic resin used to manufacture acrylic dentures, is highly flammable (Powers and Wataha 2013). Flammable and combustible liquids present the danger of personal injury and property damage. Therefore, strict storage and disposal are both essential requirements by law. In South Africa, waste resulting from such materials must be stored separately from general waste and collected by specialist hazardous waste collectors in the same manner as medical waste (Wiechers 2014).

2.3.3 Current waste management in dental laboratories

Waste from dental laboratories is handled and disposed of as general municipal waste (Haralur *et al* 2015). General waste is defined as waste which does not pose an immediate threat to people or the environment such as, household waste, builder's rubble, and garden waste, dry industrial and commercial waste (Department of Water Affairs & Forestry 2005). However, as described previously, such waste may, with decomposition and infiltration by water, produce leachate with an unacceptable potential to pollute the environment.

Of relevance to this point, is a study that was conducted by Vasanthi, Kaliappan and Srinivasaraghavan (2008) in which they tested ground-water for contaminants. The following contaminants were found: calcium, magnesium, potassium, nitrogen and ammonia. Within this list, also, were trace metals like iron, copper, manganese, chromium, nickel. It is to be noted that most of the above chemicals are to be found in dental materials, and by extension, dental laboratory waste. *Table 3* in the next page refers.

Table 3: *Dental materials and their chemical components (McCabe and Walls 2008)*

Commercial names	**Chemical components**
Gypsum stone and plaster	Calcium sulphate
Hydrocolloid impression materials	Potassium alginate, calcium sulphate, zinc oxide, potassium titanium fluoride, diatomaceous earth and sodium phosphate.
Elastomeric impression materials	Polysulphides, lithopone, titanium dioxide, dibutyl phthalate, sulphur and lead dioxide, methyl, hydrogen, polyethers, siloxane.
Inelastic impression materials	Zinc oxide, silica and calcium chloride
Acrylic resins	Methyl, ethylene, benzoyl peroxide
Casting alloys	Chromium, nickel, silver, palladium, copper, aluminium, titanium, zinc, titanium, carbon, cobalt, iron, lead, tin, mercury, beryllium, molybdenum and vanadium.
Dental ceramics	Silica, potassium and sodium, boric oxides, aluminium.
Casting investment materials	Silica, phosphate, ethyl alcohol, ammonia, hydrochloric acid

Waste from dental laboratories has not received much attention and nor discussions about dental laboratory waste management in South Africa could be retrieved. There is no documented waste management model specific to dental laboratories.

2.4 THE DETERMINATION OF WASTE MANAGEMENT ATTITUDES, PERCEPTIONS AND PRACTICES.

2.4.1 Previous evaluation of dental waste practices

Research plays an important role in reflecting on current practices of industries or organisations. In the context of dental laboratory waste management, research can also be used to influence manufacturers towards reusable materials. The previously mentioned study by Komilis *et al.* (2008) about the composition and production rate of dental laboratory solid waste in Xanthi, reported that common metals used in dental technology such as: gold, platinum, palladium, silver, beryllium, cadmium, chromium, cobalt, copper, selenium, nickel, aluminium, manganese and zinc produced waste quantities that are relatively small. Therefore, such metals could be stored in appropriate containers until collected by metal-recycling companies (Komilis *et al.* 2008).

Recycling of dental laboratory waste into non-dental industries is exemplified by a European-based dental technician, Stoodley, who initiated a dental waste service. This waste service is focused on collecting gypsum models from different dental laboratories and dental practices for recycling by a plasterboard company (Wessex Dental Laboratory 2007). Stoodley (2013 Email. comm. 7 May) explains that the idea of creating a gypsum model waste service came about since all gypsum waste had to be disposed in the correct manner. As a laboratory providing a service to a large client base delivering and collecting from them daily it made sense for him to apply for a waste carrier license from the Environment Agency and collect their gypsum models as an added service to his clients. He noted that this was something no other laboratories offered. He supplies a nine-litre container to each client, this on average holds around 50 dental models. The container is collected when it has been filled and a replacement container is left. The cost of each full container is £12.00. These models are then stored in a one ton container back at Wessex Dental Laboratory which once full is collected by a commercial waste company who take the gypsum and recycle it for the manufacture of plaster board.

As part of keeping within legal regulations, Wessex Dental Laboratory supply the dental practices with the relevant Waste Transfer Notes. Wessex Dental Laboratory

receives their Waste Transfer Notes from the commercial waste companies, thus ensuring compliance. The service was welcomed by the dentists who found other waste collectors costly and inflexible.

In dental technology, there is an existing general practice of reusing casting metals by including a certain percentage of old metal to new metal. However, a study was conducted to ascertain if there is any elevation in cytotoxicity of Ni-Cr alloys in the reused state when compared to its first-time use. The results showed significant elevation. Chandra, Kumar and Kumari (2011), discourage the reusing of Ni-Cr alloys due to the elevated cytotoxicity of Ni−Cr base metal alloys in their reused state. Even though the oral cavity has protective mechanisms, these researchers were not sure of the threshold limits. They recommend that further studies ought to be directed towards the evaluation of the tissue response to corrosion products released from Ni−Cr alloys *in vivo,* in order to consolidate the results of their study (Chandra, Kumar and Kumari 2011). If cytotoxicity puts restrictions on the reuse of these metals, recycling them for non-dental applications may prove more appropriate.

In the same context of employing research and reflecting on the dental technology industry current waste management practices, a study by Zhang *et al.* (2006) tested reusability of binder-free investments to cast precious alloys. The experiment involved the crushing of fired investment moulds into powder. The resulting powder was used again as second-use, and then in the same way used one more time as third-use. These researchers claimed good stability of the properties of the reusable investment material and precision fit of the cast product. They also argued that the manufacture of reusable dental investments would lead to drastic reduction in industrial waste produced by dental laboratories (Zhang *et al.* 2006). Such an argument directs some ecological responsibility to the manufacturers of the materials used in dental laboratories, although it is accepted that issues of dental laboratory waste management and environmental awareness do not begin and end in dental laboratories.

The studies above are of particular importance to dental laboratory waste management in South Africa, since it has been noted that the call has been made for waste generators to reflect on their waste management practices, and to take environmentally responsible actions towards their improvement.

2.4.2 Observation and interviews

The observation technique of determining perceptions and attitudes has been employed as a means of generating information that will complement the interviews method. The method of simple observation allows the researcher to gain a broader understanding of WHAT is being done in the practice, before finding out WHY things are done the way they are done (Cohen, Manion and Morrison 2011). In dentistry and dental technology, observational studies have been widely used by researchers to establish failure rates and/or the evaluation of certain procedures, dental restorations or materials (Zhang *et al.* 2006; Chandra, Kumar and Kumari 2011; Pommer *et al.* 2011; Yang 2013). In qualitative studies, observations are a useful check against what people report about themselves during interviews and what they are observed to do (Duke.edu 2015). The noted challenges of this data collection technique include behaviour modification by participants, as well as mistrust towards observer (Creswell 2007). Therefore, thorough descriptions of the purpose of the observation must be relayed to the participants in order to establish a good relationship and acceptance by the participants being observed (Constable *et al.* 2012).

Interviews have long been used as a technique of gathering information from participants by asking questions and getting them to respond verbally (Cohen, Manion and Morrison 2011). Structured interviews use an interview schedule that is similar to that of a survey questionnaire. The questions are phrased so that one has a limited range of responses such as: yes, no and maybe. Constable *et al.* (2012), state that structured interviews allow for a more focused information gathering, but have the tendency to inadequately capture elements of group dynamics that are more easily revealed through unstructured interviews. Consequently, structured interviews become an inappropriate choice in cases in which the researcher seeks to understand the issues that concern an industry in the voice of that industry.

Unstructured interviews are similarly inappropriate as a technique of collecting qualitative data for studies that determine perception and utilise thematic content analysis. These interviews may begin with one question and subsequent questions would follow from the interviewee's responses (Gillham 2000). The drawback of such

interviews is that the respondent may talk about irrelevant and inconsequential issues making it difficult to code and analyse the data.

Semi-structured interviews represent a useful compromise, as evidenced by previous perception studies in dental technology (Pillay 2013; Zondi 2014). Such interviews consist of a list of open-ended questions based on the focus areas the researcher intends to study. The open-ended nature of the questions provides opportunities for both the researcher and participant to discuss certain topics in more detail and allows the interviewer to adapt the interview according to the responses of the participant, rather than adhering to a rigidly structured list of predominantly close-ended questions (Kelly 2006 as cited in Skea 2010) .

2.4.3 Attitudes and perceptions

In some research studies, the researcher may need to gain insight into attitudes and perceptions, and how they modify human behaviour. An attitude refers to a mind-set, or a tendency to act in a particular way, due to an individual's experience and personality (Pickens 2005). An attitude includes three components:

1. An affect (a feeling),

2. Cognition (a thought or belief),

3. And behaviour (an action). (Pickens 2005)

A perception on the other hand is the process by which human beings interpret and organize reaction to stimuli and produce a meaningful experience of their world. The person interprets stimuli into something meaningful to him or her, based on prior experience (Lindsay & Norman 1977 as cited in Pickens 2005). Therefore, it can be argued that determining attitudes and perceptions in qualitative research can be made possible by the use of observation and interview data collection methods as discussed above in **2.4.2**.

2.5 CONCLUSION

The review of the literature has discussed the need for a reconsideration of waste management and the specific management of dental laboratory waste. This chapter also established that there are three factors that influence reusing and recycling. Firstly, in the case of Stoodley, the initiative was motivated by the requirements to comply with the environmental protection agencies. Secondly, there is monetary value in recycling. Lastly, some extent of environmental consciousness was identifiable.

In the absence of research into current local dental laboratory waste management, it is clear that an evaluation of attitudes and perceptions towards waste management systems and the value of reusing and recycling dental laboratory waste is both opportune and necessary. The next chapter will discuss the specifics of methodology that was employed.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This study explores the management of waste in commercial and training dental laboratories to determine the perspectives and attitudes of dental technology practitioners and dental technology academics towards reusing and recycling dental laboratory waste products. Consequently, this research engaged the views of those people within the dental technology industry in the position of influencing and thus implementing waste management. In this chapter, the research design adopted will be discussed and a detailed report of how the lines of inquiry were developed to answer the key research questions. Interviews and observations data collection methods and data analysis will also be discussed in detail. The objective of this study was to understand waste management in the context of dental laboratories, hence the adoption of a qualitative inquiry.

This chapter also discusses the theoretical and ethical principles underpinning this study as well as detailing the methodology used for sampling and data collection. Finally, it is argued that the methodology used ensured that the data obtained was trustworthy.

3.2 QUALITATIVE RESEARCH PARADIGM: A THEORETICAL FRAMEWORK

This research was conducted in a qualitative paradigm. The qualitative approach is seen as the way to gain insight through discovering meanings by improving our comprehension of the whole. Neil (2006), states that “Qualitative research explores the richness, depth and complexity of phenomena”. Broadly speaking, qualitative research refers to those kinds of research that produce findings not arrived to by means of statistical procedures or quantification but findings that are a result of rigorous interrogation and analysis of text data (Strauss & Corbin 1990 cited in Neil 2006).

A qualitative approach to an inquiry leads to semi-structured data collection technique and qualitative data analysis methods (Creswell 2009). Qualitative research focuses on the contexts and meaning of human lives and experiences in natural settings. Creswell (2007), adds that in qualitative research the inquirer inductively develops theoretical patterns of meaning, by rigorously interrogating the text data collected from

the field. A major strength of qualitative research is the depth to which explorations are conducted and descriptions are written, usually resulting in sufficient details for the reader to grasp the peculiarities of the situation (Miles and Huberman 1994). In this respect, competence in carrying out the investigation and analysis is key (Miles and Huberman 1994)

3.3 RESEARCH PARADIGM OF THIS STUDY: METHODOLOGY

This qualitative research project was conducted in the interpretive paradigm. The interpretive approach relies on naturalistic techniques such as interviews, observation and analysis of existing texts for deriving data and extracting meaning (Black 2006).

The study was limited to waste management in dental laboratories and interviewed laboratory owners, technicians and academics based in the KwaZulu-Natal province of South Africa. The study was conducted in two phases. The first phase was the observation of waste management in different dental laboratories paying special attention to whether the reuse and recycling of dental laboratory waste materials occurred, and if it did, what happened to the recycled materials. The second phase consisted of semi-structured interviews with dental laboratory owners, dental technicians/technologists and dental technology lecturers at the Durban University of Technology (DUT). The use of open-ended questions in these semi-structured interviews allowed for both the interviewer and the participants to discuss certain topics in more detail. In instances where the participant had difficulty answering a question, the interviewer would encouragingly probe for more explanation or clarity. Both these data collection phases are discussed in detail in sections **3.4.4** and **3.4.5.**

3.4 DATA COLLECTION AND SAMPLING

3.4.1 Sampling methods

A list of (KZN) KwaZulu-Natal registered dental laboratories was obtained from the South African Dental Technicians Council (SADTC). The details of the list provided by the SADTC were then verified, through reference to the yellow pages and online public databases (according to practice names) and/or telephonic verifications in respect of scope of practice. The purpose of this verification was to determine the accuracy of

SADTC data regarding physical address, email address and scope of practice of the specific laboratory.

3.4.1.1 Inclusion Criteria

The criteria for inclusion were:

1. Dental laboratories had to be registered with SADTC for minimally five continuous years.
2. The academic staff members registered with the SADTC and currently employed at DUT.
3. Laboratory owners who are actively registered with SADTC for a period of minimally five continuous years.
4. Dental technicians/technologists who are actively registered with SADTC for a period of minimally five continuous years.

3.4.1.2 Exclusion Criteria

The exclusion criteria were:

1. Registered dental technicians/technologists that are pursuing post graduate studies full time.
2. Those registered dental laboratories in which the researcher was employed before being employed at the Durban University of Technology as a lecturer.
3. Dental Technology staff who are not dental technicians and those who are not employed by DUT in terms of the University's definition of an academic.
4. Those laboratory owners who are dentists[2].
5. Those registered dental laboratories which are referred to as one-man laboratories[3].

3.4.2 The sampling technique

Dental laboratories, dental laboratory owners and employee dental technicians were randomly selected using the "simple random sampling " technique which entails

[2] It is legally possible for a dentist to own a dental laboratory, but this research is limited to the views of dental technologists/technicians.
[3] Those laboratories in which the laboratory owner works by him-/herself with no employee dental technologists/technicians.

selecting numbers from a hat to ensure equal probability of selection (Crano, Brewer and Lac 2015).

For the observation phase two lists for random sampling were created. One list was that of general dental laboratories[4] and the second was a list of specialist laboratories[5]. Two laboratories were required from each list for the observation phase of the study. The first list contained 33 laboratories and the second list 10 laboratories. Both lists were then allocated numbers. These numbers were then transferred to small pieces of paper and the numbers from the two lists placed in two separate containers. All numbers, after shuffling were drawn from each container by an independent person. Numbers drawn were recorded sequentially until all numbers in the two containers were exhausted. The laboratories drawn from the lists were then identified by reference to the lists. Thereafter the laboratories, randomly selected, were contacted and invited for participation in the order that they were randomly drawn from the respective containers. In the event that the invitation to participate in the study was declined, the next name on the list was selected until the two general and two specialist laboratories agreed to participate. The two general dental laboratories were coded as Laboratory A1 (LA1) and Laboratory A2 (LA2) and two specialist laboratories were coded as Laboratory B1 (LB1) and Laboratory B2 (LB2). Laboratory LB1 specialises in crown and bridge only and LB2 specialises in Prosthetics only. The researcher verified years of experience for dental technicians/technologists and years of establishments for dental laboratories during invitations to participate.

For the interview phase, the researcher formed a list containing 90 dental laboratory owners from the SADTC list of registered laboratories. Those laboratory owners whose laboratories were involved in the observation phase of this study were not included.

This study employed the same sequential sampling technique used for observations to obtain seven Laboratory owners and seven employee dental Technicians/Technologists. Employee dental technicians were selected according to the laboratory owner being interviewed. Thus, once the laboratory owner had been selected his or her employee was also invited to participate in the study and be

[4] A dental laboratory in which all four disciplines are practiced is referred to as a *general* dental laboratory.
[5] A dental laboratory that does not practice all four disciplines is referred to as a *specialist laboratory*.

interviewed. The laboratory owners were coded as LO1-LO and DT1-DT7 for employee dental Technicians/Technologists.

The seven academic staff who are dental technologists were purposefully selected. Purposive sampling was used because the target population was discipline specific. Tran & Perry (2003 cited in Tongco 2007) informs that one of the reasons for researchers to use purposeful sampling is a population that is too small for a random sample. The seven academics were then invited to participate and coded as academic staff AS1-AS7 respectively.

3.4.3 OBSERVATION PHASE

The number of dental laboratories for the observation phase was limited to four. This sample size is regarded as sufficient (Bailey 2007). Bailey states that sample sizes for field observations may be as small as one location being researched or two locations being compared. Constable *et al*. (2012), add that the observation data collection period can be less than six months provided that it is paired with other techniques. In this study, the observation phase was a supplement to the interviews which were the main technique of data collection.

The observation sample of this study was established to include the different types of dental laboratories that exist in the industry. The sample consisted of:

1. Two dental laboratories, one specialising in crown and bridge and the other in prosthetics; and
2. Two general dental laboratories practicing all four disciplines of dental technology (Crown and Bridge, Orthodontics, Chrome, and Prosthetics).

The main objective of conducting observations before the interviews was for to gain greater understanding of current dental laboratory waste management practices as opposed to solely relying on her industry experience. Thus, finding out what is being practiced by the industry before finding out why the industry practices waste management the way it does. In other words, it was sought to establish what materials are reused and consequently recycled as well as what materials are recycled outside of the laboratory. For this purpose, the average duration for each observation was five hours.

In carrying out the observations, a self-devised checklist containing all possible dental laboratory waste materials was employed, refer to Annexure 6. All observations were recorded by taking notes and the recording of laboratory practices of waste management with still life images. The observation sheet facilitated the recording process as opposed to relying on note taking alone. The observation schedule and observation sheet are included as Annexure 6 and Annexure 7 respectively.

It was needed to verify information observed from the laboratory personnel in the dental laboratory during the observation. When necessary, unobtrusive requests for clarification that did not interfere with flow of work in the laboratory were posed to respondents. At the end of every visit, the laboratory was given sight of the photographs captured and the completed checklist. This was done to ensure that transparency and confidentiality are maintained as per the signed research participation agreement. According to Shenton (2004), letting the participants verify data is a valuable contribution with regards to credibility of research findings. The notes gathered during observations were used to formulate a reflective report which was later used alongside interview transcripts for data analysis.

3.4.4 INTERVIEW PHASE

The number of participants interviewed were 21 in total, consisting of seven dental laboratory owners, seven employee dental technicians/technologists and seven academic staff (lecturers in the dental technology programme). In qualitative research adequacy of data is not dependant on the number of participants but in attaining sufficient data to account for and understand the phenomenon being researched. A point where the researcher no longer finds new information that contributes to the understanding of the research problem is called saturation (Creswell 2007). It was clear during the interview process that a point of data saturation was reached before all participants were interviewed. Nevertheless, all 21 participants were interviewed to ensure trustworthiness of data obtained.

All of these interviews were conducted by the same person in English at the participants' work places. The average duration of the interviews was 25 minutes with the longest interview being 43 minutes. The interviews were audio-recorded, and the participants were made aware of the recording device. At the beginning of each

interview the interviewer introduced herself and verbally reassured participants of confidentiality and freedom to withdraw, an approach supported by Gillham (2000). It is at this point that the participant signed an informed consent form outlining the purpose of the study and ethical considerations. The informed consent forms were sent to the participants electronically before the date of the interview. The questions that guided the semi-structured interviews are included as Annexure 5.

3.5 DATA TRANSCRIPTION

The audio recorded conversations were transcribed by a professional data transcriber. Upon receipt of the interview transcripts, the researcher read all the transcripts while listening to their respective recordings to rectify transcription errors. Transcription errors were found mainly in respect of dental technology terminology. Typographical errors were then corrected prior to coding of the interview data into categories and themes.

The text from the transcribed interviews and from the reflective report from field notes were coded to form conceptual categories for thematic analysis using the latest version of research software, NVivo® version 10.

3.6 DATA CODING AND THEME IDENTIFICATION

The qualitative data set consisted of interview transcripts and the reflective report that was compiled at the end of the observation phase. The interview data set was coded according to the different groups of interview participants, in order to appreciate the composition of the sample for data collection. Thereafter, themes and sub-themes were identified.

3.7 KEY RESEARCH QUESTIONS AND OBJECTIVES

This research answered the following key research questions:

1. How is the waste managed in dental laboratories?
2. What are the perceptions and attitudes of dental technicians/technologists and academics towards waste management systems that value and employ recycling?

3. What are the benefits and opportunities of recycling dental laboratory waste?

Data obtained was coded in order to address the objectives of the research which were:

1. To establish and report on the extent of waste management that entails waste reduction through reusing and recycling.
2. To uncover alternative uses for dental laboratory waste and the possible economic benefits thereof.
3. To inform the dental technology industry on environmental sustainability as a benefit of recycling and reusing.

3.8 ETHICS

The ethical clearance for this study was obtained from the DUT Institutional Research Ethics Committee, a copy of ethical approval is included as Annexure 1. Permission was obtained from the Institution's Director of Research to conduct research at DUT in the Department of Dental Sciences, to interview dental technology lecturers, refer to Annexure 2.

Informed consent was obtained from the research participants. Copies of Information letters containing the outline of the data collection procedures and the informed consent are included as Annexure 3 and Annexure 4. Denzin and Lincoln (2013) include informed consent privacy and confidentiality of participants as areas of consideration with regards to ethics. Consequently, the identities of all the research participants were kept confidential. Throughout this study, the general dental laboratories are referred to as Laboratory A (LA1-LA2) and Laboratory B (LB1-LB2) for the specialising dental laboratories. Dental technicians/technologists are referred to as DT1-DT7, dental laboratory owners as LO1-LO7 and academic staff as AS1-AS7 respectively.

3.9 TRUSTWORTHINESS

3.9.1 Understanding trustworthiness

Trustworthiness refers to the extent to which results from the generated qualitative data are believable and worthy of consideration (Bailey 2007). Guba (1981), reports on a four criteria model of ensuring trustworthiness comprising credibility, transferability, dependability and confirmability of data. This model serves to inform qualitative researchers of confirming the trustworthiness of their findings. The four aspects of Guba's model can be understood with and builds from the positivist's criteria of ensuring validity. It is noted that credibility replaces or corresponds to internal validity, transferability to external validity or generalisability, dependability to reliability and confirmability to objectivity. The evolution and application of Guba's model has been notably reviewed and adopted by most researchers and established methodologists (Shenton 2004; Morrow and Williams 2009; Denzin and Lincoln 2013).

Credibility is the extent to which the qualitative research findings are believable. It centres on the truth of the information gathered, as opposed to the amount of data gathered (Polit and Beck 2010).

Transferability is achieved when the researcher's findings are applicable in other contexts. The responsibility of the researcher is to ensure sufficient description of contextual information about the inquiry to enable other researchers to use data truthfully in different contexts (Guba 1981).

Dependability relies on the consistency of the data. However, Guba (1981: 86) advises that "the researcher must allow for apparent instabilities of data arising because different realities are being tapped or because of instrumental shifts stemming from developing insights on the part of the investigator as an instrument"

Confirmability of data is directly related to neutrality on the researcher's part. It is concerned with balancing out predispositions by the researcher ensuring that the findings are the results of the experiences of the participants rather than the researcher's preferences (Guba 1981; Shenton 2004).

3.9.2 Trustworthiness of the results of this study

In this study, Guba's model of trustworthiness was adopted, as explained above, to validate trustworthiness of the data obtained in the study.

Credibility was achieved by the number of diverse participants for interviews i.e. Dental laboratory owners, dental technicians/technologists and dental technology lecturers. The study participants interviewed were in sufficient number so as to ensure saturation of data and that data obtained was credible.

At the end of the observation visits data obtained during the visit was verified before leaving the laboratory. Consequently, the data obtained was creditable in that both the observer and the owner of the laboratory being observed were in agreement to data collected. The verification process served to reassure participants of the transparency and confidentiality that was agreed upon.

Shenton (2004), argues that "interviews should not be closed before the data obtained is verified". Consequently, at the end of each interview sub-category, the interviewer asked the interviewee if their responses could be verified. Interview questions were then repeated and the interviewee's response to each question was confirmed. Shenton (2004) provides clarity where he argues:

"Analysis and verification is something one brings forth with them from the field, not something which can be attended to later, after the data are collected. When making sense of field data, one cannot simply accumulate information without regard to what each bit of information represents in terms of its possible contextual meanings"

(Shenton 2004: 69)

In qualitative research, credibility is enhanced by the researcher's understanding of the area of study. In turn, the findings of the research project will be more trusted (Shenton 2004). The researcher's qualification in dental technology and experience in the industry enhances credibility of the data generated. Subsequently, the possibilities of the participants giving untruthful information were minimised. The researcher also independently completed a short course on waste management to gain better understanding prior to undertaking a study that deals with waste.

It was clarified to the participants, through the informed consent, that the purpose of this study was not to endorse or critique any waste management strategies, but to

explore and uncover practices of reusing and recycling and the benefits thereof. This was emphasised at the beginning of each interview and observation expressly to discourage behaviour modification and again untruthfulness of responses. The use of random sampling techniques also contributed to the elimination of research bias and to the credibility of this study. Finally, the expertise and work experience of the participants contributed to the credibility of this study. They had in depth knowledge of the properties and behaviour of dental materials in respect of recyclability and reusability.

Transferability as an aspect of trustworthiness was promoted thorough descriptions of the settings for data collection, sample makeup and research methods and techniques. These have been described in earlier sections of this chapter. The descriptive methodology would further enable the findings of this study to be related to different dental laboratories. Another factor that contributed to transferability was ensuring that the interview data is based on the context of this study. A threat that was identified was the broadness of the understanding of waste management. At the beginning of an interview, the interviewer explained the context within which the term is relevant to this study and kept the participants in check throughout the interview. More details of the explanation of waste management to the participants and supporting data will be found in the succeeding chapter.

In this study, dependability relied on the same techniques used to ensure transferability and to allow future researchers to repeat this study and evaluate the effectiveness of the research methods implemented. Hence the detailed descriptions of research methods, techniques and the phenomenon under study were given. Data collection techniques overlap were employed (observations and interviews) for compensation of weaknesses that may be found within each technique.

Qualitative researchers must be able to identify and minimise the Hawthorne effect and bias in order to enhance neutrality. Monahan and Fisher (2010), describe the Hawthorne effect as an effect that may be caused by the researcher which may cause the participants being observed to behave more conscientiously in response to their awareness of being observed. To address or possibly eliminate the potential Hawthorne effect associated with observation phase, the interviewer and the dental laboratory owner agreed upon unspecified time of arrival for the observation. In this study, possible bias was acknowledged and addressed by excluding dental

laboratories where the researcher had worked in from the research sample as well as people who are directly involved in this study.

In addition, It was ensured that the detailed findings were the perceptions of participants through verification of the transcribed data against raw audio recorded data. This also ensured that the context of the research was not lost as a result of transcription errors.

3.10 CONCLUSION

This chapter has captured how data collection was planned and executed. The sample size that was used acceptably determined the three interview groups were properly selected and interviewed. The sample for dental laboratory observations was also representative of all types of dental laboratories. The data collection strategies were applied successfully, and the planned sample was achieved. The data collected will be described and discussed in the next chapter in order to give an in depth understanding of how recycling and reusing of dental laboratory waste is viewed by the dental technology industry in KZN.

CHAPTER FOUR: FINDINGS AND ANALYSIS

4.1 INTRODUCTION

This chapter reports on the findings obtained through observations of waste handling in dental laboratories as well as the qualitative data obtained through interviews conducted in terms of this research. The observation phase was undertaken prior to the interviews and the information obtained informed the interview process.

The report of findings from the interviews completed with dental technicians/technologists, dental laboratory owners and academic staff members is supported by quotations from the respective participants. Interview transcripts were verified against audio files to ensure that the interview data was trustworthy. This data was then interrogated and themes were identified and coded. Sub-themes emerged during the process of coding. *Table 4* illustrates main themes and subthemes that were identified from the qualitative data set.

Table 4: Themes and subthemes.

THEMES	**SUBTHEMES**
Theme 1: General understanding of Waste Management	1. The understanding of dental laboratory waste materials. 2. Attitudes to the environmental impact on the earth's ecosystem. 3. Environmental impact of dental laboratory waste on laboratory facilities 4. Understandings, knowledge and attitudes to landfill sites.
Theme 2: The responsibility of knowing and compliance with waste management regulations.	1. The role of waste management education in dental technology.
Theme 3: An outlook of reusing and recycling in dental laboratories.	1. Economic considerations of reusing and recycling dental laboratory waste. 2. Practices of reusing and recycling in dental laboratories. 3. Recycling opportunities for the industry.

4.2 ANALYSIS OF FINDINGS

4.2.1 Findings from the observation phase

Recordings on an observation sheet enabled the researcher to gain insight into the types of materials commonly used in dental laboratories as well as to the dental laboratory waste (DLW) practices and the recycling and reusing of materials in selected dental laboratories. The observations served to inform the reseach interviews undertaken in this study.

The observed DLW materials are recorded, based on a study by Komilis (2009), in *Table 5* below with reference to their toxicity which consequently informs their safe method of disposal.

TABLE 5: Dental laboratory waste disposal methods.

Infectious and potentially hazardous waste. **(Disposal as hazardous waste)**	**Non-infectious toxic waste.** **(Disposal requiring specialised disposal methods)**	**Household type waste.** **(Safe to disopse of through municipal waste disposal systems)**
Hydrocolloids	Metals	Gypsum
Surgical gloves	Investment materials	Slurry water
Silicones	Dipping hardener	Porcelain
Acrylics		Cotton wool
Pumice		Sand paper
Plastic delivery packets		Waxes [modelling, inlay, etc.]
		Boil out wax
		Plastics
		Paper
		Domestic waste

It was established during the observation phase, that dental laboratories observed were reusing some of their waste products from the materials listed in *Table 5.*

The materials that were reused include sand from the sandblasting machines. This sand exists as either Aluminium Oxide, glass beads or Silicone Carbide grit. Sand was preserved and reused by using an old stocking to sift and separate investment material left behind from the process of sandblasting[6], *Figure 6(a)*. This process was carried out for both crown and bridge and chrome procedures. However, the sand that was sifted from crown and bridge sandblasters was only resued for chrome work to avoid contamination of the metal substructures for ceramic work. The reused sand was also recycled for pumicing procedures[7] in proportions of 50% sand and 50% pumice.

Figure 6(a): Used sand being sifted in order to be reused.

Other recycled waste was the waste from silicone material used for model duplication that was reused by chopping used material into multiple pieces to use again as a base when pouring in new silicone. The silicone pieces take up the extra space around the base of the model where no intricate detail is required, therefore limiting the amount of new silicone to be used in the vital anatomical landmarks, *Figure 6(b)* in the next page illlustrates. In addition to saving environmental resources, the reuse of this silicone has economic benefits to the laboratory as the material is very expensive.

[6] Sandblasting is the process whereby an abrasive sandy material is accelerated through a blasting nozzle by means of compressed air, to remove investment material from cast metal structures.
[7] Pumicing procedures are used for smoothing surfaces of acrylic appliances and prosthesis prior to polishing.

Figure 6(b): Illustrates a solid silicone mould (left) that gets chopped up to use as a base for pouring a new mould (right).

It was was also observed that left over offcuts of wax[8] were melted and poured into silicone moulds to form occlusal rims, *Figure 6(c*). Another method of reusing wax was through repeatedly dipping a glass bottle filled with ice cold water into molten wax to form wax sheets, *Figure 6(c)*.

The application of the reused wax products is limited to preparatory work such as, spacers for custom impression trays and occlusal rims[9], this is due to the loss of the elastic properties and the esthetically pleasing colour of the wax.

Figure 6(c): A wax of sheet (left) and wax occlusal rims (right) formed from molten used wax.

The left overs of acrylic denture base material and old acrylic custom impression trays were saved for reuse as fire starters for braais[10], *Figure 6(d)*.

[8] The wax referred to here is wax used in the production of dentures.
[9] Occlusal rims are used for bite registration in denture construction.
[10] A use disconnected to the commercial activity of a dental laboratory.

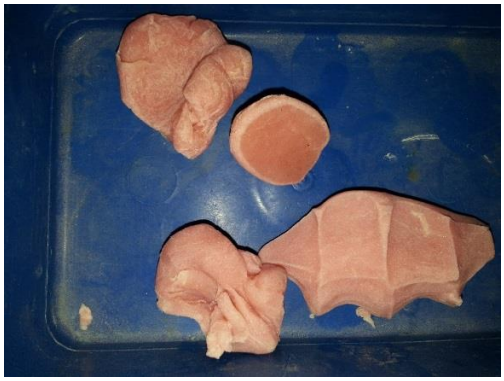


Figure 6(d): Acrylic material left from denture processing (left) and old special trays(right)

There were three different ways observed in which gypsum products were reused. Firstly, the set gypsum material was stored to be used for making slurry water[11] that assists in accelerating the rate of setting of newly mixed gypsum. This method reduces waiting times in laboratories by accelerating setting time of newly mixed gypsum, *Figure 6(e)*. Secondly, old models were used as a base of pot plants for the purposes of retaining the fertile pot plant soil. Lastly, left over gypsum soft mixture was used to produce models (in the shape of hearts, star fish, dolphins and teddy bears) and given to a day care centre who used these models to allow the day care children to paint them, *Figure 6(e)*.


Figure 6(e): Set gypsum left over from denture processing (left) and heart-shaped plaster and stone poured from a silicone mould.

From the observation sample, majority of dental laboratories were seen to creatively manage their waste through reusing and this will be further discussed in the next

[11] Slurry water is the waste water which is released by the plaster model trimmer

chapter. In addition, there was an act that was directed at preventing blockage of drainage systems by boiled out wax. This was achieved by tying a stocking at the end of the pipe outlet inorder to trap the wax and prevent it from reaching the drain. The interviews were then conducted in order to establish and report on the extent of waste management that entails waste reduction through reusing and recycling in dental laboratories. The interviews interogated whether the results of the observation phase were wide spread throught the industry.

4.2.2 Findings from interviews

THEME 1: General understanding of waste management by dental laboratory owners, employee dental technicians/technologists and dental technology lecturers in KZN.

During the interviews, an understanding of waste management was initially discussed. These discussions ensured that the rest of the data collected was within the context of this study. The data generated indicates that the different participants differently understood the term waste management. In this study, waste management refers to practices and procedures that relate to how waste is handled or dealt with, including reusing, recycling and disposal (Jee and Shagufta 2010). Only a minority of participants across the sample constituents understood waste management as defined in this study.

> *"Well, basically what comes to mind, is the stuff that we use, that we, which we can save, and then will not harm the environment and we can recycle it."*
>
> *[LO6]*

> *"It has to do with you as an individual having to identify things that you can recycle, things that should not necessarily go to landfills. Because if you try and sort out the waste, whereby there is less waste going to the landfills that means that the landfills won't get full so quickly and less land will actually be used for the landfills which means more land can be used for other things which in return can, how can I say it, reserve [sic] nature."*
>
> *[AS2]*

> *"I usually think of it as being where they dispose of waste in such a way that it does not end up in the usual place, but where it is going to be recycled or using some sort of form or way of separating it, or you know, instead of just throwing it in the bin. It is using other methods."*
>
> *[DT6]*

From the quotations above, recycling and waste disposal were identified as fundamental acts in practicing waste management as defined in this study.

Notwithstanding the positive responses, the majority of participants interviewed did not understand what waste management was. They saw waste management in a narrow

context as merely a localised laboratory practice. They understood managing waste in terms of not wasting dental materials in the laboratory.

> *"I think it is regarding the wasting of the materials".*
>
> *[DT7]*

> *"I don't know. If you're talking about wastage of materials (interviewee paused for thought before continuing), is that what you're talking about?"*
>
> *[LO3]*

Wasting of dental materials may affect the dental laboratory economically making it more profitable but interviewees were not able to see a link to saving the environment. The understanding of waste management differed between participants. One participant stated that waste management is simply a process whereby a technician knows the materials and uses them effectively thus saving costs.

> *"Waste management is a dental technician who understands the cost implications of using any dental material and from thereafter how one goes out saving costs in terms of saving materials. That is what my minimalistic understanding of what waste management is".*
>
> *[AS3]*

From the above reporting it can be seen that the focus of the study participants is on cost saving and not on any understanding that waste management involves the sustainability of the planet through environmental friendly practices.

The discussion now turns to the understanding of dental laboratory waste materials.

Subtheme 1: The understanding of dental laboratory waste materials.

Waste management requires knowledge of the classification of waste one produces. Such knowledge enables the waste producers to be able to dispose of waste safely and appropriately. The majority of participants identified the different waste materials produced by their laboratories into hazardous, potentially infectious, and non-infectious. However, even though they were able to identify waste according to the said categories they did not apply waste disposal methods that are specific to respective waste types.

Technicians were able to identify dental impression materials as potentially infectious. There was an understanding that incorrect disposal effects a greater community outside the dental laboratory.

> *"I'd say number one is the discarded impressions, after we've poured them. That is the most …, in terms of infection."*
>
> *[DT2]*

There was a general understanding that any waste material that has been exposed to the patients' mouth is infectious.

> *"Impressions, try-ins, any models that had try-ins on or anything related to that. Anything that was in contact with the patient's mouth, either directly or indirectly is a potential hazardous, well infectious."*
>
> *[AS6]*

Notwithstanding an understanding of the potential hazardous effects of some dental materials there was a general consensus that showed little concern for the correct disposal of hazardous waste by discarding this infectious waste through the normal municipal disposal system.

> *"Infectious? Okay, it could be the impression material, especially Alginate. We do like put that in the normal garbage."*
>
> *[DT4]*

Another identifiable laboratory hazard was dust from grinding during finishing procedures whereby the dental materials contain ingredients that can cause cancer and affect the respiratory tract, hence the use of facemasks.

> *"I would say mainly the dust that we do, because we use materials that can cause cancer so we do have to wear facemasks and all sorts of things like that. So it's not very good for the environment and for other people."*
>
> *[DT6]*

> *"Very hazardous is the metal. I know of people who have lung problems because of the metal they have inhaled if you do not wear a mask. Some people have a reaction to the plaster dust."*
>
> *[LO7]*

Flammability of waste products such as polymethyl-methacrylate (acrylic) was identified as a fire hazard to the laboratory.

> *"There's like so much of waste acrylic by the end of the week, you know. And that's flammable. Ja, so that's definitely a hazard. That's definitely a hazard."*
>
> *[LO6]*

In addition to acrylic being hazardous in the laboratory, it was also recognised that the material was also hazardous which should be disposed of correctly so as not to pollute the environment should a fire occur.

> *"Um, also our monomer[12] that we are using for our special trays or repairs, that monomer, the heat cure or cold cure, they are also like hazardous to the environment. If they have been mishandled they can cause some fire".*
>
> *[DT5]*
>
> *"If there is a fire nearby it [monomer] can actually make the fire worse".*
>
> *[AS2]*

In addition to flammability, non-decomposing materials were seen as a hazard to the environment. This view is relevant to the existing challenges regarding the overfilling of landfills as well as the expenses of maintaining landfill sites.

> *"The metals and gypsum models and basically all the materials that you throw out, I would say they are hazardous because they don't decompose".*
>
> *[AS4]*

The findings reported in this subtheme indicate that to some extent the participants were able to understand hazardous and infectious dental laboratory waste. The report now turns to the views and attitudes of the participants regarding environmental impact of dental laboratory waste.

Subtheme 2: The attitudes to the environmental impact of dental laboratory waste on the earth's ecosystem.

Environmental impact is defined as the possible adverse effects caused by a development, industrial, or infrastructural project, or by the release of a toxic

[12] Monomer is liquid Polymethyl-methacrylate.

substances into the environment (Jee and Shagufta 2010). Toxins may affect the environment due to improper disposal of waste and/or through leaching from the municipal or other landfill sites. The majority of participants recognised the possible environmental impact of waste from dental laboratories. These participants expressed that there is a negative impact on the environment from dental laboratory waste although they could not express what this negative impact was.

Some participants demonstrated their lack of knowledge of the toxicity of materials used in the laboratory by suggesting that they know materials that harm the environment but have no idea why and how they do.

> *"You know, there should be a specific way of disposing of Chrome cobalt investment. Ja. Because that harms the earth[13]."*
>
> *[LO6]*

> *"On the environment? I know that we do get rid of some excess plaster and the slurry, in a negligent way. But I don't understand the implications of that."*
>
> *[DT4]*

Land and water pollution are part of environmental impact from waste. A relevant comparison was made that compared dental waste materials as not decomposing, and thus polluting the environment, in the same manner as plastic shopping bags.

> *"…Now remember that plastics, plastics [bags] in stores started becoming, you started buying plastics because they were saying that they, they are polluting the environment and they take long to decompose and all that. And that's the same thing I think about dental materials".*
>
> *[AS4]*

Notwithstanding the relevance in the comparison above, not all dental materials are harmful to the environment. Gypsum is one such example since it is mined from the earth and simply dehydrated prior to dental use.

However, it was erroneously suggested that gypsum in the form of Plaster of Paris, will harm the environment based on the bacteria produced in slurry water after stagnating for a number of days. This participant, showing little understanding of what

[13] The effects of chrome cobalt investment on the environment are unknown and no literature to suggest it has, has been established.

the smell actually was or the cause of it, thought that the smell is an indication of something wrong that would harm the environment.

> *"A lot of the plaster slurries that labs produce on a daily basis have a very bad effect on the environment. They do have a very bad smell so that really can't, that kind of indicates that there is really something wrong with it."*
>
> *[AS6]*

Whilst the majority of participants recognised and understood the possibility of negative impact on the environment from not practicing waste management, they nevertheless did not practice anything to support their understanding of preserving the environment. This was justified by stating that it is in the nature of dental technicians to care about the work they produce and not care about the environment.

> *"To be quite honest dental technicians often work as just that, being a dental technician. We do our work, we go make an appliance and whatever we don't need we throw in the bin, we don't necessarily take into consideration, I included, on the effects to the environment."*
>
> *[AS3]*

The same sentiment was shared amongst other participants who understood the need for good waste management but absolved the dental technology industry from the responsibility of practicing waste management stating that in a dental laboratory everyone is busy.

> *"Obviously there is a need but the point is everybody is busy in their labs, whose job it is or who is going to take it up and see what you can recycle. The thing is who is going to take up that responsibility and do that? One of you guys[14] I think."*
>
> *[LO5]*
>
> *"But the problem is in the dental laboratory because of time and the way we're structured and obviously nowadays with the way the pricing is regulated, there's not enough time in an eight-hour day [to practice waste management]."*
>
> *[LO2]*

The fact that the industry sees waste management in terms of available time will be further discussed in the results chapter.

[14] The interviewee is referring to academics in teaching institutions.

The attitude of distancing the industry from practicing waste management due to time constraints was echoed by another participant who went further and expressed that waste management would be more effective if a third party offers to do it for the dental industry.

> *"If you have a company coming to you to collect your [dental laboratory] waste like how it is done with paper and your glass and your plastic and if there are other things like cans, it's effective."*
>
> *[AS 5]*

Although this participant recognised the constraints limiting laboratories to practice waste management, he/she, nevertheless, had a constructive opinion.

A held opinion was that dental laboratories do not generate volumes of waste that could cause concern for the environment. Persons holding this position failed to understand that small amounts do contribute to the whole. Therefore, it was stated that a dental laboratory is not a place where high volumes of waste are produced like in some large factory, implying that not much toxic waste is thus produced.

> *"Because the laboratory is a very personalized job, it's not a factory[15], like in this laboratory here, we've got four technicians and three assistants and two contracted drivers, one person that's like a secretary. So how much of work can three or four qualified technicians really produce in one day, then how much of toxic waste is over there, you know what I'm saying?"*
>
> *[LO2]*

Another expression aligned to the previous, was that small industries do not have a responsibility to practice waste management and thus indicated negating the responsibility of the industry to waste management matters.

> *"I think these big other companies, they may be more environment thing [environmental conscious], than our dental industry."*
>
> *[DT7]*

[15] A dental laboratory is however a factory, as it is a place where appliances (prostheses) are manufactured.

Subtheme 3: Environmental impact of dental laboratory waste on laboratory facilities.

The findings that are reported under this subtheme reflect the participants' understandings concerning impact of dental laboratory waste on the environment at large. It became evident that the participants were more concerned about their personal health that emanated from conditions in the laboratory as well as the effects on the environment. Because of the chemical components of dental materials there is some effect on the individuals working in the laboratory and also on the environment but do not appear to know what that effect is.

> *"I am sure it has a lot of effects on you and the environment. The chemicals and the stuff that we work with."*
>
> *[DT1]*

Interviewees did appear to understand some health and safety hazards to persons working in dental laboratories. One participant stated the possibility of saliva contamination from dental laboratory waste and the possibilities of saliva borne infectious diseases such as Hepatitis or Tuberculosis.

> *"I am also safeguarding my plaster boy[16]. Right, if I don't tell him this sort of thing, you might just find that patient the patient's impression, that patient might just have some sort of …Maybe hepatitis or tuberculosis, something like that, and they tell you any liquid or saliva contact can give you this."*
>
> *[LO1]*

Regardless of the interviewee's perception of occupational health hazards associated with contracting infectious diseases in a dental laboratory, there is an evidence of disregard of proper waste management and a reluctance to practice proper disposal methods for the contaminated waste. Another participant practices infection control but not waste management.

> *"We do use gloves when we are casting models that has blood and stuff in [on] it. The gloves are supplied for my staff. It is disposed in a general bin. Okay, so I don't have specialized glove disposal units like how a surgery is supposed to have."*

[16] The use of this term maybe offensive to some. However, the words stated by the interviewee have been transcribed verbatim.

[LO2]

In addition to occupational health hazards, laboratory infrastructures are also affected by waste handling. Slurry water and general wastewater was one of the types of waste identified as having a negative impact on the laboratories' water drainage facilities. One participant expressed that they change their drainage pipes yearly.

> *"Our plaster trap, believe me, every year, we take all the pipes out, and they put brand new pipes in."*
>
> *[LO6]*

In addition to plaster slurry, wax was identified as one of the materials that blocks the laboratories' drainage pipes. Another participant reported that he/she has resorted to using chemicals (caustic soda) to solve the wax blockade problems regardless of its fatal effects if ingested.

> *"Sometimes that wax goes into the drain and it tends to solidify and you find that thing affects your drains. And then this is where I use a caustic soda but it is very toxic, very dangerous. Just put a scoop inside of that, pour the water and it's like a charm it works, you find everything just gone down."*
>
> *[LO1]*

Caustic soda (Sodium hydroxide) may be toxic if disposed of in high concentrations into the wastewater stream, which may in turn be fatal to aquatic living organism but not necessarily to humans (Solvay 2012 online, accessed 2015).

One participant who seemed to be conscious about the environment, suggested, perhaps closer to the truth, that as much as laboratories employ preventive measures towards drain blockages, they only do so with their infrastructure in mind and not the environment.

> *"We do have special sieves, and things to try and separate the plaster from the water before it enters the drain system and so ja, I think in the laboratory, they mainly do that because they don't want the drains to be blocked, more than thinking of the environment.*
>
> *[DT6]*

Once again, responses show that dental technology practitioners are more concerned about their business and neglect the issues of sustainabilty of the planet they live in. This will be further discussed in the results chapter.

Subtheme 4: Understandings, knowledge of landfill sites and attitudes towards them.

This theme reports on findings obtained about the participant's understanding of dental laboratory waste disposal. As previously mooted in subtheme 1, understanding the type of waste one produces enables them to dispose of such waste in a responsible manner.

A minority of participants did understand that waste ends up in landfills and waste sites. However, they did not demonstrate knowing what happens to the waste thereafter.

> *"From the lab it goes into a skip and then that skip gets picked up and taken to a landfill."*
>
> *[AS6]*

> *"It gets picked up by the municipality, they then take it to the waste site."*
>
> *[LO1]*

Another participant expressed that waste ends up in a landfill but he\she does not know the legislation as to the types of waste that are legally disposable that regulates such disposal.

> *"It goes to the landfill site. Like I say, I don't know what the legislation around it is.*
>
> *[LO6]*

Some participants could identify local landfill sites and expressed what transpired at these sites.

> *"See, I know that there's one in Kennedy Road, that huge landfill. And then, there's one near my home in Marianhill. Ja, they use these huge like tractors with metal wheels, and they just trample on everything, and just level everything out."*
>
> *[DT2]*

> *"There is a dump here in Clare Estate. There is a dump area and everything is dumped in that area there. But I know they do have a different section for household waste, and different for bricks, tiles. They have a different area for that."*
>
> *[LO5]*

Apart from the above participants, the majority did not know where the waste their laboratories generate ends up. One of those participants demonstrated an uncaring attitude towards waste disposal and thus alluded that waste is not his problem since he pays the municipal rates.

> *"From the lab? You put it in plastic bags, you take it outside and they come and collect it just now. What more can I say? That's the waste department['s problem], it's not my problem. (Laughs) I pay them rates. I pay them rates".*
>
> *[LO4]*

The discussion now turns to the theme reporting on the importance of understanding and awareness of waste policies by dental laboratory owners.

THEME 2: The responsibility of knowledge and implementation of waste management regulations.

Waste management is regulated globally. In South Africa, waste management is regulated by the Department of Environmental Affairs that is recorded in a number of waste policies and acts. South African Waste Information Centre (SAWIC), a division of the Department of Environmental Affairs, makes these readily available online.

The majority of participants expressed that it is important for laboratory owners to know and implement national waste management regulations for the sake of the profession.

> *"It's imperative that laboratory owners do, because it affects their profession in the long run."*
>
> *[AS7]*

> *"I think it is something they [laboratory owners] should know because it might be good for everyone, so that nobody will be in a position where his life will be in danger because of our work."*
>
> *[DT5]*

The laboratory owners recognised that the industry needed to develop and implement industry specific regulations of waste management using the existing general guidelines as a basis.

> *"Looking at the toxicity of our waste, the volume of our waste, we should implement certain rules. Taking into guideline all the general rules of waste management, and conserving, and draw up a specific one for dental laboratories."*

[LO6]

Even those laboratory owners who did not think there is any negative impact that comes from dental laboratory waste recognised the importance of knowledge of waste management regulations.

> *"I personally don't think that our waste is getting down to anywhere it's harming, but I'm just saying, it's important for me to know [waste management regulations], yes, yes."*

[LO3]

During interviews, it was apparent that waste management and the regulations that govern it were of low priority to the industry suggesting that if a third party provided information then the industry might take cognisance of them.

> *"You know again, if they have to go and investigate they are never going to do. Maybe if a little booklet or something could be made and you know hand it out to them they might take the time to read it [and practice it]."*

[DT1]

The participants representing minority expressed that no guidelines exist for the industry, and the responsibility of the South African Dental Technicians Council to provide legislation in the Regulations that govern the Dental Technology industry.

> *"There's no guidelines in place. Council, all Council says, and I think you know that, is to have a waste trap. So there should be some specific legislation that should fall into our Gazette, and then we say, you know, this is how we dispose of this and that. So I think policies are important. And we don't have that in place".*

[LO6]

It was stated that laboratory owners leave the responsibility to their staff to deal with waste management and, incredibly, do not see waste management as a Management responsibility. Therefore, it was argued that if dental laboratory owners know waste management policies it might enable them to establish dental laboratory waste management systems.

> *"The laboratory owners assume that you as a worker would actually know what you need to do. If the laboratory owners familiarize themselves with like waste management policies then they will be able to put a system where, I mean waste management system."*

[AS2]

Subtheme 1: The role of waste management education in dental technology.

The industry's opinion towards including waste management education in dental technology was researched. From the interviews, it was mooted that waste management and environmental awareness should be taught and practiced as part of a dental technology students' training.

> *"If we educated from our roots, let's just say at the Technikon[17] there you've got a bin that's going to say gypsum, you've got a bin that's going to say wax, you've got a bin you're going to say all models and metals, you're not going to have this problem. But, it's like this here, it has to start from the kindergarten stage and then it's going to come to us, then it will work."*
>
> *[LO2]*

The notion of educating from grass roots was further endorsed. It was suggested that students should be encouraged to practice waste management and recycling as part of their training as opposed to being formally taught in class.

> *"So maybe to empower the students to practice resource management or recycling in their own environments would be more beneficial than us just doing it theoretically."*
>
> *[AS1]*

Another view was that not including environmental education in dental technology would be a big mistake. It was further suggested that the younger generation are the best starting point since the older generation seems not to care.

> *"To not include it [in the dental technology syllabus] would be a big mistake because everyone is going green. Well you see we sort of think we are an isolated entity but we are going to be touched, we all have to play our part in saving the planet and saving the environment and we're contributing to contaminating it. Absolutely, there has to be a very important aspect of the education of the upcoming technicians. Maybe the old people have a mind-set where you know "that's it, there is not much you can do with waste".*
>
> *[LO7]*

[17] The industry often refers to University of Technology training as Technikon training.

It was also suggested that maybe waste management could be taught as short courses outside the formal syllabus.

> *"It should be included; I'm not saying that it should be in a subject where it should be an exam subject. But I'm just saying that it should be …, like I know, okay, we qualified like twenty-some odd years ago, but we did like our safety course. But those little short courses that we did, helped us. So I'm sure this would be of value, definitely, to the students.*
>
> *[LO3]*

The short courses will not only benefit the upcoming dental technicians/technologists but the entire industry in terms of Continuing Professional Development (CPD).

> *"You know what; personally I think environmental studies should count in terms of journals, in terms of CPD points."*
>
> *[LO2]*

The interviews revealed many suggestions as described above. However, even though interviewees had an opinion, they themselves did very little to practice waste management.

There was a view that after qualification, waste management information can reach the industry through DENTASA[18] or the Council by using newsletters.

> *"If there are people who are involved in this [dental laboratory waste management] can give information to DENTASA or the Council, via the newsletters. That is the only way we get information about the industry at the moment, through them. Or even the AGM and all that stuff. If they have information that is going to benefit the labs in terms of cost, environment the people outside, obviously no sane person will throw that out the window. So you are not only saving money, you are also saving the environment."*
>
> *[LO5]*
>
> *"You see, when you are in a lab it's difficult to get a lot of information, we have got a body like DENTASA or a Council. If there is something for us to know – the information can be given to them and DENTASA gives us."*
>
> *[LO5]*

[18] Dental Technology Association of South Africa.

THEME 3: The outlook of reusing and recycling in dental laboratories.

From the observation stage, some dental laboratories were reusing and recycling some of their dental laboratory waste. That led to an investigation of whether there is a widespread of such practices within the dental laboratories in KZN, through the interview process.

Interviewees argued that the idea of recycling of dental laboratory waste could not be successfully implemented in dental laboratories. Those reasons include time, space, technological advancements and deteriorating properties of dental materials.

One participant suggested that to do waste management would mean researching about recycling and therefore stated that the priority of a dental laboratory is not to do research about recycling but to complete work for the clients.

> *"Because one thing in the lab, you are busy the whole time and that has first priority. You've got a job that's going out the next morning, you are not going to sit and do a research on recycling when the guy is waiting for the job. Obviously there is a need but the point is everybody is busy in their labs, whose job it is or who is going to take it up and see what you can recycle."*
>
> *[LO5]*

The more established and experienced participants representing majority of the research sample were adamant that recycling is a waste of time and that recycling is for those people who have nothing to do.

> *"I wouldn't waste my time, for my laboratory I wouldn't waste my time. Can I put it this way, practically it's a waste of time. I have been in the game for 50 years and I have never known anybody to recycle a model, and if they do they've got nothing to do."*
>
> *[LO4]*

Another participant identified space as one of the constraints for recycling, considering that different waste receptacles for different waste products would need to be provided.

> *"For me it's a space issue to facilitate these bins."*
>
> *[AS1]*
>
> *"The problem is now if you look at some laboratories, space is also an issue, okay."*

[LO2]

Technological advancements in dental laboratory procedures were envisaged to reduce waste through elimination of use of certain dental materials especially gypsum and investment materials.

> *"In the future, maybe 20 years' time, where everything is going to be scanned there probably won't be a need for gypsum."*
>
> *[LO5]*
>
> *"Besides that, if you look at it even investment too [will no longer be used], see in my laboratory we've got CAD technology, we don't even invest much work."*
>
> *[LO2]*

Another aspect that was identified as a restriction by the participants was the feasibility of recycling of dental materials by the international manufacturing companies whilst ignoring the fact that much can be done by local recycling.

> *"Because South Africa is such a small market, and these things come from Germany. So I mean, it won't be that feasible for them to collect all the dental laboratory zircon dust[19]."*
>
> *[LO6]*

Material properties deterioration was highlighted as a hindrance to recycling of dental laboratory waste. It was stated that the quality of some recycled dental materials such as wax is altered.

> *"The quality, the texture of the [recycled] wax is not the same. You know what I mean, it's not, but let's just say if you are stuck you must do it."*
>
> *[LO1]*

Because of the decline in properties of recycled dental materials, one participant suggested that perhaps dental laboratory waste could be recycled outside the dental technology industry.

> *"I think there are lots of ways to reuse the materials but maybe not in a dental context because a lot of the properties have been lost in the recycling or the first use process."*
>
> *[AS1]*

[19] Zircon is a term that is used by the industry in short for Zirconium. Zirconium is a greyish-white metal used in the construction of ceramic crowns and bridges.

Another view was that provision of recycle bins by the laboratory owners would not make their staff practice waste management.

> *"Personally for the amount of years that I've been in the laboratory, I wouldn't think the staff would use it [recycle bin system]. I think the laboratory owner won't mind implementing it but I don't think that it'll be followed adequately."*
>
> *[LO2]*

One participant representing a minority with an opposing view thought that provision of recycle bins would help the industry engage in recycling. In addition, this was the only participant who expressed that recycling is part of corporate responsibility and that it does not make sense to negligently dispose of waste.

> *"It would help us a lot. Say there was this other specific company that did all the laboratories, and they brought in bins, that said yellow, green, red. I think we'd adhere to that. And also it's about corporate responsibility. You've got to do something. You know, by just chucking everything in the [municipal waste] bin because it's easier, doesn't make much sense."*
>
> *[LO6]*

In the same context of corporate social responsibility, another participant expressed that recycling is excellent and the dental technology industry needs to come up with effective ways of collecting waste and educating each other. However, this view was his/hers alone.

> *"The recycling is excellent. Everyone is going that route. We just need to find effective ways of people to collect waste and also to educate the laboratories."*
>
> *[LO7]*

In conclusion, the results revealed that the majority of participants see recycling of dental laboratory waste as a burden. The discussion now moves to report about the views of the participants regarding economic benefits of reusing and recycling dental laboratory waste, practices of recycling that currently exist in dental laboratories and recycling opportunities for the industry.

Subtheme 1: Economic considerations of reusing and recycling dental laboratory waste.

Dental laboratories are businesses and it is evident that most activities within the laboratories are viewed in light of maximising profit. Although the major sentiment expressed was against recycling there was a general understanding and acceptance that recycling could have economic benefits for the laboratory.

The participants were able to see the benefits of waste management and recycling in terms of its positive effects on the environment.

> *"If you are saving and recycling, you are saving money, you are saving the environment. So there are no disadvantages in that."*
>
> *[LO5]*

Another participant linked the notion of financial saving to that of environmental protection.

> *"Recycling would be beneficial to their [laboratory owners] lab financially and in terms of being progressive in their field as well you know. Besides which everything is going green right now."*
>
> *[AS7]*

Concerning waste management awareness, it was mooted that putting a reward system in place benefitting all staff in the laboratory will encourage compliance to waste management and recycling.

> *"There must be, obviously there must always be some personal gain and then people will do it. Yes, there must be motivation. If you want your staff to do it, you tell your staff listen, if we're going to get a cheque for like about two thousand rand, I promise you, one thousand rand will go for a braai for you guys, then they'll do it."*
>
> *[LO2]*

The responsibility of recycling in a laboratory is discussed more fully in the next chapter.

Subtheme 2: Practices of reusing and recycling in dental laboratories.

Notwithstanding the negative attitude of the majority of participants towards recycling, there is evidence that there are some reusing and recycling acts that exist in dental laboratories. Whilst it is commendable that they were doing recycling, albeit on a small

scale, it was interesting that study participants were unable to recognise that in fact some of them were indeed practicing waste management.

Metal was one of the materials that were reused by most participants.

> *"The only metal we reuse is the chrome metal and the crown and bridge metal. We were taught to use a button, you know, we were taught to use fifty, fifty. So it's in our system."*
>
> *[LO2]*

The form of metal reuse referred is a standard practice for non-precious metals in dental laboratories.

Another participant practices metal recycling by sending waste containing metal traces outside dental laboratory for refinement. He/she further stated that there is financial gain in recycling the metal.

> *"I never throw the investment and old crucibles away. I just put them into a big tub and I send it to my gold guys[20] and they take out what trace elements of metal is inside there. We never throw any buttons away. I don't know what their processes are for stripping it, but they pay us back for that metal. So all the metal is recycled."*
>
> *[LO6]*

It is also common practice to reuse wax in most dental laboratories. The only consideration to do this is to save money. No reference to the earth's resources was noted.

> *"Wax gets reused, just to do bite rims. What we do is, we use the trimmings of it. The trimmings of it will get put into a separate bucket, and it gets melted to be used again."*
>
> *[LO3]*
>
> *"We recycle our wax. That's one thing that we do recycle. Because wax is expensive wax is like gold for us."*
>
> *[LO6]*

Sand blasting sand used during metal finishing procedures was also identified as a material that can be reused until it can no longer be useful. It was mooted that when

[20] Metal Recovery Company.

this sand is too fine to be further used it is better disposed of in a garden as opposed to filling up the bins.

> *"The sand that we use, you know in the sandblasting room is generally Aluminium Oxide which we recycle and reuse, when it gets too fine, we don't really take it and throw it away in a dirt bin or something, it goes into the garden."*
>
> *[LO2]*

Acrylic (also referred to as plastic) was reused as fire lighters due to it being highly flammable.

> *"Then you got all the waste plastic, which I keep and then I will start my braais with it because it is better than any other fire starter."*
>
> *[LO4]*

The admission of recycling is noted and will be further discussed in Chapter 5. The report now turns recycling opportunities for the dental technology industry.

Subtheme 3: Recycling opportunities for the industry

Notwithstanding the above-mentioned recycling and reusing practices, there were areas that were identified by the participants as unexplored with regards to recycling of dental laboratory waste. These ranged from materials that have a widespread use in dental laboratories to newly developed dental materials. Zirconia was identified as one such material.

> *"I actually know a lab owner that's collecting the stuff, Zirconia, and storing it in drums, and saying, "One day, maybe there'll be a process of putting it back together again."*
>
> *[LO6]*

During the interview, some benefits of gypsum in agricultural practices were mentioned, such as its ability to improve water infiltration of the soil. It was then suggested that gypsum may be recycled collectively by different dental laboratories into a gardening material.

> *"If it [gypsum] does help with water infiltration maybe all the labs can get together, and give it to a farmer or donate it to an organisation that plants their own vegetables."*
>
> *[LO6]*

An alternate use of left over mix of gypsum was identified, where it was used to cast structures for painting activities for kids[21].

> *"I have a whole box of all these little moulds [poured from leftover plaster mixture], and I've got my kids to paint on them."*
>
> *[LO3]*

Whilst this practice promotes the use of excess plaster that would have otherwise been discarded, it is important to note that overmixing of materials constitutes wastage and can be easily avoided by weighing materials for particular jobs and thereby generating no waste.

This study has earlier reported the reusability of wax. In this instance, wax is identified as a material that has potential to be recycled outside the dental technology industry for candle making.

> *"The waxes, you can give it to a community to make candles"*
>
> *[AS1]*

> *"If I have to start collecting wax it can probably go to good use, there will be somebody that will be able to buy it, [for example] the candle makers."*
>
> *[LO2]*

In accordance with the recognised opportunities of recycling of dental laboratory waste, creativity was highlighted as one way that will enable the industry to do better with waste management.

> *"We need to work on our creative side. I visited a flea market at the stadium and I was surprised at how innovative people are. Stuff that you throw away, is being remodelled and redone and made to look really spectacular. So I know dental technicians are very creative in their field so if we go a little beyond that we could think of ways to handle our waste."*
>
> *[LO7]*

> *"It takes a little bit of creativity and thinking out of the box to find sources and re-use purposes to re-use it but definitely there is definitely scope for re-use if it is well managed and there is creative thought process that goes into it."*

[21] Since a similar practice has been discussed under observation report, it is important to note that interview participants are different from observation participants.

[AS1]

The participants were forthcoming with ideas about recycling opportunities when prompted. Further discussion on recycling opportunities and the reaction of interviewees to these opportunities will be carried out in the next chapter.

4.3 CONCLUSION

In conclusion, this chapter reported on the findings obtained through observations of waste handling in dental laboratories as well as the qualitative data obtained through interviews conducted. The findings from observations prompted an investigation of whether the reusing and recycling practices reported were widespread throughout the industry.

The findings from interviews revealed a few areas that are widespread within the industry regarding waste management. Furthermore, the participants' expressions towards understanding of waste management and attitudes towards recycling did not complement their responses regarding their current reusing and recycling opportunities. The same goes for their expression about recycling opportunities for dental laboratory waste. Lastly, the themes found in this report addressed the key research questions of this study. Those are:

1. How is the waste managed in dental laboratories?

2. What are the perceptions and attitudes of dental technicians/technologists and academics towards waste management systems that value and employ recycling?

3. What are the benefits and opportunities of reusing and recycling dental laboratory waste?

The following chapter will discuss these findings in detail.

CHAPTER FIVE: CONCLUDING DISCUSSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

This study investigated the management of waste in commercial and the Dental Technology training laboratory at the Durban University of Technology. The study referred to three key research questions and provided evidence in answering these questions. The objectives of this study were to understand waste management in the context of dental laboratories through the use of qualitative inquiry. In order to gain insight into laboratory practices, observation sessions were held in a sample of randomly selected dental laboratories. In addition, semi-structured interviews were conducted with dental technology practitioners and dental technology academics. This study disclosed and reported findings of how waste is managed in dental laboratories; the understanding, perspectives and attitudes of dental technology practitioners and dental technology academics towards reusing and recycling dental laboratory waste products as well as the benefits and opportunities of recycling dental laboratory waste.

This chapter discusses the study's findings and concludes with recommendations for the dental technology industry as well as areas for further research.

5.2 DISCUSSION OF FINDINGS

5.2.1 Waste management in dental laboratories

The findings presented in the previous chapter show that waste management, where it occurred, was generally understood by the laboratory owners, the employee technicians and the dental technology lecturers as a cost saving exercise in terms of saving materials and company resources. Little reference was made to practicing waste management for environmental reasons, which is understood in this study to include saving world resources and not polluting the environment. Therefore, it is evident that dental technology practitioners are more concerned about their businesses and neglect the issues of sustainability of the planet they live in.

The negligence of the dental technology industry is further highlighted when dental laboratory owners with knowledge of harmful waste, for example saliva and blood which are known to be a health hazard inside a dental laboratory, and yet make no provision for safe disposal of such waste. There are serious consequences that may include the contraction of saliva and blood borne diseases such as Hepatitis B, which

lasts from four hours to approximately seven days on a host surface (Hepatitis B fact sheet 2017). Whilst the immunisation of oral health care workers, including dental technicians, is mandatory it is surprising that dental technicians are aware of the dangers of contaminated waste but have little concern for others outside their immediate environment. Waste pickers, scouring through municipal waste are potentially prone to being exposed to the hepatitis B virus by contacting impression materials or their packaging where the viral spores can be found.

According to Kareiva (2008) this attitude of the industry being concerned with what directly affects them and not the environment can be attributed to urbanisation, where it is not uncommon that city dwellers show a disinterest towards the interdependence that exists between them and the environment. This was evident even in the rare instances where participants recognised the possibility of negative impact on the environment, they nevertheless did not practice anything to support their understanding of preservation of the environment. It was evident that that the said recognition by these participants of the detrimental effects to the environment and not practicing waste management was just them trying to give answers that they thought interviewer wanted to hear. This showed a grave lack of environmental awareness and knowledge and extreme ignorance and, in addition, a lack of desire to do anything about waste management.

It is perturbing that dental technicians justified their lack of environmental care by stating that it is in the nature of dental technicians to only care about the work they produce and not care about the environment. They are quite prepared to use substances having no knowledge whether they are destructive to the environment or worse still, knowing that the use is causing harm but continue without practicing the necessary precautions to include waste management. The research found that the use of caustic soda in dental technology laboratories was evident. It is used for unclogging drains, is hazardous to the environment and toxic when ingested. Caustic soda whilst freely available in supermarkets is toxic if disposed of in high concertation into the waste water stream which in turn is fatal to aquatic living organisms (Materials safety data sheet 2012). The attitude is that if it is available in the shops then it must be acceptable for use.

A suggestion was mooted was that most dental materials are not harmful to the environment after they have undergone processing. Should this be true, interviewees

failed to understand that even if waste is not toxic it has a deleterious effect on other environmental factors such as the impact on disposal landfill sites in KZN. These participants did not understand that waste management goes beyond simply dealing with those materials that are hazardous to the environment. Space for landfills and their maintenance thereof have been highlighted as a societal problem and the dental technology industry carelessly contributes to polluting landfill sites, by disposing of items that do not necessarily decompose and materials that can be recycled for environmental and commercial benefits. Recently, it has been reported that the Bisasar landfill in Durban which has long been referred to as Africa's biggest is approaching its full capacity. Consequently, this landfill is now restricted to the type of waste that will be used for the soon coming capping and rehabilitation (Smit 2016).

Whilst study participants indicated that dental laboratories do not produce as much waste as normal factories do, the participants fail to understand that the size of the industry and the perceived minimal volumes of potential waste that is generated does not exempt the dental technology industry from considering the toxic effects on the environment. Inclusive of waste management is a conscientious decision by individuals to take cognisance of the possible damages the waste they produce could have towards the environment. Therefore, every industry that produces waste has no excuse not to know exactly how its waste should be deposed of.

The impact of gypsum waste materials on the environment was found to be poorly understood. The study found that plaster traps give off a pungent smell. A plaster trap is a mechanism that is installed under the sink in order to catch liquid gypsum (commonly referred to as plaster) and other solids and prevent them from reaching and clogging drainage systems. Study participants understood that the smell was an indication that the smell could be the result of hazardous elements in the drainage system. It was not understood that the smell comes from bacterial growth within the system and the bacteria from plaster traps could have a negative effect of exposing laboratory workers to the bacteria in the trap while emptying them as well as the other members of the laboratory. Even more serious is perhaps the possibility of cross contamination with work leaving the laboratory for insertion into a human's mouth. Nevertheless, literature is silent regarding the types of bacteria that may be found in plaster traps respectively and their dangers thereof.

Whilst the participants, particularly laboratory owners, of this study were not aware of waste management regulations both globally and nationally, it was surprising that they believed that the responsibility for conveying waste management regulations lies with Dental Technology Association of South Africa and the South African Dental Technicians Council. It is not part of the duties of any of the two bodies mentioned to enforce proper waste management systems in individual dental laboratories. This further highlight that waste management is not the industry's area of interest because waste policies and regulations are made readily available online by South African Waste Information Centre (SAWIC), a division of the Department of Environmental Affairs. If the industry cared about the environment, they would know about where they can find information that will assist them in becoming environmentally conscious. It is this research's contention that as members of society the industry should demonstrate the desire to practice waste management as global citizens and not have to be informed and policed into doing it.

It was suggested by interviewees that rewards and incentives may encourage staff to manage waste appropriately. Although staff incentives might encourage compliance, the rules that govern an individual's employment are what staff need to comply with. Whilst it is the nature of human beings to possess a 'what's in it for me' attitude, it is disappointing that laboratory owners seem to be not in a position to instruct staff when it comes to matters of waste management. Therefore, laboratory owners need to take responsibility and be accountable of how waste is handled in their laboratories and ensure that employees comply with systems as determined by their employers.

At this point, it is important to note that this study found that most dental laboratories that were part of the research sample are situated in the homes of dental laboratory owners. This study also found that waste from such dental laboratories is disposed of as household waste and there are no specific waste disposal systems in place for potentially infectious waste[22]. This poses concerns regarding situating a potentially hazardous business in residential areas. Perhaps, the SADTC needs to consider enforcing some waste management standards for dental laboratories, to safeguard the surrounding environment especially in residential areas. This would be aligned to the code of ethics of 2001 as stipulated in the Allied Health Professions Act which was

[22] Potentially infectious waste refers to waste that has come into contact with human saliva and possibly blood (Chapter 1, Table 2).

amended to include a section on duties towards the environment. In that section, it is asserted that one of the duties is to protect the environment and the public by assuring that healthcare waste is disposed of legally and in an environmentally friendly manner (South Africa 2015).

In the same vein of shifting responsibility, it was suggested that waste management must be included in the dental technology curriculum in a form of practical tasks in the dental technology curriculum and that the dental technology subject Jurisprudence should include waste management regulations. This view was widespread across the interview sample, including the academics. Their suggestions comprised inclusion of waste management in all modules in the dental technology programme with a practical component that will be monitored by a department selected waste management officer with assistance from student monitors from each level of study. These are positive suggestions and may change the current state of apathy to waste management in the university and later in the industry when students graduate. However, none of the academics interviewed had done anything about the current state of waste management education in the dental technology programme at DUT.

Another suggestion was that waste management could be taught as continuing professional development (CPD) short courses as opposed to it being a module eligible for examination. This is a positive suggestion; however, it can nevertheless be used as a corrective measure for those who qualified without having the knowledge of dental laboratory waste management. In that way, not only student technicians would benefit from such knowledge but the entire industry. This suggestion calls for further investigation by the UoTs concerning feasibility. Albeit sharing of knowledge through courses, there is no guarantee that the industry's attitudes towards waste management will improve.

5.2.2 Approaches and attitudes of dental technicians/technologists and academics towards waste management systems that value reusing and employ recycling

This study revealed that recycling of dental laboratory waste was seen by the participants as being impossible to be carried out. The laboratory owners respectively indicated that dental laboratories are busy places and it is not their job to recycle

waste. Once again, the industry's dissociation with waste management emerges. It is concerning that laboratory owners believe that even if they would implement reusing and recycling, the employees will not follow it adequately. That can be seen as an excuse because if it is introduced to the employees as a job requirement they will have no choice but to practice waste management.

Technological advancements in dental laboratory procedures were envisaged by some participants to reduce waste through elimination of use of certain dental materials especially gypsum and investment materials. The participant's responses implied that therefore there is no need to worry about waste management. However, the participants need to consider the irreparable damage they are contributing towards polluting the environment and destroying the earth's resources, regardless of the advanced technology. This can be seen as another excuse for the industry not to act responsibly.

From the findings of this study it was apparent that there is a link between current practices, perceptions and attitudes of waste management to the number of years of experience of the respective participants. Most study participants, whilst randomly selected were those with many years in the industry, their attitude towards recycling was very negative. They proclaimed not caring for the environment through their negligence towards waste management by stating that for the 20 to 50 years of working in this industry they do not know of anybody who recycles gypsum models. Unbeknown to them, there is a dental technician whom has embarked on recycling gypsum models into plasterboard and dry wall, in the United Kingdom[23]. Gypsum has also been reported to have an increased use in agriculture for numerous benefits to the soil. This calls for further research and investigation to establish whether plaster models can be recyclable for such purposes in South Africa.

More concerning is that the more established and experienced participants were adamant that nothing needs to be changed in the way they handle their waste. However, this attitude is not different from that of the general citizens. There is much evidence of this fact, including prevalence of societal illegal dumping activities that bear further costly consequences such as the placement of enforcement officers in the succetible areas (Smit 2016).

[23] As discussed in Chapter 2 under heading 2.4.1

5.2.3 The benefits and opportunities of reusing and recycling dental laboratory waste

The findings of this study with regards to recycling opportunities were in contradiction to the poor understanding and lack of awareness and interest of proper waste management by the dental technology industry. However, this is not surprising considering the fact that the industry was found in this research to be only concerned with making profit. Nothwithstanding the lack of awareness by the interview participants, a minority commercial laboratories were found to be reusing their waste during the observation phase. It was unclear whether these laboratories were reusing materials with the aim to prevent impact on their laboratory facilities, for example saving materials and thus generating extra income, and not for the benefit of the environment. Inadvertently, their acts are in alignment with good waste management practices and South Africa's goal of reducing waste that goes to the landfill sites.

A good example is the pouring of left over mix of plaster into silicone moulds to form artefacts to be painted on by kids[24]. However, finding alternate use for off-cut and left over material may be an indication of material wastage. If the materials were used sparingly and cautiously measured, there would not be a need to find creative alternate uses for waste. Another example is the previously reported act of preventing drain blockage by using stockings. This is a commendable alternative to the conventional wax traps. Not only does it eliminate the cost of installing wax traps, it also eliminates the time spent on cleaning such mechanisms but at the same time doing good for the environment.

Although the academics suggested ways that will ensure that environmental awareness and recycling is fostered to the student dental technicians, this study found that none of them have initiated or implimented any form of waste management. Instead, the academics alleged a number of reasons why proper waste management would not be successful. An example of such reasons is one of lack of space to accommodate recycle bins in the DUT dental laboratories. This is just an excuse to cover up for the lack of implimentation. Recycle bins exist in portable units for indoor

[24] refer to Figure 4.2.1(e) in chapter 4.

usage, and there is ample space outside the laboratories to accommodate the larger outdoor receptacles.

The minority participants who were involved in small scale recycling professed to getting monetary gain, even though the monetary gains were small. Metal refinery is a good example of opportunity to reduce metal waste. This is the kind of information that needs to be spread across the industry in light of sharing good practice. Thus, the industry will be making extra income while reducing waste and saving the environment.

Another finding of this study was the widespread practices that are known to be common in a dental laboratory, such as reusing wax and casting metal. Whilst these are common practices, the participants were adamant that they qualify them as practicing recycling. Acrylic special trays and excess denturebase material were also stored and used by some participants to start fires for grilling meat[25]. Whilst this may contribute to the reduction of acrylic waste, the fumes that are released while these materials are burnt down may pose danger to human health. It has been proven that bpa (Bisphenol A), which is toxic to human health is formed when polymer resins decompose under high thermal conditions (Suzuki *et al. 2000*).

Lastly, this study found that the participants and literature were concerned that recycled dental materials may lose the properties and precision that are required for successful dental laboratory procedures. Nonetheless, this study also revealed a possible solution being recycling the waste for non-dental purposes. As an example, one participant suggested that dental wax may be recycled into candle making. This might be viable given the properties of dental wax.

This study found that the interview participants across the board expressed ideas of how some dental materials should be recycled. However, their ideas were merely suggestions and were counteracted by the reasons why recycling cannot be succesful in their dental laboratory.

[25] The vernacular South African term is ‘braaiing’

5.3 RECOMMENDATIONS RESULTING FROM THIS STUDY

From the findings of this study, the following recommendations emerged:

1. The Dental Technology programme at DUT should introduce waste management education into the syllabus.
2. The Dental Technology programme at DUT should consider recycling its dental laboratory waste.
3. The Dental Technology programme at DUT should develop short Continuing Professional Development courses on environmental awareness for those who have never received such during training.
4. The industry and the Dental Technology programme at DUT should review their current practices of waste management and introduce and formalise the use of recycle bins.
5. Dental Technicians should be legislated to practice waste management.
6. SADTC should include an environmental awareness section in its newsletters, whereby good environmental practices can be shared.
7. The eThekwini Municipality (as well as other Municipalities in South Africa) must investigate and take action against the disposal of medical waste in the suburbs.
8. There is a need for further research that will investigate recyclability of dental materials, especially those that tend to accumulate in high volumes as waste.
9. Another area of future research is the feasibility of recycling gypsum models into agricultural farming in South Africa.
10. There should be an investigation to ascertain the quality of recycled gypsum and wax as dental materials.
11. In future, similar participants for both interviews and observations must be used to ascertain the reasons behind some existing waste management and recycling activities.

5.4 CONCLUSION

In conclusion, this study provided a thorough description of waste management in respect of reusing and recycling within the context of dental laboratories. That enabled conclusions from the research findings to be drawn.

The dental technology industry exhibited an uncaring, uninformed and ignorant attitude towards waste management and recycling in dental laboratories. Apart from the majority negative attitudes, there is evidence that there are some reusing and recycling acts that exist in specific dental laboratories. Although it is commendable that they were doing recycling, albeit on a small scale, it was interesting that the study found that study participants were unable to recognise that in fact they were practicing waste management. Therefore, dental technology industry needs to reflect on the manner of which dental laboratory waste is handled and stop distancing itself from the responsibility of acting unjustly towards the planet and its inhabitants and not only focus on the profit. The same goes for the academics of the Dental Technology programme at DUT, their daily function needs to consciously encompass waste management.

Lastly, the design of this study has been primarily concerned with establishing and reporting on the extent of waste management that entails waste reduction through reusing and recycling in dental laboratories in KZN, uncovering alternative uses for dental laboratory waste and the possible economic benefits thereof, and influencing the dental technology industry on environmental sustainability, hence the use of qualitative research techniques. Consequently, the findings of this study should not be regarded as widespread throughout the dental technology industry in South Africa, although anecdotal evidence suggests that what was found in this study is not a localised norm.

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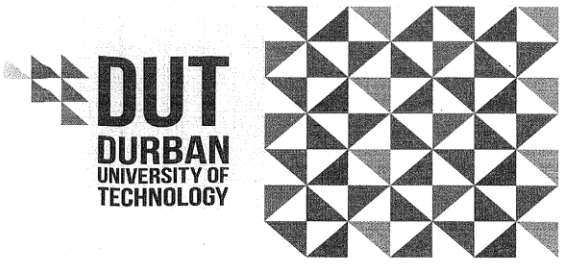
ANNEXURE 1: Ethical clearance letter



Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

24 June 2014

IREC Reference Number: **REC 35/14**

Ms Y Ngombane
P O Box 2908
Durban
4000

Dear Ms Ngombane

Dental Laboratory waste management in respect of reusing and recycling in KwaZulu-Natal

The Institutional Research Ethics Committee acknowledges receipt of your notification regarding piloting of your data collection tool.

Please note that since the interview schedule is not validated, it is recommended that a pilot study is conducted to ensure that the appropriate questions are asked to achieve the objectives of the study.

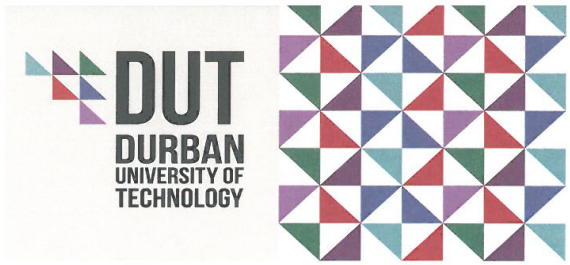
Should you choose not to conduct a pilot study, you may proceed with data collection on the proposed project.

Yours Sincerely

[redacted]

Prof J. K. Adam
Chairperson: IREC

ANNEXURE 2: Permission to conduct research at the DUT



Directorate for Research and Postgraduate Support
Durban University of Technology
Tromso Annexe, Steve Biko Campus
P.O. Box 1334, Durban 4000
Tel.: 031-3732576/7
Fax: 031-3732946
E-mail: moyos@dut.ac.za

22 July 2014

Ms Yonela Ngombane
Department of Dental Sciences
Durban University of Technology

Dear Ms Ngombane

PERMISSION TO CONDUCT RESEARCH AT THE DUT

Your email correspondence in respect of the above refers. I am pleased to inform you that the Institutional Research Committee (IRC) has granted permission for you to conduct your research at the Durban University of Technology.

We would be grateful if a summary of your key research findings can be submitted to the IRC on completion of your studies.

Kindest regards.
Yours sincerely

[redacted]

PROF. S. MOYO
DIRECTOR: RESEARCH AND POSTGRADUATE SUPPORT

ANNEXURE 3: Information letter for interview participants

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Dear Dental Technician/Technologist

I am a student pursuing a Master's degree at the Durban University of Technology through the Department of Dental Sciences.

Title of the Research Study: ***Dental Laboratory waste management in respect of reusing and recycling in KwaZulu-Natal***

Researcher: Mrs. Yonela Ngombane BTech: Dental Technology

Main Supervisor: Mr. G H Bass M Ed: Higher Education

Co – supervisor: Prof A H A Ross DTech: Homeopathy

Brief Introduction and Purpose of the Study:

Dental laboratories manufacture various dental restorations and appliances that require use of various dental materials. The same occurs in the dental laboratories at the institutions of higher learning in which dental technology is taught.

The proposed study aims to investigate the management of waste in commercial and training dental laboratories in Kwazulu-Natal (KZN), in order to determine the perspectives of dental technology practitioners and academics towards reusing and recycling dental laboratory waste products.

Saving resources and reducing the environmental impact of waste by minimizing the amount of waste disposed at landfills are known objectives of recycling. In addition, recycling may pose some economic benefits and is a viable way to reduce informal salvaging at landfills, which is undesirable due to the associated health and safety problems.

Outline of the Procedures:

You are kindly requested to participate in the individual interview process which constitutes one phase of the proposed study. Each interview is anticipated to be about one hour long and is proposed to take place at your workplace, unless a more convenient alternative is required. The interview will be recorded using a digital voice recorder. I will confirm the exact time and date with you so as to suit your availability. Only you and I will be present during the interview session.

Please note that participation in this study is voluntary and you are free to decline or withdraw if you so wish. However your invaluable input is of great importance and will contribute considerably in the success and outcomes of this study. Upon agreeing to take part, please fill in and sign the statement of agreement on the last page of this document.

Risks or Discomforts to the Participant: You will not be subjected to any risks or discomforts during the course of the interview.

Benefits: The results from this study are envisaged to positively influence the dental technology industry towards environmental friendly practices, as well as to contribute to the environmental module of General Education in dental technology studies (DUT). There are no direct benefits to you for your participation, other than being a part of a knowledge generating endeavour.

Reason/s why you may be withdrawn from the Study: You will be withdrawn from this study if you so wish, or due to illness. However there will be no adverse consequences should you choose to withdraw.

Remuneration: There is no remuneration of any kind for participating in the study.

Costs of the Study: You will not be required to cover any cost towards this study.

Confidentiality: This study has been approved by the Institutional Research Ethics Committee of the Durban University of Technology. All the information that you provide will only be accessed by the researcher, data transcriber and supervisors. The ethics committee may inspect research records. Such information will be kept safely by the department for 10 years and will be deleted thereafter. Your identity will be protected within the dissertation by means of coding (E.g. DT1-DT9 for dental technicians, LO1-LO9 for lab owners and AS1-AS7 for Academic staff)

Research-related Injury: The interview process does not pose any risk of injuries.

Persons to Contact in the Event of Any Problems or Queries:

1. Yonela Ngombane (Researcher): 083 754 0893 / 031 373 2044
2. Mr. G H Bass (Supervisor): 083 440 2870 / 031 373 2033
3. Prof A H A Ross (Co-supervisor): 082 458 6440 / 031 373 2542
4. The Institutional Research Ethics administrator: 031 373 2900

Complaints can be reported to the DVC: TIP, Prof S. Moyo on 031 373 2576 or moyos@dut.ac.za

Yours Sincerely

_____

Yonela Ngombane (Registered dental technologist)

Statement of Agreement to Participate in the Research Study:

I,…..subject's full name…., ID number……., have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by …….to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I, therefore, voluntarily agree to participate in this study.

Subject's name (print) ……..…

Subject's signature:…….…….. Date:……..…

Researcher's name (print) signature: ……..……...

Researcher's signature:……..……..Date:.....

Witness name (print) signature: ……...

Witness signature: …….....Date:…….…

ANNEXURE 4: Information letter for laboratory observation

INSTITUTIONAL RESEARCH ETHICS COMMITTEE (IREC)
LETTER OF INFORMATION

Dear dental laboratory owner

I am a student pursuing a Master's degree at the Durban University of Technology through the Department of Dental Sciences.

Title of the Research Study: ***Dental Laboratory waste management in respect of reusing and recycling in KwaZulu-Natal***

Principal researcher:	Mrs. Yonela Ngombane	BTech: Dental Technology
Supervisor:	Mr. G H Bass	M Ed: Higher Education
Co – supervisor:	Prof A H A Ross	DTech: Homeopathy

Brief Introduction and Purpose of the Study:

Dental laboratories manufacture various dental restorations and appliances that require use of various dental materials. The same occurs in the dental laboratories at the institutions of higher learning in which dental technology is taught.

The proposed study aims to investigate the management of waste in commercial and training dental laboratories in Kwazulu-Natal (KZN), in order to determine the perspectives of dental technology practitioners and academics towards reusing and recycling dental laboratory waste products.

Saving resources and reducing the environmental impact of waste by minimizing the amount of waste disposed at landfills are known objectives of recycling. In addition, recycling may pose some economic benefits and is a viable way to reduce informal salvaging at landfills, which is undesirable due to the associated health and safety problems.

Outline of the Procedures:

I hereby request for permission to conduct observation of waste handling at your dental laboratory which should take place once a week for a total period of four weeks. These observations will include the use of digital camera for activities that are only relevant to the study and may be verified by you at any point. Observations will be approximately three hours in length. I further request random observation times to enable me to find the environment in its normal operational state. I might need to verify information from the members of your laboratory, in which case an unobtrusive request for clarification that will not interfere with flow of work will be employed. Please refer to the attached observation Schedule for more information.

Please note that participation in this study is voluntary and you are free to decline or withdraw if you so wish. However, your invaluable input is of great importance and will contribute considerably in the success and outcomes of this study. Upon agreeing to take part, please fill in and sign the statement of agreement on the last page of this document.

Risks or Discomforts to the Participant: You and your staff will not be subjected to any risks or discomforts during the course of the process of observation.

Benefits: The results from this study are envisaged to positively influence the dental technology industry towards environmental friendly practices. As well as contribute to the environmental module of General Education in dental technology studies. There are no direct benefits to you for your participation, except being a part of a knowledge generating endeavour. This study will enable me to publish scholarly articles and conference papers.

Reason/s why you may be withdrawn from the study: Your lab will be withdrawn from this study should you wish and there will be no adverse consequences. Non-compliance to the agreed ethical standards will lead to your labs withdrawal from participating in this study.

Remuneration: There is no remuneration of any kind for participating in the study.

Costs of the Study: You will not be required to cover any cost towards this study.

Confidentiality: This study has been approved by the Institutional Research Ethics Committee. All the information that will be derived will only be accessed by the researcher, data transcriber and supervisor/s. The ethics committee may inspect research records. Such information will be kept safely by the department for 10 years and will be deleted thereafter. Your identity will be protected within the dissertation by means of coding (E.g. Lab A or Lab B)

Research-related Injury: The observation process does not pose any risk of injuries.

Persons to Contact in the Event of Any Problems or Queries:

1. Yonela Ngombane (Researcher): 083 754 0893 / 031 373 2044
2. Mr. G H Bass (Supervisor): 083 440 2870 / 031 373 2033
3. The Institutional Research Ethics administrator: 031 373 2900

Complaints can be reported to the DVC: TIP, Prof S. Moyo on 031 373 2576 or moyos@dut.ac.za.

Yours Sincerely

_____

Yonela Ngombane (Registered dental technologist)

Statement of Agreement to Participate in the Research Study:

(I,…..subject's full name…., ID number……., have read this document in its entirety and understand its contents. Where I have had any questions or queries, these have been explained to me by …….to my satisfaction. Furthermore, I fully understand that I may withdraw from this study at any stage without any adverse consequences and my future health care will not be compromised. I, therefore, voluntarily agree to participate in this study.

Subject's name (print) ……..…

Subject's signature:……..…….. Date:……...…

Researcher's name (print) signature: ……..……...

Researcher's signature:……..……..Date:.....

Witness name (print) signature: ……...

Witness signature: …….....Date:…….…

ANNEXURE 5: Interview schedule

Dear participant

Thank you for participating in my study. Herewith is the interview schedule which will be conducted in English:

1. Introduction of the researcher and subject.
2. Going through the information letter to ensure proper understanding of the study, your role and ethical guidelines.
3. Filling in and signing of the consent form (a witness is required).
4. Switching on of the recording device
5. Starting of the interview (to a maximum of one hour long).

On waste management:

1. To what extent do you believe that dental laboratory waste has adverse effects on the environment and climate change?
2. What do you understand to be the disposal route for solid waste from your laboratory after collection by the municipality waste services?
3. What experiences have you had with dental laboratory waste separation for recycling?
4. From your experience, what waste produced by the laboratory can be classified as hazardous, potentially infectious, and non-infectious?
5. What waste materials go down the water drainage system?
6. What operational interruptions have you experienced that may be related to waste management?
7. In your opinion, what effects would provision of recycle bins have on your laboratory's current waste management system?
8. To what extent do you believe that dental laboratory owners should familiarise themselves with local and national waste management policies?

On reusing and recycling dental laboratory waste materials:

1. What waste materials do you reuse in your laboratory?
2. What other uses of gypsum are you aware of outside of its dental applications?
3. What is your opinion on the possibilities of recycling of gypsum models?
4. To what extent would you be willing to collect wax, gypsum models, plaster from plaster traps as well as chips from articulations and flasking?
5. In your opinion, how would reducing waste affect your dental laboratory's profitability?
6. To what extent do you believe that there is a need for a more structured (reduce, reuse, recycle) waste management strategy for dental laboratories?
7. What is your opinion on the value of including environmental awareness in the dental technology undergraduate curriculum?

ANNEXURE 6: Observation schedule

Dear participant

Thank you for participating in my study. Herewith is the observation schedule:

6. Introduction of the researcher and subject.
7. Going through the information letter to ensure proper understanding of the study, your role and ethical guidelines.
8. Filling in and signing of the consent form (a witness is required).
9. In carrying out the observation, I will employ the following tools:
    - Note book.
    - Pen.
    - Digital camera.

10. I will take notes and or pictures as soon as activities not limited to the ones listed below but related to waste management are seen to take place. Refer to the attached observation sheet.

NB: I will not require a designated working area during the three hour visits, since the nature of the exercise requires a walkabout. Please note that I may need to verify information from the members of the dental lab, in which case unobtrusive request for clarification that will not interfere with flow of work will be employed. Lastly, pictures taken will not be published and the source will remain confidential.

ANNEXURE 7: Observation sheet

Date:

Time:

Place:

Duration:

This observation sheet will enable the researcher to gain insight of a naturalistic dental laboratory waste (DLW) recycling and reusing prior to conducting interviews on the beliefs, perspectives and attitudes of DLW handlers.

DLW categories and sub-components based on a study by Komilis 2009.	Recycle receptacle	General waste receptacle	General sewage system	Re-used
Infectious and potentially infectious waste				
• Hydrocolloid				
• Gloves				
• Silicones–acrylics				
• Plasticized paper				
• Pumice				
Non-infectious toxic waste				
• Metals				
• Investment materials				
• Dipping hardener				
Household type waste				
• Gypsum				
• Slurry water				
• Porcelain				
• Cotton				
• Sand paper				
• Waxes [modelling, inlay, etc.]				
• Boil out wax				
• Plastics				
• Paper				
• Domestic waste				

NOTES:

_____
_____
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