ASPECTS OF MEDICAL WASTE DISPOSAL IN THE CAPE PENINSULA

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Thesis submitted for the degree of

Master of Science

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August 1996

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DECLARATION

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For Graeme, Julie and Luis

"People respond to the hazards they perceive"

(P. Slovic, 1979)

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ABSTRACT. Tolosana, S. 1996. *Disposal of hazardous waste in Western Cape medical institutions* M.Sc. thesis, University of Cape Town.

Hazardous waste management practices at ten medical institutions in Cape Town were studied and tests undertaken to determine concentrations of specific chemicals and radioactivity in liquid effluent outflows, as well as emissions from incinerators.

To investigate the sewage outflow for Chemical Oxygen Demand (COD), N, pH and heavy metals, a continuous sampler was installed at two hospitals and a Medical School. Samples were analysed by atomic absorption spectrometry for As, Hg, Cd, Co, Cr, Cu, Mn, Ni, Pb, Zn and Fe. Mercury levels ranged from 1-70$\mu g\ l^{-1}$, exceeding the Environmental Target Quality of 0.04$\mu g\ l^{-1}$, and the South African General Effluent Standard of 20$\mu g\ l^{-1}$. All other heavy metals were below General Effluent Standard Limits. In addition, a sludge sample from the Athlone Wastewater Plant was tested for Hg, realising 6$mg\ kg^{-1}$ on a dry weight basis, which was within Department of Health (DOH) Guidelines of 10 $mg\ kg^{-1}$.

Samples of incinerator bottom ash analysed for heavy metal content gave Hg concentrations of 1.1-4.0$mg\ kg^{-1}$, and Zn concentrations of 5.1-11.0$g\ kg^{-1}$. Incinerator ash was also analysed for radio-activity and substantial levels of ^{125}I (332-650 $bq\ kg^{-1}$), and Ga^{67} (9186$bq\ kg^{-1}$) recorded, which exceeded the South African limits of 200$bq\ kg^{-1}$. In Cape Town, hospital incinerators are old, burn large amounts of plastics and produce toxic emissions. They are all situated in residential or inner-city areas, and even though there is legislation dealing with emissions and chemical waste, these laws are not being enforced.

Based on the above results, an investigation was carried out to assess attitudes to and knowledge of hazardous waste in the ten institutions. One thousand questionnaires were administered to staff, and the data from the 80% response rate statistically analysed. Results suggest that there is an urgent need for an holistic approach to toxic waste management, encompassing enforceable legislation coupled with on-going educational programmes and strong support from top management and all levels of staff.

ACKNOWLEDGEMENTS

I would like to thank the Department of Health and the Medical Research Council for their contributions towards the funding of this research, and my supervisors Dr Rodney Ehrlich of Community Health, and Professor Alec Brown of the Zoology Department for their guidance and encouragement. Many thanks as well to the numerous people at the University of Cape Town, the hospitals, the private sector, local authorities, the Sea Fisheries Research Institute and Koeberg Power Station for providing me with information and being most helpful and supportive.

At the Cape Town City Council's Scientific Services Branch at Athlone Waste Water Plant, I would like to thank Andy Pitt (now in the UK) and John Stow for their help; Hugh Ballard for endless advice and much-needed moral support, Greg Helders for information on heavy metals, Robert Beceiro-Sellero and Herman Rus for analytical testing, Hans Hadorn for help with the German translation and Percy Wilsnack for his friendly assistance. Many thanks as well to Hamid Mazema and Keith Wolpole of the City Council's Drainage and Sewage Section for the loan of the AutoSampler, and Hans Linde of Air Pollution Control for information on incinerators and boilers, and for enduring over a decade of complaints from an 'interested and affected party'!

I am most grateful to Ray Edwards of Radiation Control, Department of Health, for his time, and for the incinerator ash and emission analyses, and from the Human Sciences Research Council; De Wet Schutte and Ben Dixon for their assistance with the questionnaire. Much appreciation is due also to Corine von Schurinck of the Analytical Research Bureau and Rosemary Kreuser of the Bureau for University and Continuing Education, Stellenbosch University, for statistical help, and to Dan Wilson of the Surveying Department UCT, for time spent producing the map of hospitals and clinics.

A very special thanks to Ian Davidson of the Zoology Department, and John Keating, for stocical endurance throughout the truly dreadful sampling period - without them, most of this study would not have been possible. Thanks to those who have helped with computer and mathematical queries - Coleen Moloney, Colleen Parkins, Trevor Hutton, Lisa Kruger and Heidi Winkler. Thanks also to Jenny Day for her useful advice; and lastly, I shall always be grateful to John Field for his continuing support, statistical advice, and for suffering the consequences of my endless studies.

Many thanks to my children - Graeme, for his long-distance encouragement; Julie, for always coming to the rescue at the eleventh hour, and Luis, for his cheerful acceptance which has allowed me to spend the many required hours away from home. Their support, and that of my friends, Wendy Lucke for proof-reading, and innumerable cups of rooibos, and Susie and David Power, for advice, and many mountain walks, have made it possible for me to persevere with this dissertation - I really have appreciated their help and support.

CHAPTER 1

INTRODUCTION

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1.1 STATEMENT OF THE PROBLEM

There is uncertainty concerning the safe limits and the precise implications of the many chemical substances to which urban populations are exposed, and what the long-term effects of the mixture of these substances will be (Von Schirnding, 1992). Fortunately, there is now world-wide recognition of the urgency to reduce environmental damage, and many developed countries have introduced stringent environmental legislation with heavy penalties for non-compliance. Although South African legislation is comprehensive, it is fragmented and lacks sufficient skilled human resources and the political will for its enforcement (Lee, 1992; Rabie et al., 1992). Thus, if further degradation is to be prevented, responsibility is placed on institutions, business and individuals to take action against lax environmental standards. In Cape Town there have been numerous statements in the media (see Figure 1), for example 'City smog levels way above world standards' (Cape Times, 2.6.93, 11.8.93, 30.7.94), 'Toxic ambivalence of politicians' (21.10.94), 'SA environmental future alarming' (17.8.94), 'Ban sewage outfall pipes into the sea' (31.8.94), 'Sewerage threatens False Bay' (19.10.94), 'Fatal flaws in waste dump plans' (24.1.95), and 'Suburbs align in incinerator war' (Constantia Bulletin 25.8.94). These few statements, although intended to shock, and perhaps motivate public action, underlie a very real concern about the state of our environment. Although not perceived as major environmental pollutors, medical institutions utilise and dispose of a significant amount of hazardous substances, and it is the management of these toxic wastes which is the focus of this study.

Chemicals discharged into drains can disrupt sewerage systems and cause eutrophication in rivers (Dallas and Day, 1993), and heavy metals concentrate in the sludge at waste water treatment plants. Treatment of this sludge is expensive and there is a possibility of food chain contamination when using this as a soil conditioner (Ekama, 1993). Eventually, most of these chemicals are washed through stormwater drains or down rivers into the sea. These substances can accumulate in sediments and become further concentrated in the tissues of marine plants and animals and eventually humans. Toxic substances may change into more hazardous forms, and combinations of these pollutants could possibly have a far more dangerous effect, for example in Minamata Bay, Japan, where the conversion of inorganic to organic mercury caused widespread poisoning (Brown, 1987).

FIGURE 1: Newspaper reports during the sampling period.

Only the most important Acts which deal with toxic waste will be discussed in this study, but Appendix I details further sections of the legislation pertaining to medical institutions. In the past, the problem has been that State-owned hospitals were not bound by law, but this will no longer be the case, and the stringent regulations for incinerators and hazardous chemicals brought out recently as guidelines under the Atmospheric Pollution Prevention Act of 1965 and the Occupational Health and Safety Act of 1983 will, if they are enforced, have a substantial impact on hazardous waste management in healthcare institutions.

Besides making use of the regular Municipal Cleansing Department collections, an increasing number of hospitals and clinics now employ a private company to collect and dispose of certain forms of waste, although a substantial amount receives no special treatment. For example, all sewers in the Cape Town city bowl (which include a number of hospitals, clinics and laboratories) discharge macerated, but otherwise untreated effluent into Table Bay, and ash from hospital incinerators is taken to landfill with normal household refuse. Thus there appears to be a need for an investigation into the efficacy of waste management systems at medical institutions and their impact on local environments.

1.2 AIMS AND OBJECTIVES

The main aim of this research was to study the disposal of hazardous waste from health institutions, a topic which is not well documented in South Africa. A questionnaire was administered to staff to investigate their knowledge of and attitudes to the problems of toxic waste management. It is presumed that the ability of personnel to monitor and handle hazardous waste in a responsible manner, and to educate patients to do the same, depends on knowledge of the harmful effects of these substances, and attitude towards the environment.

The objectives of this study are to:

(i) review hospital waste disposal methods in Cape Town and to compare these with the international situation;
(ii) review potential health risks to humans and the environment associated with the disposal of toxic hospital wastes;
(iii) outline the essential legislation pertaining to hospital waste management ;

(iv) investigate the nature of effluent discharged from hospital sewers, including Chemical Oxygen Demand, Ammoniacal Nitrogen, pH, conductivity, heavy metals and radioactivity;

(v) test incinerator ash for radioactivity and heavy metal content;

(vi) administer a questionnaire to management and staff at selected Public and Private hospitals and Medical School, covering attitudes to and knowledge of toxic waste management; and

(vii) on the basis of this information to make recommendations on waste disposal management to ameliorate detrimental impacts on the community and the environment (groundwater, rivers and sea).

1.3 STRUCTURAL OUTLINE OF THESIS

In order to achieve the aims and objectives outlined above, national and international literature dealing with hazardous waste management strategies in health-care institutions are reviewed in Chapter 2. Chapter 3 summarises legislation relating to medical institutions, and in Chapter 4, the sampling and measurement of sewage outflow and incinerator bottom ash is described. In Chapter 5, the results of these tests are presented, and a discussion into the composition and local impacts of hospital incineration and sewerage outflow is reviewed. The statistical analysis of responses to the questionnaire administered to hospital staff is reviewed in Chapter 6. Chapter 7 presents the conclusions, and offers suggestions for future waste management strategies.

CHAPTER 2

REVIEW OF HAZARDOUS WASTE MANAGEMENT IN MEDICAL INSTITUTIONS

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2.1 GENERAL ISSUES

2.1.1 INTRODUCTION

Pollution has been defined as the outcome of attitudes, overpopulation, technological developments and economics. Generally people tend to ignore environmental pollution, or it is argued that it is a necessary and acceptable consequence of industrial or agricultural development, and essential to the maintenance of employment. Accompanying this attitude is the hope that in future, technology will be developed to eradicate or moderate the problem (Gilbertson et al., 1985) or more commonly, people believe pollution to be uncontrollable, and therefore just too stressful to think about.

Fortunately attitudes have changed, and environmental pollution has, according to Gilbertson et al. (1985), been seriously debated and attracted the attention of not only biologists and ecologists, but also economists, planners, geographers and politicians. Strangely, the medical profession, presumably most concerned with the effect of pollution on health, was not included in this list.

Hospitals use large amounts of polluting substances, and the types of refuse generated include persistent wastes such as heavy metals; for example cadmium (Cd), lead (Pb) and mercury (Hg); certain toxic chemicals, chemical compounds such as plastics, and nuclear wastes. All these pollutants could cause problems when released into the environment, owing to their cumulative effects, especially in the food-chain. Fuggle (1991) argues that because of the long time scales involved, and lack of knowledge of the impacts of these wastes, they should be regarded in a most serious light. Accordingly, this chapter reviews the available literature dealing with hazardous waste management in medical institutions, both locally and internationally.

2.1.2 DEFINITIONS OF HAZARDOUS AND MEDICAL WASTES

The South African definition of hazardous waste is based on that of the United Nations Environment Program (UNEP): "Waste, other than radioactive waste, which is legally defined as hazardous in the state in which it is generated, transported or disposed of. The definition is based on chemical reactivity or toxic, explosive, corrosive or other characteristics which cause, or are likely to cause, danger to health or to the environment, whether alone or in contact with other waste."

Many different definitions for hazardous waste exist, but are relatively vague, although some of the main identification criteria for these are:

- type of hazard involved (flammability, corrosivity, toxicity, reactivity);
- the generic category of the products involved (e.g. pesticides, solvents, medicines);
- technological origins (e.g. oil refining, electro-plating); and
- the presence of a specific substances or group of substances (e.g. Polychlorinated biphenyls (PCBs), dioxin, lead compounds) (Department of Water Affairs & Forestry, 1994b).

2.1.3 SOURCES OF MEDICAL WASTE

Internationally, clinical waste disposal creates problems. New York City, for example, discards approximately 30,000 tons of refuse daily, and one significant source of this waste is laboratories and hospitals. Much of the hazardous waste produced by these laboratories is used and discarded without complete knowledge of the environmental consequences; for example, to the health of cleaning staff, or the risk to water, soil and air (Barbour, 1980). Besides hospitals, clinics, and health-care facilities, there are numerous other producers of small quantities of medical waste. These include private medical and dental practices, veterinary clinics, laboratories, blood banks and home health care. Of the 160 million tons of solid waste generated each year in the United States, 3.2 million tons is medical waste from hospitals (EPA, 1989a).

US hospitals generate approximately 15 pounds of solid waste per patient per day, and of this approximately 2.25 pounds is infectious waste. In 1985 there were about 1.3 million hospital beds in 7 000 hospitals in the USA with an average occupancy rate of 69.5%. A recent EPA report "Medical Waste Management in the United States" (EPA, 1990) indicated that each year approximately 500 000 tons of Regulated Medical Waste (RMW) are produced in the United States by about 375 000 generators. Of this, approximately 77% is produced by hospitals which comprise less than 2 percent of the generators (Lee, 1992).

Table 2.1: 1986 Sources and quantities of Regulated Medical Waste (USA). *(Source: Lee, 1992).*

Generator	Number	RMW (tons year^{-1})
Hospitals	7 100	359 000
Laboratories	4 300	15 400
Clinics	15 500	16 700
Physicians	180 000	16 400

2.1.4 TYPES OF MEDICAL WASTE

Using the definition of medical waste in Lee (1992), US EPA issued regulations in which seven categories of regulated medical waste are listed:

- Cultures
- Pathological wastes
- Human blood and blood products
- Sharps
- Animal Waste
- Isolation wastes
- Unused sharps

Included are discarded medical devices capable of puncturing the skin that have been used in animal or human patient care; in medical research, or industrial laboratories, for example needles, trocars, pipettes, scalpel blades, blood vials and broken or unbroken glassware;

serum culture bottles; and slides and cover slips that have been in contact with infectious agents.

Listed separately in the EPA document, are the components of medical waste which are of most relevance to the present study: cytotoxic chemicals, hazardous chemicals, toxic metals and radioactive materials (Anon., 1993), all of which are discussed below:

Heavy metals

Metals with an atomic mass greater than that of calcium (40.078) are termed 'heavy metals' but exclude Sodium (Na), K, Mg, lithium (Li) and beryllium (Be) (Dallas and Day 1993). The metalloids, arsenic (As) and selenium (Se), have some properties of both metals and non-metals and are generally included as heavy metals (Depledge et al., 1994).

It is difficult to determine the effects on ecosystems of these metals and other pollutants. How elevated metal content impacts on soil-plant-animal systems is determined by their predominant forms. For example, heavy metals in solution are adsorbed to solid phases when sewage sludge is applied to soil, causing health risks owing to raised metal concentrations, or loss of crop yields due to phytotoxicity of, for instance, Cu and Zn (Depledge et al., 1994). Research has indicated that a combination of Cu and Al at pH <6 is toxic to some aquatic organisms (D. Musibono, Freshwater Unit, UCT, pers. comm.). Of particular concern is Cd, which is easily absorbed by mammals and is teratogenic, mutagenic and carcinogenic (Barbour, 1980). Laboratory studies on rats has demonstrated that the injection of Cd metal or salts causes malignancies, although this has not been conclusively implicated as a human carcinogen (EPA 1980). Mercury, which is a cumulative toxicant causing brain damage is also cause for concern (EPA, 1989b), and Ni is believed to be carcinogenic (Dallas and Day, 1993).

There does not appear to be universal consensus on where the various metals stand on the continuum between "extremely hazardous" on the one hand, and "potentially hazardous" on the other, and the ten metals of most concern in the USA which have been identified by EPA, differ on occasion from those shown in Table 2.2. Four of these are carcinogenic at high concentrations: As, Cd, Cr, Be, and six toxic: antimony (Sb), barium (Ba), Pb, Hg, Ag, and titanium (Ti) (Lee, 1992). To confuse the issue still further, Duffus (1980 in Dallas and Day 1993) quotes the US EPA as listing only Be and Hg as hazardous, and barium (Ba), Cd, Cu, Pb, Mn, Ni, tin (Sn), vanadium (Va) and Zn as potentially hazardous. Thus, in these three references, Cd, As and Hg are listed as both highly hazardous, and as potentially hazardous.

Table 2.2: Chemical pollutants listed by the 1971 Oslo Convention as either 'Black' (hazardous) and 'Grey' (potentially hazardous). *(Source: Hedgecott, 1994).*

'Black'	'Grey'
Cadmium and its compounds	Arsenic and its compounds
Mercury and its compounds	Chromium and its compounds
Organohalogen compounds and their precursors	Copper and its compounds
Persistent plastics	Lead and its compounds
Persistent synthetic materials	Nickel and its compounds
Substances agreed as likely to be carcinogenic	Non-persistent oils and hydrocarbons
	Phosphorus and its organic compounds
	Organosilicon compounds
	Organotin
Radioactive substances	Tainting substances (in sea foods)
	Zinc and its compounds

Ultimately, though, while much is known of the chemistry, environmental fate and toxicity of these metals, their long-term ecological effects are still unknown, and current management procedures need to be constantly improved (Hedgecott, 1994). Mercury, Cd, Pb and As are discussed in more detail below:

Mercury

Mercury is a general protoplasmic poison; it circulates in the blood and is stored in the liver, kidneys, spleen and bone. A number of mercury compounds are common air contaminants and strong allergens and can cause skin irritation and be absorbed through the skin (Sax and Lewis, 1993). Alkylmercurials are stable and lipid-soluble, and accumulate particularly in nervous tissue. In sediments, inorganic mercury can be converted to alkylmercurials by anaerobic bacteria (Dallas and Day, 1993). Mercury and mercury-organic complexes are extremely toxic to aquatic organisms and can bio-accumulate in the food chain. Intake can be via air, food and water. Alkylatid mercury compounds are a serious concern in aquatic environments as they are more toxic than inorganic forms. It is assumed that 10% of the total mercury present in a sample is in the form of organo-mercury compounds. Methyl-mercury accumulated in fatty tissue or storage organs can be mobilized into the nervous and reproductive systems. Organic forms are approximately 10 times more toxic than inorganic forms because they pass rapidly through biological membranes. The toxic effects of mercury on aquatic organisms cannot be reversed *(Draft South African Water Quality Guidelines, DWAF).*

Cadmium

Cadmium can remain in the human body for up to 47 years and tends to increase in concentration with age and eventually acts as a cumulative poison. It is a teratogen, carcinogen and possibly a mutagen, which has been implicated in numerous human deaths and severe negative effects on fish, domestic animals and wildlife populations, especially migratory birds feeding on vegetation conditioned with municipal sewage sludges (Eisler, 1985). In addition, freshwater and marine aquatic organisms accumulate Cd, and seawater concentrations in excess of $4.5 \mu g/l$ of total Cd can be considered as potentially hazardous to marine life.

The presence of other metals may result in either synergistic or antagonistic interactions. The presence of As and Hg may result in reduced toxic effects of both metals, while the interaction of Cu and Cd leads to a fivefold increase in the toxicity of each metal. The presence of Zn accentuates the toxicity of Cd to some aquatic plants. The level of uptake depends on water conditions, temperature and pH *(Draft South African Water Quality Guidelines, DWAF).*

Lead

Lead is not essential to humans and animals and has adverse effects on growth, reproduction, development, behaviour, learning and metabolism, and adverse effects on marine organisms are reported at concentrations of 1.0 to 5.1$\mu g/\ l^{-1}$ It is possible that continuous low level exposures due to widespread environmental contamination may result in adverse health effects, and environmental lead pollution is now so high that levels in human populations are nearer to clinical poisoning levels than for any other toxic chemical. It is a mutagen and teratogen, and has carcinogenic properties, impairs reproduction and liver and thyroid functions, lowers resistance to disease and, at subclinical levels, causes slight, but irreversible damage to brain development in young children (EPA, 1979; Eisler, 1988). Lead is mainly absorbed through ingestion, and varies with age, sex and diet. Dietary deficiencies in calcium, Zn, Fe, vitamin E, Cu, thiamin, P, Mg, fat, protein, minerals and ascorbic acid increase Pb absorption and its toxic effects (EPA, 1980).

In water, solubility of lead is low and pH dependent, except in areas of point source discharges (EPA, 1980). In the sediments, Pb is released when pH decreases suddenly or ionic composition changes. Most lead discharged into water is incorporated into suspended and bottom sediments and will ultimately be deposited in marine sediments.

Arsenic

Inorganic arsenic can affect humans and animals by producing mutagenic, teratogenic and carcinogenic effects. Correlations between elevated atmospheric arsenic levels and mortalities from cancer, bronchitis, and pneumonia were established in an epidemiological study in England and Wales, where deaths from respiratory cancer were increased at air concentrations >3 $\mu g/m^3$. Chronic arsenic poisoning has occurred in people from communities in Europe, South America and Taiwan exposed to elevated concentrations in drinking water (EPA, 1980). In another case, approximately 12 000 infants were poisoned in Japan (128 deaths) after drinking dried milk containing 15-24$mg\ kg^{-1}$ inorganic arsenic from contaminated sodium phosphate used as a milk stabilizer. Fifteen years after exposure, survivors are still affected by severe hearing loss and brain wave abnormalities (Pershagen and Vahter, 1979, in Eisler, 1988).

Chemical exposure in medical institutions

Emissions from hospital incinerators, and the use of hazardous substances in healthcare institutions, contribute to urban pollution, which is correlated with disease by numerous epidemiological studies (Guthrie and Perry, 1980). Hospital employees are exposed to a variety of hazardous chemicals and gases such as halothane, enflurane, methoxyflurane, nitrous-oxide, ethylene-oxide and formaldehyde, and there are additional health risks associated with the use of drugs such as cyclophosphamide and vincristine and organic reagents and solvents, and asbestos (Babich, 1985).

Chemical wastes which require special treatment include halogenated and non-halogenated organic solvents, inorganic acids, mercury batteries, Polychlorinated biphenyl (PCB)-containing waste and cytotoxic drugs. These are generated by wards, laboratories, X-ray theatres, pharmacies, pathology departments and workshops (Helten, 1995). Many of these chemicals can be toxic for long periods, (PCBs remain toxic for decades and cadmium forever, according to Barbour (1980)), and can mix with other pollutants in the environment to form complexes, or react to release more hazardous products.

Of relevance to medical institutions in South Africa which use and dispose of a large amount of chemicals, is that the local chemical industry, in line with an international atmosphere of concern for the environment, is adopting the Responsible Care initiative. This is an international enterprise which involves regulating operations by producing guidelines and audits against management practice standards (Johnston, 1995). There is a need for such regulation, as approximately 100 000 chemicals are available and new chemicals are increasing worldwide by several thousand per year (Hedgecott, 1994), each with an unknown number of by-products associated with their manufacture, degradation or destruction. Some of the most toxic, such as DDT, chlorofluorocarbons (CFCs) and mercury, are controlled (in the UK), but it is necessary to regulate or eliminate certain others to avoid past mistakes. New chemicals need to be assessed so that they do not add to the contamination of the environment (Hedgecott, 1994).

Cytotoxic chemicals

These hazardous pharmaceuticals are used in chemotherapy and are capable of impairing, injuring or killing cells. The following are regulated cytotoxic compounds:

Table 2.3 : Regulated cytotoxic compounds used in chemotherapy. *Source: (Hedgecott, 1994).*

Chlorambucil	Mitomycin
Melphalan	Duanamycin
Uracil mustard	Streptozotocin
Cyclophosphamide	

In the USA, there are approximately five million employed in the health care industry, and the population at risk for exposure to cytotoxic drugs is estimated at several thousand workers, the main exposure routes being inhalation, skin absorption, and ingestion of contaminated food or smoking contaminated cigarettes (Babich, 1985). Further research into reports of health hazards associated with cytotoxic drugs (CDs) showed that although guidelines for worker protection were developed, these were not closely followed. Only ten of the twenty-one United States cancer centers used biological safety cabinets for CD preparation in 1982, and only three out of ten hospital oncology clinics surveyed regularly used gloves. New guidelines were issued in 1984 and included drug preparation and administration, waste disposal and handling of spills, drug storage and transport, care of patients receiving CDs, medical surveillance, training and the distribution of information (Yodaiken and Bennett, 1988).

Solvents

A number of solvents are found in medical waste, especially waste originating from research laboratories and pharmaceutical companies. The US Resource Conservation and Recovery Act lists the following as hazardous solvents typically found in medical waste. These compounds may form dioxins and furans when chlorine is present (Lee, 1992).

Table 2.4 : Hazardous solvents found in medical waste. *(Source: Lee, 1992).*

Acetone	2-Butanol	Butyl-alcohol	Cyclohexane
Diethyl-ether	Ethylacetate	Ethyl-alcohol	Heptane
Hexane	Methyl alcohol	Methyl cellosolve	Pentane
Petroleum ether	2-propanol	Secondary-butyl -alcohol	Tertiary-butyl -alcohol
Tetrahydrofuran	Xylene		

Radioactivity

All matter is continuously exposed to ionizing radiation from natural sources. This contributes to approximately 88% of the average individual's total exposure, with an additional 12% from X-rays used in medical procedures (Le Roux et al., 1992). As more has been done to protect humans and the environment from ionizing radiation than from any other form of pollution, it is believed that these materials are well controlled and only small quantities are released into the environment.

In South Africa there is a range of radioactive wastes which are managed and disposed of under strict licensing codes. Control is exercised by the Department of Health for medical and industrial sources and the Council of Nuclear Safety for radioactive waste produced in the generation of nuclear power.

The management of stored radioactive waste is a universal problem, and professional opinion is divided on the safety of present storage and disposal methods. Locally, the Atomic Energy Corporation (AEC) has developed two facilities, one at Pelindaba, which was designed to treat waste generated by the operations of the Safari research reactor (the isotope production centre and research laboratories which produce radio-isotopes for medical procedures), and one at Vaalputs in Namaqualand. All wastes are solidified prior to disposal.

Radiation Hill at Pelindaba covers an area of about 6 hectares and consists of 5*m* deep trenches for the disposal of low- and intermediate-level radioactive waste; a pipe facility for the disposal of spent medical and industrial sources; a new 27*m* deep pipe facility for the storage of spent Safari fuel; Calcium fluoride (CaF_2) (from uranium extraction processes) sludge disposal evaporation ponds and the surface storage in drums of depleted uranium tailings from the enrichment plant. In the future, much of this waste will be sent to Vaalputs, which includes a waste treatment plant, disposal and pipe storage facilities and effluent storage ponds (Hambleton-Jones, 1994).

Problems do arise though. Recently it was reported in the press (Weekend Argus, 24.2.96) that a large township near Pelindaba had been exposed to significant levels of radiation from a buried radioactive waste container being damaged by a front-end loader (this incident has been verified by the AEC). Another cause for concern is that even though the Nuclear Regulatory Commission (USA) believes incineration to be the most acceptable method of disposing of low level radioactive waste (Lee, 1992), in Germiston (SA) there is now public outcry over the burning of this waste in a specialised medical waste incinerator, and if this company is forced to refuse radioactive materials, these will have to be transported to Pelindaba at significantly increased cost, with the concern that medical institutions might resort to other, less controlled, disposal methods.

To obtain an idea of the scale of nuclear waste in the USA, it is estimated that more than seven million radio-pharmaceuticals are administered, eleven million nuclear medicine procedures, and one hundred million radio-immunology procedures are performed yearly. All may generate low-level radioactive waste (Lee, 1992).

2.1.5 INTERNATIONAL HOSPITAL WASTE DISPOSAL STRATEGIES

In the USA and elsewhere, the problem of medical waste disposal is compounded by the increasing use of disposables (EPA, 1989a). Plastics pose a serious waste management problem for hospitals, and research is being carried out internationally on new technologies and strategies to address this difficulty. One solution, used extensively in Switzerland, is to use plastic products, with their high calorific value, as fuel in specifically adapted cement kilns.

Depending on size, a Swiss hospital generates up to ten times more waste per person than the private sector. The University Hospital of Basel produces approximately 3 700 tons of waste per year, 31% of this being plastics waste. Plastics cause problems for conventional incinerators, which were built for a 5-7% plastics waste capacity, and now have to deal with more than 20% - this is estimated to rise to 50% in the next four years. A major problem is that most containers do not consist of type-specific material, and the more one departs from single material type systems the worse the quality of recycling will be. Waste containers which have to be incinerated should be made from recycled plastics. These large volumes of plastics are the main cause of rising disposal costs, and in addition, pollutants such as dioxins, hydrochloric acid (HCl) and heavy metals could be present in emissions when incinerating this material (Schelker, 1995).

In Freiburg, Germany, tests undertaken on liquid effluent outflows at the Albert Ludwigs University Hospital mirror to a large extent those undertaken in this study. In February 1995, time was spent at the Department of Environmental Medicine at this hospital in discussion with Mr Scherrer and Dr Kummerer, the chemical engineers responsible for investigating effluent outflows. Their research is mentioned here, but discussed in more detail in Chapter 5.

It must be borne in mind when considering waste problems in Germany, that attitudes and public demand are generally different from those in South Africa. Most importantly, at this University Hospital, there is total commitment from top management to protect human health and the environment, and this attitude is further supported by strict, enforceable legislation.

The University Hospital has laboratories discharging the following wastes:

- heavy metals
- pharmaceuticals
- disinfectants
- chemical waste from laboratories (inorganic acids, alkaline solutions, halogen containing solvents, benzene, toluene, xylol)
- x-rays, fixatives and developing solutions
- cadmium and mercury batteries and fluorescent lamps.

Management policy controlling these wastes stipulates that pharmaceuticals be stored separately to avoid misuse, and that cytotoxics be treated as special waste and returned to central pharmacies. Developer and fixative from x-ray laboratories is stored separately and is not discarded via the sewers. Silver and old films should be recycled, and mercury thermometers replaced with digital ones. At this institution, the objectives of their waste management strategy are avoidance, reduction and re-use (Scherrer, 1994).

Recycling

It is estimated that soon many landfills will have reached their capacity, with approximately 90% of waste in the US being landfilled (Kharbanda, 1990). Only 5% is incinerated, and this waste management option tends to be even more unpopular with the public than landfill, when located in their 'backyard'. Because of the increasing problems with both landfill and incineration, recycling as a form of medical waste management has been used extensively in the US and Europe, with varying degrees of success. Some examples are detailed below:

Ethanol and xylene

A system has been developed in Slovenia for the recycling of ethanol and xylene from pathology laboratories (Grilc et al., 1995). The solvent mixture consists of ethanol, xylenes, and some non-volatile impurities such as grease and dyes. This is separated to pure ethanol by a combination of distillation and carbon adsorption. Ten litres of ethanol-xylene-water per hour can be processed by this system.

Hazardous dental waste

Hazardous dental waste consists of the following:

- x-rays and protective lead foils
- developer and fixing bath
- amalgam residues
- amalgam particles collected in spittoon of treatment unit
- material slightly contaminated with amalgam.

In 1985, the Swiss Society of Orthodontists requested a complete recovery service for silver, copper, lead and mercury. The last three items in the above list are estimated to contribute approximately 10% of the mercury pollution in Switzerland. Material slightly contaminated by mercury is a problem, and consists of cellulose and different plastics containing 0.1% mercury. This is treated in a battery recycling plant. If all Swiss dentists cooperated in this project, 10 000 - 20 000 kg of mercury would be recovered each year (Jiskra, 1995).

A closed loop hospital recycling programme has been developed in the USA, which involves collecting mixed plastics waste, sorting by type, grinding, washing, pelletizing and then reprocessing into secondary products for use in healthcare institutions. For easy sorting, materials are marked, for example high density polyethylene (HDPE) low density polyethylene (LDPE), polyvinyl chloride (PVC) and polypropylene (PP). These plastics need to be separated at point of generation and care taken to keep them apart from the infectious waste stream. This particular company manufactures and distributes 120 000 products and most of these can contain recycled material:

Table 2.4 : Hospital products made from recycled plastics. *(Source: Giovanetto et al., 1995).*

Plastics type	**Product**
30% recycled content PP	Sharps containers
100% recycled content PVC	Anti-fatigue mats
<u>Currently being considered</u>:	
PP/PE blend	Bedpans, wash basins, emesis basins, polyliners (Green and black bags)
PVC	Patient ID bands, walkway matting, shower curtains

Cement kilns

From the above literature it can be seen that plastics pose a serious waste management problem, and that extensive research is being carried out internationally to address this difficulty. As mentioned previously, in Switzerland, specially adapted cement kilns use plastics products as fuel (Schelker, 1995).

Cement production involves heating raw materials to approximately 1450°C to form clinker, which is cooled and ground with a small amount of gypsum to produce cement. Although a cement kiln is an ideal incinerator due to its high temperatures and long residence time which ensures complete destruction of organic compounds, there are constraints on the fuels that can be burned.

Internationally, tyres are the most popular alternative fuel to fossil fuel, but alternatives include waste oil, landfill gas, pyrolysis gas, peat, PCBs and municipal solid waste. Sewage sludge can also be used as fuel, although heavy metals, particularly Hg, creates problems (Jones, 1994). One ton of sludge replaces about one-third of a ton of coal, although sludges containing high levels of heavy metals still have to be disposed of in landfill. One cement manufacturer in Switzerland was, in 1995, installing a high temperature gasification plant firing at a temperature of 2000°C to enable alternative fuels contaminated with heavy metals and halogens to be utilised (Caluori, 1994). This manufacturer is at present using plastics and other alternative materials to substitute one third of their total fuel demand - replacing 25 000 tons of coal imported from South Africa, and producing less emissions. If hospitals wish to take advantage of this method of waste disposal, all plastics must be sorted and PVC eliminated, as chlorine damages the quality of cement.

2.1.6 DISPOSAL OF HAZARDOUS MEDICAL WASTE IN CAPE TOWN

Marine disposal

Chemicals being discharged from medical institutions are deposited in rivers and ultimately the sea via wastewater plants, and possibly stormwater runoff. In addition, a substantial amount of these pollutants are contributed by domestic effluents, corrosion of water pipes (Cu, Pb, Zn and Cd) and detergents, which can contain Fe, Mn, Cr, Ni, Co, Zn, Boron (B) and As. The rate at which pollutants dissipate in the water is largely dependent on waves and currents in the area. Currents in Table Bay are predominantly northerly, but surface and bottom currents are weak, especially in winter (Van Ieperen, 1971), causing poor flushing and a residence time of several days for water in the bay. Any pollutants will therefore dissipate relatively slowly (Quick et al., 1993).

All medical institutions in the Cape Town City Bowl discharge effluent into Table Bay. Marine waste disposal via submarine outfalls relies on dilution and dispersal and the ability of marine organisms to biodegrade organic wastes, as well as the binding ability of sea sediments (Department of Water Affairs & Forestry (DWAF), 1994). Brown (1976) on the other hand, believes that even though the sea has always been regarded as a vast sink, the persistence of many pollutants in the marine environment for long periods is of special concern. But, according to DWAF (1994), marine disposal, being the economic option, has been widely used in South Africa, particularly for sewage in coastal areas.

There are a number of medical institutions which are not situated within the City Bowl, and these discharge liquid effluent into the municipal wastewater plants, which are discussed in 2.2: Sewage System. Solid wastes are sent to landfill for disposal, are incinerated, or ideally, re-used or recycled. A number of these options are discussed below:

Landfill

Owing to expense and lack of efficient incinerators, the most common form of waste disposal in South Africa is landfill (DWAF, 1994). Most sites do not meet sanitary landfill standards, although this is now being addressed by the Minimum Requirements, drafted in 1995 and still in the process of compilation.

It is difficult to decide whether incinerators or landfill are preferable for the disposal of medical waste. 'Incinerators don't make waste disappear; they only process it and reduce its volume, still leaving large amounts of toxic ash that must itself be landfilled' (Denison, 1989). Ash should be chemically or physically treated and disposed of in lined landfills. This is expensive, but from experience it has been shown that if these measures are not insisted upon, the costs are far more in the long-term (leachate formed from the toxic chemicals and heavy metals present in incinerator ash can contaminate aquifers). Incinerator ash is at present not classed as special waste in South Africa, and is collected and landfilled with domestic refuse.

Recycling

Recycling of certain types of hospital waste (e.g. bottles, paper, metal and plastics) is becoming more popular in Cape Town hospitals and clinics. This aspect of waste management is only mentioned briefly as it is beyond the scope of this thesis.

2.1.7 RISK ASSESSMENT

Hazardous waste mismanagement in the past has resulted in polluted ground water, streams, lakes and rivers, and to elevated levels of toxicity in humans, aquatic species, and terrestrial animals. To prevent further contamination, US EPA has outlined regulations in an attempt to ensure safe management of hazardous waste from its generation to disposal. It has done this by (1) implementing a documented tracking system from point of generation to point of final disposal, (2) an identification and permitting system to ensure safe storage, treatment and disposal, and (3) a system of restrictions and controls for landfill.

An additional EPA programme, based on the Resource Conservation and Recovery Act (RCRA) uses risk assessment to address the problem of pollution. This is based on a constant level of exposure to a single chemical, even though in reality, exposures involve multiple chemicals which form combinations with other chemicals to form unknown compounds. Research is being carried out to provide more realistic assessments (EPA, 1990). As pointed out by Hedgecott (1994), the identity, quantity, patterns of release and distribution of chemicals are still poorly documented, leading to uncertainty in hazard assessment - an omission which needs to be urgently addressed.

Threshold Limit Values (TLVs) (issued by the American Conference of Governmental Industrial Hygienists) in the USA are used for setting limits for air pollution, but the manner in which they are produced has caused some concern. Company representatives were given responsibility for developing TLVs for more than one hundred chemicals, including thirty-six classified carcinogens. These included brand chemicals manufactured by companies that employed these representatives (e.g. Dow, DuPont, and Bayer). Dow's toxicologist was responsible for documenting TLVs for at least 30 of their halogenated hydrocarbons, pesticides, and other industrial chemical products (Anonymous, 1988). In spite of strong criticism from unions (but approval from the chemical industry) one hundred TLVs were in 1987 adopted as permissible exposure limits. Thus these limits, which were originally issued as guidelines for occupational exposure, have now become reference levels in setting limits for environmental exposure. This situation highlights the lack of sound data on chronic health effects (Anonymous, 1988).

As can be seen from the above, the establishment of limits for emissions of hazardous substances into the atmosphere and terrestrial environment appear confusing, and are ruled to a large extent by conflicting interests.

2.1.8 ECONOMICS

As mentioned previously, financial considerations are given as the reason for not insisting on the enforcement of stricter pollution control measures, even with numerous accounts of the far higher clean-up costs, for example, Minemata, Bhopal, and Chenobyl and also the on-going remediation costs (approximately $1 000 000 an hour) in an attempt to restore groundwater quality in aquifers contaminated by landfill leachate throughout the USA (Parsons, 1995). In 1986 the Superfund Amendments and Reauthorization Act authorized $8.5 billion for emergency response and remedial cleanup programs.

In 1979 the annual costs in the USA of achieving SO_2 and particulate standards were approximately $9.5 billion, while the annual health benefits were $16 billion (Lave & Seskin in Barbour, 1980). Thus, it appears that enforcement of strict SO_2 and particulate standards can be justified as there is evidence to correlate mortality rates with air pollution levels below "safe" limit thresholds. It was concluded from statistical studies of health data and pollution levels in major cities in USA that a 50% reduction of sulphate and particulate levels resulted in an increase in average life expectancy by nine months. SO_2 is emitted when burning fossil fuels, and hospital boilers and incinerators contribute to this load.

Other alternatives are technology-based effluent limits using 'best practicable technology' and 'best available technology'; the provision of subsidies for waste treatment (although it would be preferable to concentrate on processes which generate less waste); or effluent taxes or charges, with the tax being proportional to the quantity of pollutant emitted. This latter option has a number of advantages, as it relies on economic incentives which provide choices for both producers and consumers and could encourage research into non-polluting technology. Resulting taxes could be used for research into pollution control. Unfortunately, the main obstacles to effluent taxes are political, as officials prefer policies with hidden costs (Barbour, 1980).

From 1971 to 1977, 21 900 workers in the USA lost their jobs because of the closing of 118 plants - at least in part due to the imposition of air and water standards. But in this same period 678 000 new jobs were created in pollution abatement activities, including equipment manufacturing and operation, and sewage plant construction (Barbour, 1980).

2.1.9 INTERNATIONAL EDUCATION PROGRAMMES

Growing awareness of environmental degradation, pollution, volumes of waste and high disposal costs encouraged the University Clinic Zurich to introduce a programme for the efficient disposal of hospital waste (Buhler et al., 1995). This hospital of 1200 beds is approximately the size of Groote Schuur and deals with 30 000 patients and 150,000 outpatients per year. In 1993, it produced a total of 2,131 tonnes of waste, the disposal costs amounting to Sf430, 000 (approximately R1 204, 000).

This Clinic separates waste at origin into well-defined categories, and with cooperation from heads of departments, information is clearly communicated to staff by means of leaflets. Waste representatives are trained with slide shows and documents and the entire hospital staff informed of correct waste separation and disposal by attending continuous optional training courses. Employees have been motivated by a campaign (motto: "Ecology in the Hospital - Join In, Act Now") to change their own behaviour and attitudes towards the environment. The goal of this campaign is to limit toxic waste by avoidance, reduction and re-use, and to dispose of the remainder in a responsible manner (Buhler et al., 1995).

In the USA, a number of hospitals, on limited budgets, demonstrated responsibility towards surrounding communities by providing a more comprehensive health care strategy. This included anti-pollution campaigns and involving residents in an education programme which highlighted noise pollution and health hazards to land, air and water. Other hospitals started more traditional community projects that link their concern for health to the quality of the environment, for example newsletters, radio spots, lobby displays, and recycling campaigns. While most of these projects were aimed at communities, many hospitals instituted programmes to clean up their own environment. An example of this was Barnes Hospital, St. Louis, whose directors believed that unless they were able to keep the hospital free of litter, they would not be able to convince the public of their ability to effectively manage their more hazardous clinical waste (Cihlar, 1972).

2.1.10 CONCLUDING COMMENTS

It can be seen from the above that medical institutions do discharge a significant amount of hazardous waste into the environment, and staff education programmes are necessary to address the problem of potential health hazards within these institutions, and to combat hazardous substances being discharged into the environment. There is an urgent need for an holistic approach to pollution control; from attitude change, to non-waste technology, minimization, re-use and recycling. Unfortunately cost is the most significant inhibiting factor, and economics, from government down to individual level, is frequently quoted as being the decisive factor as to whether or not environmental protection is given serious consideration. This is a short-sighted viewpoint, as although initial costs of pollution control measures are high, the longer it takes for these to be instigated, the higher the eventual clean-up costs will be. Other negative outcomes of increasing pollution, and reasons for urgently addressing this problem, are deterioration in human health and loss of sustainable productivity in both the ecology and economy (Barbour, 1980).

2.2 INCINERATION

2.2.1 GENERAL

Much has been written on the advantages and disadvantages of incineration as a disposal route for medical waste, and the following is an overview of international and local literature dealing with this disposal option.

It can no longer be assumed that the atmosphere will continue to absorb an indiscriminate discharge of pollutants. Atmospheric dilution and dispersion cannot continue to accommodate the inability or unwillingness of industry and individuals to treat wastes at source or to minimize their production (Petrie et al., 1992). Toxic pollutants are a serious problem, and despite their usually low concentrations, hazardous chemicals emitted into the air may have serious short-term and long-term effects on human health and the environment.

Incineration of hospital wastes contributes significantly to air pollution. It produces numerous heavy metals as well as a large quantity of toxic chlorinated organics and alkali chlorides. Primary pollutants, such as sulphur and nitrogen oxides (SOx and NOx), particulate matter, carbon monoxide (CO) and volatile organic compounds are all discharged into the atmosphere from incinerator stacks (Petrie et al., 1992).

Under inversion conditions, a characteristic weather pattern in Cape Town, pollution, including emissions from hospital incinerators, accumulates in the stable air layers. These layers act as a lid to restrict vertical dilution of pollutants. Sulphate and nitrate pollutants, smoke and dust, nitrogen dioxide and humidity, combine to form this haze and visibility decrease (Petrie et al., 1992). A variety of factors influence the discharge and subsequent dispersal of these pollutants, including topography, airmass structure, pollutant discharge rates, height of the discharging stack, temperature at discharge, and effectiveness of emission control measures (Gilbertson et al., 1985).

2.2.2 MEDICAL WASTE INCINERATION

Historical background

In 1968, waste disposal was a national problem in the USA, and hospitals were believed to be major contributors to this dilemma. Incinerators were fed by inadequately trained staff, with a variety of materials with no thought of smoke produced or materials dispersed into the environment. It was found that much of the smoke and atmospheric pollution contributing to urban pollution could be traced to these small incinerators (Holbrook, 1968).

Cilar (1972) claimed that one of the most visible forms of pollution to impact on hospital environments was particulate matter emitted by incinerators. This was effectively controlled by laws prohibiting burning in a number of States, and subjected hospitals to pressure and undesirable publicity. This legislation caused a collapse of investments in incinerators, increased disposal costs, had a significant impact on the use of plastics and other disposables, and encouraged a return to reusable materials. So effective was this publicity that public pressure caused a hospital in New Jersey, which was located within twenty feet of a number of residential properties, to shut down its incinerator owing to complaints of pollution from fly ash and odours.

Similarly, since the early seventies, hospital waste incineration has been an ever-increasing issue in Alberta because of the emissions of particulates, hydrochloric acid (HCl) and chlorine from burning the large amounts of plastics present in this type of waste. Most hospitals relied on inefficient machines to burn their waste and almost none followed guidelines for contaminated wastes. It was estimated that Alberta hospital incinerators emitted fifty times more HCl than did major chlorine manufacturers (Powell, 1987).

By 1980 the quantity of plastic in hospital waste was still causing problems of HCl emissions in Ottawa, Ontario and in Germany. Hospital wastes normally contain from 20-30% plastics, with municipal solid waste generally containing about 3-7%. Because of these high levels of plastics, an investigation into hospital incineration techniques in Alberta was carried out to determine: (i) how HCl might be eliminated from incinerator exhaust gases; (ii) how the PVC content in incinerated waste might be reduced; and (iii) the effects of HCl emissions on health and vegetation and corrosion effects on physical structures. It was concluded that the use of properly controlled starved air incinerators with flue gas scrubbers for controlling emissions would considerably moderate these problems (Powell, 1987). On the other hand, stack surveys of small rural hospitals (< 50 beds) were found to meet the current emission standards.

In response to a request from employees at a medical centre in New York, a study was conducted of exposure to toxic odours from the hospital waste incinerator. Staff believed the manner in which the incinerator was operated was exposing them to hazardous materials. A number of workers regularly suffered from nausea, headaches, dry scratchy throat, and burning eyes. There were indications that this was due to incinerator/scrubber stack emissions, but there was no proof of over-exposure to any of the chemicals evaluated. The authors recommend the establishment of a written respiratory protection programme, although the incinerator was shut down shortly after this survey (Almaguer and Driscoll, 1991).

Lee (1992) states that the US Environmental Protection Agency (EPA) and industry believe incineration to be the best available technology for the disposal of hazardous, medical, municipal, sludge and toxic wastes. EPA indicates that 70% of hospital waste is incinerated on-site, 15% is sterilized in autoclaves, and a further 15% is transported off-site for treatment. Ten percent of the waste treated off-site is incinerated (EPA, 1989a).

In hospitals, each department tends to generate different types of waste, although the bulk is similar to domestic waste, with the exception of pathological materials and significantly higher levels of plastics and rubber. This mixture has a considerable impact on the performance of incinerators (Lee, 1992). When burning medical wastes, plastics is believed to be a main source of lead and cadmium, and the main contributor to these metals is thought to be the dye used to colour red bags for storing infectious waste (Hickman, in Lee, 1992).

Hospital Incinerators in the UK

Many hospitals in Britain continue to illegally dispose of hazardous clinical waste. Until 1989, these institutions could not be prosecuted for contravening any environmental regulation as they were owned by the State, but in 1992 new legislation was passed to hold hospitals accountable for their waste management practices (Tickell and Watson, 1992).

The British Environmental Protection Act states that incinerators must burn at a minimum temperature of 1,000°C. This requirement was made compulsory by October 1995. The problem is that most British hospital incinerators are so old that even if they were upgraded, they would not able to reach these temperatures. A report on toxic waste disposal in Wales in 1990, found that of thirty-six hospital incinerators studied, only six could reach between 800-1,000°C, with one burning at only 400°C. Most burn between 200 and 500 kilograms per hour and dispose of waste from nearby clinics and general practitioners (Tickell and Watson, 1992). When burnt at temperatures of 250°C and 400°C with a peak at 300°C, these incinerators act as 'dioxin factories', and only specialized medical waste incinerators can solve this problem.

It is calculated that approximately twenty large modern high temperature automated incinerators costing approximately 60 million Pounds could burn all clinical wastes in the UK with minimal pollution. This is believed to be a more economical alternative to replacing all existing hospital, clinic or municipal incinerators to meet present environmental legislation, which could cost approximately 400 million Pounds. This saving of over 300 million Pounds could be used for upgrading health care facilities (Tickell and Watson, 1992).

Health effects of incinerator emissions

All combustion processes emit potentially harmful substances into the air, but burning of hospital waste poses a far greater threat of toxic emissions. Hospital incinerators are still a major problem in the UK (Tickell and Watson, 1992) and the USA (Evans, Harvard University, pers. comm.), as well as in South Africa (Linde, 1994; Futter, 1994) and the difficulties associated with old machines having to cope with the escalation of plastics and hazardous substances are thus of international concern.

There has been widespread concern over the health effects from incineration of plastics, especially polyvinyl chloride (PVC), in medical waste incinerators. When PVC is burnt it emits toxic substances, for example, hydrochloric acid, dioxins and furans. PVC is used in a number of items incinerated by healthcare institutions in machines not capable of handling this type of material. Although technological advances in emission control devices in a number of countries, including the USA, Germany, Switzerland and Sweden, make it possible to control toxic substances discharged into the atmosphere, there are still many hospital incinerators which are not capable of dealing with this type of waste in the USA (J. Evans, Harvard Univ. pers comm.).

In 1990, US EPA undertook a thorough review of dioxins, and concluded that for non-cancer effects, such as damage to the reproductive, endocrine and immune systems in birds, fish and mammals, including humans, dioxin is much more toxic than previously believed. Dioxins are extremely potent in producing a variety of effects in experimental animals at levels hundreds or thousands of times lower than most chemicals and "there is adequate evidence from studies in human populations as well as in laboratory animals and from ancillary experimental data to support the inference that humans are likely to respond with a plethora of effects from exposure to dioxin and related compounds". The developing immune system and intellectual development shortly before and after birth may be highly sensitive to dioxin exposure, and finally, EPA states that dioxin is 'likely to present a cancer hazard to humans' (Environmental Research Foundation, 1994).

In 1991 a resident in the UK went to court and blamed the death of his four year old daughter from leukaemia, on pollution from an hospital incinerator. It is now feared by hospital administrations that legal action might be brought against them in many more similar cases (Tickell and Watson, 1992).

European and Japanese studies

At modern plants in Japan, Germany and Sweden, it is claimed that 99% of all measurable pollutants are removed, with the exception of mercury which can be controlled at 91-97%. These high environmental standards are attained by strict pollution control and staff training programmes. Plants are equipped with acid gas scrubbers which condense metals and control acid gases, and electrostatic precipitators for the capture of particulates. Non-combustible materials are separated before reaching the incineration plants and temperatures are constantly monitored to limit organic pollutants. In Japan and most countries in Europe, air standards are strictly controlled and violations are punished by fines, closure of plants and prison for responsible officials (Underwood, 1989).

The situation in South Africa

Present air pollution levels in the Western Cape are unacceptably high. It is often said that the Cape has the cleanest air, but this, according to Stander (1995) is a fallacy. Cape Town is often nearly as badly polluted as the Vaal Triangle, and action needs to be taken now to prevent further deterioration in air standards. Nieuwmeyer (1994) also calls for air pollution to be reduced, and comments that the pervading attitude that the 'Cape Doctor' will blow it all away is illogical and short-sighted. Emission standards are seldom met in South Africa (Saayman, 1992), owing to lack of insight perhaps, but most probably due to short-term financial gain.

Local medical waste incinerators operate at approximately 400 - 800°C. As in the rest of the developed world, the burning of organic compounds and the large volumes of plastics, make it essential to review the design and performance standards of these machines. Even though some suppliers of medical equipment claim to have excluded PVC from their products, a significant amount of chlorine occurs in medical wastes, typically in the range of 2 - 4% by mass. Dioxin and furan emissions from medical waste incinerators are significantly higher than from domestic waste incinerators, and it can be assumed that this is true for other organic pollutants (Futter 1994).

When, for example toluene, ethyl cyanide, trichlorobenzene or cytoxic drugs are incinerated and begin to degrade, products of incomplete combustion (PICs) are formed (Dellinger and Lee, 1989 in Futter, 1994). The destruction of these substances requires extremely high temperatures, and halogens in the waste, particularly chlorine, complicates this process. The destruction of dioxins and furans and PICs numbering in their hundreds or thousands requires a highly controlled specialised incinerator.

Such an incinerator produced in South Africa, employs the pyrolytic process where wastes are burnt using their own energy, but under conditions where the air supply is kept substantially below that required for complete combustion. This produces an incomplete reaction where organic material is converted into an oxygen deficient, fuel-rich gas known as pyrogas, which is then channelled into a secondary chamber (+1300°C) where a controlled amount of air is added under turbulent mixing conditions. A reaction then occurs, which converts the gas into carbon dioxide and water (Futter, 1994).

Ash

Incinerators produce bottom ash, which is not regarded as hazardous waste in South Africa and is collected and landfilled with domestic waste. In the local literature, it is claimed that the ash content is about five percent by weight of the original waste, and as it has been sterilized by fire, can safely be disposed by the refuse removal system. It is further stated that incinerators comply with the Atmospheric Pollution Prevention Act , and "incineration by the hospital itself insures control of the waste until it is completely destroyed" (Fairbrass, 1993).

In Britain, while there are strict legal requirements for the handling of ash, there is no clear guidance on its disposal. Some ash is treated as hazardous waste, but much is discarded in ordinary domestic landfill sites (Tickell and Watson, 1992).

In the USA, strict control regarding the labelling and transport of hospital waste, including incinerator ash is recommended. Guidelines specify that the ash conveyor channel should be adequately guarded, and equipment provided for the removal of ash to ensure worker protection (Williams and Hickey, 1982). Incinerator ash should be treated and disposed of separately in lined landfill, and although this is expensive, it is believed that by not doing so far greater costs will be incurred (Denison, 1989).

In Japan, ash is carefully managed by separating out non-combustibles. Large incinerators (>200 tons p.d.) are limited to five percent ash of volume burned (US plants produce 10-15% ash by volume). To protect workers from exposure to ash, it is solidified into cement blocks and disposed in lined landfill with leachate collection systems (Underwood, 1989).

Hospital Boilers

Although hospital boilers have not been investigated in this study, they use coal and heavy duty oil (HFO) as fuel, and thus contribute to sulphur dioxide and particulate air pollution in urban areas. Many epidemiological studies show that a number of diseases, including cancers, are highly correlated with this pollution, in particular respiratory cancer, with SOx (sulphur oxides) being considered the most likely contributory factor (Guthrie, 1980).

For interest, details of these boilers are presented in Appendix VI. Mowbray Maternity Hospital has recently decomissioned its boiler and all sterilizing equipment is now run on electricity, considerably improving the ambient air quality. In the Observatory area, Groote Schuur, Vincent Palotti, Red Cross and Alexandra Institute all have boilers fueled by HFO or coal, and these could contribute substantially to the air pollution problem. The Groote Schuur boilers constantly emit black smoke, and this is in part caused by the fluctuating energy demands of the hospital making it difficult to control burning temperatures.

In a study by Watts et al. (1992) emissions from a municipal waste incinerator, as well as a medical incinerator were tested and compared to those of boilers burning coal, wood and oil. Similar stack emissions were observed. This indicates that the mutagenicity of emissions may not be as greatly affected by the fuel source as by burn conditions and pollution control devices. Emissions contained potent organic mutagens, but more research would be required to determine the emission rates and the species involved.

2.2.3 CONCLUDING COMMENTS

Emissions and ash emitted from medical waste incinerators are toxic pollutants to air and land and may be health hazards to humans and cause environmental degradation. This is a universal dilemma and many developed countries are still attempting to deal with these problems. It is believed that incineration is the best option for the disposal of medical waste, and Japan, Switzerland and Germany, for example, have strict emission controls and efficient, modern and expensive incinerators. These countries classify ash as special waste which is carefully managed and buried in lined landfill sites. Britain, the USA and South Africa, and presumably other countries, still have problems with old, inefficient medical waste incinerators which produce toxic emissions and pose a health hazard to city inhabitants.

2.3 SEWAGE SYSTEM

Besides the contribution of hospital incinerator emissions to air pollution, Cape Town, with its increasing industrial development, is likely to have heavy metals, chemicals and toxic organic contaminants discharged into its sewerage system. How hospitals contribute to this load, both internationally and locally, is discussed below:

2.3.1 IMPACT OF HOSPITALS ON THE SEWAGE SYSTEM

There appear to be few studies on the composition of effluent from hospital sewage outflows. Pragay (1975) reported that sewer outlets at a number of hospitals in Buffalo, USA, were monitored in an attempt to discover whether clinical chemistry laboratories were discharging significant amounts of harmful pollutants, and if so, how this could be rectified. Results revealed that phenolic compounds (e.g. disinfectants) exceeded by about one thousand times the value permitted by the local Sewer Authority.

Lack of data was a problem encountered at all hospitals reported by Pragay (1975), and as quantity of waste is related to the size of the hospital, one possible approach was to relate the total waste of all laboratories to the total number of hospital beds. From this relationship a theoretical hospital unit was used to compare data. Pollution control included guidelines for the decontamination of certain toxic elements and compounds such as silver, arsenic, cyanide radicals, chromium, copper, iron, mercury, zinc, phenolic compounds and organic solvents; data collection (including lists of permissible limits and knowledge of the sewer system) and remedial procedures (collection, disposal, detoxification and information reference books). A long-term programme was recommended which included the design of laboratory procedures and tests which produce less pollutants, and new guidelines for the construction of hospitals and laboratories which improve safety awareness and encourage cooperation between laboratories (Pragay, 1975).

The following Table lists the toxic compounds present in the sewer outflows of Buffalo hospital laboratories in 1972.

Table 2.5: Some harmful elements and compounds discharged by the Buffalo (Metropolitan Area) Hospital Laboratories per year. *(Source: Pragay, 1975).*

Element/Compound	Volume
Ag	90*g*
As	1 100*g*
CN	5 600*g*
Cr	2 100*g*
Cu	1 000*g*
Fe	19 700*g*
Hg	3 100*g*
Zn	1 000*g*
Acids	1 500*l*
Picrate	9 600*g*
Organic solvents	3 600*l*

More recent tests on sewage samples, carried out in 1993 by scientists at the Albert-Ludwigs University Hospital in Germany, found that the Chemical Oxygen Demand (COD) was similar to that of domestic effluent; however on detailed analysis, the composition contained more toxic substances. There are strict regulations preventing German medical institutions from releasing carcinogenic or non-biodegradable compounds into the sewage system (e.g.

dentists are required to filter amalgam out of their waste water) and as wastewater treatment plants are dependant on micro-organisms, it is not permitted to discharge antibiotics, disinfectants or cytotoxics which could destroy these organisms and disrupt the system.

Despite legislation and strict monitoring of waste management practices in hospitals and laboratories, effluent concentrations of metals from health care institutions are still cause for concern. Mercury is the most significant problem in Germany and originates from thermometers, medications containing Hg, for example Mercurochrome, some disinfectants, and amalgam in dental clinics (Kummerer, 1994).

As mentioned previously, there are approximately one hundred thousand registered chemicals which could end up in waste water. For many, no concentration levels are available and a 'sum parameter' is used to describe the toxic contamination; for example, electrical conductivity, pH, COD, biological oxygen demand (BOD) and absorbable organic halogens (AOX) and does not specify particular substances. AOXs, for example fluoride, chloride, bromide and iodine, are found in significant quantities in health care waste. These compounds are not biologically or chemically degradable, and they can be lipophilic and become accumulated in human and animal fat tissue. Further examples are chlorine in bleaching agents, refrigerants and ethidium bromide (used extensively in laboratories for DNA sampling) (Kummerer, 1994).

Liquid effluent from Cape Town Hospitals

It is impossible to discuss hospital sewage outflows and not mention the potential health hazards from infectious waste, even though this is not being investigated in the present study. Unfortunately, it is difficult to prove the link between infection and marine sewage contamination, and this makes it easier for local authorities and politicians to avoid admitting that a relationship exists, and continue to permit the discharge of raw sewage into the sea. It is usually only in the case of an epidemic, such as the cholera outbreak in Naples in 1973, the hepatitis epidemics in Sweden (1956) and Alabama (1961) that the true relationship can be firmly established (Brown, 1987)

The Green Point marine outfall discharges effluent from the City Bowl, Sea Point and Green Point into Table Bay. The pipeline has been trenched and concreted into the seabed to secure it from wave, current and anchor dragging hazards. Water quality (faecal coliform count) is in compliance with the EU water quality guideline standards for bathing beaches. There are two industrial outfalls which also discharge into Table Bay.

The Athlone Wastewater Treatment Works discharges treated sewage into Table Bay via the Black River, as does Borcherds Quarry near the airport. Milnerton Municipality also discharges effluent into the Bay, and the design capacity of this wastewater plant is approximately 26 megalitres per day, with an extension being planned to discharge a further 15 megalitres per day. Other wastewater treatment works that discharge into Table Bay include Parow, Melkbosstrand and Westfleur treatment plants (Table Bay Water Quality Committee, 1994).

Effluent from hospitals in the City Bowl is macerated, but otherwise untreated, and flows into Table Bay through the Green Point pump station. Other hospitals investigated in this study discharge into the Athlone wastewater plant. From here, the treated sewage enters the Black River, where EC standards for the protection of fish and river biota are largely met at Observatory Bridge, although levels of Ni, Pb and Zn are slightly above the limits (Pitt, 1988). Mercury levels are not tested.

Chemical and metal loads in the Black River include stormwater run-off and treated sewage effluent. The source of the high nutrient value may be mainly from sewage, as the Athlone works contributes 83% of the ammonia (NH_3), 40% of the nitrate (NO_5) and 85% of the phosphorus (P) in the river (Morrison, 1982). Hospital laundries contribute significantly to the N and P load.

The Black River flows into Table Bay, where the dilution effect of the sea is believed to disperse and detoxify the waste materials discharged into it. But substances are not always progressively diluted, and can concentrate in sediments and become further concentrated in the tissues of marine plants and animals and eventually humans, who are at greatest risk from all accumulated pollutants. As mentioned previously, it has been found that toxic substances in the sea may change into more toxic forms, and these combinations of pollutants may be far more dangerous (Brown, 1987).

In a further study to estimate metals present in the water column and sediments of Table Bay, mainly from the sewage outflow from Green Point Pump Station, it was found that Cu, Ni and Hg represent the greatest inputs into the water column. These three elements are also the greatest contributors to the sediment, with Hg showing the highest concentration (Bartlett, 1985).

Henry et al., (1989) believe that heavy metals in bottom sediments generally remain immobilized. They found Hg at elevated levels in sediments around stormwater drains, with cadmium distribution being highly correlated with both Hg and Pb. As a number of officials feel that city sewers are old and damaged, sewerage could combine with stormwater outflows and this could cause the heavy metal loads. Although some levels exceed limits for Cu and Hg, it is believed that the overall situation in Table Bay is healthy when considering metal and nutrient toxicities (P. Monteiro, Sea Fisheries Research Institute, pers. comm.).

Sludges

Substances released from medical institutions into the sewage system accumulate in sludges produced at wastewater treatment plants. Stabilised sludge application to land is practised in South Africa, and apart from the fear of groundwater pollution, the biggest problem is food chain contamination. There are two main exposure routes to humans; ingestion of contaminated crops, and consumption of organs (liver, kidneys) from animals which have grazed on vegetation treated with sewage sludge (Ekama, 1992). Of the metals which accumulate in sludge, Cd is the most toxic and is commonly associated with Zn. Cadmium is zootoxic and is the only metal which carries USA federal legislation (Eisler, 1985). In South Africa, no more than 1ppm Cd is permitted in soil for consumption crops.

In a survey of 77 South African wastewater plants, Smith and Vasiloudis (1989, 1990, in Ekama, 1992) found that only 37% of sewage sludge is suitable as a soil conditioner, mostly originating from smaller works. This small usable percentage is not acceptable for a country which relies heavily on agricultural production (Ekama, 1993).

It has been shown that the management of liquid effluent outflows and sludge causes problems both locally and internationally, and the following case study from Beder (1989) of the main ocean sewage outfalls in Sydney, Australia highlights some of these concerns.

2.3.2 SEWAGE OUTFLOW INTO SYDNEY HARBOUR, AUSTRALIA : A CAUTIONARY CASE STUDY

The following account deals with bacterial and viral contamination of the marine environment as well as that from chemicals and heavy metals. Wastewater discharged by medical institutions, however small in volume, does contribute to the toxic load in the water column and sediments and can contribute to an accumulation in fish and other marine organisms, and present a threat to the environment and to public health. The situation in Cape Town is very similar to the following account of the 1989 public outcry over pollution on Sydney beaches, although the sewage being discharged into Sydney harbour differs from that going through the Green Point pump station into Table Bay, as the former deals with a far higher industrial component.

It had been reported that fish caught near one of Sydney's main ocean sewage outfalls were polluted to over one hundred and twenty times the recommended safety limits for particular compounds, and that two government authorities had not disclosed these findings, and many of the beaches had become unsuitable for swimming for more than 30% of the time. These disclosures, which received international press coverage, resulted in a significant drop in tourism - expected to last for some years, and a vast cost to the fishing industry (Beder, 1989).

There were two major areas of concern to the public. One being the health threat of polluted sea water, as sewage contains bacteria and viruses that are not removed by the treatment process. Another was the potential contamination of marine life with toxic chemicals, including heavy metals.

Authorities in Sydney had denied health risks to ease political dilemmas, and were not accountable to the public due to a lack of consistency between legislation, guidelines and licences. Industry was required to apply for licences in order to discharge toxic substances into the sewage system and these licences only stipulated limits for oil and grease, but none for toxic waste, bacterial or viral concentrations. Restricted substances were regulated by maximum concentrations and not quantity of toxic substances discharged into the sewers. An additional problem was that the Sydney Water Board had been monitoring itself, and licence conditions had been set according to its inability to control toxic wastes being discharged into the sewers, rather than according to the requirements of the legislation.

In an attempt to please all parties, government had created legislation to placate conservationists, but for fear of alienating industry, had not implemented this legislation, thus creating environmental law without power.

Mercury levels

Fish all along the coast were found to have elevated mercury levels, even though the livers, where heavy metals accumulate, were not tested. The ban which had been placed on mercury until 1988 was lifted when the Board brought out a new trade waste policy. It was later revealed that ICI had had permission from the Water Board to discharge mercury into the sewers throughout the banning period, the explanation being that 'one had to be flexible, as some people had an effluent problem which could not meet the legal standards'.

Tests had been carried out in 1973 on heavy metal concentrations in fish, and significant concentrations of Hg, Zn and Cd were found, although this report was subsequently heavily rewritten, the information distorted and all reference to heavy metals omitted.

Coliform standards

Australian Clean Waters Regulations stated that 'wastes are not to be discharged into ocean waters if they will adversely affect beaches' but this had been translated to mean coliform standards. This use of faecal coliforms as bacteriological indicators is generally acknowledged to be inadequate as it has been found that 90% of faecal coliforms die within nine hours, whereas many viruses survive in the sea for between two days and four months. In 1989, it was noted that no scientific surveys into the health of swimmers and surfers had been carried out in Australia.

The New Scientist (16/7/81, in Beder, 1989) published data from health surveys carried out in the United States on 30,000 bathers and non-bathers interviewed at New York and Boston beaches. This showed statistically significant increases in the incidence of vomiting, diarrhoea, nausea, fever and stomach aches among swimmers who had bathed in polluted waters. Hepatitis is also related to sewage-polluted water.

Engineering solutions

What is economic in engineering terms is not always so in the long term. The sewers should not be used for the disposal of toxic waste, nor should industry under any circumstances be allowed to discharge heavy metals and toxic chemicals into the sewers. In September 1989, consultants in Sydney presented a draft report confirming that the proposed extended outfalls would not solve the beach pollution problem (Beder, 1989).

In spite of this recommendation, three deepwater ocean outfalls have since been constructed, and vary from Bondi at 2.5km offshore to Malabar at 3.8km. These all reach a depth of 80m to ensure, as far as possible, submersion of the plumes. Various other solutions were investigated, including piping the wastewater inland, although this would cost considerably more, with the additional complication of land salination. These options were rejected and the government has recently stated that there will be no ocean outfalls next century (N. Ashbolt, Univ. of NSW Sydney, pers.comm.).

Other improvements were made only after media exposures and a lack of public confidence in the authorities. These decisions included the considerable raising of fines and penalties for illegal dumpers, the promised phasing out of sludge dumping at sea , the inclusions of limits on toxic substances in licences, increasing of the number of trade waste officers, the increase in charges for water and sewerage rates for large industrial concerns and more public participation in decision-making (Beder, 1989).

"Lack of communication between government servants, local authorities, academics and commerce and the unwillingness to make decisions have hampered progress in many aspects of marine pollution, this must not happen in the field of human health" (Brown, 1987). This South African concern mirrors that of the Australian situation related above.

2.3.3 COMMENTS

Even though some authors believe that the discharge of heavy metals into Table Bay does not pose a problem, all mention Hg as being cause for concern. Mercury in effluent is the main problem in German hospitals, is also high in the USA studies and appears to be similar in Cape Town. Clearly it is important to minimize the heavy metal content of sewage outflows from medical institutions, as these metals, if they do not concentrate in sea sediments, accumulate in the sludge at wastewater plants and prevent this being used as a soil conditioner. This incurs additional costs as the contaminated sludge has then to be either dumped on sacrificial land, or co-disposed in landfill. Furthermore, if Table Bay becomes as badly polluted as the Sydney beaches discussed above, there will be a loss of tourism and a danger to humans who swim , or eat fish from this polluted water.

2.3.4 GENERAL CONCLUSIONS

The preceding literature review outlined the following points:

- An holistic approach to pollution control in medical institutions is needed; with non-waste technology, minimization, re-use, recycling and education programmes all contributing towards an efficient, safe hazardous waste management strategy.

- Economics is perceived as being the most significant inhibiting factor to the safe disposal of toxic medical waste, but unless environmental protection is given priority, future remedial costs will be excessive.

- It is believed that incineration is the best disposal option for medical waste, although according to the international literature, emissions from medical waste incinerators cause health hazards to humans, and environmental degradation.

- Modern, efficient medical waste incinerators fitted with strict emission control devices are required for the safe disposal of medical waste.

- Incinerator ash should be classified as special waste and disposed of in lined landfill sites.

- Marine disposal of toxic pollutants is cause for concern and minimisation of these pollutants a priority, as these could pose a hazard to human health, the environment, and a threat to the tourist industry.

CHAPTER 3

LEGISLATION

CHAPTER 3

LEGISLATION RELATING TO THE DISPOSAL OF MEDICAL WASTES

Having reviewed the nature of waste from hospitals, this chapter provides an overview of legislation relevant to the treatment and disposal of waste from healthcare institutions in South Africa.

3.1 GENERAL

Environmental law does not ensure environmental protection (Rabie et al., 1992), and laws will remain impossible to enforce unless there is a moral conviction within the population that environmental degradation is wrong. South Africans in general, although becoming more aware of the necessity of protecting the environment, do not perceive environmental degradation as morally wrong (Cowan, 1989). Apart from this viewpoint, neglect of the environment leads to environmental degradation which impacts on ecosystems and quality of life for the population. This in turn can have an impact on the economy, either directly (degradation of soil or fish stocks), or indirectly (affecting tourism).

A further constraint to the effectiveness of legislation, is its implementation not only by environmentally concerned public authorities such as the Department of Environment Affairs, but also by those which may have conflicting interests with conservation, for example the Departments of Mineral and Energy Affairs and Agriculture. Thus, the state of the environment is mainly dependent upon whether or not public bodies are favourably disposed towards conserving the environment and whether they have the ability to do so (Rabie et al., 1992).

Fuggle (1991) maintains that a clear legal distinction should be drawn between problems arising from degradable wastes, and those from persistent pollutants, for example heavy metals such as lead, cadmium and mercury, or certain chemical compounds. For degradable wastes, it is possible to apply penalties after the incident, for example, criminal prosecution, civil actions, forfeiture or effluent taxes. But for persistent pollutants, there should be total prohibition with considerable fines for violations, as the problems arising from these wastes are long-term and cumulative.

In an Executive Summary, brought out by the Department of Environment Affairs (1992), these subtle, indirect and cumulative effects of hazardous waste and their very real threat to both health and the environment are recognised. This report aimed to develop, within the concept of Integrated Waste Management, a strategy and action plan to deal with all hazardous wastes (excluding radioactive wastes). Of concern is the serious lack of experience at all levels in waste management, as well as lack of information communicated to decision- makers, operators and people responsible for, or affected by, hazardous waste management. There are few facilities for treating hazardous waste, much waste is not regulated, and many practices entirely uncontrolled. Transport and disposal are poorly managed and the structures and procedures that are in place are not always adequate to ensure environmental safety in the event of an accident.

Laws dealing with solid waste are incorporated within at least thirty-seven Acts of Parliament (Lombard et al., 1992). At present, officials at both a national and local level do not have the political will to enforce these laws, and this concern is stressed by Lee (1992) who, in an editorial of the *South African Medical Journal*, proposes that even though the implementation of effective law enforcement will be costly, when faced with "an environment which is the source of our life and which is being systematically degraded, the question is not so much whether we can afford to do so, but whether we can afford not to." Unfortunately, the reality of the situation is that 'pollution is very often the result of the maximization of profits through the minimization of the costs of waste disposal' (Petrie et al., 1992).

3.2 POLICY

The Constitution of the Republic of South Africa (s. 29, 1996) states that "Every person shall have the right to an environment which is not detrimental to his or her health or well-being". This is an ideal which will be impossible to attain in the absence of a centralised environmental protection authority, and without the manpower and financial support to enforce the numerous statutes and regulations at present administered by local authorities.

In 1992, the Cabinet requested the Department of Environmental Affairs and Tourism (DEAT), to address the Earth Summit's Agenda 21 by initiating, in collaboration with industry and local authorities, a project for the safe management of dangerous materials (Stander, 1995). In a White Paper 'Policy on a National Environmental Management System for South Africa' (1993) this department investigates the possibility of an environmental ombudsman, and discusses the creation of a national strategy for waste management, and the development of integrated pollution control, with priority being placed on responsibility, accountability, prevention, treatment and reuse. The report states that disposal into the atmosphere, onto land and into water should be considered only as a last option.

At present, in South Africa, the national policy accepts the need for a safe and healthy environment, but always within the constraints of a developing country which has to balance a healthy environment against financial viability. As far as emission levels are concerned, a 'best practicable means' approach is applied, which causes difficulties in the monitoring of these emissions (Petrie et al., 1992).

Very recently (Cape Times, 8 April 1996) it was reported that with the release by the Department of Environment Affairs of the Consultatitive National Environmental Policy Process (CONNEPP) discussion document, *Towards a New Environmental Policy for SA*, it was hoped that by sensibly managing our natural resources, sustainable development would be achieved. Among the guiding principles of this document were the "polluter -pays" principle, the "environmental responsibility principle", where organisations and individuals have a duty to avoid damage to the environment; and the "conflict of interest principle", which states that a body with regulatory responsibilities should not have conflicting interests. Finally, it had been reported that SA would have an Environmental Protection Agency to report directly to Parliament and audit government departments and institutions to ensure they comply with environmental legislation.

Policy statements

A promising feature of South African legislation is the concept of promulgating detailed national environmental policy statements, which could become a firm basis for South African environmental law. It is these policy statements, if legally enforceable, that will have the largest impact on healthcare institutions (Anon., 1995b). Policy statements include the latest guidelines brought out by the Department of Health under the Atmospheric Pollution Prevention Act (Guidelines for the Design, Installation and Operation of Incinerators), and those to the Occupational Health and Safety Act (Draft Regulations for Hazardous Biological Substances, and Regulations for Hazardous Chemical Substances).

The Minimum requirements for the Handling and Disposal of Hazardous Waste and for Waste Disposal by Landfill (DWAF, 1994) are in the process of completion and have already had a considerable impact on landfill management. These regulations will be enforced by means of a Landfill Permit System, as well as registration of waste generators and transporters. Environmental Impact Assessments are now required for proposed landfill sites, and in order to provide affordable environmental protection, the best practicable environmental option (BPEO) will be adopted. Costs will be in accordance with the "polluter pays" principle.

Guidelines were prepared by the Department of Health and Population Development in 1991 to reduce health risks when disposing of sludge on agricultural land. Regulations for its usage stipulate disposal options dependent on the type of treatment received and the heavy metal content. It is specified that sludge be stabilised, and that the levels stipulated for Salmonella organisms and faecal coliforms be met (Pitt and Ekama, 1995). The maximum limits for metal and inorganic content in these Guidelines are listed in Chapter 5.

3.3 LEGISLATION RELATING TO HOSPITALS

Appendix I indicates relevant sections from the Acts of Parliament applicable to hospital waste management, with the exception of the Occupational Health and Safety Act, which is relevant in its entirety. The most relevant Acts are the Environment Conservation Act, the Atmospheric Pollution Prevention Act, the Occupational Health and Safety Act, the Water Act, the Nuclear Energy Act and the Hazardous Substances Act. These are discussed below:

3.3.1 Environment Conservation Act (73 of 1989)

The Environment Conservation Act is reviewed by Rabie (1992) who concludes that even with the problems of implementation, this Act should be seen as South Africa's most important environmental statute. Of interest to medical institutions, are sections covering waste management (s.20), waste reduction and dissemination of information (s. 24). The Landfill Permit System is instituted in terms of s.20 of this Act, and ensures the enforcement and implementation of the Minimum Requirements.

3.3.2 Atmospheric Pollution Prevention Act (45 of 1965)

The Atmospheric Pollution Prevention Act applies, for example, to hospital incinerators, boilers and air-conditioning plants. This Act allows for an Air Pollution Appeal Board to hear appeals on decisions made by local authorities, or appeals by members of the public against pollution hazards. The Act states that when considering the siting of fuel-burning appliances and construction of chimneys, 'no local authority shall approve of any chimney carrying smoke, gasses, vapours, grit, dust or other final escapes from any building ...' unless it is satisfied that this does not become prejudicial to health or a nuisance to occupiers of premises in the surrounding areas. If there are complaints, the Local Authority should serve a notice to abate the nuisance.

There have been no prosecutions under the air pollution control legislation, and in a report on the 'Situation of Waste Management and Pollution Control in South Africa' prepared by the CSIR Programme for the Environment (1991), it is stated that one of the main reasons for this is the fact that there are no lawyers working on enforcement. There are only eight enforcement officers to administer and police the provisions of the Act, as well as to deal with the approximately two thousand permits which allow emission of noxious and offensive gases. The fines are insignificant, being only R500 (R1000-R2000 for persistent contraventions), and the *locus standi* (legal standing - an individual must have a direct, personal interest in the issue) requirement effectively prevents the majority of the public from access to the law (Glazewski, 1991).

The latest guidelines under this Act, "Guidelines for the Design, Installation and Operation of Incinerators" (1994), provides for measures and procedures to prevent or minimize negative effects on humans and the environment from the incineration of hazardous waste, and to set up and maintain suitable operating conditions and emission limit values. The Department of Health has given the hospitals eight years to comply with these regulations.

In this amendment, medical waste is defined as "Any waste which is generated during the diagnoses, treatment or immunization of humans or animals; in research pertaining to this; in the manufacturing or testing of biological agents - including blood; blood products; and blood contaminated products; any body fluids or excretions; cultures; pathological wastes; sharps; human and animal wastes; isolation wastes; pathogens; cytotoxic materials; hazardous chemicals; toxic metals and low grade radio active materials. Any waste which unless rendered safe may prove hazardous or cause infection when anybody comes into contact with it."

To deal with this waste, minimum design criteria for incinerators will be in accordance with 'best practicable means' as determined for each individual installation by the Chief Officer. Loading of the incinerator is to be strictly controlled according to temperature, and low sulphur liquid or gas is to be used as fuel , with machines burning at not less than 1,100°C if any halogen containing substances or 1,000°C if cytotoxic materials are present. If burning at 850°C, acceptance tests will have to be performed to determine the emission of dioxins and furans, with concentrations not exceeding 0,1 ng/m^3. Tests will also be required when burning regular waste, although at present these tests can only be undertaken at considerable expense in the USA (representatives of the chemical industry in SA are currently investigating the possibility of purchasing continuous emission monitoring systems, using Differential Optical Absorption Spectroscopy. These systems have the ability to simultaneously monitor very low levels of different types of gaseous pollution).

The incinerator stack has to be a minimum of nine metres above ground level and clear the highest point of the building by not less than six metres, and the machine should be located in an area in accordance with relevant town planning schemes.

The materials to be incinerated should be of known origin and composition, and may only be burnt in a furnace designated for that particular type of waste. Records should be kept of volumes, type and origin of waste, and operators trained to the satisfaction of the Chief Officer. All levels of staff should receive adequate training, and where noxious or offensive gases are emitted, additional control equipment, e.g. scrubbers, bagfilters or electrostatic precipitators will be required.

All emissions to air should be colourless, odourless and free from mist, fume and droplets and emissions of cadmium, mercury and thallium should not exceed 0,05mg/m^3 and other heavy metals 0,5 mg/m^3. For Chloride (HCl), limits are < 10 mg/m^3, Hydrofluoric acid (HF) <2 mg/m^3, and sulphur dioxide (SO_2) <25 mg/m^3.

The Chief Officer is responsible for the control of medical incinerators, because they are now classed as scheduled processes under the amendment to the definition of Chemical Incineration Processes (No 39): 'Processes for the destruction by incineration of waste that contains chemically bonded halogens, nitrogen, phosphorus, sulphur, metal or any waste which can give rise to noxious or offensive gases'. The handling, transport and disposal of waste, ash and liquid effluents are regulated by the Department of Water Affairs.

3.3.3 Occupational Health and Safety Act (85 of 1993)

Occupational health is addressed in this legislation, and the right of employees to be informed of dangers in the workplace and to be trained to cope with these dangers is stressed. With the inclusion of the Regulations for Hazardous Chemical Substances, the Act now emphasises education and training and effective safety programmes. As medical waste management includes the handling, transportation and disposal of toxic wastes, medical surveillance and biological monitoring programmes will be required.

This new Schedule requires that the employer should be responsible for supplying assessments of potential exposure to hazardous chemical substances (HCS) and provide protection of all persons working with these substances. Employees will be required to wear monitoring equipment to measure personal exposure and undergo health assessments every two years. Records will be kept of such assessments and measurements of airborne concentrations of HCS will be required.

It is required that HCS should be stored in containers to prevent exposure during handling, and where practical all HCS waste should be recycled. All employees occupied in the collection, transport and disposal of this type of waste are to be provided with suitable personal protective equipment, and if waste disposal contractors are used, a contract should state that the contractor will comply with the provisions of these regulations.

Education and training

In addition, the OHSA requires that the employer provides the necessary information, instruction, training and supervision to ensure the health and safety at work of employees. Every employee must be aware of the potential dangers in the workplace. The Act demands that in order to prevent accidents, documentation of safe work procedures, hazardous task identification and job safety analysis should form a set of procedures for employee training programmes.

These regulations also require employers to ensure that the surrounding community is not harmed by any harmful emissions or toxic waste which might be generated by their institution. It also places duties on persons who may be exposed to these substances to obey instructions given by the employer to wear monitoring equipment, undergo health evaluations, and generally prevent hazardous chemical substances from being released.

3.3.4 Water Act (54 of 1956)

Medical institutions discharge toxic substances into the sewerage system, and from there to rivers and ultimately the sea. This Act is the most important statute controlling water resources in South Africa. Water pollution control is dependent on a standard quality of purity, with fixed maximum permissible concentrations for all toxic substances using the 'best available technology not entailing excessive costs' (BATNEEC). As there are a considerable number of new chemicals coming onto the market each year, the enforcement of these effluent standards is impossible. The dilution effect does not affect the quantity of the pollutants, although it normally reduces their toxicity to living organisms. A local authority is obliged to clean the water entering its sewage works to the required standard or be subject to the sanctions imposed (Lusher et al., 1992).

At present water pollution is controlled from point sources, although relaxation of these standards can be negotiated on the basis of technological, economic and socio-political considerations. This is allowed often without knowing the impact of the standards, or their relaxation, on the quality of the receiving waters (van der Merwe et al., 1990; Lusher et al., 1992).

With reference to landfill management, Section 20 of Act No.73 of 1989, stipulates that 'no person shall establish, provide or operate any disposal site without a permit issued by the Minister of Waster Affairs & Forestry.' Un-permitted closed sites are controlled by Section 22A of the Water Act.

3.3.5 Nuclear Energy Act (92 of 1982)

Radioactive material is defined as "any substance consisting of, or containing, any radioactive nuclide, whether natural or artificial". This Act provides for the establishment of the Atomic Energy Corporation (AEC) and Council for Nuclear Safety and to provide control (production, acquisition, disposal and importation) of radioactive nuclides. It is prohibited without written authority from the AEC to possess, use or convey these substances, and their control, outside a nuclear installation, is administered by the Department of Health (Le Roux et al., 1992).

3.3.6 Hazardous Substances Act (15 of 1973)

Control over hazardous substances is the responsibility of the Minister of Health. This Act also provides for control of substances which may cause injury, ill-health or death owing to their toxic, corrosive, irritant, sensitizing, flammable or radioactive qualities. In practice, this Act applies mainly to control of pesticides, transport of hazardous chemicals and electronic and radioactive devices. A radioactive hazardous substance is defined as "radioactive material outside a nuclear installation that does not form part of, or is used or intended to be used in the nuclear fuel cycle" and "which is used for medical, scientific, agricultural, commercial or industrial purpose, and any radioactive waste arising from such radioactive material".

3.4 REGULATIONS AND BY-LAWS

In order for there to be effective control over waste management in a developing country such as South Africa, it is essential that national policy be developed to address the inability of local authorities to control problems through the existing public health regulations and by-laws (Lombard, 1994).

At present, smoke control is the only measure used by the local authorities to control air pollution. The Cape Town Municipality Regulations relating to smoke control state that no emissions of smoke darker than a specified shade shall be permitted from any premises, although this shall not apply to smoke emanating during the start-up stage or while the appliance is being overhauled or during breakdown. In addition, no person shall use any fuel burning appliance which is not properly maintained or does not comply to these Council specifications (Reg. 1997).

The Municipal Drainage and Sewerage By-Law (see Appendix III) is based on Chemical Oxygen Demand (COD), temperature and pH. Calcium carbide should not be discharged into the sewers, nor any substance which is explosive, inflammable, poisonous or produces offensive gases or vapours. Volatile inflammable solvents and organic solvents are prohibited, as well as nuclear hazard material. Limits are set for a variety of substances as well as heavy metals, but these limits need not be met if the effluent is classed as industrial. (The Province of the Cape of Good Hope Official Gazette, 1987). With the recent emergence of draft legislation discussed previously, these local regulations will possibly be amended. To ensure uniformity of technical standards and norms in local legislation, the South African Bureau of Standards (SABS) was approached to develop standards and codes of practice (CSIR, 1991).

With regard to radioactive material, the SABS standards (0228 of 1995) states that internationally, any material with a specific activity exceeding 70 bequerels *(bq)* per kg is classified as class 7 dangerous goods. In South Africa, any material with an activity concentration of more than $100bq\ kg^{-1}$ is defined as radioactive, and medical institutions are required by the Council for Nuclear Safety to apply for nuclear licences to use, store and dispose of nuclear material.

3.5 HOSPITAL POLICY AND GUIDELINES

South African Standard

The SABS Code of Practice for the handling and disposal of waste materials in health care facilities is based on Canadian guidelines, and classifies medical wastes as follows:

- human/animal anatomical waste
- infectious non-anatomical waste
- sharps and similar waste
- chemical/pharmaceutical waste
- radioactive waste
- pressurized container waste
- general waste

This Standard details various methods of minimizing occupational hazards and health risks, such as the introduction of less hazardous substitutes for problem chemical agents, provision of protective equipment, assessment of waste management procedures and training programmes. Although toxic substances such as lead and arsenic are not dealt with in these guidelines, and this Standard does not cover incinerators in any depth, it is recommended that PVC and materials containing heavy metals should not be incinerated.

Special containers should be used for the disposal of sharps, and be incinerated on-site, although certain local authorities may allow burial in landfill. Autoclaving of sharps containers before final disposal is not recommended as it could result in incomplete decontamination of the contents.

For hazardous chemicals it is specified that expert advice should be obtained prior to their disposal. Pharmaceutical waste should be minimized, and as far as possible, recovered for reuse. This waste should be disposed of in accordance with the Medicines and Related Substances Control Act (Act 101 of 1965). Cytotoxics should be incinerated if toxic emissions can be prevented, otherwise chemical deactivation methods should be obtained from the manufacturer, or small amounts may be permitted in landfill.

Hospital policies

Policies and guidelines are extracted by medical institutions from this Standard. They generally relate to colour coding of bags and sorting of waste for disposal. Red plastic bags are used for hazardous medical waste such as blood, bloodstained body fluid, infected matter, intravenous therapy bags, administration sets, syringes, plastic contaminated by body fluids, and toxic substances e.g. cytotoxin. All these are sent for incineration, on-site or by a waste contractor. Sharps are placed in special containers and also sent for incineration (Groote Schuur Hospital. Hospital Notice No. 27/93, 17 Sept 1993). It is not legislated that hospitals posses, or abide by, these guidelines.

British Standards

British and local standards were used in formulating the Questionnaire (see Chapter 6), and for comparison with local guidelines, clinical waste categories in the British Standards are outlined below:

Group A human tissue, including blood, animal carcasses from veterinary centres, hospitals or laboratories, and all related swabs and dressings.

Group B discarded syringe needles, cartridges, broken glass and any other contaminated disposable sharp instruments or items.

Group C Certain pharmaceutical products and chemical wastes

Group E Items used to dispose of bodily secretions which do not fall into Group A, for example, bed pan liners and urine containers.

All wastes in Groups A and B must be incinerated. Although landfill is an option for other Groups, the preferred route for disposal of all clinical wastes is incineration.

Clear information, instruction and training in the identification and disposal of specific categories of clinical waste is required. Containers are colour coded, and no containers intended for incineration should be made of polyvinyl chloride (PVC). All incinerator operators require a certificate of competence, and suitable respiratory protection must be provided to protect against toxic dusts when removing ash and residue.

Incinerators should not be overloaded as this can lead to incomplete combustion and consequent risk to staff clearing the ash and residue. Cytotoxic drugs should be incinerated at a temperature of 1000°C. Fly ash contains high concentrations of heavy metals, dioxins and other toxic organic compounds, and control measures and safe systems of work must minimise exposure of employees to dust. The provision of protective clothing and suitable respirators will be necessary in addition to other control measures. Masks must be appropriate for dust containing heavy metals and toxic organic substances.

Hospitals, community medical practices, community and general dental practices and most veterinary practices dispose of small amounts of solid and liquid pharmaceuticals into the sewers and it is required that this be clearly detailed in the waste disposal policy. The discharge of Hg from hospitals, dentists, veterinary surgeries and similar premises must be controlled and minimised. The British Standards state that discharge to sewers is not a satisfactory disposal route for clinical wastes arising from the treatment of infectious conditions, or for large amount of pharmaceuticals or chemicals. Nor should they be disposed of in domestic landfill sites.

Incineration is the preferred disposal route for small amounts of solid medicines and injectables, except for chlorates and cytotoxic drugs, or where the advice of the manufacturer states otherwise (Health Services Advisory Committee UK., Revised 1992).

3.8 CONCLUDING COMMENTS

The Acts of Parliament, policy documents and regulations discussed in this chapter appear to address most problems of hazardous waste management in medical institutions, but without enlightened application of the law, and without the financial resources and expertise required, it is very difficult for this legislation to be enforced. Regulations require only that steps be taken to prevent or restrict emissions by the 'best practicable means', which allows considerable leeway and does not adequately protect the environment. There will need to be consolidation of legislation, and co-operation between government departments, local authorities and the institutions concerned to address these problems.

Very recently (Cape Times, 8.4.96) it was reported that with the release by the Department of Environment Affairs of the Consultative National Environmental Policy Process (CONNEPP) discussion document, *Towards a New Environmental Policy for SA*, it is hoped that by sensibly managing our natural resources, sustainable development will be achieved. Among the guiding principles of this document are the 'polluter-pays' principle, the 'environmental responsibility principle' and the 'conflict of interest principle', which states that a body with regulatory responsibilities should not have conflicting interests. Finally, South Africa may soon have an Environmental Protection Agency (or similar body) which reports directly to Parliament and will audit government departments and institutions to ensure they comply with environmental legislation.

CHAPTER 4

METHODS FOR SAMPLING AND ANALYSIS OF HOSPITAL WASTE EFFLUENTS AND EMISSIONS

CHAPTER 4

METHODS FOR SAMPLING AND ANALYSIS OF HOSPITAL WASTE EFFLUENTS AND EMISSIONS

4.1 INTRODUCTION

Outlined in Chapter Three, the Cape Metropolitan Drainage and Sewerage By-Law is based on Chemical Oxygen Demand (COD), temperature and pH, and the limits set for a number of potentially toxic substances, as well as heavy metals, need not be met if the effluent is classed as "industrial" (The Province of the Cape of Good Hope Official Gazette, 1987). At present medical institutions fall under these by-laws. Effluent discharged into the Black River by the Athlone Waste Water Plant has to comply with the General Standards for the purification of waste water or effluent, but not the Special Standards, which are more stringent and apply only to certain catchment areas. In the Cape Peninsula, the Hout Bay River and the Eerste River are protected by these Special Standards (Government Gazette, 1984). For incinerators, present regulations require only that steps be taken to restrict smoke by the "best practicable means".

This chapter discusses methods employed in this thesis to analyse hospital liquid effluent outflows for Chemical Oxygen Demand, Ammoniacal Nitrogen, pH, conductivity, heavy metals and radioactivity, and to test incinerator ash for radioactivity and heavy metal content. Although limited in number, these sample analyses give some idea of the content of liquid effluent discharges from medical institutions, as well as emissions from hospital incinerators.

4.2 LIQUID EFFLUENT OUTFLOWS

Plans were obtained indicating the layout of the drains, and discussed with engineers from several civil engineering firms, as well as with relevant personnel at the Provincial Administration, Cape Town City Council Sewage and Drainage Section, and technical staff at Groote Schuur, UCT Medical School, Somerset, City Park, Vincent Palotti, Red Cross, Milnerton Medi-City, Brooklyn Chest, Constantiaberg and Tygerberg Hospitals.

The liquid effluent outflows from Groote Schuur Hospital, Somerset Hospital and Medical School were sampled and subsequently analysed. These institutions were chosen because they broadly cover the range of large teaching hospitals, medium sized hospitals and academic medical schools. The accessibility of the manholes, and whether they were practical for installing the autosampler and safe for personnel, was taken into consideration before deciding on these particular institutions.

Preliminary samples

Preliminary tests were undertaken to obtain an overview of the content of hospital effluent outflows in order to decide which compounds to use as indicators of water quality in further tests. In May 1995, preliminary samples were taken at 8.30am, 12 o'clock and 3.30pm on four consecutive days at Groote Schuur from the New Hospital outflow. Each volume increment was approximately $1^1/_2$ litres, with the total volume being 5 litres. Three similar preliminary samples were taken from Medical School on the same days. This outflow includes wastewater from the Mortuary, Barnard Fuller Building (Medicine), Third Year Building (Medical Microbiology, Cytology, Forensic Medicine, Medical Microbiology), part of Falmouth Building (Neurosurgery, Cardio-thoracic Surgery, Opthalmology, Provincial Labs. for Tissue Immunology, Anatomical Pathology, Chemical Pathology) and the Physiology Building (Physiology, Medical Biochemistry).

Two samples from each institution were sent to the City of Cape Town, City Engineers Scientific Services Branch, Athlone Wastewater Treatment Plant, for a complete wastewater analysis (details of analytical methods employed by Scientific Services are included as Appendix II). The remaining two were taken to the Environmental Laboratories at Koeberg Nuclear Power Station to be tested for radioactivity, using a Hyperpure Germanian Detector with a multi-channel analyser.

Effluent sampling and analysis

All effluent samples from the three medical institutions were collected and analysed as described below:

Sampler Specification

An Epic 1011 portable, automatic wastewater sampler manufactured to IS09001 quality standards was wrapped in a large plastic refuse bag for protection, lowered into the sewerage system and secured with cable-ties. The sampler was programmed to run for 48 hours, taking one 100 ml increment every twelve minutes. These increments filled one of the 24 1 litre sample containers every two hours.

Analysis

The contents of these containers were combined to obtain an average sample, aliquots of which were analysed for Chemical Oxygen Demand (COD), Ammonia, pH, Conductivity, Arsenic (As), Mercury (Hg), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Manganese (Mn), Nickel (Ni), Lead (Pb), Zinc (Zn) and Iron (Fe). The analysis conformed to analytical methods (see Appendix II) as quoted in the American Public Health Association's *Standard Methods for the Examination of Water and Waste Water* (1992). A Geiger-Counter (Weil Mini-Monitor, Series 900) was used to test each sample for radioactivity before it was sent to Scientific Services for analysis. The Geiger-Counter is unable to detect Tritium or C^{14}.

Groote Schuur Hospital

Groote Schuur has four liquid effluent outflows. Only one was sampled, receiving effluent from the New Hospital: wards, sterilizing units, kitchens, pharmacies, outpatients, theatres, and the departments of Chemical Pathology, Otolaryngology, Anaesthetics, Bacteriology, Haematology and Nuclear Medicine. Three 48-hour sampling runs were undertaken.

Medical School

Samples were collected at two outflows: Medical School (A) which collects effluent from the Provincial Laboratories and Anatomical and Chemical Pathology and (B), being the main drain into which all the others flow (see Preliminary tests, above). One 48-hour sampling run was undertaken at both outflows A and B at Medical School.

The Anatomy Building (Anatomy and Cell Biology, and Human Genetics Laboratories) has a separate drainage system which was not tested, and the SAMIOT Building outflow which receives liquid effluent from the Animal Unit, Clinical Science and Immunology, and Haematology is situated below outflow B and was thus not included.

Somerset Hospital

Somerset Hospital has three sewage outflows. The one sampled includes effluent from the wards, Outpatients, Pharmacy, Mortuary and the South African Institute for Medical

Research (SAIMR) laboratories. Two 48-hour sampling runs were undertaken at Somerset Hospital.

Sludge sample

A 2 kg sludge sample was obtained from Athlone Wastewater Treatment Plant. A 1kg aliquot was analysed for Hg, according to *Standard Methods for the Examination of Water and Waste Water* (1992). Only mercury was tested, as Scientific Services undertake regular tests for most other heavy metals (see Fig. 5). A 1kg aliquot was taken to Koeberg Nuclear Power Station for radioactive analysis.

Personnel Safety

Personnel involved in sampling the sewers were equipped with boots, solvent-resistant overalls, gloves, and specialised gas masks which prevented the inhalation of inorganic and organic gases and vapours, acidic gases and ammonia. All personnel underwent a course of Hepatitis B injections.

4.3 INCINERATOR EMISSIONS

Red Cross Hospital

Incinerator ash

Ash was collected for three 7-day periods in September/October 1994. To ensure a representative sample, an incremental method of sampling was adopted. The time interval between increments was $24h$ and the incremental sample volume was approximately $70ml$. The total sample volume was $500ml$, collected over the 7-day period. Aliquots were taken from this sample and tested for radioactivity by Radiation Control, Department of Health, using a Multi-Channel Gamma Analyser. A further 6-day sample was collected from this hospital, tested for radioactivity, and then sent to Scientific Services for heavy metal analysis.

Stack emissions

A Rothro & Mitchell Air Sampler with an intake rate of $60l\ sec^{-1}$. was installed at the Red Cross Hospital. The Air Sampler ran continuously for two 7-day periods. This machine was also installed for seven days at a private residence adjoining the hospital. Material deposited on the Whatman 4.7cm GF/A glass micro-fibre filters was analysed for radioactivity by Radiation Control.

City Park, Somerset, Milnerton MediCity

As described above, ash was collected from incinerators at City Park, Somerset Hospital and Milnerton MediCity daily for seven days and analysed by Radiation Control. (Somerset Hospital incinerator has since been decommissioned).

5.4 DISCUSSION

Although the sampling and analytical methods discussed in this chapter will indicate a trend in the composition of liquid effluent outflows from certain medical institutions, it would have been preferable to obtain a larger number of samples from more outflows, but with staff and financial restraints, this was not possible.

The Epic 1011 Sampler is not ideally suited for local hospital outflows, as most of these drains do not have a consistently heavy flow, and the holes on the upper surface of the inlet hose become exposed and draw in air. A brick or heavy object has to be used to submerge the hose, and be secured firmly to the side of the manhole. This is to prevent its reaching the drain outlet, or the intermittent strong flows will jam the brick into the drain, blocking the system and causing overflows. Most importantly, to prevent permanent damage to the battery, it is essential that this be kept on continuous charge, even when not in use.

If the autosampler had not on occasion combined samples, owing to problems with the battery and inlet hose, it would have been possible to compare the composition of effluent discharges during day and night-time periods. In addition, due to financial, logistical and most importantly, security problems, it was not possible to connect the autosampler to flow and pH meters and to link these to a computer for continuous recordings.

In the following chapter, results obtained from these samples will be discussed.

CHAPTER 5

ANALYSIS OF MEDICAL INSTITUTION EFFLUENTS AND EMISSIONS

CHAPTER 5

ANALYSIS OF MEDICAL INSTITUTION EFFLUENTS AND EMISSIONS

5.1 INTRODUCTION

Analyses of substances being released into the liquid effluent outflows from the Medical School, Groote Schuur and Somerset Hospital, are presented here. Initially a set of "preliminary" samples were analysed as an exploratory investigation. Based on these results a revised sampling programme was carried out. In addition, incinerator emissions at Red Cross Hospital, Milnerton MediCity, City Park and Somerset Hospital are investigated. Results from both of these waste streams are then compared with regional, national and international guidelines to determine whether toxic emissions from medical institutions pose a potential threat to human health and the environment. Arising from this, suitability of the existing disposal methods are assessed.

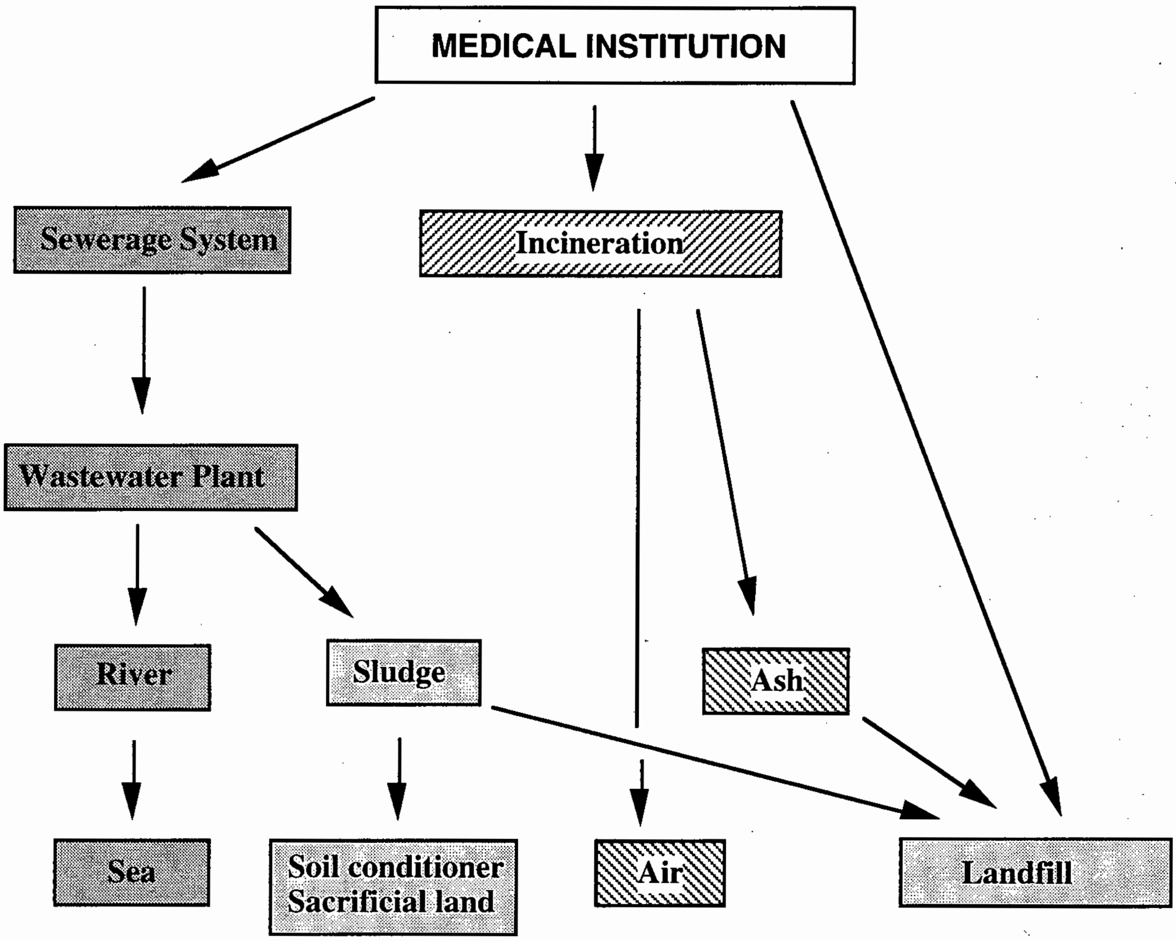
Samples from the liquid effluent outflow and incinerator emissions were tested for radioactivity, and the concentrations of specific substances including potassium, magnesium, chloride, ammonia, and arsenic in waste water were measured. Heavy metal concentrations, such as Hg, Ni, Cr, Zn, Cd, Pb and Cu in liquid effluent outflows and incinerator ash were also analysed.

Results of a similar investigation by Gartiser and Brinker (1993) on discharges from the Albert-Ludwigs University Clinic in Freiburg, Germany, in 1992 are compared with these local results.

5.2 WASTE DISPOSAL ROUTES

Liquid wastes (and those from incinerators) follow a number of routes, which are outlined in Figure 2. Effluents discharged into the sewerage system are treated in waste water plants. From here they flow into rivers and ultimately the sea, or remain in the sludge and then are used as a soil conditioner for agriculture, or are dumped on sacrificial land or co-disposed in landfill. On the other hand, all liquid effluent outflows in the City Bowl are macerated, but otherwise untreated, and are discharged through the Green Point Pump Station into Table Bay.

Figure 2: Schematic outline of various medical waste disposal routes.



5.3 LIQUID EFFLUENT OUTFLOWS

Preliminary Samples

In order to quantify volumes of liquid effluent from the various medical institutions, an average monthly ouflow was calculated from water consumption data recorded over the past two years by the Cape Town City Council. In addition to the institutions sampled, volumes consumed by City Park, Constantiaberg, Red Cross, Somerset and Vincent Palotti hospitals are included for comparison.

Table 5.1: Water consumption of medical institutions, listed as a total two-year consumption volume in m^3 and as an estimated average in m^3sec^{-1} and m^3month^{-1}. *(Source: K. Walpole, Cape Town City Council, Sewage & Drainage Section).*

Hospital	Dates	Consumption 2 years (m^3)	Average monthly consumption ($m^3 month^{-1}$)	Average monthly consumption ($m^3 sec^{-1}$)
City Park	6/7/93 to 4/4/95	226 697	9 445.0	3.6
Constantiaberg	19/5/93 to 22/2/95	165 013	6 875.0	2.6
Groote Schuur	16/7/93 to 18/4/95	772 202	32 175.0	12.4
Medical School	20/4/93 to 20/01/95	105 554	4 398.0	1.7
Red Cross	6/11/92 to 9/2/95	164 5	6 855.0	2.6
Somerset	5/10/93 to 6/10/95	258 643	10 776.0	4.2
Vincent Palotti	14/07/93 to 12/4/95	59 858	2 494.0	1.0

The estimated average volumes are used to calculate the monthly mass concentrations being discharged from Medical School and the hospitals, and are included in the tables which follow. These sample analyses reflect the lowest estimated concentrations, as only one outflow was tested at the hospitals (Somerset Hospital has three outflows, and Groote Schuur has four). Two out of the four outflows at Medical School were sampled.

The Groote Schuur outflow discharges waste water from the wards, sterilizing units, kitchens, pharmacies, outpatients, theatres, and the departments of Chemical Pathology, Otolaryngology, Anaesthetics, Bacteriology, Haematology and Nuclear Medicine, and the Medical School outflow collects liquid effluent from the Mortuary, Barnard Fuller Building (Medicine), Third Year Building (Medical Microbiology, Cytology, Forensic Medicine, Medical Microbiology), part of Falmouth Building (Neurosurgery, Cardio-thoracic Surgery, Opthalmology, Provincial Laboratories for Tissue Immunology, Anatomical Pathology, Chemical Pathology) and the Physiology Building (Physiology, Medical Biochemistry).

These preliminary samples underwent a total waste water analysis by Scientific Services, but this did not include testing for mercury, which staff at the Waste Water Plant believe to be unnecessary owing to the insignificant levels of this element found in their past sample analyses.

Table 5.2: Waste water analysis of preliminary samples from Groote Schuur Hospital and Medical School, University of Cape Town. Substances present in the waste water are given as concentrations, and estimated monthly totals in *kg* $month^{-1}$ or *g* $month^{-1}$ are calculated using an estimated average effluent outflow from both institutions.

Sample Description	Units	GROOTE SCHUUR		MEDICAL SCHOOL	
		Concentration	Av. effluent outflow $12.41 m^3 sec^{-1}$	Concentration	Av. effluent outflow $1.70 m^3 sec^{-1}$
			$kg\ month^{-1}$		$kg\ month^{-1}$
Suspended Solids	mg^{-1}	**200.0**	6 435	**538.0**	2 366
Volatile Suspended solids	mg^{-1}	**165.0**	5	**500.0**	2 199
Chemical Oxygen Demand	$mg\ l^{-1}$	**887.0**		**1189.0**	
Total Kjeldahl Nitrogen	$mg\ l^{-1}$	**86.4**	2 780	**45.2**	199
Ammonia (N)	$mg\ l^{-1}$	**63.0**	2 027	**17.1**	75
Organic Nitrogen	$mg\ l^{-1}$	**23.4**	753	**28.1**	123
Nitrite + Nitrate	$mg\ l^{-1}$	**0.1**	3.2	**0.1**	440
Total Phosphorus	$mg\ Pl^{-1}$	**6.61**	213	**7.48**	33
Ortho Phosphate	$mg\ Pl^{-1}$	**5.40**	174	**5.80**	25
pH		**7.29**		**7.02**	
Conductivity	mSm^{-1}	**235.0**		**43.0**	
Chloride	$mg\ l^{-1}$	**462.0**	14 865	**50.0**	220
Alkalinity as $CaCO_3$	$mg\ l^{-1}$	**330.0**	10 618	**109.0**	479
Heavy metals:			$g\ month^{-1}$		$g\ month^{-1}$
Cadmium	$\mu g\ l^{-1}$	**3.0**	96	**2.5**	11
Cobalt	$\mu g\ l^{-1}$	**17.0**	547	**15.0**	66
Chromium	$\mu g\ l^{-1}$	**135.0**	4 344	**138.0**	607
Copper	$\mu g\ l^{-1}$	**217.0**	6 982	**218.0**	959
Iron	$\mu g\ l^{-1}$		586	**18.5**	81
Manganese	$\mu g\ l^{-1}$	**161.0**	5 180	**157.0**	690
Nickel	$\mu g\ l^{-1}$	**140.0**	4 504	**140.0**	616
Lead	$\mu g\ l^{-1}$	**29.0**	933	**85.0**	374
Zinc	$\mu g\ l^{-1}$	**537.0**	17 278	**533.0**	2 344

Table 5.3 compares these results with some international and local limits which could apply to hospital effluent.

\# Depending on water hardness.

Table 5.3: Groote Schuur (GSH) and Medical School (MS) preliminary samples compared with local and international (Australian, Canadian, Dutch (NL)) limits. TWQR = Target Water Quality Range; CEV = Chronic Effect Value; AEV = Acute Effect Value; CTM = Cape Town Municipal by-laws and GS = General Standard. These limits are presented in $\mu g\ l^{-1}$ unless otherwise specified. *(Source: General and Special Standards : Government Gazette, 18 May 1984. Dallas and Day (1993). Draft South African Water Quality Quidelines (DWAF, Vol.7)).*

Description	Samples		South African criteria					International criteria		
$\mu g\ l^{-1}$	GSH	MS	TWQR	CEV	AEV	CTM	GS	Australia	Canada	NL
	Load month^{-1}									
COD mg^{-1}	**887**	**1189**	-	-	-	-	75	-	-	-
Ammonia mg^{-1}	**63**	**17**	<7.0	15	100	-	10	0.02-0.03	1.37-2.2	
Cadmium $\mu g\ l^{-1}$	**3.0**	**2.5**	≤0.07	0.3	3.0	*	50	0.2-2.0#	0.2-1.8#	5.0
Cobalt	**17**	**15**	-	-	-	-	-	-	-	-
Chromium	**135**	**138**	≤12	24	340	**	5 000	2.0	2.0	10
Copper	**217**	**218**	≤0.2	0.53	1.6	**	1 000	2.0-5.0#	2.0-6.0#	5.0
Manganese	**161**	**157**	≤180	370	1 300	-	400	-	-	-
Nickel	**140**	**140**	-	-	-	***	-	15-150	25	50
Lead	**29**	**85**	≤0.2	0.5	4.0	***	100	1.0-5.0	1.0-7.0#	4.0
Zinc	**537**	**533**	≤2.0	3.6	36	**	5 000	5.0-50	30	10
Iron	**18**	**18**	-	-	-	-	-	1000	-	-

* Total Cd, Hg, As not to exceed 2 000$\mu g\ l^{-1}$

** Total Cr,Cu,Zn, Fe not to exceed 50 000$\mu g\ l^{-1}$

*** Total Ni, Pb not to exceed 10 000$\mu g\ l^{-1}$

Concentration dependent on water hardness

From the data presented in Table 5.2, the following points arise:

- With the exception of cobalt (for which there are no recorded effluent standards) and manganese, all the sample concentrations in this Table substantially exceed those specified locally for the protection of aquatic environments, and are well above the Australian, Canadian and Dutch standards. Pb, Ni and Zn all exceed the British standards *(Pb: 4-20#$\mu g\ l^{-1}$ Ni: 9$\mu g\ l^{-1}$; Zn: 8-25# $\mu g\ l^{-1}$).*

- Chemical Oxygen Demand exceeds the SA General Standard limits, and could be affected by the presence of absorbed organic halogens (AOXs) which include fluoride, chloride, bromide and iodide. COD indicates the organic matter content of a sample that is susceptible to oxidation.

- There are many registered chemicals which could be present in waste water for which no legal or guideline levels are available. Some of these could be contributing to the elevated COD.

- pH and alkalinity usually vary together, so that higher alkalinity expects a higher pH. In comparison to the Medical School sample, Groote Schuur shows a higher alkalinity concentration and slightly elevated pH.

- Conductivity is higher in the Groote Schuur sample, and is a measure of the ions present in water, indicating salinity and/or total dissolved solids (Dallas and Day, 1993).

- The high levels of suspended solids in the Medical School sample would normally indicate concentrated sewage, but if this is the case, it is difficult to explain the low level of ammonia. Suspended solids are lower at Groote Schuur, and could indicate a sample diluted by cleaning, showering and bathing.

- All samples were tested with a Geiger-counter (Weil Mini-Monitor, Series 900) before being analysed at Scientific Services, but only background levels were detected.

From Table 5.3 (which includes the raw data from Table 5.2), it is clear that many parameters from the samples analysed have extremely high values for water quality in relation to internationally accepted guidelines. The explanations for these high values are unknown at present, and require further research.

With reference to Table 5.3, the following abbreviations are explained:

Water Quality Guidelines

These values are receiving water standards contained in the Draft South African Water Quality Quidelines at present being compiled by the Department of Water Affairs and Forestry (DWAF). These are criteria which refer to upper limits permitted in rivers.

TWQR:	Target Water Quality Range. A management objective which is set to equal the No Effect Range (the range of concentrations within which no measurable adverse effects are expected on the health and integrity of aquatic ecosystems)
CEV:	Chronic Effect Value. Concentration at which there is expected to be a significant risk of measurable chronic effects to the sensitive organisms in the aquatic population
AEV:	Acute Effect Value. Concentration at which there is expected to be a significant risk of acute toxic effects to the sensitive organisms in the aquatic population. If these effects persist for a short while, or occur at too high a frequency, they can cause death. This could have considerable negative consequences for the health of aquatic ecosystems, even for a short period.
GS:	South African General Standard for the purification of waste water or effluent is used for monitoring effluent discharged into, for example the Black River. In this Standard, the sum of the concentrations of the following metals shall not exceed *1000* $\mu g\ l^{-1}$ to receiving waters: Cd, Cr, Cu, Hg and Pb.
CTM:	Cape Town Municipal by-laws are guidelines for industrial effluent point source discharges.

For further Standards, Guidelines and By-laws see Appendix III.

5.4 ANALYSES OF SAMPLES FROM THE MAIN SAMPLING PROGRAMME

Table 5.4 presents the analyses of liquid effluent samples from Medical School, Groote Schuur and Somerset Hospitals undertaken by Scientific Services at the Athlone Waste Water Plant. These results are given in a single table to allow for easier comparison, and in addition, are presented separately for each institution with estimated mass monthly concentrations. The original of this Table is included as Appendix IV.

In Table 5.4, analyses of raw liquid effluent from Athlone and Green Point are included for comparison. The total monthly outflow volume from the Athlone Waste Water Plant is $1123\ m^3 sec^{-1}$, and $324\ m^3\ sec^{-1}$ is discharged from Green Point Pump Station.

Table 5.4: Analysis of medical wastewater samples from Medical School, Groote Schuur and Somerset Hospitals undertaken by City of Cape Town Scientific Services, Athlone Wastewater Plant (see Annexure IV for original).

		Med. Sch. (1a)	Med. Sch. (1b)	Med. Sch. (2)	Groote Schuur (1)	Groot Schuur (2)	Somerset (1)	Somerset (2)	Athlone	Green Point
Date of Sampling	**Unit**	95/07/20	95/08/10	95/08/03	95/08/17	95/09/14	95/10/04	95/10/13	95/07/17-95/10/09	95/07/20-95/10/12
Sample Description										
Chemical Oxygen Demand	*mg/l*	366.0	180.0	207.0	940.0	771.0	350.0	384.0	574-1270	490-807
Ammoniacal Nitrogen as N	*mg/l*	2.7	7.0	1.8	64.0	67.6	6.8	6.0	15.1-29.3	24.0-31.2
pH		6.6	6.6	6.7	7.5	7.3	7.0	7.3	6.7-7.2	6.7-7.4
Conductivity	*mS/m*	26.0	33.0	29.0	143.0	157.0	44.0	122.0	112-116	-
Arsenic as As	$\mu g l^{-1}$	0.7	0.4	0.8	0.4	0.4	0.3	0.4	-	-
Mercury as Hg	$\mu g l^{-1}$	5.0	10.0	70.0	32.0	1.0	11.0	19.0	-	-
Cadmium as Cd	$\mu g l^{-1}$	0.8	1.1	0.6	1.6	2.3	1.8	2.3	3.2-3.5	1.1-1.5
Cobalt as Co	$\mu g l^{-1}$	3.0	3.4	2.0	4.6	7.0	6.0	5.0	6-14	3-6
Chromium as Cr	$\mu g l^{-1}$	10.0	11.0	9.4	14.0	2.6	2.6	3.0	120-474	11-78
Copper as Cu	$\mu g l^{-1}$	24.0	52.0	840.0	86.0	58.0	45.0	56.0	86-145	98-281
Manganese as Mn	$\mu g l^{-1}$	17.0	16.0	24.0	64.0	65.0	39.0	64.0	85-252	40-49
Nickel as Ni	$\mu g l^{-1}$	1.4	2.4	6.0	9.4	8.0	10.0	8.0	40-174	7-9
Lead as Pb	$\mu g l^{-1}$	7.8	9.2	25.0	11.0	7.8	4.8	12.0	22-42	16-33
Zinc as Zn	$\mu g l^{-1}$	74.0	55.0	421.0	140.0	161.0	205.0	149.0	326-468	141-293
Iron as Fe	$\mu g l^{-1}$	204.0	209.0	152.0	2280.0	1420.0	2720.0	1200.0	1720-2150	786-1460

5.4.1 Medical School

The analyses of three waste water samples from two outflows at Medical School are extracted from Table 5.4 and shown in Table 5.5A with additional estimated monthly mass concentrations, calculated from an estimated average outflow volume of *1.70* m^3 sec^{-1}.

Effluent originating from Anatomy and Cell Biology, the Human Genetics laboratories, the Animal Unit, Clinical Science and Immunology, and Haematology are not included in these analyses.

Table 5.5A: Analyses of two liquid effluent samples from Medical School Outflow (1) and one from Outflow (2) are given below. Outflow (1) discharges from the Provincial Laboratories and Anatomical and Chemical Pathology. Outflow (2) includes the Morturary, Barnard Fuller Building (Medicine), Third Year Building (Medical Microbiology, Cytology, Forensic Medicine, Medical Microbiology), part of Falmouth Building (Neurosurgery, Cardio-throracic Surgery, Opthalmology, Provincial Labs. for Tissue Immunology, Anatomical Pathology, Chemical Pathology) and the Physiology Building (Physiology, Medical Biochemistry).

MEDICAL SCHOOL Average Outflow Volume: *1.70* m^3 $month^{-1}$						
Description	**Medical School (1)**				**Medical School (2)**	
($\mu g\ l^{-1}$)	Conc. **(1a)**	Load	Conc. **(1b)**	Load	Conc.	Load
		kg month^{-1}		*kg month*$^{-1}$		*kg month*$^{-1}$
Chemical Oxygen Demand	**366**		**180**		**207**	
Ammoniacal N *(mg* $^{-1}$*)*	**2.7**	12	**7.0**	31	**1.8**	8.0
pH	**6.6**		**6.6**		**6.7**	
Conductivity (mSm^{-1})	**26.0**		**33**		**29.0**	
		g month^{-1}		*g month*$^{-1}$		*g month*$^{-1}$
Arsenic ($\mu g\ l^{-1}$)	**0.7**	3.0	**0.4**	1.7	**0.8**	3.5
Mercury	**5.0**	22	**10.0**	44	**70.0**	308
Cadmium	**0.8**	3.5	**1.1**	4.8	**0.6**	2.6
Cobalt	**3.0**	13	**3.4**	14	**2.0**	8.8
Chromium	**10.0**	44	**11.0**	48	**9.4**	41
Copper	**24.0**	105	**52.0**	228	**840.0**	2 111
Manganese	**17.0**	75	**16.0**	70	**24.0**	105
Nickel	**1.4**	6	**2.4**	10	**6.0**	24
Lead	**7.8**	34	**9.2**	149	**25.0**	110
Zinc	**74.0**	325	**55.0**	242	**421.0**	1 851
Iron	**204.0**	879	**209.0**	919	**152.0**	666

Table 5.5B: Medical School samples compared with various local and international (Australian, Canadian, Dutch) guidelines and standards. TWQR = Target Water Quality Range; CEV = Chronic Effect Value; AEV = Acute Effect Value; CTM = Cape Town Municipal by-laws and GS = General Standard. These limits are presented in $\mu g\ l^{-1}$ unless otherwise specified.

MEDICAL SCHOOL Average Outflow Volume: 1.70 $m^3\ sec^{-1}$											
	Medical School			South African Criteria					International Standards		
Description *($\mu g\ l^{-1}$)*	**(1a)**	**(1b)**	**(2)**	TWQR	CEV	AEV	CTM	GS	Australia	Canada	NL
CODmgl^{-1}	**366**	**180**	**207**	-	-	-	-	75	-	-	-
Ammonia "	**2.7**	**7.0**	**1.8**	<7.0	15	100	-	10	0.02-0.03	1.37-2.2	
Arsenicμgl^{-1}	**0.7**	**0.4**	**0.8**	≤10	20	130	*	500	50	50	5.0
Mercury	**5.0**	**10.0**	**70.0**	≤0.04	0.08	1.7	*	20	0.1	0.1	0.5
Cadmium	**0.8**	**1.1**	**0.6**	≤0.07	0.3	3.0	*	50	0.2-2.0#	0.2-1.8#	5.0
Cobalt	**3.0**	**3.4**	**2.0**	-	-		-	-	-	-	-
Chromium	**10.0**	**11.0**	**9.4**	≤12	24	340	**	5 000	2.0	2.0	10
Copper	**24.0**	**52.0**	**840.0**	≤0.2	0.53	1.6	**	1 000	2.0-5.0#	2.0-6.0#	5.0
Manganese	**17.0**		**24.0**	≤180	370	1 300	-	400	-	-	-
Nickel	**1.4**	**2.4**	**6.0**	-	-	-	***	-	15-150	25	50
Lead	**7.8**	**9.2**	**25.0**	≤0.2	0.5	4.0	***	100	1.0-5.0	1.0-7.0#	4.0
Zinc	**74**	**55.0**	**421.0**	≤2.0	3.6	36	**	5 000	5.0-50	30	10
Iron	**204**	**209.0**	**152.0**	-	-	-	-	1000	-	-	-

* Total Cd, Hg, As not to exceed 2 000$\mu g\ l^{-1}$

** Total Cr,Cu,Zn, Fe not to exceed 50 000$\mu g\ l^{-1}$

*** Total Ni, Pb not to exceed 10 000$\mu g\ l^{-1}$

Concentration dependent on water hardness

The following points are made in explanation of Tables 5.5A and B:

__Medical School (1):__

- COD considerably exceeds the SA General Standard limits for industrial effluent.

- With the exception of the Cape Town Municipal by-laws, Hg levels are significantly higher than all local, Australian, Canadian, Dutch, British *($1.0\ \mu g\ l^{-1}$)*, and US EPA *($0.90\ \mu g\ l^{-1}$)*, standards and guidelines.

- Zinc concentrations are higher than all standards and guidelines in the table, with the exception of the CTM by-laws and the SA General Standard.

__Medical School (2)__

- Hg, Cu and Zn are all above those specified locally for the protection of aquatic environments, but do fall within the General Standards and the Cape Town Municipal by-law regulations. The concentrations of these three metals are well above Australian, Canadian and Dutch standards. Hg drastically exceeds the British *($1.0\ \mu g\ l^{-1}$)*, and US EPA *($0.90\ \mu g\ l^{-1}$)* standards.

- Although Aluminium (Al) was not investigated, a combination of Cu, Al and pH<6 is toxic to some aquatic organisms (D Musibono, Freshwater Unit UCT, pers.comm).

- COD exceeds the SA General Standards.

5.4.2 Groote Schuur

One of the four liquid effluent outflows from Groote Schuur was sampled, and the following are results extracted from Table 5.4 and presented in Tables 5.6A and 5.6B.

Table 5.6A: Analysis of two samples of liquid effluent from Groote Schuur (New Hospital) wards, sterilizing units, kitchens, pharmacies, outpatients, theatres, and the departments of Chemical Pathology, Otolaryngology, Anaesthetics, Bacteriology, Haematology and Nuclear Medicine.

GROOTE SCHUUR HOSPITAL Average Outflow Volume: *12.41m³ sec⁻¹*				
Sample Description ($\mu g\ l^{-1}$)	GSH (1)		GSH (2)	
	Conc.	Load	Conc.	Load
		kg month⁻¹		*kg month⁻¹*
Chemical Oxygen Demand	**940**		**771**	
Ammoniacal N (mg^{-1})	**64.0**	2 059	**67.6**	2 175
pH	**7.5**		**7.3**	
Conductivity (mSm^{-1})	**143**		**157.0**	
		g month⁻¹		*g month⁻¹*
Arsenic ($\mu g\ l^{-1}$)	**0.4**	13	**0.4**	12.9
Mercury	**32.0**	1 030	**1.0**	32
Cadmium	**1.6**	51	**2.3**	74
Cobalt	**4.6**	148	**7.0**	225
Chromium	**14.0**	450	**2.6**	84
Copper	**64.0**	2 767	**58.0**	1866
Manganese	**9.4**	2 059	**65.0**	2 091
Nickel	**11.0**	302	**8.0**	257
Lead	**11.0**	354	**7.8**	251
Zinc	**140.0**	4 504	**161.0**	5180
Iron	**2280.0**	73 359	**1420.0**	45 688

Table 5.6B: Groote Schuur sample concentrations compared with local and international (Australian, Canadian, Dutch) limits. TWQR = Target Water Quality Range; CEV = Chronic Effect Value; AEV = Acute Effect Value; CTM = Cape Town Municipal by-laws and GS = General Standard. These limits are presented in $\mu g\ l^{-1}$ unless otherwise specified.

Descripion ($\mu g\ l^{-1}$)	Sample		South African Criteria					International Standards		
	GSH (1)	GSH (2)	TWQR	CEV	AEV	CTM	GS	Australia	Canada	NL
COD$mg\ l^{-1}$	**940**	**771**	-	-	-	-	75	-	-	-
Ammonia $N mg\ l^{-1}$	**64**	**67.6**	<7.0	15	100	-	10	0.02-0.03	1.37-2.2	
Arsenic $\mu g\ l^{-1}$	**0.4**	**0.4**	≤10	20	130	*	500	50	50	5.0
Mercury	**32**	**1.0**	≤0.04	0.08	1.7	*	20	0.1	0.1	0.5
Cadmium	**1.6**	**2.3**	≤0.07	0.3	3.0	*	50	0.2-2.0#	0.2-1.8#	5.0
Cobalt	**4.6**	**7.0**	-	-	-	-	-	-	-	-
Chromium	**14**	**2.6**	≤12	24	340	**	5 000	2.0	2.0	10
Copper	**64**	**58**		0.53	1.6	**	1 000	2.0-5.0#	2.0-6.0#	5.0
Manganese	**9.4**	**65**	≤180	370	1 300	-	400	-	-	-
Nickel	**11**	**8.0**	-	-	-	***	-	15-150	25	50
Lead	**11**	**7.8**	≤0.2	0.5	4.0	***	100	1.0-5.0	1.0-7.0#	4.0
Zinc	**140**	**161**	≤2.0	3.6	36	**	5 000	5.0-50	30	10
Iron	**2280**	**1420**	-	-	-	-	1000	-	-	-

* Total Cd, Hg, As not to exceed 2 000$\mu g\ l^{-1}$

** Total Cr,Cu,Zn, Fe not to exceed 50 000$\mu g\ l^{-1}$

*** Total Ni, Pb not to exceed 10 000$\mu g\ l^{-1}$

\# Concentration dependent on water hardness

The following points summarise the major results presented in Table 5.6A.

<u>For Groote Schuur (1):</u>

- COD levels are very high.
- Ammonia concentrations are higher than TWQR, CEV and Australian, Canadian and Dutch guidelines and standards.
- Hg levels are high, exceeding all local and Australian, Canadian, Dutch, British *(1.0 $\mu g\ l^{-1}$)* and US EPA *(0.90 $\mu g\ l^{-1}$)* standards.
- Pb and Zn concentrations exceed all DWAF water quality guidelines and Australian, Canadian and Dutch standards.
- Fe concentrations appear extraordinarily high and exceed the SA General Standards.

<u>For Groote Schuur (2):</u>

- COD levels exceed SA General Standards
- Ammonia exceeds TWQR, CEV, General and Australian, Canadian and Dutch guidelines and standards.
- Hg concentration is higher than TWQR, CEV, US EPA *(0.90 $\mu g\ l^{-1}$)* guidelines and standards and all international standards included in the table.
- Cu and Zn exceed South African DWAF water quality guidelines and all Australian, Canadian, Dutch and British *(Cu: 28# $\mu g\ l^{-1}$ and Zn: 25# $\mu g\ l^{-1}$)*. Pb exceeds DWAF guidelines and all international limits included in the table.
- Fe exceeds the SA General Standard.

5.4.3 Somerset Hospital

The destination of the liquid waste stream from Somerset Hospital differs from that of Medical School and Groote Schuur, as it flows into the Green Point Pump Station, where it becomes macerated and then without further treatment, discharged into Table Bay. This hospital has three liquid effluent outflows, but only one was tested in this study.

Table 5.7A: Analyses of two samples from the outflow of Somerset Hospital which discharge liquid effluent from the wards, pharmacy, dietetics, social workers and physiotherapists in the main hospital, as well as the laboratories of the South African Institute for Medical Research. Estimated monthly mass concentrations, calculated from the average outflow volume from Somerset Hospital of *4.16* $m^3\ sec^{-1}$ are included.

SOMERSET HOSPITAL Average Outflow Volume: *4.16* $m^3 sec^{-1}$				
Sample Description ($\mu g\ l^{-1}$)	**Sample (1)**		**Sample (2)**	
	Conc.	Load	Conc.	Load
		$kg\ month^{-1}$		$kg\ month^{-1}$
COD ($mg\ l^{-1}$)	**350**		**384**	
Ammoniacal N ($mg\ l^{-1}$)	**6.8**	73	**6.0**	64
pH	**7.0**		**7.3**	
Conductivity (mSm^{-1})	**44.0**		**122.0**	
		$g\ month^{-1}$		$g\ month^{-1}$
Arsenic ($\mu g\ l^{-1}$)	**0.3**	3.2	**0.4**	4.3
Mercury	**11.0**	118	**9.0**	79
Cadmium	**1.8**	19	**2.3**	25
Cobalt	**6.0**	65	**5.0**	54
Chromium	**2.6**	28	**3.0**	32
Copper	**45.0**	485	**56.0**	603
Manganese	**39.0**	420	**64.0**	690
Nickel	**10.0**	108	**8.0**	86
Lead	**4.8**	52	**12.8**	129
Zinc	**205.0**	2 209	**149.0**	1 606
Iron	**2720.0**	29 311	**1200.0**	12 931

Table 5.7B: Somerset Hospital sample concentrations compared to local and international (Australian, Canadian, Dutch) limits. CTM = Cape Town Municipal by-laws; MWQ = Marine Water Quality Guidelines (Lusher and Ramsden, 1991); GS = General Standard. These limits are presented in $\mu g\ l^{-1}$ unless otherwise specified.

Description	Sample		SA Guidelines			International Standards		
$\mu g\ l^{-1}$	SOMERSET (1)	(2)	MWQ	CTM	GS	Australia	Canada	NL
COD $mg\ l^{-1}$	**350**	**384**	-	-	75	-	-	-
Ammonia Nl^{-1}	**6.8**	**6.0**	-	-	10	0.02-0.03	1.37-2.2	
Arsenic $\mu g\ l^{-1}$	**0.3**	**0.4**	12	*	500	50	50	5.0
Mercury	**11**	**9.0**	0.3	*	20	0.1	0.1	0.5
Cadmium	**1.8**	**2.3**	4.0	*	50	0.2-2.0#	0.2-1.8#	5.0
Cobalt	**6.0**	**5.0**	-	-	-		-	-
Chromium	**2.6**	**3.0**	340	8.0	5 000	2.0	2.0	10
Copper	**45**	**56**	1.6	5.0	1 000	2.0-5.0#	2.0-6.0#	5.0
Manganese	**39**	**64**	1 300	-	400	-	-	-
Nickel	**10**	**8.0**	-	25	-	15-150	25	50
Lead	**4.8**	**12.8**	4.0	12	100	1.0-5.0	1.0-7.0#	4.0
Zinc	**205**	**149**	36	5.0	5 000	5.0-50	30	10
Iron	**2720**	**1200**	-	-	1000	-	-	-

* Total Cd, Hg, As not to exceed 2 000 $\mu g\ l^{-1}$

** Total Cr, Cu, Zn, Fe not to exceed 50 000 $\mu g\ l^{-1}$

*** Total Ni, Pb not to exceed 10 000 $\mu g\ l^{-1}$

\# Concentration dependent on water hardness

The following points are made in explanation of Table 5.7A for samples analysed from:

Somerset Hospital (1):

- COD is considerably higher than limits set in the SA General Standards.
- Hg levels exceed MWQ, Australian, Canadian, Dutch, British *(1.0 $\mu g\ l^{-1}$)* and US EPA *(0.90 $\mu g\ l^{-1}$)* guidelines and standards.
- Cu exceeds MWQ, Australian, Canadian, Dutch and British *(28 # $\mu g\ l^{-1}$)* guidelines and standards.

- Zn considerably exceeds MWQ, Australian, Canadian, Dutch and British *(25# $\mu g\ l^{-1}$)* guidelines and standards.

- Fe concentration is higher than those recommended in the Australian and SA General Standards.

For the Somerset Hospital sample (2):

- COD values are higher than those specified by the SA General Standard.

- Hg levels exceed MWQ, Australian, Canadian, Dutch, British *(1.0 $\mu g\ l^{-1}$)* and US EPA *(0.90 $\mu g\ l^{-1}$)* guidelines and standards.

- Zn concentrations are higher than MWQ and Australian, Canadian and Dutch limits.

- Cu and Pb exceed Australian, Canadian, Dutch and British *(Cu: 28#$\mu g\ l^{-1}$; Pb: 20#$\mu g\ l^{-1}$)* standards. Pb is reported to have adverse effects on marine organisms at concentrations of *1.0-5.1 $\mu g\ l^{-1}$* (Eisler, 1988).

- Fe levels are higher than the Australian and SA General Standards.

5.5 DISCUSSION

At present, medical institutions are required to comply with the General Standard and the Cape Town Municipal by-laws; and institutions in the northern suburbs fall under the Cape Metropolitan Council by-laws (Appendix III). All limits set in these regulations are higher than those in the international standards, and in Cape Town, are generally applied to industrial effluent discharges. Limits appear to have been set without accounting for the possible synergistic effects of these substances, or the cumulative impacts on humans and the environment of long-term exposure.

Mercury is a cumulative toxicant (EPA, 1989) and is thus cause for concern. Concentrations of this heavy metal in all the hospital effluent samples analysed are high, compared to local DWAF water quality guidelines, and all the international standards listed in the tables. Mercury could originate from broken thermometers, Mercurochrome or other mercury-containing medications, disinfectants, or paint. The high Hg concentrations in the Somerset Hospital samples, and possibly from other medical institutions in the City Bowl which discharge liquid effluent into Table Bay, could have been contributing to a phenomenon observed by Eagle et al., (1982), that mercury was one of the only metals to show high levels in the vicinity of the ocean outfall, and Bartlett's (1985) observation tht Hg showed the highest concentration in the water column.

Hospital discharges in Cape Town are not regularly monitored for chemical and heavy metal content, but only for phosphates and nitrates discharged from hospital laundries, as these compounds cause eutrophication of the Black River.

It is not possible to identify substances contributing to the high COD in the sample results, nor to make in-depth observations on how the different heavy metals could affect marine, riverine or terrestrial ecosystems or human health, although some effects have been mentioned in Chapter 2.

Apart from high concentrations of Hg, all the hospital effluent samples show elevated COD, indicating substantial organic concentrations. This could be partially explained by results of tests undertaken on outflows at the Albert Ludwigs University Hospital in Freiburg. In Germany, strict legislation controls the disposal of any toxic or radioactive material via the sewers, and hospital liquid effluent outflows have a similar COD to that of household waste water. On detailed analysis though, the composition is different, containing more absorbable organic halogens (AOXs) (Kummerer, 1994). AOXs, as described previously, are toxic substances found in for example, disinfectants, cleaning agents, aerosols and detergents. Available tests do not reveal the structure or nature of the organic compounds nor the individual halogens present in a particular sample, and researchers have to rely on information provided by the chemical manufacturers .

Results of local effluent tests were sent to Germany, and in general, were not found to differ significantly from the concentrations in the waste water discharged from the University Hospital in Freiburg (K. Kummerer, Albert Ludwigs University Hospital, pers. comm.), although the Cu discharge was thought to be high in the Medical School sample, and Hg concentrations to be uniformly high. In Germany, Hg in hospital waste water originates mainly from medications (e.g. Mercurochrome) and mercury-containing disinfectants and preservatives, although this load has been lessened by reducing the use of these substances. Another source of mercury is dental amalgam from preparing and removing fillings. In Germany 95% of mercury has to be removed by law from waste water, although the process used can cause a slight remobilization of this heavy metal (K. Kummerer, pers. comm.).

In the following Table, some results have been extracted from Gartiser and Brinker (1993) which are comparable to those undertaken in the present study.

Table 5.8: Analysis of liquid effluent tests undertaken at the University Hospital, Freiburg *(Source: Gartiser and Brinker, 1993).*

Sample Description	Unit	Main Hospital Outflow		Clinics	
		23.01.92	21.07.92	Medicine 14.05.92	ENT 23.01.92
Chemical Oxygen Demand	$mg\ l^{-1}$	382	430	440	425
Organic Nitrogen	$mg\ Nl^{-1}$	3.5	< 5	<1.0	
pH		9.2	8.7	8.0	8.5
Conductivity	mSm^{-1}	63.7	40.3	73.0	59.0
Chloride	$mg\ l^{-1}$	50	38	80	
Cadmium	$\mu g\ l^{-1}$	<50	<50	<50	<50
Chromium	$\mu g\ l^{-1}$	<50	<50	<50	<50
Copper	$\mu g\ l^{-1}$	<50	<50	50	70
Mercury	$\mu g\ l^{-1}$	<1.0	<1.0	<1.0	1.0
Nickel	$\mu g\ l^{-1}$	<50	<50	<50	<50
Lead	$\mu g\ l^{-1}$	<50	<50	<50	<50
Zinc	$\mu g\ l$-1	300	0.2	250	250

In comparison with the data presented on Cape Town hospitals:

- In Table 5.8, COD is generally lower *(382-440 mg l^{-1})* than in local samples *(207-1189 mg l^{-1})*.
- Freiburg pH levels *(7.9-9.2)* exceed those in the local results *(6.6-7.5)*.
- Conductivity in Groote Schuur *(143.0-157.0)* and Somerset *(122.0)* Hospitals, exceeds levels in the German samples.
- Mercury and zinc concentrations are thought by German researchers to be high *(Hg <1 μg/l and Zn 0.2-300 μg/l)* in the Freiburg samples (K.Kummerer, Albert Ludwigs University Hospital, pers.comm), but these are lower than Cape Town effluent concentrations *(Hg 1-70 $\mu g\ l^{-1}$* and *Zn 55-537 $\mu g\ l^{-1}$)*.

Cleaning agents and insecticides used by Cape Town hospitals, for example Target flyspray, Teepol, P85, Biocide, Chlorhexadine and Sumasan all contain chemicals which could eventually be discharged into the sewerage system. Formaldehyde and degreasers could be a problem for local hospitals, although as mentioned previously, the City Council's main concern is phosphates and nitrates from laundries. These are to be phased out in future, but suppliers are waiting for direction from the multinationals.

5.6 ATHLONE WASTE WATER TREATMENT PLANT

Besides medical institutions within the City Bowl, all sewer discharges from the southern suburbs flow into the Athlone Waste Water Treatment Plant. Graphs illustrating average annual concentration levels of heavy metal content during the period 1988-1996, in raw sewage, final effluent and sludge are included as Figures 3, 4 and 5 (G. Helders, Scientific Services Athlone Waste Water Plant, unpubl. data). Heavy metals are not removed during treatment, but concentrate in the sludge or are discharged into the Black River.

The peaks indicated on all three graphs, especially noticeable in 1990/1991, are caused by specific industries discharging large amounts of heavy metals into the sewerage system. The metal plating and packaging industries were warned in 1990/91 and strictly monitored, leading to a reduction in Cd, Ni and Pb. Scientific Services is concerned with the 1995 increase in Cr, Mn and Ni in the raw effluent. The increase in Mn is not reflected in the final effluent nor in sludge concentrations, thus presumably is being discharged into the Black River. The source of the high level of Zn in 1990/91 is not known, but could have been due to the manufacture of components for Mossgas during that period. Since 1991, Ni discharges have increased, as have Cr and Mn, all originating from unknown point sources (G. Helders, Scientific Services, pers. comm.).

Metals in the sludge generally show a reduction in levels (Table 5), although Scientific Services are concerned about the slight upward trend, in 1995, of Ni and Cr. All metal concentration peaks are caused by industrial discharges, and reductions are due to the subsequent detection and monitoring by Scientific Services.

If it can be proved that a particular industry is emitting chemicals in excess of the Cape Town Municipal regulations, fines are levied. Large numbers of staff, and months of intensive sampling and monitoring are required to track a polluter, and even then it is often not possible to prove infringement of the regulations. Certain industries tend to discharge at night or into the stormwater drains to avoid detection.

Table 5.9 includes an average raw waste water analyses at Athlone (City Engineer's Annual Report, 1994/95). No heavy metals or other toxic substances are reported for these raw discharges.

FIGURE 3: Athlone Wastewater Treatment Plant. Average heavy metal concentrations in raw effluent, measured over 8 years (1988-1995) *Source: G Helders, unpublished data, 1996.*

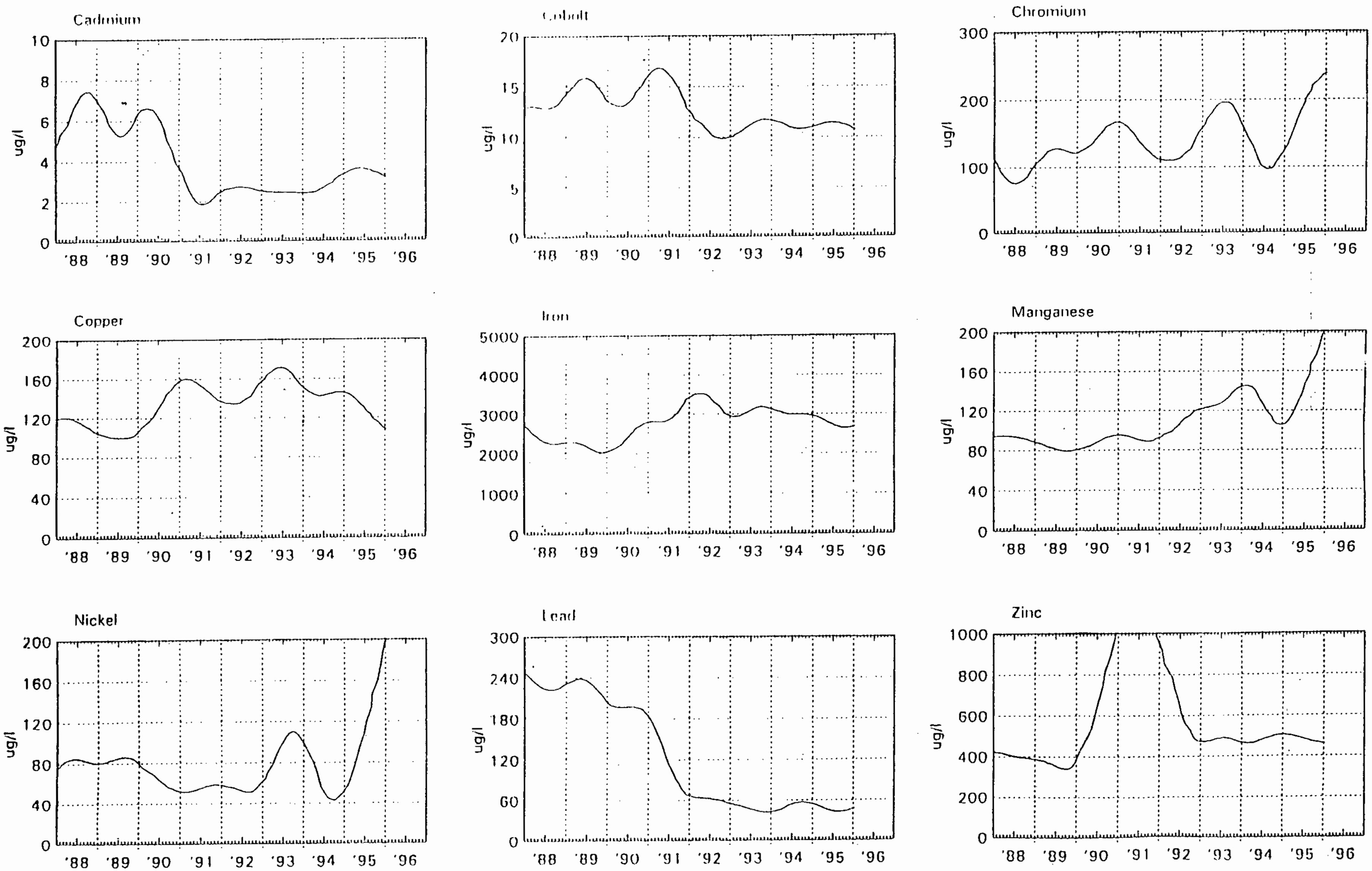


Figure 4: Athlone Wastewater Treatment Plant. Average heavy metal concentrations in final effluent, measured over 8 years (1988-1995). *Source: G Helders, unpublished data, 1996.*

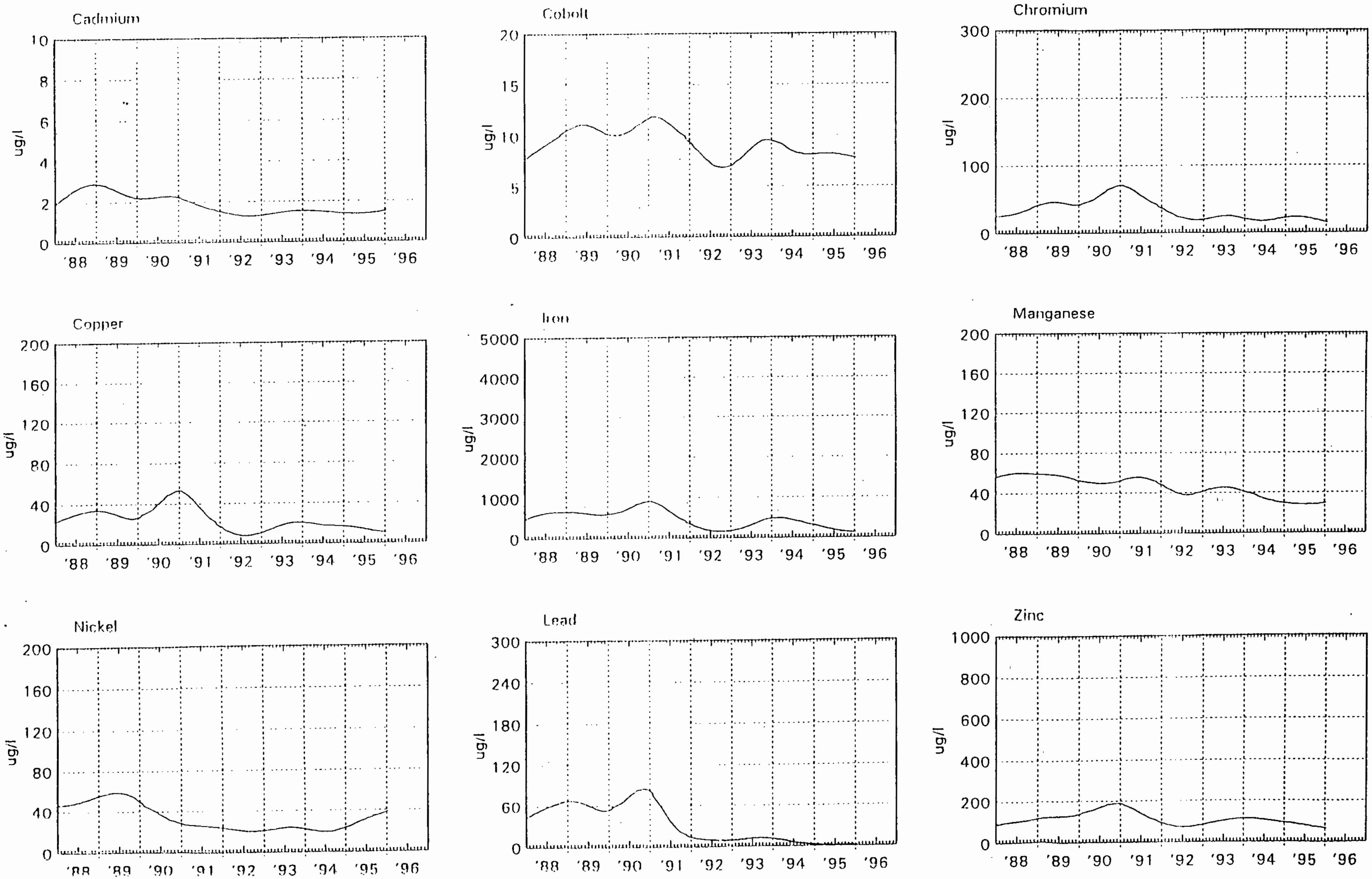


Table 5.9: Athlone Waste Water Treatment Plant : Analytical data - average and maximum levels in raw waste water for 1994/5. All results reported in *(mg l^{-1})* except where otherwise stated. *(Source: City Engineer's Annual Report, 1994/95).*

Analytical Data	Raw Waste water	
	Average	Maximum
Suspended solids	370	870
Volatile suspended solids	330	750
Chemical Oxygen Demand	930	1800
Ammonia as N	25	34
Organic Nitrogen as N	23	35
Nitrite + Nitrate as N	-	-
Total Phosphorus as P	9	13
pH	7	7
Conductivity *(mSm^{-1})*	120	140
Chloride	200	260
Alkalinity as $CaCO_3$	220	260

Table 5.10 is included to show analyses of drinking water from the various dams during the medical effluent sampling period. The substances shown here would not have had any significant impact on sample analyses, although most heavy metals are not indicated in this report.

Table 5.10: Analyses of Cape Town water supplies for the period of 1991-1993. Approximate areas of distribution: Steenbras - Southern Suburbs; Voelvlei - Northern Suburbs, Epping, City Bowl and Green Point; and Wemmershoek - Paarl to Bellville, Northern Suburbs and City Bowl. *(Source: H. Ginsburg, City Engineer's Department, Scientific Services Branch, Athlone).*

Description		Steenbras			Voelvlei			Wemmershoek	
$mg\ l^{-1}$ unless otherwise stated	Typical Analysis	Limits for 95% of samples Low	High	Typical Analysis	Limits for 95% of samples Low	High	Typical Analysis	Limits for 95% of samples Low	High
Conductivity mSm^{-1}	13	10	17	14	11	16	9	7	11
Alkalinity as $CaCO_3$	24	17	29	15	12	23	29	27	32
Chloride (Cl)	21	17	27	26	21	35	10	6	15
Aluminium (Al)	0.23	0.10	0.45	0.05	0.01	0.31	0.18	0.09	0.39
Iron (Fe)	0.03	0.01	0.12	0.02	0.001	0.09	0.07	0.02	0.16
Manganese (Mn)	0.01	0.003	0.04	0.001	0.001	0.01	0.02	0.004	0.07
Ammoniacal N	0.01	<0.01	0.03	0.01	<0.01	0.03	0.01	<0.01	0.06
Total Phosphorus (P)	0.01	<0,001	0.06	0.01	<0.001	0.04	0.01	<0.01	0.05
Total Dissolved Solids	89	63	116	74	46	106	59	22	138

5.6.1 Sludge

As previously mentioned, liquid effluents from the medical institutions which do not discharge into the sea, concentrate in the sludge at waste water plants (see Figure 5). For this study, one sludge sample was analysed by Scientific Services for Hg only, and this was found in a concentration of *$6mg\ kg^{-1}$* (dry mass basis), which is below the limits set by the Department of Health (DOH) guidelines for sludge management. No other heavy metals were investigated, as these are regularly monitored at Athlone (see Figure 5). This sample was also tested for radioactive content by researchers at Koeberg Power Station, and traces of ^{137}Caesium were detected, but only at background levels. This nuclide has a 30 year half-life, and traces are believed to originate from nuclear tests carried out in the 1950s and '60s. ^{137}Caesium is occasionally used in radiotherapy, and resulting waste should be sealed and sent to the nuclear disposal site at Pelindaba.

Sludge for agricultural land application must comply to Type D specifications (suitable for application on agricultural land) as outlined in the DOH guidelines (Table 5.11). At present, sludge at Athlone is classed as Type B, and unsuitable for agricultural use. This sludge is transported at considerable cost to the Coastal Park disposal site at Muizenberg, where besides reducing the lifespan of the disposal site, its beneficial use as a soil conditioner is lost (Pitt and Ekama, 1995).

Table 5.11: Maximum heavy metal content in *mg kg* $^{-1}$ dry sludge for classification as Type D in terms of the 1991 DOH Guidelines *(Source: Pitt and Ekama, 1995).*

Heavy Metal	Limit *(mg kg-1)*	Heavy Metal	Limit *(mg kg-1)*
Cadmium	20	Cobalt	100
Chromium	1750	Copper	750
Manganese	-	Nickel	200
Lead	400	Zinc	2750
Molybdenum	25	Mercury	10

5.7 OCEAN OUTFLOWS

There are a number of medical institutions, including Somerset Hospital, discharging effluent through the recently extended ocean outflow in Table Bay (see Appendix XII for distribution of hospitals and clinics in the Cape Peninsula). In the Sydney outfall case study (Beder, 1989) discussed in Chapter 2, it was suggested that extended deepwater outfalls might have little benefit in reducing the effects of this pollution, as owing to less turbulence, there may be less diffusion further from the shore. It was also concluded that extended outfalls might make the situation worse, as the sewage could reach beaches further afield. In the USA, the Office of Technology Assessment has cautioned that the routine discharge of sewage into marine environments is introducing large numbers of viruses and bacteria, and that concentrations of these disease-causing organisms may be increasing (Beder, 1989).

Minimal treatment of liquid effluent relies on the ocean to supply further treatment, but as surfers in Sydney, Australia, have pointed out 'No-one wants to swim in a secondary treatment plant!' (Beder, 1989). However, experts in Sydney, and here in Cape Town, tend to differ on health risks, and there has been little investigation into health effects of pollution in Table Bay, although there is a study presently underway at the Medical Research Council on potential health implications of polluted marine environments (N.Strauss, Medical Research Council, pers.comm).

5.8 RADIOACTIVITY

All liquid effluent samples tested showed only backgrond levels of radioactivity, although from responses to the questionnaire (Chapter 6) staff were concerned about the management and disposal of radioisotopes used in medical procedures. The DOH Radiation Control Section, in collaboration with Koeberg Power Station, has on occasion, detected and traced low levels of, for example I^{125}, in the sewage system to individual patients (R. Edwards, Radiation Control, pers. comm.). Sometimes these very low levels can be accumulated in aquatic food chains, depending on the the type of organisms, their feeding habits, and type and level of radioactive chemical involved (Lamb, 1985).

5.9 SUMMARY OF LIQUID EFFLUENT OUTFLOWS

The following is a summary of liquid effluent outflows from medical institutions:

- International studies have found the presence of Hg, Zn and absorbable organic halogens to be of concern in hospital waste water.
- From international experience, ocean outflows are potentially hazardous to humans and the environment.
- Local medical institutions emit ammonia and heavy metals, in particular Hg and Fe into the sewers in concentrations above the South African General Standards, while Hg, Cr, Cu, Pb and Zn exceed Australian, Canadian and Dutch standards. The British standards are exceeded by Hg, Pb, Zn, and Cu, and Hg is present in concentrations above those specified by US EPA.
- Medical waste in landfill creates health risks for workers, and heavy metals from incinerator ash could leach into groundwater.
- No radioactivity above background levels was detected in the effluent samples.
- Heavy metals from medical institutions accummulate in sludge at waste water plants, thus preventing its use as a soil conditioner, and causing pollution of land and the marine environment.
- Ideally, adherence to limits should be strictly enforced, as the immediate expense of implementation would lead to long-term savings. USA costs for on-going clean-ups of contaminated groundwater amount to $1,000, 000 per hour.

5.10 INCINERATOR EMISSIONS

There are 10 operational hospital incinerators in the Cape Town area (Appendix VI). Some burn only paper waste, but others, such as the Booth Memorial Hospital, City Park, Louis Leipoldt, Milnerton MediCity, Red Cross and Vincent Palotti, regularly burn medical waste. The 2 Military Hospital in Wynberg burns sharps, plastics and pharmaceuticals once a month, and Groote Schuur burns radionuclides, pharmeceuticals and plastics, once or twice a month.

The Groote Schuur incinerator has been partially closed down, due in part to the corrosion of the hospital's aluminium windows, and complaints by staff of offending odours and deposits of particulate matter, perhaps aggravated by the low elevation of the stack (see staff responses in Chapter 6, comments in Appendix VIII, and incinerator details in Appendix VI). There have been attempts to increase the burning temperature of this machine by experimenting with increased air-flow, but the problems have not yet been resolved.

The escalating use of plastics causes a problem for hospital incinerators, which were originally designed to burn only 10-15% plastics, and now have to deal with a plastic composition of approximately 40% (Schelker, 1994). Medical suppliers state that most of their disposables for medical use are of flexible PVC; for example, administration sets and intravenous bags which, when burnt, produce toxic emissions.

Even though guidelines have been established by the Department of Health to control air emissions from incinerators, the Municipal regulation No. 1997 (1968) relating to smoke control continues to be the only regulation in use and, as noted previously, even this is not strictly enforced. Hospital incinerators are monitored only when complaints are received from the public, and no fines are administered. No filters are fitted on these machines, and all hospitals are situated in residential or densely populated areas. Some hospitals burn waste from institutions which do not have their own facilities, for example City Park burns for N1City and on occasion, Wynberg Hospital, and Louis Leipoldt incinerates for Leeuwendal.

All hospital incinerators are operated manually by unskilled labour. This practice causes overloading and indiscriminate adjustment of operating temperatures. The resulting black smoke is offensive, and leads to adverse community reaction. In some cases the refractory linings of the incinerators have been replaced and modified contrary to the manufacturer's design, with the result that the appliance is incapable of operating without excessive smoke emission (Linde, 1994).

5.10.1 Radioactivity in Ash

Medical institutions use radioactive materials in a number of applications. These radioactive materials are detrimental to humans, and may be ingested or inhaled. Depending on its physical and chemical properties, radioactivity, especially from particulate emissions, may be metabolized and concentrated in particular body organs, where high localized irradiation may occur (Le Roux, 1992). If radionuclides are not sent to the commercial waste company for disposal, they are burnt in hospital incinerators.

The British standards (Atomic Energy and Radioactive Substances, Amended 1992) for the radionuclides present in the hospital samples, stipulate $400bq\ kg^{-1}$. The South African Bureau of Standards (SABS) states that all radioactive substances over an activity concentration of more than $100bq\ kg^{-1}$ are dangerous to a greater or lesser degree, as they could damage body tissue, either from internal or external irradiation. Safe limits employed by Radiation Control (DOH) for ^{51}Cr, ^{125}I and ^{67}Ga specify that these radionuclides should not exceed $400bq\ kg^{-1}$. The normal limit for ^{67}Ga is $185bq\ kg^{-1}$ (R. Edwards, Radiation Control, pers.comm).

To investigate whether hospital incinerators emit radioactivity, samples of incinerator ash were collected from the Red Cross, Somerset and Milnerton MediCity Hospitals and analysed by the Department of Health, Radiation Control. Methods of collection and analysis are described in Chapter 4, and the results of these tests are shown below.

Red Cross Hospital

A preliminary investigation into the Red Cross Hospital incinerators was undertaken in 1993 as an Environmental Law Masters project, looking specifically at the legal implications of burning medical waste in a residential area. This report is included as Appendix V.

The Red Cross Hospital has two burners. At present, incinerator A, which burns mainly paper and wet waste, has mechanical difficulties. Incinerator B burns all waste, and the two machines together normally burn approximately one tonne of solid waste daily from Monday to Friday, and 340 kg on Saturdays and Sundays. The bulk of this is disposable nappies, the remainder consisting of the unknown contents of sealed plastic bags of waste from the wards. A relatively small quantity of petri dishes, syringes, and plastic containers are also burnt. All incinerator ash is collected with the domestic refuse and taken to the City Council's landfill site at Vissershok. Waste awaiting incineration is stockpiled in open Waste-away containers and on the ground. A potential problem, should the incinerators emit substantial toxic emissions, is a creche situated only a few metres away from the two incinerators and boilers.

Table 5.12: Radioactivity analysis of ash from Red Cross Hospital Incinerator A: (burning paper and wet waste) and B: (burning all waste).

RED CROSS HOSPITAL					
RADIO-NUCLIDE	INCINERATOR A: PAPER AND WET WASTE		INCINERATOR B: ALL WASTE		
	96/03/06 Aliquot Mass = 150g	94/10/01 Aliquot Mass = 130g	94/10/01 Aliquot Mass =100g	94/10/21 Aliquot Mass = 150g	96/02/29 Aliquot Mass = 90g
	bqkg^{-1}	*bqkg^{-1}*	*bqkg^{-1}*	*bqkg^{-1}*	*bqkg^{-1}*
^{125}I	21	24	653	332	
^{67}Ga	166	22	2	2 296	854
^{212}Pb	37	24	33	26	33
^{214}Pb		28	35	49	
^{228}Ac		21	28	7	
^{208}Tl	9	8	10	43	9
^{214}Bi		27	48		
^{40}K	479	436	520	438	403
^{51}Cr		47	67		

The essential points to note from these analyses are:

- Incinerator B contains high levels of Gallium and Potassium; both exceed the SABS recommendations of 100*bq/kg*. Gallium exceeds the DOH recommendations of 400 *bq/kg*.
- I^{125} levels exceed the British standards of 400*bq/kg*.
- Potassium levels indicate the burning of cardboard and paper.

City Park

Analysis of ash collected from City Park in central Cape Town, is presented below in Table 5.13. Levels of ^{67}Ga are extremely high in this sample. City Park does not possess a permit for Gallium, and the elevated level recorded here was caused by burning waste from Wynberg Hospital.

Table 5.13: Radioactivity analysis of ash from the City Park incinerator.

CITY PARK (95/03/10) Aliquot Mass = 170g	
Nuclide	*bq kg⁻¹*
Iodine (^{125}I)	36
Gallium (^{67}G)	7 671
Lead (^{212}Pb)	57
Potassium (^{40}K)	136

Somerset Hospital and Milnerton MediCity

Details of ash analyses collected from Somerset Hospital and Milnerton MediCity are given in Table 5.14 and the values are all at background levels. Somerset Hospital has since closed down its incinerator (in 1995) due to financial considerations and complaints by residents in Green Point.

Table 5.14: Radioactivity analysis of ash from the Somerset Hospital and Milnerton MediCity incinerators.

Nuclide	SOMERSET HOSPITAL (95/03/24) Aliquot Mass = 120g	MILNERTON MEDICITY (94/11/08) Aliquot Mass = 170g
	bqkg^{-1}	*bqkg*$^{-1}$
Lead (^{212}Pb)	30	18
Lead (^{214}Pb)	114	11
Actinium (^{228}Ac)	23	11
Thallium (^{208}Tl)	9	6
Bismuth (^{214}Bi)	58	13
Potassium (^{40}K)	477	133

5.10.2 *Heavy metals in incinerator bottom ash*

As it was not possible, due to financial considerations, to test incinerator emissions for substances other than radioactivity, ash was collected and analysed (as described in Chapter 4) to investigate the presence of heavy metals. Table 5.15 indicates the heavy metal concentrations in two samples of ash collected at Red Cross Hospital. Ash is disposed with domestic refuse in the City Council's landfill site at Vissershok.

Table 5.15: Heavy metal analysis of two incinerator ash samples from Red Cross Hospital.

RED CROSS HOSPITAL INCINERATOR ASH (All Waste)		
Description	Sample 1	Sample 2
(mg kg-^{1})		
Arsenic	0.04	0.42
Mercury	1.08	3.95
Cadmium	2.90	2.50
Cobalt	8.0	7.4
Chromium	13.0	46.3
Manganese	6 240.0	6 640.0
Nickel	11.0	69.1
Lead	91.4	46.4
Zinc	10 800.0	5 080.0

From these analyses the following points arise:

- Cr, Pb, Hg, Ni levels are high, and Zn levels extremely high in both samples when compared with inorganic waste disposal limits for leachate given in Table 5.17, indicating that these metals could be a problem when ash is landfilled.

- The DOH Guidelines for heavy metals in dry sludge (Pit and Ekama, 1995) indicate a limit of 2750*mg/kg* for Zn. Concentrations in both samples considerably exceed this limit.

- From these results it is not possible to estimate the concentrations being emitted via the stack, but it can be assumed that heavy metal emissions are being discharged into the atmosphere.

- As can be seen from Table 5.16, Hg and As are relatively volatile metals, and the high concentrations in the incinerator ash sample could indicate that higher levels were present in the exhaust gasses (it is possible that Cd could also be emitted, as this incinerator is capable of burning at 800°C).

Table 5.16: Boiling point of heavy metals *(Source: Perry and Chalton, 1993).*

Metal	Boiling point (^{o}C)
Arsenic	613
Mercury	357
Cadmium	765
Cobalt	2900
Chromium	2665
Copper	2595
Manganese	2150
Nickel	2730
Lead	
Zinc	906
Iron	3000

All incinerator ash from Cape Peninsula hospital incinerators is taken to the Municipal landfill site at Vissersok, and the US and Swiss limits for hazardous inorganic wastes in landfill given in Table 5.17 are included for comparison. Any wastes in the USA which are present in concentrations above the levels shown, cannot be disposed in landfill without special treatment, for example encapsulation (Van Niekerk, 1994).

Table 5.17: US EPA and Swiss limits for inorganic waste disposal in landfill - maximum concentrations for priority pollutants *(Source: van Niekerk, 1994; Brunner and Frey, 1995).*

Component	**Concentration in leachate EPA limits *(ppm)***	**Concentration in leachate Swiss limits *(ppm)***
Arsenic	5.0	-
Barium	100.0	-
Cadmium	1.0	0.10
Chromium	5.0	-
Lead	5.0	1.0
Mercury	0.2	0.01
Selenium	1.0	-
Silver	5.0	-
Copper	-	0.50
Zinc	-	10.0

5.10.3 *Radioactive aerosols from incinerators*

Red Cross Hospital is located in a residential area, and it was thus selected to investigate for emissions of radioactive aerosols. Air samples were taken at this hospital and analysed for radioactivity (see Chapter 4). The air-sampler could be placed only at one location, where it would be safe from theft, thus successful sampling was problematic due to the variable and strong nature of the prevailing winds in Cape Town. During most of the sampling period, a strong south-easter blew emissions away from the sampler, and only for approximately four hours, was there a slight north-westerly drift. The sampler was installed for a week at a neighbouring residence, and although the filters soon became black, no radioactivity above background levels was detected. Owing to financial constraints, it was not possible to analyse the particulates deposited on the filters.

The following table shows that all radioactivity was present only at background levels during the sampling period, although particulates and heavy metal emissions could be cause for concern (see Table 5.19).

Table 5.18: Radioactivity analysis of Red Cross Hospital incinerator emissions sampled from a neighbouring residence and from the hospital.

RED CROSS HOSPITAL			
	Neighbouring residence	Hospital	
Radio-nuclide	95/04/28 Sample Volume = 541 862*l*	94/04/28 Sample Vol. = 9 000*l*	94/08/08 Sample Vol. = 9 000*ll*
	bqkg⁻¹	*bqkg⁻¹*	*bqkg⁻¹*
^{125}I	-	-	-
^{67}Ga	-	-	-
^{212}Pb	2	3	5
^{214}Pb	1	3	9
^{228}Ac	1	3	5
^{1208}Tl	4	10	2
^{214}Bi	1	3	-
^{40}K	1	8	-
^{51}Cr	-	-	-
^{7}Be	-	1	7

5.10.4 *Incinerator emission limits*

The following table does not include radioactivity, but indicates some emission limits for incinerators set in Europe and South Africa. As mentioned previously, the South African guidelines brought out by the Department of Health in 1994 have not yet been enforced. Tests have been undertaken on emissions from a South African medical waste incinerator, and as the outcome of these analyses remain confidential, similar results from incinerators in the USA are included in Table 5.19 (C. Albertyn, Consulting Engineers CC, pers. comm.).

Table 5.19: Summary of incinerator emission standards in the EC, Sweden and South Africa*. Included is an analysis of uncontrolled emissions from medical waste incinerators tested in California *(Source: EC and Swedish data limits in Saayman, 1992 , Air Pollution Engineering Manual, USA; C. Albertyn, Consulting Engineers CC, pers comm.).*

Compound	EC Directive Standards	Swedish Standards	South African* emissions	California ** measured uncontrolled
HEAVY METALS (mg/m^3)				
Lead	5.0	0.05	0.05	0.4 - 14.6
Chromium	5.0		0.05	0.01 - 0.179
Copper		5.0	0.06	0.00005
Manganese	5.0		0.05	0.005 - 0.194
Nickel	1.0		0.05	ND - 0.063
Arsenic	1.0		0.05	ND - 0.019
Cadmium	0.1	0.2	0.05	0.032 - 0.4
Mercury	0.1	0.08	0.05	0.00051 - 12.3
ACID GASES (mg/m3)				
Hydrochloric acid	50	100	< 10	970 - 4 700
OTHER (ng/m3)				
Dioxins (PCDD)		0.1	0.1	106.5 - 2 164.3
Furans (PCDF)		0.1	0.1	256 - 4 139
PARTICULATES (mg/m3)	50-100	20	180	150 - 570

* Guidelines under the Atmospheric Pollution Prevention Act brought out by the Department of Health (1994).

** In addition to the compounds listed above, low-molecular-weight-organics, e.g. ethane, ethylene, propane, propylene, trichlorotrifluoroethylene, tetrachloromethane, trichloroethylene, tetrachloroethylene, etc., and carbon monoxide can also be present.

The implications from the Californian data is that similar emissions are likely from the hospital incinerators monitored here. However, there is no data on the relative volumes of material burnt or of the combustion temperatures, and thus the Californian data may not be directly comparable to the Cape Town hospital incinerators, but could rather be compared to specialised medical waste incinerators in Gauteng and Durban, and perhaps to the commercial incinerator at Vissershok.

As the Cape Town hospital incinerators are burning at lower temperatures, it would clearly be advantageous to undertake a more detailed analysis of emissions from these stacks.

5.11 DISPOSAL OPTIONS

Landfill

Landfill is the most popular disposal option in South Africa, and medical waste in landfill can cause considerable health risks for workers (J.Ball, Jarrod Ball & Associates, pers. comm.). Owing to the expense of having contaminated and otherwise hazardous waste collected by specialised commercial disposal companies, this waste is disposed by some medical institutions via the domestic collection service and taken to the Cape Town City Council waste site at Vissershok. As mentioned previously, all hospital incinerator ash (see Table 5.15 for analysis), is landfilled.

Recently it was stated by a City Council spokesman (P. Novella, at a CCC Public Participation workshop for the permitting of their Vissershok landfill site), that the average volume of medical waste entering Vissershok over the past six months was calculated as 8 tons per month.

Cement kilns

An alternative to medical waste incinerators, widely employed in Switzerland, are cement kilns. In February 1995, a Congress on Recovery, Recycling and Re-integration, which reviewed mechanical processes, logistic networks, separation technologies, chemical and biological processes, and hospital waste, was attended in Geneva, Switzerland. The main message which emerged from this Congress, was the need for an holistic approach to waste management, and on co-operation, not competition. This was in part negated (in the hospital and thermal sessions) by confrontations between the cement kiln and waste incinerator companies - both vying for their share of the market. As discussed earlier in this survey, cement works appear to be efficient at disposing of waste, which they use as fuel. PVC and materials containing chlorine cannot be burnt in these kilns, as they damage the quality of the cement, so hospitals are required to sort their waste before collection. In Europe, all plastics are labelled, so it is simple to identify PVC. In South Africa, PVC is not labelled, and is almost impossible to differentiate from other polymers.

When not recycled, waste from the University Hospital of Basel in Switzerland is sent to a cement kiln for incineration, as this is a more economical option. As mentioned above, this preference by the hospitals for employing cement kilns to dispose of medical waste, causes problems for the extremely expensive waste incinerator companies, which by law have to be fitted with the latest and most efficient emission control devices. Ciba-Geigy installed, at considerable cost, a designated medical waste incinerator in Basel, and in 1995 legislation was being created to force hospitals to use this incinerator. There is strict legislation governing the disposal of toxic waste (chemical, radioactive, heavy metals) in Switzerland and staff adhere rigidly to these laws (R. Schelker, University Hospital Basel, pers.comm).

Thermolysis

This process is believed to be a less polluting option than incineration; where a small quantity of lime is added to the waste, and when heated to 500°C, will neutralize chlorine and produce calcium chlorine. The thermolysis oven produces activated carbon and a combustible gas which can be used to generate power (de Broux, by e-mail, pers. comm.).

Commercial Waste Disposal Companies

Waste-tech

Most medical institutions employ Waste-tech for the disposal of their hazardous waste. The Waste-tech incinerator, sited at Vissershok, is a Macroburn 500, which does attain high temperatures (800-1000°C) and is supervised by trained personnel, although it is not fitted with emission control devices. It is planned to upgrade this incinerator in the near future. Volumes of waste sent to this disposal company vary, depending on the financial status of the hospital (G. Chalmers, Waste-tech, pers.comm).

Figure 5.20: Radioactivity analysis of ash from the Waste-tech medical waste incinerator. *(Source: Radiation Control, DOH).*

WASTE-TECH (94/10) Sample Mass = 300g	
Nuclide	***bq/m³***
^{125}I	93
^{51}Cr	1027

- Chromium levels are high in this sample (DOH safe limit: 300 *bq m³*).

National Hygiene

National Hygiene is a waste disposal company at present applying for a licence to incinerate medical waste in a specialized incinerator. This machine is capable of burning at high temperatures (1200°C) and is controlled by sophisticated computerised equipment. This company was prevented from operating in Retreat by public pressure, but now wishes to operate on Council land at Vissershok, near the incinerator operated by Waste-tech.

A Public Participation meeting was held in April 1996 by National Hygiene, where it was estimated that Provincial hospitals alone produce a daily total of 4.5 tons of medical waste. This does not include waste generated by laboratories, vets, pathologists, clinics, dentists, doctors and the private hospitals. It was suggested that only 2.5 to 3.0 tons of medical waste is incinerated daily, with the remainder being landfilled. It is difficult to reconcile these figures with the estimates previously quoted by a City Council spokesman, that Vissershok landfill site was receiving an average of 8 tons of medical waste per month. If these figures are correct, it would be interesting to know where the approximately 37 additional tons, from Provincial Hospitals alone, are being disposed? Waste-tech has possibly the most informed estimate of the quantities of medical waste produced in the Cape Peninsula, but unfortunately, their figures are confidential.

At the National Hygiene Public Participation meeting, it was argued that incinerator bottom ash was a neutral component, able to be landfilled with domestic waste and posing no risk to the environment, groundwater or handlers. International research suggests that this ash should been treated as special waste and disposed of in specialised landfill sites. A study at present being undertaken at Scientific Services at Athlone Waste Water Plant into the co-disposal of heavy metals in landfill (H. Ballard, Scientific Services, pers. comm.) is investigating the uptake of these metals, and how the different levels impact on leachate. This would not be permitted in Europe or the USA, but is being considered as a disposal alternative in developing countries.

It was also argued at this meeting, that as this incinerator complies with modern standards, no air-borne pollution would result, either in the form of smoke, or invisible pollutants such as dioxin or furans. This is debatable, as research indicates that burning at these high temperatures produces combinations of pollutants, the nature and effects of which are unknown (Futter, 1994).

5.12 SUMMARISING COMMENTS ON INCINERATOR EMISSIONS

The following points summarise the results and discussion of radioactivy and heavy metal analyses of incinerator ash and stack emissions:

- British, US and European research (see Chapter 2), and local heavy metal concentrations in incinerator ash indicate that incineration of clinical waste in residential or inner city areas does pose a long-term health risk.

- Particulates and volatile heavy metals are emitted from hospital incinerator stacks in Cape Town.

- City Park and Red Cross Hospital are emitting radiation at levels beyond those recommended as safe by the Department of Health.

- PVC is incinerated in hospital burners in Cape Town, and international research has shown that this causes toxic stack emissions such as hydrochloric acid (HCl), dioxins and furans. Burning of PVC is banned in the USA and Europe.

- No emission control devices are fitted to hospital incinerators, which burn at temperatures promoting the formation of dioxins and furans, and other products of incomplete combustion. At present, the costs of testing stack emissions for these substances is considerable, but the data presented here indicate that such testing is required.

To improve the waste management of substances affecting both liquid effluents and medical waste incineration, the Regulations for Hazardous Chemical Substances, and Guidelines for the Design, Installation and Operation of Incinerators and the Minimum Requirements for Landfill need to be enforced (see Chapter 3), although with current lack of trained personnel, financial restraints and lack of political will, this remains problematic. For waste management strategies to be effective, committment to environmental and human health by top management within medical institutions is crucial.

CHAPTER 6

QUESTIONNAIRE INVESTIGATING ATTITUDES TO HAZARDOUS WASTE MANAGEMENT IN MEDICAL INSTITUTIONS

CHAPTER 6

QUESTIONNAIRE INVESTIGATING ATTITUDES TO HAZARDOUS WASTE MANAGEMENT IN MEDICAL INSTITUTIONS

6.1 INTRODUCTION

It is believed that the ability of staff at healthcare institutions to monitor and handle hazardous waste in a responsible manner, and to educate patients to do the same, depends on their knowledge of the harmful effects of these substances, and their attitude towards the environment. This questionnaire was administered to personnel at medical institutions in order to gauge their attitudes towards hazardous waste management, and to ascertain whether their responses correspond to their behaviour, for example, do they profess environmental concern and still discard hazardous chemicals into the sewers, or demonstrate knowledge of the hazards of burning certain plastics, and yet accept that their incinerators discharge toxic emissions into the atmosphere? It is hoped that the analysis of responses to this questionnaire will provide some answers to these questions.

In general, staff were most co-operative when asked to fill in the questionnaire, although one Medical Superintendent, one Professor in charge of radioactive substances, and two doctors refused, as well as the entire staff of one State laboratory. The distribution of the questionnaire was complicated by disruption in the hospital services and a general nurses strike. At the same time, the Regulations for Hazardous Chemical Substances (under the Occupational Health and Safety Act) were published, and made certain hospital staff wary of answering the questionnaire. Considering these limitations, it was remarkable that out of the 1,000 questionnaires distributed to staff at the 10 institutions, 802 were returned (80%).

6.2 UK HOSPITAL WASTE MANAGEMENT QUESTIONNAIRE

The only available reference to a questionnaire dealing with medical waste was one carried out in the UK by Harrison (1992). In this study, it was believed that safe waste management practices were not being followed at this particular hospital, and that a questionnaire was necessary to assess the level of knowledge regarding current practice, and to promote discussion on local needs. The main concerns addressed by the questionnaire were the transmission of blood-borne infection, for example Hepatitis B and HIV, management of landfill sites, and the effect of waste disposal on the environment.

In this hospital, control of infection was accomplished by written procedures, policies and standards. With these procedures in mind, the questionnaire was designed to investigate classification, segregation, and disposal of waste, as well as attitudes to previous training programmes. Two hundred questionnaires were distributed to different categories of staff, and although replies were anonymous, only 70 were returned (34 %).

The questionnaire established that most respondents could explain the difference between clinical and non-clinical waste, but were unsure of correct disposal methods. They were also unsure of the sorting of sharps from clinical waste, and doctors were the least able to classify accurately the different categories of waste. Six percent of staff were confused with colour coding and which waste bags to use, and 94% did not know how to dispose of pharmaceutical and chemical waste. Only 22% reported any previous training, and none of these were doctors. Ninety six percent considered it necessary to implement on-going training programmes to address environmental issues and the promotion of workplace safety.

It was believed that these training programmes would create management structures to ensure responsibility and accountability at all levels, and managers of service departments such as the laundry, portering and incineration, were requested to continuously monitor disposal practices. It was concluded that in order for any programme to succeed, it would be essential to have the full support and commitment of hospital management (Harrison, 1992).

6.3 QUESTIONNAIRE ON TOXIC WASTES IN CAPE PENINSULA MEDICAL INSTITUTIONS

This present study of hospital hazardous waste management practices in the Cape Peninsula does not address the problem of infected biological wastes, nor training programmes, but is primarily concerned with hospital incinerators and chemical wastes being discharged into the sewers.

The questionnaire (Appendix VII) was designed using the British and South African Standards, and besides dealing with attitudes towards hazardous waste management, includes legislation, hospital policy and economic considerations. In a preliminary survey, the questionnaire was completed by a cross-section of staff at Somerset Hospital in central Cape Town.

Questions were then slightly modified, and administered to 1,000 randomly selected personnel at ten institutions in Cape Town by data gatherers from the Human Sciences Research Council (HSRC). Staff filled in the questionnaires, and the 802 responses were collected by the HSRC and returned for data capture and analysis. Hospital staff categories comprised Administration, Professional, Nursing, Technical and General. At the Medical School, instead of nurses, Researchers are included in this list.

Provincial clinics

No questionnaires were administered to Provincial clinics, but the waste management strategies of ten randomly selected clinics were investigated by telephone. The Sister-in-Charge was asked how hazardous wastes were managed, and the responses are detailed in the following Table.

Table 6.1: Waste management practices of ten clinics in the Cape Town area.

Clinic	Medical waste disposal	Other
Mannenberg	Waste-tech	Paper collected by company
Wynberg	Waste-tech	SAPPI collects paper
Claremont	Waste-tech. Expired medicines to Council stores in Ndabeni	Sell paper
Bishop Lavis	Waste-tech. Suppliers collect X-ray chemicals	
Crossroads	Waste-tech. Expired medicines down drains Swabs etc. to Rentokil	
Maitland	Waste-tech	
Grassy Park	Waste-tech	
Sea Point	Waste-tech	
Langa	Waste-tech and Ikapa Town Council	
Strandfontein	Waste-tech. Expired medicines sent back to pharmacy	Recycle papers

From Table 6.1 it can be seen that all these Provincial clinics use Waste-tech to deal with their hazardous waste, and Municipal or local town council waste removal services to collect their domestic waste. Swabs and infected waste collected by Rentokil are stored and compacted by Wasteman, and disposed of in landfill.

6.4 AIM OF STUDY

The aim of this study is to disprove the null hypothesis that there is no difference in the attitudes and knowledge of staff at Public and Private hospitals, and Medical School. As a corollary, this should affect the way in which they manage their hazardous wastes.

The medical institutions studied represent large teaching hospitals (Groote Schuur, Tygerberg), secondary hospitals (Somerset, Vincent Palotti), private mediclinics (Milnerton MediCity, City Park, Constantiaberg) and specialist hospitals (Red Cross Children's Hospital, Brooklyn Chest) and university Medical Schools (University of Cape Town). For the purpose of this investigation, these are divided into 3 groups, namely Provincial hospitals, Private hospitals and Medical Schools, although Appendix X indicates frequencies and percentages of responses to all questions by the different categories of staff at all institutions.

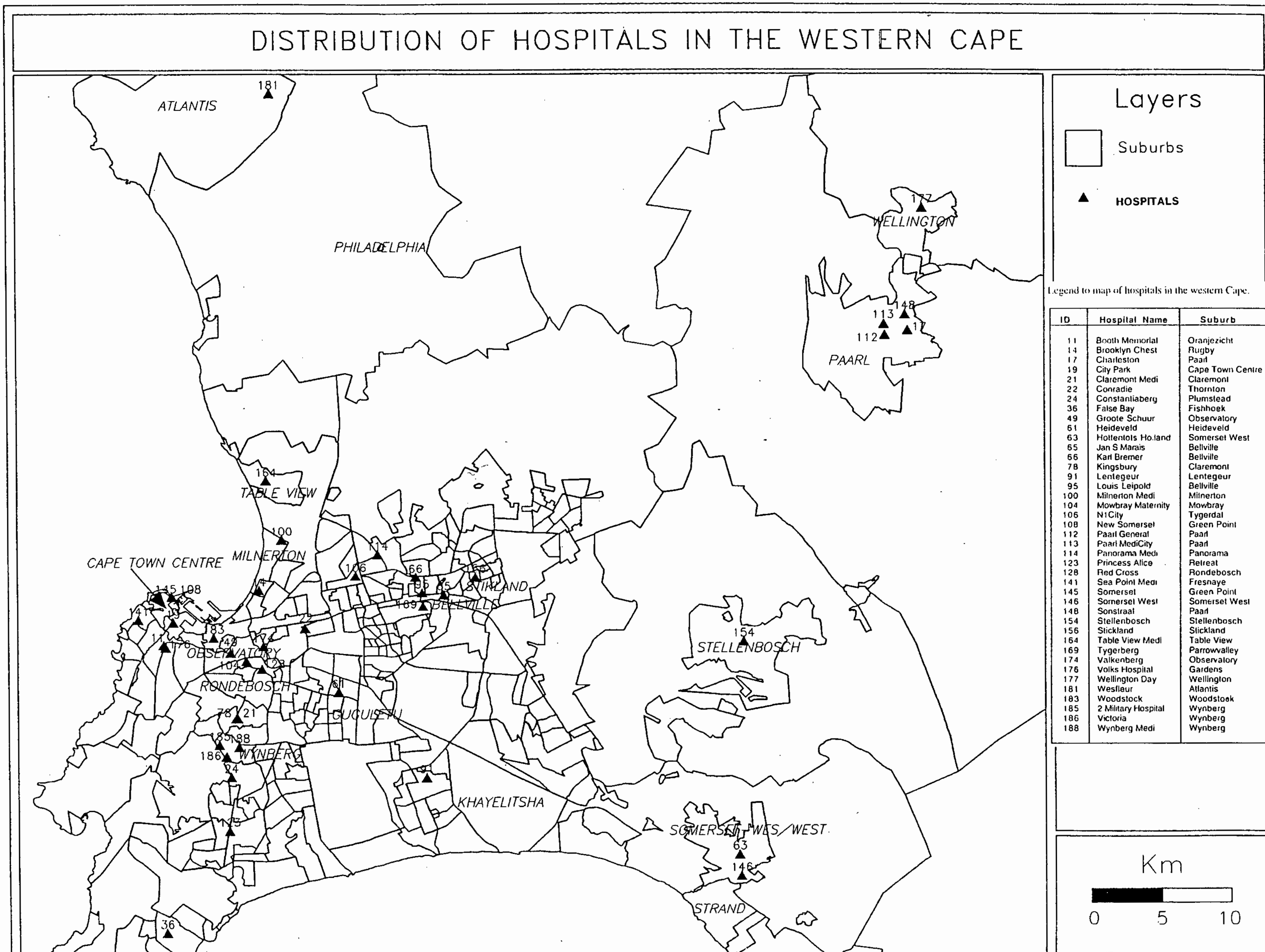
The medical institutions are divided into three groups indicated below:

- Public hospitals:
  Brooklyn Chest
  Groote Schuur
  Red Cross
  Somerset
  Tygerberg
  Vincent Palotti

- Private hospitals:
  City Park
  Constantiaberg
  Milnerton MediCity

- Medical schools:
  UCT Medical School.

All analyses and frequencies are compared within these three medical institution categories. The questionnaire sample size distributed to these three groups are indicated in Table 6.2. A map showing the distribution of these hospitals is included as Figure 6.



Legend to map of hospitals in the western Cape.

ID	Hospital Name	Suburb
11	Booth Memorial	Oranjezicht
14	Brooklyn Chest	Rugby
17	Charleston	Paarl
19	City Park	Cape Town Centre
21	Claremont Medi	Claremont
22	Conradie	Thornton
24	Constantiaberg	Plumstead
36	False Bay	Fishhoek
49	Groote Schuur	Observatory
61	Heideveld	Heideveld
63	Hottentots Holland	Somerset West
65	Jan S Marais	Bellville
66	Karl Bremer	Bellville
78	Kingsbury	Claremont
91	Lentegeur	Lentegeur
95	Louis Leipold	Bellville
100	Milnerton Medi	Milnerton
104	Mowbray Maternity	Mowbray
106	N1City	Tygerdal
108	New Somerset	Green Point
112	Paarl General	Paarl
113	Paarl MediCity	Paarl
114	Panorama Medi	Panorama
123	Princess Alice	Retreat
128	Red Cross	Rondebosch
141	Sea Point Medi	Fresnaye
145	Somerset	Green Point
146	Somerset West	Somerset West
148	Sonstraat	Paarl
154	Stellenbosch	Stellenbosch
156	Stickland	Stickland
164	Table View Medi	Table View
169	Tygerberg	Parrowvalley
174	Valkenberg	Observatory
176	Volks Hospital	Gardens
177	Wellington Day	Wellington
181	Wesfleur	Atlantis
183	Woodstock	Woodstock
185	2 Military Hospital	Wynberg
186	Victoria	Wynberg
188	Wynberg Medi	Wynberg

FIGURE 6 : Distribution of health facilities in the western Cape. *Source: CCC Town Planning Section, D. Wilson, Surveying Dept., UCT and research of this thesis*

Table 6.2: Sample size of questionnaires administered to medical institutions in the Cape Peninsula.

Medical Institution	N	%
State hospitals	715	89.2
Private hospitals	66	8.2
Medical School	21	2.6
Total	802	100.0

When considering the random sample size of each hospital, it should be borne in mind that these institutions are of differing sizes, and that the questionnaire was administered to approximately 5% of the total number of staff. Table 6.3 indicates whether a particular institution is Public or Private and shows the number and percentages of questionnaires returned.

Table 6.3: Numbers and percentages of responses from Cape Town medical institutions.

Medical institution	Type of institution	N	%
Brooklyn Chest	Public	11	1.4
City Park	Private	38	4.7
Constantiaberg	Private	20	2.5
Groote Schuur	Public	301	37.5
UCT Medical School	Medical School	21	2.6
Milnerton MediCity	Private	8	1.0
Red Cross	Public	51	6.4
Somerset	Public	40	5.0
Tygerberg	Public	292	36.4
Vincent Palotti	Public	20	2.5
	Total	802	100.00

6.5 INDEPENDENT VARIABLES

Some of the independent variables in the questionnaire are Age, Gender, Education and Job Description. These are detailed in the following Tables:

Table 6.4: Gender ratios of questionnaire respondents showing numbers and percentages.

Gender	N	%
Male	291	36.3
Female	496	61.8
No response	15	1.9
Total:	802	100

It is clear from Table 6.5 that there were many more females (61.8%) than males (36.3%) involved in this study.

Table 6.5: Age ratios of questionnaire respondents.

Age	N	%
20-29 years	208	25.9
30-49	474	59.1
50-59	93	11.6
60+	13	1.6
No response	14	1.7
Total:	802	100

- It was expected that most staff would fall within this 30-49 age group (59.1%) as it represents a 20 year interval, and is an age when most people are employed.

As far as education is concerned, most respondents (55.6%) have University, Technicon, College or Post-graduate qualifications. Details are shown in Table 6.6.

Table 6.6: Education levels of questionnaire respondents.

Level of Education	N	%
Junior School	30	3.7
Std. 8	107	13.3
Matric	203	25.3
University	120	15.0
Technicon	88	11.0
College	89	11.1
Post-Grad	149	18.6
No response	16	2.0
Total:	802	100

- The largest single educational group are Matriculants (25.3%), although overall 42.3% of staff members range from Junior School to Matric. Staff with a tertiary education (University, Technicon and College) comprise 37%, with Post-graduates comprising 18.6%.

Concerning Job Description, the following responses were received:

Table 6.7: Job Description of staff at Cape Town medical institutions.

Staff Categories	N	%
Administrative	81	10.1
Professional	172	21.5
Nursing	320	39.9
Technical	135	16.8
General	68	8.5
Unclassified	5	0.6
Medical School*	21	2.6
Total:	802	100

- The high percentage of nurses (39.9%) confirms the conclusion that the reason for there being more female respondents than males, was the large number of female nursing staff (see Table 6.4).

- It was not possible to place a number of Medical School staff into hospital categories, as most of them are professionals as well as post-graduates, and students as well as researchers. To prevent confusion, this is handled by grouping them simply as 'Medical School'.

There was also confusion among hospital staff as to whether or not some nurses and technical personnel should be classified as 'professional', but at present, these are classifications under which all personnel at medical institutions in the Cape Peninsula are employed.

6.6 SUMMARY OF INDEPENDENT VARIABLE DATA

From the previous independent variables it can be seen that:

- Public hospitals contain the largest sample size (89.2%)
- Females constitute the largest gender ratio (61.8%)
- Nurses constitute the largest staff category (39.9%)
- The largest age group is 30-40 years (59.1%)
- Staff with tertiary education form the largest group (55.6%)

6.7 DEPENDENT VARIABLES

There are 37 questions relating to hazardous waste management. Questions 1-10 include Yes/No/Don't Know options, and for the remaining 27 questions, the Lickert Scale is used where 1 = Strongly Disagree and 5 = Strongly Agree. The Chi-Square statistical test was employed to analyse the data. To eliminate the cells having expected counts less than 5, all Don't Know/Neutral/Missing answers were disregarded. Where there is a significant difference between the responses from the three categories of medical institution in Lickert Scale questions, the raw data are included for greater clarification.

Questions have been divided into 9 categories, namely: Legislation, Policy, Radioactive Waste, Sewage System, Incineration, Training, Economics, Attitudes and Staff Safety. The questions which relate to each of these categories are shown in Table 6.9.

All responses to the questionnaire were confidential, and respondents were only asked to fill in their Hospital and Section or Laboratory. As Question 1 was open-ended, it was decided to enter these responses in 12 main categories, although the categories 'Other' and 'Medical Waste' have proved to be ambiguous, and should have been defined more clearly. Perhaps it would have been less confusing to have had separate categories for 'sharps' and 'HIV', which are both major concerns (see comments in Appendix VIII). It should be keep in mind that because of the open nature of this question, a respondent could express more than one concern, therefore the responses do not total 802. The number of staff concerned about the different categories of toxic waste are listed in Table 6.8. Further responses to this question from specific medical institutions are elaborated upon in Appendix IX.

Table 6.8: Responses to Question 1: *Which toxic wastes produced by medical institutions are of most concern to you?*

Type of waste	N	%
Radioactivity	250	31.3
Medical waste	211	26.3
Chemicals	144	18.0
Other	89	11.0
Incinerator emissions	32	4.0
Plastics	26	3.2
Heavy metals	6	0.7
Phosphate/Nitrates	7	0.9
Boiler emissions	5	0.6
Antibiotics	4	0.5
Hormones	2	0.2
Air Conditioners (PCBs)	2	0.2

- From this table it is clear that the hazardous wastes produced by medical institutions of most concern to staff, are radioactivity (31.3%), medical waste (26.3%) and chemicals (18.0%).

- Generally, people tend to be more aware of radioactive wastes due to reasonably strict monitoring of the comprehensive legislation governing the purchase, use, storage and disposal of these materials, and perhaps to extensive media coverage.

Table 6.9: Categories into which questions have been grouped.

LEGISLATION

2 Do you think that South African legislation dealing with the safe disposal of toxic hospital waste is adequate?

11 Hospitals should be exempt from pollution control legislation

POLICY

3 Are you familiar with <u>hospital</u> policy dealing with toxic waste disposal?

5 Are you aware of measures to check the strict observance of hospital policy regarding:
a) radioactive waste?
b) chemical waste?

13 Hospital policy should identify hazardous waste

16 Hospital regulations ensure the safe disposal of:
a) PVC
b) organic solvents (eg chloroform)
c) cyanides
d) heavy metals

19 Hospital policy addresses the identification and quantification of risk to personnel involved in the handling of waste

RADWASTE

4 Does your department generate the following:
a) radioactive waste?

12 The following hazardous hospital wastes have a detrimental effect on public health
b) radioactive

SEWAGE SYSTEM

4 Does your department generate the following
b) chemical waste?

12 The following hazardous hospital wastes have a detrimental effect on public health
a) chemical

23 The following can be disposed of via the sewage system:
a) solvents (eg chloroform)
b) acids (eg sulphuric acid)
c) antibiotics
d) cytotoxic drugs

24 Clinical waste can be disposed of via the domestic waste system

INCINERATION

12 The following hazardous hospital wastes have a detrimental effect on public health
c) incineration of chlorinated plastics (PVC)

7 Are you easily able to distinguish PVC from other plastics?

17 All hospital waste should be incinerated

18 All incinerator personnel should possess a certificate of competence

21 Chlorinated compounds should be incinerated e.g. PVC

22 Respiratory protection should be provided against toxic dusts for incinerator personnel

25 incinerator residues (ash) should be dealt with as special waste

TRAINING

6 Do you think that hospital staff are adequately trained to deal with hazardous waste?

ECONOMICS

8 Do you think that it should be compulsory for hospitals to employ private waste companies to dispose of their toxic waste?

9 Do you think that the hospital can afford the cost involved to strictly monitor all hazardous waste?

26 It is too expensive to provide adequate protection for all personnel involved in handling hazardous material

27 Which of the following methods of clinical hazardous waste disposal do you think is the most efficient?
indicate only <u>one</u>)
Commercial waste companies? Cement kilns?
Municipal waste collection?
Own incineration?

ATTITUDES

10 There needs to be more awareness of
a) environmental issues
b) workplace safety

20 Waste generated by hospitals has a serious impact on the environment

STAFF SAFETY

10 There needs to be more awareness of
b) workplace safety

14 Records of hazardous material use should be kept by all departments

15 Staff should be protected against contamination by the toxic wastes generated in hospitals

In the following Section the responses to the questions are presented under the categories listed in Table 6.9.

6.7.1 LEGISLATION

When considering the number of questions concerning legislation, the following details were observed:

Table 6.10: *Question 2: Do you think that South African legislation dealing with the safe disposal of toxic hospital waste is adequate?*

			Yes		No	
Institution	**Total *f***	**Total Response**	*f*	%	*f*	%
Public hospitals	715	349	99	**28**	250	**72**
Private hospitals	66	32	5	**16**	27	**84**
Medical School	21	14	5	**36**	9	**64**
Total:	802	395	109	**27**	286	**72**

- Overall, staff do not think that South African legislation dealing with toxic waste is adequate, with staff at Private institutions being the least sure that they find this legislation satisfactory.

Table 6.11: *Question 11: Hospitals should be exempt from pollution control legislation.*

(i)

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	460	127	**28**	333	**72**
Private hospitals	66	41	3	**7**	38	**93**
Medical School	21	21	1	**5**	20	**95**
Total:	802	522	131	**25**	391	**75**

- Overall opinion is that hospitals should not be exempt from pollution control legislation.
- Staff at Private hospitals and Medical School appear the most adamant concerning exemption from pollution control.
- The difference between medical institutions was found to be significant: ($\chi^2 = 13.058$, 2df, $p < .01$).

(ii) Raw Data.

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	46	287	244	64	63
Private hospitals	0	38	25	2	1
Medical School	0	20	0	0	1
Total:	46	345	269	66	65

6.7.2 POLICY

Table 6.12: *Question 3: Are you familiar with hospital policy dealing with toxic waste disposal?*

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	609	248	**41**	361	**59**
Private hospitals	66	57	35	**61**	22	**39**
Medical School	21	20	13	**65**	7	**35**
Total:	802	686	296	**43**	390	**57**

- Public hospital staff appear to be the least familiar with hospital policy, and Medical School staff the best informed.
- The difference between medical institutions was found to be significant: ($\chi^2 = 13.098$, df 2, $p < .01$).

Table 6.13: *Question 5(a): Are you aware of measures to check the strict observance of hospital policy regarding radioactive waste?*

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	564	193	**34**	371	**66**
Private hospitals	66	49	16	**33**	33	**67**
Medical School	21	18	15	**83**	3	**17**
Total:	802	631	224	**35**	407	**64**

- Medical School staff are most aware of policy concerning radioactive waste.
- The difference between medical institutions was found to be very significant: ($\chi^2 = 0.000$, df 2, $p < .01$).

Table 6.14: *Question 5(b): Are you aware of measures to check the strict observance of hospital policy regarding chemical waste?*

	Total *f*	Total Response	Yes		No	
			f	%	*f*	%
Public hospitals	715	534	183	**34**	351	**66**
Private hospitals	66	53	29	**55**	24	**45**
Medical School	21	17	12	**70**	5	**29**
Total:	802	604	224	**37**	380	**63**

- Medical School staff are most aware of hospital policy regarding chemical waste, although staff at Public hospitals appear to be unsure of measures to ensure the strict observance of this policy.
- The difference between medical institutions was found to be highly significant: (χ^2 = 18.564, df 2, $p < .01$).

Table 6.15: *Question 13: Hospital policy should identify hazardous waste.*

Institution	Total *f*	Total Response	Yes		No	
			f	%	*f*	%
Public hospitals	715	694	674	**97**	20	**3**
Private hospitals	66	66	65	**98**	1	**1**
Medical School	21	21	21	**100**	0	**0**
Total:	802	781	760	**97**	21	3

- Staff from all institutions strongly agree that hazardous waste should be identified by hospital policy.

Table 6.16: *Question 16(a): Hospital regulations ensure the safe disposal of halogenated plastic material (PVC).*

(i)

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	614	272	**44**	342	**56**
Private hospitals	66	57	35	**61**	22	**39**
Medical School	21	17	7	**41**	10	**59**
Total:	802	688	314	**46**	374	**54**

- Staff appear uncertain whether or not hospital regulations ensure the safe disposal of halogenated plastic material, although Private hospital staff are slightly more positive that these regulations ensure that PVC is safely managed.

- The difference between medical institutions was found to be significant: ($\chi^2 = 6.290$, df 2, $p < .05$).

(ii) *Raw Data*

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	338	4	88	131	141
Private hospitals	21	1	8	25	10
Medical School	10	0	4	1	6
Total:	369	5	100		157

Table 6.17: *Question 16 (b): Hospital regulations ensure the safe disposal of organic solvents (eg chloroform).*

(i)

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	618		**45**	337	**54**
Private hospitals	66	50	29	**58**	21	**42**
Medical School	21	19	14	**74**	5	
Total:	802	687	324	**47**	363	**53**

- Staff at the Medical School feel that organic solvents are safely disposed of at their institution, with less conviction being felt by Public and Private hospitals.
- The difference between medical institutions was found to be significant: (χ^2 = 8.431, df 2, $p < .05$).

(ii) Raw Data

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	335	2	79	144	137
Private hospitals	21	0	13	23	6
Medical School	5	0	2	5	9
Total:	361	2	94	172	152

Table 6.18: *Question 16 (c): Hospital regulations ensure the safe disposal of cyanides.*

(i)

Institution	Total f	Total Response	Yes responses f	Yes responses %	No responses f	No responses %
Public hospitals	715	632	281	**44**	351	**55**
Private hospitals	66	59	34	**58**	25	**42**
Medical School	21	19	13	**68**	6	**31**
Total:	802	710	328	**46**	382	**54**

- Medical School staff are somewhat more positive about the ability of regulations to ensure the safe disposal of cyanides.

- The difference between medical institutions was found to be significant: ($\chi^2 = 7.642$, $p < .05$).

(ii) Raw Data

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	350	1	62	130	151
Private hospitals	25	0	6	20	14
Medical School	6	0	2	4	9
Total:	381	1	70	154	174

Table 6.19: *Question 16 (d): Hospital regulations ensure the safe disposal of heavy metals (e.g. lead, mercury, barium).*

(i)

Institution	Total *f*	Total Response	Yes responses		No responses	
			f	%	*f*	%
Public hospitals	715	620	287	**46**	333	**54**
Private hospitals	66	57	34	**60**	23	**40**
Medical School	21	18	12	**67**	6	**33**
Total:	802	695	333	**48**	362	**52**

- Medical School staff are somewhat more positive that their regulations ensure the safe disposal of heavy metals.
- The difference between medical institutions was found to be significant: ($\chi^2 = 6.337$, df 2, $p < .05$).

(ii) Raw Data:

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	330	3	74	134	153
Private hospitals	23	0	6	20	14
Medical School	6	0	3	3	9
Total:	359	3	83	157	176

Table 6.20: *Question 19: Hospital policy addresses the identification and quantification of risk to personnel involved in the handling of waste.*

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	631	348	**55**	283	**45**
Private hospitals	66	59	38	**64**	21	**35**
Medical School	21	17	11	**65**	6	**35**
Total:	802	707	397	**56**	310	**44**

- Overall, staff are ambivalent as to whether or not hospital policy addresses risk to personnel while handling waste.

6.7.3 RADIOACTIVE WASTE

Table 6.21: *Question 4 (a): Does your department generate radioactive waste?*

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	562	101	**18**	461	**82**
Private hospitals	66	55	4	**7**	51	**93**
Medical School	21	20	16	**80**	4	**20**
Total:	802	637	121		516	**81**

- Medical School appears to produce the most radioactive waste.

- The difference between medical institutions was highly significant: ($\chi^2 = 53.667$, df 2, $p < .01$).

Table 6.22: *Question 12 (b): Radioactive waste has a detrimental effect on public health*

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	656	568	**86**	88	**13**
Private hospitals	66	63	61	**97**	2	**3**
Medical School	21	18	16	**89**	2	**11**
Total:	802	737	645	**87**	92	12

- Staff at all institutions strongly agree that radioactive waste has a detrimental effect on public health.

6.7.4 SEWAGE SYSTEM

Table 6.23: *Question 4 (b): Does your department generate chemical waste?*

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	539	229	**42**	310	**57**
Private hospitals	66	57	30	**53**	27	**47**
Medical School	21	20	16	**80**	4	**20**
Total:	802	616	275	**45**	341	**55**

- Medical School staff feel they do generate chemical waste. Private hospital staff are equivocal, and 57% of staff at Public hospitals feel they do not!

- The difference between medical institutions was found to be significant: (χ^2 = 12.604, df 2, $p < .05$).

Table 6.24: *Question 12 (a): Chemical wastes have a detrimental effect on public health.*

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	655	567	**86**	88	**13**
Private hospitals	66	61	58	**95**	3	**5**
Medical School	21	20	18	**90**	2	**10**
Total:	802	736	643	**87**	93	**13**

- Staff at both Private hospitals and Medical School feel very strongly about the detrimental effect of chemical wastes on public health, and to a lesser extent, so do staff at Public hospitals.

Table 6.25: *Question 23: (a) Solvents, (b) acids, (c) antibiotics, (d) cytotoxic drugs can be disposed of via the sewage system.*

(a) Solvents:

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	505	140	**28**	365	**72**
Private hospitals	66	36	9	**25**	27	**75**
Medical School	21	16	1	**6**	15	**94**
Total:	802	557	150	**27**	407	**73**

(b) Acids:

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	491	103	**21**	388	**79**
Private hospitals	66	37	7	**19**	30	**81**
Medical School	21	15	2	**13**	13	**87**
Total:	802	543	112	**21**	431	**79**

(c) Antibiotics

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	506	180	**35**	326	
Private hospitals	66	46	21	**46**	25	**54**
Medical School	21	15	2	**13**	13	**87**
Total:	802	567	203	**36**	364	**64**

(d) Cytotoxic drugs

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	479	76	**16**	403	**84**
Private hospitals	66	39	5	**13**	34	**87**
Medical School	21	17	1	**6**	16	**94**
Total:	802	535	82	**15**	453	**85**

- Staff at all institutions generally feel that these substances should not be disposed of via the drains, although Public and Private hospitals are less sure of antibiotics. Medical School staff appear particularly adamant that solvents should not be discarded into the sewage system.

Table 6.26: *Question 24: Clinical waste can be disposed of via the domestic waste system (refuse and sewage).*

(i)

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	479		**38**	297	**62**
Private hospitals	66	44	7	**16**	37	**84**
Medical School	21	15	3	**20**	12	**80**
Total:	802	538	192	**36**	346	**64**

- Staff at Private hosptials and Medical School feel that this type of waste should not be disposed of via the domestic waste system, while staff at Public hospitals are ambivalent.

- The difference between medical institutions was found to be highly significant: (χ^2 = 10.220, df 2, $p < .01$).

(ii) *Raw Data*

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	115	182	230	114	68
Private hospitals	9	28	22	5	2
Medical School	1	11	6	3	0
Total:	125	221	258	122	70

6.7.5 INCINERATION

Table 6.27: *Question 12(c): Incineration of chlorinated plastics (PVC) has a detrimental effect on public health.*

			Yes		No	
Institution	**Total *f***	**Total Response**	*f*	%	*f*	%
Public hospitals	715	652	518	**79**	134	**20**
Private hospitals	66	57	49	**86**	8	**14**
Medical School	21	18	15	**83**	3	**17**
Total:	802	727	582	**80**	145	**20**

- There is agreement within all medical institutions that incineration of chlorinated plastics has a detrimental effect on public health.

Table 6.28: *Question 7: Are you easily able to distinguish PVC from other plastics?*

			Yes		No	
Institution	**Total *f***	**Total Response**	*f*	%	*f*	%
Public hospitals	715	571	156	**37**	415	**73**
Private hospitals	66	58	23	**40**	35	**60**
Medical School	21	16	3	**19**	13	**81**
Total:	802	637	182	**28**	463	**72**

- Staff from all institutions are unable with confidence to distinguish PVC from other plastics.

Table 6.29: *Question 17: All hospital waste should be incinerated.*

(i)

Institution	Total *f*	Total Response	Yes		No	
			f	%	*f*	%
Public hospitals	715	538	365	**68**	173	**32**
Private hospitals	66	35	26	**74**	9	**26**
Medical School	21	14	7	**50**	7	**50**
Total:	802	587	398	**68**	189	**32**

- Perceptions regarding incineration of all hospital waste tend to be ambiguous, and raw data are thus included for elaboration.

(ii) Raw Data

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	136	37	173	162	203
Private hospitals	4	5	30	13	13
Medical School	1	6	7	4	3
Total:	141	48	210	179	219

Table 6.30: *Question 18: All incinerator personnel should possess a certificate of competence.*

Institution	Total f	Total Response	Yes		No	
			f	%	f	%
Public hospitals	715	678	643	**95**	35	**5**
Private hospitals	66	61	58	**95**	3	**5**
Medical School	21	20	20	**100**	0	**0**
Total:	802	759	721	**95**	38	**5**

- There is strong agreement that all incinerator personnel should possess a certificate of competence.

Table 6.31: *Question 21: Chlorinated compounds should be incinerated (eg. PVC).*
(i)

Institution	Total f	Total Response	Yes		No	
			f	%	f	%
Public hospitals	715	583	249	**43**	334	**57**
Private hospitals	66	45	12	**27**	33	**73**
Medical School	21	17	3	**18**	14	**82**
Total:	802	645	264	**41**	381	**59**

- There is a feeling against incineration of PVC from Private hospitals and Medical School staff, and a slight approval for incineration of these plastics from the Public hospital staff.

- The difference between medical institutions was found to be significant: (χ^2 = 8.362, df 2, $p < .05$).

(ii) Raw Data

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	284	50	122	129	120
Private hospitals	32	1	21	8	4
Medical School	6	8	4	0	3
Total:	322	59	147	137	127

Table 6.32: *Question 22: Respiratory protection should be provided against toxic dusts for incinerator personnel.*

			Yes		No	
Institution	**Total *f***	**Total Response**	*f*	%	*f*	%
Public hospitals	715	699	653	**93**	46	**6**
Private hospitals	66	61	58	**95**	3	**5**
Medical School	21	18	17	**94**	1	**5**
Total:	802	778	728	**93**	50	**6**

- There is strong consensus that respiratory protection should be provided against toxic dusts for incinerator personnel.

Table 6.33: *Question 25: Incinerator residues (ash) should be dealt with as special waste.*

Institution	Total *f*	Total Response	Yes		No	
			f	%	*f*	%
Public hospitals	715	605	461	**76**	144	**24**
Private hospitals	66	47	29	**62**	18	**38**
Medical School	21	18	12	**67**	6	**33**
Total:	802	670	502	**75**	168	**25**

- Most staff at all institutions agree that incinerator ash should be dealt with as special waste, although there are a number who do not believe that this is necessary.

6.7.6 TRAINING

Table 6.34: *Question 6: Do you think that hospital staff are adequately trained to deal with hazardous waste?*

Institution	Total *f*	Total Response	Yes		No	
			f	%	*f*	%
Public hospitals	715	549	90	**16**	459	**84**
Private hospitals	66	48	22	**46**	26	**54**
Medical School	21	17	4	**23**	13	**76**
Total:	802	614	116	**19**	498	**81**

- Generally staff feel that training is inadequate, although Private hospitals are more satisfied with the training they receive.

- The difference between medical institutions was found to be highly significant: ($\chi^2 = 25.212$, df 2, $p < .01$).

6.7.7 ECONOMICS

Table 6.35: *Question 8: Do you think that it should be compulsory for hospitals to employ private waste companies to dispose of their toxic waste?*

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	608	434	**71**	174	**29**
Private hospitals	66	58	36	**62**	22	**38**
Medical School	21	7	16	**47**	8	**53**
Total:	802	681	447	**70**	204	**30**

- An interesting divergence of opinion appears between the Public hospital staff and the Medical School staff, the former agreeing that waste companies should deal with toxic waste, while 53% of Medical School staff are against the use of private companies for toxic waste disposal. This divergence is also reflected in Table 6.38.

- The difference between medical institutions was found to be significant: ($\chi^2 = 0.045$, df 2, $p < .05$).

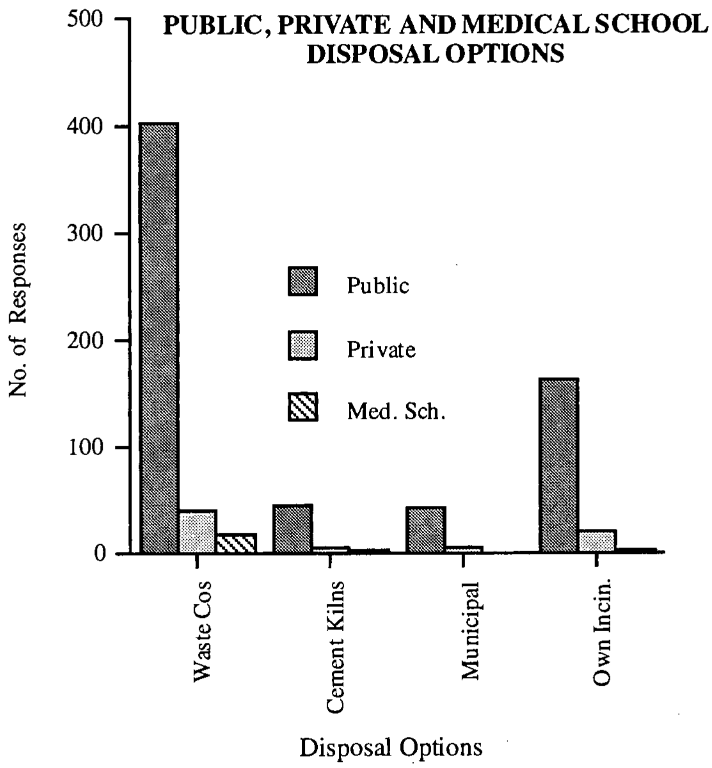
Table 6.36: *Question 9: Do you think that the hospital can afford the cost involved to strictly monitor all hazardous waste?*

Institution	Total *f*	Total Response	Yes *f*	Yes %	No *f*	No %
Public hospitals	715	517	234	**45**	283	**55**
Private hospitals	66	52	40	**77**	12	**23**
Medical School	21	12	9	**75**	3	**25**
Total:	802	581	283	**49**	298	**51**

- Private hospital and Medical School staff clearly believe they can afford the cost of monitoring hazardous waste, whereas generally staff from public institutions believe that they cannot afford this cost.
- The difference between medical institutions was found to be highly significant: (χ^2 = 22.349, df 2, p < .01).

Table 6.37: *Question 27: Which of the following methods of clinical hazardous waste disposal do you think is the most efficient?*

Commercial waste companies?
Cement kilns?
Municipal waste collection?
Own incineration?



Total f =	Public hospitals	715
	Private hospitals	66
	Medical School	21

- The majority of staff at all medical institutions believe that commercial waste companies are the most efficient way to dispose of their hazardous waste.

Table 6.38: *Question 26: It is too expensive to provide adequate protection for all personnel involved in handling hazardous material.*

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	404	104	**26**	300	**74**
Private hospitals	66	35	4	**11**	31	**88**
Medical School	21	14	2	**14**	12	**86**
Total:	802	453	110	**24**	343	**76**

- Staff generally believe that expense should not be spared in protecting their personnel against exposure to hazardous waste.

6.7.8 ATTITUDES

Table 6.39: *Question 10(a): There needs to be more awareness of environmental issues.*

(a) Environmental issues:

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	678	667	**99**	9	**1**
Private hospitals	66	63	63	**100**	0	**0**
Medical School	21	21	21	**100**	0	**0**
Total:	802	760	751	**99**	9	**1**

- There is strong agreement at all institutions that there needs to be greater awareness of environmental issues.

Table 6.40: *Question 20: Waste generated by hospitals has a serious impact on the environment.*

(i)

Institution	Total f	Total Response	Yes f	Yes %	No f	No %
Public hospitals	715	603	498	**82**	105	**17**
Private hospitals	66	50	46	**92**	4	**8**
Medical School	21	18	11	**61**	7	**39**
Total:	802	671	555	**83**	116	**17**

- There is general agreement from staff at Public and Private hospitals that hospital waste has a serious impact on the environment. There is less certainty among Medical School staff.

- The difference between medical institutions was found to be significant: ($\chi^2 = 8.897$, df 2, $p < .05$).

(ii) Raw Data

Institution	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Public hospitals	100	5	111	254	244
Private hospitals	3	1	16	27	19
Medical School	6	1	3	9	2
Total:	109	7	130	290	265

6.7.9 STAFF SAFETY

Table 6.41: *Question 10 b) : There needs to be more awareness of workplace safety.*

(b) Workplace safety:

Institution	Total f	Total Response	Yes		No	
			f	%	f	%
Public hospitals	715	671	668	99	3	0
Private hospitals	66	65	64	98	1	1
Medical School	21	19	19	100	0	0
Total:	802	755	751	99	4	0

- There is strong agreement at all institutions that there needs to be greater awareness of workplace safety.

Table 6.42: *Question 14: Records of hazardous material use should be kept by all departments.*

Institution	Total f	Total Response	Yes responses		No responses	
			f	%	f	%
Public hospitals	715	640	606	95	34	5
Private hospitals	66	55	54	98	1	2
Medical School	21	19	19	100	0	0
Total:	802	714	679	95	35	5

- Staff at all institutions strongly agree that hazardous material records should be kept by all departments.

Table 6.43: *Question 15: Staff should be protected against contamination by the toxic wastes generated in hospitals.*

Institution	Total f	Total Response	Yes responses f	Yes responses %	No responses f	No responses %
Public hospitals	715	703	694	**99**	9	**1**
Private hospitals	66	65	65	**100**	0	**0**
Medical School	21	20	19	**95**	1	**19**
Total:	802	788	778	**99**	10	**1**

- There is strong agreement that staff should be protected against contamination by toxic hospital waste.

6.8 CONCLUSIONS

The preceding analysis indicates the following major points from the questionnaire:

Legislation

- Overall opinion indicates that medical institutions should not be exempt from pollution control legislation, with staff at Private hospitals and Medical School being the most adamant. There is a highly significant difference between institutions on this issue.
- Staff generally feel that legislation relating to toxic waste is not adequate.

Policy

- Most Medical School and Private hospital personnel state that they are familiar with policy dealing with toxic waste disposal, while Public hospital staff appear to be the least familiar, with the difference of opinion between institutions being highly significant.

- Overall, staff in Public and Private hospitals are not aware of policies relating to radioactive substances, but most Medical School staff are aware of the relevant policy. The difference between institutions is highly significant on this issue.

- Concerning chemical waste, there is a highly significant difference between the responses of Medical School staff, 70% of whom are aware of measures to ensure the strict observance of policy dealing with this type of waste, and that of Public and Private hospitals, whose staff generally appear not to be aware of these measures.

- Medical School respondents feel more positive about the ability of regulations to ensure the safe disposal of organic solvents, cyanides and heavy metals, Private hospital personnel are less sure and Public hospital staff are the least convinced in the efficacy of regulations to ensure the safe disposal of these substances.

- Staff are uncertain whether their institutions ensure the safe disposal of PVC. Private hospital personnel are more postive that their regulations ensure the safe management of these plastics.

- Respondents from all institutions feel strongly that hospital policy should identify hazardous waste, but not so many are sure that this occurs.

Radioactive waste

- Of most concern to staff is radioactivity, followed by medical waste and chemicals.

- Staff throughout all institutions believe radioactive waste has a detrimental effect on public health.

- Medical School appears to generate the most radioactive waste. Overall, staff in Public and Private hospitals are not aware of generating this type of waste.

Sewage system

- Most Medical School personnel believe that their departments generate chemical waste, whereas 57% of staff in Public hospitals believe that they do not.

- Staff at all medical institutions feel strongly that solvents, acids and cytotoxic drugs should not be disposed of via the sewage system, with Medical School respondents being particularly adamant concerning solvents.

- Staff at Public and Private hospitals are not so concerned about antibiotics.

- There was a significant difference between institutions concerning the disposal of clinical waste via the Municipal refuse collection system. Staff at Private hospitals and Medical School feel that this waste should not be disposed of via the domestic waste system, while personnel at Public hospitals are ambivalent.

Incineration

- Generally, Private hospital personnel feel that all hospital waste should be incinerated, with 68% of Public hospital staff, and 50% of Medical School staff agreeing.

- There is agreement within all institutions that incineration of chlorinated plastics has a detrimental effect on public health, although staff are generally unable to distinguish this from other plastics.

- There is a general feeling against incineration of PVC from Private and Medical School staff, and a slight approval for incineration of these plastics from the Public hospital personnel.

- Staff feel strongly that incinerator operators should both possess a certificate of competence and utilize protective devices against toxic dusts (neither of which is currently required or provided).

- There is a general feeling throughout all institutions that incinerator ash should be dealt with as special waste, although 25% of respondents did not believe that this was necessary.

Training

- Few staff feel that they are adequately trained to deal with hazardous wastes, although respondents from Private hospitals are more satisfied with the training they receive. The difference between medical institutions on this issue was found to be highly significant.

Economics

- Staff are divided as to whether the costs involved to monitor hazardous wastes can be justified, with Private hospital and Medical School respondents being more amenable to the idea, and those at Public hospitals against, indicating a highly significant difference of opinion.

- Most Private hospital and Medical School respondents believe that expense should not be spared to protect their personnel from exposure to hazardous waste.

- There is a significant difference between the Public hospitals, where 71% of staff believe it should be compulsory to employ private waste companies to dispose of their hazardous waste, and Medical School, where 53% of staff were against the use of private companies.

Attitudes

- There is strong feeling from personnel at all institutions that there needs to be greater awareness of environmental issues.

- All staff strongly recognize that medical waste, and to a lesser degree, chemical waste, has a detrimental effect on public health.

- There is also an highly significant difference in the responses of Staff at Public and Private hospitals, who generally feel that hospital waste has a serious impact on the environment. There is less certainty among Medical School staff.

Staff Safety

- Generally, staff within all institutions believe that records of hazardous material use should be kept by all departments.

- There is strong agreement that workplace safety should be considered a matter of utmost importance to management, and that personnel should at all times be protected against the toxic wastes generated by medical institutions.

General comments

From the analysis of all questionnaire responses together, the Null Hypothesis stating that there is no difference in the attitudes and knowledge of staff at Public and Private hospitals and Medical School, has been rejected ($\chi^2 = 293.755$, df 73, $p < .01$). The Chi-square test indicates, allowing for the disparity in numbers (see Table 6.2), that there is a <.01 probability of there being a difference in attitudes and knowledge between categories of medical institution.

Without having been able to sample the liquid effluent outflows from Private hospitals, it is not possible to correlate the difference in attitudes and knowledge of their staff, to the way in which they manage their hazardous chemical wastes.

Although Medical School staff are generally more aware of the issues involved in hazardous waste management than personnel from Public hospitals, there is no evidence from the analyses of their outflows, that they are more concerned about the disposal of their hazardous chemical wastes.

The greater awareness shown by Private hospital personnel regarding incineration does not manifest itself in the actual running of incinerators, as both Private and Public hospital incinerators emit radioactivity above international and local limits and burn PVC and chemicals without emission control devices.

CHAPTER 7

RESEARCH FINDINGS AND CONCLUSIONS

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7.1 INTRODUCTION

The main aim of this study was to examine hazardous waste levels in health institutions in Cape Town, and administer a questionnaire to staff in order to investigate their knowledge of and attitudes to toxic waste management. Objectives included comparing existing disposal methods with those used internationally, reviewing relevant international and South African legislation, and to discuss potential health risks to humans and the environment. An important objective was to examine the nature of effluent discharged from hospital liquid outflows, and incinerator stack emissions. On the basis of this research, recommendations are presented which aim to mitigate detrimental effects associated with the disposal of toxic hospital wastes.

Objectives sought in this thesis may be viewed within a global context. The 1992 UNCED "Earth Summit' Agenda 21 has focussed international opinion on sustainable development and protection of the environment, and has highlighted the necessity and long term benefit of preventing problems before they arise. This will have an increasing significance for the South African economy, and tourist industry in particular, whose clients demand clean air and a healthy environment - an important consideration for Cape Town, which boasts magnificent scenery and beaches, both of which could be harmed by pollutants from medical institutions.

7.2 HEALTH EFFECTS

The literature reflects an uncertainty of the long-term effects on humans exposed to the mixture of chemicals present in city areas. Incubation periods tend to be long, and make cause and effect difficult to ascertain. Air pollution, though, has been proved to contribute towards respiratory problems, and dioxins and furans are believed to impair intellectual development in children and damage the immune system. In addition, US EPA has stated that dioxin is likely to present a cancer hazard to humans (Von Schirnding 1992). Emissions from hospital incinerators, and the use of hazardous substances in healthcare institutions do contribute to urban pollution, which is correlated by numerous epidemiological studies with disease (Guthrie & Perry, 1980).

Other hazardous substances present in hospital waste are cytotoxic drugs, which since the 1940s have been implicated in the development of malignancies in animals and humans, and have been associated with chromosomal damage and teratogenesis (Dossing & Lanek, 1984). Barbour (1980) states that cancer kills one-fourth of living US citizens, and environmental causes are said to be responsible for 60-90% of all these cases.

7.3 LIQUID EFFLUENT OUTFLOWS

Industrial development and population growth has caused an increasing coastal pollution problem, and very little is known about chronic effects of the mixture of toxic pollutants discharged into the sea. As noted by Brown (1987), sewage is the most important pollutant from a public health perspective, and the volume of untreated, or only primary treated liquid effluent discharged into the sea, will incur great expense in the future. This investigation has demonstrated that medical institutions make a considerable contribution to this liquid effluent load.

The South African "General Standard" is the legislation which applies to industry as well as to medical institutions. These permitted limits are generously high compared to international standards. Even using these industrial limits, the Hg concentration at one institution was $70 \mu g\ l^{-1}$, which exceeded by 3.5 times the General Standard of $20 \mu g\ l^{-1}$, and all known international standards identified in this research. Further findings on liquid effluent include:

- Local medical institutions emit ammonia and heavy metals, in particular Hg and Fe, into the sewers in concentrations above the South African General Standards, while Hg, Cr, Cu, Pb and Zn exceed Australian, Canadian and Dutch standards. The British standards are exceeded by Hg, Pb, Zn, and Cu, and Hg is present in concentrations above those specified by US EPA.

- International studies find the presence of Hg, Zn and absorbable organic halogens in hospital waste water to be of concern, and pollutants present in ocean outflows to be potentially hazardous to humans and the environment.

- As the chemical content of the hospital and medical institution sewage outflows is high compared to international and South African water quality guidelines, this clearly contributes significantly to the pollution of land (via the sludge), the rivers, and the receiving coastal waters. However, it is beyond the scope of this thesis to study the impacts of the effluent discharge in the sea.

It can be seen from the few samples investigated here, that outflows from Cape Town medical institutions do contribute to the heavy metal and toxic component which concentrates in the sludge at Athlone Waste Water Plant, and is discharged into the rivers and sea. These samples were collected only at four outflows at three institutions, but when multiplied by the outflows from all other hospitals, with the addition of laboratories, private doctors' practices, clinics, dentists and veterinary clinics, the accumulated impact over time is clearly considerable. Even though a large number of medical institutions employ a commercial company to dispose of their hazardous waste in a more controlled manner, this company also has the problem of either incinerating or landfilling these wastes, with subsequent impacts on the environment and potential hazards for human health.

No radioactivity was detected in the liquid effluent samples analysed in this study, although control of radioactive waste in certain sections of one large teaching hospital does not appear to be satisfactory. The multiplicity of regulations for the transport, storage and disposal of this waste; from Acts of Parliament, Radiation Control (DOH), ICI, UCT, Waste-tech, City Council and Regional Services Council and the hospital itself, cause confusion. Lack of education also appears to be a difficulty; for example, staff place radioactive HIV blood into black bags, which are collected by a commercial company or the Municipal refuse collection for disposal in landfill. To help alleviate this problem, it is hoped to initiate an education programme for all levels of staff in the hospital (M. Shackleton, pers.comm.).

7.4 INCINERATION

From investigation of incinerators, the main findings are:

- Toxic emissions from medical waste incinerators contain high concentrations of radioactivity, for example, ^{125}I (332-650 *bq* kg^{-1}), and Ga^{67} (9186*bq* kg^{-1}). As PVCs are burned, HCl and dioxins are emitted which are known health hazards to humans, as well as contributing to environmental degradation.
- Incinerator bottom ash contains high Hg and Zn concentrations 1.1-4.0*mg* kg^{-1} , and Zn 5.1-11.0*g* kg^{-1} , which when landfilled, are available to leach into groundwater.
- International research has indicated that incineration of clinical waste in residential or inner-city areas poses a long term health risk for adjacent residents. Particulates emitted from stacks and local heavy metal concentrations in incinerator ash indicate that the same could apply in Cape Town.

Although recently a number of guidelines, specifically for air pollution (under the Atmospheric Pollution Control Act) and chemical waste (under the Occupational Health and Safety Act) have been produced, these still need to be enforced. Although the authorities are aware of the dangers of toxic waste incineration, there has been very little they could do to improve matters - given the lack of stringent legislation and insufficient personnel to monitor the situation. Even though costs are high for the safe disposal of toxic hospital waste, it is surely a matter for public debate as to whether it is acceptable for incinerators which are emitting known carcinogens, to be allowed to operate in built-up areas. But costs are also high for running these machines and a number of hospitals, for example Brooklyn Chest and Somerset Hospital, have found it worthwhile to decommission their incinerators and send all waste to a commercial waste company.

It is difficult to make many positive recommendations concerning local hospital incinerators, as it is not possible for these machines to be upgraded to burn safely and efficiently, even with considerable financial outlay. Accordingly it would be preferable that commercial waste companies should deal with all waste at present burnt in hospital machines, although these commercial incinerators should also be monitored using a modern comprehensive multi-analytical system. Such a system could simultaneously monitor very low levels of various gaseous pollution and facilitate the study of relationships between various pollutants in the atmosphere.

7.5 RESULTS OF STAFF QUESTIONNAIRE ON MEDICAL WASTE MANAGEMENT

This investigation was carried out to assess attitudes to and knowledge of hazardous waste in the ten Cape Town medical institutions. One thousand questionnaires were administered to staff, with an 80% response rate. Responses were statistically analysed, and the major findings were:

- Staff are most concerned about radioactivity, medical waste and chemicals.
- Most staff believe that medical waste, and to a lesser degree, chemical waste, has a detrimental effect on public health.
- Generally it is felt that legislation relating to toxic waste is inadequate and that hospital policy should identify hazardous waste, but staff are divided as to whether the costs involved in monitoring of wastes can be justified.
- Respondents are not sure whether substances such as solvents, antibiotics and drugs should be disposed via the sewage system, but there is stronger support for the incineration of all hospital waste, with the exception of PVC.
- Staff feel strongly that incineration operators should be trained and wear protective clothing and masks.
- There is strong feeling from staff at all institutions that there needs to be greater awareness of both environmental issues and workplace safety, and that they should be protected against toxic wastes and trained to deal with this type of waste.

7.6 RECOMMENDATIONS FOR IMPROVING HOSPITAL WASTE MANAGEMENT PROTOCOLS

Based upon the research findings presented in the thesis, the following recommendations and suggestions are presented for consideration for improving hospital waste management protocols. Many of these should be addressed when designing an holistic system of toxic waste management for medical institutions, although most can only be implemented when a national monitoring system with enforceable effluent standards is developed:

- Environmental audits for waste discharge should be established and hospitals be held accountable for their toxic wastes. This implies that waste management systems need to make sure that there is accountability at all levels.

- Top management in medical institutions need to commit to an improved, and auditable, management strategy.

- Hazardous waste education programmes should be established and presented within the medical institutions, perhaps combined with programmes provided by Waste-tech.

- Staff should be encouraged to participate, and be included in waste management decision-making to ensure the effort at improving waste management practices is as effective as possible.

- A continuous information programme for staff on air and water pollution in Cape Town could be implemented, and hospitals and clinics should become involved in specific local environmental issues and encourage community participation.

- Monopolies in the commercial waste industry are counter-productive, and to provide competitive prices and an high quality, safe service, there needs to be competitive technologies involved in the disposal of medical waste.

- Consideration should be given to using non- or less hazardous alternatives in medical applications, for example Cybergreen instead of EthBr as a staining agent for DNA testing, and where possible, Phenoxytol instead of Formalin for preserving specimens.

- Incineration of medical waste should not be permitted in residential or densely populated areas.

- Cement kilns could be investigated as an alternative to medical waste incinerators. This is an economical and efficient option if the waste can be sorted and PVC's eliminated.

- Yet another possible alternative to incineration could be thermolysis.

- It would be preferable if commercial waste companies could deal with all waste at present burnt in hospital machines. These commercial incinerators should be fitted with emission control devices and be monitored using a modern comprehensive multi-analytical system to ensure that air pollution limits are not exceeded.

- Incinerator ash should be treated as special waste and be disposed of in lined landfill sites.

- There are methods available for recovering heavy metals from incinerator emissions (Brunner and Frey 1995), as well as numerous chemicals used in medical institutions. These need to be investigated.

- Legislation should be introduced to ensure that all plastics products are clearly labeled to prevent the incineration of PVC.

- Single material type systems need to be encouraged to facilitate efficient sorting and recycling.
- Waste containers to be incinerated should be made from recycled materials, and materials containing red dyes (Cd) should be avoided.

- Until labeling is implemented, representatives of medical supply companies should be informed of the plastics composition of their products.

- Untreated liquid effluent should not be discharged into the sea.

- Restricted substances should not be regulated by maximum concentrations, but by quantity of toxic pollutants discharged into the sewers.

- The public should be informed of the dangers inherent in careless waste management practices.

- Environmental health education should be included in medical curricula and students informed of environmental pollution and its effect on health.

- Advanced multidisciplinary and interdisciplinary training at postgraduate level in waste management and pollution control should be provided at universities.

- An ethic of "care for the environment" needs to be developed, and cooperation between politicians, local authorities, academics and scientists, waste companies, and staff at all levels in medical institutions needs to be encouraged. Without realisation of this need, and without cooperation, and commitment to mitigating environmental impacts, any waste management strategy is unlikely to be successful.

- Finally, as suggested by Lee (1992), it is not sufficient for medical practitioners only to deal with the harmful effects of environmental degradation on humans once they occur, but very importantly, they need also to be assertive in preventing this degradation.

7.7 SOME LIMITATIONS OF THE PROJECT

Although the results obtained in this study may be considered indicative of the composition of liquid effluents from certain medical institutions, it may be considered preferable to obtain a larger number of samples. The outflows of private hospitals should have been tested, as without these results, it cannot be verified whether or not chemical or radioactive substances are discarded into the sewers at these institutions.

Continuous computerised monitoring equipment would have made it possible to investigate differences in the day- and night-time effluent discharges. Unfortunately, with staff and financial restraints, this was not possible. The sampler used for collecting liquid effluent samples tended to be erratic, so that accurate timing was difficult. Many more installations were required to perfect the sampling procedure, but time and staff constraints prevented this additional sampling.

It was also not possible to test for organics such as dioxins and furans owing to the cost of sending these samples to the US for analysis. Nor has it been possible to investigate the impact of emissions from coal or oil burning boilers or many of the hazardous wastes mentioned in the literature, although all of these could likewise have a considerable impact on human health and the environment.

7.8 SUGGESTIONS FOR FURTHER RESEARCH ON TOXIC WASTES IN MEDICAL INSTITUTIONS

Questions posed by Gilberton et al. (1985) and encountered throughout the literature on hospital waste management, remain important areas that need to be thoroughly researched. These include issues such as:

- What are the long term effects of pollution?
- Are projected trends of pollution concentrations reliable?
- What is the biological significance of the synergistic behaviour of pollutants?
- How safe are industrial processes which involve the use of toxic substances?
- How representative of field conditions are the laboratory experiments from which much data on the biological significance of pollutants are derived?

The fact that these questions have not yet been adequately answered needs to be borne in mind when further research into medical waste management is undertaken. Arising from the findings in this thesis, it is evident that future research could focus on:

- The long-term impact of the continuing discharge of liquid effluents into Table Bay.
- The source of heavy metal content in hospital liquid effluent.
- Alternatives to toxic chemicals used in medical applications.
- The investigation of additional hospital outflows not sampled in this study.
- More detailed research on specific toxins emitted from medical institutions.
- The potential for recycling of metals present in incinerator emissions.
- The effect of radioactive emissions from medical waste incinerators on human health.
- The investigation for toxic pollutants in particulates emitted from incinerator stacks.
- Effective hazardous waste education programmes.

7.9 CONCLUDING THOUGHTS

From this study, and from international and local literature, it has been demonstrated that there is an urgent need for an holistic approach to pollution control, including attitude change, non-waste technology, minimization, re-use and recycling. Unfortunately cost appears to be the most significant "driver" as to whether or not environmental protection is given serious thought.

As can be seen in Brown (1987), and reinforced by the Sydney, Australia effluent discharge example (Beder, 1989), lack of communication between government, local authorities, academics and commerce, and their inability to make decisions, have obstructed progress in pollution control management. It is also believed (Epstein, 1978) that industry takes advantage of scientific uncertainties to play down the risk posed by any alleged carcinogen. To exacerbate the situation, most government officials are elected only for short periods, and thus policies tend to be uncoordinated and focussed on immediate economic and political gain. In addition, countries are continuously faced with difficult trade-offs between environmental preservation, economic growth, jobs and health (Barbour 1980). All these conflicting interests pose a potential hazard to the environment and to human health, and thus to long term economic and social benefits.

In order to address environmental concerns, comprehensive legislation is required, and this should ideally be underlined by a binding national environment policy to pull together all fragmented laws, regulations, policy statements and guidelines, and an environmental tribunal formed, with management advisory committees to advise government. Only with this comprehensive, enforceable legislation will the problem of medical waste be addressed. In South Africa, penalties for transgressing pollution limits are minimal and there is at present little possibility of enforcement, owing to financial constraints and lack of trained personnel.

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APPENDICES

Appendix I

APPENDIX I: Some relevant sections of Acts which could relate to toxic waste from medical institutions *(Source: Adapted from P.Teurlings, DEA Guides to Legislation, February 1993).*

Act	Section	Summary	Responsible Minister
Atmospheric Pollution Prevention Act (Act 45 of 1965)	11	Provisional registration certificate shall specify purification measures for effluents discharged from appliances installed for preventing or reducing to a minimum any noxious or offensive gases escaping into the atmosphere, and for the prevention of the release of noxious or offensive constituents from effluents when they come into contact with other effluents in drains or drainage canals	National Health and Population Development
	15	Installation of fuel burning appliances. Not permitted to install any fuel burning appliances unless fitted with effective appliances to limit emissions of grit and dust (gritty particles and fine solid matter) to satisfaction of local authority	
	16	No local authority shall approve any chimney or opening for carrying smoke, gases, vapours, fumes, grit or dust from any building, or for installation of any fuel burning appliance, unless the chimney is high or fuel burning appliance is suitably sited	
	24	Local authority may require any person to furnish information as to the fuel or refuse used in fuel burning appliances	
	31	Dust Control Levy to meet wholly any expenditure required to be incurred for the more effective prevention of the pollution of the atmosphere by dust.	
	45A	The Minister may contribute towards the expenditure incurred by any person in connection with research relating to the combating of atmospheric pollution; or incurred by any local authority in connection with the acquisition of equipment to combat atmospheric pollution.	
Environment Conservation Act (Act 73 of 1989)	2	Protection of ecological processes, natural systems and natural environment	Environment Affairs & Tourism
	4	Establishment of Council for the Environment	
	5	Council may hear representations relating to matters affecting the environment	
	12	Establishment of Committee for Environmental Management	
	20	Waste Management. Directions regarding disposal sites. No person shall discard waste or dispose of it in any other manner, except at a disposal site (fine not exceeding R100 000 and/or 10 years imprisonment)	
	21	Identification of activities that will probably have detrimental effect on environment	
	24	Regulations regarding waste management - can be made concerning the submission of statistics on the quantity of waste produced; the classification of different types of waste; the reduction of waste; recovery, reuse or recycling; effective disposal of waste, control of import and export of waste and any other matter concerning disposal of waste and protection of the environment.	
	26	Regulations regarding environmental impact reports	
	28	Regulatory powers: may relate to application of provisions of any international convention, treaty or agreement relating to the protection of the environment	

Act	Section	Summary	Responsible Minister
Health Act (Act 63 of 1977)	20 34 38	Local authority measures to prevent pollution and to purify water intended for human use Regulations for standards for cemeteries in vicinity of natural resources Regulations relating to sewage or other waste which could pollute water and to report and remove this waste	Nat. Health and Pop. Develop.
Hazardous Substances Act (15 of 1973)	29	To provide for the control of substances that may cause injury or ill health or death to humans by reason of their toxic, corrosive, irritant, strongly sensitizing or flammable nature etc. To provide for the division of such substances into groups in relation to degree of danger. Regulations can be made for the protection of any person from the harmful effects of exposure to radiation emanating from any Group III hazardous substance and providing for control over the dumping or disposal of radioactive material.	Nat. Health and Pop. Develop.
National Policy for Health Act (Act 116 of 1990)	2	Determination of national policy for health. Minister may determine the national policy in respect of any matter for promotion of health for individuals and society given available finance, natural resources and manpower	
Nuclear Energy Act (92 of 1982)	41 51	Any licensee shall be liable for any nuclear damage caused during his period of responsibility by any radioactive waste that is conveyed, discharged or released. The authority to control and regulate the discharding of nuclear waste vests in the corporation	Trade and Industry
Regional Services Council Act (Act 109 of 1985)	3	Establishment of regional services councils Shall be charged with regional environment conservation function dealing with sewerage purification works, main sewerage disposal pipe lines and reusage systems and refuse dumps	Local Gov. & Nat. Housing
Water Act (Act 54 of 1956)	21 22 23 24 26	Effluent discharged into sewer shall be deemed to be effluent used by the relevant local authority Steps to be taken under Sec 26 to prevent the pollution of water Pollution of water an offence (Fine not exceeding R50 000 and/or 2 yrs imprisonment can be imposed) Director-General may take additional measures. Minister may suspend or limit use of any polluting substance Regulations can be made relating to prevention of wastage or pollution of water and sea water and of damage to environment caused by water	Water Affairs and Forestry
Dumping at Sea Control Act (73 of 1980)	4	Within 30 days after the end of each calendar year a report shall be urnished to the Minister as to the nature and quantities of all substances or articles dumped or disposed of at sea and the location, time and method of the dumping or disposal	National Health
Sea Fishery Act (12 or 1988)	47	Any person who dumps or allows to enter or permits to be dumped or discharged in the sea anything that is or may be injurious to fish, fish food or aquatic plants or that may disturb the ecological balance in any area of the sea shall be guilty of an offence. (A fine not exceeding R50 000 and/or 6 years imprisonment can be imposed)	
Sea-Shore Act (Act 21 of 1935)	10	Regulations can be made for the prevention or the regulation of the depositing or discharging on the sea-shore or in the sea of offal, rubbish or anything liable to be a nuisance or danger to health	"

Appendix II

APPENDIX II: Analytical methods for testing COD, Ammoniacal Nitrogen, pH, Conductivity, As, Hg and additional metals (*Source: Standard Methods for the Examination of Water and Waste Water* (1992).

CHEMICAL OXYGEN DEMAND (Reflux method)

1. Reagents:

COD acid. Concentrated H_2SO_4 plus dissolved silver metal
N/4 potassium dichromate solution
N/20 potassium dichromate solution
Mercuric sulphate
N/8 ferrous ammonium sulphate solution
Ferroin indicator
1+3 sulphuric acid

2. Procedure:

a. Add a few small pumice stones into a COD flask
b. Add appromately 0.4g mercuric sulphate
c. Add a total of 20ml sample and distilled water. To the blank add 20ml distilled water only.
d. Accurately add 10ml N/4 potassium dichromate solution (high method) with a bulb pipette
e. Add 30ml COD acid
f. Fit flask on reflux apparatus and only then shake to mix acid and aqueous layers
g. Turn on cooling water and switch on heating element until boiling takes place; continue refluxing for 2 hours
h. Prepare a standard in an Erlenmeyer flask with 10ml potassim dichromate solution and 100ml 1+3 sulphuric acid
i. Allow to cool before titrating with N/8 ferrous ammonium sulphate solution and 2 drops ferroin indicator (high method). Note: Add indicator near endpoint only.
Colour change: yellow/orange FAS -> green FAS + ferroin -> brown.

AMMONIACAL NITROGEN

1. Reagents:

Borate buffer
Mixed indicator
2% boric acid

1% boric acid
N/1,12 sulphuric acid
N/56 sulphuric acid
Nessler reagent
Stock ammonium solution, 1000 mg N l^{-1}
Standard ammonium solution, 10mg N l^{-1}

2. Procedure:

a. Add sample and distilled water to Kjeldahl flask so that the total volume is 250ml. Also do a blank sample
b. Add a few pumice stones
c. Add 5ml borate buffer to the kjeldahl flask and wash ground glass joints with distilled water. Fit onto distilling apparatus
d. Turn on cooling water and switch on heating element.

<u>High method</u>:

e. Distill over into a 250ml Erlenmeyer flask containing 30ml 2% boric acid and 8 drops of mixed indicator, with the tip of the delivery tube immersed in the solution
f. When the level of liquid in the Erlenmeyer flask reaches 150ml remove flask and switch off heating element
g. Titrate with N/56 sulphuric acid until pale pink endpoint.

pH AND ALKALINITY

1. Procedure:

a. Switch on the pH meter
b. Take the temperature of the buffer solutions and adjust the temperature setting on the pH meter
c. Place the electrode in the buffer pH 7 solution. When the reading has stabilised adjust the pH meter to read 7.00 on the pH scale
d. Place the electrode in the buffer pH 4 solution. When the reading has stabilised adjust the slope setting on the pH meter so that the reading is 4.00 on the pH scale
e. Pour a measured amount (usually 50ml) of sample in a suitable container
f. Place the electrode in the sample. Take the temperature of the sample and adjust the temperature setting accordingly
g. Allow the reading to stabilise and record the pH of the sample
h. Lower the pH to 8.3 by titrating with N/50 hydrochloric acid using a magnetic stirrer for good mixing. Record the volume used

i. Continue to titration to pH 4.5. Record the total volume used

j. Calculate the alkalinity as $CaCO_3$ l^{-1}.

CONDUCTIVITY

Reagents:

0.1000 M potassium chloride solution

5% acetic acid

Procedure:

a. Make sure the conductivity electrode platinum black surfaces are clean before commencing measurement

b. Calibrate the instrument

c. Measure the conductivity of samples.

ARSENIC

Analytical method for As using Atomic Absorption and vapour generation accessory:

1. **Reagents:**

   Sodium Borohydride solution

   Potassium iodide solution

   Hydrochloric acid solution (approx 6M)

2. **Pretreatment:**

   If the As in the sample is not wholly in the inorganic form, the following acid digestion procedure on samples, standards and blanks must be used. The required volume of the working standard solution diluted with deionised water to give a final volume of 50ml is used to prepare the range of As standards.

   Digestion procedure:

   To 50ml of solution add 7ml (1+1) suphuric acid and 5ml concentrated nitric acid. Evaporate the solution to copious white fumes of SO_3 on a hot plate. The fuming is more noticeable on removal of the clock-glass and occurs when the volume of solution is 10-20ml. Allow the solution to cool and then add about 25ml of deionised water. Again evaporate to SO_3 fumes to expel oxides of nitrogen, cool the solution, wash down the clock-glass and transfer the solution to a 50ml volumetric flask and make up to the mark with deionised water.

Sample preparation:

Prepare a range of standard As solutions up to 150μg l^{-1} using the working standard solution (1μg ml^{-1}) and at least one blank using 50ml deionised water. In order to ensure that all As (V) is reduced to As(III) before measurement, add 1ml of 15% potassium iodide solution to each 50ml of sample or standard and allow to stand for at least 45 minutes.

3. Final Atomic Absorption instrument operating conditions:

Wavelength	193.7 nm	Slit width	1.0nm
Lamp current	7.0 mA	Burner head height	5.4
EHT:	Single beam -424 V;	double beam	-464V
Absorption expansion	2.0		
Pump flow rates	Sample approx 6.5 ml min^{-1}; Acid/stannous chloride, approx 1.0 ml min^{-1}		
Gas flow settings	Air approximately 8; Acetylene approx 2.		

MERCURY

Analytical method for Hg using Atomic Absorption and vapour generation accessory:

Reagents:

1. Mercury standards:

a. Intermediate standard solution.

Dilute 5ml concentrated standard (Titrisol 1g l^{-1} = 1000ppm) to 500 ml with deionised water to give a 10ppm solution stabilised by adding 5ml of 10M HNO_3. This solution may be stored for approximately 1 year. 1.00 ml = 10.0 μg Hg.

b. Working standard solution.

Dilute 10ml of the intermediate Hg solution with deionised water to 100ml in a volumetric flask to which 1ml 10M nitric acid has been added. This solution may be kept for approximately 3 months. 1.00 ml = 1.0 μg Hg.

2. a. Stannous chloride solution

Hydrochloric acid solution (approx 5M)

Sulphuric acid (1:1 v/v)

Nitric acid (1:1 v/v)

Poassium permanganate (3.75% m/v)

Ammonium persulphate (3.4% m/v)

Sodium chloride/Hydroxlamine hydrochloride

b. **Pretreatment:**

If the Hg in the sample is not wholly in the inorganic form, the following acid digestion procedure on samples, standards and blanks must be used. The required volume of the working standard solution diluted with deionised water to give a final volume of 50ml is used to prepare the range of mercury standards.

Digestion procedure:

Transfer 50ml of the sample to a clean BOD bottle. Add 5ml 1:1 sulphuric acid and then 2.5ml permanganate solution and, after mixing, allow to stand overnight. If the purple colour fades, add more permanganate to the sample until the colour persists for at least 15 minutes. If it is necessary to add more permanganate in this way, an equivalent volume of deionised water should be added to the blank and standard solutions being used. Add 5ml ammonium persulphate solution and heat the sample solution in a water bath at 95°C for 2 hours. Add 5ml of the sodium chloride/hydroxylamine hydrochloride solution which should be sufficient to reduce the excess potassium permanganate and make the reaction mixture colourless.

c. Sample preparation:

Prepare a range of standard Hg solutions up to 50μg l^{-1} using the working standard solution (1 μg ml^{-1}) and at least two blanks using 50 ml deionised water.

3. **Final Atomic Absorption instrument operating conditions:**

Wavelength	253.7 nm	Slit width	0.5nm
Lamp current	3.0 mA	Burner head height	2.4
EHT:	Single beam -300 V	double beam	-328V
Absorption expansion	1.0		
Pump flow rates	Sample approx 6.5 ml min^{-1}; Acid/stannous chloride, approx 1.0 ml min^{-1}		
Nitrogen gas pressure	340 kPa		

METAL ANALYSIS BY ATOMIC ABSORPTION AND ATOMIC EMISSION

1. **Reagents:**

Digestion acid

10 N nitric acid

1% Cs^+ solution

0.5% Cs^+ in 5 N HNO_3 solution

10% sodium sulphite solution

Blank solution

2. Preparation of samples:

a. Collect a measured volume of sample (up to 1000ml) in glass or plastic bottles

b. Add 10ml of digestion acid

c. Sludge and solid samples may be weighed directly into 250ml Erlenmeyer flasks and the 10ml digestion acid added

d. Put liquid samples in 250 or 500ml Erlenmeyer flasks

e. Slowly boil down adding more sample to flask if available

f. Remove from hotplaste and allow to cool

g. Add 2ml 0.5% Cs+ in 5 N HNO_3 solution and add about 20ml distilled water

h. Slowly boil for about 5 minutes

i. Remove from hotplate and allow to cool

j. Add 1 drop 10% sodium sulphite solution to reduce any oxidised species to a lower oxidation state

k. Wash into a 100ml volumetric flask, make up to the mark with distilled water and mix

l. Transfer to clean plastic containers

m. Allow to stand for a length of time so that any insoluble residue can settle before reading.

3. SODIUM, POTASSIUM, CALCIUM AND MAGNESIUM DETERMINATION

a. Pipette desired volume of sample into a 50ml volumetric flask

b. Add 1ml 0.5% Cs^+ in 5N HNO_3 solution

c. Make up to the mark with distilled water and mix

d. Immediately transfer to a clean plastic container

e. Allow to stand for a length of time so that any suspended particles can settle before reading.

Appendix III

ANNEXURE III : ADDITIONAL STANDARDS AND GUIDELINES

1. *Current Nutrient Standards*

SA1: SA Special effluent standard; SA2: SA General effluent standard (DWAF 1991); SA3: Recommended value for the protection of aquatic organisms (Kempster et al., 1980; USA: Chiaudani & Premazzi, 1988 (cited by SA National Water Quality Guidelines, 1993); Australia: Protection of aquatic ecosystems (Hart et al., 1992); Canada: Canadian guidelines, 1987; United Kingdom: Gardiner and Zabel, 1989 (cited by SA National Water Quality Guidelines, 1993). Netherlands: Chiaudani and Premazzi 1988, cited by SA National Water Quality Guidelines, 1993 and Van der Gaag et al., 1991) *(Source: Adapted from Dallas and Day, 1993).*

Metal ($\mu g/l$)	SA1	SA2	SA3	USA	AUSTRALIA	CANADA	NL	UK
As	500	100	10 min 1000 max	190	50	50	5.0	25
Be			1.0 min 1100.0 max		4.0			
Cd	50.0	50.0	0.1 min 30.0 max	0.4 - 12*	0.2 - 2.0*	0.2 - 1.8*	5.0	5.0
Cr	50.0	50.0	0.01 min 0.1 max		2.0	2.0	10.0	5.0 - 50*
Co			1000.0	100.0				
Cu	1000.0	20.0	5.0 min 200.0 max		2.0 - 5.0*	2.0 - 6.0*	5.0	1.0- 28.0*
Pb	100	100	20.0 min 100.0 max		1.0 - 5.0	1.0 - 7.0*	4.0	4.0 - 20.0*
Hg	20.0	20.0	0.05 min 10.0 max	905.0	0.1	0.1	0.5	1.0
Fe		300	200.0 min 1000.0 max		1000.0			
Ni			25.0 min 50.0 max		15.0 - 150.0	25.0	50.0	9.0
Zn	5000.0	300.0	30.0 min 100.0max		5.0 - 50.0*	30.0	10.0	8.0 - 25.0*

* concentration dependent on water hardness.

2. *Current Nutrient Standards*

SA1: SA Special effluent standard; SA2: SA General effluent standard (DWAF 1991); SA3: Recommended value for the protection of aquatic organisms (Kempster et al., 1980; USA: Chiaudani & Premazzi, 1988 (cited by SA National Water Quality Guidelines, 1993); Australia: Protection of aquatic ecosystems (Hart et al., 1992); Canada: Canadian guidelines, 1987; United Kingdom: Gardiner and Zabel, 1989 (cited by SA National Water Quality Guidelines, 1993) *(Source: Dallas and Day, 1993).*

Nutrient (mg/l)	SA1	SA2	SA3	USA	AUSTRALIA	CANADA	UK
Total nitrogen					0.05 - 0.50		
Nitrate (as N)	1.5			90.0		90.0	
Nitrite (as N)				0.06		0.06	0.03
Total ammonia	1.0	10.0		0.02	0.02 - 0.03	2.2 at pH = 6.5 10°C 1.37 at pH = 8.0 10°C	
Ammonia (as N)			0.016				
Total Phosphorus					0.04 - 0.06		
Phosphate(soluble ortho-phosphate as P)	1.0		0.1				

3. ***Standards for the purification of waste water or effluent*** *(Source: General & Special Standards : Government Gazette, 18 May 1984).*

Sample Description	Unit	National General Standard	National Special Standard	Cape Town Municipal By-laws	Cape Metropolitan Council By-laws
Suspended solids	$mg\ l^{-1}$	25	10	6 000	4 000
Volatile Sus. solids	$mg\ l^{-1}$	-	-	-	-
COD	$mg\ Ol^{-1}$	75	30	-	5 000
Tot. Kjeldahl Nitrogen	$mg\ Nl^{-1}$	-	-	-	-
Ammonia	$mg\ Nl^{-1}$	10	1	-	-
Boron	$mg\ l^{-1}$	-	0.5	-	5 000
Organic Nitrogen	$mg\ Nl^{-1}$	-	1.5	-	-
Nitrite + Nitrate	$mg\ Nl^{-1}$	-	-	-	-
Total Phosphorus	$mg\ Pl^{-1}$	-	-	-	25
Ortho Phosphate	$mg\ Pl^{-1}$	-	-	-	-
pH		5.5 - 9.5	5.5 - 9.5	-	5.5 - 12.0
Conductivity	$mS\ m^{-1}$	75	250	-	300
Chloride	$mS\ m^{-1}$	-	-	-	500
Residual chlorine	$mg\ l^{-1}$	-	Nil	-	-
Fluoride	$mg\ l^{-1}$	-	1.0	-	-
Alkalinity as $CaCo_3$	$mg\ l^{-1}$	-	-	-	-
Sulphides	$mg\ l^{-1}$	-	0.05	20 000	50
Soluble ortho phosphate	$mg\ l^{-1}$	-	1.0	-	20
Sodium	$mg\ l^{-1}$	90*	50*	-	500
Soap, oil & grease	$mg\ l^{-1}$	2.5	Nil	400	-
Phenoylic compounds	$mg\ l^{-1}$	0.1	1.01	-	50
Cadmium	$\mu g\ l^{-1}$	50	50	) Total not	5 000
Mercury	$\mu g\ l^{-1}$	20	20	) to exceed	5 000
Arsenic	$\mu g\ l^{-1}$	500	100	) 2 000	5 000
Cobalt	$\mu g\ l^{-1}$	-	-	-	-
Chromium	$\mu g\ l^{-1}$	5 000	50	) Total not	10 000
Copper	$\mu g\ l^{-1}$	1 000	20	) to exceed	20 000
Zinc	$\mu g\ l^{-1}$	5 000	30	) 50 000	30 000
Iron	$\mu g\ l^{-1}$	-	30	-	50 000
Manganese	$\mu g\ l^{-1}$	400	100	-	-
Nickel	$\mu g\ l^{-1}$	-	-	) Total not	5 000
Lead	$\mu g\ l^{-1}$	100	10	) > 10 000	5 000
Cyanides	$\mu g\ l^{-1}$	-	500	20 000	25 000
Selenium	$\mu g\ l^{-1}$	-	50	-	5 000

* Above that of intake water

Cape Town Municipal Industrial Effluent By-laws

There is no limit placed on the substances which show no values, but a R1.00 levy is charged on each additional 1000*mg/l* COD above the calculated permissible amount for a particular industry, although the City Engineer may set limits if he perceives an emission to be detrimental to the system. Hospitals are classed as industrial institutions under these by-laws. Phosphates and nitrates from hospital laundries are of most concern to the Sewage and Drainage section of the Cape Town City Council, who regularly monitor these substances, as they cause eutrophication of rivers.

Cape Metropolitan Council (CMC) Industrial Effluent By-laws

Parow and Bellville municipalities have separate by-laws. Parow Municipality discharges its effluent to Borchards Quarry, which falls under the CMC by-laws. Treated effluent from this plant is discharged into the Black River.

In Bellville there are no fixed standards for effluent discharged from industrial point sources, but these vary depending on the type of industry. Toxic discharges are evaporated in ponds and either sent to Vissershok hazardous waste site, or co-disposed in landfill. Hospital outflows are not specifically monitored, but the sewers are tested for phosphates and nitrates at a central point. Any liquid effluent entering the Kuils River has to conform to the Department of Water Affairs Special Standards .

There is considerable uncertainty which by-laws and regulations will apply, now that the new municipal boundaries have been created.

Appendix IV

APPENDIX IV: CERTIFICATE OF WASTE WATER ANALYSIS

CITY OF CAPE TOWN

CITY ENGINEER'S DEPARTMENT

SCIENTIFIC SERVICES BRANCH

Ref: CB.2/A4

CERTIFICATE OF ANALYSIS

RE: MEDICAL WASTEWATER SAMPLES

Sample Description		UCT Med. Sch.	UCT Med. Sch.	UCT Med. Sch.	Groote Schuur	Groote Schuur	Somerset	Somerset	Athlone Raw	Green Pt. Raw
Date of Sampling		1995/07/20	1995/08/03	1995/08/10	1995/08/17	1995/09/21	1995/10/4	1995/10/13	1995/07/17-1995/10/09	1995/07/20-1995/10/12
Lab Reference Number		256	257	258	259	260	261	262		
Chemical Oxygen Demand as O	mg/ℓ	366	207	180	940	771	350	384	574-1270	490-807
Ammoniacal Nitrogen as N	mg/ℓ	2.7	1.8	7.0	64	67.6	6.8	6.0	15.1-29.3	24.0-31.2
pH	-	6.6	6.7	6.6	7.5	7.3	7.0	7.3	6.7-7.2	6.7-7.4
Conductivity	mS/m	26	29	33	143	157	44	122	112-116	-
Arsenic as As	µg/ℓ	0.7	0.8	0.4	0.4	0.4	0.3	0.4	-	-
Mercury as Hg	µg/ℓ	5.0	70	10	32	1.0	11	9	5	-
Cadmium as Cd	µg/ℓ	0.8	0.6	1.1	1.6	2.3	1.8	2.3	3.2-3.5	1.1-1.5
Cobalt as Co	µg/ℓ	3.0	2.0	3.4	4.6	7.0	6.0	5.0	6-14	3-6
Chromiuim as Cr	µg/ℓ	10	9.4	11	14	2.6	2.6	3.0	120-474	11-78
Copper as Cu	µg/ℓ	24	840	52	86	58	45	56	86-145	98-281
Manganese as Mn	µg/ℓ	17	24	16	64	65	39	64	85-254	40-49
Nickel as Ni	µg/ℓ	1.4	6.0	2.4	9.4	8.0	10	8.0	40-174	7-9
Lead as Pb	µg/ℓ	7.8	25	9.2	11	7.8	4.8	12	22-42	16-33
Zinc as Zn	µg/ℓ	74	421	55	140	161	205	149	326-468	141-293
Iron as Fe	µg/ℓ	204	152	209	2280	1420	2720	1200	1720-2150	786-1460

REMARKS: See covering letter.

Mercury level measured in Athlone Sludge (96/1/15): Hg = 6 mg/kg (dry mass basis)

Note: 1 µg/ℓ ≡ 0.001 mg/ℓ

DIRECTOR OF SCIENTIFIC SERVICES

Appendix V

APPENDIX V:

ENVIRONMENTAL LAW

NAME: S. TOLOSANA
DATE: 1 April 1993

Legal and environmental aspects of incineration of hospital waste in a smoke controlled residential area

CONTENTS **Page No.**

BACKGROUND AND INTRODUCTION

In the early 1980's the Red Cross War Memorial Children's Hospital erected two *Macroburn* incinerators in response to complaints by residents living in Park Estate, Rondebosch. These were installed to replace a stack that was too low and deposited black soot on the inside walls of houses adjoining the hospital property - as well as emitting an unpleasant odour. The new incinerators are more efficient, as they do not deposit black dust, but the emissions still have an unpleasant odour and are, as before, a potential health hazard. As stated by Petrie, Burns and Bray in *Environmental Management in South Africa, (1992),* air can no longer be considered an infinitely renewable and resilient resource, and incineration of hospital wastes contribute significantly to air pollution and can produce toxic emissions.

A number of major hospitals in Cape Town make use of incinerators to dispose of their medical waste as this appears to be the most efficient way of eliminating infectious material. Incineration is carried out on a fairly large scale, using specially designed equipment. For example, at the Red Cross Hospital in Rondebosch, about a ton of waste is burnt per day, broken up into six separate batches. Incineration of each batch uses 40 litres of paraffin, so in addition to the solid waste, about 240 litres of paraffin are burnt each day.

HEALTH RISKS

It appears that very little has been published on the health risks of hospital incinerator emissions in South Africa, and no study of note of which I am aware has been produced for the Cape Town metropolitan area. Of all the waste materials that are known to be burnt in hospital incinerators, plastics pose one of the most serious potential health hazards. Although plastics have many advantages, their disposal is problematic. In contrast to natural fibres and materials which normally undergo complete combustion to carbon dioxide and water, plastics require far higher temperatures, and there is some uncertainty as to whether the temperatures achieved in incinerators used in Cape Town are high enough to guarantee complete combusion. Despite the paucity of information regarding incinerators in this country, it is possible to extrapolate from general information available in the literature, on the toxicity and hazards associated with the combustion gases of the most commonly used plastics.

Over time, humans might be exposed to a mixture of chemicals; the effects of which are not well understood. It is probable that most environmentally related disease goes unrecognized, as individuals move over time, and the long incubation periods make it difficult to pinpoint exposures. Acute health effects are usually easier to detect than chronic ones, and low-level chemical exposures may play a contributory, rather than a primary role in increasing the incidence of disease, but it is nevertheless well known that there is an association between air pollution and respiratory complaints. In future it might be possible to assess the effects of exposure based on recent research into biological and biochemical markers of exposure - for example DNA adducts (Von Schirnding, 1992). As well as contributing to disease, air pollution has a considerable nuisance value, causing unpleasant odours and irritation to eyes and mucous membranes.

AIMS OF THIS STUDY

The aim of this study is threefold:

1. To give a brief technical background to the typical plastic waste materials that are likely to find their way into hospital incinerators, and to give some indication of the toxicity of the combustion gases at typical incineration temperatures.

2. To give a brief review of the policy regarding regulation of incineration in a smoke controlled zone at the local and national governmental level.

3. To set out the legal mechanisms available to private individuals to protect the quality of the environment in which they live, and to comment on legal mechanisms that local authorities may apply to prosecute contraventions and to enforce the policy identified in (2) above.

APPROACH

The approach that has been adopted for this study has been to conduct informal interviews with selected key persons in local authorities, within the hospital hierarchy at a number of levels, expert consultants in engineering and chemistry, representatives of the plastics industry, as well as to conduct an analysis of relevant policy and legal documentation.

Time and budgetary constraints have precluded an in-depth analysis of the problem, and no direct sampling and analysis of combustion materials and combustion gases could be carried out. A number of speculative statements appear in this study regarding the potential health hazards of incinerators, but I feel that the evidence presented to me during the interviews warrants bringing this information to the attention of the reader. At most, I would hope that this would provide incentives for in-depth follow-up studies.

TECHNICAL BACKGROUND

As stated above, the locally produced *'Macroburn'* incinerators used by the Red Cross Hospital burn approximately one ton of solid waste a day from Monday to Friday, and 340 kg on Saturdays and Sundays. The two incinerators are each loaded with 170 kg of solid waste - the bulk being disposable nappies. Apart from a realtively small quantity of petri dishes, syringes, and plastic containers, the remainder consists of the unknown contents of sealed plastic bags of waste from the wards. Groote Schuur Hospital has had problems with PVC and other potentially harmful objects finding their way to the incinerator, so one can speculate that without strict monitoring, the same might be happening at the Red Cross*, especially as the pollutant plume can at times cause symptoms related to contact with hydrochloric acid (which is emitted when burning PVC). The incinerators use paraffin** for fuel, and burn at 650°C for the initial firing and again at 400°C. This second firing, according to the technician in charge, prevents the formation of black smoke.

Konkel (1987) describes experimental results that show that toxic compounds - polychlorinated dibenzo-dioxins (PCDD's), and polychlorinated dibenzo-furans (PCDF's), are present in furnace emissions as gases or vapours (see Appendix). In this study, the material being incinerated was municipal solid waste.

PCDD's are produced either by organic compounds containing chlorine adhering to the surface of salt particles on the combustion grate, or PCDD's and PCDF's forming on or just above the burning grate owing to combustion of organic pre-cursors contained in other waste. Concentration depends on the temperature at which the waste is burned; it has been found that under laboratory conditions, over 99% of dioxins are destroyed at temperatures above 700°C and 99.99% at 957°C. As it is impossible to regulate

* Aerosol containers are occasionally put into the ward waste bags, and these explode when heated, causing a safety hazard for the personnel loading the incinerator.

** There is no tax levy on paraffin, making it cheaper than diesel - but it takes longer to burn.

temperature, air supply and other variables under normal incineration conditions, it can be concluded that the combustion process can not always be controlled to ensure minimal dioxin emissions. The emissions could either be in gaseous or particulate form or a combination of both - making their control problematic, but a fabric filter is more efficient than an electrostatic precipitator, and raising combusion temperature and residence time does improve the chance of their being destroyed.

In a paper by Tschirley (1986), it is stated that dioxins, produced in a variety of combustion processes, are extremely toxic for animals. Many acute symptoms have been observed in humans from exposure to dioxins; these include chloracne, digestive disorders, effects on some essential enzyme systems, aches and pains in muscles and joints, effects on the nervous system and psychiatric effects. There are possible chronic effects which are difficult to ascertain, as little is known about the effect of protracted low-level exposure. In 1977 polychlorinated dibenzo-p-dioxins (PCDD's) were found in the fly ash from a municipal incinerator in Rotterdam in the Netherlands, causing the milk from cattle grazing in the vicinity to become toxic. In 1980 it was hypothesized that PCDD's can result from trace chemical reactions in fire as they have been found in the effluent and ash of many combustion processes.

The six main types of plastic which are likely to reach the Red Cross Hospital incinerator are: Polyethylene Terephthalate (PET), High Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-density Polyethylene (LDPE), Polypropylene and Polystyrene. These are used in packaging and other products, and are summarised below:

PET - Polyethylene terephthalate: e.g. Coca-Cola bottles. Similar in appearance to PVC but when bent, forms fine creases. When burnt at 450-600°C emits carbon dioxide and water. When not properly combusted, carbon monoxide is emitted. Antimony - 1ppm is present in the ash when PET is burnt (pers.comm - plastics manufacturer).

HDPE - High Density Polyethylene: Tupperware, white Jik bottles, Sta-soft bottles, etc. - tough, lightweight and generally colourful.

PVC - Polyvinyl Chloride: Bottles, credit cards, flooring, most clear trays and punnets, shower curtains etc. Clear shiny plastic or clear bottles with a slightly blue hue. Forms a white crease when bent. When incinerated, gives off hydrochloric acid which is a potential health hazard. Some experts believe it also releases toxic dioxins.

LDPE - Low-density Polyethylene : Plastic bags, soft plastic around building products.

Polypropylene: **Disposable nappy liners, plastic lids, drinking straws, broom fibres, yogurt containers, cottage cheese tubs, carpets, etc.

Polystyrene: Styrofoam cups, packaging for various products - fruit and vegetable trays etc. Butane has now been replaced by Pentane in the manufacturing process.

When the fire is poorly ventilated, all plastics generate CO (Carbon Monoxide). The following table can be used as a rough guideline on the main combustion products:

Table 1: Combustion products from various plastics.

Combustion Product (mg/g sample)	**PP**	**PVC**	**HDPE**	**ABS**
Carbon Dioxide (CO_2)	1195	730	753	298
Carbon Monoxide (CO)	284	442	180	27
Methane (CH_4)	25	5	8	
Ethylene (C_3H_6)	6		31	
Propylene (C_3H_8)	21		20	
1,3 Pentadiene (C_5H_8)	6		9	
Hydrochloric Acid (HCl)		583		
Benzene (C_6H_6)		36		
Hydro-cyanic Acid (HCN)				36

PP - Polypropylene
PVC - Polyvinyl Chloride
HDPE - High Density Polyethylene
ABS - Acronitrile Butadien Styrene

Toxicity classification of these combustion products is complex, and attempts to produce hygenic standards for gases, vapours and particles have been made in various countries. *The American Conference of Governmental Industrial Hygienists* , produces 'Threshold Limited Values' each year, which stipulate conditions under which personnel can safely work.

** Contents of disposable nappies

woodpulp	65%	absorbent gel	2%
polypropylene waterproof outer cover	16%	rayon liner	8%

Table 2: US Threshold Limit Values.

Combustion Product (mg/g sample)	**Threshold Limit Values** (TLV) USA 1978 Time-Weight Average (TWA) (mg/m²)
Carbon Dioxide (CO_2)	9000
Carbon Monoxide (CO)	55
Methane (CH_4)	inert
Ethylene (C_3H_6)	inert
Propylene (C_3H_8)	inert
1,3 Pentadiene (C_5H_8)	not classified
Hydrochloric Acid (HCl)	c
Benzene (C_6H_6)	(canc?)
Hydro-cyanic Acid (HCN)	c T

- c = ceiling indicates that these figures should not be exceeded even on a short-term basis
- T = tentative values and (canc?) indicates that these substances are suspected to be carcinogenic
- In the case of benzene this has subsequently been proved - 1,3 Pentadiene is not classified in *The American Conference of Governmental Industrial Hygienists*. The respective Soviet authorities rate it somewhere between carbon monoxide and carbon dioxide
- Less critical products are HDPE and PP

(Source: Anonymous, pers.comm).

POLICY

A policy which states that "the air should be clean" is impractical, since this is too vague and idealistic to form the basis of law. For policies to aid law makers, they must be feasible and specific; for example, "Levels of pollutants in metropolitan areas of South Africa should be reduced to within the USA NEPA limits 90 percent of the time by the year 2010". The Atmospheric Pollution Prevention Act 45 of 1965 attempts to address the problem of air pollution, but is not specific enough and is not strictly enforced. As the Minister retains the prerogative and power to specify policy guidelines as he sees fit in consultation with his/her Department this could lead to decisions being made for reasons of political expediency (for example, allowing ISCOR to pollute the Highveld air for the last few decades).

LEGISLATION

At present, the Red Cross Hospital is a Teaching Institution which falls under the the Provincial Administration. Recently a Draft Bill was tabled which might result in the hospital becoming an Academic Health Complex. This could perhaps change legal implications, but for the purpose of this report, the law can be divided into the Atmospheric Pollution Prevention Act which is passed by Parliament, and Cape Town Municipality Regulation Number 1997 relating to smoke control, which was passed by the Municipality in 1968. This latter legislation arises out of the Atmospheric Pollution Prevention Act. Another Act which is concerned with air pollution is The Public Health Act 36 of 1919 (as amended) which classifies air pollution as a statutory nuisance to be regulated by local authorities and enforced by way of notice of abatement and criminal sanction. Enforcement of this Act is problematic, as proof of injury or danger to health is difficult to produce.

(a) The Atmospheric Pollution Prevention Act requires that a National Air Pollution Advisory Body be set up to advise local authority on all matters relating to the control, abatement and prevention of air pollution and to publicise the problems of air pollution in general. Furthermore, it allows for an Air Pollution Appeal Board to hear appeals *inter alia* on decisions made by local authorities, or appeals by members of the public against pollution hazards. The Act states that considering the siting of fuel burning appliances and construction of chimneys, 'no local authority shall approve of any chimney carrying smoke, gasses, vapours, grit, dust or other final escapes from any building ... ' unless it is satisfied that this does not become prejudical to health or a nuisance to occupiers of premises in the surrounding areas. If there are complaints, the Local Authority should serve a notice to abate the nuisance and if this is not successful, an individual would have to bring a civil case against the polluter, but only if he/she is able to prove *locus standi.* Another problem arises if an individual wishes to lodge a complaint about potentially harmful emissions - the Red Cross Hospital cannot be prosecuted by the City Council pollution control, as both are semi-government institutions. Perhaps when the status of the Hospital changes - to that of teaching institution - this will change.

The Minister may from time to time publicize (in the Government Gazette), lists of controlled areas. Within these controlled areas, a certificate to emit smoke must be obtained from the relevant local authority (City Council). This certificate would normally be granted if the applicants can demonstrate that they have tried to prevent or reduce to a minimum, by " the best practicable means" emissions of noxious or offensive gases produced, or likely to be produced, by the process in question.

In a report on the situation of waste management and pollution control in South Africa prepared by the CSIR Programme for the Enviroment it is stated that one of the main reasons why there have been no prosecutions under the air pollution control legislation is that there are no lawyers working on enforcement. There are only eight enforcement officers administering and policing the provisions of the Act, as well as the 2000 permits granted to operate the emission of noxious and offensive gases. *(J Glazewski 1991)* . The fines are insignificant - only R500 (R1000-2000 for persistant contraventions) - and the *locus standi* requirement, where an individual must have a direct, personal interest in the issue, effectively prevents the majority of the public from legitimate access to the law. A clause in the Act also permits polluters to withhold information concerning their practices. There is also a serious lack of specialised personnel in the Department of Justice (Attorney General's office) involved in environmental law, and most specifically with pollution control.

(b) Cape Town Municipality Regulations (No. 1997 relating to smoke control): Relevant sections of this legislation are:

1. No emissions of smoke darker than a specified shade shall be permitted from any premises.
2. This shall not apply to smoke emanating during the start-up stage or while the appliance is being overhauled or during breakdown.
3. No person shall use any fuel burning appliance which is not properly maintained or does not comply to Council specifications.

The Council Pollution Control experienced problems with the Red Cross incinerators with regard to the above when they were first installed, but believe that compliance with the regulations has now been achieved. Groote Schuur Hospital experienced similar problems with incineration, but from the 31 March 1993, all medical waste from this hospital will be collected and disposed of by Waste Tech, a commercial waste disposal company. The Cape Provincial Administration, who are opposed to this company becoming a monopoly, want to open a centralized incinerator, perhaps in Paarden Eiland. On the other hand, the City Council Pollution Control would rather use existing incinerators in the Docks belonging to PORTNET, and use these, in collaboration with a private contractor, to dispose of waste from Red Cross, Somerset and Mowbray Maternity Hospitals as well as Council clinics, which at the moment send all medical waste to landfill.

POLICY : Shortcomings by comparison to the international situation

At present, in South Africa the national policy appears to be based on the need for a safe and healthy environment (as outlined in the Department of Health and Population Development 1990 report), but always within the constraints of a developing country which has to balance the desire for a healthy environment against what is financially viable. As far as emission levels are concerned, a 'best practicable means' approach is applied, which makes monitoring of these emissions problematic (Petrie, Burns and Bray, 1992).

In the EC Policy document (Sec (89) 934 *final* 1989) "A Community Strategy for Waste Management", it is stated that proposals on new and existing incinerators were under study, and that incineration would only be acceptable within strict limits and subject to stringent emission standards and monitoring. Similarly, in a booklet brought out by the British Department of the Environment, it is stated that great care is taken to safeguard against harmful emissions to the atmosphere from incinerators. Methods employed to achieve this are the scrubbing of waste gases with water to remove acid constituents. All new incinerators which deal with plastic or toxic waste will be fitted with scrubbers and there will be a time period for old installations to be retrofitted with these. The costs of building, operating and maintaining incinerators to the necessarily rigorous standards required by legislative controls are very high, but in the UK are backed by legislation and very closely monitored.

CONCLUSIONS AND RECOMMENDATIONS

The Atmospheric Pollution Prevention Act 45 of 1965 appears to address most problems of pollution, but without enlightened application of the law, and without the manpower and expertise required, there is no way to enforce this legislation. The Act does allow for an Air Pollution Appeal Board to hear appeals on decisions made by local authorities, or appeals by members of the public against pollution hazards, or the nuisance value caused, but with the secrecy clause and the *locus standi* requirement, civil action is problematic. Regulations only require that steps be taken to prevent or restrict emissions by the 'best practicable means', which allows for considerable leeway and does not protect the environment. There should be a better working relationship between the Department of Health, Department of Environment Affairs and the local authorities in adressing this problem.

Financial constraints for installing efficient incinerators are real, but often pollution control equipment is not installed as it is perceived that the expense would render the process uneconomical and non-viable. This is a shortsighted viewpoint, and has only exacerbated a problem which will incur additional expense in the future. Perhaps by applying an environmental management systems approach, where compliance with environmentally sound policies and objectives is achieved at all levels within a particular institution, financial goals could be achieved while at the same time protecting the environment and improving the quality of life. It appears that incineration does pose a health hazard and does affect the quality of life, so it is essential when burning waste (especially PVC), to guard against incomplete combustion by regulating the flow of oxygen through the incinerator. Correct temperature control as well as the installation of filters or scrubbers would minimize health risks. All technical managers in the plastics industry who were interviewed (international as well as local) were adamant that no plastics should be incinerated without scrubbers or filters being fitted to control hazardous emissions.

The FRD report into the Disposal of Hazardous Substances is likely to emphasise the "polluter pays principle", where fines for pollution activities are increased (Glazewski, 1991). Perhaps emissions from incinerators would be easier to control if they were privately owned. Legislation could then be enforced, requiring regular inspection and upgrading of all equipment. Ultimately however, the emphasis in future should be on education, waste reduction and where possible, re-use.

ACKNOWLEDGEMENTS

I would like to thank the Medical Superintendent of the Red Cross War Memorial Children's Hospital for permitting me to do this project as well as all those people who gave up their time to help me with information.

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Appendix VI

APPENDIX VI: DETAILS OF INCINERATORS AND BOILERS IN CAPE TOWN

INCINERATORS AND	BOILERS	No. of							Waste#	Weight	No. of	Stack	Diam.	Operating	Flue
HOSPITAL	*Area*	*Beds*	*Application*	*Fuel*	*Make of Appl.*	*Additional Information*	*Days in Use*	*Hours of Burning*	*Kg p.d.*	*Kg/load*	*Loads*	*Height m*	*(mm)*	*Temp. oC*	*Temp. oC*
Boilers and Operational Incinerators															
Booth Memorial	Oranjezicht	97	Incinerator	Gas	Unknown	Burns waste from wards only	Mon-Fri	10 minutes	73	25	1	11.30		800	
City Park*	Cape Town	213	Incinerator	Diesel	Macroburn 70B	Burns for NICity & Wynberg Hospital	Daily	8h00 - 15h00	160	35 kg/hr		59.79	380		800
Groote Schuur	Observatory	1241	Boiler	Coal	JT MK IV		Once a month	0h00 - 24h00				49.00			248
			Boiler	Coal	JT MK IV		Not in use					49.00	248		
			Boiler	Coal	John Thompson		Daily	0h00 - 24h00				49.00	748		293
			Incinerator	Diesel	Macroburn		Not in use								293
			Incinerator	Diesel	Macroburn	Burns pharmeceuticals & radionuclides	1-2 /month		931	170	3			400-650	293
Lentegeur Psychiatric	Mitchell's Pl.	1555	Boiler	Coal	John Thompson		Mon-Fri	7h00 - 16h00				23.00	598		320
			Boiler	Coal	John Thompson		Not in use					23.00	598		320
			Boiler	Coal	John Thompson		Not in use					23.00	598		320
			Incinerator	Diesel	Lucifer 450 LA	Hospital waste to WasteTech	When needed	8h00 - 13h00	1166			14.70	560		320
			Boiler	Coal	John Thompson		Daily	0h00 - 24h00				20.00	800		320
Louis Leipoldt Hospital**	Parow	237	Incinerator	Diesel	Bradlee	Burns for Leeuwendal	Daily	8h00 - 15h00	234	25 max	1	25.00	250	800	
Milnerton MediCity	Milnerton	100	Incinerator	Diesel	SA Incinerator	Burn medical waste	Sun-Sat	8h00 - 13h00				8.50	290		
2 Military Hospital	Wynberg	320	Incinerator	Diesel	Macroburn 150A	Plastics, sharps, pharmaceuticals			240						
Red Cross Hospital	Rondebosch	227	Incinerator	Paraffin	Macroburn 330	Sometimes burns for other institutions	Daily	7h00 - 16h00		170	3	27.00	630	400-650	320
			Incinerator	Paraffin	Macroburn 330		Daily	7h00 - 16h00		170		27.00	630	400-650	320
			Boiler	HFO	JT P63		Daily	0h00 - 24h00				25.00	300		320
			Boiler	HFO	JT P63		Standby					25.00	300		320
Vincent Palotti	Pinelands	149	Steam Boiler	HFO	John Thompson		Daily	0h00 - 24h00				18.40	382		320
			Steam Boiler	HFO	John Thompson		Daily	0h00 - 24h00				18.40	382		320
			Incinerator	Diesel	Macroburn 50A		Tues-Sat	7h30 - 16h00	112	25		12.80	315		320
			Incinerator	Diesel	Macroburn 20B	In addition uses WasteTech	Mon-Fri	7h30 - 12h00				32.00	250		293
Volks	Gardens	125	Steam Boiler	Diesel	Cyclotherm H/W	Has additional electric sub-boiler	Not in use								
			Incinerator	Diesel	Macroburn 20B			8h00-12h00	94	10					
Waste-Tech	Vissershok	N/A	Incinerator	Diesel	Macroburn 500B	Medical Waste	Sun-Sat	7h00 - 18h00			Cont.	18.28	933	900-1000	
Boilers and Non-operational Incinerators															
Peninsula Maternity	Cape Town (closed)		Boiler	HFO	JT Demipac E		Not in use					21.33	533		
Woodstock	Woodstock (day hosp)		Boiler	Diesel	Cyclotherm	Uses Waste-Tech	Not in use					15.30	400		
			Boilder	Diesel	Cyclotherm		Not in use					15.30	400		293
			Incinerator	Diesel	Lucifer 150A		Not in use					12.00			
Somerset	Green Point	430	Boiler	HFO	John Thompson		Daily	0h00 - 24h00				21.00	500		320
			Boiler	HFO	John Thompson		Standby					21.00	500		320
			Incinerator	Paraffin/Oil	Lucifer 250	WasteTech	Not in use					16.70	350		320
			Incinerator	Paraffin/Oil	Macroburn 330	WasteTech	Not in use					16.70	780		320
Alexandra Institute	Maitland	662	Boiler	Coal	John Thompson	Uses Wasteman	Daily	0h00 - 24h00				15.50	850		320
			Boiler	Coal	JT MK3		Standby								293
			Boiler	Coal	John Thompson		Standby								
Mowbray Maternity	Mowbray	206	Boiler	HFO	Ray Boiler		Daily	0h00 - 24h00				18.30	380		320
Dr Abdurhaman	Kewtown (Day Hosp)		Incinerator	Diesel	Lucifer 150 LA	WasteTech	Not in use					12.40	300		293
Heideveld Community	Athlone		Boiler	Diesel	Ideal Standard	Currently installing electrical appliance	Mon-Fri	7h00 - 16h00				12.20	230		1
			Incinerator	Diesel	Lucifer 150 LA	WasteTech	Not in use					12.20	280		293
Nico Malan Nursing College	Athlone		Boiler	HFO	JT Demipac E		Daily	4h00 - 20h00				18.00	330		
Princess Alice	Retreat	158	Boiler	Coal	Bradlee (v)17		Not in use					15.80	508		
			Boiler	Coal	Bradlee (v)17		Not in use					15.80	508		293
			Incinerator	Diesel	Lucifer		Not in use					12.80	300		293
Victoria	Wynberg	175	Boiler	HFO	Ray Package	WasteTech, Wasteaway for plastics	Daily for three mths	0h00 - 24h00				19.80	300		320
			Boiler	HFO	Ray Package		Daily for three mths	0h00 - 24h00				19.80	300		320
			Incinerator	Diesel	Macroburn		Not in use					12.00	230		320
Tygerberg	Bellville	1744	Incinerator			WasteTech	Not in use								
Brooklyn Chest	Brooklyn	320	Incinerator	Diesel	Macroburn 50	WasteTech	Not in use					17.03	324		

Appendix VII

APPENDIX VII:

QUESTIONNAIRE ON THE MANAGEMENT OF CHEMICAL, RADIOACTIVE AND INCINERATED HOSPITAL WASTE

UNIVERSITY OF CAPE TOWN
MSc in Community Health
S. TOLOSANA

The objective of this study is to assess knowledge and attitudes of staff to toxic waste management in hospitals. This research is supervised by Dr R Ehrlich of the Department of Community Health, Medical School, and co-supervised by Professor A C Brown, Zoology Department, University of Cape Town.

You will not be identified in this survey, and all information will be treated as confidential.

Hospital: .... **Section/Lab** ....

1. Which toxic wastes produced by medical institutions are of most concern to you?

....

....

....

Please answer the following questions by ticking the appropriate box:

		Yes	No	Don't know
2.	Do you think that South African legislation dealing with the safe disposal of toxic hospital waste is adequate?	☐	☐	☐
3.	Are you familiar with <u>hospital</u> policy dealing with toxic waste disposal?	☐	☐	☐
4.	Does your department generate the following:			
	(a) radioactive waste?	☐	☐	☐
	(b) chemical waste?	☐	☐	☐
5.	Are you aware of measures to check the strict observance of hospital policy regarding:			
	(a) radioactive waste?	☐	☐	☐
	(b) chemical waste?	☐	☐	☐
6.	Do you think that hospital staff are adequately trained to deal with hazardous waste?	☐	☐	☐
7.	Are you easily able to distinguish PVC from other plastics?	☐	☐	☐
8.	Do you think that it should be compulsory for hospitals to employ private waste companies to dispose of their toxic waste?	☐	☐	☐
9.	Do you think that the hospital can afford the cost involved to strictly monitor all hazardous waste?	☐	☐	☐

How would you respond to the following statements?

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Dont Know
10. There needs to be more awareness of						
(a) environmental issues	☐	☐	☐	☐	☐	☐
(b) workplace safety	☐	☐	☐	☐	☐	☐
11. Hospitals should be exempt from pollution control legislation	☐	☐	☐	☐	☐	☐
12. The following hazardous hospital wastes have a detrimental effect on public health						
(a) chemical	☐	☐	☐	☐	☐	☐
(b) radioactive	☐	☐	☐	☐	☐	☐
(c) incineration of chlorinated plastics (PVC)	☐	☐	☐	☐	☐	☐
13. Hospital policy should identify hazardous waste	☐	☐	☐	☐	☐	☐
14. Records of hazardous material use should be kept by all departments	☐	☐	☐	☐	☐	☐
15. Staff should be protected against contamination by the toxic wastes generated in hospitals	☐	☐	☐	☐	☐	☐
16. Hospital regulations ensure the safe disposal of:						
a) halogenated plastic material (PVC)	☐	☐	☐	☐	☐	☐
b) organic solvents (eg chloroform)	☐	☐	☐	☐	☐	☐
c) cyanides	☐	☐	☐	☐	☐	☐
d) heavy metals (e.g. lead, mercury, barium)	☐	☐	☐	☐	☐	☐
17. All hospital waste should be incinerated	☐	☐	☐	☐	☐	☐
18. All incinerator personnel should possess a certificate of competence	☐	☐	☐	☐	☐	☐
19. Hospital policy addresses the identification and quantification of risk to personnel involved in the handling of waste	☐	☐	☐	☐	☐	☐
20. Waste generated by hospitals has a serious impact on the environment	☐	☐	☐	☐	☐	☐
21. Chlorinated compounds should be incinerated (e.g. PVC)	☐	☐	☐	☐	☐	☐
22 Respiratory protection should be provided against toxic dusts for incinerator personnel	☐	☐	☐	☐	☐	☐
23. The following can be disposed of via the sewage system:						
a) solvents (eg chloroform)	☐	☐	☐	☐	☐	☐
b) acids (eg sulphuric acid)	☐	☐	☐	☐	☐	☐
c) antibiotics	☐	☐	☐	☐	☐	☐
d) cytotoxic drugs	☐	☐	☐	☐	☐	☐
24. Clinical waste can be disposed of via the domestic waste system (refuse and sewage)	☐	☐	☐	☐	☐	☐
25. Incinerator residues (ash) should be dealt with as special waste	☐	☐	☐	☐	☐	☐

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	Dont Know
26. It is too expensive to provide adequate protection for all personnel involved in handling hazardous material	☐	☐	☐	☐	☐	☐

27. Which of the following methods of clinical hazardous waste disposal do you think is the most efficient?
(indicate only <u>one</u>)

- Commercial waste companies? ☐
- Cement kilns? ☐
- Municipal waste collection? ☐
- Own incineration? ☐

28. Area of Residence: ....

29.

Age:	20-29	30-49	50-59	60+

30.

Sex:	M	F

31.

Education:	Jun.Sch.	Std 8	Matric	University	Tech	College	Post Grad

32.
32 (a) Hospitals (4a-h)

Job Description:	Technical	Admin	Professional	Nursing	General	Unclassified

32 (b) Medical School 4(i-o)

Job Description:	Technical	Admin	Professional	Research	General	Student	Unclassified

Have you encountered any problems with hazardous waste disposal? If so, please elaborate.

____

____

____

General comments:

____

____

____

____

Appendix VIII

APPENDIX VIII:

QUESTIONNAIRE COMMENTS

Replies to the Questionnaire (Appendix VII) are anonymous. Under each staff category (Administration, Professional, Nursing, Technical and General), verbatim responses to the following questions have been entered as "Concerns"* "Problems" or "Comments":

1) Which toxic wastes produced by medical institutions are of most concern to you?

2) Have you encountered any problems with hazardous waste disposal? If so, please elaborate.

3) General comments.

* Most replies to this question could be entered into the database, and comments recorded here are only those which require elaboration.

BROOKLYN CHEST

ADMINISTRATION:

Concern:

1. Contaminated "sharps". Sputum.

PROFESSIONAL:

No comment.

NURSING:

Comments:

1. Alle persone moet enige hospitaal afvalstowwe hantering as gevaarlike beskou.
2. Regte hantering van geftige afvalstowwe sal voldoende wees in hospitale.
3. Policies appear to be adequate at most times, but individuals don't always apply policies as they should, therefore creating a hazard to themselves and others, as well as the environment.

Problems:

4. Yes, correct handling of sputum and disposal thereof, as well as body fluids and blood-stained articles.

TECHNICAL:

Comments:

1. Daar sal drasties verandering moet intree met die hele sisteem van verwydering.

GENERAL:

No comment.

2. I would like to see that access to the incinerator room be more strict and that only people involved in the disposal and incineration process should be allowed entry.

3. All our waste disposals are carefully controlled.

GENERAL:

No comment.

LABORATORY:

Comments:

1. More research and education needed.

2. More awareness should be made to staff about safe disposal of wastes e.g. red bags i.e. wastes to be incinerated to be taken there immediately and not left in passages for general collection.

3.
   - Hospitals can recycle more.
   - Staff need more "hazardous waste" lectures.
   - From disposal to incinerator - process too long.

Problems:

4. Yes, but problems related more to lack of education.

5. Yes - chemotherapy - radiation during X-rays in theatre.

CITY PARK

ADMINISTRATION:

No comment.

PROFESSIONAL:

Comments:

1. I would appreciate some talks or lectures to advise myself and staff re problems mentioned above in questionnaire.

2. Difficult problem in emerging Third World country.

Problems:

3. Yes - inadequate disposal.

4 Yes. Patients bring us their syringes/needles etc to be disposed of - Have 1 x HIV positive patient, also asked to dispose of expired drugs NB.

5. Bloed deppers ? HIV.

NURSING:

Comments:

1. Waste not separated for correct disposal/usage so unnecessary incineration. Staff not educated or motivated to dispose of waste correctly, easier to use general waste. Staff not educated on where waste ends up so unaware of consequences of own actions.

Problems:

2. Reluctance of staff to change.

3. Blood contaminated waste. Staff and cleaners negligent.

4. Yes. Blood products at work. The terrible stench from Vissershok dump site.

5. Yes - Inadequate protection of staff expected to handle this waste material.

TECHNICAL:

Comments:

1. Certain questions have been poorly worded. e.g. 19 & 16. Does this question refer to what would be ideal - or the policy at <u>this</u> institution? I have accordingly left 19 blank and marked 16 neutral. 3. also applies to above.

CONSTANTIABERG

ADMINISTRATION:

Comments:

1. There should be far stricter control on all waste disposal.

PROFESSIONAL:

Concerns:

1. Used Enoma bags, catheters & syringes. X-ray development chemicals. Heavy metals eg. barium.

NURSING:

Comments:

1. Have had no training on how to dispose of waste properly.
2. Own incineration would have been most efficient because of the risk of an accident on the way to the landfills.
3. I feel it is important for stricter legislation to be introduced with regard to disposal of hazardous waste - especially the transport thereof and control of final disposal.

Problems:

4. Not at this hospital.

TECHNICAL:

Comments:

1. Very ignorant when it comes to waste disposal.

GENERAL:

Comments:

1. Only contaminated hospital waste should be incinerated.
2. Q17 *(All hospital waste should be incinerated)* : Depends on type of waste.

LABORATORY:

Comments:

1. Have had no training on how to dispose of waste properly.

2. I feel that much education needs to be provided regarding waste disposal.

Problems:

3. Yes. Before out-sourcing to WasteTech, we had an incident of needle stick injury to the hospital cleaning staff.

GROOTE SCHUUR

ADMINISTRATION:

Comments:

1. Hospital Policy should be made known to all personnel whatever their function may be.

2. Attended forums where the subject was discussed and feel that this matter should be dealt with most serious thought of future disasters.

3. Poor sorting resulted in some medical waste being mixed up with domestic dry waste. Contractor dumped this at landfill site. Embarrassment for hospital. Divisional Council had to clean up area at our cost. Staff education the critical factor here.

4. As average Mr Citizen, I know nothing of chemical waste, other than what is shown on TV or in the newspaper.

5. I feel strongly about the disposal of toxic waste, especially radioactive material. It is a danger to the environment, humans, animals and insect life. A more efficient way has to be found for the safe disposal of all toxic wastes.

6. Completed the questionnaire with a limited knowledge on its subject . (x 2)

7. I feel that people in general know very little about hazardous waste.

8. I think a study (feasibility) should be conducted to see whether commercial waste disposal companies are more efficient than incineration or municipal waste collection.

9. SA should definitely not become a dumping ground for other countries excess waste.

10. South Africans in general are ignorant when it comes to disposal of substances which may affect the environment.

11. Met die skoonmaak van die skoorstene by GSH beland fyn swart as op die admin personeel se motors. Algemene voorsorg moet getref word teen ondraaglike rook en verbrandings reuke en rook.

Problems:

12. The problem of disposal of Bio and Hazardous waste is terribly expensive due to the monopoly of companies supplying this service.

13. Not of note, but am aware of consequences.

14. Not directly, but I do have knowledge of used syringes which were dumped on a Municipal waste dump.

15. Clearing out of old chemicals in Stores. Disposal of infected/soiled foam mattresses.

16. Incineration. Black soot on motor-cars etc. (damages and scratches paint)
Pollution - Dryness of nose and difficulty in breathing, headaches.

17. Incineration smoke - acidic odours.

PROFESSIONAL:

Comments:

1. Monitoring of all hazardous waste should be essential.

2. It is extremely difficult for a non-trained individual to provide accurate, non-emotive information about waste disposal. A policy should be formulated by experts on the basis of scientific fact, not by 'key' people in waste disposal.

3. Any system is only as good as the people operating it, and also its level of priority in their work environment.

4. Adequate waste handling is a matter of evolution. Education; legislation; penal codes will not stop the problem - we have to have long to develop the ethic. Then some toxic wastes should probably not be made available in the first place.

5. Quite a lot of active recycling could reduce waste but takes quite a bit of re-education and the only reason schools actually make money is because a lot of work is done by very capable volunteers.

6. Q.26 *(..too expensive to provide adequate protection against hazwaste):* I don't know the cost - but the staff's health should definitely be protected.

7. Hospital has to afford the cost involved to strictly monitor all hazardous waste.

8. Infected sharps disposal is a problem at all levels. Probably best handled by commercial company.

9. My staff and myself are at risk of accidental infection (often through an accidental self induced finger prick). We try to take all measures to avoid this.

10. My sister-in-law in Johannesburg (at Wits in the Microbiology Dept) freely used radio-active materials with <u>no</u> education on disposal/safety etc. (Research) Probably the same here???

11. The hospital should undertake to improve awareness on all the issues mentioend on these pages.

12. The hospital should undertake to improve awareness on all the issues mentioned on these pages.

13. As I am not dealing with it every day in my work I am not aware of the procedures and process surrounding toxic waste, but feel strongly that it should be dealt with in the safest way to both hospital personnel, patients and environment.

14. Just ignorant! - don't deal directly with it! Need more awareness, factual information.

15. As I do not deal with hazardous wastes (or do not know that I am dealing with them!) I have very little knowledge of their disposal and the regulations affecting it.

16. I feel very inadequate to answer questions on this important problem.

17. I am unaware of what is produced.

18. Don't know enough about toxic wastes to comment!

19. Not really sure which toxic wastes are produced.

20. Just ignorant! - don't deal directly with it! Need more awareness, factual information.

21. Don't know enough about toxic wastes to comment!

22. I am unaware of what is produced.

23 Not really sure which toxic wastes are produced.

24 My knowledge is a bit restricted when it comes to this subject.

25. I'm very ignorant regarding this topic.

26. Don't know much about this subject. I agree that hospital waste is important are unaware of its disposal.

27. Generally we as student interns don't have much to do with what happens with the waste we create in the process of caring for our patients - Education is required!

28. Don't know enough!!

29. Although I am not well informed on medical waste and its disposal, I do know that it has a longlasting devastating effect on all life (marine and land, animal and human) if inadequately handled and disposed of and I think, is one of the most critical environmental issued that must be addressed. Don't destroy our earth!!

30. Our dept.(physiotherapy) does not have contact with waste - irrelevant questionnaire.

31. Difficult for physiotherapists to comment.

32. You have not addressed the problem of infected hospital waste (often used needles) which needs special handling for disposal - often off-site incineration.

Problems:

33. Biological hazards are poorly managed. The radiation problems seem well served - even if the policies are laborious - chemical waste seems an unknown concept.

34. Yes. General lack of education overall. Concerned about P-32, I125, I131, Ir-192, Ra-226, Rb-181, Tc-99m.

35. Bags of soiled, hospital waste lying around in passages, falling off trucks.

36. Needles/glass-containers often too small/missing/inadequate wall thickness ie. needles stick through.

37. Before the incinerator was shut down I used to have soot dumped on my desk which was being sucked into the air conditioning system. This disappeared once the incineration of waste was largely moved away from the hospital.

38. Nursing staff not taking appropriate steps when disposing of cytotoxics e.g. throwing in normal refuse.

39. No, not to my knowledge.

40. ? Hole in ozone layer.

41. No, we never handle it or go near it.

42. Not really involved.

<u>Concern</u>:

44. Any toxic wastes which may harm me or my family.

45. Cyanides.

46. Not known specifically, but all toxic waste concerns me because it impacts negatively on our environment.

47. Incinerated needles.

48. Don't know which wastes are produced.

NURSING:

<u>Comments</u>:

1. This is a valuable survey which is long overdue. May this have a positive outcome to all people involved, and the environment.

2. As patient advocates we need to protect our patients as well as our staff and the community - regardless of the expense.

3. Staff dealing with hazardous waste should be protected sufficiently. Our country should spend more money on waste disposal as this is in the interest and health of our population.

4. If the hospital deals with disposal of hazardous waste itself then it has to make funds available to do this properly and ensure the safety of its staff and the public (community).

5. Staff should be more informed on hospital policy regarding management of toxic waste.

6. Safety to be improved at GSH. Full time Risk Control Manager to be employed.

7. Hospital staff are inadequately trained to deal with hazardous waste and therefore take unnecessary risks.

8. I think the personnel's level of awareness regarding toxic waste should be raised, especially with regard to the detrimental effects indiscriminate disposal has on the environment and subsequently the public.

9. Not familiar with all toxic waste but radio-active toxic waste sounds most "scary".

10. I am very concerned about the method of disposal of medical waste.

11. I find myself remarkably ignorant of this entire topic and I suspect many others will be as ignorant.

12. Unfortunately toxic waste and the environment does greatly concern me, but I am poorly informed.

13. Staff would appreciate to have more input into medical toxic waste management.

14. Staff should be more informed about waste disposal and the hazards involved.

15. I'm not well informed and would like to know more.

16. I would like to see more educational programmes related to this subject.

17. Ashamed to say my education in abovementioned topic lacking.

18. Question 27 *(most efficient hazwaste disposal method?)*: Not sure which is the most efficient. As I never thought of, or had dealings with toxic waste, I would like to know more about this subject if possible.

19. Disposal of mercury from broken Baumanometers or Thermometers. Each and every hospital employee should be thoroughly educated re the appropriate waste disposal of material he/she comes into contact with.

20. We have a commercial waste company doing our waste disposal providing an efficient service but the system is not being utilized as designed, the cost is astronomical. We are still in possession of a decommissioned incinerator. In addition, all we need is the utilization and training opportunities for existing staff. Working in environmental hygiene services - waste disposal section.

21. I think that waste disposal in the hospital is a farce and that NOBODY takes it seriously enough. Much more attention should be given to separating and disposing of hospital waste e.g. glass, plastic, paper.

22. I believe in recycling and believe not enough is being done in this regard. The amount of waste left to companies (waste) to dispose of could be markedly reduced.

23. I have on a few occasions seen waste lying outside the delivery area e.g. old drip bags and empty plastic bottles.

24. Staff at the hospitals should have the maximum protection against all kind of waste. Any toxic waste must be treated with the utmost care - we only have one world - one ozone layer and one life!

25. We are trying hard to keep our environment safe and clean.

Problems:

26. Air ventilation not adequately cleaned - causes most of the staff and patients' respiratory (upper) problems.

27. No, only from air pollution due to incineration. Allergies and hyper-sensitive irritated airway.

28. Fallout from hospital incinerator. Airborne waste (methylene chloride). Improper incineration of hospital waste does not destroy carcinogens. Waterborne waste - flushing down of chemicals - gluteraldehyde. Injection needles lying on floors/grounds. Emission of chemicals into atmosphere.

29. Some people in our township collect hardware items like mattresses and then push it to certain corners of our streets and burn the material off the mattress to sell the remaining wire. The smoke coming from these incidents has a filthy smell and makes washingday a nightmare. We also have a "river" running past our house along the N2 highway which carries ?waste water which the authorities have promised to close but have not yet come so far; idle children whose parents are at work, play in the river and develop diseases like hepatitis B and skin-diseases.

30. Yes, pricked by a needle in a red bag and treated for it, that was long ago in old hospital.

31. Yes, encountered other medical staff with accidental needleprick injuries and a pregnant person in contact with a patient who had a radium implant.

32. Yes - Sharps disposed into red plastic bags exposing health workers to needle stick injuries. Leakage of body fluids from red bags; overfilled sharps containers. When the hospital incinerated its own hospital waste unqualified general assistants operated the incinerator. This led to problems such as overloading, environmental pollution etc.

33. Yes. Contaminated linen post urea.

34. Waste soiled by human secretions. PVC disposals. Soda lime disposal.

Concerns:

35. Plaster of Paris dust.

36. Fumes from incinerator.

37. Air pollutants.

38. Asbestos (x2).

TECHNICAL:

Comments:

1. Pollution problems. Incinerators need to be upgraded. Waste disposal companies disregarding codes of conduct. The strictest policies should be applied to alleviate

the environment from the present pollution and toxic waste problems we are presently faced with.

2. Hazardous waste is on the increase and we need to look at new ways of monitoring disposal - generally not strict enough.

3. Correct and thorough application of hospital policy concerning hazardous waste can reduce (at source of generation) volumes produced by 60%.

4. Since using WasteTech, no problem with waste. Boiler emits black smoke because it has to be flushed twice a day - don't think electrification is a possibility. Nobody to enforce regulations.

5. Companies have the general know-how to deal with all types of waste, even if expensive to hospitals, the long-term benefit to staff and communities could be tremendous.

6. I am not very informed as to present methods of waste disposal, I should hope that commercial waste companies are subject to adequate controls and inspection.

7. Even though protection for staff and adequate training is expensive, in the long run, it could save the hospital thousands in medical bills should untrained/unprotected staff become seriously ill/die as a result of inadequate measures taken.

8. I feel the hospital should and must make money available for the monitoring of hazardous waste.

9. Funds need to be allocated in the right direction.

10. I do not think that there is enough awareness of the regulations and measures provided for waste disposal in general.

11. Most staff and the general public are ignorant of the harmful effects of toxic wastes and the effect that it has on one's health or the environment.

12. After working for 2yrs at GSH, I'm unsure of the steps that are involved in disposing of waste products. I feel we should all be educated in this subject of safe waste disposal.

13. Staff need to be educated about toxic waste!

14. A need for hospital staff education!!

15. Staff should be generally educated about hazardous wastes - not only if you happen to work with them.

16. I do not believe that staff are adequately educated concerning waste disposal and exactly what is hazardous and which chemicals are not.

17. Sufficient education should be given to all staff dealing with toxic waste with regards to the disposal thereof.

18. Training and awareness programmes should be instituted and maintained at all levels of staff. This should apply especially for the workers without technical skills, eg. cleaners, messengers etc.

19. I don't really know much about all this, but I am concerned about the environment and public health.

20. Q15 *(Staff should be protected against hazardous waste)* : This certainly does not happen in certain areas. Protection from exposure to cytotoxics has improved.

21. Carelessness of hospital staff (x 2)

22. Medical research workers (labs) tend to be less disciplined than workers in a clinical environment, with regard to safe disposal of waste.

23. I think we need greater awareness of disposing of waste (esp. patient waste, infected waste)

24. Disposal of toxic wastes is a sensitive subject due to the various multitudinous environmental societies which have to be considered. Great care must be taken to satisfy everyone to the advantage of all living organisms on this planet. BUT HUMAN BEINGS MUST BE OUR PRIME CONCERN!

Problems:

25. Ash fallout from incinerator and boiler a problem.

26. Ash fallout from incinerator/boiler.

27. Yes. Dumped on our cars and above in surrounding areas of our offices, deposits were found in the carpeting. We had respiratory problems in our Dept. from boiler stack outfall.

28 Ash deposit from boilers - very bad at hospital.

29. Am aware of tissue containing radio-isotopes being incinerated and the incinerator being condemned until proper decontamination had occurred.

30. Yes. Mixing of waste for incineration with waste intended for recycling. Unclear marking of containers with toxic waste.

31. Yes. Waste that is able to abe re-used (recycled) is often put with toxic or unreusable materials and incinerated (or disposed of).

32. Commercial cost of hazardous waste disposal does not represent true value for money because of the lack of competition.

33. Radioactive dockets are only issued to staff working in these areas. I feel it should be compulsory for all members of staff.
34. I have not encountered exposure to hazardous waste, but exposure to toxic chemicals occurs frequently without protection e.g. formalin exposure.

35. Yes. We needed to dispose of a large jar of mercury - the hospital did not know what to do with it.

36. Disposal of chemical waste (acids) in laboratories.

37. Disposal of liquid waste is not adequate. Presently being thrown into local sewage system.

38. Acetone and 10% Hcl is regularly disposed of in the sinks.

39. Disposing of waste from bloodgas analyzer.

40. Storage space.

41. The only real problem lies with the indifference of staff who often can't be bothered to do things in the correct way!!

42. No - since WasteTech contract.

43. I do not approve of RSA becoming a site where other country's waste is disposed in addition to our own. There is some agreement pending which Australia wishes SA will not sign, regarding non-distribution of waste in Africa.

Concerns:

44. Human products contaminating the equipment we maintain such as blood gas analysers, ventilators, etc. I don't think that the laws governing waste sites are clear enough for commercial companies to undertake disposal. Controversy about a site at Midrand used by WasteTech.

45. Bloodgas analyzer waste, invasive catheters, sharps used on patients eg. needles; introducers etc.

46. Bloodgas analyzer waste, HIV^+ and other infective waste (eg. towels, dressings etc.)

47. Waste contaminated by body fluids.

48. Bloodgas analyzer waste, infected patient's blood and breathing circuits.

49. Flammables etc. which are combined and disposed of in the sink.

GENERAL:

Comments:

1. In this hospital, great care is taken of disposing waste properly. Staff are adequately trained and updated regarding the handling and disposal thereof.

2. The hospital staff does a great job. They must keep the good work up, not only for our safety, but for the patients as well as the community.

3. There is a need for hospitals and private companies to merge their services regarding all types of waste for disposal safely that will financially benefit the country as a whole and not use much money from the health budget for this purpose.

4. These toxic wastes are very harmful to your health. If not treated you can end up for the worst.

5. Clean air. It is of the utmost importance that all hospital staff and the general public be made aware of the health hazards of toxic waste and what it's all about.

6. Concerned about effective incineration of hazardous substances. Concerned about awareness and sense of responsibility of all those dealing with hazardous waste.

7. I once heard of laboratory hazardous waste that was placed together with normal waste in waste disposal room. Need for orientation regarding hazardous waste disposal to enhance my job description or function.

8. Staff members responsible for disposing of this waste do not always seem to know or care about the impact of careless behaviour in this regard. We have seen this often in strike actions where waste has been left unattended for days in a hospital, creating an obviously dangerous situation to the patients and hospital personnel.

9. Contaminated sharps thrown into red bags or on the floor by doctors and nursing staff. General assistants are injured and extra money has to be spent to treat them.

10. Dirty passages. Keep clean.

11. Dit sal goed wees as hospitale hulle personeel kan beskerm deur voldoende wegdoen van gevaarlike hospitaal afval.

MEDICAL SCHOOL

ADMINISTRATION:

Comments:

1. Specific staff should be well trained and made responsible for disposal and handling of toxic waste. To work in conjunction with external company? To be regularly retrained, to be required to report regularly. Regular inspections by superiors/safety office (including unexpected spot checks) are necessary.

Problems:

2. Not personally but become aware of serious problems resulting from neglect from time to time.

Concerns:

3. Radioactive, carcinogens, potential long-term pollutants eg. very stable chemicals such as xylol.

PROFESSIONAL:

Comments:

1. This is a topical, important and timely study.

2. We have a research interest in disposal of pesticide wastes.

3. I hope this improves awareness.

Problems:

4. Yes - May 1995 - public incident involving bulging can of solvent waste.

5. Swabs (contaminated) washed up in the drains of Observatory in 1993/4.

6. On the efficiency of commercial waste companies. Only if they did the job properly (which up to now seems doubtful).

Concerns:

7. Formaldehyde, organic solvents - used in tissue processing. Infectious hazards.

RESEARCH:

Comments:

1. Some of the questions are not specific enough.

2. Commercial waste companies would be the most efficient means of disposing of clinical waste, but only if they did the job properly (which up to now seems doubtful).

3. Q8 *(Should it be compulsory for hospitals to use commercial waste companies?):* Answered No, but this may be the best solution, provided the private companies can be controlled in their waste disposal.
   Q24 *(Clinical waste can be disposed of via the domestic waste system):* A study in Germany showed that the bulk of hospital waste is less infectious than house-hold waste. Hospitals also use excessive amounts of disinfectants which are all pollutants. Simple heat sterilization is sufficient for infectious contaminated waste.

Problems:

4. The problem with EthBr is the volume of waste generated. We wanted to make our own disposal mechanism but then a dispute arose between us and WasteTech. As a result a lot goes down the sink! We have done our bit to solidify and clean up our waste but I'm not sure about other users.

5. No with regard to waste disposal but with leaking gas pipes.

6. The system changes regularly. Sometimes the regulations are too strict, sometimes too lenient. Appears that non-research or non-medical people are involved in drawing up the regulations.

Concerns:

7. Ethidium bromide, mutagenic chemicals used in molecular work.

8. Gas leaks.

9. Any waste that can be classified as toxic or hazardous is of extreme concern.

10. H-Thymidine, Tissue culture waste, Phenol, Chloroform + other chemicals.

TECHNICAL:

Comments:

1. Waste-Tech drums bulged due to a mixture of fluids - xylol, alcohol, stains etc.

2. General public do not take Hazwaste disposal seriously enough.

3. Finding definitive information on disposal of chemicals - ethidium bromide. Ignorance.

Problems:

4. Yes - how to dispose of e.g. ethidium bromide.

Concerns:

5. Phenol, ethidium bromide, guanidium Thio-Cynate, chloroform, radio-active isotopes. H-Thymidine, tissue culture waste, phenol, carcinogens, potential long-term pollutants e.g. very stable chemicals such as xylol.

6. Radioactive material, mutants e.g. ethidium bromide, neurotoxins e.g. Acrylamide.

GENERAL:

Concern:

1. All radioactive, medical and chemical waste produced by Medical School.

MILNERTON MEDICITY

ADMINISTRATION:

Comments:

1. Very concerned about environmental pollution.

PROFESSIONAL:

No comment.

NURSING:

Problems:

1. Too little attention is given to adequate handling of waste disposal. Cost should outweigh risk ie: risk at any cost

TECHNICAL:

No comment.

GENERAL:

No comment.

LABORATORY

Comments:

1. I feel private waste disposal companies take the public for a ride e.g. WasteTech. They don't obey the laws and regulations and take chances. The general public (and workers!) are uninformed and ignorant. Stricter controls should be imposed.

Problems:

2. Yes, ignorance.

RED CROSS HOSPITAL

ADMINISTRATION:

Comments:

1. Public should be educated in chemical, radioactive and incinerated hospital waste - most important: hospital employees and environmental issues and workplace safety.

2. Public to be enlightened.

Problems:

3. Yes, "sharps" in the hospital are an ongoing problem because needles, broken glass, etc. can spread diseases like infectious hepatitus and AIDS. Therefore this waste disposal is strictly controlled.

4. This hospital also occasionally picks up a problem with noxious fumes from the incinerator being wind-borne across a nearby suburb. This too is carefully monitored and controlled.

Concerns:

5. Infectious diseases spread by needles and broken glass (blood, strong acids and alkalis utilised by the laboratories. Burning of infectious waste (i.e. bandages & nappies). Nuclear waste produced by radiation treatment and testing.

PROFESSIONAL:

Comments:

1. I am not very well informed on these matters.

2. Good heavens "Don't know".

3. Most questions deal with subjects beyond my field of expertise. As regards cost, we can't afford to do what we are already doing; that does not mean that in an ideal world we shouldn't be doing better as far as waste disposal is concerned.

4. Some of the questions are a bit vague.

5. Some questions could benefit from a comment-type section, as the options provided were too dogmatic. What are "cement kilns" and who uses them???

Concern:

6. I am unaware of toxic wastes produced by hospitals, research institutions produce large amounts of directly toxic (radiochemicals, solvents) and potentially biologically toxic wastes: these latter wastes (e.g. radioactive) probably concern me most.

NURSING:

Comments:

1. Knowledge of hazardous waste disposal is very limited. Would love to learn more.

2. Need for more care/teaching/control of persons doing incinerating, collecting of waste.

3. We need to be aggressive in control of waste disposal and environment protection. I am a fishing person and get very angry at the abuse inflicted on our beautiful environment.

4. In order to answer questions in this questionnaire one needs to be kept up to date with current waste disposal methods and research.

5. If companies will take care of waste products. It has to be paid for and hospital has no money available.

6. I think they should really make a plan to see to it (toxic waste disposal).

7. Media -> please inform public - importance of waste disposal and how it is being disposed.

8. Dit is goed om na die probleem te kyk, maar finansieel gaan dit moeilik vir die hospitaal wees.

Problems:

9. Chimney stacks too low. Should be built higher. When one walks past all the ash falls on a person. Our creche also too near the chimney stacks.

10. Chemo/cytotoxins, antibiotics, air pollution, aerosols. Becoming a more serious problem. Too expensive to incinerate and pollution very bad.

11. The pieces flying out of the cooling towers, Athlone.

12. Yes. "Sharps". Boxes do not have permanent seal when full, which could be opened by anyone after use.

Concerns:

13. Those toxic wastes that pollute the environment.

NURSES:

Comments:

1. Do anaesthetic gasses effect health? e.g. At present permanent staff with chest problems - they do have history of allergies - gasses? contributory factors. Female staff with recurrent inevitable abortions.

2. Insure that waste companies are kept in line - preclude all loopholes.

3. Recycle non-hazardous waste e.g. plastic syringes.

4. Need to be more informed - have regular in-service training and update staff on current issues

Problems:

5. Yes, more in-service training is required to achieve competency in disposal of waste.

6. Know too little about impact of above on the environment and people handling it to comment.

7. Education required.

Concerns:

8. Not familiar with all toxic wastes therefore unable to prioritize which concerns me the most.

TECHNICAL:

Comments:

1. More should be done about toxic waste to make this country more environment-friendly.

GENERAL:

Comments:

1. Patients as well as staff should be educated re - toxic waste.

Concerns:

2. Needles in plastic bags worries me most.

TECHNICAL:

Comments:

1. Legislation is required with regard to refrigerants.

Problems:

2. Refrigerants e.g. when repairs are carried out on air conditioning equipment, contractors discharge the refrigerant (CFC & HCFC) into the atmosphere. Typical quantities are approximately 60 kg.

3. Black soot coming from chimneys of incinerator.

GENERAL:

1. I do welcome this questionnaire and would like to see these fears and uncertainties being addressed as soon as possible.

2. I would like to see that all personnel are safely protected.

SOMERSET HOSPITAL

ADMINISTRATION:

Comments:

1. I am very much afraid of the dusty smokes produced by the incinerators.

PROFESSIONAL:

Comments:

1. People tend to get het up about miniscule general environmental hazards while practicing much more deleterious personal habits. A smoker has no right to complain about chloroform disposal. The objective evidence for ozone depletion is less than compelling.
2. Glad this issue is being addressed.
3. I do not know enough about the subject to comment on it.
4. I am regrettably ignorant but would like to know more.
5. More information/training required re hazardous waste disposal.

Problems:

6. I am aware that re Koeberg Nuclear Station - very few people in hospitals know about decontamination of exposed people and collection of water etc used in washing them down.
7. Lack of public and staff education/caring. "Not my problem" syndrome. "Green Overkill" i.e. Too many decisions are taken because they sound environmentally correct, but they are taken without sufficient background knowledge.
8. Different wards seem to have slightly different policies as to the disposal policy. I feel that people/employees are too ignorant of recycling of waste and of environmental impact of hazardous/medical waste. I feel that with a little education we could all cut the cost or possibly even earn the hospital some income by correctly disposing of/recycling our waste.
9. Lack of staff education, and hazardous waste management inadequate. Different bins should be provided for recycling of glass and paper.
10. Having to separate blood-contaminated needles from blood-contaminated syringes/tubing before disposal (waste company requires "sharps" to be separated from "other contaminated items).

TYGERBERG

ADMINISTRATION:

Comments

1. Waste in general should get more attention - starting with the Government and private companies working together.
2. Alle personeel behoort behoorlik ingelug te wees van stowwe wat giftig is of nie.
3. Alle personeel se gesondheid en veiligheid moet as eerste prioriteit beskou word ongeag finansiele tekorte.
4. Ongewingsake moet ten alle tye eerste gestel word.
5. Matieels word neergele, maar onverskillige en natatigheid matieels nie voldoende nie, asook arbeids verger die probleme.
6. Workers should be informed about the hazards of certain waste and what is, and is not dangerous or hazardous to their health.
7. Ek hoop dat die verwydering van afvalstowwe op die veiligste en doeltrefendste manier moet geskied.
8. Daar bestaan nog baie onkunde i.u.m. die verwydering afvalstowwe (chemies en radioaktieve afval).
9. Maatrieels word neergele, maar onverskillige en nalatigheid maak die maatreels nie voldoende nie, asook arbeidsonrus verger die probleme.

Problems

10. Gebruikte inspuitingsnaalde wat nie op die regte manier verwyder word nie.

PROFESSIONAL:

Comments

1. I agree that hazardous waste disposal would be much more efficiently handled by a private company, but at this stage can we really afford it?
2. Strongly suppport adequate/stringent waste control.
3. Beslis 'n groot probleem - meer so omdat dit nie 'n bekostegbare item in SA is nie.
4. RSA's toxic waste legislation is totally inadequate.
5. Know too little about the subject as a medical doctor.
6. Geen kennis (x 4)

7. Ek weet nie hoe die afval hanteer moet word nie maar voel dat dit veilig vir omgewing en personeel moet wees en dat dit deur kundiges gedoen word.

8. One can provide protection for people that work with waste, but it is another thing to get them to use it.

9. People are not always able to understand the importance because of ignorance, despite careful explaining.

10. One of the problems of waste disposal is the low productivity of the people responsible for the process, thus leaving it exposed for longer periods than necessary.

11. Waste collection points are available - what happens to the waste is not always known. Precautions for handling infective materials are taken, but are not always effective.

Problems

12. Adequate knowledge to be appropriately made available by responsible personnel for this purpose. Although concerned I personally do not have time or powers to make this my problem.

13. Yes - waste disposal boxes/containers lying in hospital foyers/lifts.

14. Havn't thought about it.

15. Total unawareness amongst staff of hazards in waste management.

16. Ophoping in sale tussen pasiente swak identifikasie van punte.

17. I don't know enough about toxic products produced. What concerns me is the lack of recycling facilities for obvious "clean" waste.
I really know little about the subject.

Concerns

18. Isotopes & chemo. None. All the wastes are professionally monitored and handled by professional staff, supervised by a monitoring committee as required by law.

19. Nitrous Oxide.

20. Anything harmful to the environment.

NURSING:

Comments

1. Dit is baie goed om hierdie afval te bespreek. Dit raak een en alle wat in 'n hospitaal werk.

2. Beskerm u personeel (x2).

3. Strenger beheermaatrieels asook wetgewing moet toegepas word.

4. Is nie bekend met hospitaal beleid rakende die verwydering van giftige afvalmateriaal nie (x2).

5. If people are not aware of toxic waste severe damage can be done to the community because of lack of knowledge. All toxic waste areas should be clearly demarcated and identified.

6. Plastiekhouers van Waste-Tech firma deksels is nie altyd heel nie. Die "stuts" of drukkertjie aan kante is uit en seel nie. In huishoudelik word daar gebruik gemaak van rubber handskoene as daar met afval gewerk word en dit is nie van die sterkste soort handskoene nie. Dit raak gou taai en stukkend.

7. Gevaarlike afval moet deur professionele persone verwyder word.

8. People don't use the waste holders as they are supposed to be used. People in charge should be more strict and less accidents will be caused.

9. Hoop dat daar aandag gegee sal word aan personeel se beskerming en wat moed die afvalmerk as ook te beskerm teen die gifstowwe.

10. Al wat belangrik is in ons heidige werksomstandighede is dat afval op die korrekte manier verwyder en getermineer oed word en alles ten goede vir die personeel en pasiente sal uitwerk.

11. Nie voldoende sorg by beskerming van X-strale.

12. 'n Gebrek aan inligting aangaarde gevaarlike afvalstowwe en die hantering deur verpleegpersoneel kom wel voor asook identifisering daarvan.

13. Die begrip PVA is onbekend. Antwoorde daarna is neutraal. (5)

14. Verpleegpersoneel weet baie min v.n.a. hantering van hospitaal afvalstowwe.

15. Geen begrip van wat aangaan.

16. Het nie genoeg ervaring van gevaarlike afvalverwydering nie.

17. Verpleegpersoneel weet baie min van die hanteering van hospitaal afvalstowwe.

18. Het nie genoeg ervaring van gevaarlike afvalwerwydering nie.

19. Verpleegpersoneel en algememe hospitaalwerkers is oor die algemeen nie goed genoeg ingelig omtrent die hantering en risikos verbonde aan verskillende soorte afval waarmee 'n hospitaal te kampe het nie.

20. Dit is baie belangrik vir korrekte verwydering van die giftige stowwe, omdat dit langtermyn werklike probleme veroorsaak.

21. Afvalprodukte behoort korrek hanteer te word in alle afdelings van die hospitaal om 'n veilige omgewing te skep vir ons personeel en pasiente.

22. Strenger beheermaatreels asook wetgewing moet togepas word by the hantering, verwydering en verbranding van gevaarlike afvalstowwe.

23. In huishoudelik word daar gebruikgemaak van rubber handskoene as daar met afval gewerk word en dit is nie van die sterkste sort handskoene nie. Dit raak gou taai en stukkend.

24. Vuil spuite en naalde. Septiese verband pakke.

Problems

25. Yes - Go to Crossroads and see for yourself.

26. Nog nie in kontak gewees.

27. Nog nie te doen gehad nie.

28. NEE. Geen begrip van wat aangaan.

29. Ja, vullis dromme loop meeste van die tyd oor.

30. Die ophoping van afval en die kieme wat die versprei.

31. Verlore iridium naald.

TECHNICAL:

Comments

1. Policy inadequate.

2. Daar moet baie streng opgetree word oor die hantering van chemiese en radioaktiewe hospitaalafval.

3. Die behoorlike riglyne vir afvalstowwe. Opleiding oor afvalstowwe.

4. More information should be made available to the public so that a greater awareness can be created on the above subject.

5. Although I believe commercial waste companies are the right thing, they should be under strict control measures to monitor the disposal of the waste.

6. I feel that no private companies should be involved with waste disposal of any sort from a hospital since this results in inadequate control.

7. Verwydering v. afvalstowwe is onvoldoende bv. bloedprodukte wat in Wast-tek bokse rondstaan.

8. Het nie kennis van giftige afvalstowwe in hospitaal met betrekking tot hanteering en uitkenning.

9. Don't know about hospital toxic wastes. Just get this toxic waste disposal sytem in tip-top shape, if it is not yet. Thank you.

Problems

10. Often encounter blood-stained gloves in hospital lifts used for waste disposal. I also don't believe medical waste and patients should travel in the same lift.

11. Having hypodermic needles in wash hand basin waste pipes. Although the hospital has waste disposal containers, we still find needles in the wash hand waste pipes.

12. Blood in lifts leaking out of containers.

13. Re-use of dangerous waste containers resulting in contamination of equipment.

14. PVC pyp. Verbranding van dagga.

15. Heavy carbons

Concerns

16. All those affecting people in the workplace and the environment.

GENERAL:

Comments

1. Ek dink die verwydering van die afval in die hospitaal is baie swak.

2. Die verwydering van afvalstowwe is vreeslik swak.

3. Beter voorsorgmaatreels kan getref word met die hantering en verwydering van vullisafval en ander gevaarlike materiaal.

4. Die studente gooi naalde in swart sakke in plaas van houers en ons word gesteek met besmette naalde.

5. Dripbottel se glaskrewe het my gesny.

6. Waar die vullis hier ophoop by the huistak en slegs minder afgee is eerstens ongebrypbaar.

7. Vuil spuit naalde.

Problems

8. Ja, die naalde het my baie gesteek.

9. Ja, ek het self vullis verwyder in die hospitaal.

10. Ek het 'n naald prik weg van 'n besmette naald toe ons die vullis nog verwyder het vanaf die sale.

11. Naald het my in knie gesteek. Dit was in 'n vullis sak.

12. Vuil spuit naald, gesteek in been vanuit 'n vullessak.

13. Die vullis afvalstowwe kan in die plastiese houers verwyder word en in die verbrandingsoond verbrand.

VINCENT PALOTTI

ADMINISTRATION:

No comment

PROFESSIONAL:

Problems:

1. Private company dumping hospital waste in residential areas.

NURSING:

Comments:

1. Some hospitals comply with regulations and dispose of their "sharps" effectively i.e. private companies supply containers to the hospital. General practitioners often do not comply as "nobody would really know" what they are doing with their sharps. It costs them money, so why bother to do anything about it.

2. The disposal of hazardous waste is extremely important and cost should not be the most important factor, but the most effective method of disposal.

3. Educating staff not always easy as they do not always pay attention or they don't want to know because the procedure is a lot of "extra work".

Problems:

4. Disposal of sharps easily overlooked in the rush of emergency and needle pricks may occur.

TECHNICAL:

1. None of the correct methods and proceedings are used.

GENERAL:

No comment.

LABORATORY:

No comment.

Appendix IX

APPENDIX IX

Question 1: Additional information for specific medical institutions

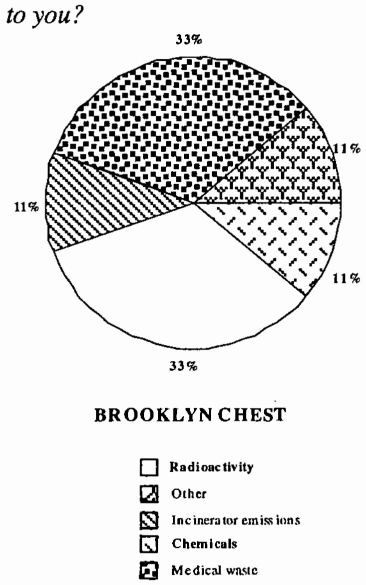
The following Figures indicate replies to Question 1 received from the hospitals and Medical School. Additional comments written in this open question are detailed under *Concerns* in Appendix VIII.

PUBLIC HOSPITALS

BROOKLYN CHEST

Brooklyn Chest is a hospital catering mainly for tuberculosis patients. It has a total staff of 249. Eleven questionnaires were administered to the different categories of staff, and 11 returned.

Figure IX.1: Responses of all Brooklyn Chest staff to Question 1: *Which toxic wastes produced by medical institutions are of most concern to you?*



- Figure 6.1 indicates that the toxic wastes of most concern at this hospital are medical waste (33%) and radioactivity (33%).

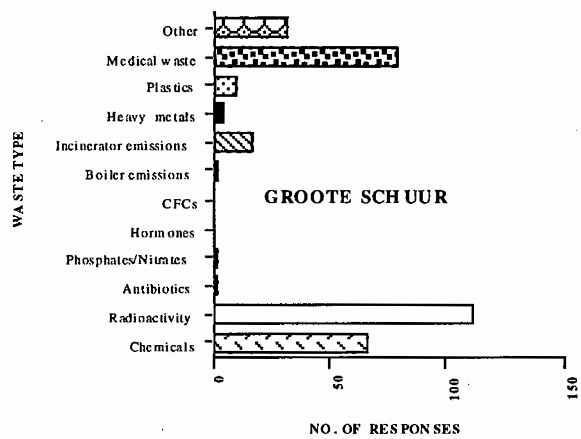
- 'Other' at this institution could include sputum and sharps, and 'medical waste'; body fluids and blood-stained articles.

- Plastics and incinerator emissions are also a concern, even though the incinerator has been decommissioned owing to financial considerations.

GROOTE SCHUUR

Groote Schuur is a large teaching hospital in Observatory, Cape Town, with a staff of 9261. Four hundred and twenty-three questionnaires were administered to the different categories of staff, and 301 returned .

Figure IX.2: Responses of all Groote Schuur staff to Question 1:



- Radioactivity and general medical waste are main concerns.

- Additional 'medical waste' worries were blood gas analysers, ventilators, HIV+, infected towels and dressings, and infected blood.

- 'Other' wastes include catheters, sharps, introducers, Plaster of Paris dust and asbestos.

- Chemicals, for example those combined with other substances and discharged into the sinks.

Radioactive waste

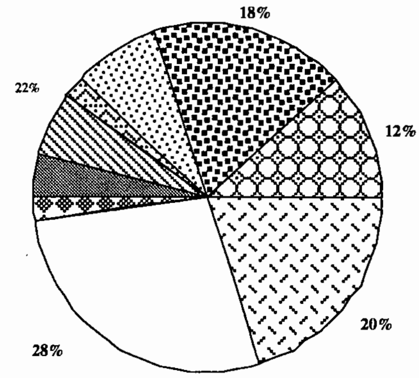
Only one of the four sewage outflows from Groote Schuur Hospital was sampled (see Chapters 4 and 5) owing to the depth of the channels and difficulty in securing the sampler. One of the outflows, which was not tested, had not been opened for many years and is believed to contain potentially high levels of radioactivity (M.Shackleton, Onchology, Groote Schuur Hospital, pers. comm.) which could have proved a health hazard to sampling staff.

Some staff believe Waste-tech causes problems with radioactive waste, as instead of flushing small amounts of this waste into the sewers, this has to be stored until a larger amount is amassed for disposal.

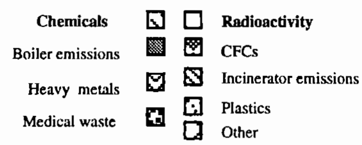
RED CROSS HOSPITAL

Red Cross Children's War Memorial Hospital is situated in the residential area of Rondebosch. It is a teaching hospital for UCT Medical School, and has a staff of 1641. Seventy-fiveq uestionnaires were distributed, and 51 returned.

Figure IX.3: Responses of all Red Cross staff to Question 1:



RED CROSS HOSPITAL



- Red Cross staff were most concerned about radioactivity (28%), as well as chemicals (20%), plastics and incinerator emissions. The incinerator does emit significant levels of radionucleides and chemicals (see Chapter 5), thus their concern is justified.

- Staff were also concerned about medical wastes (18%).

- Additional concerns not indicated in Figure IX.3 include: ignorance of toxic waste. produced by hospitals which could pollute the environment.

- Chemicals including solvents, acids, alkalis and radiochemicals used by laboratories.

- Burning of infectious bandages and nappies.

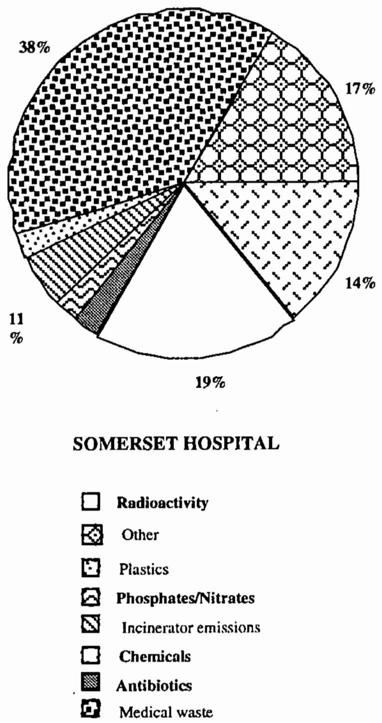
- Nuclear waste produced by radiation treatment and testing.

- Infectious diseases spread by sharps and infected blood.

SOMERSET HOSPITAL

Somerset Hospital is situated in Green Point near the Waterfront. This hospital specialises in the treatment of HIV and AIDS. It employs 978 personnel. Forty-five questionnaires were administered to the different categories of staff, and 40 returned.

Figure IX.4: Responses of all Somerset Hospital staff to Question 1:



- The majority of staff (38%) were concerned about medical waste (this includes infected wastes, and is expected in a hospital dealing specifically with HIV patients).

- Radioactivity, chemicals and other wastes are also of concern.

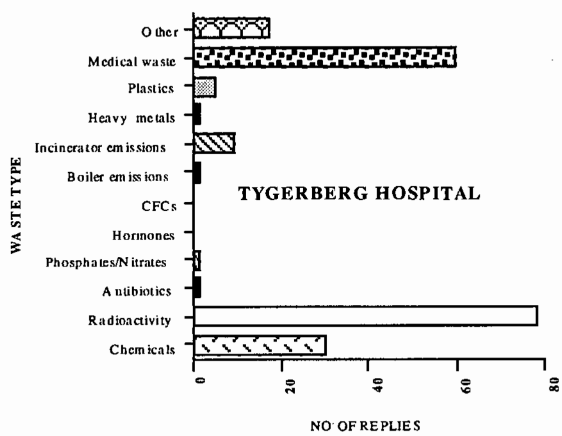
- Concern was expressed for incinerator emissions (this incinerator has since been decommissioned owing to complaints by residents, and financial considerations).

- An additional concern was needles in plastic bags.

TYGERBERG HOSPITAL

Tygerberg is a large Public teaching hospital in the northern suburbs, with a staff of 7030. Three hundred and twenty-six questionnaires were administered to the different categories of staff, and 292 returned.

Figure IX.5: Responses of all Tygerberg Hospital staff to Question 1:



- Staff are mostly concerned with radioactivity, medical waste and chemicals.

- Problems appear to be similar at Tygerberg and Groote Schuur, with staff expressing concern for the same hazardous wastes.

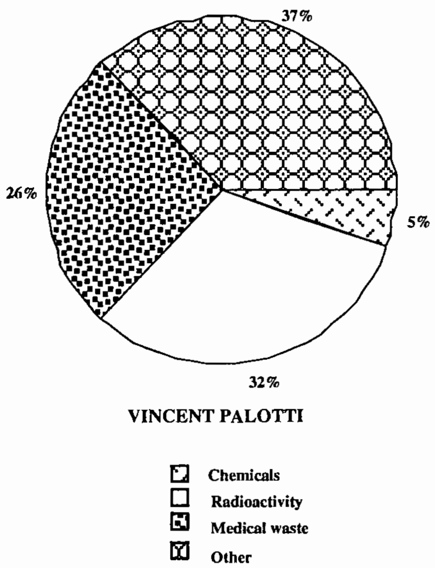
- Isotopes and nitrous oxide were believed to be a problem.

- It was stated by one respondent that all wastes are monitored and 'handled by professional staff, supervised by a monitoring committee as required by law', sentiments not shared by many other staff at Tygerberg (see Appendix VIII).

VINCENT PALOTTI

Vincent Palotti is a State-aided hospital in Pinelands run by the Catholic Church, with a staff of 318. Twenty questionnaireswere administered to different categories of staff, and 20 returned.

Figure IX.6: Responses of all Vincent Palotti staff to Question 1:



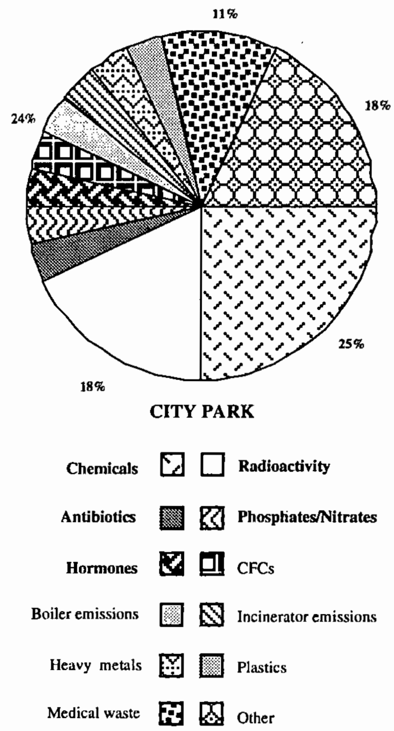
- 'Other' wastes (37%), such as HIV and sharps were of most concern to Vincent Palotti staff, followed by radioactive and medical waste.

PRIVATE HOSPITALS

CITY PARK

Clinic Holdings, a Public Company, operates City Park, which is situated in central Cape Town and has 804 staff members. Forty-three questionnaires were distributed at this hospital, and 38 returned.

Figure IX.7: Responses of all City Park staff to Question 1:



- Chemicals were the main concern at this hospital (25%), but staff appear to be worried about a wide range of toxic wastes.

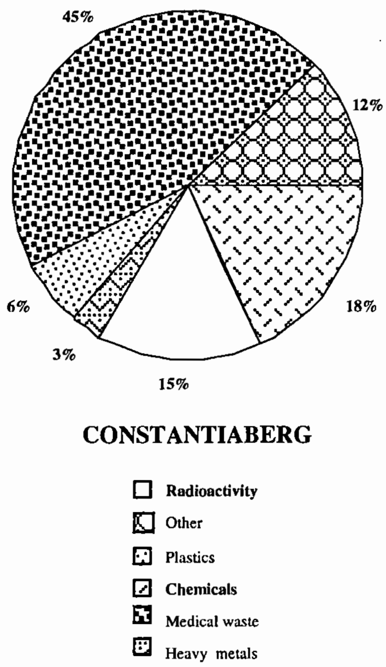
- 'Other' (18%) and radioactivity (19%) were also concerns.

CONSTANTIABERG

Constantiaberg belongs to the MediClinic Group and is situated in Constantia, with a staff of 427.

Twenty-three questionnaires were administered to the different categories of staff, and 20 returned .

Figure IX.8: Responses of all Constantiaberg staff to Question 1:

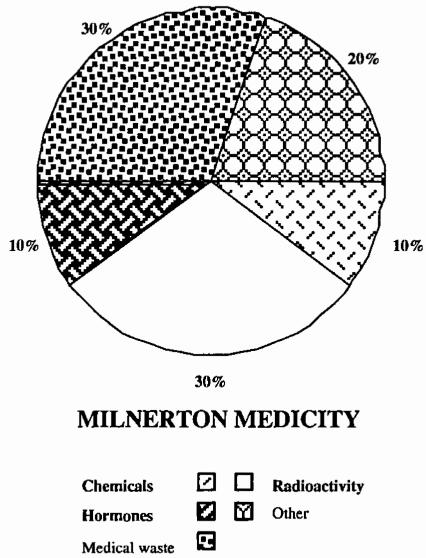


- Medical wastes were of most concern (45%) at Constantiaberg, with chemicals (18%) and radioactivity (15%) also being a problem.
- Additional concerns were Enoma bags, catheters and syringes, X-ray development chemicals, and heavy metals, for example barium.

MILNERTON MEDICITY

This Private hospital belongs to Medicor Hospitals and is situated in Milnerton, with a staff of 184. Twelve were administered to staff, and 8 returned.

Figure IX.9: Responses of all Milnerton MediCity staff to Question 1:

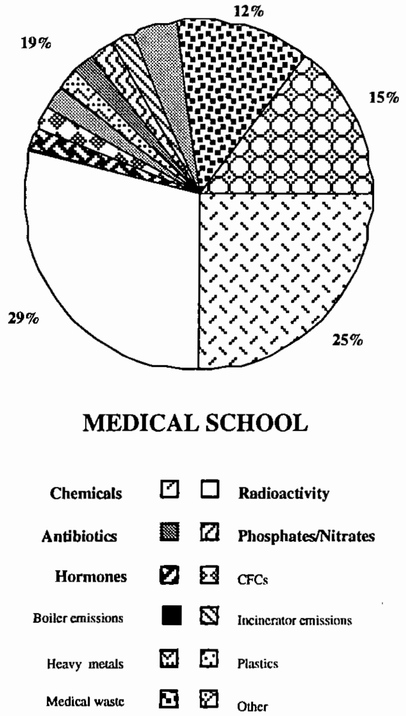


- Radioactivity (38%) was of prime concern to staff at this hospital, followed by medical waste (30%), 'Other' (20%) and hormones (10%). It is not known why this particular institute should express more concern for hormones.

MEDICAL SCHOOL

Medical School adjoins Groote Schuur Hospital in Observatory. One hundred and eighty-two Staff and Students work at Medical School. Twenty-one questionnaires were distributed, and 21 returned .

Figure IX.10: Responses of all Medical School staff to Question 1:



- The graph indicates concern for most hazardous wastes, but particularly radioactivity (29%) and chemicals (25%).

Additional problems were phenol, mutagenic chemicals e.g. ethidium bromide, guanidium, Thio-Cynate, chloroform, H-Thymidine, tissue culture waste, chloroform, formaldehyde, organic solvents carcinogens, neurotoxins e.g. Acrylamide, potential long-term pollutants e.g. very stable chemicals such as xylol.

Medical School first encountered problems with hazardous waste management when the City Council warned that acids were being discharged through stormwater drains into the Liesbeeck River. Another more recent incident has further highlighted problems with toxic waste. In June 1995, a swollen drum containing hazardous waste was discovered at Medical School, and Waste-tech, Metro Emergency Service, the Fire Brigade and the Bomb Squad were called to control the potentially dangerous situation. Despite instructions on the safe storage of chemicals, this drum was believed to contain xylol and other chemicals, as a high percentage of carbon monoxide was detected at the site following the puncturing of the drum. The resulting spillage was cleared by Waste-tech.

A number of comments on the questionnaire (see Appendix VIII) related to problems encountered with Ethidium bromide, a toxic mutagen used as a stain in DNA testing. Researchers attempted to filter it through charcoal, but this caused problems with Waste-tech, with the result that this chemical is again being discharged into the sewers (N. Sweijd, Medical School, pers. comm.). A substance which can be used instead of EthBr, SYBR Green I nucleic acid stain made by GIBCO BRL and Molecular Probes is available locally and is believed to be five times more sensitive than EthBr, and while still being an interclating dye, is not carcinogenic nor harmful to the environment. If this substitute is used permanently, camera equipment for photographing gels has to be modified, and instead of the orange filter used in photographing EthBr stained gels, another filter is required for different wavelengths (N.Barker, University of the Western Cape, pers. comm.)

There is no available data on the exact composition or volume of waste incinerated at local hospitals

Most hospitals and medical institutions in Cape Town employ Waste-tech to dispose of their hazardous clinical waste and Wasteman or the City Council to collect general refuse.

There does not appear to be strict control of hazardous substances at medical institutions, even though there are regulations and hospital policy addressing these issues. Private medi-clinics tend to be more efficient and have more control over the substances they use. The ten clinics, and a number of veterinary practices which were contacted, all employ Waste-tech for their sharps and any hazardous waste, and return overdue pharmaceuticals to the supplier or the Council Stores in Ndabeni. Overall though, there appears to be confusion over the composition of chemical substances used in laboratories, and their potential toxicity.

Appendix X

APPENDIX X: Question responses within staff categories: Frequencies and percentages

QUESTION	ALL RESPONDENTS n = 802			PROFESSIONAL n = 172			NURSING n = 320			ADMINISTRATION n = 81			TECHNICAL n = 135			GENERAL n = 68		
	Yes	No	M	Yes	No	M	Yes	No	M	Yes	No	M	Yes	No	M	Yes	No	M
2 Do you think that South African legislation dealing with the safe disposal of toxic hospital waste is adequate?	13.6 109	35.8 287	50.6 406	8.4 11	27.9 48	65.7 113	20.3 65	38.4 123	41.3 132	12.3 10	35.8 29	51.9 42	9.6 13	34.1 46	56.3 76	8.8 6	47.1 32	30
3 Are you familiar with hospital policy dealing with toxic waste disposal?	36.8 295	48.8 391	14.5 116	27.3 47	53.5 92	19.2 33	51.6 165	38.4 123	10.0 32	19.8 16	60.5 49	19.8 16	26.7 36	57.8 78	15.6 21	26.5 18	55.9 38	17.6 12
4 Does your department generate the following: a) radioactive waste?	15.1 121	64.1 514	20.8 167	12.8 22	70.9 122	16.3 28	15.3 49	60.9 195	23.8 76	0 0	76.5 62	23.5 19	23.0 31	62.2 84	14.8 20	7.4 5	60.3 41	32.4 22
b) chemical waste?	34.3 275	42.5 341	23.2 186	53.5 92	27.9 48	18.6 32	31.9 102	41.6 133	26.6 85	1.2 1	70.4 57	28.4 23	41.5 56	44.4 60	14.1 19	11.8 8	50.0 34	38.2 26
5 Are you aware of measures to check the strict observance of hospital policy regarding: a) radioactive waste?	27.9 224	50.9 408	21.2 170	24.4 42	60.5 104	15.1 26	34.7 111	40.3 129	25.0 80	8.6 7	75.3 61	16.0 13	29.6 40	52.6 71	17.8 24	16.2 11	50.0 34	33.8 23
b) chemical waste?	27.9 224	47.4 380	24.7 198	20.9 36	59.9 103	19.2 33	36.6 117	35.3 113	28.1 90	12.3 10	65.4 53	22.2 18	23.0 31	57.0 77	20.0 27	25.0 17	38.2 26	36.8 25
6 Do you think that hospital staff are adequately trained to deal with hazardous waste?	14.5 116	62.1 498	23.4 188	8.7 15	63.4 109	27.9 48	18.4 59	66.6 213	15.0 48	11.1 9	56.8 46	32.1 26	12.6 17	57.8 78	29.6 40	16.2 11	55.9 38	27.9 19
7 Are you easily able to distinguish PVC from other plastics?	22.8 183	57.6 462	19.6 157	13.4 23	76.7 132	9.9 17	22.5 72	49.7 159	27.8 89	25.9 21	53.1 43	21.0 17	30.4 41	60.0 81	9.6 13	32.4 22	42.6 29	25.0 17
8 Do you think that it should be compulsory for hospitals to employ private waste companies to dispose of their toxic waste?	59.4 476	25.6 205	15.1 121	46.5 80	31.4 54	22.1 38	65.0 208	24.4 78	10.6 34	64.2 52	17.3 14	18.5 15	61.5 83	23.7 32	14.8 20	61.8 42	25.0 17	13.2 9
9 Do you think that the hospital can afford the cost involved to strictly monitor all hazardous waste?	35.3 283	37.2 298	27.6 221	58	41.9 72	24.4 42	33.8 108	40.0 128	26.3 84	35.8 29	33.3 27	30.9 25	37.0 50	38.5 52	24.4 33	41.2 28	22.1 15	36.8 25

SA = Strongly Agree
S = Agree
N = Neutral
D = Disagree
SD = Strongly Disagree
M = Missing/Don't Know

QUESTION	ALL RESPONDENTS (n =802) SA	A	N	D	SD	M	PROFESSIONAL (n = 172) SA	A	N	D	SD	M
10 There needs to be more awareness of a) environmental issues	63.5 509	243	3.0 24	.4 3	0 0	2.9 23	62.8 108	31.4	4.7 8	.6 1	0 0	.6 1
b) workplace safety	64.2 515	29.3 235	2.5 20	.4 3	.1 1	3.5 28	59.3 102	35.5 61	4.7 8	0 0	0 0	.6 1
11 Hospitals should be exempt from pollution control legislation	8.1 65	8.1 65	3.4 27	30.3 243	43.0 345	7.1 57	1.2 2	2.3 4	.6 1	30.8 53	62.2 107	2.9 5
12 The following hazardous hospital wastes have a detrimental effect on public health a) chemical	39.9 320	40.4 324	4.9 39	1.4 11	.5 4	13.0 104	40.1 69	46.5 80	4.7 8	0 0	0 0	8.7 15
b) radioactive	47.6 382	32.8 263	4.2 34	1.7 14	.9 7	12.7 102	50.6 87	33.7 58	5.2 9	.6 1	.6 1	9.3 16
c) incineration of chlorinated plastics (PVC)	38.0 305	34.5 277	4.9 39	2.1 17	.5 4	20.0 160	32.0 55	40.1 69	3.5 6	2.3 4	.6 1	21.5 37
13 Hospital policy should identify hazardous waste	61.6 494	33.0 265	.7 6	.4 3	.1 1	4.1 33	62.8 108	36.0 62	.6 1	0 0	0 0	.6 1
14 Records of hazardous material use should be kept by all departments	47.0 377	37.9 304	7.0 56	2.6 21	.6 5	4.9 39	39.0 67	46.5 80	7.0 12	3.5 6	.6 1	3.5 6
15 Staff should be protected against contamination by the toxic wastes generated in hospitals	71.3 572	25.7 206	.9 7	.5 4	0 0	1.6 13	67.4 116	30.8 53	1.2 2	0 0	0 0	.6 1
16 Hospital regulations ensure the safe disposal of: a) halogenated plastic material (PVC)	19.6 157	19.5 156	7.6 61	5.0 40	.9 7	47.5 381	14.0 24	15.7 27	7.0 12	5.2 9	1.7 3	56.4 97
b) organic solvents (eg chloroform)	19.0 152	21.4 172	7.0 56	4.6 37	.5 4	47.5 381	11.6 20	20.3 35	6.4 11	3.5 6	1.2 2	57.0 98
c) cyanides	21.7 174	19.2 154	5.6 45	3.1 25	.1 1	50.2 403	17.4 30	20.9 36	2.3 4	2.3 4	0 0	57.0 98
d) heavy metals (e.g. lead, mercury, barium)	21.9 176	19.6 157	6.0 48	4.4 35	.4 3	47.8 383	17.4 30	19.8 34	2.9 5	4.7 8	0 0	55.2 95
17 All hospital waste should be incinerated	27.3 219	22.3 179	8.4 67	17.8 143	6.0 48	18.2 146	7.6 13	15.7 27	12.8 22	26.7 46	7.6 13	29.7 51
18 All incinerator personnel should possess a certificate of competence	53.1 426	36.8 295	4.2 34	.7 6	.4 3	4.7 38	43.6 75	44.8 77	4.7 8	1.7 3	.6 1	4.7 8
19 Hospital policy addresses the identification and quantification of risk to personnel involved in the handling of waste	21.7 174	27.8 223	4.6 37	5.6 45	2.1 17	38.2 306	14.5 25	24.4 42	7.0 12	4.7 8	4.7 8	44.8 77
20 Waste generated by hospitals has a serious impact on the environment	33.0 265	36.2 290	10.6 85	5.6 45	.9 7	13.7 110	20.3 35	38.4 66	12.8 22	6.4 11	0 0	22.1 38
21 Chlorinated compounds should be incinerated e.g. PVC)	15.8 127	17.1 137	8.5 68	9.9 79	7.4 59	41.4 332	7.6 13	6.4 11	7.6 13	11.6 20	8.7 15	58.1 100
22 Respiratory protection should be provided against toxic dusts for incinerator personnel	58.7 471	32.0 257	1.5 12	1.0 8	.1 1	6.6 53	52.3 90	38.4 66	1.2 2	1.2 2	0 0	7.0 12
23 The following can be disposed of via the sewage system: a) solvents (eg chloroform)	7.1 57	11.6 93	5.7 46	23.6 189	24.3 195	27.7 222	1.2 2	13.4 23	4.7 8	20.3 35	29.1 50	31.4 54
b) acids (eg sulphuric acid)	4.7 38	9.2 74	4.4 35	25.4 204	27.8 223	28.4 228	.6 1	8.7 15	3.5 6	23.3 40	32.0 55	32.0 55
c) antibiotics	6.5 52	18.8 151	7.0 56	20.4 164	20.9 168	26.3 211	1.7 3	18.6 32	7.6 13	19.8 34	23.8 41	28.5 49
d) cytotoxic drugs	3.9 31	6.4 51	5.0 40	21.7 174	29.6 237	33.5 269	1.2 2	7.6 13	4.1 7	21.5 37	34.3 59	31.4 54
24 Clinical waste can be disposed of via the domestic waste system (refuse and sewage)	8.7 70	15.2 122	7.7 62	24.4 196	27.7 222	16.2 130	4.7 8	12.2 21	4.7 8	23.3 40	35.5 61	19.8 34
25 Incinerator residues (ash) should be dealt with as special waste	24.3 195	38.3 307	7.7 62	8.0 64	2.0 16	19.7 158	16.9 29	39.0 67	9.3 16	7.6 13	0 0	27.3 47
26 It is too expensive to provide adequate protection for all personnel involved in handling hazardous material	5.2 42	8.5 68	6.9 55	34.5 277	25.4 204	19.5 156	2.9 5	7.0 12	7.0 12	33.7 58	25.0 43	24.4 42
27 Which of the following methods of clinical hazardous waste disposal do you think is the most efficient? indicate only **one**)												
Commercial waste companies?	57.2	459					65.7	113				
Cement kilns?	5.5	44					3.5	6				
Municipal waste collection?	5.6	45					.6	1				
Own incineration?	22.3	179					18.6	32				
Missing	9.4	75					11.6	20				

QUESTION	NURSING (n = 320) SA	A	N	D	SD	M	ADMINISTRATION (n = 81) SA	A	N	D	SD	M
10 There needs to be more awareness of a) environmental issues	70.0 224	26.3 84	1.6 5	.3 1	0 0	1.9 6	56.8 46	33.3 27	2.5 2	0 0	0 0	7.4 6
b) workplace safety	74.1 237	21.3 68	.6 2	.3 1	0 0	3.8 12	55.6 45	32.1 26	3.7 3	0 0	0 0	8.6 7
11 Hospitals should be exempt from pollution control legislation	12.5 40	10.0 32	5.0 16	35.6 114	29.7 95	7.2 23	6.2 5	7.4 6	4.9 4	34.6 28	32.1 26	14.8 12
12 The following hazardous hospital wastes have a detrimental effect on public health a) chemical	45.3 145	37.5 120	4.7 15	1.6 5	0 0	10.9 35	34.6 28	34.6 28	7.4 6	1.2 1	0 0	22.2 18
b) radioactive	173	31.6 101	3.4 11	2.2 7	.3 1	8.4 27	43.2 35	30.9 25	4.9 4	1.2 1	0 0	19.8 16
c) incineration of chlorinated plastics (PVC)	45.6 146	31.6 101	5.9 19	2.5 8	.3 1	14.1 45	38.3 31	29.6 24	2.5 2	1.2 1	0 0	28.4 23
13 Hospital policy should identify hazardous waste	64.4 206	30.6 98	1.3 4	.6 2	.3 1	2.8 9	51.9 42	30.9 25	1.2 1	0 0	0 0	16.0 13
14 Records of hazardous material use should be kept by all departments	50.6 162	35.9 115	5.9 19	2.5 8	.3 1	4.7 15	48.1 39	35.8 29	2.5 2	4.9 4	1.2 1	7.4 6
15 Staff should be protected against contamination by the toxic wastes generated in hospitals	77.8 249	21.3 68	.3 1	.3 1	0 0	.3 1	67.9 55	24.7 20	1.2 1	0 0	0 0	6.2 5
16 Hospital regulations ensure the safe disposal of: a) halogenated plastic material (PVC)	24.4 78	23.1 74	9.1 29	3.8 12	0 0	39.7 127	16.0 13	19.8 16	6.2 5	4.9 4	1.2 1	51.9 42
b) organic solvents (eg chloroform)	22.8 73	24.7 79	8.4 27	3.8 12	.3 1	40.0 128	16.0 13	17.3 14	7.4 6	3.7 3	1.2 1	54.3 44
c) cyanides	26.3 84	20.0 64	7.8 25	2.2 7	0 0	43.8 140	17.3 14	17.3 14	6.2 5	3.7 3	1.2 1	54.3 44
d) heavy metals (e.g. lead, mercury, barium)	25.9 83	21.3 68	8.1 26	3.4 11	0 0	41.3 132	18.5 15	17.3 14	6.2 5	3.7 3	1.2 1	53.1 43
17 All hospital waste should be incinerated	41.9 134	26.3 84	3.8 12	12.8 41	4.4 14	10.9 35	28.4 23	19.8 16	16.0 13	12.3 10	4.9 4	18.5 15
18 All incinerator personnel should possess a certificate of competence	64.7 207	30.0 96	1.6 5	.3 1	0 0	3.4 11	45.7 37	37.0 30	8.6 7	1.2 1	1.2 1	6.2 5
19 Hospital policy addresses the identification and quantification of risk to personnel involved in the handling of waste	26.9 86	31.6 101	3.8 12	5.3 17	.9 3	31.6 101	14.8 12	24.7 20	2.5 2	3.7 3	2.5 2	51.9 42
20 Waste generated by hospitals has a serious impact on the environment	47.8 153	33.8 108	7.5 24	4.4 14	.3 1	6.3 20	27.2 22	34.6 28	11.1 9	9.9 8	0 0	17.3 14
21 Chlorinated compounds should be incinerated e.g. PVC)	23.1 74	25.9 83	7.5 24	5.6 18	5.6 18	32.2 103	16.0 13	13.6 11	9.9 8	12.3 10	4.9 4	43.2 35
22 Respiratory protection should be provided against toxic dusts for incinerator personnel	65.6 210	28.8 92	.3 1	.6 2	.3 1	4.4 14	56.8 46	24.7 20	3.7 3	1.2 1	0 0	13.6 11
23 The following can be disposed of via the sewage system: a) solvents (eg chloroform)	12.5 40	14.7 47	7.8 25	26.9 86	18.8 60	19.4 62	3.7 3	8.6 7	6.2 5	18.5 15	23.5 19	39.5 32
b) acids (eg sulphuric acid)	7.2 23	11.3 36	5.3 17	30.3 97	25.6 82	20.3 65	2.5 2	6.2 5	5	17.3 14	27.2 22	40.7 33
c) antibiotics	10.3 33	25.0 80	8.1 26	21.9 70	17.5 56	17.2 55	2.5 2	14.8 12	7.4 6	16.0 13	23.5 19	35.8 29
d) cytotoxic drugs	5.0 16	9.7 31	6.9 22	24.1 77	27.8 89	26.6 85	1.2 1	4.9 4	3.7 3	16.0 13	27.2 22	46.9 38
24 Clinical waste can be disposed of via the domestic waste system (refuse and sewage)	14.7 47	18.4 59	11.6 37	25.0 80	20.6 66	9.7 31	1.2 1	14.8 12	9.9 8	18.5 15	29.6 24	25.9 21
25 Incinerator residues (ash) should be dealt with as special waste	31.3 100	37.5 120	6.9 22	8.8 28	2.8 9	12.8 41	18.5 15	43.2 35	4.9 4	6.2 5	1.2 1	25.9 21
26 It is too expensive to provide adequate protection for all personnel involved in handling hazardous material	7.2 23	8.8 28	7.8 25	34.7 111	27.2 87	14.4 46	4.9 4	6.2 5	9.9 8	29.6 24	22.2 18	27.2 22
27 Which of the following methods of clinical hazardous waste disposal do you think is the most efficient? indicate only **one**)												
Commercial waste companies?	50.9	163					51.9	42				
Cement kilns?	5.6	18					13.6	11				
Municipal waste collection?	8.4	27					4.9	4				
Own incineration?	27.2	87					19.8	16				
Missing	7.8	25					9.9	8				

QUESTION	TECHNICAL (n = 135) SA	A	N	D	SD	M	GENERAL (n = 68) SA	A	N	D	SD	M
10 There needs to be more awareness of a) environmental issues	59.3 80	35.6 48	4.4 6	0 0	0 0	.7 1	48.5 33	32.4	4.4 3	1.5 1	0 0	13.2 9
b) workplace safety	60.7 82	33.3 45	2.2 3	.7 1	.7 1	2.2 3	51.5 35	38.2 26	2.9 2	0 0	0 0	7.4 5
11 Hospitals should be exempt from pollution control legislation	3.0 4	4.4 6	2.2 3	23.7 32	62.2 84	4.4 6	19.1 13	25.0 17	4.4 3	22.1 15	13.2 9	16.2 11
12 The following hazardous hospital wastes have a detrimental effect on public health a) chemical	35.6 48	43.0 58	3.7 5	1.5 2	2.2 3	14.1 19	26.5 18	41.2 28	7.4 5	2.9 2	1.5 1	20.6 14
b) radioactive	37.8 51	38.5 52	3.7 5	1.5 2	3.0 4	15.6 21	32.4 22	30.9 21	4.4 3	2.9 2	1.5 1	27.9 19
c) incineration of chlorinated plastics (PVC)	31.1 42	38.5 52	5.9 8	1.5 2	.7 1	22.2 30	27.9 19	35.3 24	2.9 2	1.5 1	1.5 1	30.9 21
13 Hospital policy should identify hazardous waste	62.2 84	35.6 48	0 0	.7 1	0 0	1.5 2	55.9 38	32.4 22	0 0	0 0	0 0	11.8 8
14 Records of hazardous material use should be kept by all departments	45.2 61	39.3 53	10.4 14	2.2 3	.7 1	2.2 3	47.1 32	30.9 21	10.3 7	0 0	1.5 1	10.3 7
15 Staff should be protected against contamination by the toxic wastes generated in hospitals	68.1 92	28.9 39	.7 1	1.5 2	0 0	.7 1	61.8 42	29.4 20	2.9 2	0 0	0 0	5.9 4
16 Hospital regulations ensure the safe disposal of: a) halogenated plastic material (PVC)	17.0 23	20.0 79	8.1 11	7.4 10	.7 1	48.9 66	17.6 12	22.1 15	0 0	5.9 4	1.5 1	52.9 36
b) organic solvents (eg chloroform)	17.0 23	20.0 79	8.1 11	7.4 10	0 0	47.4 64	20.6 14	19.1 13	0 0	5.9 4	0 0	54.4 37
c) cyanides	20.0 27	17.0 23	7.4 10	4.4 6	0 0	51.1 69	14.7 10	19.1 13	0 0	4.4 3	0 0	61.8 42
d) heavy metals (e.g. lead, mercury, barium)	20.0 27	17.0 23	7.4 10	5.9 8	.7 1	48.9 66	17.6 12	23.5 16	0 0	4.4 3	1.5 1	52.9 36
17 All hospital waste should be incinerated	16.3 22	17.0 23	9.6 13	25.9 35	7.4 10	23.7 32	33.8 23	35.3 24	7.4 5	7.4 5	1.5 1	14.7 10
18 All incinerator personnel should possess a certificate of competence	47.4 64	43.7 59	5.9 8	0 0	.7 1	2.2 3	42.6 29	33.8 23	5.9 4	1.5 1	0 0	16.2 11
19 Hospital policy addresses the identification and quantification of risk to personnel involved in the handling of waste	15.6 21	28.9 39	6.7 9	8.9 12	1.5 2	38.5 52	32.4 22	25.0 17	0 0	4.4 3	1.5 1	36.8 25
20 Waste generated by hospitals has a serious impact on the environment	19.3 26	38.5 52	16.3 22	6.7 9	3.0 4	16.3 22	38.2 26	38.2 26	5.9 4	2.9 2	1.5 1	13.2 9
21 Chlorinated compounds should be incinerated e.g. PVC)	5.9 8	12.6 17	10.4 14	18.5 25	8.9 12	43.7 59	23.5 16	22.1 15	8.8 6	5.9 4	2.9 2	36.8 25
22 Respiratory protection should be provided against toxic dusts for incinerator personnel	63.7 86	30.4 41	3.0 4	.7 1	0 0	2.2 3	35.3 24	45.6 31	0 0	1.5 1	0 0	17.6 12
23 The following can be disposed of via the sewage system: a) solvents (eg chloroform)	4.4 6	3.7 5	3.0 4	27.4 37	31.9 43	29.6 40	8.8 6	14.7 10	5.9 4	14.7 10	14.7 10	41.2 28
b) acids (eg sulphuric acid)	5.2 7	6.7 9	3.0 4	26.7 36	31.9 43	26.7 36	7.4 5	8.8 6	2.9 2	17.6 12	14.7 10	48.5 33
c) antibiotics	5.9 8	11.1 15	4.4 6	24.4 33	24.4 33	29.6 40	8.8 6	13.2 9	7.4 5	13.2 9	11.8 8	45.6 31
d) cytotoxic drugs	4.4 6	1.5 2	3.0 4	24.4 33	32.6 44	34.1 46	8.8 6	1.5 1	4.4 3	14.7 10	11.8 8	58.8 40
24 Clinical waste can be disposed of via the domestic waste system (refuse and sewage)	4.4 6	9.6 13	5.2 7	29.6 40	35.6 48	15.6 21	11.8 8	19.1 13	2.9 2	22.1 15	14.7 10	29.4 20
25 Incinerator residues (ash) should be dealt with as special waste	22.2 30	37.0 50	10.4 14	9.6 13	2.2 3	18.5 25	22.1 15	39.7 27	5.9 4	4.4 3	2.9 2	25.0 17
26 It is too expensive to provide adequate protection for all personnel involved in handling hazardous material	3.7 5	6.7 9	5.2 7	39.3 53	30.4 41	14.8 20	5.9 4	19.1 13	1.5 1	36.8 25	10.3 7	26.5 18
27 Which of the following methods of clinical hazardous waste disposal do you think is the most efficient? indicate only **one**)												
Commercial waste companies?	60.0	81					58.8	40				
Cement kilns?	5.2	7					1.5	1				
Municipal waste collection?	3.0	4					13.2	9				
Own incineration?	20.7	28					22.1	15				
Missing	11.1	15					4.4	3				