COMPOSITION AND GENERATION OF HEALTH CARE WASTE IN SOUTH AFRICA

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ABOUT THE SPEAKER

Mr Kristiansen has vast experience in waste management - including hazardous/infectious waste, sanitary engineering, water supply and environmental. He has, among others, been posted in Egypt for more than 1½ year and in South Africa for 3 years managing comprehensive large-budget health care waste management projects including capacity building, development of policies, strategies and guidelines as well as practical implementation of technical and training solutions with procurement, supervision and commissioning of treatment plants and waste handling equipment. Furthermore, he has been on several missions to South East Asia and to Southern Africa on assignments and project preparation missions and he has substantial experience in Eastern and Central Europe from several assignments in the region, including Russia, Ukraine, Belarus, Moldova, Latvia, Lithuania, Poland and Hungary.

Dr. Moeketsane Eugenius Senaoana is a highly experienced statistician for DMSA and has carried out numerous comprehensive data analyses assignments within several fields of activity.

ABSTRACT

A comprehensive sampling and sorting of health care waste has been conducted in Gauteng three times each time for a period of 14 consecutive days. This was done for the purpose of quantifying the impact of interventions in the management of health care risk waste (medical waste) at a 720 bed pilot project hospital in Gauteng. The study included three separate sampling periods during the period 22 July 2002 - 10 June 2003:

(1) Pre-intervention sampling of Health Care Waste at Leratong Hospital 22 July to 02 August 2002.
(2) Sampling of HCRW from private and public health care facilities at an incinerator located in Roodepoort (Johannesburg) 19 August to 30 August 2002.
(3) Post-intervention sampling of Health Care Waste at Leratong Hospital 26 May – 10 June 2003

It is believed that it is the first time that such a comprehensive composition study has been conducted in Southern Africa and possibly on the continent as a literature review has not revealed any similar data from the continent.

The results of the study show that there is a critical and significant mis-segregation of health care waste occurring today and, hence, a considerable scope for improving the safety, health and financial impacts of health care waste management if segregation is addressed more efficiently. Furthermore, the post-intervention study demonstrates that very significant improvements in the segregation and containerisation of health care waste can be achieved by a combination.

COMPOSITION AND GENERATION OF HEALTH CARE WASTE IN SOUTH AFRICA

INTRODUCTION

DACEL has commissioned a comprehensive HCW Composition and Generation Study that has been conducted in conjunction with health care waste management pilot projects.

The objectives of the study were to:

(1) Assess the pre-and post intervention efficiency of the health care waste segregation and compare that against the general segregation efficiency for public and private health care facilities in Gauteng in general
(2) Assess the scope for reducing quantities of HCRW requiring expensive containerisation and treatment by improving the availability of containerisation and receptacles and staff awareness of correct waste segregation principles
(3) Assess the impact of the interventions made at Leratong Hospital in terms of the waste segregation efficiency
(4) Determine the main constituents and the composition and generation rates for health care risk waste requiring special treatment and health care general waste being disposed to communal landfills

The Study is providing detailed information, based on actual sorting of waste, on the segregation efficiency, waste composition and waste generation at Leratong Hospital for both HCRW and HCGW as well as information on the segregation efficiency and waste composition of HCRW generated by both private and public hospitals in Gauteng in general via sampling at a central treatment plant. The pictures below show the sorting process in progress.

Sampling of HCGW and HCRW generated at Leratong Hospital took place in July and August 2002 before the implementation of the pilot activities. The sampling at Leratong Hospital was repeated 26 May – 9 June 2003 to monitor the impact of the interventions on segregation efficiency, waste generation and composition. The sampling of HCRW from both public and private hospitals at a central treatment plant in Gauteng took place in August and September 2002

Numerous documents, photos, video sequences etc. including the complete report on the health care waste generation and composition study are available for download at www.csir.co.za/ciwm/hcrw and at a later stage from www.dacel.gpg.gov.za

INTERNATIONAL DATA AVAILABLE ON HEALTH CARE WASTE COMPOSITION

A review of various sources from the internet and various publications by the WHO and various international development organisations shows that only very few health care waste composition studies have been conducted internationally and so far none in Africa.

Generally, there is much difference in the use of nomenclature for the waste fractions and it seems that in some studies it was indiscriminate disposal of both the infectious and the non-infectious part of the total waste stream, whereas in other studies only the segregated “infectious” waste stream was subjected to the sampling. Most studies have focused on the constituents such as paper, plastic, glass etc. whereas the sampling that was conducted for this study focused on the parameters that would indicate the level of correct segregation. The purpose of composition studies carried out also varies internationally where, for example, studies focusing on the constituents such as paper, plastic, rubber, metal etc. are mostly carried out for the purpose of assessing the calorific value of the health care risk waste to enable engineers to design incinerators for a particular thermal loading, studies like this one in Gauteng, was conducted to assess the risks associated with the waste management system, the level of mis-segregation and the scope for improving segregation and possibly saving costs by avoiding general waste in the health care risk waste stream.

It is therefore difficult to compare the results of composition studies conducted under very different socio-economic and infrastructural conditions without carefully assessing the context. This paper will not attempt to do such a comparison.

It is believed that especially in the urban regions of Southern Africa the results of the Gauteng study would be representative, as there seems to be a similar approach to containerisation and colour coding throughout the region.

Table 1 below shows a brief summary of findings of some composition studies identified in the literature review.

Table 1: *Results of Various International HCW Composition Studies.*

Material	HCRW	HCRW	HCRW	HCRW	HCRW	HCRW	HCRW	HCRW	HCW	HCW	HCGW
	% w/w	% w/w	% w/w	% w/w	% w/w	% w/w	% w/w	% w/w	% w/w	% w/w	% w/w
	Vietnam	Thailand	Italy	USA	China	China	China	USA	Nepal (11 hospitals)	India (10 hospitals)	USA
Year	**1998**	**2002**	**1992**	**1997**	**1993**	**1993**	**1993**	**1989**	**1997**	**1993-96**	**1989**
Paper&cardboard	0.8		34.0	45.0	16.0	34.0	51.0	31.0		15.0	39.0
Plastic	10.1	14.3	46.0	15.0	50.0	21.0	18.0	29.0		10.0	20.0
Rubber	-	19.3						12.0			1.4
Textiles	-	16.3			10.0	14.0	2.0	5.0		15.0	2.1
Food				10.0	21.0	17.0	7.0	1.0			11.7
Yard waste	-			3.0							2.0
Glass	20.9		7.5	7.0	1.0	11.0	8.0	3.2		4.0	4.8
Metals	2.9	18.2	0.4	10.0	0.5	1.0	9.0	1.1		1.0	7.2
Fluids			12.0					17.7			9.9
Misc. Organics	52.9		0.1	10.0	1.5	2.0	5.0				1.9
Anatomical	0.6	15.4	0.1								
Infections waste	12.0	16.6							30.2%	1.5	
General Waste									69.8%	53.5	
TOTAL	**100.2**	**100.0**	**100.1**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0%**	**100.0**	**100.0**
Reference:	Source: Report on " Medical Waste Management " by Ministry of Health (MoH) - 1998	http://www.ojhas.org/issue3/suwannee/suwa.htm	Liberti L et al. (1994). Optimization of infectious hospital waste management in Italy. Part I: Waste production and characterization study. Waste management and research, 12(5): 373–385. Quoted in A. Prüss "Safe management of wastes from health-care activities	Robert Fenwick AHA Conf. 5/91. http://uvmce.uvm.edu:443/hlthcare/impact/EPA-HOLLY/index.htm , cleduc@zoo.uvm.edu, 12/22/1997	Chih-Shan L, Fu-Tien J (1993). Physical and chemical composition of hospital waste. Infection control and hospital epidemiology, 14(3):145–150. Quoted in A. Prüss "Safe management of wastes from health-care activities	Chih-Shan L, Fu-Tien J (1993). Physical and chemical composition of hospital waste. Infection control and hospital epidemiology, 14(3):145–150. Quoted in A. Prüss "Safe management of wastes from health-care activities	Chih-Shan L, Fu-Tien J (1993). Physical and chemical composition of hospital waste. Infection control and hospital epidemiology, 14(3):145–150. Quoted in A. Prüss "Safe management of wastes from health-care activities	Brown (1989):H L Brown, Thomas Jefferson University Hospital Waste Characterisation Study, Drexel University, 1989	Khatmandy Valley Study. Cf. "Concept paper on health care waste management", Bimala Shresta, Department of Community Medicine & Family Health, Tribhuwan University Teaching Hospital, March 1997.	National Environmental Engineering Research Institute. Quoted in A. Prüss "Safe management of wastes from health-care activities	Brown (1989):H L Brown, Thomas Jefferson University Hospital Waste Characterisation Study, Drexel University, 1989

It appears from Table 1 that the use of nomenclature and the way of classification differs much between the different studies and particular care should be taken when concluding based on these results unless there is detailed information available about the actual classification used and the approach to the study.

METHODOLOGY

<u>Overall Study Concept</u>

The overall study concept consist of the following key components:

(1) Random sampling on a daily basis over a period of 14 consecutive days during a period where there are no public holidays or other unusual events.

(2) The numbers of samples were determined to allow for a manageable and affordable workload for the sorting team while allowing for all samples to be processed within a 24-hour period and resulting in an acceptable level of precision. 10 daily random samples of each type of receptacle. If the total population of a certain category is less than 10 the entire population is sampled. This results in between 6.5-10% level of precision (d) where

$$n = \frac{(z_{\alpha/2}\sigma)^2}{d^2}$$ with 95% confidence level

(3) Sampled receptacles for pathological waste were not emptied and sorted in detail for obvious reasons but only visually checked without manipulating the contents to assess if

the contents were indeed pathological waste. All other sampled receptacles were opened and emptied and sorted completely

(4) Waste from specialised services within the hospital that are outsourced to third parties namely i) the blood bank, ii) the laboratory as well as iii) segregated recyclables being collected by recyclers (cardboard and plastic jerry cans) was weighed on a daily basis but not sampled from.

(5) The total waste generation, including all types of solid waste, was weighed on a daily basis

Hazmat Support Services, a subsidiary of Enviroserve Pty Ltd, was appointed to carry out the physical sorting while DMSA, the Specialist in Data Management and Statistical Analysis, was appointed to carry out the statistical data analyses and reporting.

Occupational Health and Safety

Due to the nature of the waste and the risk of serious physical and emotional stress, injuries and infection there was an enormous focus on the occupational health and safety at all stages of the process. The main activities and policies in this regards included:

(1) All personnel on site were extensively trained in the risks, the types of waste, it's constituents, reporting and actions required in case of incidents

(2) All personnel on site went through an inoculation programme prior to the commencement of work. .

(3) The work place was divided into a 'Cold Zone' (no precautions and street clothes can be worn), a 'Warm Zone' (changing area for staff) and a 'Hot Zone' (Area where physical sorting takes place). After work or before breaks the workers would pass through the 'Decontamination Zone' that allowed for disinfection of all footwear, gloves and outer clothing.

(4) In the 'Warm Zone' all personnel would wear complete full-face respiratory protection, with air supplied from external compressors, and sealed disposable full-body suits taped to rubber boats and rubber gloves. Passage between the 'Warn Zone' and the 'Hot Zone' was via a basin of disinfectants where spraying down of the full-body suits was possible

(5) A specialised medical practitioner was on call and inspected the workplace and the use of protective equipment

(6) A strict policy of 'no touch'. I.e. all items were handled using tweezers and scopes with long handles. No handling of waste items by gloved hands was allowed with the exception of the actual outer receptacles containing the samples

(7) Forms used for recording observations in the 'Warm Zone' where photocopied to clean pages and the photocopiers glass was disinfected. Potentially contaminated pages are kept safely for clarification purposes only and further processing was done via the clean sheets.

(8) All samples were disposed in the incineration located at the sorting site immediately after processing of the samples

The main occupational concerns were the possible contraction of HIV/AIDS and Hepatitis B as well as other possible diseases. Internationally there is still limited data on the actual rate of infection for these diseases, however, it seems that various international studies support that 0.3% of persons exposed to a needle stick injury from a know HIV/AIDS infected person will contract HIV/AIDS whereas the rate for Hepatitis B is as high as 30% (Ref. 4). Both of these diseases are incurable.

Picture 2: *Selected photographs from the site of waste sorting (Roodepoort, Johannesburg)*

More than 2100 samples were processed over a total of 42 working days during the period July 2002 – June 2003. Unfortunately one unsafe incident did occur during this period where one staff member suffered a needle stick injury due to a needle being stuck to the bottom of a disposable cardboard box. The contingency plan for such occurrences was immediately put to use, including anti-retroviral treatment and we are glad to report that with more than 12 months having passed since the incident all medical check have shown that no infections have been caused by the incident.

Sampling for the Medical waste study

In the planning of sample surveys a decision had to be made about the size of the sample to be included in the study. This is a very important decision as too large a sample could result in poor utilization of resources and too small a sample will tend to give results of insufficient precision and hence diminish the usefulness of the results. Sampling theory provides a framework within which sample sizes can be determined scientifically.

The sample size of each type of container is calculated on the basis of statistical criteria and assumptions made by the investigator. In what follows it is assumed that the unit cost of sampling is the same for all types of containers and that the i-th waste component of the waste mixture is reported in terms of the proportion of containers in which this component is present.

Generally speaking, the precision of the sample is related to the absolute sample size and not to the ratio of the sample size to the population size. The sample size, n, for any type of container is, therefore, as follows:

$$n = \frac{(z_{\alpha/2}\sigma)^2}{d^2} \qquad (1.0)$$

where:

$\mathbf{z}_{\alpha/2}$ is the standard normal variate corresponding to the desired confidence probability (usually $z_{\alpha/2}$=2 for approximately 95% confidence);

σ is the (unknown) population standard deviation of the component. For the proportion of containers containing this component, $\sigma = \sqrt{p(1-p)}$ where **p** is the (unknown) true fraction/ proportion of the medical waste component in the population. In each case we will estimate the unknown parameter from its sample equivalent;

d is the desired precision. This is the range of uncertainty in the estimated fraction of the waste component one is prepared to accept at the specified level of confidence.

For simplicity we use the following parameters for calculation of the sample sizes:

$z_{\alpha/2}$=2 , **p** =0.5 (2.0)

This value of **p** gives a conservative estimate of the sample size.

The following table illustrates the calculation of sample sizes for various precision levels, d.

Table 3: *Calculation of a Sample Size for a given Precision Level*

Precision, d	Sample Size: $n=4*0.025/d^2$
0.14	51
0.100	100
0.071	199
0.058	298
0.05	400

In what follows we outline the sample design for the HCW pilot study to be conducted at the two facilities over a 2-week period: Leratong Hospital and a Treatment Facility.

We sampled 10 containers of each type every day for 2 weeks. This gave a total sample of 120-140 of each type for the hospital in 10, 12 or 14 days. According to Table 2 the sample size, n=100 for each type of container will give a 10% level of precision, or better, when estimating the waste component fraction.

If less than 10 containers of any type is available a day, then all the containers of that type should be taken

For the sampling at the treatment facility the HCRW delivered for incineration comes from both private and public health care facilities. Since a large amount of waste was delivered daily to the treatment facility (over the 12-day period) we proposed that a sample size of 120 containers (10 a day) of each type should be taken for 2 weeks (12 days) from each facility (private and public). That is, a total sample of 240 containers of each type delivered to the treatment facility should be taken. This provided a 6.5% level of precision or better when estimating the given medical waste component fraction.

Selecting Samples

An important aspect of sampling is to ensure that it is valid to extrapolate the conclusions drawn from the results to the population. The selected samples should, therefore, be representative of the population. To ensure a representative selection, samples should be taken randomly from all the containers of the same type/size category in the storage facility. If necessary, the containers could all be numbered and a random sample selected. A small program generating random numbers was developed.

Similarly, 10 HCRW containers of a given type from the public health facilities and 10 from the private health facilities delivered to the treatment facility should be sampled at random each day and analysed for a period of 12 days.

Table 4: *Proposed Daily Sorting Samples sizes*

Container type	**Daily Sample**		
	Leratong Hospital	Treatment Facility	
		Public Health Facility	**Private Health Facility**
5 L Sharps	10	10	10
10 L Sharps:	10	10	10
25 L Sharps	10	10	10
10 L Specican (Pathological waste)	10	10	10
50 L Cardboard box *(or bags from stackable boxes in post intervention study)*	10	10	10
140 L Cardboard box *(or bags from wheelie bins in post interventions study)*	10	10	10
General waste bags	10	not applicable	not applicable

For analysis purposes a comprehensive list of waste components that broadly defines the component categories is given in Table 4. Sampling for Leratong hospital was done at the premises of the facilities and then taken to the site designated for sorting. HCW containers of different types were numbered and marked.

Sorting and weighing of HCW took place at the incinerator at Roodepoort. Sampling was performed each day shortly before the waste removal truck arrives, when all the waste containers generated on that day were available.

Sorting and weighing procedures

For waste sorted from receptacles for general infectious waste (50 litre and 142 litre boxes or reusable containers)

- All waste to be sorted and each category should be weighed;
- Super mix and fines to be recorded in its appropriate category;
- Liquids to be recorded with the mass of the container included and then the tare mass estimated and subtracted to determine the net mass.
- PVC contents to be separated and recorded by mass (if possible) after various categories are all weighed;
- Sealed sharps containers and “specicans”/containers for pathological/anatomical waste are to be removed from the larger containers for separate analysis in the particular categories.

For waste sorted from sharps containers (e.g. 5 litre, 10 litre and 20 litre)

- Non-sharps are to be removed from stream and weighed and counted (to provide a measure of how many incorrect objects there are per sharps container);
- Super mix and fines should be recorded in its appropriate category;
- The balance of the HCW stream is then recorded as sharps and weighed. The net mass should be determined accordingly.

For waste sorted from specican containers (buckets: 5 litre, 10 litre and 20 litre)

- Containers are to be investigated against strong light (without opening) or visually inspected from the top opening of the container to assess if the contents are: i) mostly liquid, ii) mostly solids, and iii) appears to contain correctly sorted anatomical/pathological waste.
- The total mass of the Specican and its contents is to be recorded
- The number of Specicans containing incorrect waste components are to be recorded

For Health Care General Waste (e.g. from black plastic bags, but excluding separately sorted foodstuff)

- All waste to be sorted and each category (HCGW and HCRW) should be weighed;
- Super mix and fines to be recorded in its appropriate category;
- Liquids to be recorded with the mass of the container included and then the tare mass subtracted to determine the net mass
- PVC contents do not need to be separated and recorded as the HCGW and should not be incinerated.

For Food Waste only: No sorting at all. Only weighing of daily generation.

It may not be advisable (for safety purposes) to open and segregate the contents of some containers such as those containing pathological waste. In this case only the mass and the contents should be recorded.

On completion of daily studies, clean the sorting area and all equipment used. The area should be disinfected for public health reasons.

It should be noted that at Leratong hospital the Lab is a separate entity being serviced by Sanumed and not by Buhle Waste. The blood bank in turn is a separate entity managed by the SA Blood Transfusion services, who transfer all HCRW to their main office from where it is disposed of by DisposTech. Therefore HCW from these sources was clearly identified. The weighing of all HCRW generated also included the amounts generated at the Blood bank and the Laboratory at Leratong Hospital.

Trial Study

In order to assess the feasibility of the study as well as testing the survey equipment a trial studies of the two health facilities and the treatment facility was be undertaken. Trial study at Leratong hospital was done one week prior to the main study. One day of sorting and recording was carried out to test the procedures.

Training of sorting personnel

For efficient and safe conduct of the study a comprehensive training programme was prepared for the sorting personnel. Trainers qualified in sampling and surveys and in HCW should were engaged in the training of the sorting personnel. From a statistical perspective the whole process of sampling, sorting and recording of the data was covered. The importance of selecting representative samples and accuracy in recording the masses was stressed as well as the obvious occupational and safety issues.

Separate, pre-printed sheets were available for each type/size of container. A broad description of waste component/categories is given in Table 4 below.

Table 5: *Description of Waste Component Categories*

Waste Category	Description
General Infectious waste	Bandages, gloves, drip bags, urine bags, containers with blood products, used vacutainers, non-glass test tubes, petri dishes etc.
Pathological waste	Body Tissue including its packaging
Sharps	Needles + Syringes, Scalpels, Broken or unbroken glass (test tubes, petri dishes, vials, ampoules) etc.
Chemical waste	Pharmaceutical Waste, Chemical waste, e.g. from Labs. Thermometers, batteries and other heavy metal containing waste
Health care general waste (HCGW)	Packaging materials, flowers, and magazines, including packaging material from disposable syringes, drips etc.
Food waste	Any putrecible materials of food origin
Radioactive Waste	Detected with "dose rate meter".

RESULTS

Baseline Results from the Private and Public Health Care Facilities in Gauteng

The baseline study was intended to establish the average current segregation efficiency and waste composition for health care risk waste in Gauteng. A Study conducted in 2000 (Ref. 1) has estimated to the total HCRW generation in Gauteng at approx 1200 tonnes per month including both large and small generators such as undertakers, laboratories, vets, tattoo artists etc.

Table 6: *Result of 14 day sampling of HCRW from Public Hospitals and Clinics in Gauteng at Central Incinerator totals refer to the*

Public Health Facilities in Gauteng	**Incorrectly Disposed**		**Correctly Disposed**			
Health Care Risk Waste Only	**HCGW**	**Other HCW**	**Infectious**	**Pathological**	**Sharps**	**Total**
Container Type	**kg/Day**	**kg/Day**	**kg/Day**	**kg/Day**	**Kg/Day**	**kg/Day**
General Infectious Waste	2556.9	2026.62	3684.94	.	.	8268.46
Sharps Containers	3.98	72.34	.	.	54.66	130.98
Anatomical W Containers	.	.	.	97.19	.	228.17
Total	2560.88	2098.96	3684.94	97.19	54.66	8627.61
Percent	**29.68%**	**24.33%**	42.71%	1.13%	0.63%	100.00%

Table 7: *Result of 14 day sampling of HCRW from Private Hospitals and Clinics in Gauteng at Central Incinerator*

Private Health Facilities in Gauteng	**Incorrectly Disposed**		**Correctly Disposed**			
Health Care Risk Waste Only	**HCGW**	**Other HCW**	**Infectious**	**Pathological**	**Sharps**	**Total**
Container Type	**kg/Day**	**kg/Day**	**kg/Day**	**kg/Day**	**kg/Day**	**kg/Day**
General Infectious Waste	1705.37	576.8	4226.07	.	.	6508.24
Sharps Containers	13.07	395.2	.	.	325.9	734.17
Specican Containers	13.89	22.12	.	13.94	.	784.12
Total	1732.33	994.12	4226.07	13.94	325.9	8026.53
Percent	**21.58%**	**12.39%**	52.65%	0.17%	4.06%	100.00%

Pre- and Post-intervention Results from Leratong Hospital

Table 8 below shows the main results of both the pre-intervention and the post-intervention studies for easy comparison or the proportions of mass for each sub/category in both studies.

Table 8: *Pre- and Post Intervention Results from Leratong Hospital*

		Pre-Intervention Study				**Post-Intervention Study**			
Waste Type	**Waste Component**	**N**	**Proportion**	**Total Mass**	**Mass/day**	**N**	**Proportion**	**Total Mass**	**Mass/day**
General Infectious Waste	**Infectious**		0.74173		224.62		0.92722		276.54
	Sharps		0.00120		0.36		0.00117		0.35
	Chemical		0.00490		1.49		0.00006		0.02
	HCGW	120	0.25216	3634.00	76.36	204	0.06363	4175.39	18.98
	Sealed Sharps		.		.		0.00782		2.33
	Other(Not specified systems		0.00000		0.00		0.00010		0.03
	Total Correct (Infectious)	**120**	**0.74173**	**3634**	**224.62**	**204**	**0.92722**	**4175.39**	**276.54**
	Total Incorrect		**0.25826**		**78.21**		**0.07278**		**21.71**
Sharps	**Infectious**		0.12055		2.40		0.21478*		0.44
	Sharps	71	0.85891	238.55	17.07	94	0.77509*	29.00	1.61
	Chemical		0.01992		0.40		0.00074		0.00
	HCGW		0.00061		0.01		0.00940		0.02
	Total Correct (Sharps)	**71**	**0.85891**	**238.55**	**17.07**	**94**	**0.77509**	**29.00**	**1.61**

		Pre-Intervention Study				Post-Intervention Study			
Waste Type	Waste Component	N	Proportion	Total Mass	Mass/day	N	Proportion	Total Mass	Mass/day
	Total Incorrect		**0.14109**		**2.80**	**94**	**0.22491**		**0.47**
Specican & Amputations	**Pathological**	13	1.00000	67.45	5.62	31	1.00000	232.95	16.64
	Other	1	1.00000				0.00000		0.00
General Waste (HCGW)	**Infectious**	120	0.04352	21526.	78.07	129	0.02477	26968.0	47.72
	Sharps		0.00000		0.00		0.00065		1.26
	Chemical		0.00108		1.94		0.00011		0.21
	HCGW		0.95540		1713.86		0.97071		1869.86
	Other		0.00000		0.00		0.00376		7.24
	Total Correct (HCGW)	**120**	**0.9554**	**21526.5**	**1713.87**	**129**	**0.97071**	**26968**	**1869.86**
	Total Incorrect		**0.0446**		**80.01**		**0.02929**		**56.42**
Lab, Morgue & Blood Waste	**Lab**			165.65	13.80	56		259.38	18.53
	Morgue			116.65	9.72			198.62	14.19
	Blood			82.45	6.87			31.38	2.24
Pigswill	**Drums**			2072.70	172.73			2174.00	155.29
Vials	**Vials**			.	.			37.00	2.64
Grand-total				**27903.45**	**2325.32**			**34105.72**	**2436.13**

*NOTE: *) Due to the change in procedure for the handling of vials an error has occurred. The new procedure included separation of whole, empty and unbroken vials for placement is special containers for subsequent recycling/landfilling. However, there where some vials placed in the sharps containers. In the study these vials where erroneously classified as misplaced infectious waste, whereas, it should have been classified as correctly placed sharps. Hence, the sum of "infectious" and "sharps" needs to be considered when comparing to the Pre-interventions data. In our assessment and supported by numerous inspections in the wards, the amount of misplaced "infectious waste" had been significantly reduced. It is not unlikely that the real proportion of "infectious" in the sharps containers have been reduced from approx 12% in the pre-intervention study to perhaps 6% in the post intervention study. Hence, it can be assumed that the remaining part of the "infectious" was indeed the very heavy glass vials that should have been classified as correctly placed "sharps".*

Table 9 below shows the total waste generation over the 2-weeks sampling period for both the pre- and the post-intervention studies as well as the relative waste generation per patient per day.

Table 9: *Total mass (kg) estimated over the sample period - mass /day*

Leratong Pre- and Post-Intervention Studies												
Waste Type	Waste Disposal											
	Correctly Disposed				Incorrectly Disposed				Total			
	HCGW		HCRW		HCGW		HCRW		HCGW		HCRW	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
General Infectious Waste	0.00	0.00	224.62	276.54	76.36	18.98	1.85	2.73	76.36	18.98	226.47	279.27
Sharps	0.00	0.00	17.04	1.61	0.01	0.02	2.79	0.45	0.01	0.02	19.83	2.06
Laboratory	0.00	0.00	13.80	18.53	0.00	0.00	0.00	0.00	0.00		13.80	18.53
Morgue	0.00	0.00		14.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.19
Specican & Amputations	0.00	0.00	5.62	16.64	0.00	0.00	0.00	0.00	0.00	0.00	5.62	16.64
Blood bank	0.00	0.00	6.87	2.24	0.00	0.00	0.00	0.00	0.00	0.00	6.87	2.24
Sub-total	0.00	0.00	267.95	329.75	76.37	19.00	4.64	3.18	76.37	19.00	272.59	332.93
Percentage	0%	0%	76.79%	93.70%	21.89%	5.40%	1.33%	0.90%	21.89%	5.40%	78.11%	94.60%
General Waste (HCGW)	13.86	1869.86	0	0	0	0	80.01	56.43	1713.86	1869.86	80.01	56.43
Percentage	.50%	97.07%	0%	0%	0%	0%	4.50%	2.93%	95.50%	97.07%	4.50%	2.93%
GRAND TOTAL	1713.86	1869.86	267.95	329.75	76.37	19.00	84.65	59.61	1790.23	1888.86	352.60	389.36
Percentage	.98%	82.08%	12.50%	14.47%	3.56%	0.83%	3.95%	2.62%	83.55%	82.91%	16.45%	17.09%
Grand total per patient per day (kg/p/d)	.374	3.740	0.527	0.660	0.150	0.038	0.167	0.119	3.524	3.778	0.694	0.779

CONCLUSIONS

The tables 6-9 above show that:

1. There is, generally, a significant amount of mis-segregated HCGW placed in the receptacles for general infections waste (HCRW). At public hospitals in general this is in the range of 30% whereas at private hospitals this is in the range of 22%. This means that today there is a significant amount of waste being treated at a high cost and unnecessarily as HCRW. Hence, significant savings could be achieved by segregating HCW more correctly.

2. It has been possible to achieve a significant improvement in the segregation of waste at Leratong Hospital as a result of the interventions that included new equipment, training and supervision. Hence, the amount of HCGW in the general infectious waste receptacles (HCRW) has been reduced from approximately 25% to 7%. However, a reduction in the overall HCRW quantity has not been seen from the pre- to the post intervention study, among others, due to the fact that significant amounts of HCRW was previously disposed off as HCGW and this misplaced waste has to a large extent in the post-intervention study been placed in the correct HCRW receptacles. Even though the proportions of HCRW in the general waste are relative small (4.4% in the pre-intervention study and 2.5% in the post intervention study) the actual quantities are relative high because of the much higher amounts of HCGW.

   Table 10: *Estimated daily amounts of misplaced health care waste*

	Misplacement of waste in kilograms per day (excluding sharps containers and specicans)		**Total misplaced**
	HCRW in the general waste delivered to communal landfill (kg/day)	HCGW in the infections waste to be incineration (kg/day)	Kg/day
Pre-intervention	78	76	154
Post intervention	47	19	66

   Hence, whereas the amount of misplaced general waste has been significantly reduced to 25% the amount of misplaced infectious waste has only been reduced to 60%.

3. Of the total waste generation from Leratong Hospital approximately 84% is general waste (HCGW) and approximately 16% is medical waste (HCRW). This corresponds well with usual international figures.

Table 11*: HCW Components and Proportions by weight (Excluding food waste/pigswill)*

Waste components	**Pre-interventions Study May-June 2002**		**Post Intervention Study June-July 2003**	
	kg/day	**% (w/w)**	**kg/day**	**% (w/w)**
General Infectious Waste	302.83	14.13%	298.25	13.09%
Sharps	19.84	0.93%	2.08	0.09%
Laboratory	13.8	0.64%	18.53	0.81%
Pathological waste	5.62	0.26%	30.83	1.35%
Blood bank	6.87	0.32%	2.24	0.10%
Sub-total	**348.96**	**16.29%**	**351.93**	**15.45%**
General Waste (HCGW)	**1793.87**	**83.71%**	**1926.29**	**84.55%**
GRAND TOTAL	**2142.83**	**100.00%**	**2278.22**	**100.00%**
Grand total per patient per day (kg/p/d)	**4.218**		**4.557**	

4. The amount of sharps was significantly reduced from the pre- to the post-intervention study. This is because empty and unbroken glass vials were separate and containerised separately as part of the intervention and disposed of to a general waste landfill. Because of the relative heavy glass vials a significant amount of sharps containers have been saved and the content of the sharps containers was dramatically changed. Unfortunately a consistent error was introduced in the post-intervention study in the classification of vials. Hence it appears that the sharps containers were used more correctly during the pre-intervention study that afterwards. However, numerous inspections on site and interviewing of the sorting staff has resulted in the firm belief that correct use of sharps containers actually has *improved* as a consequence of the interventions. Therefore the actual level of correct use of sharps containers is estimated at:

Table 12: *Estimated level of correct use of Sharps containers (proportions by weight)*

	Correctly placed	**Misplacement of waste in kilograms per day**			**Total misplaced**
	Sharps	Misplaced infectious waste	Misplaced chemical waste	Misplaced HCGW	
Pre-intervention	0.85891	0.12055	0.01992	0.00061	0.14109
Post intervention (apparent due to error)	0.77509	0.21478	0.00074	0.00940	0.22491
Post intervention (*estimated after subjective adjustment for error)	0.92985*	0.06*	0.00074	0.00940	0.07015*

As a general and final conclusion it is demonstrated that considerable and significant improvements in the level of segregation has been achieved at Leratong Hospital since the interventions in the form of improved receptacles, improved placement of receptacles, provision of internal transportation systems and training and awareness programmes.

Furthermore, it is concluded that there appears to be a widespread problem in the Gauteng at both private and public health care facilities, and possibly in all of South Africa, with poor segregation of health care waste into the infectious/hazardous and the domestic waste categories. This in turn compromises occupational health and safety, cost-efficiency and public safety, in particular in respect of health care risk waste being disposed at communal landfills.

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