# CHAPTER FOUR: RESULTS AND DISCUSSIONS

## 4.1 LIST OF GOVERNMENT HOSPITALS IN WEST MALAYSIA

Government Hospitals are the major source of Clinical Waste generating points in Malaysia. Tables 4.1 and 4.2 give the number of Government Hospitals under the Ministry of Health Malaysia.

Table 4.1 MOH Hospitals in West Malaysia

| States | General Hospital | District Hospitals with Specialist Care | District Hospitals without Specialist Care |
|---|---|---|---|
| Perlis | 1 | | |
| Kedah | 1 | | 8 |
| Pulau Pinang | 1 | | 4 |
| Perak | 1 | 6 | 10 |
| Selangor | 1 | 5 | 4 |
| Wilayah | 1 | 3 | |
| Negri Sembilan | 1 | 1 | 3 |
| Malacca | 1 | 2 | 1 |
| Johor | 1 | 3 | 7 |
| Pahang | 1 | 1 | 9 |
| Terengganu | 1 | | 3 |
| Kelantan | 1 | 1 | 8 |

Table 4.2 MOH Hospitals in East Malaysia

| States | Number of Hospitals |
|---|---|
| Sabah | 21 |
| Sarawak | 21 |
| Total | 42 |

The hospitals in Sabah and Sarawak are either with or without specialist treatment care. However, all general hospitals are equipped with specialist care facilities. Specialist care is defined as some facilities available within the hospital units for advanced diseases like Cancer, Dialysis, thoracic and transfusion conditions. Advanced surgical facilities are also available in these hospitals. While most of the hospitals do not have these facilities, the ones with specialist care are well equipped to face advanced medical care of patients.

## 4.2 DISTRIBUTION OF BEDS IN THE GOVERNMENT HOSPITALS

Table 4.3 indicates the of distribution of beds in the MOH controlled hospitals in the States of Malaysia. Among the States, Perak remains the one to have the highest number of beds in about 15 Government hospitals distributed all over the State. General Hospital in Ipoh remains the one with highest bed capacity of 990 followed by the District Hospital in Taiping, which has 608 beds. The increase in bed capacity depends on certain factors in which one is the concentration of population where the demand for medical care is high. These hospitals, ranking high in bed capacity, usually have specialist medical care facilities to cope with the demand of local residents and the suburbs.

Table 4.3 Distribution of beds in Government Hospitals of Malaysia (1997)

| States in Malaysia | Total number of beds |
|---|---|
| Perlis | 404 |
| Kedah | 2105 |
| Pulau Pinang | 2397 |
| Perak | 7050 |
| Selangor and Wilayah | 6433 |
| Negeri Sembilan | 1348 |
| Malacca | 999 |
| Johor | 5032 |
| Pahang | 1963 |
| Terengganu | 1200 |
| Kelantan | 2089 |
| Sabah | 3212 |
| Sarawak | 4422 |

## 4.3 LICENSED PRIVATE HOSPITALS IN MALAYSIA

Apart from Government Hospitals, there are licensed private hospitals operating all over the country rendering medical care to the public. These private hospitals either have specialist care or normal treatment facilities. Though these hospitals and clinics do come under the purview of the Ministry of Health Malaysia, they are given liberty to treat and dispose their clinical wastes on their own accord. However, the system of disposal is monitored by Ministry of Health Malaysia so as to ensure health safety for

ersonnel and public. Table 4.4 shows the bed strength in these private hospitals. The State of Selangor and the city of Kuala Lumpur have the highest number of beds at 828. The more developed States (Pulau Pinang, Perak, Johor and Selangor) also seem to have the larger number of beds, as demands in these States are higher.

Table 4.4 Bed capacity in Licensed Private Hospitals (States-wise)

| States in Malaysia | Bed capacity |
|---|---|
| Kedah | 101 |
| Pulau Pinang | 656 |
| Perak | 526 |
| Selangor and Wilayah | 828 |
| Malacca | 92 |
| Negeri Sembilan | 70 |
| Johor | 313 |
| Pahang | 53 |
| Terengganu | 19 |
| Perlis | 19 |
| Sabah | 40 |
| Sarawak | 123 |

## 4.4 CLINICAL WASTE MANAGEMENT IN TELUK INTAN DISTRICT HOSPITAL (CASE STUDY 1)

To determine the waste type, quantity, identification and quantification of clinical wastes in the hospital analysis was carried out on three typical days of a week. The quantity of waste generated varied from day to day depending on the number of patients registered on the respective days. Sunday, being the weekend holiday recorded the lowest volume

of (109.5kg) (Table 4.5). The waste generation on Monday increased (Table 4.6) to 170.8 kg while the volume on Tuesday dropped again to 150.6 kg (Table 4.7). Certain departments like Dental had sharp increase on Tuesdays since Tuesday is being allotted for dental surgical activities. Whilst the clinical waste was separated for quantification, certain waste items were beyond recognition due to ageing process or mere mixed up with other items. However, maximum effort was taken to identify the wastes with assistance from support services staff and/or paramedical staff in the hospital.

Table: 4.5 Waste identification and quantification (in kg) on Sundays *

| Waste items | General and Medical wards | Accident and Emergency wards | Labour ward | Physiotherapy ward | Orthopedic surgery | General & other surgery | Dental surgery | Gynaecology | Out-patients | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Ampouls and vials | 4.0 | 2.0 | | | 0.5 | 1.0 | | 0.4 | 0.8 | 8.7 |
| Baby napkins | 3.0 | | | | | | | 1.8 | | 4.8 |
| Blister packings | 2.0 | 0.5 | | 1.3 | | | | | | 3.8 |
| Blood stained cloths | 6.0 | 6.0 | 6.5 | | | | | 5.2 | | 23.7 |
| Body tissues & Organs | | 0.5 | | | 1.1 | 0.8 | 0.5 | | | 2.7 |
| Disposable infusion sets | 3.0 | 2.0 | 3.5 | | 0.5 | | | 0.5 | | 10.0 |
| Dispo. needles & syringes | 2.5 | 0.5 | | | | 0.2 | | | | 4.4 |
| Disposable thermo covers | 2.0 | | | | | | | | 1.2 | 2.7 |
| Gauzes stained | 4.0 | 3.0 | | | | | | | 0.2 | 8.3 |
| Gloves | 0.5 | 1.2 | 1.5 | | 0.5 | | | | 1.3 | 4.4 |
| Left out medicines | 0.5 | | | 0.3 | | | | | | 0.8 |
| Metal lids | | 0.5 | | | | | | | 0.2 | 0.7 |
| Plaster bandages | 2.0 | 1.5 | | | 0.6 | | | 0.6 | 1.0 | 5.4 |
| PVC medicine bottles | 2.0 | 1.5 | | | | | | | 0.4 | 4.0 |
| Saline bottle and bags | 1.5 | 0.5 | 2.3 | | | | | | 0.5 | 4.3 |
| Sanitary napkins | 1.5 | | | | | | | | | 1.5 |
| Scalpels | 0.5 | | | | 0.2 | 0.3 | | | | 1.0 |
| Swabs/cottons stained | 1.0 | 1.5 | 6.8 | | | 0.4 | 1.2 | | 1.2 | 12.1 |
| Unidentified body fluids | 2.5 | 0.5 | 2.2 | | 0.3 | 0.8 | 0.8 | 0.2 | | 6.4 |
| Total: | 38.5 | 21.7 | 22.8 | 1.6 | 3.9 | 3.0 | 2.5 | 8.7 | 6.8 | 109.5 |

*(Mean of 2 replicates)

Further, kitchen and canteen wastes are not included, as they may not require treatment as for clinical wastes. The weights in certain departments like Scan and Radiology are not

included as they are either negligible or could be included with the waste from adjoining wards.

Fluid and semi fluid waste included items like discarded medicines, vomits, decomposed tissues (not identifiable), wound crusts caked blood spots, smears, puss etc. due to extensive disfiguration.

Of all departments, general and medical wards generated the highest volume. The items of wastes generated in this department included mostly all types of wastes excepting baby napkins and scalpels linens and transfusion sets. The bulk of wastes mostly contained items like ampouls, vials , disposable syringes, disposable diffusion sets, semi fluid items like vomit, swabs and gauzes etc.

Table 4.6 Waste identification and quantification on Mondays *(in kg))

| Waste items | General and Medical wards | Accident and Emergency wards | Labour ward | Physiotherapy ward | Orthopedic surgery | General & other surgery | Dental surgery | Gynaecology | Out-patients | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Ampouls and vials | 7.0 | 1.2 | 1.8 | | 0.7 | | | 1.2 | 1.2 | 13.1 |
| Baby napkins | 2.0 | | | | | | | | 2.0 | 2.0 |
| Blister packings | 2.5 | 1.8 | 3.6 | 1.8 | | | | | 1.8 | 11.5 |
| Blood stained cloths | 7.5 | 6.8 | 7.8 | | | 0.6 | | | 4.8 | 27.5 |
| Body tissues & Organs | | 1.1 | | | 0.9 | 0.2 | | | | 2.2 |
| Disposable infusion sets | 7.0 | 3.8 | 4.2 | | | 1.2 | | | 1.2 | 17.4 |
| Dispo. needles & syringes | 4.8 | 1.8 | | | | | | 1.1 | 0.8 | 8.5 |
| Disposable thermo covers | 2.2 | | | | | | | | 1.2 | 4.1 |
| Gauzes stained | 4.0 | 3.1 | | | | | | | 1.2 | 8.3 |
| Gloves | 1.2 | 1.1 | 2.1 | | | 0.2 | | 0.2 | | 4.8 |
| Left out medicines | 1.5 | | | | | | | | 0.5 | 2.0 |
| Metal lids | | 0.4 | | | | | | | | 0.4 |
| Plaster bandages | 4.2 | 1.5 | | 0.8 | 1.1 | | | | 1.2 | 8.8 |
| PVC medicine bottles | 4.8 | | | | | | | | 1.3 | 6.1 |
| Saline bottle and bags | 1.8 | 2.5 | 3.8 | | 0.8 | 1.6 | | | | 10.5 |
| Sanitary napkins | 3.5 | | 1.8 | | | | | 4.2 | | 9.5 |
| Scalpels | 0.8 | | | | 0.5 | 0.2 | | | | 1.5 |
| Swabs/cottons stained | 3.8 | 2.2 | 6.8 | | 2.3 | 1.0 | 1.6 | 0.6 | 4.2 | 22.5 |
| Unidentified body fluids | 1.2 | 3.1 | 3.6 | | 0.1 | 0.4 | 0.6 | 0.4 | 1.2 | 10.1 |
| Total: | 59.8 | 30.4 | 35.5 | 2.6 | 6.6 | 5.4 | 2.2 | 7.7 | 20.6 | 170.8 |

*(Mean of 2 replicates)

A sharp increase in waste from Dental care ward was recorded on Tuesday (Table 4.7) due to the day being one of the two days scheduled for dental surgery in the hospital. General and medical wards were the largest wards with a high bed capacity and hence a large volume (54 kg) of clinical wastes was recorded. This trend is observed through out the week regardless of weekdays or weekends. Unidentified items include solid, semi solid and liquid wastes since they are mixed beyond recognition.

No wastes other than those of clinical origin were found contained in the yellow bags and this was indicative of maximum precaution taken in clinical waste segregation by the hospital administration. Clinical waste minimization could lead to lower waste management cost to the MOH hospitals. Hence strict waste segregation is followed.

Table 4.7 Waste identification and quantification (in kg) on Tuesdays *.

| Waste items | General and Medical wards | Accident and Emergency wards | Labour ward | Physiotherapy ward | Orthopedic surgery | General & other surgery | Dental surgery | Gynaecology | Out-patients | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Ampouls and vials | 7.5 | 0.9 | 1.2 | | | | | 0.9 | 1.9 | 12.4 |
| Baby napkins | | | | | | | | | | |
| Blister packings | 3.9 | 1.4 | 2.8 | 1.2 | | | | | 1.8 | 11.1 |
| Blood stained cloths | 6.1 | 1.6 | 6.9 | | | | | | 3.7 | 18.3 |
| Body tissues & Organs | | 0.8 | | | 0.2 | 0.6 | 0.6 | | | 2.2 |
| Disposable infusion sets | 5.9 | 2.8 | 3.1 | | 0.4 | 0.4 | 0.4 | | 1.1 | 13.0 |
| Dispo. needles & syringes | 4.1 | 1.8 | | | | 1.4 | 1.4 | | 0.5 | 9.2 |
| Disposable thermo covers | 1.9 | | | | 0.8 | | | 0.9 | 1.1 | 4.7 |
| Gauzes stained | 3.7 | 1.8 | | | | | | | 1.1 | 6.6 |
| Gloves | 0.9 | 0.7 | 1.8 | | | 0.3 | 0.2 | | | 3.9 |
| Left out medicines | 2.7 | 0.9 | | | | | | 0.2 | 0.3 | 4.1 |
| Metal lids | | | | | | | | | | |
| Plaster bandages | 4.1 | 3.1 | | 0.7 | | | | | 0.8 | 8.7 |
| PVC medicine bottles | 2.8 | 3.0 | | | | | | | 1.8 | 7.6 |
| Saline bottle and bags | 1.7 | 0.5 | 3.1 | | 0.7 | 1.6 | | | | 7.6 |
| Sanitary napkins | 2.6 | 1.2 | 1.8 | | | | | 3.8 | | 9.4 |
| Scalpels | 0.4 | 0.5 | | | | 0.4 | | | | 1.3 |
| Swabs/cottons stained | 3.1 | 1.9 | 7.0 | | | 1.8 | 2.8 | 0.6 | 4.1 | 22.6 |
| Unidentified body fluids | 2.8 | 0.6 | 1.3 | 0.9 | | 0.5 | 0.7 | 0.2 | 1.1 | 8.1 |
| Total: | 54.2 | 23.5 | 29.0 | 2.8 | 2.1 | 7 | 6.1 | 6.6 | 19.3 | 150.6 |

*(Mean of 2 replicates)

## 4.5 BED OCCUPANCY RATE IN THE MOH HOSPITALS OF MALAYSIA

The bed occupancy rate in the Ministry of Health Malaysia controlled hospitals varies from area to area depending on the population concentrations. However, the rate ranges from 42% to 69% (Table 4.8). The rate is found to be generally high in the hospitals in East Malaysia (Sabah & Sarawak). It was observed that heavyly populated areas generally have higher bed occupancy rate. Also the bed occupancy rate depends on the type of hospital (general or district), availability of specialist care and the location (urban/rural) of the hospital.

Table 4.8 State-wise Bed Occupancy rate in MOH Hospitals in Malaysia

| States in Malaysia | Bed occupancy rate (1997) (%) |
|---|---|
| Perlis | 55.5 |
| Kedah | 52.1 |
| Pulau Pinang | 50.1 |
| Perak | 42.10 |
| Selangor & Wilaya | 64.43 |
| Negeri Sembilan | 43.32 |
| Malacca | 52.1 |
| Johor | 44.18 |
| Pahang | 51.33 |
| Terengganu | 49.01 |
| Kelantan | 67.78 |
| Sabah | 64.35 |
| Sarawak | 69.53 |

## 4.6 CLINICAL WASTE MANAGEMENT IN THE NORTHERN STATES OF PENINSULAR MALAYSIA, SABAH AND SARAWAK

Wastes in theses States are handled by Faber Mediserve Sdn.Bhd. Owing to rapid development or expansion and other factors like health care necessity, disease control measures etc, the data vary from year to year and the differences are however marginal, especially in waste generation and availability of handling tools. Table 4.9 summarises the details for hospital-wise waste generation volume, number of beds and bed occupancy

rate in the hospitals found in the Northern states of Peninsular Malaysia, Sabah and Sarawak, which is the focus of this dissertation. There are all in 19590 beds, while the bed occupancy rate is 58.11%. The waste generated by these hospitals account for 1,473,772 kg, which is 42.11 % of the total waste generated in Malaysia.

Table 4.9 Bed capacity, bed occupancy rate and waste generation (in kg/year) in the Northern States of Peninsular Malaysia, Sabah and Sarawak Hospitals for the year 1998.

| Description | Total | Mean |
|---|---|---|
| Beds | 19590 | 275 |
| Bed occupancy rate | 3952 | 55.52 |
| Waste volume (kg) | 2,739,000 | 38,000 |

## 4.7 CLINICAL WASTES HANDLING TOOLS AND FACILITIES

Table 4.10 is the list of handling tools and storage area for clinical waste in the Northern states of Peninsular Malaysia, Sabah and Sarawak Most hospitals have either only or no vehicles at all except Kuching hospital which has two vehicles. The transport facility by closed vehicle mostly depends upon the volume of waste generated in a particular hospital. Depending on need, the vehicle used by one hospital is shared by other nearby hospitals to transport the wastes to incinerators. Heavy-duty weighing platforms are provided to all hospitals, as it is an important tool to quantify wastes of the origin. Hospital storage area is used as a transit point where wastes stay for a temporary period until being further transported to incinerator. Quantity of clinical and autoclave bags are based on the consumption survey of the previous years. Tags in equivalent quantity are used to fasten the bags for preventing leakage in transport and storage.

Table: 4.10 Clinical Wastes handling tools and facilities available in the year 1998 in the Northern States of Peninsular Malaysia, Sabah and Sarawak.

| Description | Total | Mean |
|---|---|---|
| Vehicle | 11 | - |
| Heavy duty weighing balance | 72 | 1 |
| Storage area ($m^3$) | 662 | 9.323 |
| Clinical bags | 2,356,000 | 33,000 |
| Autoclave bags | 95,700 | 1,300 |

The largest number of clinical bags were used in Pulau Pinang general hospital while the autoclave bags were highly used in Queen Elizabeth hospital in Kota Kinabalu, which is also one of the four hospitals to have the largest storage area for clinical wastes.

The availability of other clinical waste management tools and equipment are summarised in Table 4.11. The staff strength assigned for the job in the MOH hospitals of Northern states of Peninsular Malaysia, Sabah and Sarawak are also given in this table. The disposal tools, apart from those in the list, also include antibacterial agents in fluid form, sweepers, scoops, mops etc. The handling staff members in all locations are either experienced in similar jobs or qualified in the line work. Handlers are required to wear protective wears to avoid cross infection and such items like clinical aprons, face masks, gloves etc are not included.

Table 4.11 Clinical Waste disposable tools and handling staff in 1998 in the Northern States of Peninsular Malaysia, Sabah and Sarawak.

| Description | Total | Mean |
|---|---|---|
| Auto tape | 201 | 3 |
| Bag ties | 191,000 | 26,000 |
| Sharp bins | 6,600 | 929 |
| Labels | 6,859,000 | 96,000 |
| Spill kit | 236 | 3.32 |
| Waste handling staff | 121 | 1.70 |

The General hospitals in Ipoh and Pulau Pinang used the highest amount of sharp bins. Average bag ties used were 26000, whereas the largest number was used in Pulau Pinang General hospital (150,000). The staff handling clinical waste is 121 in number (total) while the average staff per hospital was 1 to 2.

## 4.8 DAILY WASTE GENERATION DATA IN THE NORTHERN STATES OF PENINSULAR MALAYSIA , SABAH AND SARAWAK IN THE YEAR 1997 AND 1998.

In the year 1997, the daily clinical waste generation in the Northern States (Perlis, Kedah, Pulau Pinang and Perak) of Malaysia was 1741 kg which increased to 2330 kg/day in 1998 (Fig 4.1). Prior to 1997, the volume generated was 933 or less. In Sabah and Sarawak, the daily waste generation (in the year 1997) was about 1110 kg, which subsequently increased to 1709 kg/day in 1998. The total daily generation of clinical waste in the six States was 2852 kg in 1997 and with a rate of increase of 43.30%, the volume reached a 4087 kg per day in 1998.

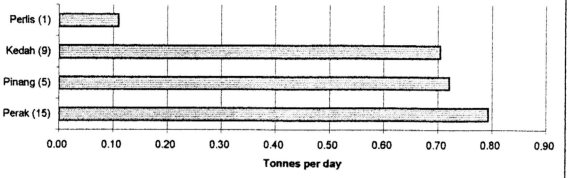


Figure 4.1. Daily clinical waste generation in the Northern States in 1998.
( Figure in bracket indicates the number of hospitals in the respective State).

Figure 4.2 indicates the average volume of waste generated from hospitals in the State of Perak. While the predicted volume was 073 kg/occupied bed/day, the mean volume was 0.49 kg/bed/day.

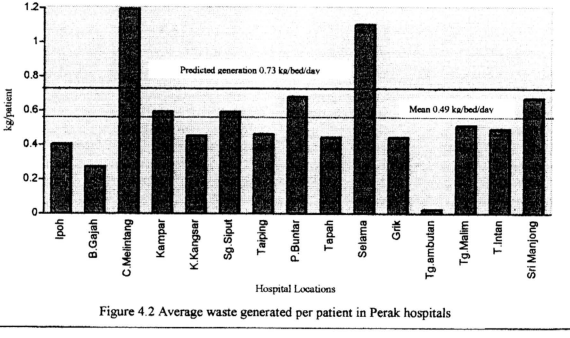


Figure 4.2 Average waste generated per patient in Perak hospitals

Figure 4.3 shows the predicted and mean volume of clinical waste generated in the government hospitals of three of the Northern States (Pulau Pinang, Perlis and Kedah).

While the predicted volume was 0.73 kg/patient/day, the mean volume remained 0.56 kg/bed/day.

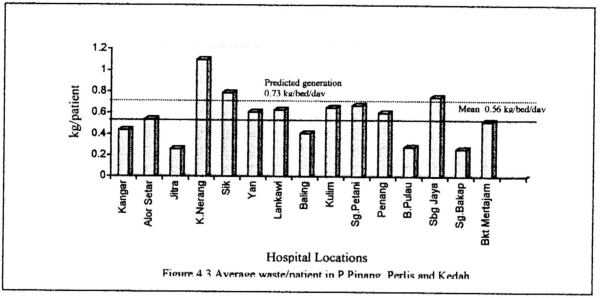


Figure 4.3 Average waste/patient in P.Pinang, Perlis and Kedah

Figure 4.4 indicates the predicted and generated clinical waste generated in the State of Sabah. The average collection was 9561 kg per day.

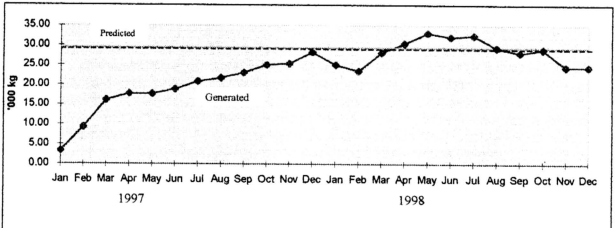


Figure 4.4 Clinical waste in Sabah State (1997-98)

Figure 4.5 shows both predicted and average clinical waste generation from the hospitals of in Sabah State. Predicted volume was 0.73 kg/bed/day and the mean recorded was 0.57 kg/bed/day.

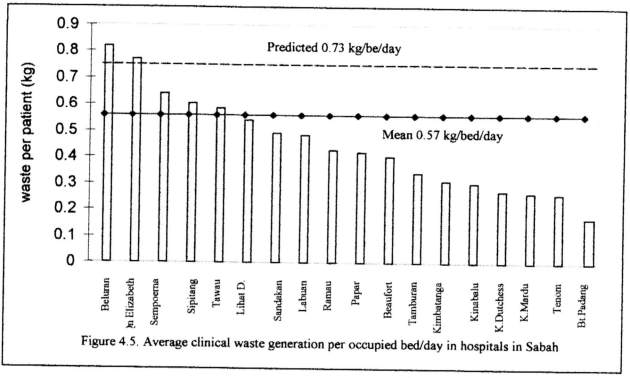


Figure 4.5. Average clinical waste generation per occupied bed/day in hospitals in Sabah

In Sarawak, the total clinical waste collected in 1997-98 was 0.489 tonnes and in the year 1998 the average collection was 776 kg/day (Fig 4.6).

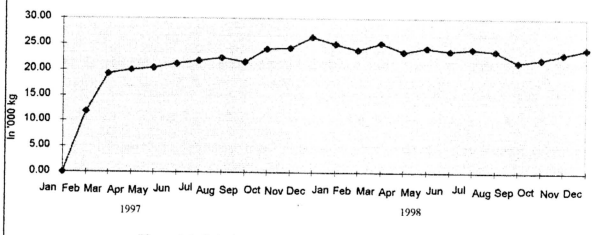


Figure 4.6 clinical waste collection in Sarawak 1997-98

The hospitals in Sarawak State have generated an average of 0.49 kg per occupied bed per day in the year 1998 while the volume predicted was 0.73 kg/bed/day (Fig 4.7)

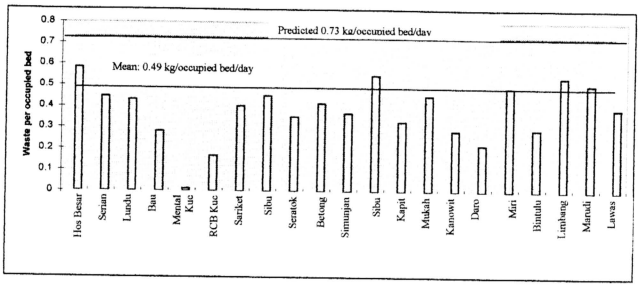


Figure 4.7 Average waste per occ.bed per day in Sarawak Hospitals (1998)

Figure 4.8 compares the clinical waste generated per occupied bed/day in the Northern and Eastern States of Malaysia with waste generated from some developed nations. The range of volume per occupied bed remains at 0.49kg to 0 .56 kg for Malaysian States whereas the developed countries generated 4 - 5 times more waste. Middle East, Asian and Latin American countries generated more waste than Malaysia but less than those found in developed countries. The volume in Japan reached almost double that of Malaysia. United Kingdom and North American countries are the highest clinical waste generators in the world and compared to Malaysia, they generate almost five times higher.

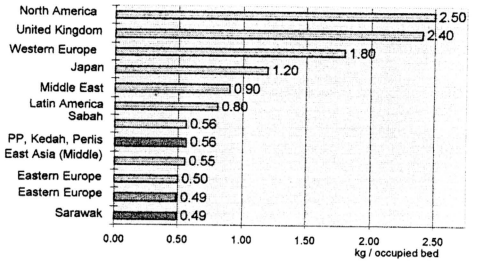


Figure 4.8 Clinical waste volume compared with other countries

## 4.9 WASTE GENERATION IN THE MOH HOSPITALS IN 1998

The waste generation volume (Table 4.12) in the MOH hospitals of Malaysia has been significantly stabilized due to segregation awareness of handling personnel in the year 1998.

This is evidenced by sharp fall in the average volume of waste per day per occupied bed to 0.51 kg compared to predicted volume of 0.73 kg.

Table 4.12 Waste generation volume in the year 1998 in the MOH hospitals Malaysia.

| States | Total waste generated (kg) | Waste generated per occupied bed per day (kg) |
|---|---|---|
| Perlis | 39980 | 0.52 |
| Kedah | 257087 | 0.65 |
| P.Pinang | 263162 | 0.58 |
| Perak | 289587 | 0.22 |
| Selangor | 272288 | 0.61 |
| Kuala Lumpur | 452124 | 0.83 |
| N.Sembilan | 181807 | 0.64 |
| Melaka | 125412 | 0.67 |
| Johor | 456221 | 0.48 |
| Pahang | 209730 | 0.59 |
| Kelantan | 145174 | 0.57 |
| Terengganu | 173396 | 0.82 |
| Total West Malaysia | 2865977 | 0.52 |
| Sabah | 340744 | 0.49 |
| Sarawak | 283212 | 0.45 |
| Malaysian Total | 3,489,934 | |
| Mean | 249,281 | 0.51 |

## 4.10 EMISSION STANDARDS AND OPERATING CONDITIONS

Department of Environment Malaysia has set certain standards of emission of pollutants whereby all clinical incinerators in the country are monitored and controlled. Table 4.13 summarises the standards set by Department of Environment for heavy metals and other parameters in the incinerator emission.

Table 4.13 Stack emission standards and operating condition

| | |
|---|---|
| Gas Temperature | 150°C |
| Fly Ash | 50mg/$m^3$ |
| Oxygen (minimum) | 11% |
| Cl | 50 mg/$m^3$ |
| Br | 5mg/$m^3$ |
| F | 2mg/$m^3$ |
| NOx | 100 mg/$m^3$ |
| SOx | 50 mg/$m^3$ |
| CO | 100 mg/$m^3$ |
| Cd, Hg, Ti | 0.1 mg/$m^3$ |
| As, CO, Ni, Se, Te | 0.1 mg/$m^3$ |
| Sb, Pb, Pb, Cr, CN, Mn, Sn | 5 mg/$m^3$ |
| Opacity Bacharach | 2 max |
| Unburned particles in ashes | 3% max |
| Incinerator temperature (minimum) | 900°C |
| Post Combustion temperature | 100°C |

Chlorine related components show an increased level of presence due to varieties of packaging materials used in clinical and medical items used in hospital environment. However, the level is within the tolerance of DOE regulations. Poly-vinyl-chloride packagings, being a safe components in keeping medicines and other medical equipment for long shelf life, is said to be one of the factors for the results showing an increased level of Cl present. Cadmium, Lead, Mercury, Copper, Arsenic and Zinc levels show levels within the normal range of regulations (Table 4.14).

## 4.11 STACK EMISSION ANALYSIS

Table 4.14 Stack Emission Analysis

| | |
|---|---|
| Site: | Taiping, Perak |
| Source tested: | Bio-medical Waste Incinerator Stack |
| Sampling period: | 8.30 am to 12.00 pm |
| Operating condition | Normal or 300-350 kg/hour waste being incinerated |
| Tested by: | Unitek environmental and Universiti Technology Malaysia |
| Tested conditions: | |
| Stack diameter at sampling plane | 0.5 (m) |
| Average gas stack temperature | 154°C |
| Average stack velocity | 8.8(m/s) |
| Average CO2 conc (% v/v) | 7.3 |
| Average O2 conc (% v/v) | 13.5 |
| Moisture content (% v/v) | 8% |

| Smoke Density Parameter | Scale | Limit |
|---|---|---|
| Smoke | Ringlemann | Ringlemann 1 |

| Other Parameters | | | |
|---|---|---|---|
| Parameter | Conc. | Limit | % of Limit |
| Total Particulate | 82 | 200 | 41 |
| Hydrogen Sulfide | 2.1 | 7.5 | 28 |
| Nitrogen Oxides (as SO3) | 256 | na | |
| Carbon monoxide | 370 | na | |
| Sulfur acid mist and/or sulfur trioxide (as SO3) | 27.2 | 100 | 27 |
| Hydrogen chloride | 36.5 | 400 | 9.1 |
| Fluorides ad HF | <0.02 | 100 | <1 |
| Total VOCs (as N-hexane) | <0-04 | na | |
| Heavy metals (total of Sb, As, Cd, Pb, Hg and other compounds) | 0.003 | 40 | <1 |
| Antimony and its compounds | <0.002 | 25 | <1 |
| Arsenic and its compounds | <0.002 | 25 | <1 |
| Cadmium and its compounds | 0.002 | 15 | <1 |
| Lead and its compounds | 0.001 | 25 | <1 |
| Mercury and its compounds | <0.002 | 10 | <1 |
| Copper and its compounds | <0.0005 | 100 | <1 |
| Zinc and its compounds | 0.0013 | 100 | <1 |

Na: Not available

The residue ash (Table 4.14 and Table 4.15)analyses tests show the pollution limits are within the DOE regulated levels. The tests were conducted randomly and in optimum operating condition. Further, SOX and NOX emission limits are also within the required parameters of API tolerance level.

Table 4.15 Residue ash analysis

| | | |
|---|---|---|
| 1 | pH of ash | 10.8 |
| 2 | Original sample weight | 2.28 kg |
| 3 | Glass metallic content | 1.91 kg |
| 4 | Moisture content | 0.02 % w/w |
| 5 | Combustible content | 4.28 % w/w |
| 6 | Inorganic content: (all values mg $l^{-1}$) | |
| | Cadmium | 0.01 |
| | Lead | <0.01 |
| | Arsenic | 0.07 |
| | Chromium | 2.03 |
| | Selenium | <0.04 |
| | Sulphate as SO4 | 1,180 |
| | Chloride | 2,550 |
| | Nitrate | 7.8 |
| | Mercury | 0.05 |
| | Copper | 0.22 |
| | Manganese | 0.06 |
| | Nickel | 0.20 |
| | Phosphate | 2.3 |

## 4.12 FINAL RESULTS OF DIOXIN AND FURAN ANALYSIS

The final concentration of the PCDDs and PCDFs are calculated based on the international toxic equivalency unit (ITEQ). The limit imposed by DOE for Dioxin/Furan concentration from a clinical waste incinerator is 0.1000 ng/$Nm^3$ The analysis reports indicated the concentration of above chemicals to be 0.0554 ng/$Nm^3$ (Table 4.16) which is well within the imposed limit.

The tests are being carried out twice a year to ensure prevention of air pollution and the reports are submitted to Department of Environment Malaysia as part of mandatory requirement of Environmental Quality (Clean Air) Act. (1978).

Apart from twice yearly toxic equivalent investigation, periodic maintenance of the incinerator plant is carried out to ensure proper treatment of clinical wastes to the pre-set limits imposed by DOE.

A monthly overhaul of essential machines of the plant is being carried out since the right conditions of this machinery ensure the best or optimum results in rendering the treatment processes complete. Records for all such maintenance services are kept for ready reference by Health and Environment authorities.

In order to make sure the toxic elements emitted are consistent and within the preset limits throughout the year, the investigations are carried out on a random attempt on any day.

Table 4.16 Stack emission analysis

| Parameter | Concentration | Limit (ITEQ) |
|---|---|---|
| Dioxin/Furan | 0.0554 | 0.1000 ng/Nm$^3$ |

| Dioxin and Furan Compounds | Level in sample (ng) | ITEQ | ITEQ in sample (ng) | ITEQ in sample (ng/Nm$^3$) |
|---|---|---|---|---|
| PCDF/PCDD Congeners | | | | |
| 2,3,7,8 Tetrochlorodibenzofurans | 0.25 | 0.1 | 0.025 | 0.0166 |
| Non 2,3,7,8,Tetrachlorodibenzofurans | 5.8 | 0 | 0 | 0.0000 |
| 2,3,7,8,Tetrochlorodibenzo-p-dioxin | 0.005 | 1 | 0.0025 | 0.0017 |
| Non 2.3.7.8.Tetrachlordibenzo-p-dioxin | 10.395 | 0 | 0 | 0.0000 |
| 1,2,3,7,8 Pentachlorodibenzofuran | 0.05 | 0.05 | 0.0025 | 0.0017 |
| 2,3,4,7,8,Pentachlorodibenzofuran | 0.07 | 0.5 | 0.035 | 0.0232 |
| Non 2.3.7.8.Pentachlorodibenzofuran | 0.26 | 0 | 0 | 0.0000 |
| 1,2,3,7,8 Pentachlorodibenzo-p-dioxin | 0.02 | 0.5 | 0.01 | 0.0066 |
| Non 2,3,7,8,Pentachlorodibenzo-p-dioxin | 0.19 | 0 | 0 | 0.0000 |
| 1,2,3,4,7,8Hexachlorodibenzofurans | 0.02 | 0.1 | 0.002 | 0.0013 |
| 1,2,3,6,7,8 Hexachlorodibenzofurans | 0.01 | 0.1 | 0.002 | 0.0007 |
| 2,3,4,6,7,8 Hexachlorodibenzofurans | <0.01 | 0.1 | 0.0005 | 0.0003 |
| 1,2,3,7,8,9 Hexachlorodibenzofurans | <0.01 | 0.1 | 0.0005 | 0.0003 |
| Non 2,3,7,8 Hexachlorodibenzofurans | 0.08 | 0 | 0 | 0.0000 |
| 1,2,3,4,7,8 Hexachlorodibenzo-p-dioxin | 0.01 | 0.1 | 0.001 | 0.0007 |
| 1,2,3,6,7,8 8 Hexachlorodibenzo-p-dioxin | 0.01 | 0.1 | 0.001 | 0.0007 |
| 1,2,3,7,8,9 8 Hexachlorodibenzo-p-dioxin | 0.02 | 0.1 | 0.002 | 0.0013 |
| Non 2,3,7,8 8 Hexachlorodibenzo-p-dioxin | 0.06 | 0 | 0 | 0.0000 |
| 1,2,3,4,6,7,8 Heptachlorodibenzofurans | 0.03 | 0.01 | 0.0003 | 0.0002 |
| 1.2.3.4.7.8.9 Heptachlorodibenzofurans | 0.02 | 0.01 | 0.0002 | 0.0001 |
| Non 2,3,7,8 Heptachlorodibenzofurans | 0.15 | 0 | 0 | 0.0000 |
| 1,2,3,4,6,7,8 Heptachlorodibenzo-p-dioxins | 0.01 | 0.01 | 0.0001 | 0.0001 |
| Non 2,3,7,8 Heptachlorodibenzo-p-dioxins | <0.01 | 0 | 0 | 0.0000 |
| Octachlorodibenzofuran | 0.03 | 0.001 | 0.00003 | 0.0000 |
| Octachlorodibenzo-p-dioxin | 0.05 | 0.001 | 0.00005 | 0.0000 |
| Total Toxic Equivalents (ng/Nm$^3$) | | | | 0.0554 |

Nm^3 = Gas volume in dry cubic meters at STP (0°C, 101.3kPa) and referenced to 11% Oxygen

The investigations for toxic equivalents were carried out at normal working conditions of the plant. No special arrangements or prior uptuning are done since the results are expected to reflect the maximum reality. The volume of wastes incinerated is also maintained at its optimum capacity like on any other day. Hence, the results so obtained are considered to be consistent and actual of the process.