CHAPTER 4

RESULT AND DISCUSSION

4.1 Composition and Generation of Hospital Waste

The purpose of this section was to examine the physical composition and the generation of hospital waste. This information is a basis for identifying hospital waste management, waste minimization option and establishing the degree of segregation.

First, the compositions of solid waste in collection container were investigated to determine the composition of hospital waste stream as discarded. Then medical, domestic, and recyclable wastes were separately collected for 24 hour along two weeks to determine the composition of hospital waste stream, and their generated rate as generated. In the extent of all hospital in Chiang Mai, 2 public hospitals and 8 private hospitals were determine by their willingness from 8 public hospitals under the heading of the Ministry of Health and 12 private hospitals in Chiang Mai City.

4.1.1 Breakdown of the overall hospital waste stream

The total waste stream from hospital can be divided into municipal solid waste and special healthcare waste. No risk healthcare waste includes all waste comparable to domestic waste, such as packaging materials, non-infectious bedding, building rubble/demolition waste, hotel function waste (household, kitchen, administration), and other such wastes generated from patient wards and other patient care not related to medical care. In The first phase of hospital waste survey, overall hospital solid waste stream of 12 surveyed hospitals was weighted at the collection point. Solid waste was divided in to 9 items and weighted separately to find out the composition. Result of this survey is presented in Table 4.1. The typical breakdown of the overall hospital solid waste stream are as follow: 1) Organic Waste-52.9 percent, 2) PP, PE, PVC bottles and bags- 10.1 percent, 3) Bandage and plaster- 8.8 percent, 4) Metal and cans- 2.9 percent, 5) Glass and medicine tubes- 2.3 percent, 6) Syringes and syringes needles- 0.9 percent, 7) Waste paper, cartons, and paper-0.8 percent, 8) Human parts

for lab analysis- 0.6 percent, and 9) Soil, cobble, and other solid matters- 20.9 percent. According to this results, approximately 22.7% (by weigh) of the solid waste in the collection container was considered containing hazardous material. This indicated the improper waste segregation practice in the surveyed hospitals.

TABLE 4.1 Typical Breakdown Of The Overall Hospital Solid Waste Stream

Hospital Waste Composition	**Ratio (% by weigh as discarded)**
Organic waste	52.9
PP, PE, PVC bottles and bags	10.1*
Bandage, plaster	8.8*
Metal, cans	2.9
Glass, medicine tubes	2.3*
Syringes and syringes needles	0.9*
Waste paper, cartons, paper	0.8
Human parts for lab analysis	0.6*
Soil, cobble, and other solid matters	20.9
Total	100.0

* This Composition was considered containing hazardous material (EPA)

- PP, PE, PVC was found to be the source of dioxin in incineration
- Bandage and plaster was classified as infectious waste
- Medicine tube was classified as the chemotherapy waste
- Syringes and needle was classified as infectious waste
- Human parts was classified as infectious waste

4.1.2 Composition Of Domestic Solid Waste Composition In Hospital Waste Stream

Then, the survey focused on the composition of domestic waste portion in hospital waste stream, hazardous portion generated from medical care was not included in this section. Results in Figure 4.1 demonstrate the variation of the

municipal solid waste composition in hospital waste stream, with details summarized in the Table 4.2. The composition of hospital solid waste is typically: 48.5 percent paper and paperboard, 20.5 percent food waste, 13.1 percent plastic, 1.5 percent household hazardous waste, 1.7 percent metal, 1.3 percent glass, 3 percent yard trimming and 10.4 percent other. This closer examination of municipal solid waste composition in hospital waste stream reveals that many items are recyclable materials amenable to waste minimization.

TABLE 4.2 Composition of Domestic Solid Waste in Hospital Waste Stream

Waste Category	**Composition (% By weight as generated)**
Paper (paper, paper board, and corrugated card board)	48.5
Food and other organics	20.5
Plastic	13.1
Household hazardous waste	1.5
Metals	1.7
Glass	1.3
Other	10.4
Yard trimming	3.0

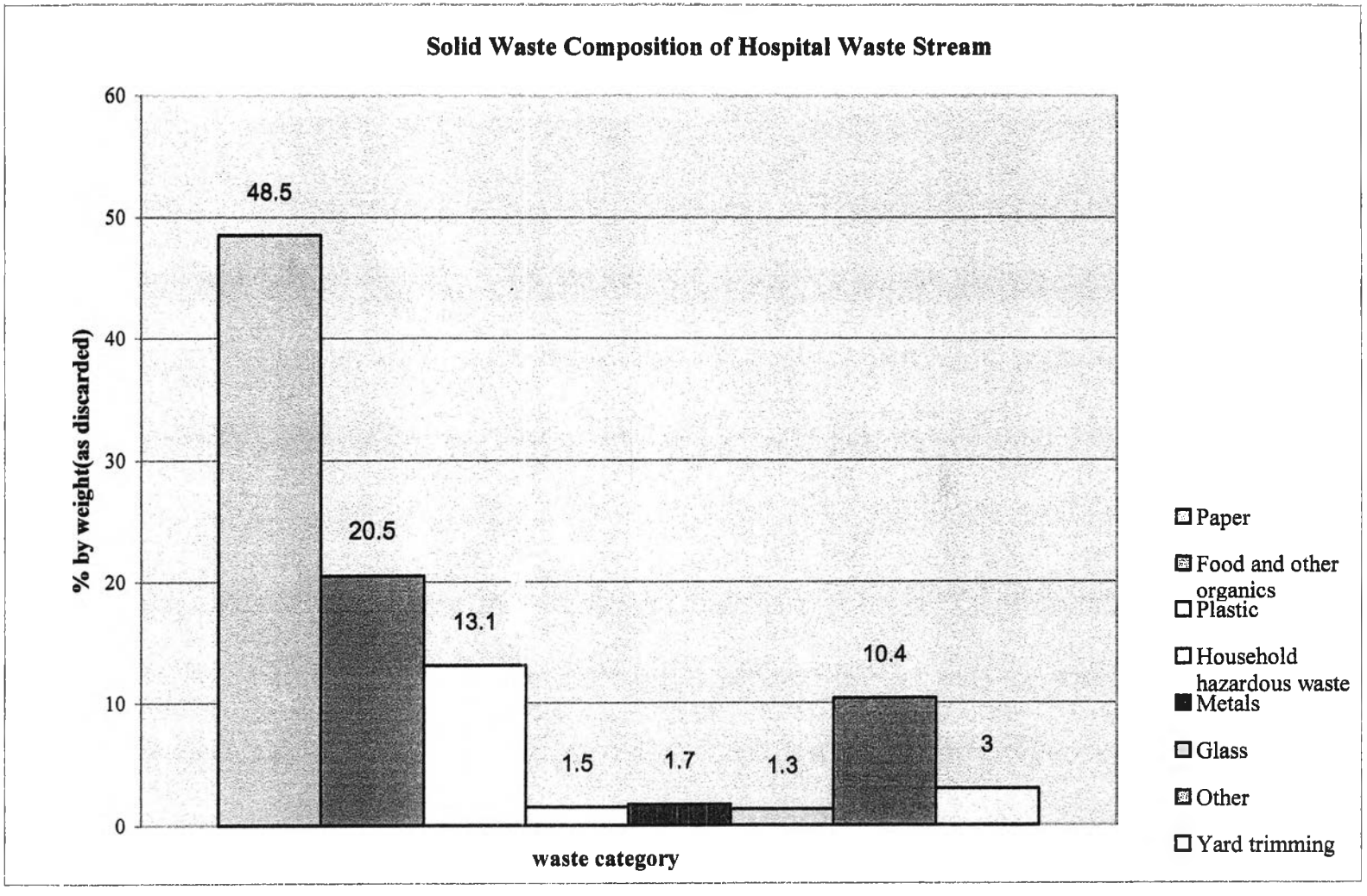

FIGURE 4.1 Solid Waste Compositions In Hospital Waste Stream (Based On Municipal Solid Waste Portion)

4.1.3 Hospital solid waste (classified by physical characteristic)

In this section, the generation of hospital waste composition (classified by physical characteristic of solid waste as medical waste, domestic waste, and recyclable materials) was determined. Medical, domestic, and recyclable wastes were separately collected for 24 hour along two weeks to determine the composition of hospital waste stream, and their generated rate as kilogram per occupied bed per day and as kilogram per patient per day. The results of this study are presented in Appendix C.

With regard to generation rates, the survey result summarized in Table 4.3 give the proportion of each composition in hospital waste stream and the daily average waste generation of public and private hospital. According to the survey results amount of daily average solid waste per bed (as depicted in figure 4.2) was found as 2.665 kg in public hospital and as 3.98 kg, in private hospitals. The distribution of physical composition of total solid waste from public and private hospital was studied. In public hospitals 2.06 kg medical solid waste, 0515 kg domestic solid waste and 0.09 kg recyclable materials were created among total daily solid waste per occupied bed. On the other hand in private sectors 2.44 kg medical solid waste, 1.20 kg domestic solid waste and 1.035 kg recyclable materials were created among total daily solid waste per bed. According to the survey results amount of daily average solid waste per patient (as depicted in figure 4.3) was found as 0.615 kg in public hospital and as 0.647 kg, in private hospitals. The distribution of physical composition of total solid waste from public and private hospital was studied. In public hospitals 0.464 kg medical solid waste, 0.186 kg domestic solid waste and 0.030 kg recyclable materials were created among total daily solid waste per patient. On the other hand in private sectors 0.340 kg medical solid waste, 0.201 kg domestic solid waste and 0.118 kg recyclable materials were created among total daily solid waste per patient.

As depicted in figure 4.4, the compositions of private hospital waste stream are medical waste-52%, domestic waste -26%, and recyclable material- 22%, while the compositions of public hospital waste stream are medical waste-78%, domestic waste-19%, and recyclable material- 3%.

According to the survey result, the amount of daily average solid waste per occupied bed and the amount of daily average solid waste per patient of private hospital were found to be higher than public hospital but this does not mean public hospital generates waste lower than private hospital that have the same bed size. Quantity of waste generation depends on bed occupancy rate and number of patient. In private hospital, the daily bed occupancy rate is about 30 to 43%, while the daily bed occupancy rate of public hospital is about 93 to 90% and number of out patient of public hospital was found 35 to 60 percent higher compared to private hospital. Patient- care ward of private hospital also represents a significant source generating large amount of domestic solid waste so the amount of daily average solid waste per occupied bed of private hospital is much higher than public hospital.

TABLE 4.3 The Generation Of Hospital Waste Composition (Medical Waste, Domestic Waste, And Recyclable Materials) In 12 Surveyed Hospitals.

Group	Hospital	Generation rate as kg/occupied bed/day				Generation rate as kg/patient/day			
		Total waste	Medical waste	Domestic waste	Recyclable material	Total waste	Medical waste	Domestic waste	Recyclable material
1 <100 beds	Public Hospital	2.95	2.15	0.67	0.13	0.391	0.276	0.087	0.016
	Private Hospital	3.98	2.35	1.23	0.64	0.384	0.224	0.122	0.060
	Average	**3.46**	**2.25**	**0.95**	**0.39**	**0.385**	**0.234**	**0.115**	**0.051**
2 100-299beds	Public Hospital	2.88	2.22	0.58	0.08	0.662	0.510	0.133	0.018
	Private Hospital	4.81	2.44	1.52	0.845	0.789	0.394	0.251	0.147
	Average	**3.85**	**2.33**	**1.05**	**0.46**	**0.747**	**0.432**	**0.212**	**0.104**
3 300-499beds	Public Hospital	2.75	0.95	1.5	0.25	0.790	0.560	0.433	0.071
	Private Hospital	4.96	2.6	1.64	0.72	1.025	0.538	0.338	0.149
	Average	**3.86**	**1.78**	**1.57**	**0.49**	**0.907**	**0.549**	**0.386**	**0.110**
4 >500 beds	Public Hospital	2.38	1.97	0.36	0.05	0.615	0.509	0.093	0.013
	Private Hospital	4.95	2.37	1.33	1.25	1.039	0.498	0.279	0.263
	Average	**3.67**	**2.17**	**0.85**	**0.65**	**0.827**	**0.503**	**0.186**	**0.138**
Average		**3.71**	**2.13**	**1.10**	**0.50**	**0.636**	**0.381**	**0.196**	**0.089**

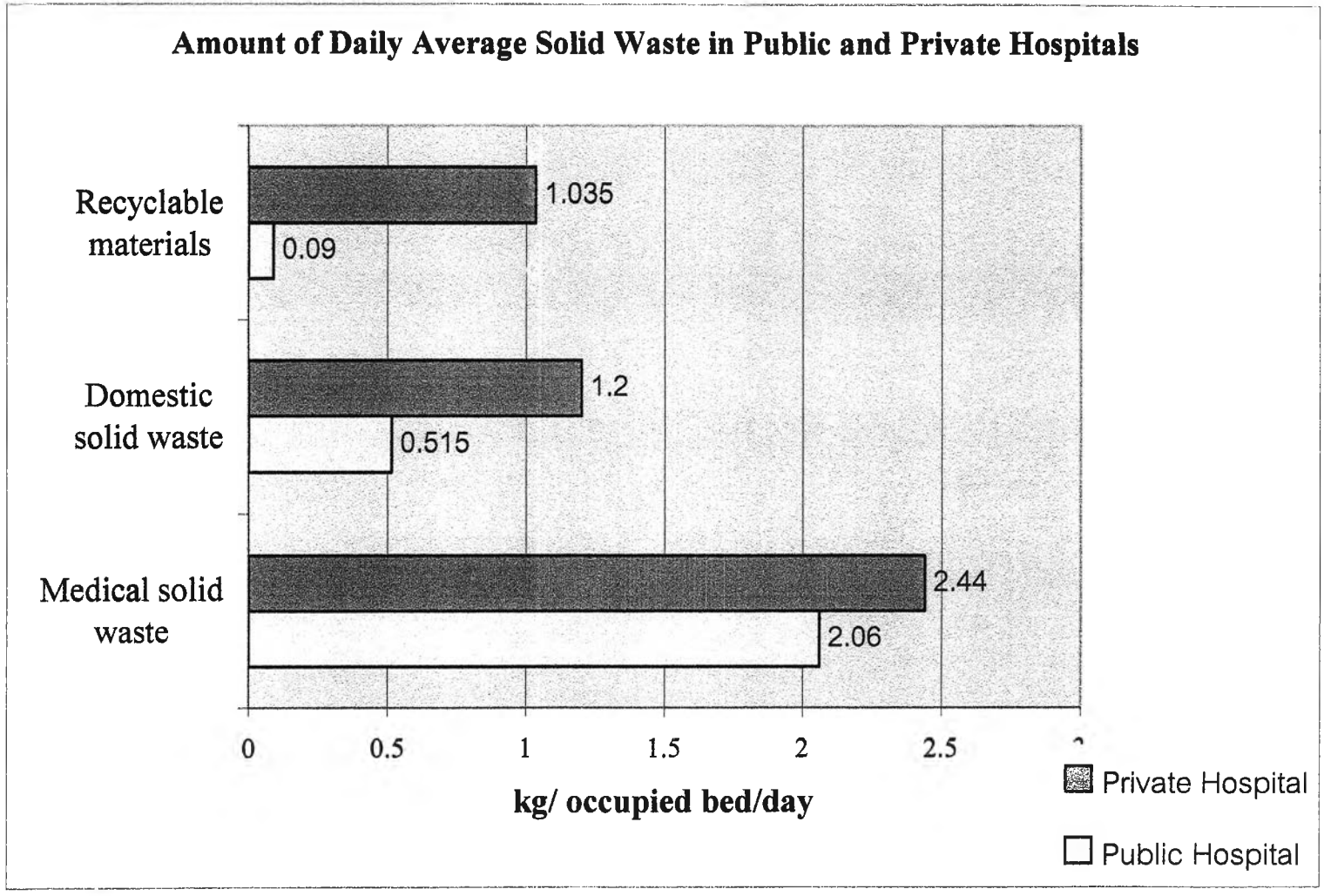

FIGURE 4.2 Comparison On Public Hospital And Private Hospital On Solid Waste Generation As *Kg/Occupied Bed/Day*

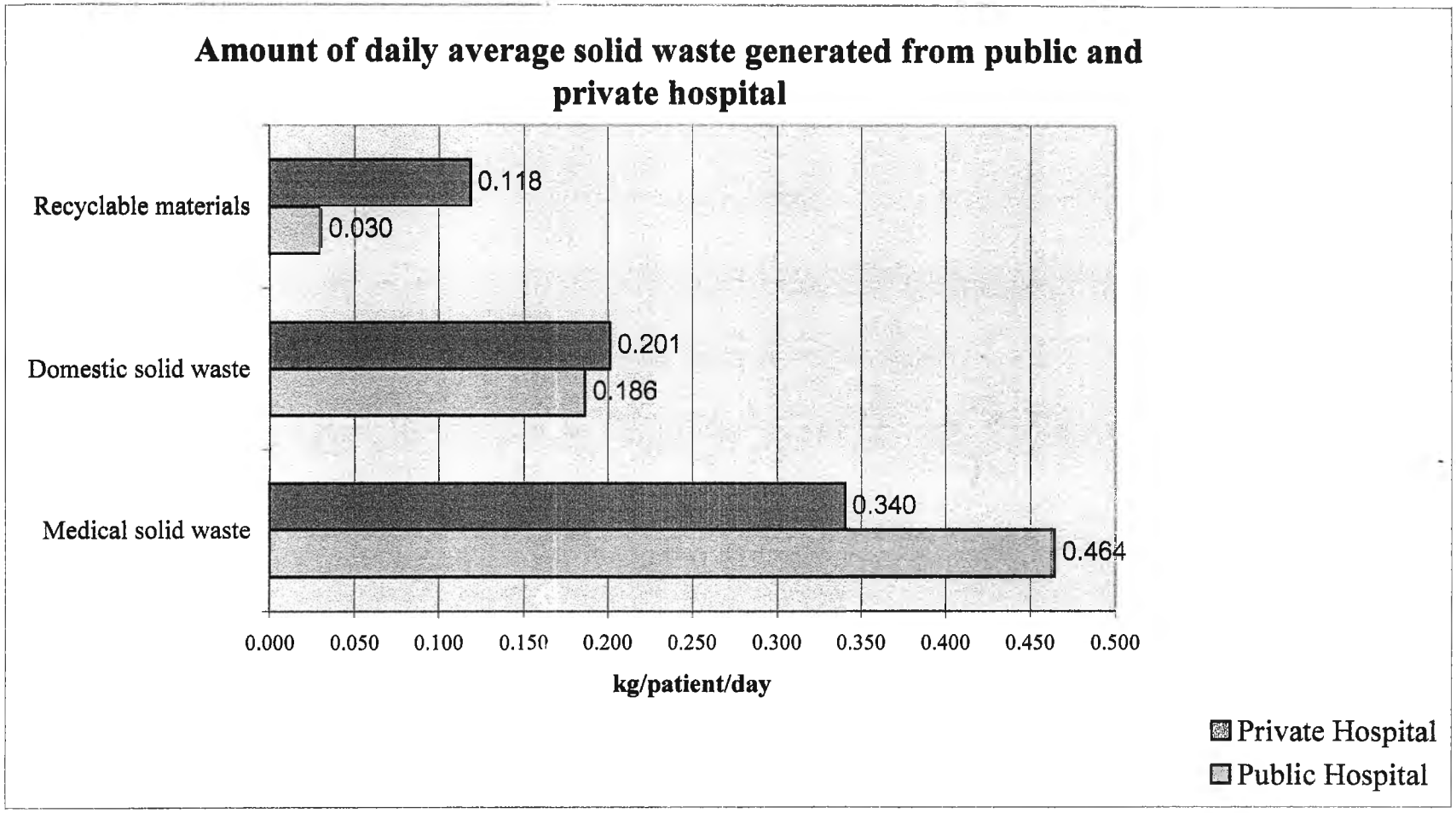

FIGURE 4.3 The Comparison On Public Hospital And Private Hospital On Solid Waste Generation As *Kg/Patient/Day*

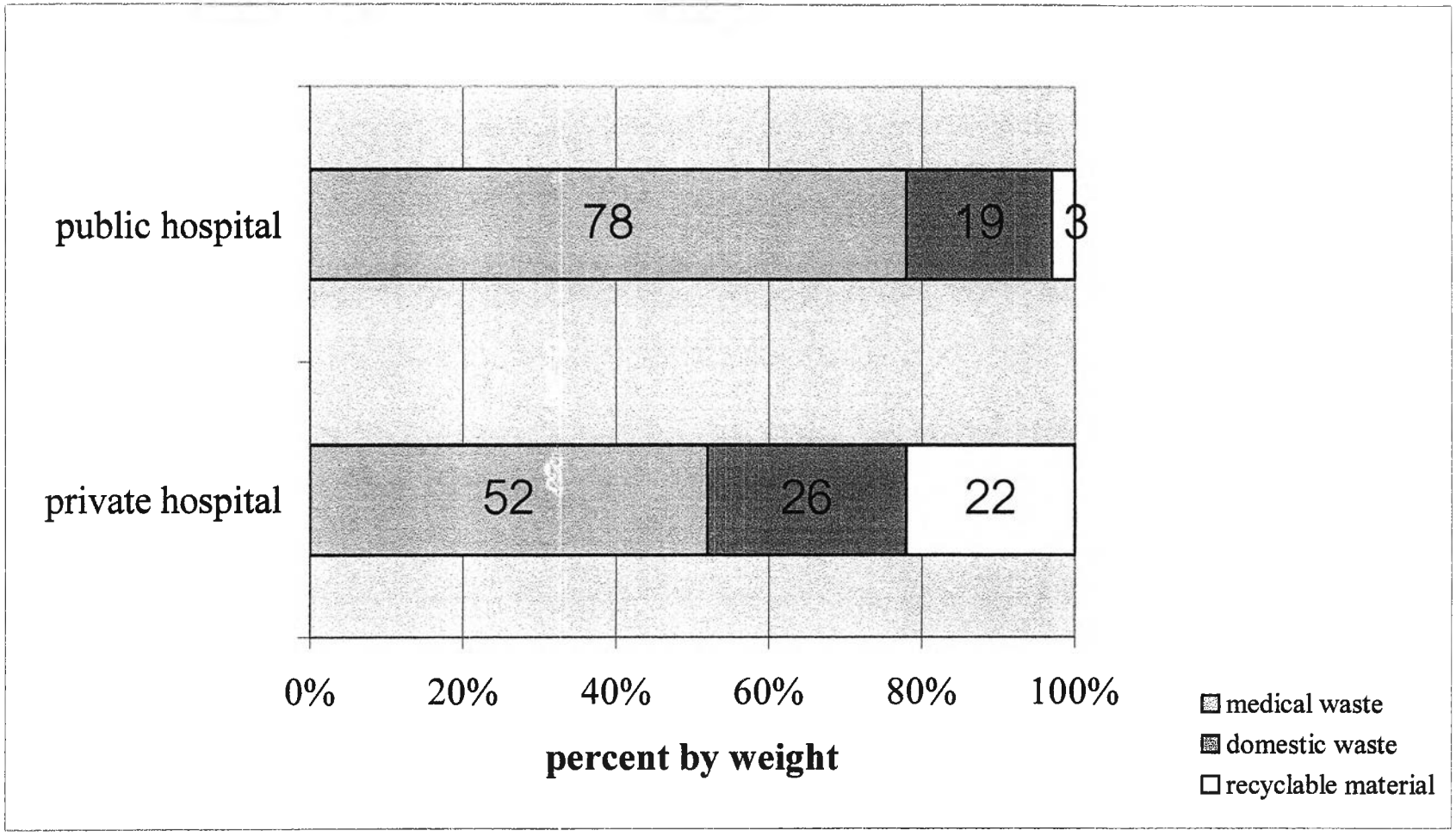

FIGURE 4.4 The Comparison On Public And Private Hospital On Solid Waste Composition (Classified By Physical Characteristic)

4.1.4 Medical waste

In this section, the compositions of medical waste classified into 5 categories were examined. The survey result is presented in Table 4.4. As depicted in figure 4.5, the compositions of medical waste stream surveyed from public hospital are pharmaceutical-22%, sharp-18%, infectious waste-38% chemical waste 6.5% and other-15.5%, while the compositions of medical waste stream surveyed from private public stream are pharmaceutical-27%, sharp-15%, infectious waste-32% chemical waste 5.2% and other-16.8%.

According to the result, infectious waste (such as blood, swab, gauze, diaper, and culture) presented the largest composition of medical waste stream generated from general hospital and followed by pharmaceutical waste, sharp, chemical waste and other. The medical waste composition from public hospital is not much different from private hospital. The composition of pharmaceutical from private hospital was found higher compared to public hospital, while other composition from public hospital was found lower.

TABLE 4.4 Composition Of Medical Waste Stream In Surveyed Hospital

Hospital	**Medical Waste Stream**				
	Pharmaceutical waste (% of total medical waste)	**Sharp** (% of total medical waste)	**Infectious waste** (% of total medical waste)	**Chemical waste** (% of total medical waste)	**Other** (% of total medical waste)
Public Hospital	22	18	38	6.5	15.5
Private Hospital	27	15	32	5.2	19.8

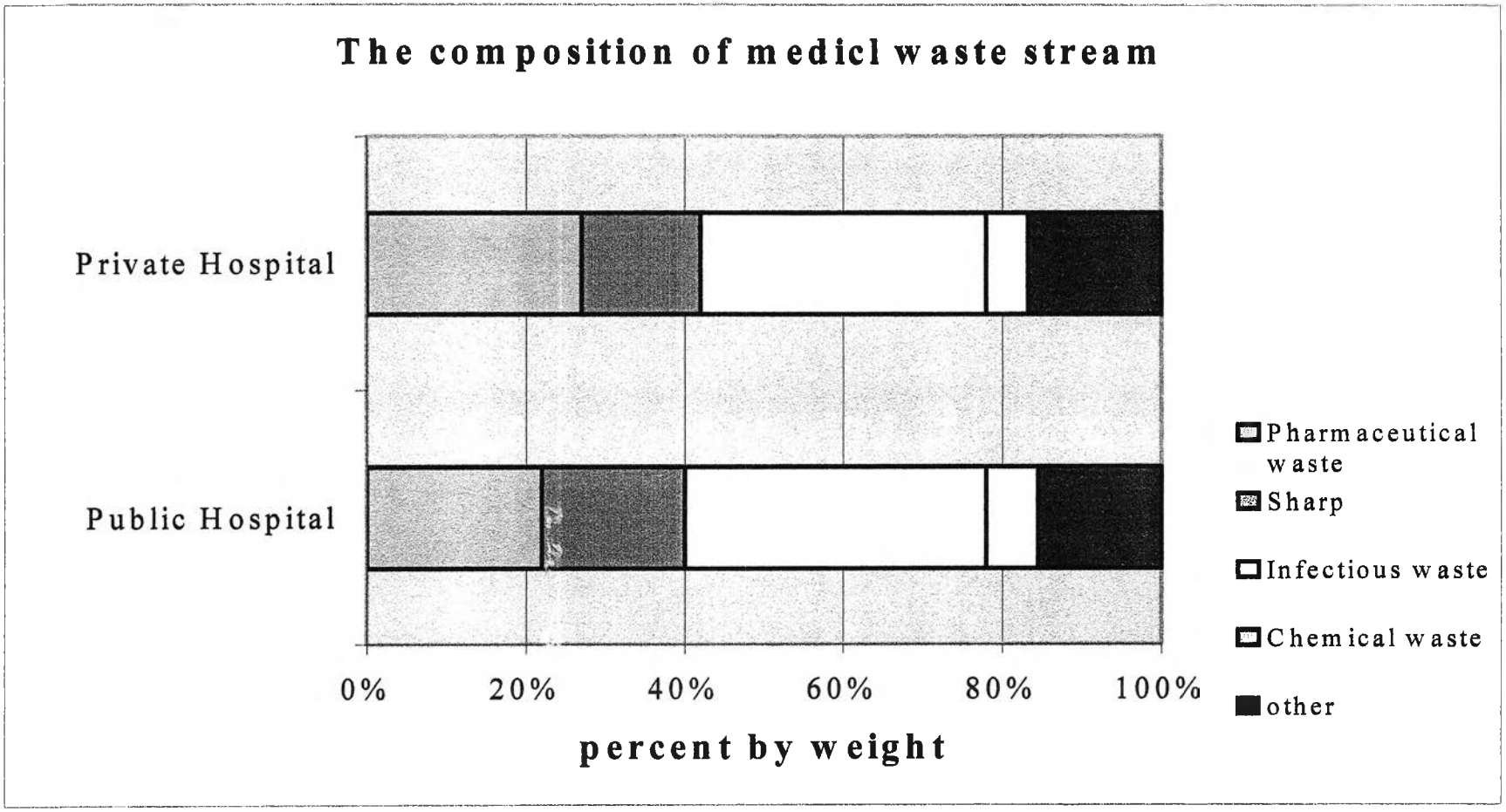

FIGURE 4.5 Comparison On Public And Private Hospital On Medical Waste Composition

4.2 Hospital Waste Management Study

4.2.1 Existing Waste Management In Hospital

In this section, the existing waste management in selected hospital was surveyed using questionnaires (in Appendix A), interviewing and site observation. The surveyed results are summarized in Table 4.5. The survey documented that the majority of hospitals in Chiang Mai City transport their waste for off-site incineration as 'infectious waste' and 'domestic waste'. From this study, some hospital did not segregate chemotherapy waste, chemical waste, and household hazardous waste. When such wastes enter the MSW stream, pathogens or the hazard in the wastes pose a great hazard to the environment and to those who come in contact with the wastes. At the various generation points: emergency room, operating room, patient care ward, and etc. trash/receptacles are provided. In the course of the days activities it is the duty of the hospital staff to empty these receptacles into an intermediate larger receptacles placed within the vicinity of respective work places. However, segregation of medical waste into categories is not significant especially in the small hospital and public hospital. The survey result show that only sharps and placentas from labor wards and theatre body products are significantly separated from other wastes. The personnel responsible for waste collection and transportation within the hospitals are mainly ward attendants (cleaner).According to the summarized in tabulation, 70% of hospital surveyed used the protective gear like gloves, boots and marks during waste handling.

The current waste management practice observed at 12 hospitals is that all waste, potentially infectious, office, general hospital, food and hazardous materials are mixed together as they are generated, collected, transported and finally disposed of. As a result of this failure to establish and follow segregation practice, the waste leaving hospitals is infectious and hazardous. No matter what final strategy for treatment and disposal of wastes is selected, it is critical that waste is segregated (preferably at the point of generation) prior to treatment and disposal.

4.2.2 Alternative Medical Waste Disposal Options

At this time, no alternative medical waste disposal technologies, such as autoclaving, are being used on-site on a large scale by hospitals. The future of alternate medical waste disposal systems is promising, but these technologies have

been slow to gain acceptance. The high initial costs of these systems have been a deterrent, although the momentum for investigating these systems seems to be picking up. This study documented significant interest on the part of hospitals to investigate alternative medical waste treatment technologies. Most health care facilities send their non-regulated medical waste (i.e., normal trash) to municipal incinerator, which is the cheapest disposal method. Only a few hospitals, particularly those with a heat recovery incinerator, burn their normal trash.

4.2.2.1 Recycling

Although there seems to be a leveling of recycling activities, and a need to initiate recycling of new and different materials, the current paper and cardboard recycling programs found in hospitals are well entrenched and running smoothly. five of the surveyed hospitals that are recycling do not have a paper-recycling program; most of these facilities just recycle cardboard. For many of the recyclable categories, more than half of the hospitals do not currently have a recycling program. Thus, there is still a great potential for recycling within hospitals. One hospital reported that when their recycling program started in 1999, they were able to reduce the number of dumpster pick ups from four per week to three per week.

Nine hospitals responded positively to the survey question asking whether or not steps had been taken to reduce wastes. Many explained how they have reduced the use of disposable products. A number described how they are reusing and/or recycling their plastic eating utensils and cups. To help identify prudent purchasing practices, hospitals have formed product committees. These committees evaluate all products with regards to cost, feasibility, safety, and environmental factors such as recycling.

4.2.2.2 Plastics

One of the unique characteristics of hospital waste is the large quantity of high quality plastics. This study indicates that plastics represent approximately 13.1 of the hospital waste stream. Our survey suggests that the amount of plastic in the waste stream may have increased slightly. Plastics composed 13.1%, by weight, of the wastes of those surveyed hospitals that reported in this survey. A number of hospitals have been able to successfully

recycle clean plastics from surgical areas, although programs such as this do not see widespread participation.

TABLE 4.5 Existing Waste Management In Surveyed Hospitals

Waste Management	Number of hospitals	% of total hospital surveyed
1. Waste Segregation		
- Sharp	12	100
- Infectious Waste	12	100
- Chemotherapy waste	9	75
- Chemical waste	8	67
- Household hazardous waste	7	58
- Recyclable material	9	75
- Pressurized container	2	17
2. Waste Container		
- Box or glass bottle for sharps with labeling	10	83
- Red bag for Infectious Waste	12	100
- Clearly marked containers and bag color	10	83
3.Infectious Waste Handling		
- Autoclave on site before send to municipality	3	25
- Off-site incineration with no pretreatment	6	50
- On-site Incineration (mixed with general solid waste and others medical waste)	1	8
- Burn on land (in-site)	2	17
4. Chemical waste handling		
- Drain to sewer system without pre-treatment	7	58
- Drain to sewer system with pre-treatment (neutralization, dilution)	3	25
- Send chemical containers to GENCO	2	17
- Discarded chemical containers with infectious waste(red bag) and send to municipality	6	50
- On-site Incineration (mixed with general solid waste and others medical waste)	1	8

Waste Management	Number of hospitals	% of total hospital surveyed
5. Staff		
- Use protective gear during waste handling	10	83
- Collection time schedule	5	42
- Educated and training	7	58
6. Treatment		
- Off-site incineration (by Municipality)	8	67
- Burning on land (in-site)	3	25
- On-site Incineration (mixed waste)	1	8

4.2.3 Recommendation for Managing Hospital Waste

The waste minimization program has been working on several interventions that hold promise for significantly reducing the medical waste stream in some hospital in Chiang Mai City. This section reviewed the success waste minimization program conducted in Chiang Mai City and proposed the alternative options to minimize hospital waste regarding waste minimization.

4.2.3.1 Case Study

The waste minimization program has been working on several interventions that hold promise for significantly reducing the medical waste stream in some hospital in Chiang Mai City. This section reviewed the success waste minimization program conducted in Chiang Mai City and proposed the alternative options to minimize hospital waste regarding waste minimization.

- **Hospital H/ Converting To Reusable Sharps Containers**

Hospital H-a 250-bed hospital reviewed its 2000 purchase records and determined that approximately 18,000 sharps containers were used. The weight of each type of empty sharps container was recorded and calculations were completed that documented the hospital could divert 13 tons of medical waste annually by switching to reusable sharps containers. These

containers are of a far more durable construction than traditional sharps containers and are expected to last five years or longer. After being dumped by mechanical means, the empty sharps containers are washed and disinfected before being returned to the hospital for reuse. The department also recently approved a safety needle device as a single use sharps container that allows the device's placement directly into the red bag waste stream. This device also eliminates the need for sharps containers.

- **Hospital J**

Hospital J is a 350-bed private hospital. Hospital J is the first hospital in Chiang Mai City to received ISO 14001 certification for its environmental management system on December 19, 2000. Hospital J's accomplishments have involved improving waste management programs to minimize the Hospital's impact on the surrounding environment, increasing staff awareness of environmental issues through training, establishing arrangements with external stakeholders to address specific environmental issues, and developing programs to improve the Hospital's environmental performance.

Environmental Benefits:

In 2000 alone, hospital J achieved the following through implementation of its Environmental Management System Action Plan:

- 27.5 tones of white paper diverted from disposal;
- 40% increase in recycling materials collected as a result of the introduction of 22 recycling container stations throughout the Hospital;
- 21% reduction in the volume of biomedical waste generated;

In 2001, hospital J is continually improving, by achieving the following accomplishments:

- Approximately 60 tones of white paper diverted from disposal;
- Approximately 20% increase in recyclables collected from 2000;
- 20% reduction in amount of biomedical waste generated in comparison to 1999 data;

- Fluorescent Lamp Recycling: Since the end of 2001, the hospital is diverting 20-40 fluorescent lamps per month from landfill, and has diverted 644 lamps to date.
- Minimized the use of Disposables in Operating Room: Operating staff responsible for material requisition has minimized the use of disposables such as table covers and drapes required in surgical procedures. Reusable gore materials have replaced these disposable products.

Economical benefit:

Hospital J has achieved a 28% reduction in the total volume of waste generated. Specific projects such as the biomedical waste reduction project implemented in 2000 achieved a $5000 savings.

4.2.3.2 Alternative Options To Minimize Hospital Waste Regarding Waste Minimization.

In this section, alternative options regarding wast minimization were proposed. Table 4.6 summarized waste minimization practices for reduce hospital waste.

TABLE 4.6 Alternative Options To Minimize Hospital Waste Regarding Waste Minimization

Hospital Administration	▪ Make a public commitment to waste prevention and recycling ▪ Incorporate waste impacts into the procurement criteria for evaluating products and processes ▪ Institute departmental accountability ▪ Review waste disposal contracts ▪ Establish training programs in appropriate and safe waste handling practices for clinical and housekeeping staffs ▪ Review office procedures to reduce waste generation
Materials Management	▪ Reduce inventories(reduce warehousing requirements and costs, as well as reduce the need to stockpile supplies that may expire) ▪ Review patient care unit replenishment requirements (reduce supplies hoarding and decrease the amount of supplies discarded because shelf life has been exceeded) ▪ Encourage suppliers to consider reusable distribution packaging

Medical/Surgical	▪ Reduce admission kit components (reduce costs and wastes) ▪ Improve quality and reduce quantity of surgical drapes (higher quality drapes may reduce the total number of drapes used per procedure and associated procurement costs) ▪ Reduce items and standardize Operating Room (OR) packs (It also reduces the potential for items to be discarded unused) ▪ Donate unused Operating Room supplies ▪ Emptying I.V. bags prior to disposal in the trash (reduces the weight of the waste and reduces the cost of waste management services) ▪ Consider opportunities to increase the use of reusable instrument parts where possible ▪ Install refillable soap and lotion dispensers
Central Sterile Services	▪ Use rigid sterilization containers ▪ Consider lightweighting sterilization covers where possible (Lightweighting may reduce both purchasing costs and the cost to manage waste from your facility)
Pharmacy	▪ Encourage delivery in reusable totes (Reduced inventory decreases the potential for expired pharmaceuticals.) ▪ Return outdated pharmaceuticals to the distributor ▪ Reduce admixtures waste(Produce smaller quantities of admixtures several times each day or just prior to delivery to patient rooms to avoid disposal of unused product.)
Building Services and Housekeeping	▪ Reduce the use of plastic bags ▪ Reduce the use of plastic bags ▪ Replace paper towel dispensers in public rest rooms with hot air hand dryers (Hot air dryers provide significant operating benefits. Elimination of paper towels reduces labor to service a restroom by as much as 50 percent) ▪ Use refillable dispensers for cleaning chemicals
Waste Management	▪ Minimize red bag locations.(Reducing the number of containers designated for regulated medical waste (RMW) helps to ensure that only the appropriate RMW is discarded into the containers. This cuts the costs associated with the RMW stream because less non-regulated and recyclable waste can be discarded into the RMW stream containers. Additional benefits include reduced supply costs and reduced labor costs to manage the RMW containers) ▪ Collect regulated medical waste in reusable containers (helps staff avoid inappropriate disposal of non-regulated or recyclable wastes, decreases the quantity of RMW generated and the RMW management costs, as well as supply and labor costs) ▪ Collect sharps in reusable containers (reduces both supply and labor costs) ▪ Enhance diversion of materials for recycling (Use staff training as an opportunity to reinforce the source separation of recyclable materials including corrugated cardboard, office paper, plastic, and metal and glass food and beverage containers)

4.3 Hazardous Waste Survey Result

4.3.1 Findings

4.3.1.1 Finding of Waste Survey at Hospital A

Hospital A is a general hospital with 500 beds and 2800 employees. Clientele consists of approximately in-patient person per day 235 and outpatient per day 750 to 800. This hospital has not implemented any programs specifically designed to minimize waste. In-house departments, which generate hazardous waste include a pharmacy, pathology, radiology, histology, the clinical testing laboratory, dialysis, and engineering. Primary sources of hazardous wastes include haemodialysis, the clinical testing laboratory, and the pharmacy.

Department of Pharmacology &Therapeutics

The pharmacy purchases antineoplastic chemicals, which are inventoried through a computerized central receiving system. Supplies kept in-house at a given time are inventoried to last two week. Antineoplastic drugs used as chemotherapy agents are the hospital's largest source of hazardous waste by volume. Approximately two five-gallon disposal cans are filled with liquid chemotherapy waste each week. Gowns, gloves, and other articles contaminated by cytotoxic drugs are bagged and placed in 55-gallon steel drums. All chemotherapy waste are transported off-site for disposal. Chemotherapy and antineoplastic waste stream waste of this hospital is illustrated in Figure 4.6.

Department of haemodialysis

Hazardous waste generated through haemodialysis includes 4% formaldehyde that has been pumped through 18 individual dialysis units, at the rate of 250 cc's per day. Effluent lines from these machines are connected to the municipal sewer system. Tubing from the units is discarded as infectious waste. Dialysis waste stream of this hospital is illustrated in Figure 4.7.

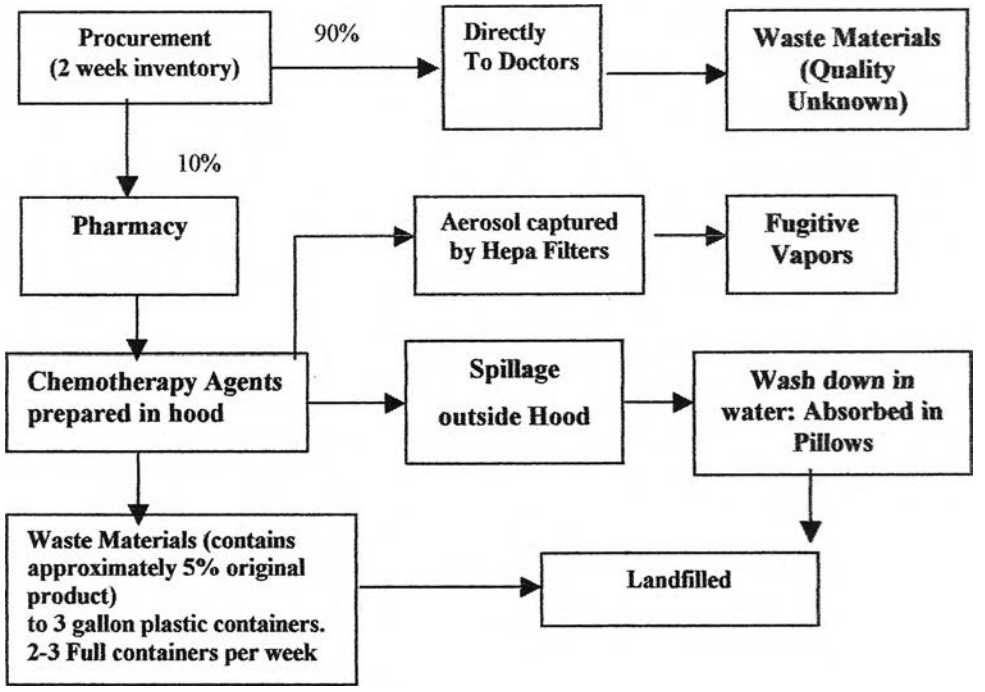

FIGURE 4.6 Pharmacy And Chemotherapy Waste Stream Of Hospital A

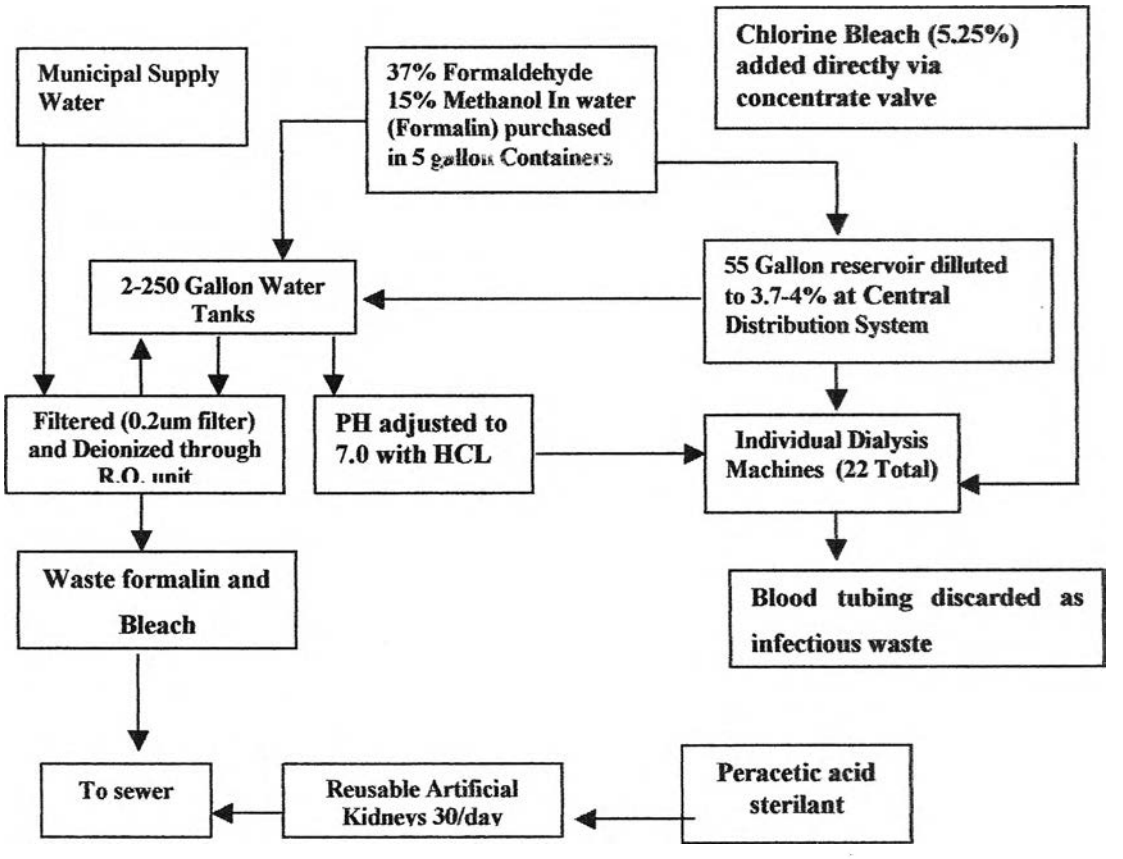

FIGURE 4.7 Dialysis Waste Stream From Hospital A

Clinical Testing Laboratory Department

Radioactive tagging in the clinical testing laboratory is also a source of hazardous waste at this hospital. Approximately 1200 ml per week of radioactive water, or tritium, are generated. About five gallons per month of radioactive solid waste are also generated. Tritium is a beta-emitter with a half-life of 57 years. An additional 200-ml per week of toluene are evaporated under a hood. Radioactive wastes are transport off site for disposal. Radioactive waste stream of this hospital is illustrated in Figure 4.8.

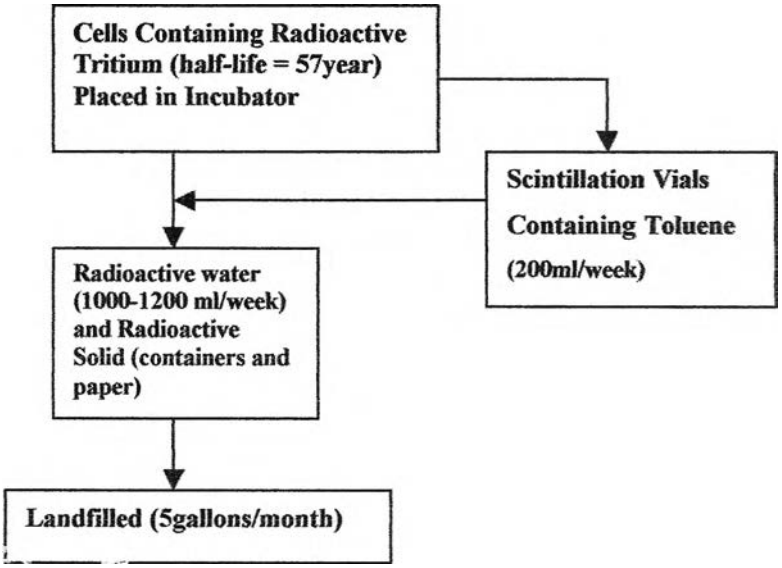

FIGURE 4.8 Clinical Testing Lab (Radioactive Tagging) Waste Stream Of Hospital A

4.3.1.2 Finding of Waste Survey at Hospital B

Hospital B is a general hospital with 350 beds and 2100 employees. Clientele consists of approximately in-patient person per day 135 and outpatient per day 492. This hospital has conducted ISO 14000 certified and internal environmental compliance audit. Waste minimization, however, has not been specifically addressed.The types of in-house departments are typical for full-service hospital, although much of the laboratory work is performed through a regional laboratory at a separate location. This regional laboratory manages some of the hazardous waste streams that the hospital would

otherwise be required to manage itself. Procurement of Hazardous materials is conducted through a central clinic and separate general purchasing department. The housekeeping department maintains hazardous waste manifests.

Department of Pharmacology &Therapeutics

The pharmacy generates antineoplastic wastes, which are incinerated on site every month. It also generates outdate drugs, which are returned to the regional pharmacy. Chemotherapy waste stream of this hospital is illustrated in Figure 4.9.

Department of haemodialysis

The haemodialysis department generates 4% formaldehyde waste, which is disposed of to the sewer at a rate of about 10 liters per week. It also generates 5.25% sodium hypochlorate, which is also discharged to the sewer at a rate of about 12 liters per week. Dialysis waste stream of this hospital is illustrated in Figure 4.10.

Department of Pathology

The laboratory and pathology departments generate primarily xylene and formaldehyde waste, in the amount of about two gallons per month of Xylene and one gallon per month of formaldehyde. In both cases, this waste is discharged to the sewer. Reagents are used in "contained packs" for unit applications, which then are disposed of as infectious waste.

Department of Radiology and Imaging

The radiology/imaging department generates hazardous waste consist of fixer, developer, and mercury on occasion. Silver from the fixer is extracted and 20% of the solution is recycled. Although mercury disposal does not occur on a routine basis, it is handle regionally

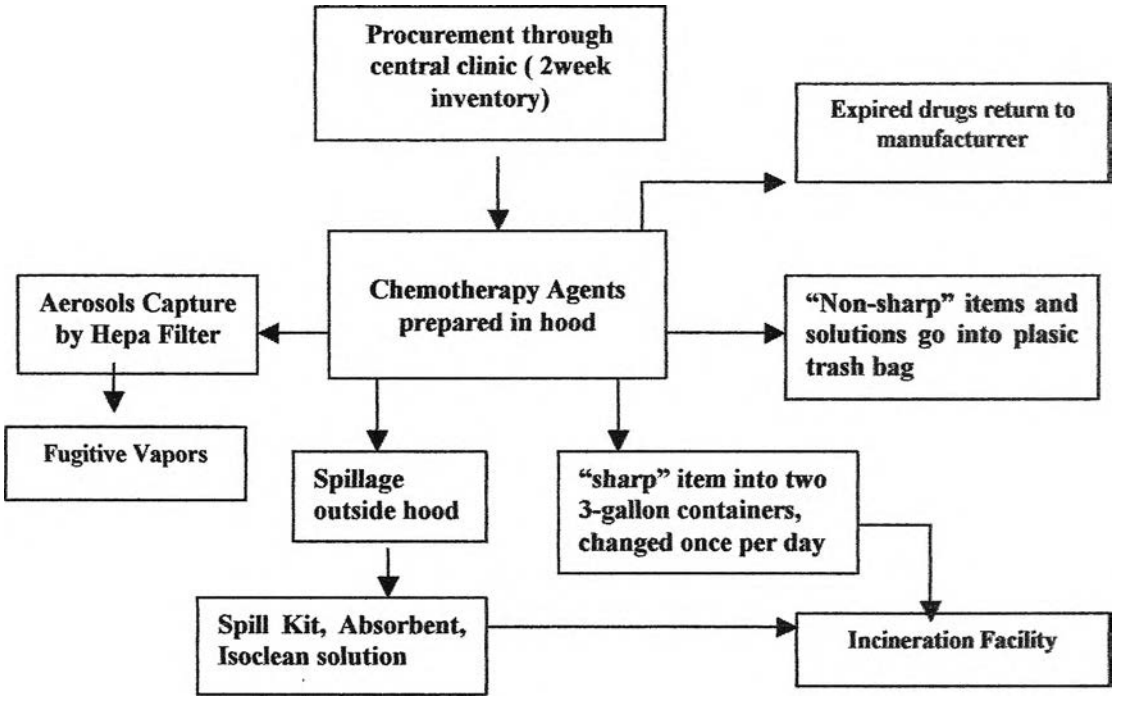

FIGURE 4.9 Chemotherapy Waste Stream Of Hospital B

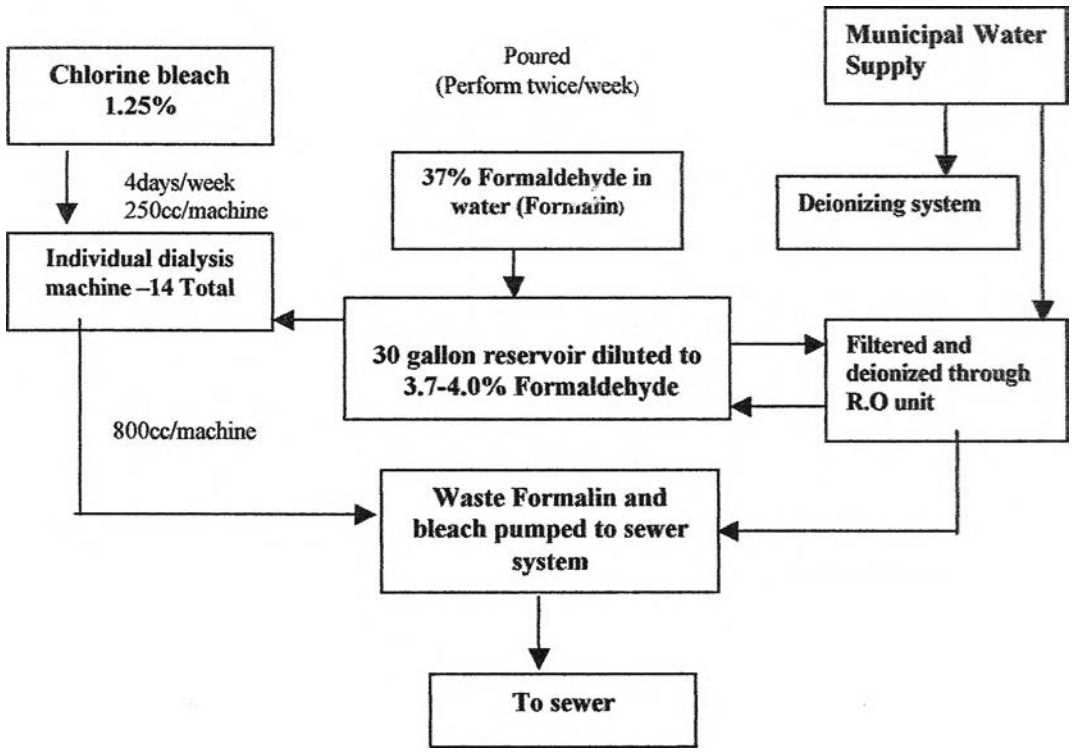

FIGURE 4.10 Dialysis waste stream of Hospital B

Respiratory Therapy Department

The respiratory therapy department generates approximately 600 ml. Of 70% alcohol per day, which is discharged to the sewer.

Central sterile supply department

The Central Sterile Supply Department generates only ethylene oxide, which is vented to the atmosphere and sewer.

Engineering Department

The engineering department handles various hazardous materials. It generates only about three gallons per month of used oil, which is transported off site for disposal. This department also uses solvents, aerosols, and water-based latex paints, which are consumed.

4.3.2 Benchmarking of Hazardous Waste Management in surveyed hospital

In this section, the management of hazardous waste stream generated from hospital was study. The results hazardous waste management study can summarized in Table 4.7, and discussion presented below.

TABLE 4.7 Hazardous Waste Management In Surveyed Hospital

Hazardous Material	Point of Generation	Point of Use and Disposal	Common Disposal
Chemotherapy and antineoplastic chemicals	Prepared in central clinic or pharmacy	- Patient Care areas - Pharmacy - Special Clinics	- Incineration as RMW - Disposal as HW
Formaldehyde	- Pathology - Autopsy - Dialysis - Nursing Units	- Pathology - Autopsy - Dialysis - Nursing Units	- Diluted and flushed down sanitary sewer
Photographic Chemicals	- Radiology - Satellite Clinics offering radiology services	- Radiology - Clinics offering radiology services	- Developer and Fixer is often flushed down sanitary sewer - X-ray film is disposed of as solid waste

Hazardous Material	Point of Generation	Point of Use and Disposal	Common Disposal
Solvents	- Pathology - Histology - Engineering - Laboratories	- Pathology - Histology - Engineering - Laboratories	- Evaporation - Discharged to Sanitary sewer
Mercury	- Throughout all clinical areas in thermometers, blood pressure cuffs, cantor tubes, etc. - Laboratories	- Clinical areas - Labs	- Broken thermometers are often disposed in sharps containers - Disposed of as RMW or SW
Anesthetic Gases	- Operation Theater	- Operation Theater	- Waste gases are often direct vented by vacuum lines to the outside
Ethylene Oxide	- Central Sterile Re-processing - Respiratory Therapy	- Central Sterile Re-processing - Respiratory Therapy	- Vent exhaust gas to the outside
Radio nuclides	- Radiation Oncology	- Radiation Oncology	- Secure storage for time required for decay of nuclear elements (check with local authority for requirements)
Disinfecting Cleaning Solutions	- Facilities Management, - Operating Theater	- Diagnostic Areas - Operating Theater - Facilities Management	- Dilution, disposal in sewer

4.3.2.1 Chemotherapy waste

Chemotherapy waste account for the largest volume of hazardous waste produced by surveyed hospitals. An average of 0.06 to 0.27 m^3 of chemotherapy waste per week was generated by the hospitals surveyed. The generations of chemotherapy waste from different sources of surveyed hospital are presented in the following tabulation. The results show that, pharmacy is the largest source generating chemotherapy waste. Only a small percentage of these wastes contain concentrated amounts of chemotherapy compounds. Much of the waste volume is associated with lightly contaminated items such as personnel proactive clothing and gauze pads. Waste materials

are placed into plastic bags or plastic containers that are either replaced daily, or when they are full. Sharp items such as needles are also discarded, but may be separated and handled as infectious waste. These wastes are either transported off-site to landfill or incinerated as infectious waste. From the records of hospital A, the quantity of chemotherapy waste was dramatically decreased with the reducing generation of residual material and ordering appropriately sized containers.

TABLE 4.8 Chemotherapy Waste Generated In Hospital And Hospital B

Sources of chemotherapy waste	Hospital A			Hospital B		
	Average (m^3/Week)	m^3/day	% by volume	Average (m^3/Week)	m^3/day	% by volume
1) Pharmacy	10.61	1.52	68	13.36	1.91	62.7
2) Patient care ward	2.37	0.34	15.2	2.92	0.42	13.7
3) Special clinic	1.17	0.17	7.5	3.17	0.45	14.9
4) Other	1.45	0.21	9.3	1.87	0.27	8.8

4.3.2.2 Formaldehyde waste

Formaldehyde also represents a significant source of hazardous waste at surveyed hospitals. For use in dialysis, formaldehyde is generally purchased as a 37 percent formaldehyde-in-water solution (formalin). It is subsequently diluted with filtered, deionized water to achieve a final formaldehyde concentration of 2-4 percent. The formalin is either pumped or poured into dialysis machine to disinfect the membranes and the effluent is discharged to the sewer. The comparisons on generated rate of formalin waste from hospital A and hospital B is presented in the following tabulation. The results show that quantity of used formalin solution of hospital B (16.4 cc/machine/day) is higher than hospital A, and generated rate of formalin waste of hospital B (800liter/machine/day) is also higher than hospital A (472.7liter/machine/day). However, from the record of 2 surveyed hospitals reported that use of RO units allows a reduction in the cleaning frequency requirement of dialysis machines. Other departments, formaldehyde are generally used to preserve

specimens with small quantities of waste generated and discharged to the sewer. Discharging a hazardous material to the sewer may be illegal and is generally an undesirable management practice, even if sanitation authorities allow such disposal.

TABLE 4.9 Benchmarking Of Formalin Waste In Hospital And Hospital B

Hospital	Waste formalin discharge to sewer (m3/day)	Pumped formalin solution (cc/day)	Number of Dialysis machine (machine)	generation of waste formalin(liter/machine/day)	Use of formalin solution (cc/machine/day)
A	10.4	250	22	472.7	11.4
B	11.2	230	14	800.0	16.4

4.3.2.3 Photographic waste

Full-service hospitals generally have a radiology department. The photographic developing solutions used in X-ray departments consist of two parts, a fixer and a developer. The fixer normally contains 5-10 percent hydroquinone, 1-5 percent potassium hydroxide, and less than 1 percent silver. The developer contains approximately 45 percent glutaraldehyde. Acetic acid is a component of stop baths and fixer solutions. These two chemical solutions usually are obtained in 30- or 55- gallon drums. The contents are routed from these drums directly to the developing machine. Silver-containing effluent from the fixer solution is passed through a steel wool filter or otherwise treated to recover this precious metal. The remaining aqueous waste, containing approximately 1.4 percent glutaraldehyde, 0.3percent hydroquinone, and 0.2 percent potassium hydroxide, is typically discharged to the sewer. Some hospitals utilize X-ray services that also provide silver recovery as part of the package. The generation rate of photographic chemical of the surveyed hospitals is presented in Table 4.10.

TABLE 4.10 Benchmarking Of Photographic Waste In Hospital A (reusing develop) And Hospital B (no reusing developer)

Hospital	Photographic Waste	Daily average waste generation	Daily average of examined patient	Generation rate as kg/ examined patient
A	fixer	7.53	56	0.13
	Developer	4.95	56	0.09
B	fixer	12.32	85	0.14
	developer	23.5	85	0.28

The generation rate of developer waste from hospital A (0.09-kg/ examined patient) is much lower compare with hospital B due to reusing developer in photo-processing. In additional, silver recovery program in hospital A has been reported decreasing management cost of used film and cartridge.

4.3.2.4 Radioactive waste

Radioactive wastes are generated in nuclear medicine and clinical testing laboratory department. At the public hospital surveyed, radioactive materials in nuclear medicine were retained on site until they decayed to nonhazardous level. In clinical testing laboratories, solvents are also used for radioactive tagging. Wastes at the audited hospitals are generated at a rat of about 80 cubic centimeters per week. The radioactive wastes are transported off site for land disposal.

4.3.2.5 Solvent waste

Solvent wastes are typically generated in various departments throughout a hospital. These include pathology, histology, engineering, embalming, and laboratories. Volumes of the solvent wastes generated at the hospitals surveyed were small. Specific solvents used in medical setting include halogenated compounds such as methylenechloride, chloroform, freons, trichloroethylene, and 1,1,1-trichloromethane. Other solvents include

nonhalogenated compounds such as xylene, acetone, ethanol, isopropanol, methanol, toluene, ethyl acetate, and acetonitrile. Xylene, methanol, and acetone were the most frequently used solvents at the surveyed hospitals. Xylene and ethanol are used in histology and cytology laboratories of hospital anatomic pathology departments. In issue processing, ethanol dehydrates and xylene clears tissue prior to paraffin infiltration and embedding. Then xylene is used to remove paraffin and ethanol to hydrate sections before staining. Ethanol and xylene are again used to dehydrate and clear sections before the cover slip is applied to the microscope slide preparation.

While acetone and methanol waste are usually evaporated or discharged to the sewer, the xylene wastes are normally handled as hazardous materials. Some of these wastes are absorbed in specimens, which are then treated instead as infectious wastes. Solvent wastes are typically stored in 30- or55- gallon drums and are either recycled or transported off site for incineration. In the past, small quantities of solvent wastes were routinely disposed of via lab packs to landfills. This alternative is becoming increasingly less desirable due to higher disposal costs, long-term liability, and limitations introduced by new, more stringent regulations.

4.3.2.6 Mercury

The primary sources of mercury waste at surveyed hospitals include broken or obsolete equipment, and amulgam waste from dental clinic. Mercury wastes are recently decreasing in quantity due to the substitution of solid-state electronic sensing instruments (thermometers and blood pressure gauges) for those containing mercury. Mercury from broken equipment is recovered and reused (if uncontaminated). Mercury losses due to spillage may not be frequently recovered; no mercury spill kits were present in any of the two surveyed hospitals.

As a result of a lack of waste segregation, many of these hazardous materials are flushed down a waste water drain that flows directly to an open sewer or river, are mixed into general solid waste for disposal in municipal bins or are mixed into wastes which are incinerated as potentially infectious waste. According to the hazardous waste management survey, there was little or no observable capacity for the management, treatment, recycling or final disposal of hazardous wastes in our country (e.g. chemicals, mercury, batteries). Hospitals seeking to segregate hazardous wastes are left with little or no option for safe disposal. The development of an industry which is capable of managing hazardous wastes (chemicals) is essential. On-site reprocessing technology is available for hospitals for materials such as xylene or formal in, and recovery technology for silver from developing solution. These technologies may be cost prohibitive at this time. Pollution prevention and the choice of nonhazardous or less hazardous material is the only real option left to hospitals, which should be followed regardless of the existence of a hazardous waste industry.