Environmental Action Plan for A Hospital in Bangkok

by

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Abstract

This study was conducted at a hospital in Bangkok. This hospital is a general medical hospital with 538 beds and offers treatment up to 18 years of age patients.

Currently the hospital is facing problems in terms of high water consumption. The daily average water consumption of 1,034 m^3/d consisted of hospital use (1,589 L/bed/d) and dormitory purposes (517 L/head/d). The water consumption in the hospital is 2 to 3 times higher than the other reported findings. As part of the waste audit program, possible water wastage reduction options were identified in hospital dormitories.

In view of chemical or toxic wastes generated, it has been found that the hospital generated around 57 mL/bed/d. It was noted that approximately 37 percent of total chemical wastes discharged to sewers was contributed by laundry section which led to be the largest generator of chemical wastes. Air pollution, in terms of total dust, was collected in three sections of the hospital. It was found that there was no significant amount of dust concentration compared with the Thai standard. On the other hand, noise pollution for both indoor (62 dBA) and outdoor (75 dBA) of the hospital were higher than the other reported studies (30-45 dBA). Environmental Action Plan (EAP) was developed in this study with respect to three objectives; water wastage reduction, chemical/toxic wastes minimization and provide safe and pleasant working environment.

Introduction

Issues of improving the management of hospital wastes are receiving increasing attention throughout the world since hospitals generate tons of medical waste each year. The waste generated has been increasing due to the use of disposable materials and development in medicine production. Hazardous and Toxic Materials (HTM) Office Board of Public Works, Los Angles (1995) estimated that around 15 percent of hospital waste is contaminated with infectious agents potentially hazardous to human health such as hepatitis and human immunodeficiency virus (HIV) and to the environment. As these changes have been gradual and waste disposal was not previously perceived as a major concern, the response of the hospital field has been largely piecemeal and uncoordinated.

In many developing countries, not only is solid waste considered a major problem because of the large percentage of hospital-generated waste but other wastes such as wastewater and air pollution have been becoming serious problems. Due to the lack of investment and infrastructure, in some cases, wastewater discharged from hospitals often runs directly into nearby water bodies (Nelson et al., 1993). Improperly discharged wastes to sewers will generate wastewater potentially dangerous to handlers. Moreover, most hospital

incinerators were never designed for the disposal of large quantities of waste and consequently have become overloaded, causing air pollution in surrounding areas.

In minimizing risk to the environment and human health, for many years, environmental protection activities by hospitals focus on treating and disposing waste through the end-of-pipe approach. This approach has few advantages such as straight forward and simple operations; low risks and meets the required standards in a short span of time. However, it provides only a short-term solution. The difficulty of handling and disposing of by-products such as sludge and dust is growing as environmental and economic concerns, additional costs and land limitations aggravate existing problems.

Numerous studies have been carried out on solid waste management of hospitals but little previous data is available on wastewater. This study investigates water and wastewater of a hospital in Bangkok. The results obtained will serve to identify areas where control measures are necessary; enhance decision making tools for management to identify opportunities for reducing waste; and would be applicable to other urban hospitals generating similar types of waste.

Methodology

Water and Wastewater Auditing

The study investigation was carried out to investigate the available potentials of water conservation, waste minimization and comfortable environment. It consists of understanding a detail survey of both water and wastewater systems.

Sampling

Water Supply

The source of raw water in this hospital was drawn from the municipal water supply. Therefore, water sample was collected only from the tap water (see Figure 1, sampling point no.12). Grab sampling method was chosen in this case because it is ascertained that the quality of water is relatively constant all the time.

Wastewater

The wastewater discharged from each building is conveyed to Central Wastewater Treatment Plant (CWWTP) through closed PVC pipe. The main problems encountered during fixing the sampling points were:

- it was extremely difficult to locate the sewers, there was no detail pipe/sewer line flow diagram available at the hospital,
- the wastewater from other hospitals/institutes are also mixed with the hospital under study (see Figure 1).

Based on above difficulties, it was agreed to use the manholes as an access for taking samples both for quality and quantity. The other sampling sites were at discharge point of each unit operation that discharges different types of wastewater.

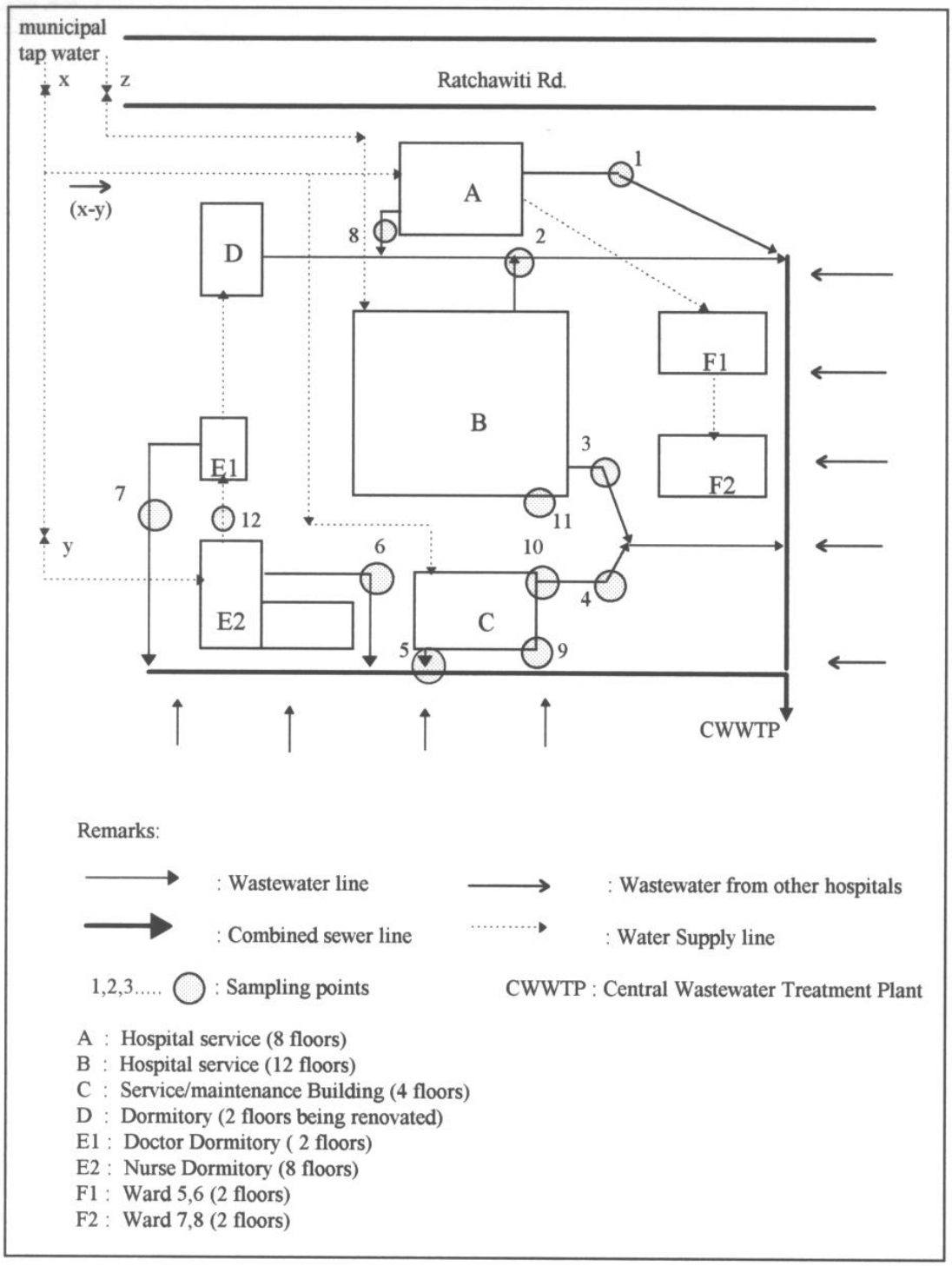

Figure 1 Water and Wastewater Layout and Sampling Points

Central Wastewater Treatment Plant (CWWTP)

The CWWTP was designed to treat wastewater from five hospitals/institutes. Therefore, the auditing of this plant is not within the scope of this study. However, the wastewater

characteristics data is used as comparative data with existing wastewater characteristics of 'A' hospital.

General Environmental Evaluation

General environmental evaluation for limited parameters were conducted by measuring Noise and Air Particulate.

Sound Level Meter (SLM) was used to evaluate the noise exposure value in term of Sound Pressure Level (SPL). The universal flow sample pump connected with 0.5 μ PVC filter is a personal pump used in this research to evaluate the concentration of dust/particulate in a working area (indoor and outdoor).

Environmental Action Plan (EAP)

Environmental management for this study are mainly concerned with water supply, wastewater, air and noise pollution. This program was developed to improve the environmental performance of the hospital with respect to three objectives as follows:

1. Water wastage reduction by 65 percent in the year 2002
2. Recommend hospital waste management and chemical/toxic waste minimization
3. Provide safe and pleasant working environment by reducing noise pollution by 35 % in the year 1998

Results and Discussion

It has been found that the characteristics of water used in the hospital meet three different drinking water standards. It means the water drawn from municipal water supply is safe to be used as water source in hospitals except several departments/sections such as pharmaceutical, milk preparation and kitchen which demand high quality of water standards for its processes. In fulfilling of its high water quality, a distillation unit is installed to treat the tap water before using in the pharmaceutical section. Likewise, the filtration units are installed in milk preparation and kitchen sections.

Table 1 Water Supply Characteristics at the Hospital Compared with Other Standards

No	Parameters	Units	Source			
			'A' Hospital	Thailand (MSTE, 1994)	India (MUDI,1991)	WHO (1984)
1	pH	-	6.8	6.5-8.5	7.0-8.5	6.5-8.5
2	Color	Pt-Co	5	5	5	15 (TCU)
3	Turbidity	NTU	2	5	2.5	5
4	TS (TDS)	mg/L	313.3	500	500	1000
5	Iron (Fe)	mg/L	0.02	0.5	0.1	0.3
6	Manganese (Mn)	mg/L	<0.025	0.3	0.05	0.3
7	Copper (Cu)	mg/L	ND	1.0	0.05	1.0
8	Calcium (Ca)	mg/L	54	75	75	-
9	Chloride (Cl)	mg/L	14	250	200	250
10	Nitrate (NO_3)	mg/L	0.33	45	45	45
11	Sulphate (SO_4)	mg/L	29.2	200	200	400

Water consumption in this hospital was found to be 1034 m^3/d. It was observed that the daily average water consumption from March to April was 1003 m^3/d, 1028 m^3/d and 1072

m^3/d respectively. The continuos increase of water consumption in this hospital is mainly due to the extension of hospital facilities such as shops and other new wards facilities. Three installed watermeters in different buildings were used to record total water consumption in the hospital. Out of three installed watermeters, one watermeter called 'Y' records water consumption of dormitories (E1 and E2). While 'Z' and '(X-Y)' record water consumption of hospital purposes. Figure 3 shows different water consumption.

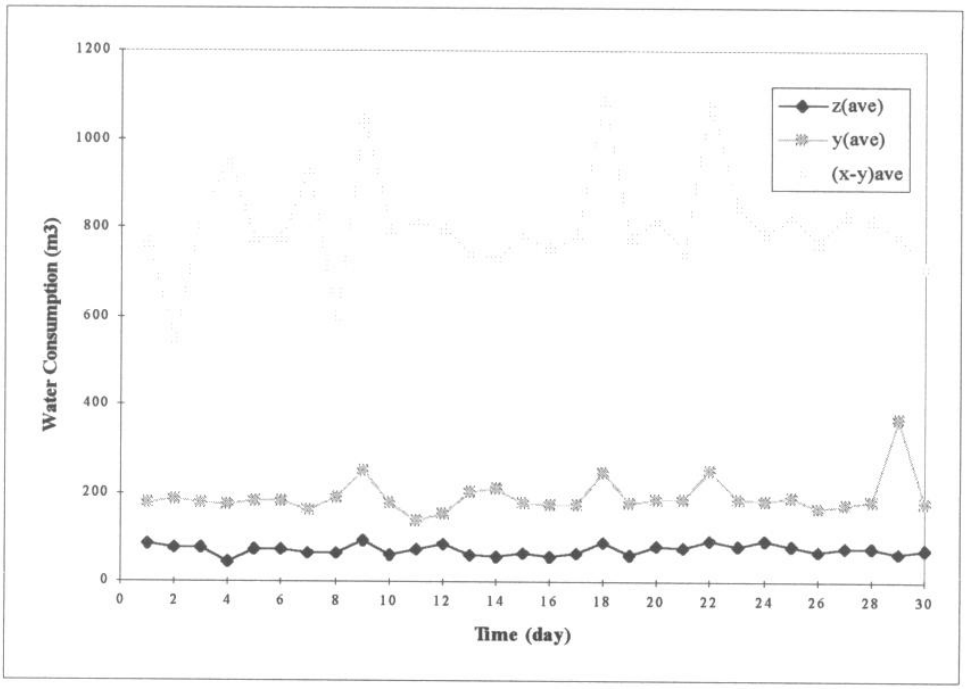

Figure 2 Water Consumption Based on Three Different Watermeters

According to Figure 2, the average of wastewater record of hospital activity water consumption '(X-Y)' is higher compared with other. This occurs because of activities and number of population in these sections are much more that other as presented in Table 2.

Table 2 Installed Watermeters and Activities Served

Watermeter	Activities Served (Average)
(X-Y)	No. of inpatients = 287 No. of outpatients = 762 No. of attendants = 2098 No. of staff (include doctors & nurses) = 939 Other facilities: laundry, kitchen, cafeteria, boiler, milk preparation
Y	No. of population (dormitory) = 348
Z	No. of inpatients = 131 No. of outpatients = 30 No. of attendants = 322 No. of staff (include doctors & nurses) = 301 Other facilities: chemical lab., cooling tower

5

Total water consumption of hospital excluding dormitories is calculated by adding up watermeter record of '(X-Y)' and 'Z', Based on observation (March-May, 1997), the total average water consumption was 855 m^3/d. This hospital is having 538 number of beds, therefore, water consumption per bed per day was 1,589 L/bed/day. The average water consumption in the dormitories were calculated from watermeter reading of 'Y' which is 180 m^3/d. Total number of population in these dormitories were 348, therefore, water consumption per head per day was 517 L/head/day.

Table 3 presents comparison of hospital water consumption per bed per day at this hospital with other studies. Meanwhile, water consumption of dormitory per head per day compared with other studies are presented in Table 4.

Table 3 Water Consumption in the Hospital Compared with Other Studies

Sources	Water Consumption (L/bed/d)	Water Consumption (m^3/d)
1. 'A' Hospital	1,589	855
2. India (MUDI, 1991)	650	350
3. Metcalf and Eddy, 1991		
- bed	568	353
- employee	38	

Table 4 Dormitories Water Consumption in the Hospital Compared with Other Studies

Sources	Water Consumption (L/head/day)
1. 'A' Hospital Dormitory	517
2. India (MUDI, 1991)	132
4. Metcalf and Eddy, 1991	150

According to Tables 3 and 4, It has been found that the water consumption for both the hospital and dormitories are higher than other studies. Based on these earlier bench marks, one could be stated that the average water consumption by this hospital is 2 to 3 times higher than the other reported findings. This high per capita water consumption, necessitates the need for a detail water audit.

Water Uses

Water uses in each activity of this hospital has been calculated by different methods. The overall water uses in each activity is shown in Figure 3.

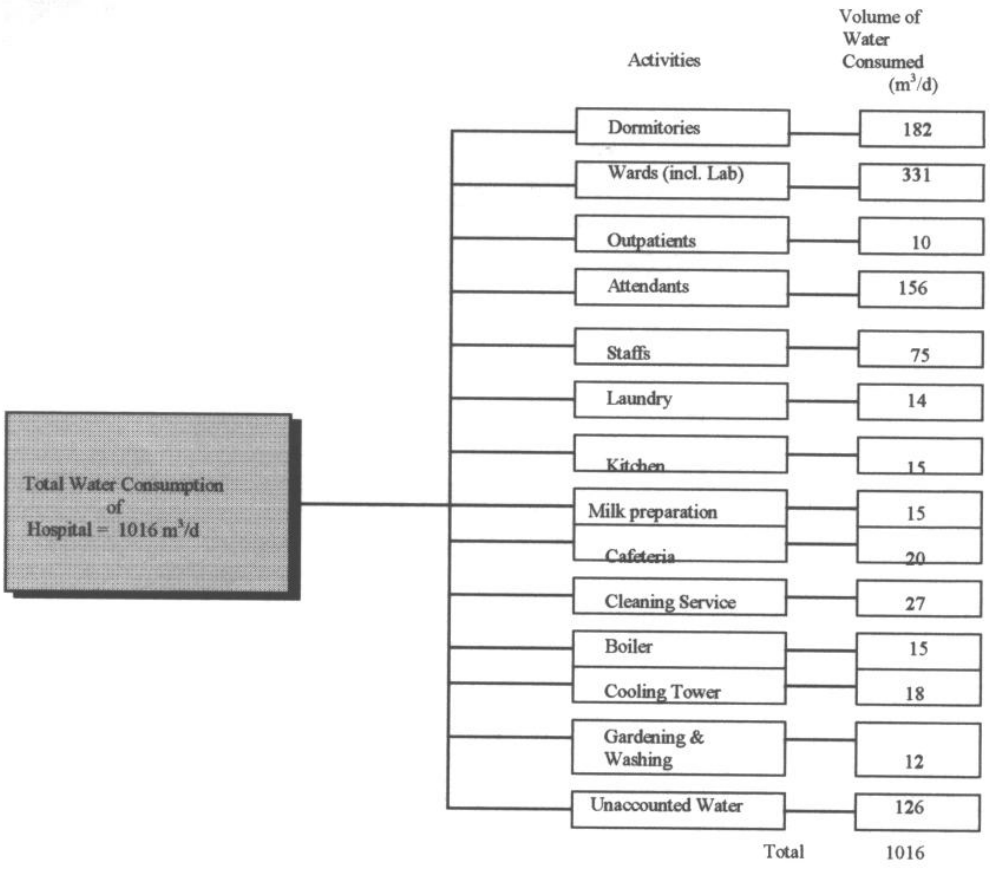

Figure 3 Estimation of Water Uses in Each Activity

This can be concluded that water consumption in the wards including the laboratories is the highest (331 m^3/d) compared with other activities. It was surprisingly known that the attendants of this hospital have also consumed significant amount of water (156 m^3/d) which is mainly for toilet purposes. Total number of attendants during observation were 2600 in a day. This is a unique case especially for a typical hospital where the patients are always accompanied by their parents during examination. Moreover, most of inpatient parents also stay in the hospital for 24 hours. Number of attendants are totally influenced by the number of patients. Based on the observation and interview, this can be defined that the ratio of patient and attendant were 1:2.

There are only three main watermeters installed in this hospital. These watermeter were installed in different buildings. Therefore, it was very difficult to measure the water consumption in each section precisely. Consequently, there was about 126 m^3/d of unaccounted water consumption and this could not be detected at all. Based on site observation, unaccounted water was possibly due to leakages along the pipes and reservoir, water used in constructions and other water uses that could not be detected.

Leakage Detection

Leakage detection was conducted by closing all the valves of this pipe system (tap, shower, toilet etc.) for about an hour. It was found that the water level in 9 fiber glass reservoirs

dropped by 16 cm, corresponding water loss is 70 m^3/day, which is around 7% of total hospital water consumption

Hospital Wastewater

Characterization of hospital wastewater from each sampling point has been done along with measurement of wastewater flowrate. The results are presented in Table 5 and 6.

Table 5 Wastewater Flowrate in Hospital Compared with Other Studies

Sources	Wastewater Flowrate (L/bed/day)	Percentage to Water Consumption (%)
1. 'A' Hospital	1182	63
2. Metcalf & Eddy, 1991	625	85
3. CTC, Thailand, 1994	904	80

Table 6 Hospital Wastewater Characteristics Compared with Other Studies

Parameters	Unit	'A' Hospital at various streams	Indonesia (Moersidik,1993)	Thailand (CTC, 1994)
1. pH	-	4.4 - 10.1	5.9 - 12.5	7.2
2. TSS	mg/L	23.3 - 376	36 - 269	103
3. TDS	mg/L	340 - 1720	-	-
4. COD	mg/L	50.6 - 880	154 - 642	232
5. BOD_5	mg/L	27.8 - 795	118 - 302	113
6. TKN	mg/L	10.2 - 71.7	-	32

Here it can be noted that the flowrate of wastewater in 'A' hospital was higher than other studies, though the percentage related to water consumption is lower. Whereas, the characteristics of wastewater in this hospital are almost having the same values with other studies. An attention should be paid to laundry wastewater which discharges its wastewater to sewers directly with high pH (10) and temperature (80°C).

Infectious and Chemical Wastes

It was very difficult to get an accurate data concerning the chemical wastes used and discharged to sewer since there was no the book record of chemical used in each section. Nevertheless, observation of infectious and chemical wastes discharged to sewers have been done by directly observing and interviewing to the sections where these wastes are generated.

The percentage of liquid chemical wastes in this hospital is less than 1 percent compared with the total wastewater produced. A sample of wastewater from laboratory was taken and analyzed. The characteristics of sample taken was not significant compared with combined hospital wastewater, the relative low value of the laboratory wastewater is possibly caused by high dilution of tap water at sampling point. Nonetheless, physically this waste could be recognized easily since it has a violet color. The characteristics of laboratory wastewater compared with combined hospital wastewater is presented in Table 7.

Table 7 Characteristics of Laboratory Wastewater

Parameters	Unit	Laboratory Wastewater	Combined Wastewater
1. pH	-	6.72	6.68
2. TSS	mg/L	19.2	152
3. TDS	mg/L	373.3	400
4. COD	mg/L	96.4	400
5. BOD_5	mg/L	35.1	240
6. TKN	mg/L	37.0	63.7

It has been found that this hospital generated about 57 mL/bed/d of chemical wastes. It was found that the highest amount of chemical waste produced to be 341 L/month of disinfecting solution and 645 kg of detergent and bleaching powder was from laundry section. This chemical waste contributed around 37 percent of the total chemical wastes produced in this hospital. The percentage of liquid chemical wastes produced based on the sources of waste are shown in Figure 4.

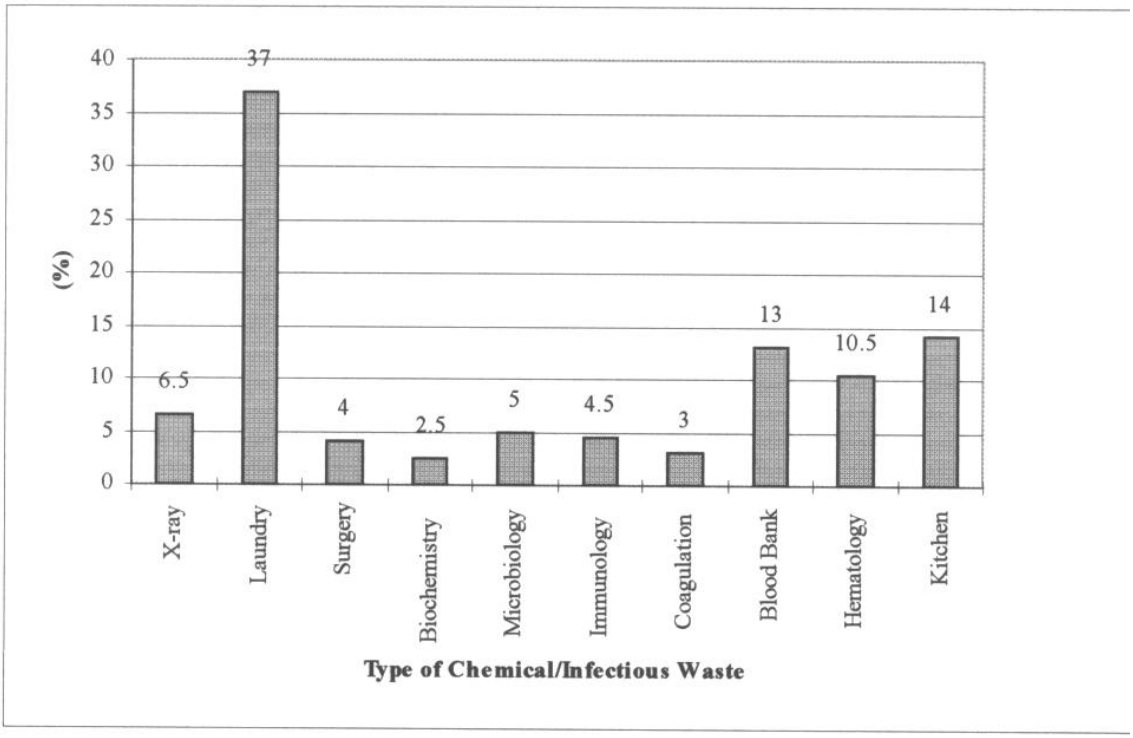

Figure 4 Percentage of Liquid Chemical/Toxic Waste

Work Environment in Hospital

Noise Pollution

Noise pollution measurement has been done for both the indoor and outdoor of the hospital. Table 8 presents general noise level in hospital compared with other studies.

Table 8 Noise Level in 'A' Hospital Compared with Other Studies

Sources	Noise Level (dBA)
1. 'A' Hospital (day time)	
- outdoor	61.7 - 87.9
- indoor	60.0 - 63.5
2. Chhatwat et al., 1989	
- day	45
- night	35

According to Table 8, it can be concluded that all of noise level in 'A' hospital both of indoor and outdoor are higher than other studies. Based on observation, there were no workers who work in the boiler, diesel and vacuum pump room for more than 1 hour, therefore, noise effects to workers caused by these instruments were not considered seriously except in laundry room. However, most of indoor and outdoor noise pollution in this hospital are caused by boiler, vacuum pumps, cooling tower, laundry machine, vehicle, diesel, construction, air conditioner, traffic and attendants.

During surveys it has been found that one of the surgical staffs complained about speech interference during conducting operation of the patients due to air condition noise. She always faced difficulties to communicate with the doctor during operation of patient which required for the surgeon to repeat the instructions many times to ensure communication.

Noise level in surgical room has been measured and it was found that the noise level was 60.0 - 63.5 dBA. Compared with other studies 45 dBA (Chhatwat et al., 1989), noise in surgical room are quite high, so the staff complaint should be seriously considered in order to prevent any accidents.

Air Particulate

The concentrations of air particulate at various type of work are presented in Table 9.

Table 9 Concentration of Air Particulate of Various Type of Work

Section	Date	Sampling Duration (min.)	Pump Flowrate (L/min)	Room Temp. (°C)	Wt. Of Particulate (mg)	Conc. (mg/m^3)
Information (A)	22-4-97	190	1	22	0.5	2.15
Transportation (B)	22-5-97	150	1	35	1.1	3.8
Service Buil. (C)	7-5-97	136	1	33	0.7	2.8

Measurement of air particulate has been done in three different locations. The particulate concentration of three measured data were meeting the Thai standard (15 mg/m^3, for working hours) released by MSTE, 1994.

Environmental Action Plan (EAP)

Base on the environmental audit conducted at this hospital, a detail EAP was prepared and the summary is presented in Table 10.

Table 10 Environmental Action Plan (EAP)

Recommendations	Year Implementation	Responsibility
1. Good housekeeping :		Service Section.
- Repair of leaking valve in nurse dormitory, kitchen, milk preparation	1997	
- Repair of cracked ground reservoir in service building	1997	
- Repair of floating valve of dormitory reservoir	1997	
- Modify cleaning basin, milk prep. and kitchen section (120 cm x 45 cm x 32 cm) to (120 cm x 45 cm x 15 cm) (6 basins)	1997/1998	
2. Plumbing fixtures replacement to waste saver :	1998 to 2002	Service Section approved by Adm. Sec.
- showerhead (147 units)		
- watertap (235 units)		
- lavatory faucet (363 units)		
- toilet value (264 units)		
- urinal faucet (38 units)		
3. Hospital waste minimization :		
- Plastic bags color coding/segregation	1997	Service and Adm. Section recommended by Green Team
- Inventory of drugs and chemicals distributed to each section by computerizing	1998/2000	
- Drugs dispensing in ward/other section controlled by computerizing	1997	Adm. Section
- Material/device substitution i.e. :		
* halogenated solvent ⟶ non halogenated solvent	1998/1999	
* mercury based thermo. ⟶ electronic sensing devices	1999	
* chemical sterilization ⟶ sonic sterilization	1999	
- Process :		Service, X-ray and Surgery Sec. Recommended by Green Team
* Install Reverse Osmosis water supply equipment to solve formaldehyde waste problem for dialysis machines	1998	
* Extend processing bath life in x-ray section	1998	
- add ammonium thiosulfate		Service and X-ray Sec. Recommended by Green Team
- add acetic acid to keep pH low		
- Silver recovery :		
* Metallic replacement	1999	Training, Adm. Section, and Green Team
* Electrolytic disposition	1999	
- Educate hospital staff/community :	1997 to onwards	
* Increase awareness of hospital staff and management by applying that each section in hospital should be responsible for their own disposals cost		
* Inform about their performance in waste minimization against goals and objective through bulletin/pamphlet,		

11

etc. * Waste exchange day program is suggested in env. days or other special days * Training of the hospital staff * Bonus to staff who has suggested and participated for waste reduction		Adm, Phar-macy sec. and Med. Supplier
- Encourage the external institutions that influence with the hospital activities	1997 to onwards	
4. Noise abatement :		Service, Surgical, Adm. Section recommended by Green Team
- Provide/install the wall sound insulation (wood wool slab) * boiler room * water pump room * vacuum room * diesel room * chiller room	1997 to 1998	
- Provide ear defenders * boiler room * vacuum pump * diesel room * chiller and compression	1997	
- Provide earplugs in laundry room	1997	
- Install hood/exhaust insulation in surgical room	1997	
- Curtain in ward	1997/1998	
5. Other :		under Rachawithi hospital authority
- Central wastewater treatment plant * install small diameters screen after barscreen * install automatic removal of retained objects from the screen	1997	
- Provide impervious concrete bund wall for storage of infectious waste	1997/1998	Green Team, Adm., Pharmacy, and Service Sec.
- Set up on regular drug collection programs	1998 to onwards	

note : The Green team is a group work in this hospital which deals with the general hospital environmental improvement and chaired by Deputy Director of Medical.

Conclusions

1. Total water consumption volume in 'A' Hospital was 2 to 3 times higher than the other studies mentioned. This volume was divided for dormitory purposes (517 L/head/d) and hospital use (1,589 L/bed/d).
2. The water leakage detection has been done in hospital dormitories. It was discovered that about 70 m^3/d or 7 percent of total tap water consumption were used inefficiently. As a result, the hospital has been losing about 263,000 Baht per year for this reason.
3. Chemical or Toxic wastes generated in this hospital were 57 mL/bed/d in which laundry section is the largest as generator of chemical waste. Moreover, handling of toxic wastes should be strictly regulated, since the hospital which has 538 beds may produce more than 300 kg of toxic waste/month.

4. Noise pollution for both the indoor (62 dBA) and outdoor (75 dBA) of the hospital were higher than other studies (30-45) dBA. This occurred due to there was no noise control on the rooms which produce noise nor in the recipient.
5. An Environmental Action Plan (EAP) should be developed to improve the environmental performance of the hospital with respect to three objectives; water wastage reduction, chemical or toxic minimization and provide safe and pleasant working environment.

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