ENVIRONMENTAL ACTION PLAN FOR A HOSPITAL

by

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Abstract

This study was conducted in the Queen Sirikit National Institute of Child Health, often called Children's 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 and the percentage of wastewater to water supply was 63 percent. As partly the waste audit program, possible water wastage reduction options were identified in hospital dormitories. It was discovered that about 70 m^3/d or 7 percent of total water consumption were used inefficiently due to bad housekeeping. As a result, the hospital has been losing 263,000 Baht per year.

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).

At present, a 'Green Team' has been set up in the hospital which deals with the general hospital environmental improvement. In this connection, an 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.

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Abbreviations

AIDS	Acquired Immune Deficiency Syndrome
AIT	Asian Institute of Technology
BOD_5	Biochemical Oxygen Demand (5 Days)
COD	Chemical Oxygen Demand
CTC	Clean Technology Consultant
CWWTP	Central Wastewater Treatment Plant
EAP	Environmental Action Plan
EGAT	Electricity Generating Authority Thailand
d	Day
h	Hours
HIV	Human Immunodeficiency Virus
HTM	Hazardous and Toxic Materials
L	Liter
MSTE	Ministry of Science Technology and Environment
MUDI	Ministry of Urban Development India
OBR	Occupancy Bed Rate
PVC	Polyvinyl Chloride
RCRA	Resource Conservation and Recovery Act
RO	Reverse Osmosis
SLM	Sound Level Meter
TDS	Total Dissolved Solid
TKN	Total Kjeldahl Nitrogen
US-EPA	Enviromental Protection Agency, USA
Victoria-EPA	Environmental Protection Authority, Victoria, Australia
WHO	World Health Organization

Chapter 1

Introduction

1.1 Background

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.

At present, the preferred approach in waste management strategy is (Thornton, 1990):

1. waste avoidance or waste reduction,
2. waste reuse, recycling and reclamation,
3. waste treatment, and
4. waste disposal.

The first step in developing waste management strategy is to conduct a waste audit. This will identify the type, volume and sources of waste being generated and give a comprehensive look at a site or process to facilitate an understanding of material flows and to focus attention on areas where waste reduction and cost saving is possible.

Numerous studies have been carried out on solid waste management of hospitals but little previous data is available on wastewater. The present 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.

1.2 Objectives

The objectives of the study are to:

- study the present water system and its management;
- identify possible optimum management options leading to improvement of the water system;
- identify each waste stream leaving the hospitals premises, using a flow diagram, with a major focus on wastewater stream;
- establish how and why each wastewater stream is generated;
- quantify wastewater discharges and their flow variability and characterize every waste stream for their physical and chemical characteristics;
- identify suitable treatment options;
- prepare detail Environmental Action Plan (EAP) for the hospital.

1.3 Scope of Study

This study will be limited to a general medical hospital type which has 538 beds. Although general environmental evaluation such as noise and air pollution will be conducted at initial stages a detailed audit will be confined to water and wastewater issues only.

All options of design recommendations and modifications will be limited to environmental and economical evaluation components merely with objective water saving and pollution reduction, along with environmental improvement.

Chapter 2

Literature Review

2.1 Overview of Hospital Wastes

The public is increasingly concerned over the improper disposal of medical waste, particularly those contaminated with communicable disease agents. Medical wastes include all types of wastes generated by health care organizations such as hospitals, clinics, physicians offices, dental offices, veterinary facilities, other medical laboratories and research facilities.

HTM Office Board of Public Works, Los Angles, 1995 defines hospital wastes as the wastes are generated in hospital including general (domestic) and medical including infectious wastes.

Litchfield and Phelan, 1992 states that infectious waste as any substances containing microorganisms, helminths or viruses which pose a threat to the health of human beings or any other beneficial user of the environment due to their volume or virulence.

2.2 Generation of Hospital Wastes

U.S. Department of Health and Human Services (1990) defined that the waste generation rates within the hospitals depend on the factors:

a. Hospital Type
b. Hospital Size
c. Occupancy Rate
d. Inpatient/Outpatient Ratio
e. Geographic Location

<u>Hospital Type</u>

The hospital can be classified into this following four types:

1. General Medical and Surgical Hospital
2. Psychiatric Hospital
3. Tuberculosis Hospital
4. Other Specialty Hospital

Almost 85 percent of waste generated from the hospitals in the USA is contributed by general medical and surgical hospital as presented in Table 2.1.

Hospital Size

Hospital size is traditionally determined by the number of beds, which has a positive correlation between size and waste generation rate. This is because, large hospitals offer more services than the small ones, this is probably the case. The volume of waste generated per bed has proven to be an effective way to estimate waste generation in the hospital category.

Occupancy Rate

One of the determinant of the amount of medical waste hospitals generated is occupancy rate. In the USA, the rate for general medical and surgical hospitals which present the majority of all hospitals is 62.3 percent. Padmi and Mufidah (Bandung, Indonesia), 1996 defined that occupancy rate a hospital having 1010 bed was 68.8 percent.

Inpatient/Outpatient Ratio

In general, inpatients generate more medical waste than do outpatients, In the USA, ratio of inpatient and outpatient is 0.07 percent. However, the reliability of this ratio as an indicator for waste generation is influenced by the increasing number of services provided on an outpatient basis and a change in the type of services provided on this basis.

Geographic Location

Differences in waste generation rates may exist between urban and rural hospitals. At present, more hospitals are in urban areas. Additional information on how these rates differ is needed to determine the degree of importance of geographical distribution as a determinant for hospital waste generation.

Table 2.1 presents the waste generated by different types of hospital in the USA (US-EPA, 1991) and hospital waste generation in several countries.

Table 2.1 Hospital Waste Generation in Several Countries

Country	Quantity of Waste (ton/year)	Source
USA	465,000	US-EPA, 1991
Italy	150,000	Liberti et al., 1996
UK	200,000	Liberti et al., 1996
Victoria, Australia	21,000	Victoria-EPA, 1993

The hospital waste production rates (Kg/bed/day) in several countries (developed and developing countries) are tabulated in Table 2.2.

Table 2.2 Hospital Waste Production Rates

Country	Quantity of Waste (kg/bed/day)	Source
USA	4.5	WHO, 1994
UK	3.3	WHO, 1994
Italy	0.25 - 7.0	Liberti et al., 1996
Netherlands	1.3 - 6.5	Liberti et al., 1996
Australia (Victoria)	0.75 - 10.1	ACHWD, 1988
Brazil (Sao Paulo)	3	Neto et al., 1990
Indonesia (Bandung)	2.12	Padmi and Mufidah, 1996
Malaysia	0.3 - 2.4	Ogawa, 1993

Most of a hospital's waste is general refuse, and the remaining waste is contaminated with infectious agent e.g. microbiological cultures, blood and blood products, isolation wastes from patients with communicable diseases, pathological specimens and sharps. The percentage between general and infectious wates are presented in Table 2.3.

Table 2.3 The Percentage of General and Infectious Waste

General Waste (%)	Infectious Waste (%)	Source
77	23	Victoria-EPA, 1993
90	10	Garvin, M.L., 1995
65 - 80	35 - 20	Ogawa, H., 1993
87.4	12.6	Padmi and Mufidah, 1996

2.3 Sources, Types and Categories of Hospital Waste

2.3.1 Sources and Types

Advisory Committee on Hospital Waste Disposal (ACHWD), Health Department Victoria (1988) has identified source and type of hospital wastes generated at every section in the hospital as presented in Table 2.4.

Table 2.4 Source and Type of Hospital Wastes

Source (Hospital Section)	Type of Waste
1. Office, Administration	Paper, Confidential document for destruction.
2. Wards	General, Infectious, Sharps, Cytotoxic, Radio Active, Blood, Glassware, Placentae.
3. Pathology/Laboratory/Mortuary	Infectious, Sharps, Glassware, Radio-active, Human Tissue, Solvents.
4. Radiology	Old film, Used developing fluids.
5. Catering	All food waste, Packing materials.
6. Pharmacy	Obsolete pharmaceuticals, Patients, Ward medication returns.
7. Treatment Plant Residue	Oil & Grease, Incinerator ash, fly ash, sludge.
8. Other	Garden waste, engineering waste including solvents.

Source: ACHWD, Health Department Victoria (1988)

2.3.2 Categories of Waste

The USA uses the following classification and definitions for regulated medical waste (WHO, 1994):

1. Isolation Wastes
2. Cultures and Stocks of Infectious Agents and Associated biological
3. Sharps
4. Human Blood and Blood Product
5. Animal Waste
6. Unused Sharps
7. Cytotoxic Wastes
8. Radio-active Waste

<u>Isolation Waste</u>

Biological waste and discharged materials contaminated with blood, excretion, exudates, or secretions from humans who are isolated to protect others from certain highly communicable diseases, or isolated animals known to be infected with highly communicable diseases (They may also be called highly infectious waste).

<u>Cultures and Stocks of Infectious Agents and Associated Biological</u>

Including cultures from medical and pathological laboratories; cultures and stocks of infectious agents from research and industrial laboratories; waste from the production of biological; discarded live and attenuated vaccines; and culture dishes and devices used to transfer, inoculate and mix cultures.

Sharps

Sharps that have been used in animal or patient care or treatment or in medical research, or industrial laboratories, including hypodermic needles, syringes (with or without the attached needle, pasteur pipettes, scalpel blades, blood vials, needles with attached tubing , and culture dishes (regardless of presence of infectious agents). Also included are the other types of broken or unbroken glassware that were in contact with infectious agents, such as used slides and cover slips.

Human Blood and Blood Product

(1) Liquid waste human blood; (2) product of blood; (3) items saturated and/or dripping with human blood; or (4) items that were saturated and/or dripping with human blood that are now caked with dried human blood; including serum, plasma, and other blood components, and their containers, which were used or intended for use in either patient care, testing and laboratory analysis or the development of pharmaceuticals. Intravenous bags are also included in this category.

Animal Waste

Contaminated animal carcass, body parts, and bedding of animals that were known to have been exposed to infectious agents during research (including research in veterinary hospitals), production of biological, or testing of pharmaceuticals.

Unused Sharps

The following unused, discarded sharps: hypodermic needles, suture needles, syringes, and scalpel blades.

Cytotoxic

Which in addition to being toxic are mutagenic and/or teratogenic when discarded or spilled.

Nelson et al., 1993 stated that most of countries in Asia including Thailand has adopted the definitions of medical waste similar to that used in the USA.

The Indonesian Ministry of health has adopted a definition of clinical waste that is similar to that of the USA. Nevertheless, the types of waste that are specifically listed are as follows (Department of Health of The Republic of Indonesia, 1990):

- Group A: Surgery and autopsy waste, infectious liners

- Group B: Sharps
- Group C: Laboratory waste and postmortem waste
- Group D: Chemical and pharmaceutical waste
- Group E: Medical equipment such as bedpans, urinoir etc.

Physically, hospital waste can be grouped into three group (Abdurachman, 1992) as presented in Table 2.5

Table 2.5 Physical Type and Source of Hospital Wastes

Type of Waste	Source
Solid Waste	Radiology, Laboratory, Pharmaceutical, Bandage/ Linen, Cafeteria, Kitchen, Anatomy
Wastewater	Chemical laboratory, Pharmaceutical, Kitchen, Laundry, Blood/Urine, Toilet/Shower
Gas	Laboratories, Radiology, Pharmaceutical, Incinerator

Source: Abdurachman, 1992

2.3.3 Hospital Wastewater

The hospital wastewater can be considered as either domestic or toxic/chemical wastes.

<u>Characteristics of Hospital Wastewater</u>

A study to find out the characteristics of hospital wastewater has been done in Jakarta, Indonesia in 1993. The water quality analysis was conducted to measure the parameters of wastewater such as physical and chemical related to the standard. It was found that the physical parameters indicated by color and pH. The color was neutral and pH was 6-6.8 except the wastewater from laundry (pH 12.5).

In Thailand, the characteristics of hospital wastewater from 21 provinces (Clean Technology Consultant, CTC, 1994) was found to be that BOD, SS and pH were 113 mg/L, 103 mg/L and 7.17 respectively.

Table 2.6 presents the hospital wastewater characteristics in Indonesia compared with Thailand.

Table 2.6 Characteristics of Hospital Wastewater

Parameter	Unit	INDONESIA	THAILAND

		(Moersidik, 1993)	(CTC, 1994)
1. pH	-	5.9 - 12.5	7.17
2. Ammonium	mg/L N	0.21 - 2.2	-
3. Phosphate	mg/L P	6.32 - 7.91	4.22
4. SS	mg/L	36 - 269	103
5. COD	mg/L	154 - 642	232
6. BOD_5	mg/L	118 - 302	113
7. $KMnO_4$ (org. matt.)	mg/L	125 - 437	-
8. Fat, Oil and Grease	mg/L	-	29.6
9. TKN	mg/L	-	32.4

The characteristics of hospital wastewater of these two studies are almost same though some parameters such as fat, oil and grease and TKN are not been compared. However, hospital waste is very heterogeneous in nature and often contains some infectious elements. Therefore, it becomes essential that handling and disposal of the waste are conducted safely.

Liquid Toxic or Chemical Wastes

Hospitals use toxic chemical and hazardous materials for diagnostic and treatment purposes. These wastes volume are relative small compared with its domestic wastewater. If this toxic or chemical wastewater is directly discharged to the sewer prior to the treatment, it may affect the biological process during treatment. Table 2.7 presents the examples of potential sources and types of hazardous/toxic wastes generated by hospitals.

Table 2.7 Examples of Potential Sources and Types of Toxic Wastewater

Some Sources of Toxic Waste		Examples of Potentially Toxic Waste	
Blood Bank	Intensive Care	Acids/Caustics	Disinfectant
Dentistry	Clinical Lab.	Alcohols	Formaldehyde
Dialysis	Pharmacy	Ammonia	Xylene
Emergency	Radiology	Bromide	Toluene
Laundry	Pathology	Chloride	Infectious Waste
Kitchen	Nursing	Photographic Chem.	Mercury

Source: Cross and Robinson, 1989

Cross and Robinson, 1989 as presented in Table 2.8 stated that a hospital having 200 bed generates 21.4 mL/bed/day of toxic wastes. Figure 2.1 indicates that any hospital with over 125 beds may qualify as a small quantity generator because they generate the toxic wastes over 100 kg per month. Meaning, for a 200 bed hospital results in 152 Kg of toxic waste per month. This rate (over 100 Kg/month) qualifies a hospital as a small quantity generator of toxic waste, this waste is required to be sent off site to an authorized treatment, storage and disposal facility. Thus, hospitals must be aware of environmetal regulations and responsible in disposing of infectious and hazardous waste properly. In USA, it should be control under the Resource Conservation and Recovery Act (RCRA).

Table 2.8 Toxic Waste Generation Rate

Type of Material	Generation Rate (mL/bed/day)
Liquid Scintillation Waste	1.24
Toluene	0.001
Xylene	5.73
Formalin	7.48
Alcohol	6.67
Other	0.29
Total	21.4

Source: Cross and Robinson, 1989

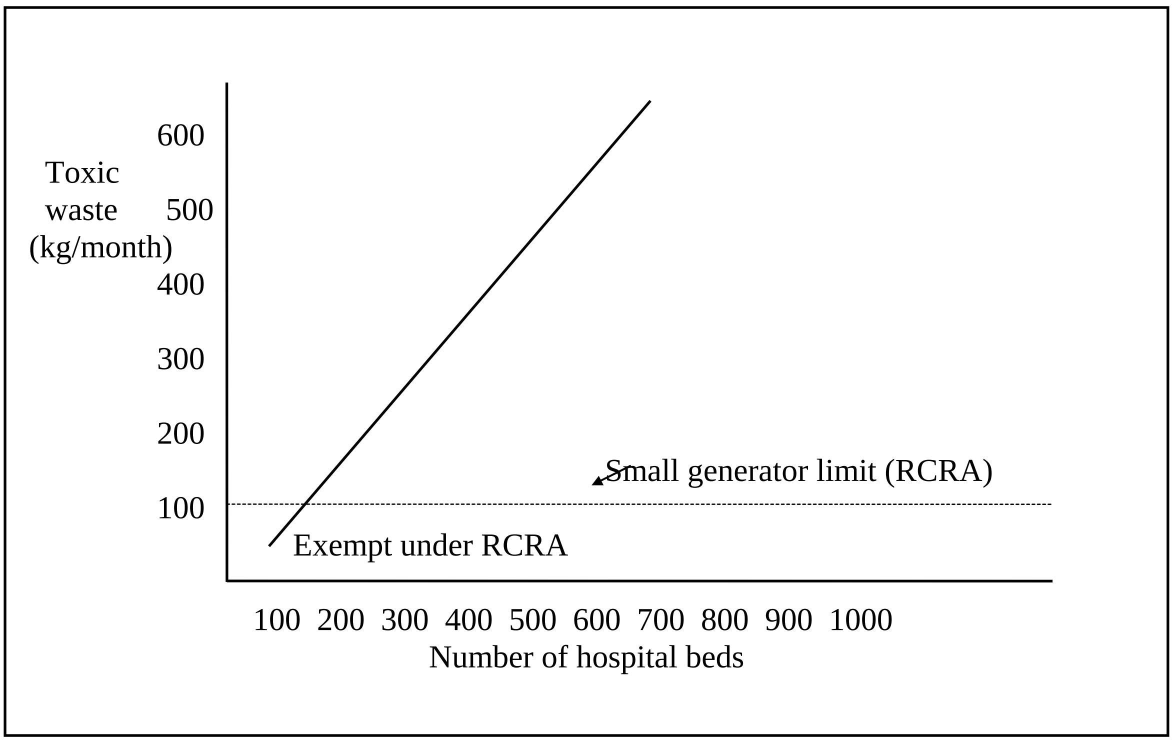


Figure 2.1 Toxic-waste Rates Related to Number of Bed

2.3.4 Infectious Waste

The American Hospital Association as cited in Garvin, 1995 estimated the approximately 10-20 percent of solid waste produced for every patient day is considered potentially infectious. 10-20 percent of which is infectious waste must be treated prior to disposal.

Table 2.9 presents the composition of infectious waste which is found in the hospitals (Liberti et al., 1994)

Table 2.9 Infectious Hospital Waste Composition

Material	(%)
Plastics	46.1
Paper	33.8
Liquids	11.9
Glass	7.6
Metals	0.4
Anatomical specimens	0.1
Other	0.1
Total	100

Source: Liberti et al., 1994

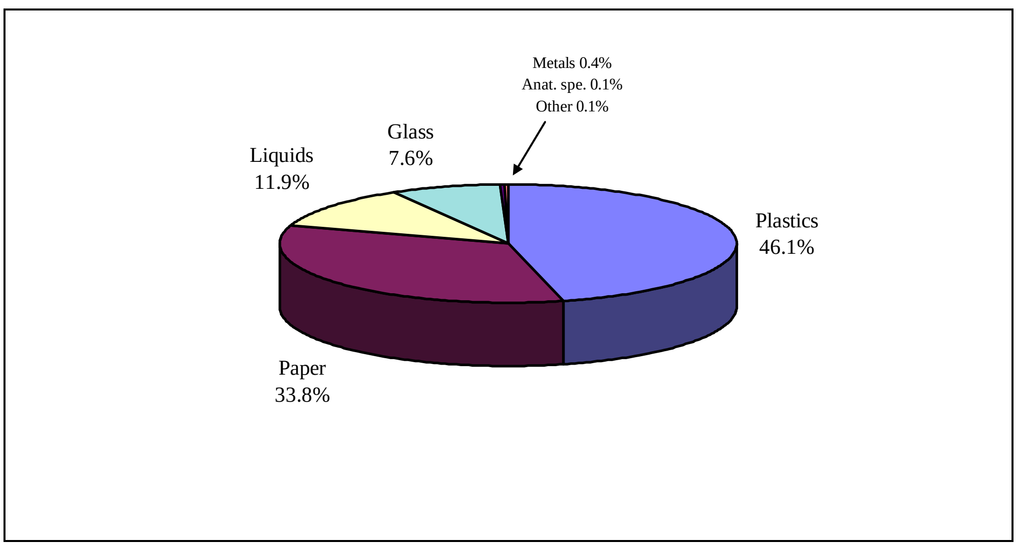


Figure 2.2 Composition of Infectious Hospital Waste

2.4 Hospital Waste and Environment Risks

2.4.1 Hospital/Medical Waste in the Environment

Cheremisinoff and Shah (1990) identified the relation between the hospital/medical waste system and its wastes in the environment as shown in Figure 2.3. This can be relied that medical wastes are released to the environment by many hospital activities in terms of as air emission, wastewater and solid waste.

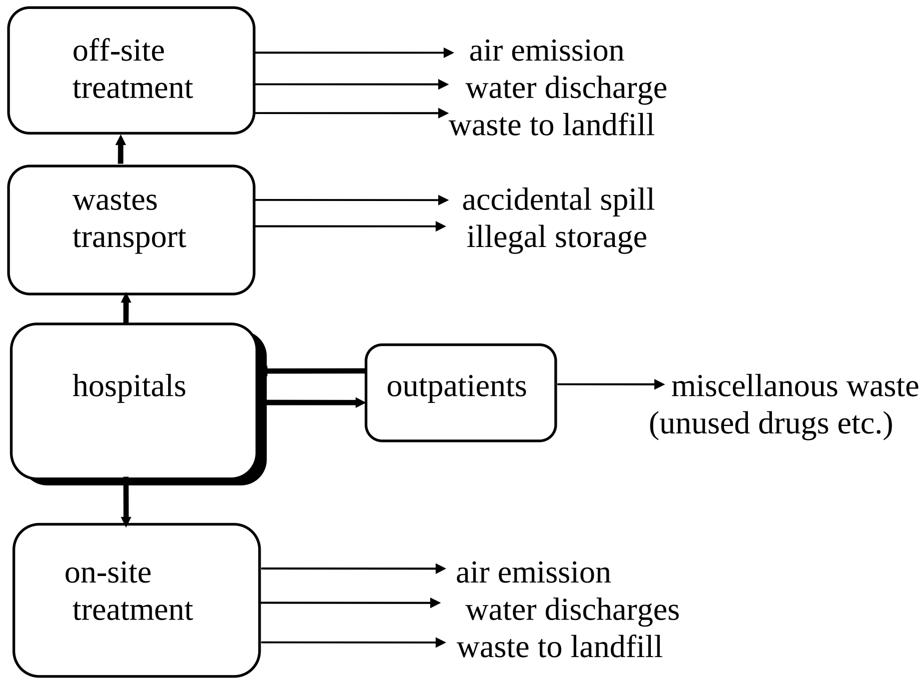


Figure 2.3 Hospital Waste in the Environment
(modified from Cheremisinoff and Shah, 1990)

2.4.2 Disease Relationship

Meaney and Cheremisinoff (1989) has defined that infectious diseases occurred as a result of interaction between an infectious agent (pathogen) and a susceptible host. Medical wastes are such a source of pathogen. Interaction between the host and the pathogen may take one of two forms-infection or intoxication. Intoxication refers to the induction of a disease by the production of a toxin by a pathogen. *Clostridium botulinium* causes botulism in this manner. Infection is the host by the pathogen and is a more common form of disease induction.

In order to be successful, a pathogen must accomplish four distinct stages of infection:

- enter the host,

- metabolize using host tissues,
- withstand the host's immune system (antibody attack), and
- cause damage to the host

The successful completion of each stage of infection depends on:

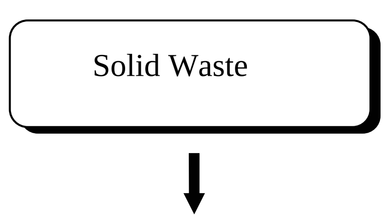
- virulence,
- number,
- mode of entry, and
- susceptibility of host.

There are several modes of disease transmission from solid wastes, but lack of information makes statistical confirmation impossible. In recent years the EPA has initiated research in epidemiology and this should promote a greater understanding of the solid waste or disease relationship as shown in Figure 2.4. Sickness induced is largely dependent on the specific pathogens which attack the host. Diseases are largely named after the inducing pathogen. Typhoid fever is caused by *Salmonella typhi*; Cholera is caused by *Vibrio Cholerae* and Dysentery is caused by *Shigella dysentrie*. By establishing a strict medical or hospital waste management plan and enforcing it, this can eliminate the potential for infection by staff, patients and general public. It is essential that waste which has any potential for infection be treated prior to disposal, to remove any further threat to public health.

2.4.3 Occupational Risks

Potential occupational exposures include direct exposure to patients, visitors and workers who handle or come into proximity to waste. Fereres, 1991 defined that all personnel at the hospital are exposed to health hazards of contaminated or infectious wastes, specially those involved in direct case. Nursing personnel and specially laboratory technicians, are exposed to blood and blood soaked objects from patients and should beware of the health hazards of handling any kind of blood sample or object contaminated with blood, regardless diagnosis of the patients.

Reinhardt and Gordon, 1991 stated that occupational risks are also a serious concern outside of the institution. Normal trash is subjected to a great deal of scrutiny in many parts of the country. Landfill and refuse incinerator operators attempt to segregate waste for recycling and other disposal route. Municipal waste facilities are more likely to carefully screen wastes from businesses and institutions to prevent entry of those wastes that are perceived to be hazardous to their worker or the environment.



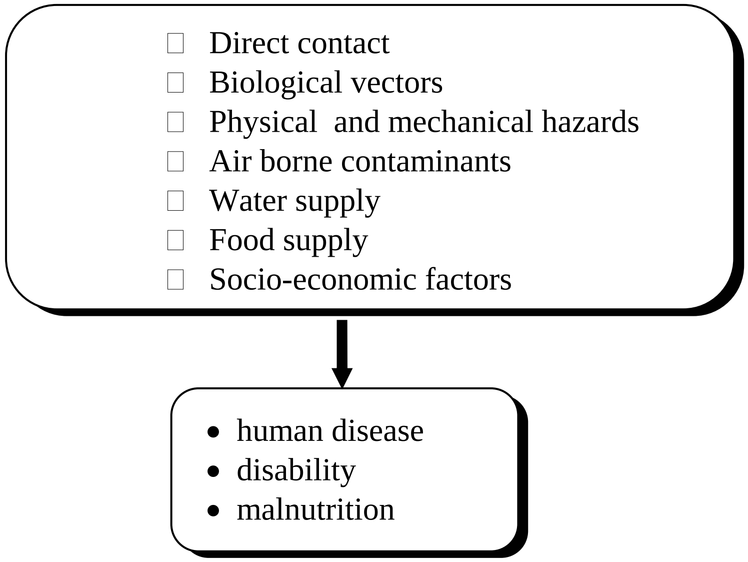


Figure 2.4 Pathways of Disease Transmission
(modified from Meaney and Cheremisinoff, 1989)

2.4.4 Environmental Risks

Environmental risks include the possibility of a release of waste to ground water, surface water or air.

Victoria-EPA, 1994 reported a study (in a hospital which has 516 beds, occupancy rate = 0.87 and 2500 staff) of environmental impacts associated with hospital functions and operations that has been done in Victoria, Australia. It was found that specifically, the environmental consequences which result from the pollution of air include the enchanced green house effect (global warming), ozone layer depletion, acid rain, phytotoxity, damage to materials and aesthetics (odor and visibility) and the human health threat associated with toxic emission (see Table 2.10, 2.11, and 2.12). The environment consequences associated with discharges to stormwater or sewer include contamination of water supply, pollution of water ways used for recreational purposes, algal blooms, degradation of aquatic ecosystems, and diminished aesthetic enjoyment (see Table 2.13 and 2.14). The natural resource depletion issues relate primarily to forest, fossil fuel resources, wasteful water use and landfill waste disposal.

<u>Green house Gas</u>

Hospital functions that contribute to global warming is presented in Table 2.10.

Table 2.10 Hospital Functions that Contribute to Global Warming

Hospital Function	Equivalent tones $C0_2$ /year	%
Motor Vehicles	4,320	10.3
Boiler House	21,280	50.7
Electricity Use	14,461	36.8
CFC_s	906	2.2

Ozone Depletion

Hospital functions that contribute to ozone depletion in terms of CFC emission is presented in Table 2.11.

Table 2.11 CFC Emission

CFC	Yearly Volume Purchased (kg)	Estimated Loss to Atmosphere (kg)
R12 (refrigerator)	200	140
R22 (AC)	250	175
502 (large freezer)	10	7

Air Emission

Hospital functions that contribute to air emission is presented in Table 2.12

Table 2.12 Pollutant Emission (tones per annum)

Hospital Function	Oxide of Nitrogen	Carbon Monoxide	Particulate	Oxide of Sulfur
Boiler House	105.0	3	125	58.5
Incinerator	0.2	N/A	0.2	0.2
Electricity Use	21.5	N/A	N/A	27.3
Vehicle Use	29.0	142	14	N/A

Strormwater Discharges

Discharge of to the stormwater drainage systems are a significant threat to human health and natural environment. Pollutants which enter the storm water system proceed untreated into these natural waterways. Particulate matter which enters waterways increases the turbidity of the water and can potentially hinder the passage of the sunlight necessary for the photosynthetic process of aquatic plants.

Discharges to Sewer

- Photographic chemicals:

Table 2.13 Photographic Chemical (No. of bed 516)

Solution	Volume Discharged (liter/year)
Fixer Developer	2,330 1,390

- Unconsumed food:

Table 2.14 Unconsumed Food from Patient Meals

Meal Times	Waste Produced (tones/year)
Breakfast Lunch Dinner	5.11 14.16 17.81

- Laboratory Chemicals:

The use of liquid waste such as chloroform and xylene from the hematology, hispathology, microbiology and biochemistry laboratories are potentially harmful to the environment if there is no treatment prior to discharge.

- Laundry Effluent

Some chemicals used in laundry section such as disinfecting solutions are potentially harmful to the environment.

Resource Depletion

Resource depletion refers to the consumption of natural resources at rate greater than that at which they are replenished. The disposal of consumable items contribute to resource depletion.

Water Use

Water is important to many hospital functions. It is necessary for the delivery of patient care, production of steam, laundry, garden etc. There are number of environmental impacts associated with the supply use and disposal of water. Water supply facilities require large engineering works which have significant environmental consequences. Energy is required to construct and operate water distribution systems. Moreover, additional pressure is placed on the sewerage system by increased water consumption, potentially decreasing the effectiveness of treatment processes.

2.5 Hospital Waste Management

2.5.1 Recommended Medical Waste Handling Procedure

A management plan for hospital wastes should be established to ensure protection of public health and environment. The plan should incorporate a cradle-to-grave approach to infectious medical or hospital wastes that has been investigated for Resource Conservation and Recovery Act (RCRA) of waste since 1978 (Meaney and Cheremisinoff, 1989).

The major elements of a management strategy for medical wastes are (Victoria-EPA, 1993):

- Waste Minimization;
- Waste Segregation;
- Labelling and Packaging;
- Waste Handling and Transportation;
- Waste Treatment and Disposal.

In addition, the management plan must outline the required training, refresher training and any hospital or medical plans for staff dealing with medical wastes.

Basic medical waste management concept is shown in Figure 2.5.

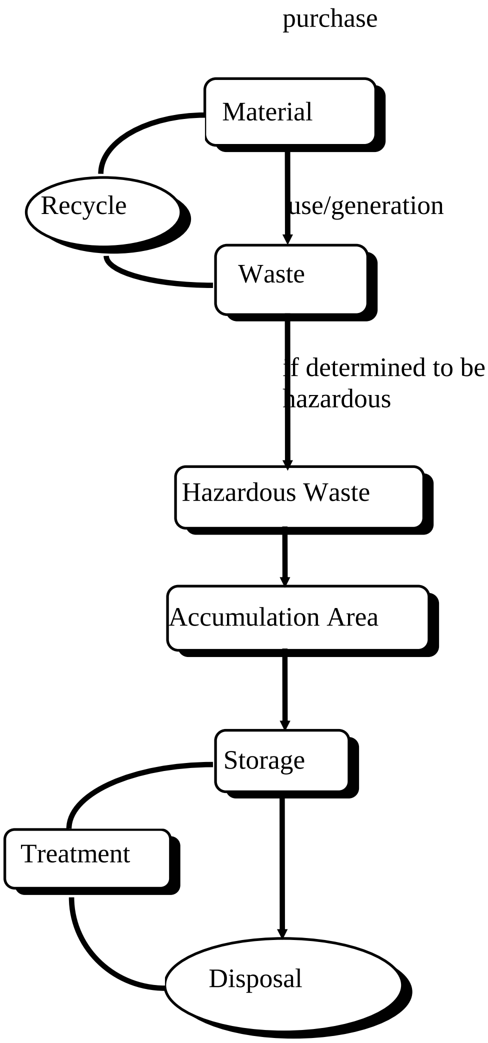


Figure 2.5 Basic Waste Management Concepts
(Reinhartdt and Gordon, 1991)

2.5.2 Hospital Wastewater Treatment

Cheremisinoff and Shah, 1990 stated the assessment of the risk of hospital wastewater is based upon dilution. In developed countries, most hospital are connected to relatively large community waste disposal systems and hospital wastes represent only a small fraction of the volume of sewage. A major concern in the disposal of hospital waste is that hospitals have their own sewage treatment facilities (usually found in developing countries). Smaller systems may be more hazardous owing to smaller volumes of wastewater and hence, less dilution of contaminants. Furthermore, smaller systems are less efficient and may permit the discharge of infectious agents into ground water or other media, which may, in turn permit these agents to survive, a hazard to both hospital personnel and the nearby community. Studies have shown that the majority of pathogens contributed by hospitals are adequately destroyed by conventional treatment systems.

The general wastewater treatment methods depend on biological processes, principally bacteria feeding on organic material in the wastewater. If the composition of the wastewater is significantly modified by the addition of chemical or toxic compounds such as formaldehyde, solvents are allowed into sewer/drains, the operation of the treatment plants can be seriously affected, perhaps making them completely ineffective for some days. For this reason, disposal of hazardous chemicals into toilets must be done in small quantities and with careful monitoring, if at all. If the bacteria (that process the wastewater in the treatment plants) are inactivated, only suspended material will be removed from the wastewater as it passes through the plant. If compounds that are added to the wastewater can not be served as food for the bacteria, they will pass straight through the plant without being changed, making the effluent unfit for any use and polluting the water that receives the effluent (WHO, 1994). Therefore, hospital wastewater deserves to be given more attention in terms of environmental problems.

2.6 Guidelines

2.6.1 Hospital Water Supply

Standard of Water Supply

A clean water supply is an essential requirement, without which a hospital can not function adequately. Most, if not all, of the infection control measures in hospitals demand water in one form or another. If there are no defined criteria for hospital water supplies, then the safety standard for drinking water should be applied (Mehtar, 1992). The standards of water supply/drinking water in different countries are attached in Table A.1, Appendix A.

Water Consumption

The water consumption will be different depending on the types of hospital. It depends on factors such as type of hospital, number of patients, hospital size, location (as mentioned in section 2.2). Moreover, some hospitals provide dormitories for their staff (nurse and doctor), this should be distinguished between water consumption for dormitory and hospital purposes itself. Studies on hospital water consumption dan dormitory have been done by different authors as summarized in Table 2.15 and 2.16.

Table 2.15 Hospital Water Consumption

Source	Water Requirement (L/bed/day)

	Range	Typical
1. Ministry of Urban Development, New Delhi, India, 1991:		
- bed	-	650
- employee	-	-
2. Al-layla et al., 1978:		
- bed	200 - 650	425
- employee	20	20
3. Tchobanoglous and Schroeder, 1985:		
- bed	500 - 1000	450
- employee	20 - 60	40
4. Metcalf and Eddy, 1991		
- bed	492 - 984	738
- employee	19 - 57	38
5. Dep. of Health, Indonesia, 1990:		
- bed	600 - 900	750

Table 2.16 Dormitories Water Consumption

Source	Water Requirement (L/head/day)
1. Ministry of Urban Development, New Delhi, India, 1991	132
2. Tchobanoglous and Schroeder, 1985	135
3. Metcalf and Eddy, 1991	150

2.6.2 Quantity of Hospital Wastewater

Metcalf and Eddy, 1991, defined that typical flowrates of wastewater from hospital is about 625 L/bed/day and 38 L/employee/day. While Clean Technology Consultant (CTC), 1994, found the flowrates of wastewater from 25 hospital at 25 Provinces in Thailand having 90 - 1005 beds was 904 L/bed/day. This value seems to be higher than other studies as presented in Table 2.17.

Table 2.17 Typical of Wastewater Flowrates from Hospital

Source	Wastewater Flowrate	Percentage to Water Consumption

	(L/bed/day)	(%)
1. Metcalf and Eddy, 1991	625	85
2. CTC, 1994	904	80

2.6.3 General Environmental

Particulate

According to the Air Pollution Standard released by Pollution Control Department, Ministry of Science Technology and Environment (MSTE), Thailand, 1994 the atmospheric mineral dust concentration in the workplace throughout normal working periods shall not exceed the specific level of 15 mg/m^3 (as total dust).

Noise

Noise in the environment has been a unique situation which makes it difficult to adequately compare noise with other environmental contaminant. Although it has been tempting to consider analogies to water, air or solid waste problems, noise should be considered a totally separate entity. Table 2.18 presents the comparison of noise level for the hospital from different studies.

Table 2.18 Acceptable Noise Level for Hospital

Source	Noise Level (dBA)
1. Duerden, 1970	30
2. Crocker, 1971	
- outdoor	40
- indoor	40
3. Chhatwal et al., 1989	
- day	45
- night	35

2.7 Waste Auditing or Assessment

A waste auditing or waste assessment is an essential starting point for identifying areas where waste reduction can be incorporated into an existing plan (Victoria-EPA, 1994).

The objective of conducting a waste auditing is to identify each and every gas, liquid and solid waste stream leaving the industrial or hospital premises, to quantify how much is being discharged, to calculate the costs incurred through pretreatment, storage, handling and disposal, and to determine the liabilities associated with the generation of those wastes.

By implementing a detail waste audit, a waste generator can:

- save money by reducing waste treatment, raw materials, and other operating costs,
- reduce potential environmental liabilities and meet statutory obligations to protect the environment, and
- protect public health and workers health and safety.

The waste auditing procedures are illustrated in Figure 2.6.

2.8 Water Conservation and Waste Minimization

2.8.1 Water Conservation

Water purification is an expensive and difficult undertaking, for a hospital and a clean water supply and delivery system should be guaranteed by the authorities. Water is often supplied by the municipal water authorities and is the stored before distribution through the hospital. Such stored water must be monitored for contamination at regular intervals (Mehtar, 1992).

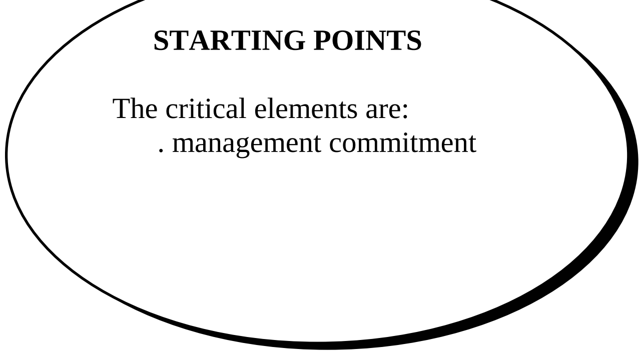
When dealing with increasing demand on water supply or water shortage problem and environmental awareness, water conservation is becoming a pressing issue. Good house keeping practices such as shut off water supply to equipments not in use and control of leakages should be the first priority in selecting water conservation methods. Gagnon (1984) summarized information on the potential water reduction, actual effectiveness, relative cost and brief reviews of some of these devices and practices as presented in Table 2.19.

2.8.2 Waste Minimization

Waste minimization is the use of practices or processes which reduce, as much as possible, the amount of waste generated, or the amount which requires subsequent treatment, storage, or disposal. It includes any activity other than dewatering or compaction, that results in the reduction of total volume, quantity, or toxicity of industrial (hospital).

Two aspects of waste minimization are:

1. Source reduction
2. Recycling



. access to background data
. personnel involvement
. resources to accomplish objective

THE NEXT STEP

Establish effective procedures by:
. selecting an auditing team
. determining the scope of the auditing
. collection of preliminary data
. identification and characterization of input materials, products and waste stream
. a comprehensive analysis of plant and equipment evaluation of data
. the preparation of the waste auditing report

SELECTING THE AUDITING TEAM

Select your auditing team of:
. site or works manager (leader)
. production manager or technical manager
. environmental engineer or officer
. supervisor with hands-on experience and knowledge on how the process operates on a day to day basis
. process engineer
. waste treatment supervisor
. marketing manager of officer
. employee or union representative
. outside consultant, with knowledge and experience of environmental management, regulatory and control systems

Figure 2.6 Waste Auditing Procedures
(modified from EPA, 1994)

Table 2.19 Brief Review of Some Water Saving Devices

Method	Potential Water Use Reduction	Effectiveness	Relative Cost

1. Public education	Little direct reduction	Effective in conjuncti-on with other measures	Medium
2. Low flow shower-heads	(7 - 15) %	Limited to new cons-truction or replacement of worn fixture.	Low
3. Low flow faucets	(1 - 3) %	Limited to new cons-truction or replacement of worn fixture.	Medium
4. Pressure reducing valves	(10 - 30) %	Applicable only in area having pressures exceeding 80 psi.	Medium
5. Wash water recycle	up to 40 %	Effectiveness limited by cost and public acceptability.	High
6. Water conserving clothes washing machines	(2 - 3) %	Local or state ordi-nances would be required to control type of units sold in a given area.	High
7. Toilet dam/low volume toilets	(10-20) %	Actual effectiveness is lower due to tendency to double flush in actual use	Low to medium

Source: Gagnon 1984

<u>Source Reduction</u>

HTM Office Board of Pubic Works, Los Angles (1995) identified that source reduction can be achieved by materials or process modifications and by the implementation of policies and procedures that would reduce wastes. The key operating practices that can be utilized to affect waste minimization are as follows:

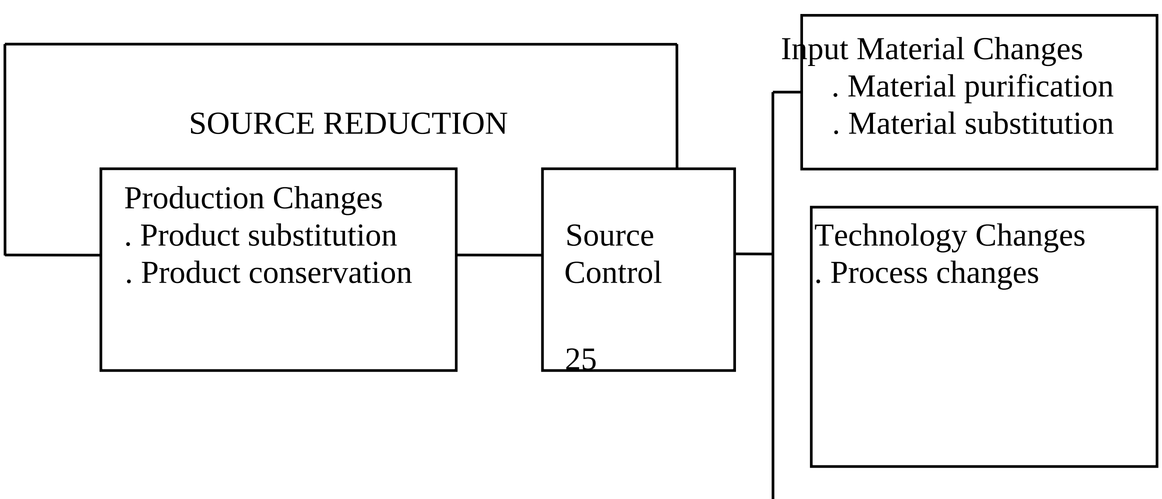
- waste segregation,
- centralize purchasing and dispensing of drugs and other hazardous chemicals,
- use first-in, first-out policy in dispensing of drugs and chemicals to minimize the waste generated because of exceeded shelf life,
- require inventory checks before ordering or using new stock,
- minimize acceptance of free samples that are likely to leave as hazardous waste, and
- provide employee training in hazardous materials management and waste minimization.

The training should include chemical hazards, spill prevention, preventive maintenance and emergency preparedness and response. Hospital and other care organizations that generate infectious wastes should provide employees with infectious waste management training. The training should include an explanation of the infectious waste management plan and an assignment of the roles and responsibilities for implementation of the plan. This training is important for all employees who handle infectious wastes.

<u>Recycling</u>

Recycling is the retrieval of materials or products either for reuse in their original form or for reprocessing into products of similar composition e.g. spent solvents in the hospitals are generated by the laboratory, pathology, histology and maintenance departments, sometimes aqueous-based cleaners can be substituted for hazardous solvents used in maintenance and many solvents can be recovered by on-site distillation and recycled.

Technique associated with both these aspects are illustrated in Figure 2.7 and Waste minimization methods for some toxic chemicals and hazardous materials of general hospitals are presented in Table 2.20.



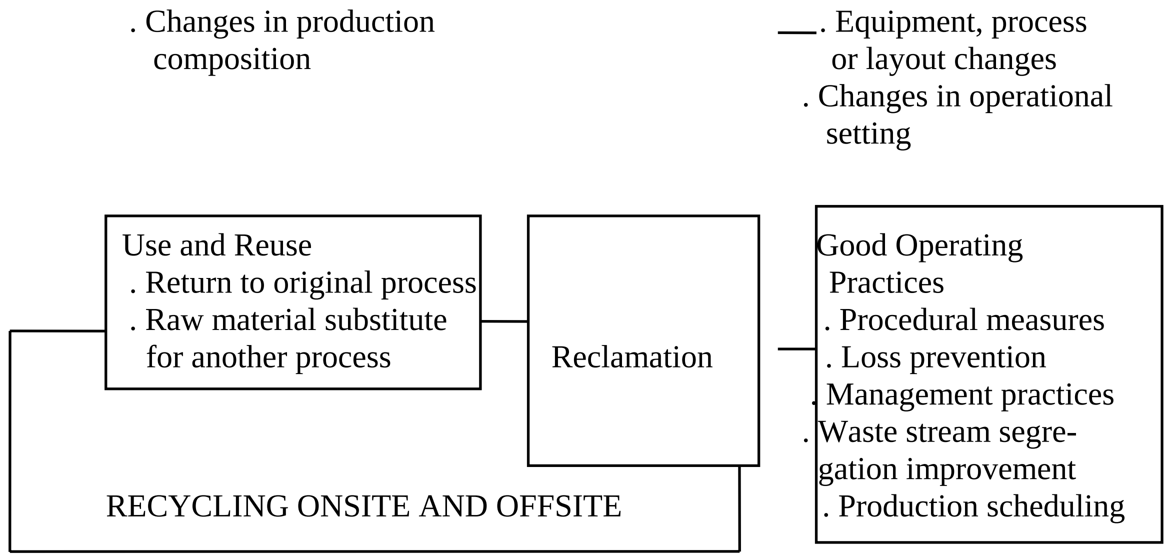


Figure 2.7 Waste Minimization Techniques
(Victoria-EPA, 1993)

Table 2.20 Waste Minimization Methods for Toxic Chemicals and Hazardous Materials of General Hospitals

Waste Category	Waste Minimization Method
Chemotherapy and Antineoplastics	Reduce volume used. Optimize drug container sizes in purchasing. Return outdated drugs to manufactures. Centralize chemotherapy compounding location.

	Minimize waste from compounding hood cleaning. Provide spill cleanup kits.
Formaldehyde	Minimize strength of formaldehyde solutions. Minimize wastes from cleaning of dialysis machines and RO units. Use reverse osmosis (RO) water treatment to reduce dialysis. Capture waste formaldehyde. Investigate reuse in pathology, autopsy laboratories
Photographic-Chemicals	Return off-spec developer to manufacturer. Cover developer and fixer tanks to reduce evaporation, oxidation. Recover silver efficiently. Recycle waste film and paper. Use squeegees to reduce bath losses. Use countercurrent washing.
Solvents	Substitute less hazardous cleaning agents, methods for solvents cleaners. Reduce analyte volume requirements. Use pre-mixed kits for tests involving solvent fixation. Use calibrated solvent dispensers for routine tests. Segregate solvent wastes. Recover/reuse solvents through distillation.
Toxics, Corrosives and Miscellaneous Chemicals	Inspection and proper equipment maintenance for ethylene oxide sterilizers. Substitute less toxic compounds, cleaning agents. Reduce volumes used in experiments. Return containers for reuse, use recyclable drums. Neutralize acid waste with basic waste. Use mechanical handling aids for drums to reduce spills. Use automated systems for laundry chemicals. Use physical instead of chemical cleaning methods.

Source: US-EPA, 1990

Chapter 3

Background Information of the Research Site

3.1 Location of the Hospital

This Queen Sirikit National Institute of Child Health, often called Children's Hospital, is a general medical hospital, which offers treatment of patients up to 18 years of age. It is located in Bangkok (see Figure 3.1) and caters to patients from city and outskirts.

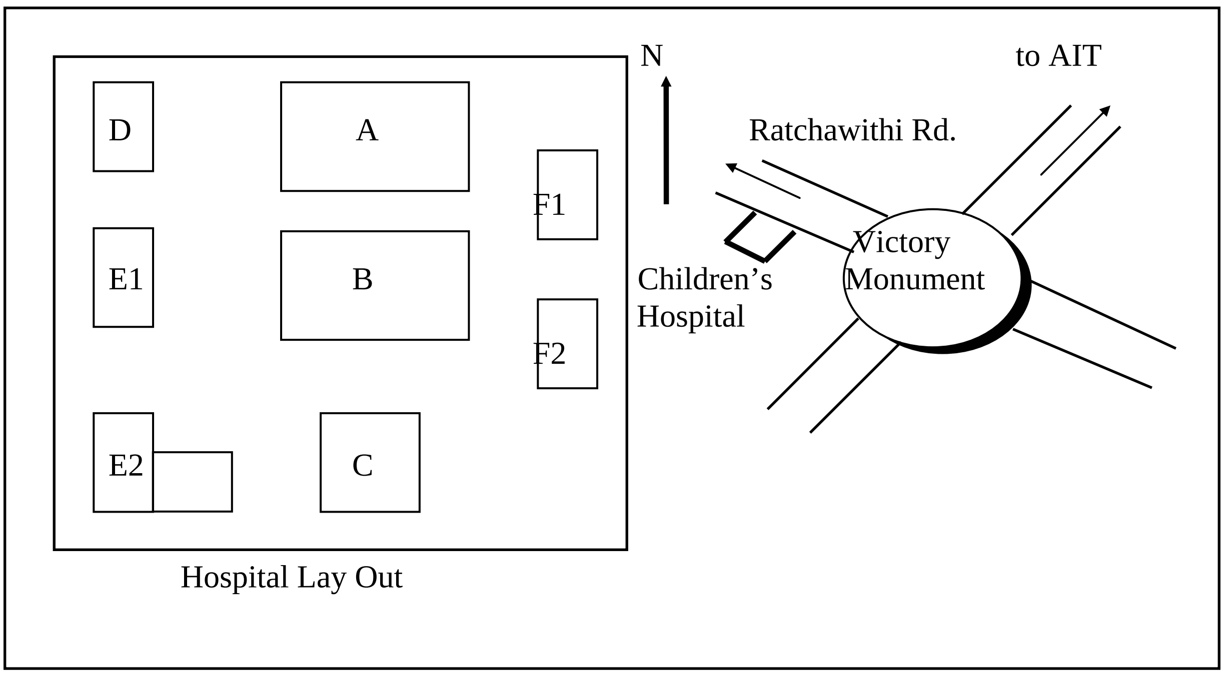


Figure 3.1 Site Location and Lay Out

This hospital is divided into eight buildings with different functions or activities. Type of activities in each building and floor are presented in Table 3.1

3.2 Hospital Status

Based on the data in 1996, this hospital has 538 beds. The average occupancy rate is 58.18 percent and the ratio inpatient to outpatient is 0.0325. The patient are classified into different rooms which depend on types of disease. Number of patient and classification of disease are tabulated in Table 3.2

Number of visitors in this hospital is high enough because most of patients are always accompanied by their parents or relatives during treatment. Number of patients and visitors in each building are presented in Table 3.3.

Table 3.1 Building and Its Functions/Activities

No	Building	Floor	Functions/Activities
1	A	1st 2nd 3rd 4th 5th 6th 7th 8th	parking area, cafeteria registration, outpatient service, dispensary of medicine, shop, x-ray, public health consultancy heart diseases, dispensary of medicine, dental, x-ray, ENT, dermatology, vaccine, brain, public health consultancy biochemical Lab., surgery (operation room), blood bank, anesthesia wards, offices offices. library meeting room advertising room
2	B	1st 2nd 3rd 4th 5th 6th -10th 11th 12th	parking area, electricity room, AC central room OPD, orthopedic, pharmaceutical x-ray, day care nursery, offices ICU, NICU, surgery clinical pathology inpatient wards pharmaceutical distilled water installation, Basket ball field
3	C	1st 2nd 3rd 4th	material godown, laundry kitchen milk preparation, ward inpatient wards empty room
4	D	1st-2nd	being renovated (since February ‘97)
5	E1	1st-2nd	doctor dormitory
6	E2	1st-8th	nurse dormitory
7	F1	1st-2nd	wards
8	F2	1st-2nd	wards

Table 3.2 Classification and Total Number of Patient based on Data 1996

No	Room/Building	Type of Diseases/Patient	No. of Patient
1	VIP A/ B	General	10
2	VIP B/ B	General	14
3	Children 1/ B	General	-
4	Children 2 / B	Orphan	12
5	Children 3 / C	General diseases (< 2 years)	27
6	Diarrhea / B	Diarrhea	16
7	Children 4 / B	General diseases (> 2 years)	24
8	Children 5 / F1	Premature delivery	37
9	Children 6 / F1	Surgery	46
10	Children 7 / F2	New baby born (fever)	33
11	NICU / B	New baby born (severe)	7
12	Children 8 / F2	Heart, Kidney, Blood, Brain	30
13	Infant surgery / A	Infant surgery	23
14	Orthopedics / B	Bones and Joints	11
15	Emergency / B	Severe symptom	8
16	EENT / A	Eye, Ear, Nose and Throat	15
Total			313

3.3 Organization

The hospital has approximately 1255 staffs including doctors and nurses. Generally, the employees and officers work for 8 hours a day with working time from 8.00 to 16.00 hours. However, some employees such as the nurses and doctors work in shifts (3 shifts a day).

Management of this hospital in under control of Department of Medical Services, The Ministry of Public Health. Figure 3.2 shows the organization chart of children's hospital

Table 3.3 Number of Patient and Visitors in Each Building based on Data 1996

No	Building	Patients		Visitors	
		Inpatient	Outpatient/day	Inpatient	Outpatient/day
1	A	38	824	76	2472
2	B	102	30	204	60
3	F1	83	-	166	-
4	F2	63	-	126	-
5	C	27	-	54	-

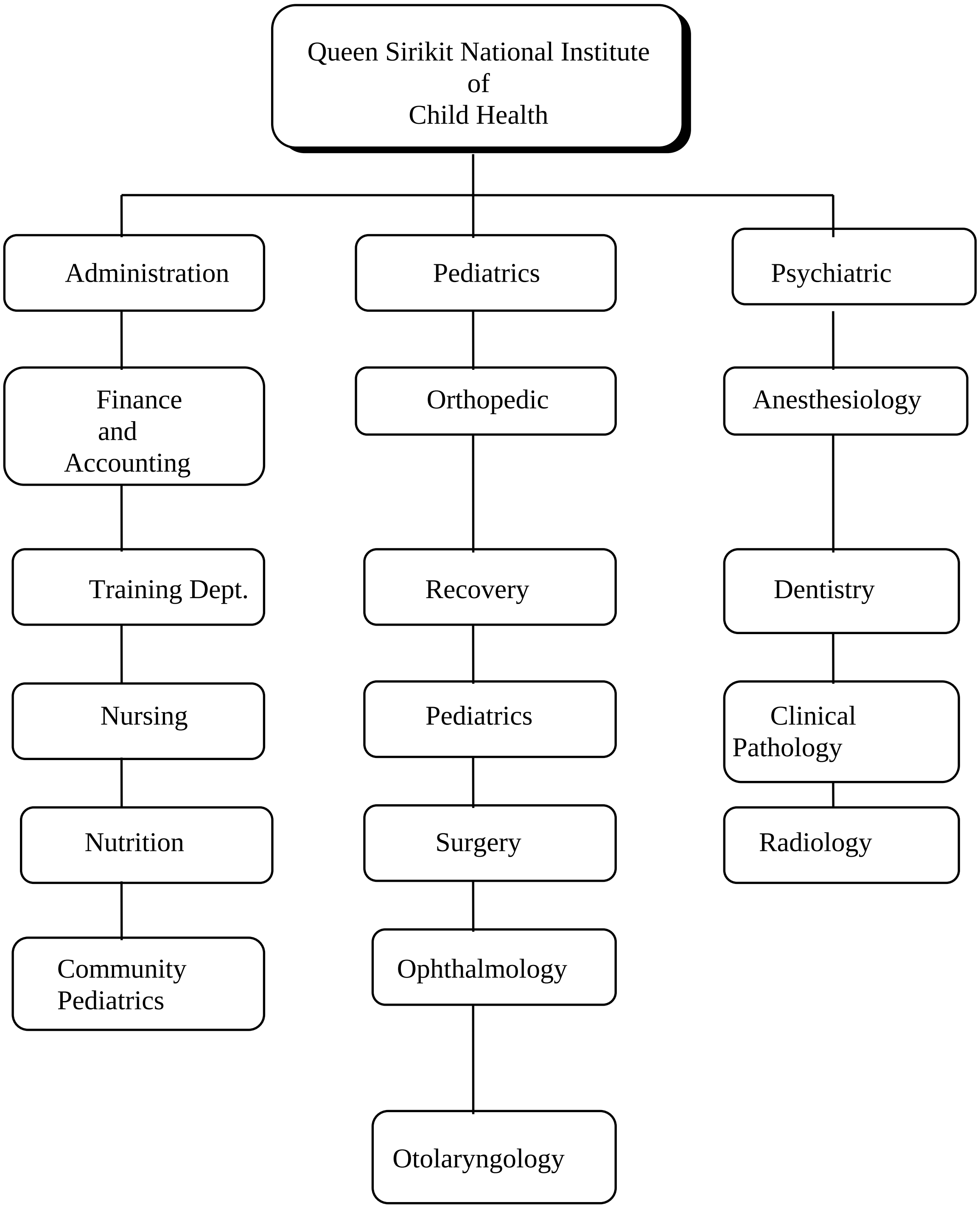


Figure 3.2 Organization Chart of Children's Hospital

3.4 Hospital Activities and Environmental Impact Issues

As mentioned in Table 3.1, it can be presumed that the functions/activities in this hospital has been linked to specific environmental impacts due to :

1. Water Use
2. Discharge of Wastewater
3. Noise and Air Pollution
4. Solid Waste

However, the scope of this research is limited to water, wastewater, noise and air pollution. The solid waste component is not included in the scope of its study.

3.4.1 Water Use

Water is an essential commodity to many hospital functions. It is necessary for the patient wards, operational of laundry, kitchen, production of steam, garden and ground maintenance. Water supply is drawn from the municipal supply pipe and supplied through the galvanize iron (GI) pipe with various diameter (2.5 - 15 cm). The total volume of water consumed and its cost in year 1996 were 297,323 m^3 and 3,071,204 Bath respectively.

Three watermeters with diameter of 15 cm (1 unit) and 7.6 cm (2 units) are installed and all these watermeters record water consumption in this hospital (see Figure 3.3). Total water consumption is considered as total recorded of different watermeters of ‘X’ and ‘Z’. Watermeter of ‘Y’ only records building of E2 and E1. Sizes of watermeter installed in different buildings are summarized in Table 3.4

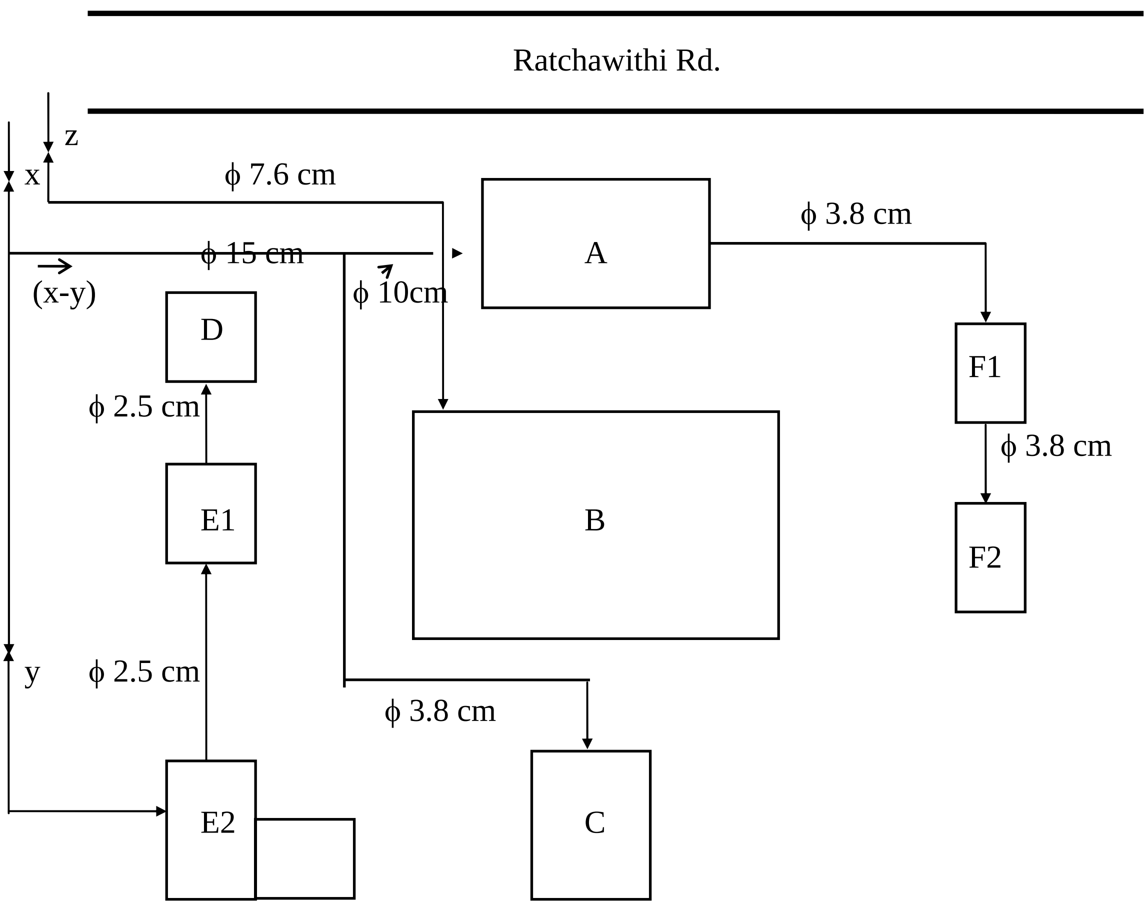
3.4.2 Wastewater

Though data on wastewater quality and quantity are not available, but based on site observation it can be ascertained that some activities in this hospital has potential to produce wastewater with different characteristics. The main activities that produce wastewater are as follows :

1. Laundry
2. Kitchen
3. Laboratory Chemical
4. Boiler
5. Shower/Toilet
6. Cooling Tower

Types of wastewater coming out from the above activities are either :

1. Domestic
2. Chemical/Toxic



Remarks :

→ : Water supply line

→← : Water meter

A (Siam Building, 8 floors)
B (Mahitalla Building, 12 floors)
C (Service Building, 4 floors)
D (Narisara Building, 2 floors)
E1 (Doctor Dormitory, 2 floors)
E2 (Nurse Dormitory, 8 floors)
F1 (Wards, 2 floors)
F2 (Wards, 2 floors)

Figure 3.3 Lay Out of Water Supply Line

Table 3.4 Size of Water Installed in Different Building

No	Watermeter	Building Served
1	X (dia. 15 cm)	A, C, F1, F2, E2, E1,D
2	Z (dia. 7.6 cm)	B
3	Y (dia. 7.6 cm)	E2, E1, D
4	(X- Y)	A, C, F1, F2

The wastewater is being conveyed through closed PVC pipe sewer to the Central Wastewater Treatment Plant (CWWTP) located in Ratchawithi hospital area. Lay out of wastewater line is shown in Figure 3.4

3.4.3 Central Wastewater Treatment Plant (CWWTP)

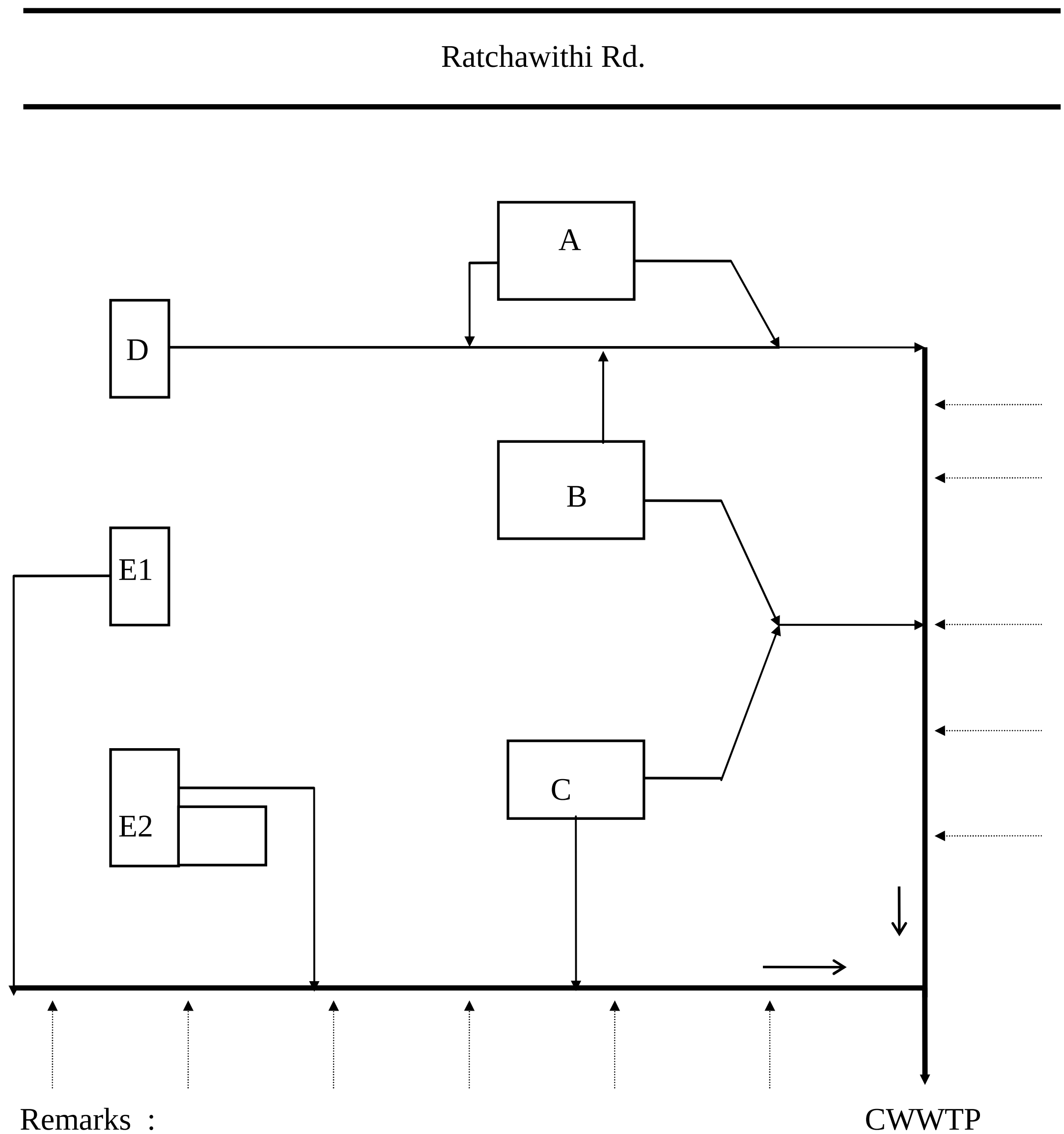
CWWTP is located in Ratchawithi hospital area, it caters the wastewater from :

1. Children's Hospital
2. Ratchawithi Hospital
3. Institute of Dermatology
4. Institute of Clinical Pathology
5. Bangkok Nursing College

The treatment process of this CWWTP is a biological process with activated sludge as a main process. This treatment plant was designed to treat 3,200 m^3/day of the total wastewater with the characteristics as presented in Table 3.5 and the diagram of treatment units is shown in Appendix B.

Table 3.5 Wastewater Influent Characteristics

Parameter	Concentration Average
pH	7.1
SS, mg/L	90
VSS, mg/L	65
COD, mg/L	430
BOD_5, mg/L	300
N, mg/L	46
P, mg/L	2.2
Total Coliform (MPN index/100 mL) x 10^5	450



Remarks :

→ : Wastewater line (Children's hospital only)

➞ : Combined sewer line (with other hospital)

┈▸ : Wastewater from other hospital

A (Siam Building)

B (Mahitalla Building)

C (Service Building)

D (Narisara Building)

E1 (Doctor Dormitory)

E2 (Nurse Dormitory)

CWWTP : Central Wastewater Treatment Plant

Figure 3.4 Lay Out of Wastewater Line

3.4.4 Air and Noise Pollution

Air and noise pollution in the hospital is caused both within the hospital and from outside hospital surrounding. The activities that cause hospital air and noise pollution are presented in Table 3.5.

Table 3.5 Activities Cause Hospital Air and Noise Pollution

No	Activities	Type of Pollution
1	Laundry	Noise
2	Boiler	Noise and Air Particulate
3	Cooling Tower	Noise
4	Generator	Noise and Air Particulate
5	Vacuum Pumps	Noise
6	Central AC Pumps	Noise
7	Motor Vehicle Use	Noise and Air Particulate
8	Outside Activities (i.e. traffic)	Noise and Air Particulate

Chapter 4

Methodology

4.1 Study Program

The study investigation was carried out to investigate the available potentials of water conservation, waste minimization and comfortable environment. The general research methodology is outlined in Figure 4.1.

4.2 Identify the Scope of the Audit

In order to identify the scope of audit based on the waste management problems, the following steps were taken:

1. General observation and interview
2. Understanding the overall design information
3. Understanding the hospital activities and its process
4. Defining the scope of the audit

4.3 Collection of Preliminary Data

This data collection was focused on problems identified for the audit. The types of information were:

1. Design informations
   - hospital layout
   - plumbing system
2. Input and output informations
   - water supply source and its distribution
   - sources of wastewater and points of discharge
   - wastewater treatment plant
3. Economic informations
   - water consumption cost
   - energy consumption cost

4.4 Water and Wastewater Auditing

Waste minimization might not be implemented without waste auditing. It was believed that water and wastewater audit gave reliable data of different waste generated in various stages as well as all the possible operational problems associated with production. Hence, this becomes a prerequisite for further implementation of waste minimization, save additional cost of waste treatment and improvement of the water system and its management. Figure 4.2 illustrates the water and wastewater distribution and collection system, and sampling points.

4.4.1 Water Supply System

Investigation was conducted to understand the whole water supply system in the hospital. It consists of understanding on overview of the water supply system through actual site survey of the source, main supply and distribution network.

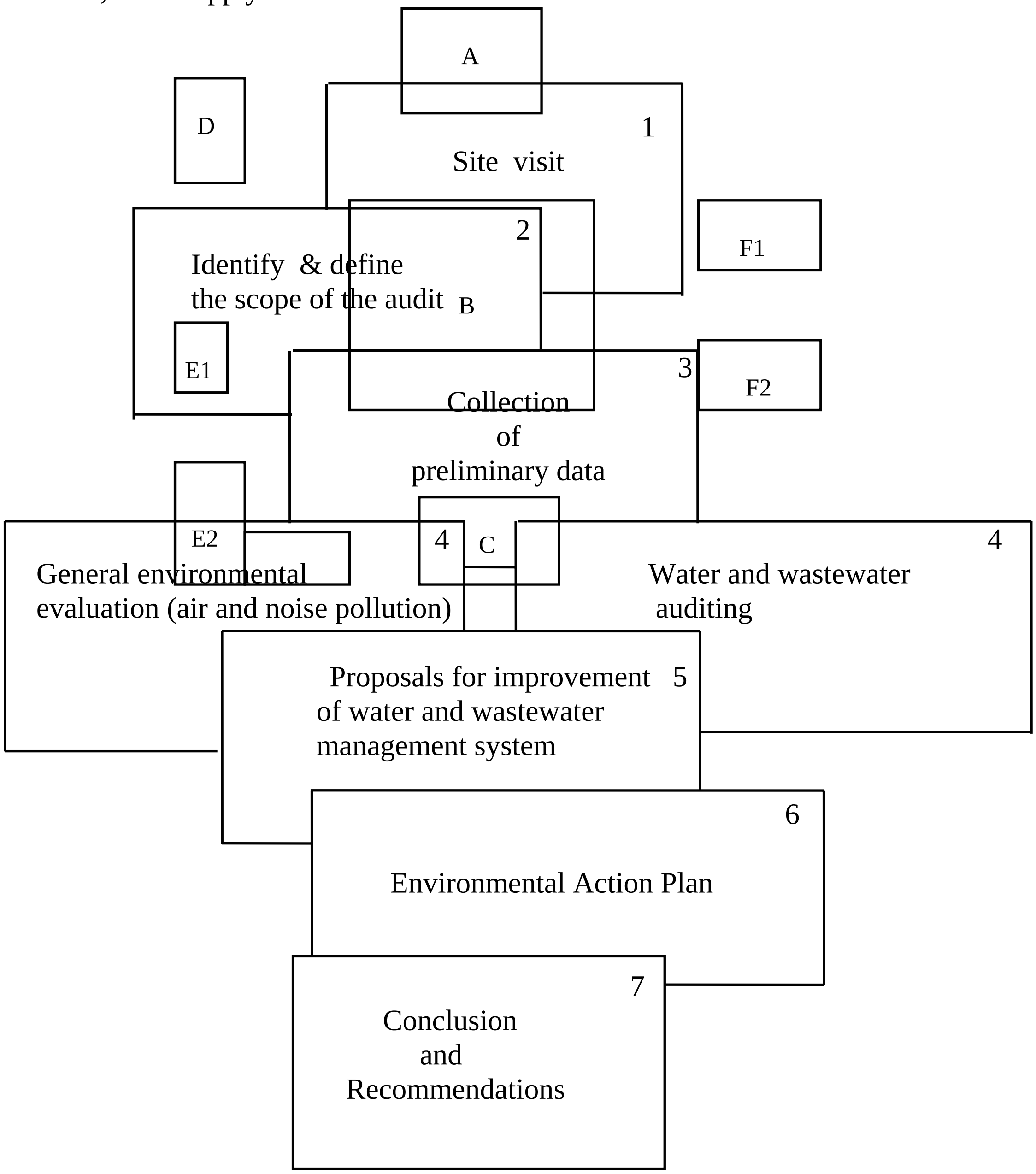
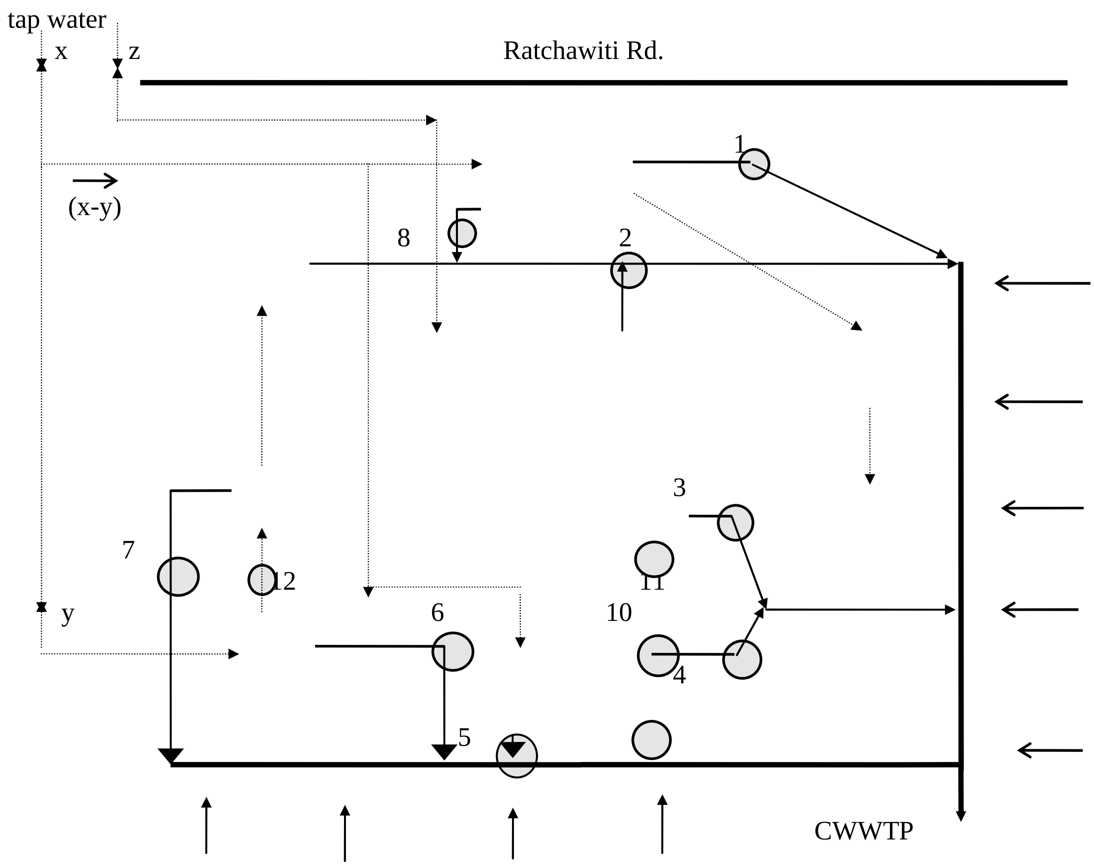


Figure 4.1 Research Methodology Outline



Remarks:

: Wastewater line
: Wastewater from other hospitals
: Combined sewer line
: Water Supply line
1,2,3..... : Sampling points
CWWTP : Central Wastewater Treatment Plant

A : Siam Building (8 floors)
B : Mahittala Building (12 floors)
C : Service Building (4 floors)
D : Narissara (2 floors being renovated)
E1 : Doctor Dormitory (2 floors)
E2 : Nurse Dormitory (8 floors)
F1 : Ward 5,6 (2 floors)
F2 : Ward 7,8 (2 floors)

Figure 4.2 Water and Wastewater Layout and Sampling Points

4.4.2 Wastewater System

To locate the sampling points of the wastewater, same concept used for water supply was adopted by reviewing the total of the wastewater collection system. Attention was taken to observe various wastewater outlets from different types of wastewater discharges. To understand the chemical/toxic or hazardous waste systems, it was conducted by observation and interviewing employees who are incharge of that particular operations.

4.4.3 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 4.2, 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 not detail pipe/sewer line flow diagram available at the hospital,
- the wastewater from other hospitals/institutes are also mixed with the children's hospital (see Figure 4.2).

Based on above difficulties, it was agreed to use the manholes as an access for taking samples both of quality and quantity. Manhole is the inspection chamber of wastewater having average size 75 cm length x 75 cm width x 100 cm depth. It is placed when two or more pipes interconnect. Manhole is usually constructed at easy access site and sometimes in the middle of the road as in the children's hospital. Therefore, the manhole covers used in this study area are high grade concrete which are substantially big and heavy (see Figure 4.3).

Figure 4.3 Manhole

The other sampling sites were at discharge point of each unit operation that discharges different types of wastewater. The various of activities are kitchen, cafeteria, laundry and laboratory chemical (see Figure E.1, Appendix E). Due to operational and access difficulties to sampling sites, hence grab sampling technique was chosen.

The wastewater samples were taken from each building and some unit operations as shown in Figure 4.4, the samples were collected in sampler bottle and transported to Environmental Engineering Laboratory AIT for analysis.

4.4.4 Characterization

Sample of wastewater was taken from each unit operation as mentioned in 4.4.3 and analyzed in the Environmental Engineering Laboratory, while tap water analysis was analyzed at laboratory of Electricity Generating Authority (EGAT). The water and wastewater quality parameters were selected based on the Law and Standard on Pollution Control in Thailand (MSTE, 1994).

The parameters analyzed and corresponding methods used for determination of raw water and wastewater characteristics are tabulated in Table 4.1.

Figure 4.4 A Sampling Point of Wastewater

Table 4.1 Parameter Analyzed and Method Used

Parameters	Methods
Water	
pH	pH meter
Color	B.H.D. Lovibond
Turbidity	Turbidity meter
TDS	Filtration/Evaporation
Iron (Fe)	A.A.
Manganese (Mn)	A.A.
Copper (Cu)	A.A.
Calcium (Ca)	EDTA Titration
Chloride (Cl)	Argentometric
Nitrate (NO_3)	Cadmium Reduction
Sulfate (SO_4)	Turbidimetric
Wastewater	
pH	pH meter
Temperature	Thermometer
BOD_5	Azide Modification
COD	Dichromate reflux
Suspended Solid	Filtration
TDS	Filtration/Evaporation
Nitrogen TKN	Macro Kjeldahl

4.4.5 Water Consumption Measurement

Water consumption in this hospital was measured by using water meter. There are three water meters installed in different building as mentioned in Table 3.4 and shown in Figure C.1, Appendix C.

4.4.6 Wastewater Flowrate Measurement

Two types of wastewater flowrate measurement methods were used, namely:

1. Electromagnetic current meter
2. Bucket and Stopwatch

Electromagnetic current meter

This instrument consists of two units called main unit and detector (see Figure C.2, Appendix C). The operation principle is utilized faraday's law of electromagnetic induction, obtain current speed by measuring the electro motive force generated when water of electro body is crossed the magnetic field generated from sensor. The flowrate was obtained by multiplying measured velocity with cross section area of pipe/channel.

Bucket and Stopwatch

This method was used at location where the current meter did not fit due to space limitation (see Figure C.3, Appendix C). The known volume of bucket was installed at the point of discharge, the flowrate was calculated by measuring the time when water filled the bucket. Bucket and stopwatch method was used at sampling point of number 5 and 6 as shown in Figure C.4, Appendix C.

4.4.7 Central Wastewater Treatment Plant (CWWTP)

As mentioned in Chapter 3, the CWWTP was designed to treat wastewater from other three hospitals/institutes, one nursing collage and children's hospital. 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 the children's hospital.

4.5 General Environmental Evaluation

General environmental evaluation for limited parameters were conducted by measuring:

1. Noise
2. Air Particulate

Noise

Sound Level Meter (SLM) was used to evaluate the noise exposure value in term of Sound Pressure Level (SPL). The SLM instrument consists of three main functions called microphone and preamplifier, display and key panel (see Figure C.5, Appendix C). The noise was given in the unit of dBA. Sampling points of noise measurement were conducted in indoor and outdoor as shown in Figure 4.5. The major noise sources in the hospital were from boiler room, laundry, vacuum pump, generator, cooling tower, central AC and chiller pump.

Air Particulate

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). This personal pump was connected to the plastic holder with 0.5 μ PVC filter by the hose. The 0.5 μ PVC filter has function to filter dust/particulate having size more than 0.5 μ. To have the concentration of dust/particulate (mg/m^3), factors of temperature and air pressure at the sampling were considered. The sampling instrument used in this study is shown in Figure C.6, Appendix C.

4.6 Environmental Action Plan (EAP)

Environmental management for this hospital are mainly concerned with water supply, wastewater, solid waste, 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

The proposed action plan was formulated which depends on short and long term of hospital needs.

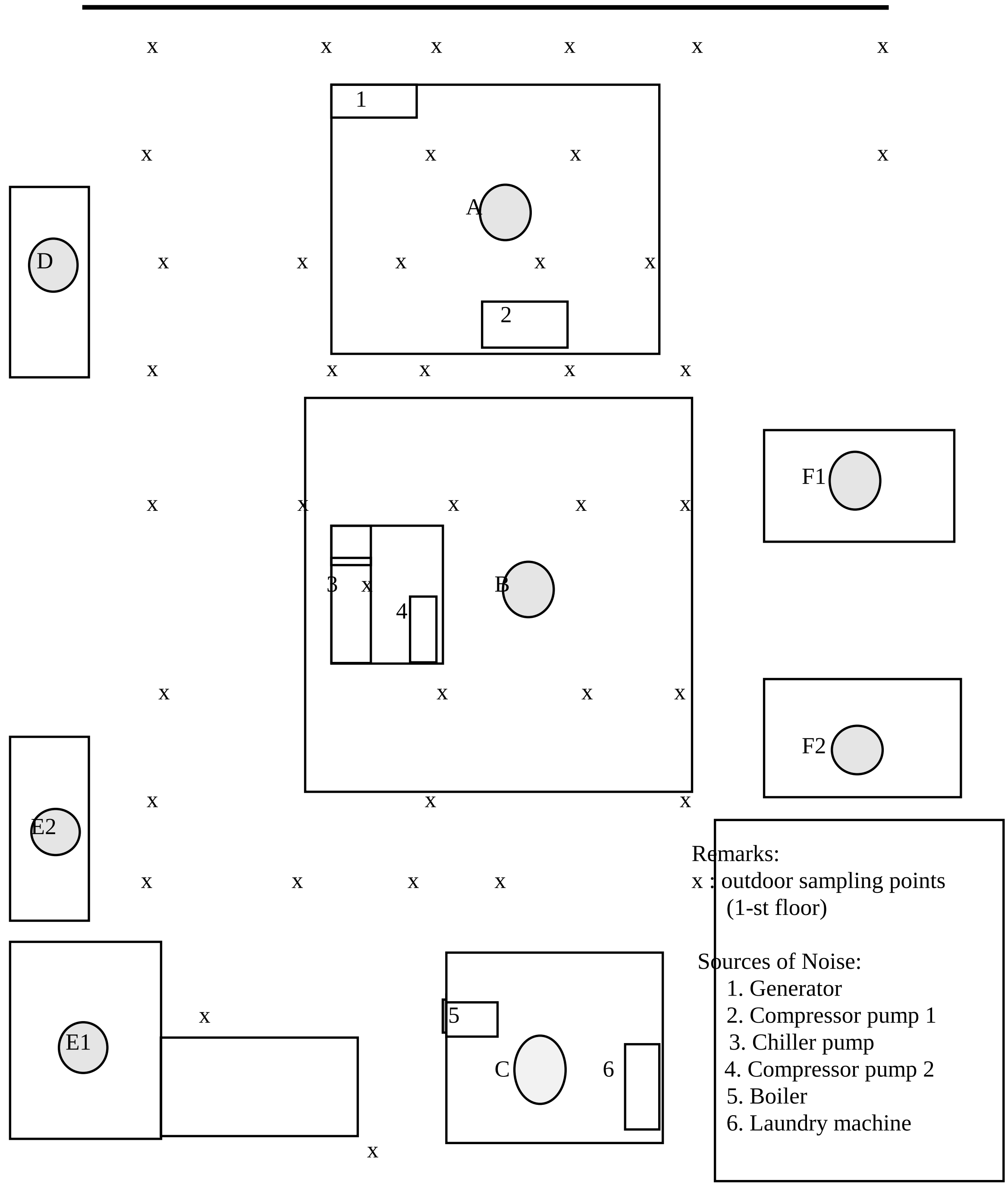


Figure 4.5 Noise Sampling Points (Outdoor)

Chapter 5

Results and Discussions

5.1 Introduction

The main discussion in this chapter is divided into following three parts, namely:

1. Hospital water and wastewater audit;
2. Work environment in the hospital (Noise and Air Pollution) ;
3. Environmental Action Plan.

The chemical or toxic wastes were discussed and included in the wastewater audit. These wastes are taken into consideration because of inevitably they are directly discharged into the sewers. The overall of material balance of water and wastewater for both the quality and quantity in this hospital could not be derived since the hospital sewer systems are combined with other hospitals and institutes nearby. Nevertheless, the water and wastewater analysis was derived based on water coming in and wastewater coming out at the points of discharge.

The evaluations of work environment are focused on noise pollution and air particulate only. At the end of this chapter, an environmental action plan is discussed to overcome the existing problems and waste reductions in the near future by establishing the target to improve the hospital environment in terms of water conservation, toxic wastes minimization and noise abatement.

5.2 Hospital Water and Wastewater Audit

5.2.1 Water Consumption

Source of water used in this hospital is only from tap water supplied by municipal water authority. Since there is no defined criteria for water supply to the hospital, the standards for drinking water are applied for this hospital. Comparison of water supply characteristics at this hospital and other prevailing standards are presented in Table 5.1.

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 5.1 Water Supply Characteristics at the Hospital Compared with Other Standards

No	Parameters	Units	Source			
			Children's 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	mg/L	<0.025	0.3	0.05	0.3
7	(Mn)	mg/L	ND	1.0	0.05	1.0
8	Copper (Cu)	mg/L	54	75	75	-
9	Calcium (Ca)	mg/L	14	250	200	250
10	Chloride (Cl)	mg/L	0.33	45	45	45
11	Nitrate (NO_3)	mg/L	29.2	200	200	400
	Sulphate (SO_4)					

Water consumption in this hospital has been observed during March to May 1997. It was found that the daily total average of water consumption within three different months were 1034 m^3/d. Figure 5.1 shows comparison of daily average water consumption in three different months.

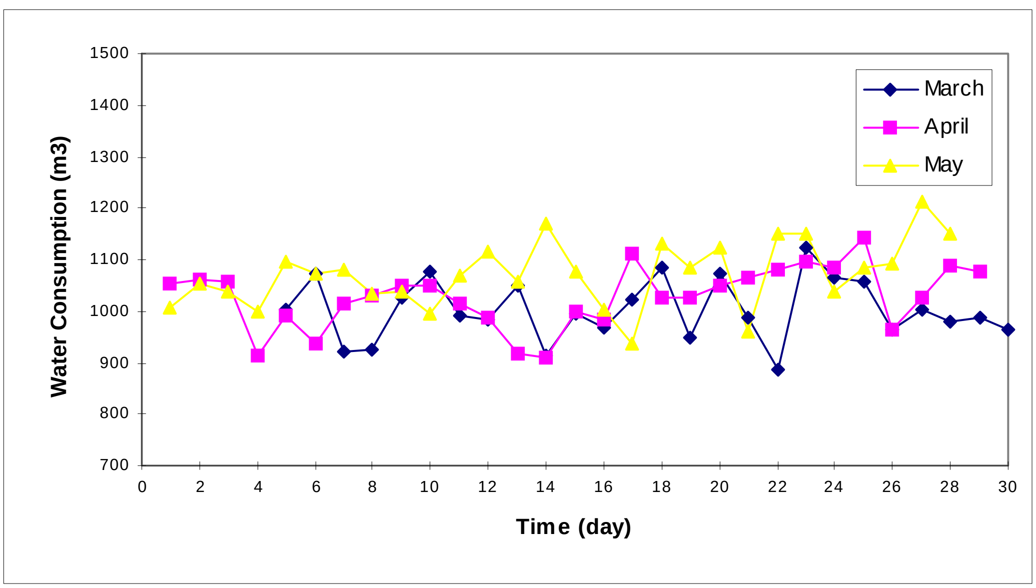


Figure 5.1 Daily Water Consumption

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 especially in Mahittala building which was finished construction in March 1997. By now, some other facilities are still under construction, this indicates that current water demand would be higher.

As presented in Table 3.4, 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 5.2 shows different water consumption based on three watermeters installed.

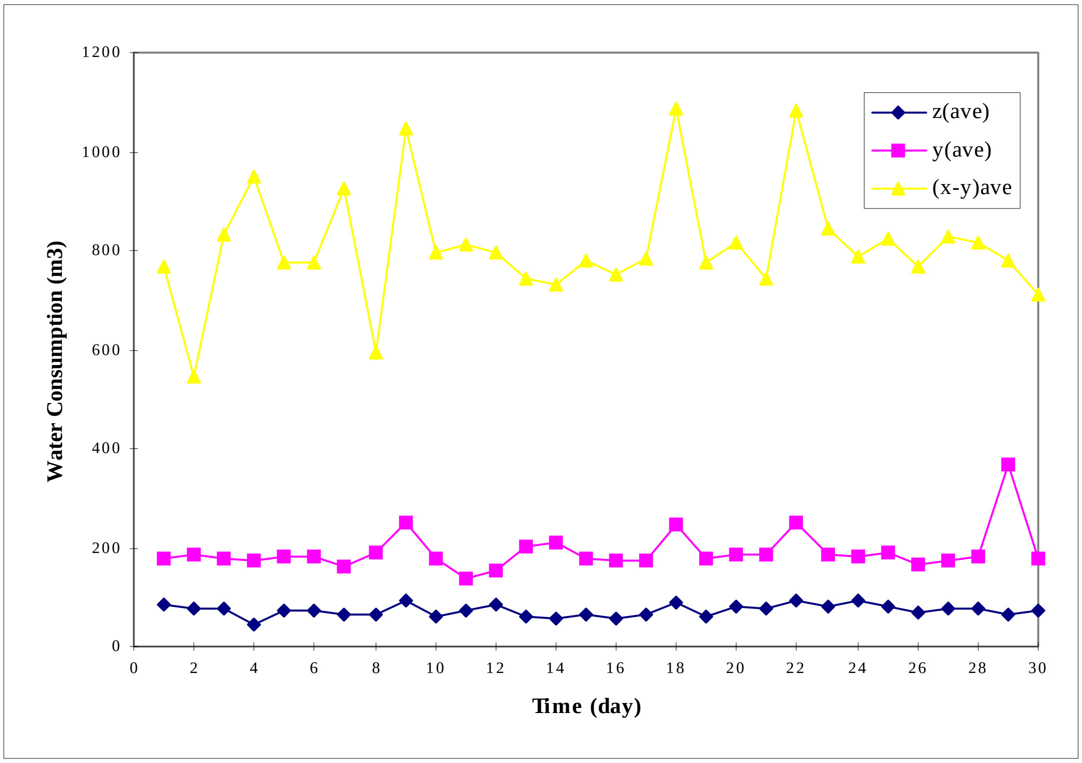


Figure 5.2 Water Consumption Based on Three Different Watermeters

According to Figure 5.2, the average of watermeter 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 also much more than others as presented in Table 5.2.

Table 5.2 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

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 5.3 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 5.4.

Table 5.3 Water Consumption in the Hospital Compared with Other Studies

Sources	Water Consumption (L/bed/d)	Water Consumption (m^3/d)
1. Children's Hospital	1,589	855
2. India (MUDI, 1991)	650	350
3. Tchobanoglous, G and Schroeder, ED., 1985		
- bed	450	292
- employee	40	
4. Al-layla et al., 1978		
- bed	425	254
- employee	20	
5. Metcalf and Eddy, 1991		
- bed	568	353
- employee	38	

Table 5.4 Dormitories Water Consumption in the Hospital Compared with Other Studies

Sources	Water Consumption (L/head/day)
1. Children's Hospital Dormitory	517
2. India (MUDI, 1991)	132
3. Tchobanoglous, G. and Schroeder, ED, 1985	135
4. Metcalf and Eddy, 1991	150

According to Tables 5.3 and 5.4, It has been found that the water consumption for both the hospital and dormitories are higher than other studies which are not directly addressed to the specific hospital as children's hospital which caters patients up to 18 years of age. Therefore, the water audit on this specific hospital is needed to account water consumption in its activities, so that the results can be used as a reference for further study. Nevertheless, 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.

5.2.2 Water Uses

Water uses in each activity of this hospital has been calculated by different methods as presented in Table D.1, Appendix D. The overall water uses in each activity is shown in Figure 5.2.

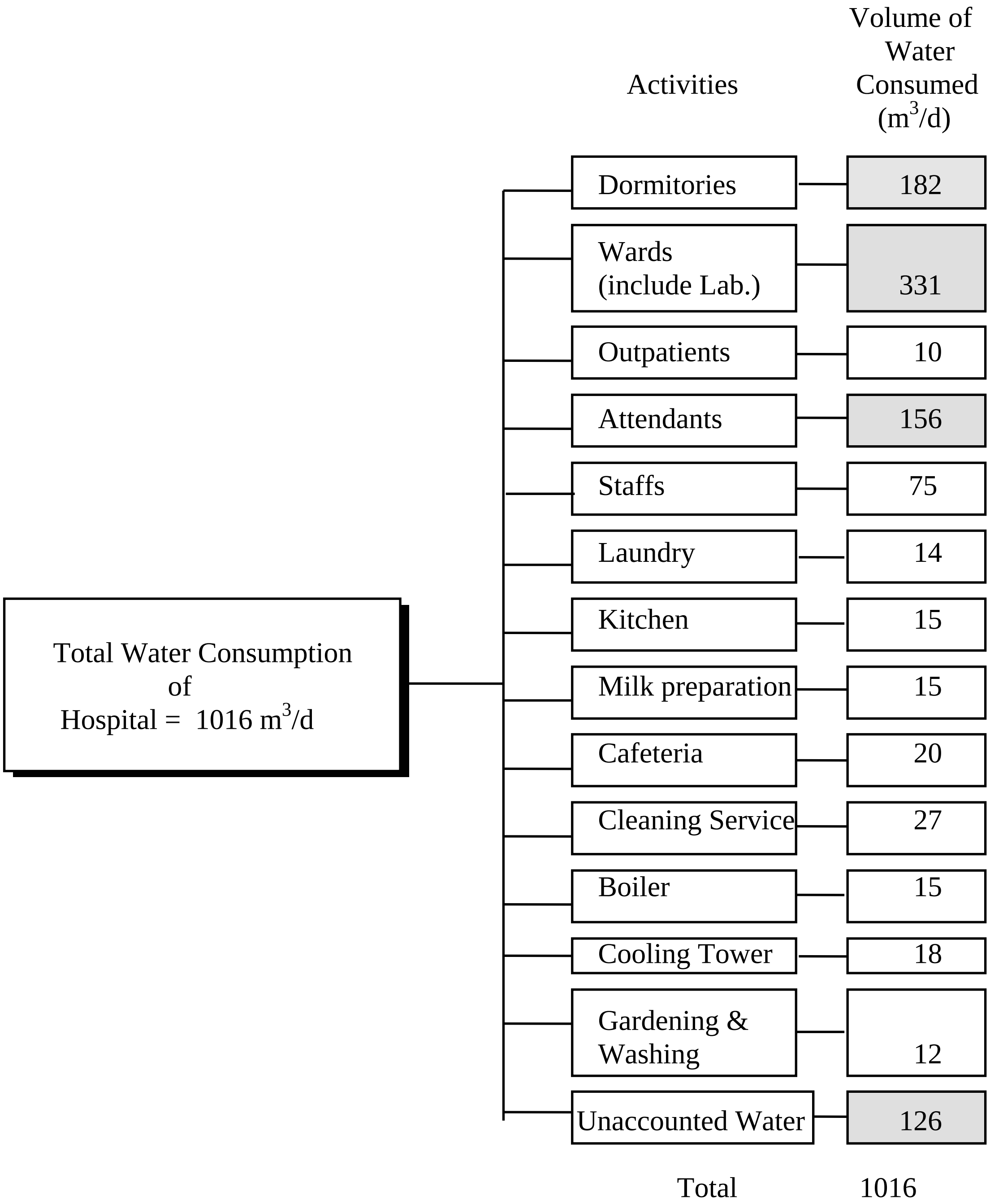


Figure 5.3 Estimation of Water Uses in Each Activity

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 children's 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.

As presented in Table 5.4, the water consumption in dormitories are also quite high (182 m^3/d). During this observation, it was found that:

- leakages have occurred in some water supply installations (taps, reservoir etc.),
- water was also used for buildings construction.

For these reasons it can be presumed that the water use in the dormitory was not efficient.

A special attention should be given to the sections of Milk preparation and Kitchen. Specially during cleaning bottles or plates, it was found that the water taps were always fully opened though they did not use the water for their purposes. This caused inefficient water use, beside that, the basins were designed that contribute to more water use. These basins size were 120 cm length x 45 cm width x 32 cm depth. Since the milk bottles (during cleaning) are required to float only on the surface of water, the basin depth of 32 cm seems too deep that causes the workers to fill the basin until full. Moreover, they preferred not to close the water taps but let the water overflow the rim of basins and the same case happens during cleaning in the kitchen. It should be noted that during observation water supplied was also not working properly, so they have to provide other plastic basins to store more water specially for vegetables cleaning. This situation should not occur in a hospital water supply system, because water is extremely essential in hospital, especially in terms of hygienic food to be served to the patients.

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. An effort in detecting leakages has been done in dormitory buildings and detailed report is given in Section 5.2.3.

5.2.3 Leakage Detection

The detection of leakages has been done on 8 May, 1997 at 10.00-11.00 with the assistance of service officers. E1 and E2 were both dormitories and was selected for leak detection because the watermeter in these buildings recorded high water consumption compared with other studies (as mentioned in Table 5.4).

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 reservoirs having diameter (D) 161.4 cm each droped by 16 cm (see Figure 5.4).

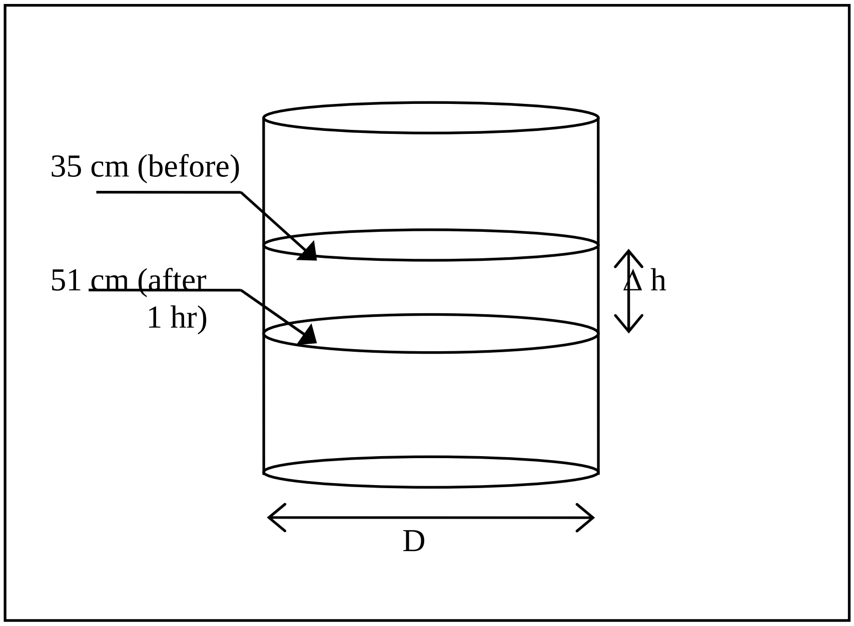


Figure 5.4 Water Level in a Reservoir

Volume of water loss can be defined by calculating:

Area = $1/4 \pi D^2 = 20{,}459.6 \text{ cm}^2$

Volume of water loss = A x Δh

= 20,459.6 x 16

= $327{,}353.6 \text{ cm}^3$

= 0.33 m^3 (for 1 tank)

Total volume of water loss = 9 x $0.33 \text{ m}^3 = 2.97 \text{ m}^3/\text{h}$.

During survey of leakage detection, it was found that there were 5 persons in this building using the water. Therefore, the above calculated quantity does not indicate the actual water loss. The estimated water loss is calculated by assuming 1 person consumed 10 L/h, it can be calculated for 5 persons water consumed was 50 L/h. Hence, the total volume of water loss would be 2.97 m^3 - 0.05 m^3 = 2.92 m^3/h or 70 m^3/day, this can be concluded that around 7% of hospital water consumption has been used inefficiently.

According to hospital water bill, 1 m^3 of water supplied is equal to 10 Baht (in average). Hence, 70 m^3/d of water loss x 10 bath = 700 Baht/d. Meaning, this hospital has been losing their money for about 700 Baht/day or 262,800 Baht/year. Likewise, the water is conveyed from ground reservoirs to elevated reservoirs by the pumps, so it can be predicted that it would strongly affect in term of less energy consumption.

This leakage detection could not be conducted for other buildings since 2 other watermeters installed cater for more than 2 different hospital activities. Leakage detection by closing all the valves is impossible since water supplied to their sections are quite important from time to time. By installing the watermeters in each section the problem of inefficient water use could possibly be detected.

5.2.4 Hospital Wastewater

Characterization of hospital wastewater from each sampling point has been done along with measurement of wastewater flowrate. Characterized and calculated data of wastewater can be seen in Table E.2, E.3, E.5 and E.6, Appendix E.

Total wastewater flowrates in first and second measurements were 680 m^3/d and 591 m^3/d respectively. This correspond to the percentage of wastewater produced was 63 percent in average of total hospital water consumption. Several studies and standards has been done related to the quality and quantity of hospital wastewater as presented in Table 5.5 and Table 5.6.

Table 5.5 Wastewater Flowrate in Hospital Compared with Other Studies

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

Table 5.6 Hospital Wastewater Characteristics Compared with Other Studies

Parameters	Unit	Children's Hospital at	Indonesia (Moersidik,1993)	Thailand (CTC, 1994)

		Various Streams		
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

It has been found that the quantity of wastewater in children's hospital was 1182 L/bed/day (see Table 5.5) which is higher than other studies, though the percentage related to water consumption is lower (63 percent). Generally, the characteristics of wastewater in this hospital as summarized in Table 5.6 and detailed in Table E.2 and E.3, Appendix E 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^oC). In order to prevent pipe damages caused by this wastewater, a neutralizing chamber and cooling system are needed to bring pH to be 6 - 7 and temperature to be 35 - 37^oC.

Although there are oil trappers in operation for preliminary treatment of kitchen and cafeteria wastewater, but based on the analyzed wastewater in this study, these oil trappers seem to be in efficient in term of treatment efficiency. It was prove that the oil and grase content and other parameters such as BOD (518-795) mg/L and COD (840-880) mg/L were still high in terms of concentration. An interceptor traps with proper capacity and loading should be installed to cope the problems of this wastewater before being discharged to the sewers

5.2.5 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. Table 5.7 presents the sections in this hospital which have been observed, quantity of waste generated and its waste management. In order to provide management with accurate figures, it is required to record the chemical/toxic wastes in terms of weight or volume from time to time in each section where is the wastes being produced.

Table 5.7 Sources, Type, Quantity and Existing Waste Management

Sections	Type of Chemical and Infectious Wastes	Quantity (L/month)	Current Waste Management Practice

1. X-ray/Radiology	- fixer	30	- returned to supplier
	- developer	30	- discharged to sewer
2. Laundry	- disinfecting solution	341	- discharged to sewer
	- detergent	435 Kg/month	- discharged to sewer
	- bleaching	210 Kg/month	- discharged to sewer
3. Surgery	- formaldehyde	6.75	- sent to Pathology institute
	- blood	20	- sent to Ratchawiti hospital
	- cidex/disinfectant	5	- discharged to sewer
	- hibiscrub	15	- discharged to sewer
	- mediklen powder (bacteria killer)	1.2 Kg/month	- discharged to sewer
	- alcohol (70%)	10.35	- discharged to sewer
	- phenol	0.23	- discharged to sewer
4. Biochemistry Lab.	- hypochlorite (clorox) solution + samples	6	- discharged to sewer after 1/2 day detention
	- blood + hypochlorite	15	- discharged to sewer after 1 day detention
	- alcohol	2	
5. Microbiology Lab.	- cidex	20	- dis. to sewer (aft. autoclave)
	- 10% NaCl	1.8	- dis. to sewer (aft. autoclave)
	- disinfecting solution (teepol, hibiscrub)	N/A	- discharged to sewer
	- gramstain & H_2SO_4	0.2	- discharged to sewer
	- steritab	40 tab.	- discharged to sewer
	- 95% alcohol	18	N/A
	- 70% alcohol	4.5	N/A
6. Immunology Lab.	- sodium dichloro S-triazine trione (disinfectant)+sample	40	- dis. to sewer after 1 day detention
	- 5% hypochlorite	0.6	- discharged to sewer
	- steritab	80 tab	- discharged to sewer
	- formalin	0.004	- discharged to sewer
	- alcohol	1.2	- discharged to sewer
7. Coagulation Lab.	- detergent (teepol)	7.6	- discharged to sewer
	- disinfectant antiseptic (pen-v)	7.6	- discharged to sewer
	- pose-chlorite	11.4	- discharged to sewer
	- contaminon CL+ hypochlorite	2	- discharged to sewer
	- sodium citrate+blood	0.05	- discharged to sewer
8. Blood Bank	- disinfecting chem. (clorox)	53	discharged to sewer
	- saline+blood	20	discharged to sewer
	- contaminon CL	30	discharged to sewer
	- anti A,B, & AB	1	discharged to sewer
	- Alcohol	12	discharged to sewer

9. Hematology			
	- EDTA (anti coagulant)	N/A	discharged to sewer
	- 3% acetic acid	0.6	discharged to sewer
	- 70% alcohol	7	discharged to sewer
	- gramstain+eosin+ methylene blue + giemsas+azure B chld	2.5	discharged to sewer
	- blood+clorox	1.5	discharged to sewer
	- cleaning agent (coulter clenz)	2.5	discharged to sewer
	- balance electrolyte sol. (ISOTON III)	80	N/A
	- lyse S III diff	1.33	discharged to sewer
	- TEB pH 8.6	0.02	discharged to sewer
	- NaOH	0.4	discharged to sewer
	- ferric cyanide	0.24	discharged to sewer
	- saturated ammonium sulfate	0.24	discharged to sewer
	- toluene	0.06	discharged to sewer
	- urine+$FeCl_3$	0.08	sent to Rachawithi hospital
	- Xylene	0.008	N/A
	- formalin	0.001	N/A
10. Kitchen	- washing chemical	40	discharged to sewer
	- dryer chemical	20	discharged to sewer
	- scale removal chem.	20	discharged to sewer
	- sunlight (detergent)	45	discharged to sewer
11. Wards	N/A	N/A	
12. Cleaning Service	N/A	N/A	

Considering to Table 5.7, 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 5.5.

Most of liquid chemical wastes were directly discharged to the sewers, except some chemical wastes such as fixer (X-ray dept.) which is returned to the suppliers and other chemicals included in the red bags which are sent to Rachawithi hospital (see Figure C.7, Appendix C).

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 5.8.

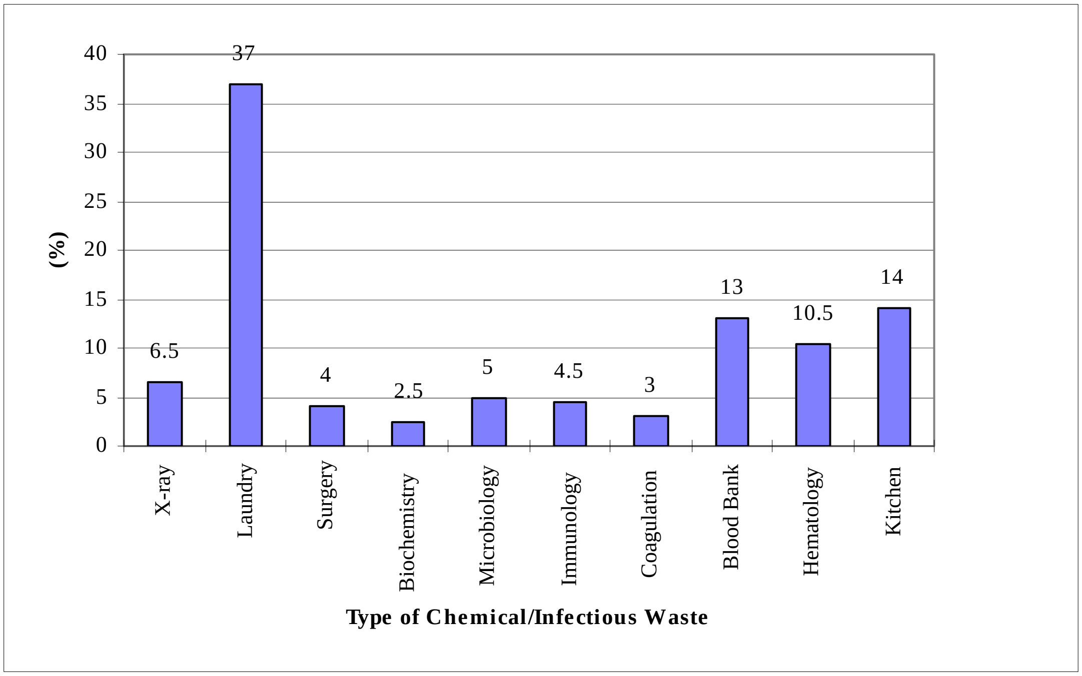


Figure 5.5 Percentage of Liquid Toxic Chemical Wastes

Table 5.8 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

According to Cross and Robinson, 1989 as stated in Figure 2.1, this children's hospital which has 532 beds may qualify as a small quantity generator which produce more than 300 Kg of toxic wastes in a month. In the USA, handling of toxic wastes for over 100 Kg/month should be under RCRA-permitted.

5.2.6 Central Wastewater Treatment Plant (CWWTP)

As mentioned in section 4.4.7, The CWWTP was not taken into account in auditing, because it caters for four other institutes and hospital nearby. But, it was considered as a comparison of quality and quantity of children's hospital effluent. Figure 5.7 shows the process treatment of CWWTP.

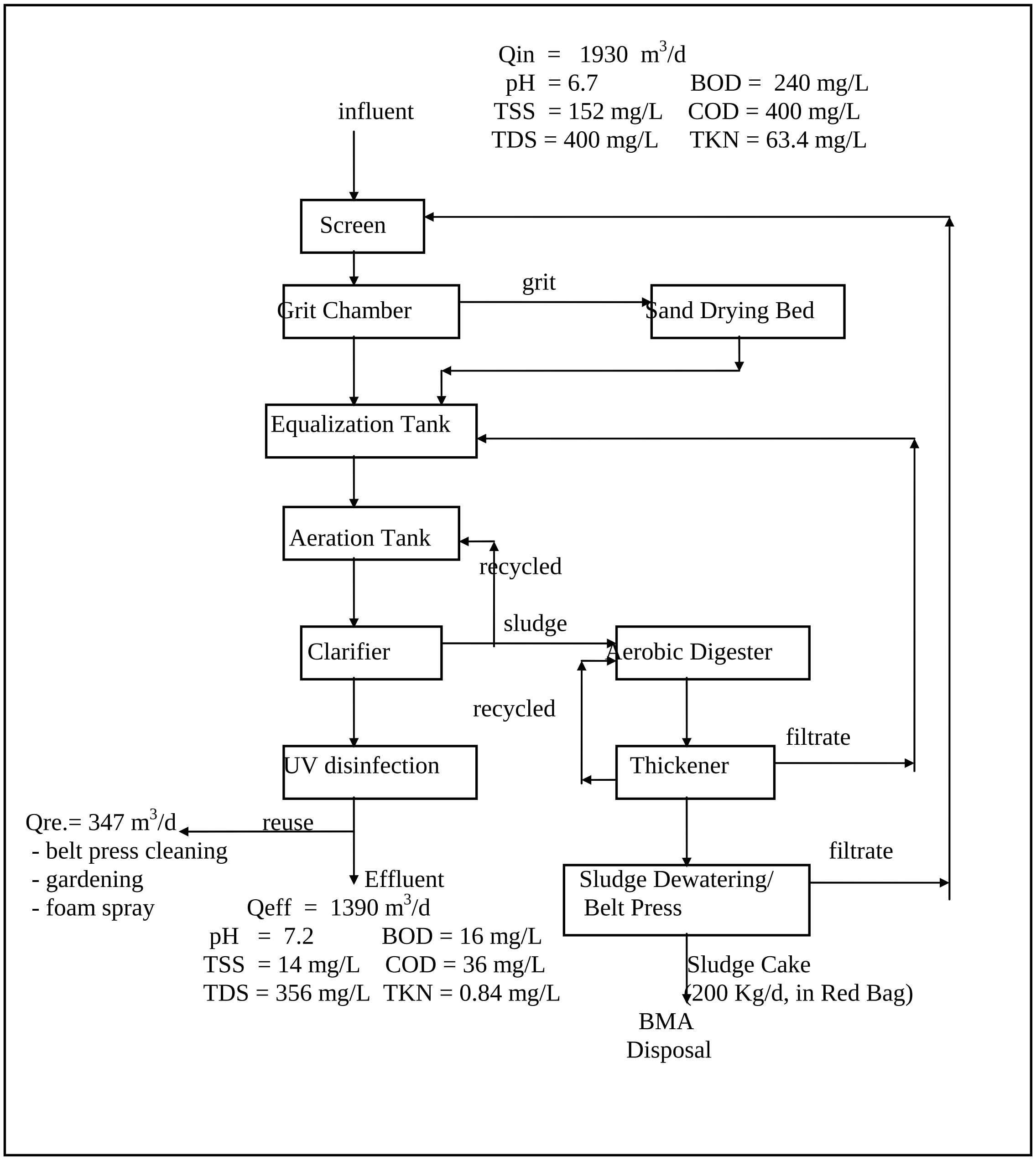


Figure 5. 6 Process Treatment of CWWTP

Compared with the prevailing standard in Thailand, all of the effluent parameters of this CWWTP are meeting the standard as presented in Table 5.9

Table 5.9 CWWTP Effluent Compared With The Standard

Parameters	CWWTP	Thailand (MSTE, 1994)
1. pH	7.2	5 - 9
2. TSS (mg/L)	14	30

3. TDS (mg/L)	356	500
4. BOD_5 (mg/L)	16	20
5. TKN (mg/L)	0.84	35

Table 5.10 presents comparison of wastewater produced in children's hospital, other institutes/hospital discharging their waste to CWWTP.

Table 5.10 Comparison of Existing Wastewater Produced and Designed

Sources	Wastewater Designed (*) (CTC, 1994), m^3/d	Existing Wastewater (m^3/d)
Children's Hospital	760	634
Other Institutes/Hospital	2440	1296
Total	3200	1930

(*) including planned expansion

According to Table 5. 9 and 5.10, it can be concluded that the CWWTP is functioning properly though it has been in operation for only 6 months. Nevertheless, some problems experienced during operation are:

- the influent pumps are always clogged by big particles passing through the screen (bar only). Types of big particles found are plastics, cloths, glove and sanitary napkins. The other things that are also found are blood, body parts and syringes. In solving these problems, they installed another screen (smaller diameter) infront of bar screen. Though they fixed double screens, but pumps are still clogged.

- during field visits it was observed that the workers never used their personal protection during work. This situation should be improved since the wastes that they handle are harmful. The items which should be provided during working are boots, gloves and masks.

5.3 Work Environment in Hospital

Two parameters measured for work environment in the hospital, are:

1. Noise Pollution
2. Air Particulate

5.3.1 Noise Pollution

Noise pollution measurement has been done for both the indoor and outdoor of the hospital. Table 5.11 presents general noise level in hospital compared with other studies and noise level in different buildings are presented in Table 5.12.

Table 5.11 Noise Level in Children's Hospital Compared with Other Studies

Sources	Noise Level (dBA)
1. Children's Hospital (day time)	
- outdoor	61.7 - 87.9
- indoor	60.0 - 63.5
2. Duerden, 1970	30
3. Crocker, 1971	
- outdoor	40
- indoor	40
4. Chhatwat et al., 1989	
- day	45
- night	35

According to Table 5.11 and 5.12, it can be concluded that all of noise level in children's 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.

Table 5.12 Noise Level in Different Buildings/Rooms

Building/Floor	Sampling Date	Room	Noise Level (dBA)
SIAM (A)			
1. 1st floor	7-5-97	outdoor	65.2 - 87.9
	30-3-97	diesel	103.7 - 107.2

 2. 2nd floor 3. 3rd, 4th floor 4. 6th floor	28-3-97 2-4-97 2-4-97 2-4-97	vacuum pumps corridor corridor corridor	88.0 58.7 - 80.0 58.7 - 75.0 64.0 - 67.0
MAHITTALA (B) 1. 1st floor 2. 2nd floor 3. 3rd floor 4. 4th floor 5. 5th floor	 7-5-97 28-3-97 28-3-97 9-4-97 9-4-97 9-4-97 7-5-97 30-3-97 30-3-97	 outdoor chiller & compressor chiller's office corridor corridor corridor surgical room corridor pathology lab.	 61.7 - 78.9 88.1 - 93.8 68.1 65.2 64.7 64.5 60.0 - 63.5 65.0 52.0
SERVICE (C) 1. 1st floor 2. 3rd floor	 7-5-97 26-3-97 26-3-97 26-3-97	 outdoor boiler room laundry room ward (c3)	 66.3 - 64.7 73.2 - 82.6 70.4 - 86.7 63.0 - 66.0
WARD (F1) 1. 1st floor	 16-4-97	 ward (c5-6)	 62.0 - 63.0
WARD (F2) 1. 1st floor	 16-4-97	 ward (c7-8)	 62.0 - 63.0
DORMITORY (E1) 1. 1st floor	 22-5-97	 outdoor	 72.9
DORMITORY (E2) 1. 1st floor	 22-5-97	 lobby	 63.7

Some noise pollutions which may effect on staff and patients in this hospital are as follows (Chhatwal et al., 1989);

1. Mental stress
2. Frustration
3. Task interference
4. Irritability
5. Sleep interference
6. Communication/speech interference
7. Habit of talking
8. Concentration interference

9. Invasion of privacy
10. Temporary hearing loss

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 such as 45 dBA (Chhatwat et al., 1989) and 40 dBA (Crocker, 1971), noise in surgical room are quite high, so the staff complaint should be seriously considered in order to prevent any accidents.

In the light of noise reduction in this hospital, there are three methods in noise control which can be possibly applied are:

1. Noise control at source:
   - put adequate lubrication
   - sound insulation
   - sound absorption
2. Noise control at path:
   - barrier wall
   - curtain in rooms
3. Noise control at the receiver (specially to the workers who work at the points of source):
   - ear defender
   - ear plugs

5.3.2 Air Particulate

In this study, air borne particulates matter measurement were done in three locations, these are:

1. Information room (1st floor of A building),
2. Transportation section room (1st floor of B building),
3. Service room (1st floor of C building)

The concentrations of air particulate at various type of work are presented in Table 5.13.

Table 5.13 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 (Siam, A)	22-4-97	190	1	22	0.5	2.15
Transportation (Mahit., B)	22-5-97	150	1	35	1.1	3.8
Service Buil. (1st fl.)	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.

5.4 Environmental Action Plan (EAP)

An EAP was developed to response to the key environmental impacts which were identified. The EAP aims to improve the environmental performance of this 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 wastes minimization
3. Provide safe and pleasant working environment by reducing noise pollution by 35 percent in the year 1998

5.4.1 Water Wastages Reduction

As discussed, this hospital consumed more water compared with other studies. In addition, number of hospital facilities such as new hospital wards and shops have been increasing. With regard to the water reduction, therefore, this action plan has been targeted to water wastage reduction by 65 percent in the year 2002. The water wastage control is planned by substituting low quality plumbing fixtures in this hospital with high quality water saving fixtures. To achieve this objective, factors to be considered are limited budget, available technology and important water user.

The following steps are proposed for water wastage reduction:

1. Good house-keeping,
2. Replacement of plumbing fixtures

Good house-keeping

The first step towards water wastage control program should be good house-keeping practices to be applied such as closing of water taps after use, repair of leaking valve and connections. It was proved that at least (5-7) percent of water can be safe if good house-keeping was applied as described in section 5.2.3.

Replacement of plumbing fixtures

The next step to water wastages reduction program should be to replace low quality plumbing fixtures. Water flowing out from present plumbing fixtures was directly measured. The proposed maximum water used of the internal plumbing is presented in Table 5.14 which is based on American Standard for a fixture specification.

Table 5.14 Current and Proposed Water Flow in Different Plumbing Fixtures

Fixture	Unit	Current Water Used	Proposed Max. Water Used
1. Showerhead	L/minute	21.2 - 25.0	9.5
2. Water tap	L/minute	13.3 - 20.0	7.5
3. Lavatory faucet	L/minute	10.2 - 32.0	7.5
4. Toilet Valve	L/flush	16.0 - 20.0	6.0
5. Urinal faucet	L/flush	6.0 - 10.0	4.0

The current status of all plumbing fixtures in hospital excluding F1 and F2 buildings are total number, type of fixtures and the date of installation presented in Table 5.15. Plumbing fixtures in buildings F1 and F2 are not considered because according to hospital plan, these buildings will be destroyed in the end of this year and a new building will be built instead. It is suggested to install good quality water conservation plumbing in this new building.

Table 5.15 Current Status of Plumbing Fixtures in Hospital

Types and Year Installation of Fixtures	Total Number

Ordinary (1979 - 1997):	
1. Showerhead	147
2. Water tap	235
3. Lavatory faucet	363
4. Toilet valve	264
5. Urinal faucet	38
Water Saver (1996):	
1. Showerhead	95
2. Water tap	95
3. Lavatory faucet	429
4. Toilet valve	228
5. Urinal faucet	76

Replacement of the plumbing fixtures are based on the following factors:

1. Date of installation of the fixtures
2. Sections discharge lot of water
3. High water consumption plumbing fixtures
4. Other factors as presented in Table 2.19

Concerning the replacement of fixtures, it should be replaced every year from 1998 to 2002 as presented in Table 5.16.

Table 5.16 Yearly Proposed Fixtures Replacement

Fixture	Year/No. of Replacement				
	1998	1999	2000	2001	2002
1. Showerhead	27	27	36	35	22
2. Water tap	46	46	54	49	40
3. Lavatory faucet	70	69	78	77	69
4. Toilet valve	50	50	59	57	48
5. Urinal faucet	8	8	8	8	6

Comparison between present and proposed water use of different plumbing fixtures are presented in Table 5.17.

Table 5.17 Present and Proposed Water Use of Different Plumbing Fixtures

Fixture	Water Use (L/minute)		Duration of Water Use (minute/day)	Vol. Water Use (Liter)	
	Present (average)	Proposed		Present	Proposed

1. Showerhead	23.1	9.5	20	462	190
2. Water tap	16.7	7.5	8	133.6	60
3. lavatory faucet	21.1	7.5	8	168.8	60
4. Toilet (L/flush)	18	6.0	2	36	12
5. Urinal (L/flush)	8	4.0	3	24	12

By comparing volume water use of present and proposed plumbing fixture in every year from 1998 to 2002, it has been found that the percentage of water wastages reduction in the year 2002 will be 59 percent as presented in Table 5.18.

Table 5.18 Effects of Proposed Action Plan on Water Wastages Reduction

Year	Present Water Use (Liter)	Proposed Water Use (Liter)	Water Wastages Reduction (%)
1998	32,428	12,786	12
1999	32,259	12,726	12
2000	39,328	15,564	14
2001	37,598	14,990	14
2002	23,688	11,374	7
Total	165,301	67,440	59

Total water wastage reduction in the year 2002 is about 65 percent consisted of 5-7 percent (good house-keeping) and 59 percent (plumbing fixture replacement).

Total cost of this program (in terms of plumbing fixtures purchasing only) has been calculated. The price of each plumbing fixture was adopted from the market price list which is offered in 1996. Price contingencies have been anticipated by increasing by 10 percent of the basic price in every year and total capital investment was considered by adding 20 percent (as installation cost) of annual capital investment. Total estimated cost in every year is presented in Table 5.19.

Table 5.19 Total Estimated Cost

Fixture	Total Price (Baht)				
	1998	1999	2000	2001	2002
1. Showerhead	61,182	67,311	98,712	105,560	72,996
2. Water tap	47,656	52,394	67,662	67,571	60,640
3. Lavatory fau.	72,520	78,591	97,734	771,379	104,604
4. Toilet valve	323,700	356,050	462,147	491,112	454,944
5. Urinal faucet	15,536	17,088	18,800	20,680	17,058
Capital Investment	520,594	571,434	745,055	1,456,302	710,242
Total Cap. Invest.	624,713	685,721	894,066	1,747,562	852,290

The total capital investment cost of plumbing fixtures in the year 2002 is about 5,000,000 Baht. Pay back period (return money) is calculated by multiplying the percentage of water wastage reductions with annual water consumption bill and water price (it is assumed that annual water consumption to be 297,323 m^3 based on data in 1996 and water price to be 10 Baht/m^3). With the proposed investment starting from 1998, the wastage of water will be minimized significantly as well as the cost recovery can be achieved by the end of year 2005 as presented in Table 5.20 and Figure 5.7.

Table 5.20 Investment versus Return Money

Year	Cumulative (Baht)	
	Investment	Return Money
1998	624,713	
1999	1,310,434	356,788
2000	2,204,500	713,576
2001	3,952,062	1,129,828
2002	4,804,352	1,546,080
2003	4,804,352	1,754,206
2004	4,804,352	3,508,412
2005	4,804,352	7,016,824

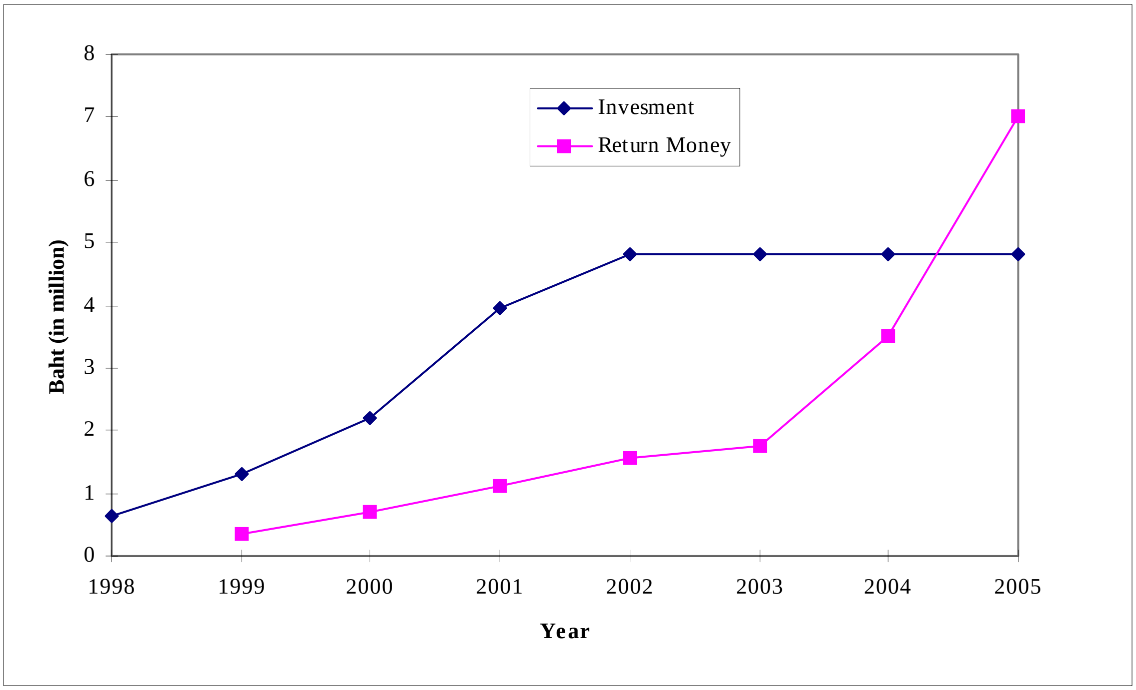


Figure 5. 9 Investment Vs. Return Money

5.4.2 Hospital Waste Management

To improve the management of the hospital wastes, the management process that should be strictly employed are:

1. Segregation and Waste Minimization
2. Storage
3. Packing and Transport
4. Treatment and Disposal

It was found that the wastes after segregation were shifted to transfer station at Rachawithi Hospital and left with the management of this hospital. Therefore, this action plan will focus on the points of waste segregation and waste minimization only.

Segregation

Waste segregation at the source is essential for the proper waste management at the hospital. Mixtures of infectious waste and non infectious (general) wastes must be treated as if the wastes were infected. Moreover, significant cost savings can be achieved through minimizing the volume of the infected waste after proper segregation.

Waste segregation at the point of origin was applied in this hospital by adopting the following system of color coding. The current system of plastic bag color coding is presented in Table 5.21.

Table 5.21 Current System of Plastic Bag Color Coding

Color of Bag (Plastic)	Type of Waste	Printed Identification on Bag
Red	Infectious	-
Black	General	-

The amount of waste generation in this hospital status for the month of May 1997 was 480 Kg/d (General Waste) and 59.4 Kg/d (Infectious waste) or 89 percent of general waste and 11 percent of infectious waste.

In addition to the current system of plastic bag color coding, there are other wastes that be separated from two existing bags. Likewise, printing identification of waste on bags are required. The proposed color coding of this hospital is presented in Table 5.22.

Table 5.22 Proposed Plastics Bags Color Coding

Color of Bags (Plastic)	Type of Waste	Printed Identification on Bag
Red	Infectious	'Biohazard' symbol and mark infectious waste (see Appendix I)
Black	General: - Paper - Plastic - Rubbish	 Paper Plastic Rubbish
Purple and White	Cytotoxic	Telophase (see Appendix I)

In addition to the Table 5.22, the following items which are found at present condition and require to be improved are:

- All the bags must be tied and affixed with an appropriate identification label showing the source of the bag.

- For the disposal of sharps, special container with an appropriate identification that cannot be punctured should be provided to transport these wastes to incineration plant.

- Wire baskets should be provided in hospital wards and other departments for bottle/glass collections.

- The sanitary napkins should be placed in red bags and destroyed by incinerator.

- Aerosol cans which have contained pharmaceutical substances should be collected separately from other hospital waste and it should be burnt in an appropriate incinerator. Collection in wire basket can suitable because the contents are easily recognized.

- It has been found that mercury (mainly from thermometer breakage to be 300 units/month) are disposed in the black bag. It is proposed that mercury should be collected in a special container and transported to a recycler. Using electronic devices to measure temperature and blood pressure is the most effective way to minimize mercury from the waste stream.

- Storage of infectious wastes before transported to the final disposal should be surrounded by an impervious concrete bund wall not less than 15 cm in height (Victoria-EPA, 1993). All loading and unloading of waste must take place within the bunded area.

Figure 5.10 illustrates proposed hospital waste management streams in Children's Hospital.

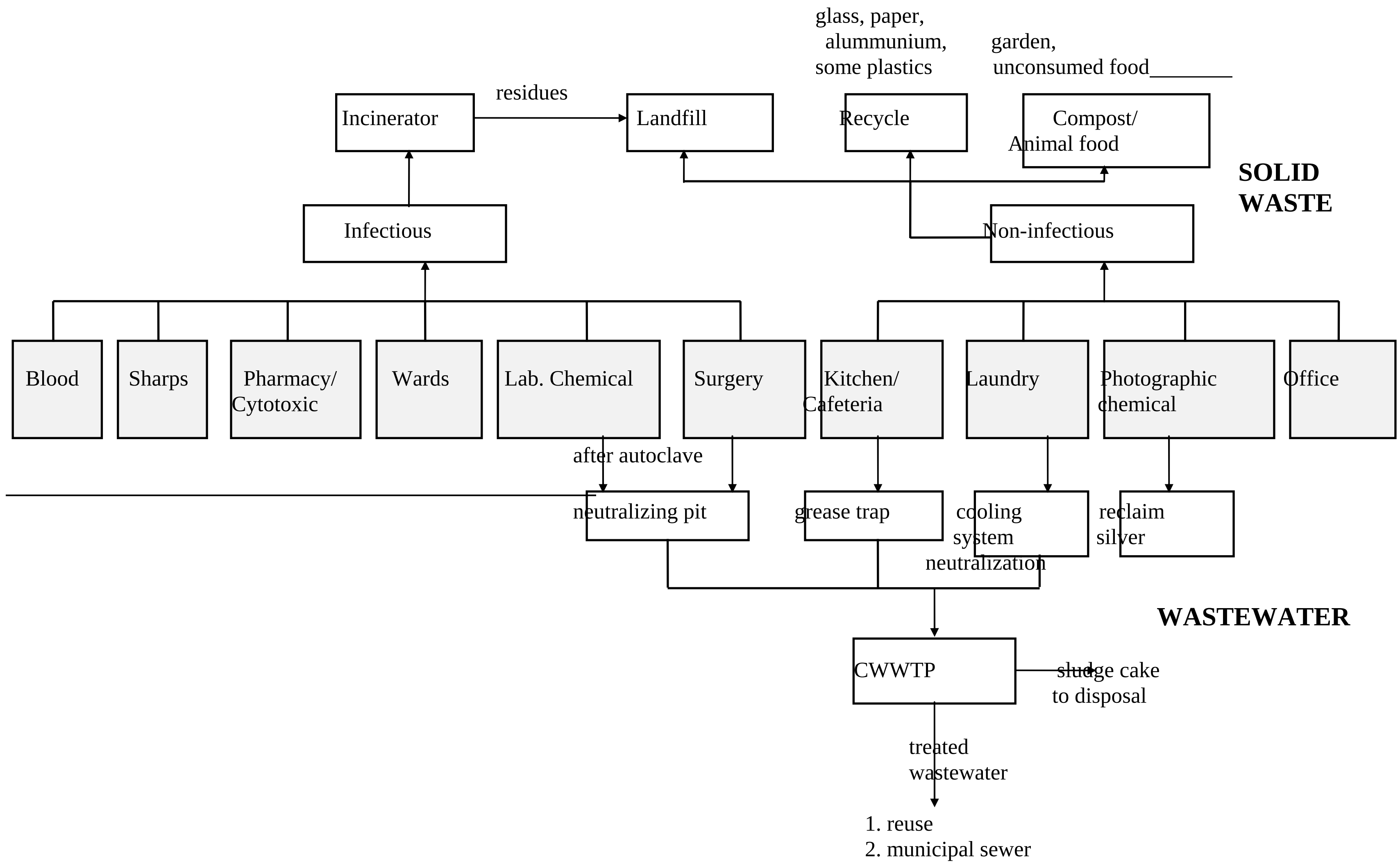


Figure 5..10 Proposed Solid Waste and Wastewater Management Streams

Waste Minimization

Minimization of waste can be carried out as follows:

1. Waste minimization options:
   - Source Reduction
   - Recycling and Reclamation
2. Identification of waste minimization programs

Source reduction

This is an important step that should be practiced in waste minimization. Source reduction that can possibly be applied in this hospital are:

- waste segregation (as discussed)
- centralized purchasing and dispensing of drugs and chemicals
- use first in and first out in dispensing drugs and chemicals
- material substitution
- process change

Table 5.23 summaries the operating practices that can be utilized in this hospital to affect waste minimization.

Recycling and Reclamation

The recycling and reclamation are limited to the toxic/chemical wastes discharged to the sewers as it regularly happens in this hospital. Some toxic/chemical wastes that can be potentially recycled and reclaimed are formaldehyde, photographic chemical, solvent and mercury.

a. Formaldehyde

Sawyer and McCarty, 1967 as cited in US-EPA, 1990 defined that the dilute formalin waste stream contains approximately 4 percent formaldehyde, 1 percent methanol and 95 percent water. Surplus of formaldehyde waste from dialysis unit can be used to recover organic material in rayon manufacturing.

b. Photographic chemical

Photoprocessing chemical consists of developer, fixer and rinse water. Silver is a component in most photographic film. The wastewater from photoprocessing contains silver which can be recovered by following methods:

Table 5.23 Operating Practices for Source Reduction

Source Reduction Practices	Existing	Proposed
1. Waste segregation	As discussed	As discussed
2. Centralized purchasing and dispensing of drugs and chemicals	It has been practiced in Pharmacy section, but the drug and chemical records which are distributed to each section are not clear	Inventory of drugs and chemicals distributed to each section should be computerized
3. Use first in and first out policy in dispensing drugs and chemicals	It has been practiced only in Pharmacy section controlled by the computers	Should be applied to other section that use the drugs and chemicals
4. Material substitutions	a. Halogenated solvent (Toluene & Xylene) b. Mercury (Mercury-based thermometer) c. Chemical sterilization (Glutaraldehyde & Phenol)	a. Non halogenated (simple alcohols, ketones) b. Electronic sensing devices c. Sonic sterilization
5. Process	a. Formaldehyde waste from cleaning of dialysis equipment b. Fixer and Developer Wastes	a. Install Reverse Osmosis (RO) water supply equipment to solve formaldehyde waste problem. The use of RO units allow a reduction in the cleaning frequency requirements of dialysis machines. RO can be cleaned with hydrogen peroxide instead of formaldehyde b. Extend processing bath life: - adding ammonium thiosulfate, which doubles the allowable concentration of silver build up in the bath - adding acetic acid to the fixing bath as needed to keep the pH low

- Metallic Replacement:
The spent fixing bath is pumped into a cartridge containing steel wool. An oxidation-reduction reaction occurs and the iron in the wool replaces the silver in solution. The silver settles to the bottom of the cartridge as a sludge.

- Electrolytic Deposition:
In an electrolytic recovery unit, a low voltage direct current is created between a carbon anode and stainless steel cathode. Metallic silver plates onto the cathode. Once the silver is removed, the fixing bath may be used in the photographic development process by mixing the desilver solution with fresh solution. Recovered silver is worth about 80 percent of its commodity price.

c. Solvent

In this hospital, the sources of solvent wastes are the laboratory chemical including pathology, service and some other sections. By distillation system the wastes of ethanol and xylene in pathology section can be reused annually, resulting in a 65 percent decrease in the volume of these wastes (Metropolitan Hospital ‘s Waste Reduction Committee, 1997). Another thing that the solvent wastes with sufficiently low chlorine content can be used as a fuel supplement in cement kilns and some industrial boilers.

d. Mercury

The source of mercury in this hospital is mainly from the broken thermometer. It was found that about 300 units per month of middle size thermometer were broken. Mercury can easily be recycled depending on the type or degree of contamination. Residual mercury in reservoir of broken devices can be coarsely filtered and reused. While mercury recovered from spills which are contaminated can be distilled to remove impurities.

<u>Identification of Waste Minimization Programs</u>

This steps is addressed to hospital community and other external institutions which are important factors that influence the success of the waste minimization programs. These programs are divided into two following steps:

1. Education of hospital staff or community;
2. Encouragement of the external institutions that influence with the hospital activities.

1. Hospital Staff or Community Education

- Applying the regulation that each section in this hospital should be responsible for their own waste disposal costs. This will increase awareness of hospital staff and management concerning the financial impacts of the waste that they dispose of.

- Informing (feed back) about their performance in waste minimization against goals and objectives, so that the hospital staff will be able to assess the benefits due to their actions. The information of their performance can be disseminated through hospital bulletin or pamphlet as a strategy to foster awareness. It will also lead to transfer of knowledges and ideas among friend and neighbor.

- Waste exchange day; on this day all the departments should display their wastes (non infectious). All these wastes should be listed in a directory and a waste exchange directory must be compiled for showing variety of waste items available within the hospital which can be reused by other persons or sections.

- Training of the hospital staffs is an important thing. The subjects that should be taught must include information regarding the need for waste minimization along with the techniques for achieving it. Sample of course subject is attached in Appx. J.

- Reward the staff who have suggested and participated for waste reduction in hospital. This can motivate all of the staffs in achieving waste minimization programs.

Encouragement of the External Institutions that Influence with the Hospital activities

- Maintain the existing system properly and improve the program as the needs arise. The long term sustainability of waste reduction initiative depends on the continued monitoring of changing markets, trends and habits. If a department changes their purchasing habits, changes can be easily made and the system can be adapted to incorporate these changes.

- Develop external relations with institutions in the community in the role of educator or in the form of partnerships to increase the positive impact of waste reduction practices. For instance, many chemicals used in hospital maintenance and laboratories are supplied in container which after use can be returned to the supplier for cleaning and reuse. This can minimize the wastes in hospitals.

- A program can be pioneered by this hospital by setting up on regular drug collection to allow local residents to dispose of their expired medication to a special container provided in this hospital before transport to incineration.

5.4.3 Noise Abatement

It has been identified that noise level from the sources of noise in this hospital such as boiler, chiller and compressor, vacuum pumps and cooling tower were 73.2 - 93.8 dBA. In the light of noise abatement, Duerden (1970) stated that by installing the single leaf walls (50.8 mm of wood wool slab) as a wall insulation in the sources of noise rooms, the noise can be reduced (transmission loss) by 35 dBA. This will reduce the noise in the hospital to 48 dBA (outdoor noise), therefore this noise level is close to Chhatwat et al.'s study (45 dBA). In addition, installation of hood/exhaust (AC) insulation in surgical room should be implemented as the staff has been complained.

However, a strictly regulation should be practiced to the employees of laundry room to use the ear plugs provided by the hospital during work. In addition, ear defender should also be provided in the rooms of vacuum pumps, chiller and compressor, diesel and boiler. Moreover, the curtains can be fitted in each hospital ward or other rooms, this also can help in terms of indoor noise reduction.

5.4.4 Summary of Environmental Action Plan

ENVIRONMENTAL ACTION PLAN
Objectives: • Water wastage reduction by 65 % in the year 2002. • Better hospital waste management. • Noise abatement by 35 % in the year 1998

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 (ref. Table 5.16)	Service Section approved by Adm. Sec.
- showerhead (147 units)		
- watertap (235 units)		
- lavatory faucet (363 units)		
- toilet value (264 units)		
- urinal faucet (38 units)		

Recommendations	Year Implementation	Responsibility

3. <u>Hospital waste minimization</u> :		
- Plastic bags color coding/segregation - Inventory of drugs and chemicals distributed to each section by computerizing - Drugs dispensing in ward/other section controlled by computerizing	1997 1998/2000 1997	Service and Adm. Section recommended by Green Team
- Material/device substitution i.e. : * halogenated solvent → non halogenated solvent * mercury based thermo. → electronic sensing devices * chemical sterilization → sonic sterilization	 1998/1999 1999 1999	Adm. Section
- Process : * Install Reverse Osmosis water supply equipment to solve formaldehyde waste problem for dialysis machines * Extend processing bath life in x-ray section - add ammonium thiosulfate - add acetic acid to keep pH low	1998 1998	Service, X-ray and Surgery Sec. recommended by Green Team
- Silver recovery : * Metallic replacement * Electrolytic disposition	1999 1999	Service and X-ray Sec. recommended by Green Team
- Educate hospital staff/community : * 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, 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	1997 to onwards	Training, Adm. Section, and Green Team
- Encourage the external institutions that influence with the hospital activities	1997 to onwards	Adm, Pharmacy sec. and Med. Supplier

Recommendations	Year Implementatio n	Responsibility
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 :		
- Central wastewater treatment plant * install small diameters screen after barscreen * install automatic removal of retained objects from the screen	1997	under Rachawithi hospital authority
- Provide impervious concrete bund wall for storage of infectious waste	1997/1998	
- Set up on regular drug collection programs	1998 to onwards	Green Team, Adm., Pharmacy, and Service Sec.

note : The Green team members are presented in Table H.3, Appendix H

Chapter 6

Conclusions and Recommendations

Conclusions and recommendations for improving the environmental performance in terms of water and wastewater audit; noise and air pollution and Environmental Action Plan at the Children's Hospital can be developed as follows.

6.1 Conclusions

1. Total water consumption volume in Children's 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). The said hospital catered patients up to 18 years of age. Although the other studies did not directly address to a specific hospital, it is firmly believed that there is a need for a detailed audit concerning its specific water use.

2. Hospital wards including laboratories had been found to be the largest consumer of water at 331 m^3/d. This was attributed to both patients and attendants since the patients were always accompanied by their parents during examination. It was noted that the ratio of patient to attendant was 1:2. Which means, the patient attendants also consume significant amount of water (156 m^3/d).

3. 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.

4. The quality of wastewater in this hospital were relatively having the same values with other reported findings. Whereas, laundry wastewater caused it has 10 pH and 80^{o}C temperature are needed to be given special attentions accordingly, while kitchen and cafeteria which have the value of BOD, COD and SS were (518-795) mg/L, (840-880) mg/L and (246-263) mg/L respectively.

5. Chemical or toxic wastes generated in this hospital were 57 mL/bed/d in which laundry section is the largest as generator of this waste (about 37 percent of total chemical wastes which were discharged to sewers). Moreover, this hospital which has 538 beds may qualify as a small quantity generator which produces more than 300 kg of toxic waste a month. Hence, handling of this toxic wastes should be strictly regulated.

6. 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 room which produce noise nor in the recipient.

7. An Environmental Action Plan (EAP) was developed to improve the environmental performance of this hospital with respect to three objectives; water wastage reduction, chemical or toxic minimization and provide safe and pleasant working environment.

6.2 Recommendations

1. The water meters should be installed in each section to measure water consumption precisely. In addition, it is very useful if it connects with leakage detection.

2 In order to provide efficient management, it is required to record all chemical or toxic wastes in terms of weight or volume from time to time in the sections where wastes are being produced.

3. An neutralizing chamber and cooling water should be installed to neutralize pH of laundry wastewater from 10 to 6-7 and to reduce temperature from 80^{o}C to 37^{o}C.

4. In the light of water wastage reduction, the following steps that are to be taken:

   - Good house keeping
   - Replacement of inefficient plumbing fixtures
   - Hospital staffs training

5. Operating practices for waste minimization that are to be taken:

   - Waste segregation by improving plastic bag color coding and storage
   - Computerizing an inventory of drugs and chemicals distributed to each section
   - Material substitution:
     . apply non-halogenated solvent
     . apply electronic sensing devices instead of manual thermometer
     . sonic sterilization
   - Process change
   - Hospital community education such as awareness of waste disposal cost, employees involvement and incentive program

6. In order to noise abatement, the steps should be taken are:

   - to install wall insulation in the sources of noise rooms
   - to provide ear plugs for laundry employees and ear defender for the rooms of boiler, chiller, diesel and vacuum pumps
   - to install hood/exhaust insulation of surgical room air conditioner (AC)

7. Further research:

- As estimated that approximately 10-20 percent of hospital waste is considered potentially infectious, a study is necessary to develop and find out the detail characteristics of infectious hospital waste both quantitative and qualitative including bacteriological which is leading to optimize the management of infectious hospital waste.
- Detail life cycle analyses of medical products to determine their environmental impacts and to identify alternatives.
- Development of a strategy to incorporate environmental management principles into course/training programs for hospital staff

Conclusions

- Total water consumption in Children's hospital is 2 to 3 times higher than the other reported findings.

- Hospital wards including laboratories was to be the largest consumer of water ($331 m^3/d$).

- About 7% of tap water were used inefficiently. As a result, the hospital has been loosing 263,000 Baht/year.

- This hospital which has 538 beds may qualify as a small quantity generator of toxic wastes (>300 kg/mo). Therefore, the toxic wastes handling should be strictly regulated.

- Noise pollution in this hospital was (62-75) dBA. It was higher than other reported studies (30-45) dBA.

Recommendations

1. Good-house keeping.

2. Operating practices for waste minimization.

3. Further study:

   - Characterize quality and quantity the infectious wastes for proper handling.

   - Determine the environmental impacts caused by medical products.

   - Develop an EAP include training program for hospital staff

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APPENDIX A

Table A.1 Comparison of Chemical and Physical Water Standards Recommended by the WHO, the United States, and Several Developing Countries

Chemical and Physical Parameters	WHO Guideline Value (1984)	United States (1977)	Thailand (1994)	India (1991)
Total Hardness (mg/l as $CaCo_3$)	500	-	-	200
Turbidity (NTU)	5	1 to 5	5.0	2.5
Color (TCU)	15	-	5.0	5.0
Iron, as Fe (mg/l)	0.3	0.3	0.5	0.1
Manganese, as Mn (mg/l)	0.3	0.05	0.3	0.05
pH	8.5	-	6.5 - 8.5	7.0 - 8.5
Nitrate, as NO_3 (mg/l)	45	45	45	45
Sulphate, as SO_4 (mg/l)	400	-	200	200
Fluoride, as F^4 (mg/l)	1.5	1.4 to 2.4	0.7	1.0
Chloride, as Cl (mg/l)	250	250	250	200
Arsenic, as As (mg/l)	0.05	0.05	0.05	0.05
Cadmium, as Cd (mg/l)	0.005	0.01	0.01	0.01
Chromium (mg/l)	0.05	0.05	0.05	0.05
Cyanide, as Cn (mg/l)	0.1	0.01	0.2	0.05
Copper, as Cu (mg/l)	1.0	1.0	1.0	0.05
Lead, as Pb (mg/l)	0.05	0.05	0.05	0.1
Mercury, as Hg (mg/l)	0.001	0.002	0.001	0.001
Selenium, Se (mg/l)	0.01	0.01	0.01	0.01

APPENDIX B

APPENDIX C

Figure C.1 A Water Meter

Figure C.2 Electromagnetic Current Meter

Figure C.3 A Sampling Point (Space Limitation)

Figure C.4 Bucket and Stopwatch

Figure C.5 Sound Level Meter

Figure C.6 Air Pump Sampler

Figure C.7 Infectious Hospital Waste Storage in Rachawithi

Figure C.8 Transport of Infectious Hospital Waste

APPENDIX D

Table D.1 Water Uses Calculation based on March - April 1997

No	Activity	Calculation Method	Water Consumption (m^3/day)
1	Dormitory	Water meter record	182
2	Wards (including laboratory)	- No. of inpatients : 331 L/day - Water consumption : 1000 L/patient/day *	331
3	Outpatient	- No. of outpatient : 969 /day - Water consumption : 10 L/patient/day *	10
4	Attendants	- No. of attendants : 2600 - Water consumption : 60 L/att./day *	156
5	Staff	- No. of staffs : 1255 - Water Consumption : 60 L/att./day	75
6	Laundry	Direct observation (calculation attached)	14
7	Kitchen	Direct observation (calculation attached)	15
8	Milk Preparation	Direct observation (calculation attached)	15
9	Cafeteria (Siam + Service)	Water meter record	20

No	Activity	Calculation Method	Water Consumption (m^3/day)
10	Cleaning Service	Direct observation : - Q tap : 1 L/4 second - duration : 5 hours - No. of building to be cleaned/day : 6	27
11	Boiler	Direct observation: - Q steam : 13 m^3/day - Q ww : 2 m^3/day	15
12	Cooling Water	Water meter record	18
13	Gardening/Watering	Direct observation - Q tap : 1 L/second - duration : 4 hours - No. of location : 4	12
14	Unccounted Water	a. Total water hospital consumption by water meter : 1016 m^3/day b. Total water consumption by activities (1 to 13) : 890 m^3/day c. Unccounted water = (a - b)	126

(*) 1. Tchobanoglous and Schroeder, 1985
2. CTC, 1994
3. Kiya and Murakawa, 1989

DIRECT OBSERVATION (CALCULATION)

I **Laundry** :

1. Hospital Laundry :

   - volume water for 4 machines : 2340 litre
   - washing frequency : 4 times/day
   - total water consumed : 2340 x 4 = 9.4 m^3/day

2. Dormitory Laundry :

   - 2 units of sharps = 960 litre
   - 1 units of PAL = 510 litre
   - total water consumed = 1.5 m^3/day

3. Water consumed by laundry :

   9.4 + 1.5 m^3/day = 10.9 m^3/day

4. Water loss = 30 %

5. Total water consumed by laundry = 14 m^3/day

II. **Kitchen** :

1. Cleaning by manual (general patient)

   - Q tap : 1 litre/4 second
   - cleaning frequency : 3 times/day
   - duration : 120 minutes
   - total water consumed = 5.4 m^3/day

2. Cleaning by manual (VIP patient)

   - Q tap : 1 litre/4 second
   - cleaning frequency : 3 times/day
   - duration : 90 minutes
   - total water consumed = 4.1 m^3/day

3. Cleaning by machine

   - 80 rak/day x 4 litre/rak = 0.320 litre/day

4. Pot Washing

    - volume of pot = 0.038 m^3
    - no. of pot = 4
    - frequency = 6
    - total water consumed = 0.9 m^3/day

5. Vegetables Washing and Cooking

    - Q tap : 1 litre/4 second
    - duration : 3 hours
    - total water consumed = 2.7 m^3/day

6. Total (1 + 2 + 3 + 4 + 5) = 5.4 + 4.1 + 0.32 + 0.9 + 2.7 = 13.42 m^3/day

7. Water loss = 10 % of total water consumed

8. Total water consumed in kitchen = (6 + 7) = 14.76 ≅ 15 m^3/day

III. <u>Milk Preparation</u> :

1. 1^{st} basin (bottle washing) :

    - volume basin : (120 x 45 x 32) cm^3 = 172.8 litre (0.173 m^3)

    - Q tap : 1 litre/4 second
    - duration : 45 minute = 2700 second
    - total water consumed = (2 * volume basin) + (2700 sec. * 1 litre/4 sec.) = 0.85 m^3

2. 2^{nd} basin (bottle + disinfectant) :

    - total water consumed = (2 * volume basin) + (3600 sec. * 1 litre/4 sec.) = 1.25 m^3

3. Brushing :

    - Q tap : 1 litre/3 second
    - duration : 5 hours
    - total water consumed = 6 m^3

4. 2^{nd} washing :

- Q tap : 1 litre/3 second
- duration : 5 hours
- total water consumed = 4.5 m^3

5. 1st basin (nipple washing) :

   - as no. 1 + (60 litre x 4) = 11 m^3

6. 2nd basin (nipple + disinfectant) :

   - frequency : 2 basin a day (2 x 172.8 litre)
   - total water consumed = 0.35 m^3

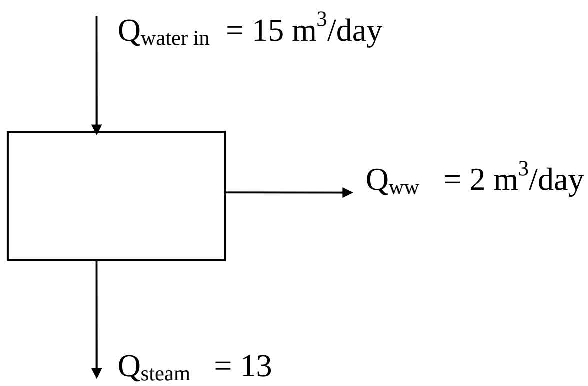
7. Final washing :

   - 4 hours x 1 litre/25 sec. = 0.58 m^3/day
   - 3 hours x 1 litre/23 sec. = 0.47 m^3/day

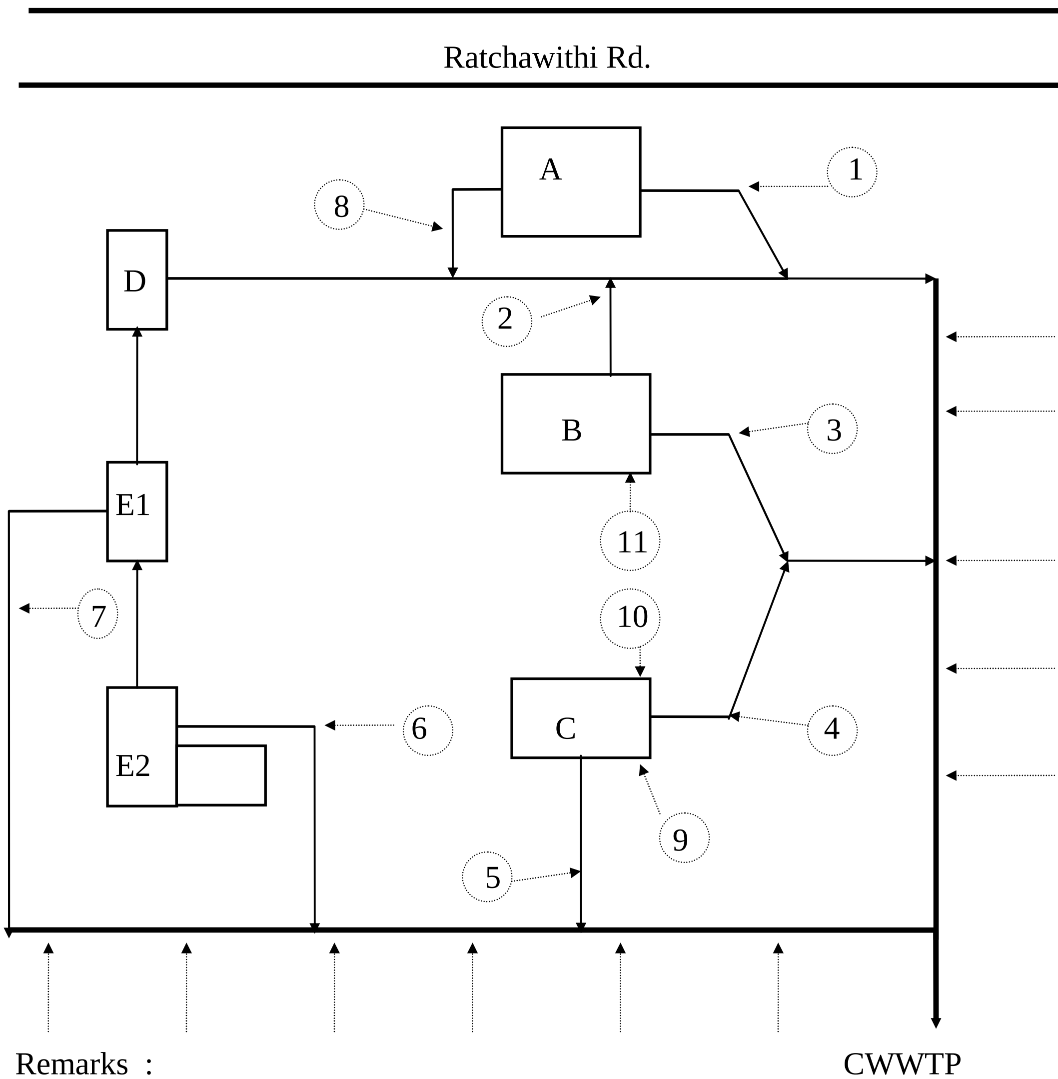
8. Water consumed for milk feeding = 150 litre/day = 0.15 m^3/day

9. Total water consumed :
   (0.85 + 1.25 + 6 + 4.5 + 1.1 + 0.35 + 0.58 + 0.47 + 0.15) = 15.25 m^3/day

IV. <u>Boiler</u> :



APPENDIX E



Remarks :

⟶ Wastewater line (Children's hospital only)

⟶ Combined sewer line (with other hospital)

⟶ Wastewater from other hospital

○ ⟶ Sampling point

A (Siam Building) = 1 Laboratory = 11

B (Mahitalla Building) = 2, 3 Kitchen = 10

C (Service Building) = 4, 5 Laundry = 9

D (Narisara Building) = - Cafeteria = 8

E1 (Doctor Dormitory)= 7

E2 (Nurse Dormitory) = 6

CWWTP (Central Wastewater Treatment Plant)

Figure E.1 Lay Out of Wastewater Line and Sampling Points

Table E.1 Tap Water Characteristics

Date of Sampling : 22 - 4 - 97
No. of sampling point : 12

Constituent	Unit (mg/l as)	Concentration
Calcium	$CaCO_3$	54
Iron	Fe	0.02
Manganess	Mn	< 0.025
Copper	Cu	Trace
Chloride	Cl	14
Sulfate	SO_4	29.2
Nitrate	NO_3 - N	0.33

Table E.2 Wastewater Characteristics

Date of sampling : 22 - 4- 97

Sampling Point	pH	TSS (mg/l)	TDS (mg/l)	COD (mg/l)	TKN (mg/l)	BOD_5 (mg/l)
E1 (7)	7.16	32.0	443.3	112.3	25.10	72.74
E2 (6)	7.14	72.0	423.3	111.6	22.20	88.5
C (5)	6.71	28.0	370	67.1	14.13	32.9
C (4)	8.95	24.0	403	51.6	10.18	27.8
B (2)	7.03	96.0	403.3	58.7	14.0	41.7
B (3)	6.58	44.0	390	62.6	13.41	34.5
A (1)	7.19	40.0	480	104.2	55.32	67.8
Cafeteria (8)	6.34	316.0	513.3	185.2	58.56	150
Laundry (9)	10.09	56.0	1720	170.3	22.68	93
Kitchen (10)	4.75	376.0	546.7	762.2	50.12	552
Chemical (11)	6.72	19.2	373.3	96.4	36.96	35.1

Table E.3 Wastewater Characteristics

Date of sampling : 22 - 5 - 97

Sampling Point	pH	TSS (mg/l)	TDS (mg/l)	COD (mg/l)	TKN (mg/l)	BOD_5 (mg/l)
E1 (7)	6.79	83.3	403.3	176	37.92	114
E2 (6)	6.65	26.7	393.3	96	19.82	74
C (5)	6.58	23.3	426.7	57	16.04	46
C (4)	6.81	23.3	377.7	54	12.96	36.2
B (2)	6.73	43.3	363.3	92	15.36	45
B (3)	5.89	93.3	370	50.6	16.21	45.4
A (1)	6.86	36.7	340	107.2	71.68	59.3
Cafetaria (8)	4.39	263.3	800	840	37.52	795
Laundry (9)	9.75	56.7	740	184	31.08	102
Kitchen (10)	4.28	246.7	666.7	880	59.08	517.5

Table E.4 Central Wastewater Treatment Plant Characteristics

Date of sampling : 30 - 5 - 97

Sampling Point	pH	TSS (mg/l)	TDS (mg/l)	COD (mg/l)	TKN (mg/l)	BOD_5 (mg/l)
Influent	6.68	152	400	400	63.4	240
Effluent	7.16	14	356	36	0.84	16

Table E.5 Wastewater Flowrate

Date	Time	Building	V (cm/s)	A (cm^2)	Q (cm^3/s)	Q average (m^3/d)	Method
22-4-97	14.00	E1 (7)	24.3	12	291.6		
			25.6		307.2		Electromagnetic current meter
			25.0		300.0		
			28.6		343.2		
			27.2		326.4		
						27.1	
		E2 (6)				22.8	Stopwatch & Bucket
		C (4)				7.2	Stopwatch & Bucket
		B (3)	8.2	26.1	214.0		Electromagnetic current meter
			8.3		216.6		
			8.5		221.9		
			8.6		224.5		
			9.1		237.5	19.3	
		B (2)	21.8	91.2	1988.2		Electromagnetic current meter
			21.1		1924.3		
			26.0		2371.2		
			18.2		1659.8		
			19.3		1760.2	167.7	
		C (5)				86.4	Stopwatch & Bucket
		A (1)	22.6	182.3	4120		Electromagnetic current meter
			26.6		4849.2		
			19.1		3481.9		
			24.6		4484.6		
			16.2		2953.3	343.7	
					Total :	**680.2 m^3/d**	

Table E.6 Wastewater Flowrate

Date	Time	Building	V (cm/s)	A (cm^2)	Q (cm^3/s)	Q average (m^3/d)	Method
22-5-97	9.35	E1 (7)	30.1 29.9 29.4 30.1 29.0	15	451.5 448.5 441.0 451.5 435	38.5	Electromagnetic current meter
		E2 (6)	-	-	-	24.2	Stopwatch & Bucket
		C (4)	-	-	-	5.8	Stopwatch & Bucket
		B (3)	29.7 29.7 29.9 29.5 29.4	30.45	904.4 895.2 910.5 898.3 895.2	77.8	Electromagnetic current meter
		B (2)	16.5 17.1 16.9 16.6 13.8	91.2	1504.8 1559.5 1541.3 1513.9 1258.6	127.5	Electromagnetic current meter
		C (5)	-	-	-	77.8	Stopwatch & Bucket
		A (1)	14.9 15.4 15.3 14.6 15.9	182.3	2716.3 2807.4 2789.2 2661.6 2898.6	239.7	Electromagnetic current meter
					Total :	**591.3 m^3/d**	

APPENDIX F

Table F.1 Water Consumption Bill (status 1996)

Month	Water Consumption (m^3/moth)		Total Water Consumption	Price (Baht)		Total Price (Baht)
	Mahitalla	Siam		Mahitalla	Siam	
January	0	28,009	28,009	420	279,095.45	279,515.45
February	0	23,702	23,702	420	298,279.75	298,599.75
March	0	36,717	36,717	420	365,740.05	366,160.05
April	0	28,502	28,502	420	284,000.80	284,420.80
May	0	27,183	27,183	420	270,876.75	271,296.75
June	0	31,896	31,896	420	317,771.10	318,191.10
July	0	12,101	12,101	420	120,810.85	121,230.85
August	0	11,111	11,111	420	110,960.35	111,380.35
September	0	13,737	13,737	420	137,089.05	137,509.05
October	0	30,426	30,426	430	310,751.10	311,181.10
November	4	28,056	28,060	430	293,591.10	294,021.10
December	4	25,875	25,879	430	277,268.40	277,698.40
Total			**297,323**	**Total**		**3,071,204.75**

Table F.1a Estimation of Cost per Unit Fixture

Fixture	Cost/Unit (Baht)						
	1996	1997	1998	1999	2000	2001	2002
Shower	1,873	2,060	2,266	2,493	2,742	3,016	3,318
Water tap	856	942	1,036	1,139	1,253	1,379	1,516
Lavatory	856	942	1,036	1,139	1,253	1,379	1,516
Toilet	5,350	5,885	6,474	7,121	7,833	8,616	9,478
Urine	1,605	1,766	1,942	2,136	2,350	2,585	2,843

Table F.2 Water Consumption in March 1997

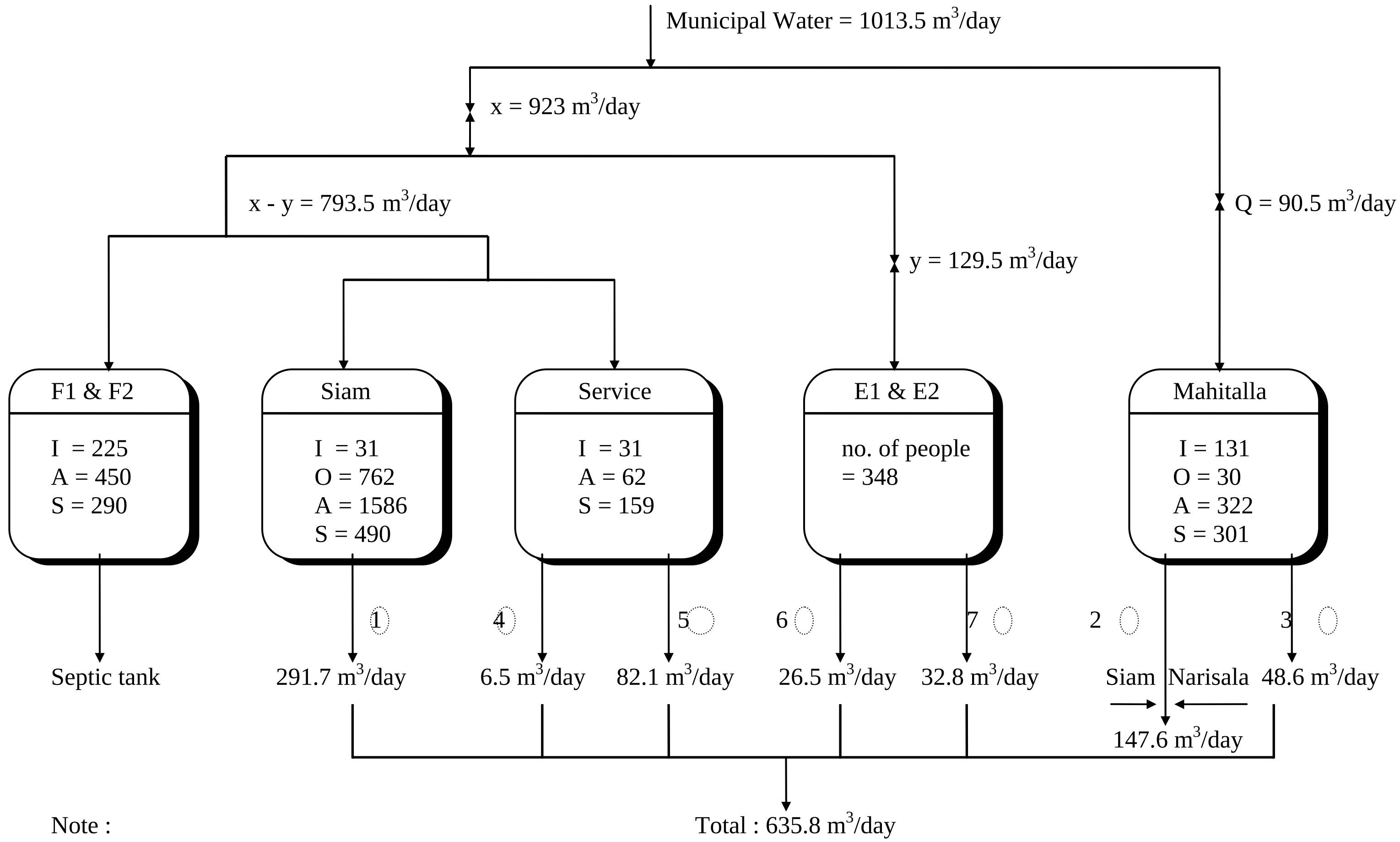
	Watermeter Record				Water Consumption		
Date	X	Z	Y	(X-Y)	z	y	(x-y)
5	333520	6745	14136	321114	62	180	760
6	336190	6807	14316	321874	74	194	806
7	337190	6881	14510	322680	23	187	713
8	338090	6904	14697	323393	47	187	693
9	338970	6951	14484	324086	47	206	774
10	339950	6998	15090	324860	77	183	817
11	338970	7075	15273	325677	71	186	734
12	340950	7146	15459	326411	74	145	765
13	341870	7220	15604	327176	60	184	806
14	342780	7280	15788	327982	33	191	689
15	344650	7313	15979	328671	47	197	753
16	345600	7360	16176	329424	47	179	741
17	346520	7407	16355	330165	73	186	764
18	347470	7480	16541	330929	73	194	816
19	348480	7553	16735	331745	49	173	727
20	349380	7602	16908	332472	73	196	804
21	350380	7675	17104	333276	47	194	746
22	351320	7722	17298	334022	47	195	645
23	352160	7769	17493	334667	72	193	857
24	353210	7841	17686	335524	136	174	756
25	354140	7977	17860	336280	78	186	794
26	355120	8055	18046	337074	76	152	738
27	356010	8131	18198	337812	73	178	752
28	356940	8204	18376	338564	50	193	737
29	357870	8254	18569	339301	47	195	745
30	358810	8301	18764	340046	73	177	713
31	359700	8374	18941	340759	-	-	-
Total Average of water consumption					**62.65**	**184.81**	**755.58**

Table F.3 Water Consumption in April 1997

	Watermeter Record				Water Consumption		
Date	X	Z	Y	(X-Y)	z	y	(x-y)
1	360660	8452	19127	341533	92	187	773
2	361620	8544	19314	342306	83	194	786
3	362600	8627	19508	342592	79	187	793
4	363500	8706	19695	343465	44	179	691
5	364450	8750	19874	344576	70	191	729
6	365370	8820	20065	345305	48	187	703
7	366260	8868	20252	346008	75	178	762
8	367200	8943	20430	346770	91	175	765
9	368140	9034	20605	347535	162	369	1571
11	370080	9196	20974	349106	65	62	888
12	371030	9261	21036	349994	68	144	776
13	371950	9329	21180	350770	27	258	632
14	372840	9356	21438	351402	28	258	622
15	373720	9384	21696	352024	48	180	770
16	374670	9432	21876	352794	74	162	748
17	375580	9506	22038	353542	72	184	856
18	376620	9578	22222	354398	93	363	1597
20	378580	9671	22585	355995	80	170	800
21	379550	9751	22755	356795	96	170	800
22	380520	9847	22925	357595	79	168	832
23	381520	9926	23093	358427	88	179	831
24	382530	10014	23272	359258	83	170	830
25	383530	10097	23442	360088	74	195	875
26	384600	10171	23637	360963	44	165	755
27	385520	10215	23802	361718	77	164	786
28	386470	10292	23966	362504	78	177	833
29	387480	10370	24143	363337	86	173	817
30	388470	10456	24316	364154	-	-	-
Total Average of water consumption					**69.10**	**178.93**	**780.03**

Table F.4 Water Consumption in May 1997

	Watermeter Record				Water Consumption		
Date	X	Z	Y	(X-Y)	z	y	(x-y)
1	389540	10549	24500	365040	76	164	766
2	390470	10625	24664	365806	74	173	807
3	391450	10699	24837	366613	78	171	789
4	392410	10777	25008	367402	48	166	784
5	393360	10825	25174	368186	88	173	837
6	394370	10913	25347	369023	93	166	814
7	395350	11006	25513	369837	100	122	858
8	396330	11106	25635	371135	53	211	769
9	397310	11159	25846	371464	67	172	798
10	398280	11226	26018	372262	45	173	777
11	399230	11271	26191	373039	77	170	820
12	400220	11348	26361	373859	107	169	841
13	401230	11455	26530	374700	96	163	797
14	402190	11551	26693	375497	108	181	879
15	403250	11659	26874	376376	97	158	822
16	404230	11756	27032	377198	53	179	771
17	405180	11809	27211	377969	48	156	734
18	406070	11857	27367	378703	100	178	852
19	407100	11957	27545	379555	74	184	826
20	408110	12031	27729	380381	92	187	843
21	409140	12123	27916	381224	85	189	961
22	410016	12208	28105	381911	148	383	1771
24	412170	12356	28488	383682	56	199	781
25	413150	12412	28687	384463	96	187	803
26	414140	12508	28874	385266	92	184	816
27	415140	12600	29058	386082	82	183	947
28	416270	12682	29241	387029	99	175	875
29	417320	12781	29416	387904	-	-	-
Total average of water consumption					**79.71**	**175.57**	**816.57**



Note :
I : inpatient
A : outpatient
O : attendant
S : staff
Q_{out} and Q_{in} ratio = 635.8/1013.5 = 63 %

Figure G.1 Water and Wastewater Analysis

APPENDIX H

Table H.1 Number of Patient and OBR during 1 week observation

Date	Day	Bed Occupancy (inpatient)	OBR (%)	No. of outpatient
20 - 3 - 97	Thursday	434	80.7	846
22 - 3 - 97	Saturday	308	57.3	238
25 - 3 - 97	Tuesday	328	61.0	1273
28 - 3 - 97	Friday	310	57.6	698
30 - 3 - 97	Sunday	317	58.9	175
31 - 3 - 97	Monday	313	58.2	986
2 - 4 - 97	Wednesday	307	57.1	1119
Average		331		762
Average without weekend				984

Table H.2 Number of Staff

Staff	**Number**
I. Officer :	**608**
- Doctor	62
- Dentist	9
- Pharmacist	12
- Nurse	378
- Other technician	147
II. Employees :	**647**
- Permanent	279
- Temporary	368
Total	**1255**

Table H.3 Green Team Organization

Position	Section
Chairman	Deputy Director in Medical
member	Deputy Director in Nursing
member	Administration
member	Nursing
member	Finance and Accounting
member	Supplier and Store and Maintenance (Service)
member	Technical Cooperation
member	Consultant

APPENDIX I

Figure I.1 Infectious Waste 'Biohazard' Symbol

Figure I.2 Cytotoxic 'Telophase' Symbol

Source:
1. Victoria-EPA, 1993
2. US-EPA, 1990

APPENDIX J

Sample of Course Subjects
(Source: Thornton, 1992 and Anakamanee, 1992)

I. Training of staff on:

- Role of the hospital in the community, include:
  - function of the hospital and public opinion on hospital
  - the generation of waste affects the community and the environment
  - the social consequences of waste production
- An overview of the hospital's waste management strategy, include:
  - Types of waste
  - Sources of waste
- Handling of, and regulatory requirements of infectious, and chemical waste
  - Storing and transporting containers of biomedical waste
  - Handling in disposal site
- Managing sharps and cytotoxic drugs
  - Discarding sharps
  - Handling cytotoxic drugs
- Risks of biochemical waste
  - Handling and protection of chemical waste
- Emergency response e.g., clean up of split cytotoxic waste, decontaminating split infectious waste
- Waste minimisation, include:
  - Need for and benefits to patients, employees, employeers and the community
  - Explain the direct effect that an employee can have
  - Communicate managements commitment
  - Waste minimisation terminology
  - Overview of environmental regulations and government policy, and rationale behind them

- Examine current and possible operational practices, with an emphasis on developing staff initiative
- Explore suggestions for solutions to identified problems

- Redistilling chemicals

- Operating the incinerator and autoclave

- Personal protective equipment

II. Education Methods:

- Booklets
- Videos
- Pamphlets
- Seminars
- Posters
- Continuing meetings
- Bulletin
- Local Broadcast