CHAPTER 4

METHODOLOGY

The methodology employed in the study is a combination of the following tasks :

4.1 Data Collection

To better understand the background of solid waste in municipality of Khon Kaen, the procedures that involved in data collection are :

1) Literature review on government reports and studies.

2) The background data in the aspects of solid waste generation amount, composition, population, population growth rate, economic indicator such as Gross Provincial Product (GPP).

3) The interview with the relevant government officers had provided information of the data sources, which also guided the personnel observation during the study.

The source of the data are :

- Khon Kaen Municipality Office.
- Office of the National Economic and Social Development Board.
- Department of Town and Country Planning, Ministry of Interior.
- Department of Pollution Control, Ministry of Science Technology and Environment.
- Department of Health, Ministry of Public Health.

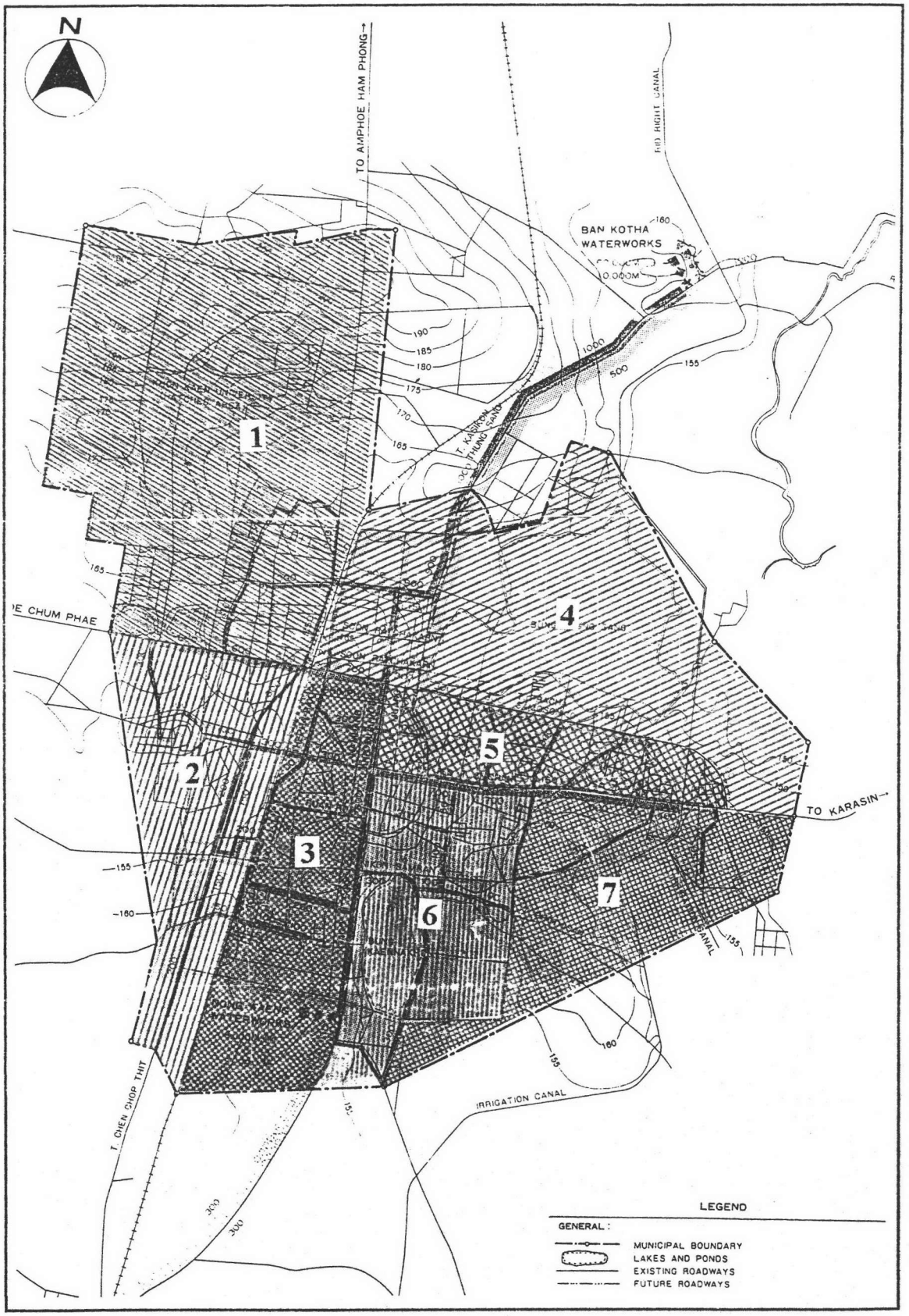


Figure 4.1 Sampling Zones

2) Commercial

The commercial is divided into different categories as follows :

- Store
- Factory
- Office
- Hotel
- Restaurant
- Theater
- Market
- Shopping Complex

3) Institutional is divided into :

- School
- Hospital
- Government Office

4) Municipal Service is divided into :

- Street
- Park

Table 4.1 Variables and Sample Size

Type of Source	No. of Samples	No. of Sampling Days	Sample Selection Criteria (Independent variables)
1. Residential	66	7	population in household, income, population density in the area.
2. Commercial			
2.1 Factory	30	5	no.of employees,area, production rate,capiatal, horse power,work hour.
2.2 Store	30	6	no.of employees,area, visitors per day,work hour.
2.3 Office	15	5	no.of officials,area,visitors per day,work hour.
2.4 Hotel	14	5	no.of rooms, no.of sold rooms,area, no.of employees, electricity consumption, price level, other service.
2.5 Restaurant	14	7	no. of seats, area, no.of employees,visitors per day, work hour.
2.6 Theater	6	7	no. of seats, area, no. of employees, no. of shows.
2.7 Market	4	7	no. of shops, area, density, work hour.
2.8 Large Store	3	3	no. of shops, no. of employees, area,visitors per day .
3. Institutional			
3.1 School	25	5	no. of students, no. of officials, area, building area, work hour.
3.2 Hospital	5	5	area, no. of beds, no. of officials, no. of outpatients per day, no. of operations per day, no. of life births per day.
3.3 Government Office	25	5	no. of officials, area, visitors per day, work hour.
4. Municipal Service			
4.1 Street	7 (2 km)	7	area, no. of lanes , no. of vehicles per day .
4.2 Park	2	3	area,visitors per day .

4.3 Equipment

1) Weigh scale

2) Solid waste container

- plastic bag (size 0.6 m x 0.9 m)
- small bucket (volume 10-15 liter)
- big bucket (volume 50-100 liter)

3) measuring tape

4) plastic sheet (size 3 m. x 5 m.)

5) mixing equipment such as shovel, take, etc.

6) aluminum tray

7) pincers

8) rubber gloves

9) mask

10) hot air oven

4.4 Solid Waste Generation Rate

The total municipal solid waste generated is determined by the following equations (Suthin Yoosuk) :

$$W_i = m_i \times p_i \qquad \text{...(4.2)}$$

$$W = \sum_{i=1}^{n} W_i \qquad \text{...(4.3)}$$

$$Q = \frac{W}{\text{Total population}} \qquad ...(4.4)$$

where W = Total quantity of wastes generated, (weight/time)

W_i = Quantity of wastes generated at each source, (weight/time)

m_i = Waste generation rate at each source, (weight/time)

p_i = Amount of generation sources, (source)

Q = Total municipal solid waste generation rate, (weight/capita/time)

4.5 Composition Analysis

The samples in each source are mixed thoroughly and applied conning and quartering techniques as show in Fig.4.2. The large objects are removed from the samples. Final sample size of about 50 liter is sorted into eleven components making up three broad categories of combustible, non-combustibles and miscellanecus as follows :

a) Combustibles

i) Garbage - including all wastes from selling, preparation, cooking and serving food.

ii) Paper - all kind of waste paper, newspaper and cardboard

iii) Plastic - all kind of plastic materials

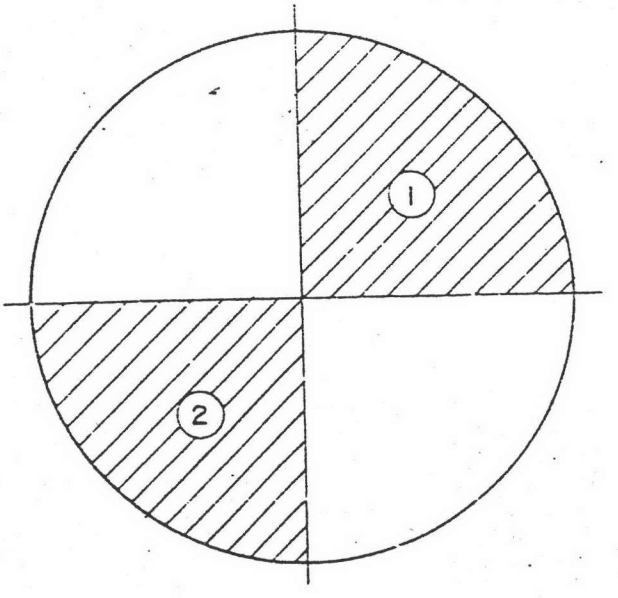
iv) Rubber - all kind of rubber materials

v) Leather - all kind of leather materials

vi) Wood - all kind of wood materials, branches, and leaves

vii) Textiles - cloth, fibers and thread

a) Conning



b) Quartering and Selecting Opposite Parts

Figure 4.2 Conning and Quartering Technique

b) Non - Combustible

i) Glass - all kind of glass materials, bottle and broken glass.

ii) Metal - ferrous and non - ferrous metal

iii) Stone, Ceramic - including brick, concrete, gypsum, sand, etc.

c) Miscellaneous - all materials are not obviously sorted into above categories such as dirt, ashes, synthetic, etc.

Calculation :

$$C = \frac{W_1 \times 100}{W} \qquad ...(4.5)$$

Where

C = Percentage of each component, (%)
W_1 = Weight of each component, (Weight)
W = Total Weight, (Weight)

4.6 Bulk Density Determination

1) The solid waste was put into an empty bucket of 50-100 l.

2) Lift the box 30 cm from the ground and drop it squarely. Repeat for three to four times.

3) Add more waste into the bucket till it was completely full. Then weigh the full bucket

Calculation :

$$D = \frac{W_1 - W_2}{V} \qquad ...(4.6)$$

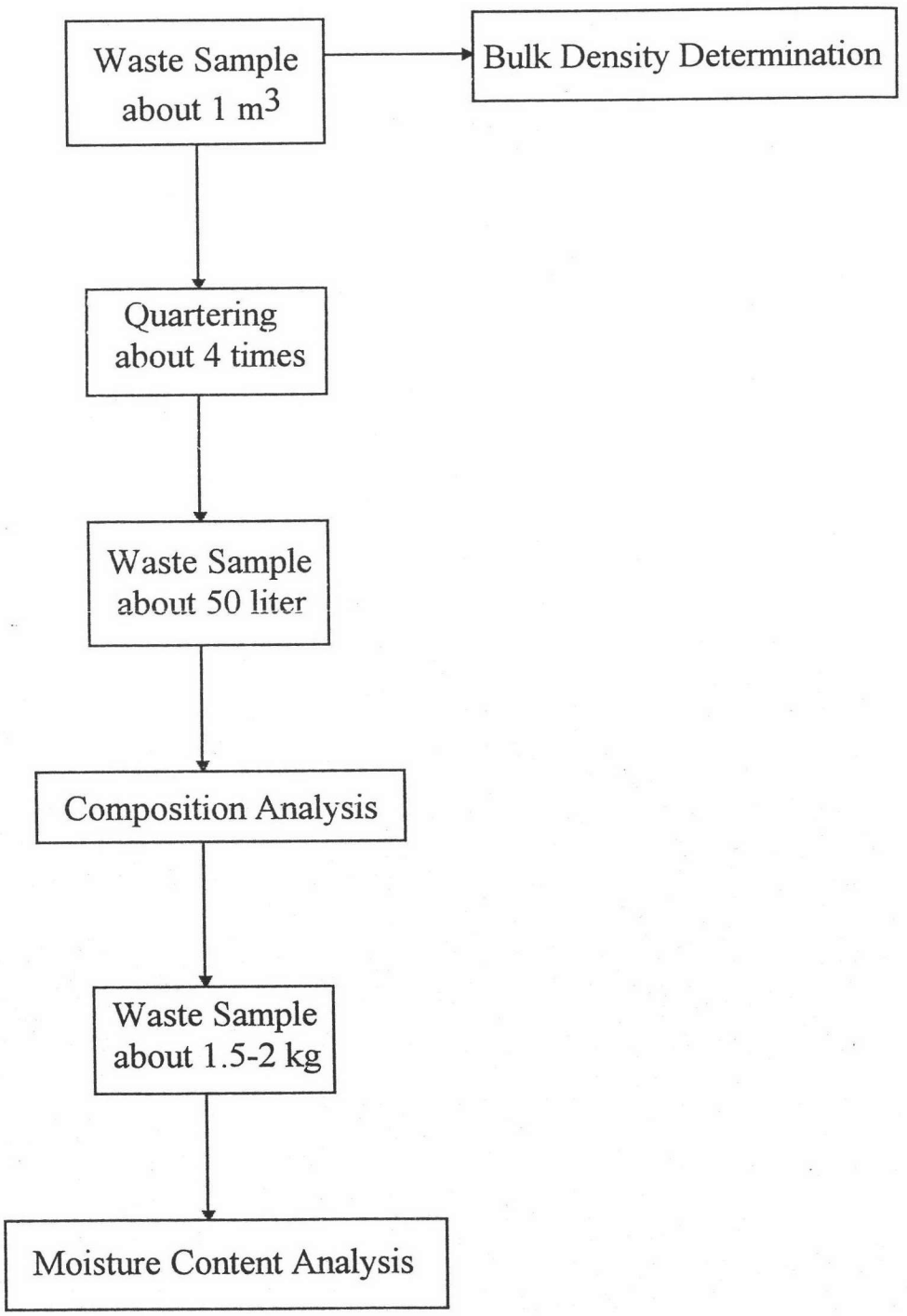


Figure. 4-3 Diagram of Physical Composition Analysis

Where

D = Bulk density
W_1 = Weight of waste and bucket, (kg)
W_2 = Weight of empty bucket, (kg)
V = Volume of bucket, (m^3)

4.7 Moisture Content Analysis

1) Place 1.5 kg to 2 kg of the waste sample on a weighed aluminum tray and record the weight of the sample

2) Put the sample into a hot air oven at 105°C for 72 hours.

3) Reweigh the dry sample

Calculation :

$$MC = \frac{(W_1 - W_2) \times 100}{W_1} \qquad ...(4.7)$$

MC= Moisture content, (%)
W_1 = Weight of waste before drying in oven, (kg)
W_2 = Weight of dry waste, (kg)

4.8 Data Analysis

The relationship for determining the generation rate from each source of solid waste generation is derived by statistical analysis using the multiple linear regression analysis of the following form:

$$y = a + bx_1 + cx_2 + \ldots\ldots + nx_n \qquad ...(4.8)$$

Where

y = the dependent variable
(solid waste generation, kg/day or l/day)

$x_1, x_2, ..x_n$ = the independent variables (influenced parameters as shown in table 4.1)

a,b,c,...n = constants.

In oder to develop the models, this study uses the following criteriafor deciding if the fit is good or not :

- Multiple correlation coefficient (R).
- Multiple coefficient of determination (R^2). If the values of both R and R^2 approach the ideal value of 1 is indicates a good fit of the model.
- t - statistic for independent variables and F-test for overall significance.
- Standard error of estimate (S) : the lower this value, the better the fit of model.

For the statistical analysis in this study using statistical package for social science (SPSS) software package .