CHAPTER 5

RESULTS AND DISCUSSION

5.1 Estimation of generation rate

5.1.1 Residential

The survey of residential solid waste was conducted to obtain solid waste generation rate, income lavel, number of people in the house and population density in area. The data of each sample house were shown on Table D.1 in App. D. The variables input in the equation are defined below:

Dependent variable :

$Y_{r.}$ = Solid waste generation rate, kg/house/day

Independent variable :

X_{r1} = Number of people in the house

X_{r2} = Income level

Where X_{r2} = 1 if income less than 10,000 bahts/month

X_{r2} = 2 if income between 10,000 to 25,000 bahts/month

X_{r2} = 3 if income more than 25,000 bahts/month

X_{r3} = Population density in the area was classified into three level follow as :

X_{r3} = 1 if the house was in low density area

X_{r3} = 2 if the house was in medium density area

X_{r3} = 3 if the house was in high density and commercial area

Before proceeding with any analysis of data, it was considered appropriate to check if the independent variables were really independent and if any multicolinearity existed amongst the variables. A simple linear regression analysis was utilized to find the regression coefficient, R^2, between the independent variables. A summary of these correlation factors is presented in Table 5.1. Review of the regression coefficients in Table 5.1 indicates that the R^2 values are small, indicating poor multicolinearity amongst the independent variables. If the regression

coefficient, R^2 , is 0.7 between two independent variables, it is still statistically acceptable to consider them as independent variables. (S. Makridakis, S.C. Wheelwright and V.E.McGee,1983 quoted in Alikhan, M.Z. and Burney, F.A.,1989)

Table 5.1 Regression Correlation Coefficient between Variables of Residential, R^2

Independent variables	Y	Xr1	Xr2	Xr3
Y	1.0000 (N= 65)	.0669 (N= 65)	.0466 (N= 65)	.0065 (N= 65)
Xr1	.0669 (N= 65)	1.0000 (N= 65)	.0015 (N= 65)	.0231 (N= 65)
Xr2	.0466 (N= 65)	.0015 (N= 65)	1.0000 (N= 65)	.0174 (N= 65)
Xr3	.0065 (N= 65)	.0231 (N= 65)	.0174 (N= 65)	1.0000 (N= 65)

Note: N= number of cases
" . " is printed if a coefficient cannot be computed

The equation obtained is in the following form :

$$Y_r = 0.115X_{r1} + 0.242X_{r2} + 0.503 \qquad ...(5.1)$$

$$R = 0.343\,,\ R^2 = 0.118\,,\ S = 0.827$$

significant(α): sig $t_{Xr2} = 0.029, t_{Xr2} = 0.063$, sig $F = 0.020$

Obviously solid waste generation rate is affected significantly by number of people in the house and income level.

Table 5.2 to 5.4 show that the actual values from survey and the estimated values of the equation are quite close. From the survey the average of kilogram per capita per day(kg/capita/day) of high, medium and low income are 0.38, 0.32, 0.32 respectively, give that the average of kg/capita/day for over all samples is 0.34.

Table 5.2 Low Income Residential Solid Waste Generation Rate Actual Values and Predicted Values

No.	No.of People	Actual		Predict	
		kg/house/day	kg/capita/day	kg/house/day	kg/capita/day
1	2	0.9	0.45	1.0	0.50
2	11	0.7	0.06	2.0	0.18
3	5	0.9	0.18	1.3	0.26
4	13	1.2	0.09	2.2	0.17
5	5	2.9	0.58	1.3	0.26
6	5	2.1	0.42	1.3	0.26
7	4	1.1	0.28	1.2	0.30
8	2	1.2	0.60	1.0	0.50
9	4	2.2	0.55	1.2	0.30
10	5	1.2	0.24	1.3	0.26
11	4	1.3	0.33	1.2	0.30
12	6	0.9	0.15	1.4	0.23
13	4	1.3	0.33	1.2	0.30
14	3	1.3	0.43	1.0	0.33
15	4	1.6	0.40	1.2	0.30
16	5	0.8	0.16	1.3	0.26
17	4	0.5	0.13	1.2	0.30
18	8	0.7	0.09	1.7	0.21
19	5	0.5	0.10	1.3	0.26
20	4	2.3	0.58	1.2	0.30
21	5	2.6	0.52	1.3	0.26
Max.	13	3	1	2	1
Min.	2.0	0.5	0.1	1.0	0.2
Avg.	5.1	1.3	0.32	1.3	0.29
Std.	2.6	0.7	0.2	0.3	0.1

Table 5.3 Medium Income Residential Solid Waste Generation Rate Actual Values and Predicted Values

No.	No.of People	Actual		Predict	
		kg/house/day	kg/capita/day	kg/house/day	kg/capita/day
1	4	1.5	0.38	1.4	0.35
2	6	3.5	0.58	1.7	0.28
3	6	1.7	0.28	1.7	0.28
4	6	2.8	0.47	1.7	0.28
5	3	1.0	0.33	1.3	0.43
6	4	1.0	0.25	1.4	0.35
7	7	0.7	0.10	1.8	0.26
8	4	0.8	0.20	1.4	0.35
9	5	1.0	0.20	1.6	0.32
10	3	0.8	0.27	1.3	0.43
11	5	1.3	0.26	1.6	0.32
12	4	1.3	0.33	1.4	0.35
13	7	2.7	0.39	1.8	0.26
14	5	2.3	0.46	1.5	0.30
15	4	1.4	0.35	1.4	0.35
16	4	1.0	0.25	1.4	0.35
17	5	0.8	0.16	1.6	0.32
18	3	0.6	0.20	1.3	0.43
19	7	3.7	0.53	1.8	0.26
20	1	0.3	0.30	1.1	1.10
21	3	0.8	0.27	1.3	0.43
22	3	1.9	0.63	1.3	0.43
23	7	1.7	0.24	1.8	0.26
Max.	7	4	1	2	1
Min.	1.0	0.3	0.1	1.1	0.3
Avg.	4.6	1.5	0.32	1.5	0.37
Std.	1.6	0.9	0.1	0.2	0.2

Table 5.4 High Income Residential Solid Waste Generation Rate Actual Values and Predicted Values

No.	No.of People	Actual		Predict	
		kg/house/day	kg/capita/day	kg/house/day	kg/capita/day
1	4	2.6	0.65	1.7	0.43
2	10	3.0	0.30	2.4	0.24
3	3	0.9	0.30	1.6	0.53
4	6	1.2	0.20	1.9	0.32
5	7	2.3	0.33	2.0	0.29
6	5	1.4	0.28	1.8	0.36
7	4	1.3	0.33	1.7	0.43
8	4	1.1	0.28	1.7	0.43
9	5	2.8	0.56	1.8	0.36
10	5	2.8	0.56	1.8	0.36
11	3	1.6	0.53	1.6	0.53
12	6	3.9	0.65	1.9	0.32
13	4	0.5	0.13	1.7	0.43
14	5	1.0	0.20	1.8	0.36
15	5	1.4	0.28	1.8	0.36
16	7	2.2	0.31	2.0	0.29
17	3	1.0	0.33	1.6	0.53
18	3	2.9	0.97	1.6	0.53
19	3	0.5	0.17	1.6	0.53
20	6	2.2	0.37	1.9	0.32
21	6	1.3	0.22	1.9	0.32
Max	10	4	1	2	1
Min	3.0	0.5	0.1	1.6	0.2
Average	5.0	1.8	0.4	1.8	0.4
Std.	1.7	0.9	0.2	0.2	0.1

5.1.2 Commercial

5.1.2.1 Factory

Five factory groups as characterized by Thailand Standard Industrial Classification (TSIC) Codes were taken into this study. Such as food operations, wood operations, transportation equipment operations, machinery operations and textile operations. The obtained data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, value for solid waste generation unit were obtained as shown in Table 5.5. (see all Table E.2 to Table E.6 in App.E)

Table 5.5 Factory Solid Waste Generation Rate

No.	Factory	No. of factories	Average kg/employee/day
1	Food processing	6	2.55
2	Textile & Apparel products	6	0.81
3	Wood products	6	6.85
4	Transportation equipment (Garage)	6	1.76
5	Machinery	5	1.93

5.1.2.2 Store

The variables input in the equation are defined as below :

Dependent variable :

Y_s = Solid waste generation rate , kg/store/day

Independent variable :

X_{s1} = Area , m^2

X_{s2} = Number of employees, employee

X_{s3} = Number of visitors per day, visitor

X_{s4} = Work hour per day, hour

Table 5.6 Regression Correlation Coefficient between Variables of Store, R^2

Independent variables	Y	X_{s1}	X_{s2}	X_{s3}	X_{s4}
Y	1.0000 (N= 30)	.0451 (N= 30)	.1098 (N= 30)	.0010 (N= 30)	.0156 (N= 30)
X_{s1}	.0451 (N= 30)	1.0000 (N= 30)	.0154 (N= 30)	.3079 (N= 30)	.0025 (N= 30)
X_{s2}	.1098 (N= 30)	.0154 (N= 30)	1.0000 (N= 30)	.0016 (N= 30)	.0450 (N= 30)
X_{s3}	.0010 (N= 30)	.3079 (N= 30)	.0016 (N= 30)	1.0000 (N= 30)	.0386 (N= 30)
X_{s4}	.0156 (N= 30)	.0025 (N= 30)	.0450 (N= 30)	.0386 (N= 30)	1.0000 (N= 30)

Note: N= number of cases

" . " is printed if a coefficient cannot be computed

Table 5.6 indicates that poor relationships existed amongst the independent variables.

The following equation are obtained :

$$Y_{s1} = 4.057x10^{-3} X_{s1} + 0.464 \quad ...(5.2)$$

$R = 0.212$, $R^2 = 0.045$, $S = 0.508$,
significant(α): sig $t_{Xs1} = 0.260$, sig $F = 0.260$

$$Y_{s2} = 0.077X_{s2} + 0.361 \quad ...(5.3)$$

$R = 0.331$, $R^2 = 0.110$, $S = 0.491$,
significant(α): sig $t_{Xs2} = 0.074$, sig $F = 0.074$

Table 5.7 Store Solid Waste Generation Rate Actual Values and Predicted Values

NO.	kg/store/day			Error	
	Actual	Predict			
		(1)	(2)	(1)	(2)
1	0.3	0.7	0.5	-0.5	-0.2
2	0.3	0.6	1.0	-0.3	-0.7
3	0.5	0.6	0.7	-0.1	-0.2
4	0.8	0.7	0.8	0.2	0.0
5	0.5	0.7	0.7	-0.2	-0.2
6	0.4	0.9	0.7	-0.5	-0.3
7	2.5	0.7	1.1	1.8	1.4
8	0.5	0.6	0.8	-0.1	-0.3
9	0.6	0.7	0.5	-0.1	0.1
10	0.9	0.7	0.7	0.3	0.2
11	1.1	0.7	0.6	0.4	0.5
12	0.6	0.7	0.5	-0.1	0.1
13	0.4	0.8	0.6	-0.4	-0.2
14	0.4	0.6	0.6	-0.2	-0.2
15	0.4	0.6	0.6	-0.2	-0.2
16	0.3	0.6	0.5	-0.3	-0.2
17	0.5	0.6	0.5	-0.2	-0.1
18	0.3	0.6	0.7	-0.3	-0.4
19	0.9	0.8	0.7	0.1	0.2
20	0.5	0.6	0.7	-0.2	-0.2
21	1.9	0.9	0.7	1.1	1.2
22	0.7	0.8	0.8	-0.1	-0.1
23	0.5	0.7	1.1	-0.2	-0.6
24	0.4	0.7	0.7	-0.3	-0.3
25	1.7	0.6	0.6	1.1	1.1
26	0.4	0.7	0.7	-0.3	-0.3
27	0.9	0.7	0.9	0.2	0.0
28	0.7	1.5	0.7	-0.8	0.0
29	0.7	0.7	0.5	0.0	0.2
30	0.3	0.6	0.6	-0.3	-0.3
Max.	2.5	1.5	1.1	1.8	1.4
Min.	0.3	0.6	0.5	-0.8	-0.7
Avg.	0.7	0.7	0.7	0.0	0.0
Std.	0.52	0.17	0.17	0.52	0.49

Note: (1):for Equation(5.2), (2):for Equation(5.3)

Equation(5.2),(5.3)andTable 5.7 indicate that the equation(5.3) is more fit than equation(5.2) but the area(X_{s1}) in equation(5.2) is recommended as the important variable in the first or rough estimation of store solid waste generation or in case of the employee(X_{s2}) data can not be obtained.

The average of store solid waste generation rate from the survey in the unit of affecting factor is 0.013 kg/m^2/day and 0.18 kg/employee/day (see also Table E.7 in App.E).

5.1.2.3 Private Office

The variables input in the equation are defined as below :

Dependent variable :

Y_p = Solid waste generation rate , kg/day

Independent variable :

X_{p1} = Area , m^2

X_{p2} = Number of workers, person

X_{p3} = Number of visitors per day, person

X_{p4} = Work hour per week, hour

Table 5.8 Regression Correlation Coefficient between Variables of Private Office, R^2

Independent variables	Y	X_{p1}	X_{p2}	X_{p3}	X_{p4}
Y	1.0000 (N= 15)	.4880 (N= 15)	.7611 (N= 15)	.0859 (N= 15)	.0031 (N= 15)
X_{p1}	.4880 (N= 15)	1.0000 (N= 15)	.4836 (N= 15)	.0890 (N= 15)	.0032 (N= 15)
X_{p2}	.7611 (N= 15)	.4836 (N= 15)	1.0000 (N= 15)	.1771 (N= 15)	.0228 (N= 15)
X_{p3}	.0859 (N= 15)	.0890 (N= 15)	.1771 (N= 15)	1.0000 (N= 15)	.0043 (N= 15)
X_{p4}	.0031 (N= 15)	.0032 (N= 15)	.0228 (N= 15)	.0043 (N= 15)	1.0000 (N= 15)

Note: N= number of cases

" . " is printed if a coefficient cannot be computed

Table 5.8 indicates that poor relationships existed amongst the independent variables.

The following equation are obtained :

$$Y_{p1} = 5.746x10^{-3} X_{p1} + 1.406 \quad ...(5.4)$$

$R = 0.699$, $R^2 = 0.488$, $S = 2.184$,
significant(α): sig $t_{Xp1} = 0.004$, sig $F = 0.004$

$$Y_{p2} = 0.166X_{p2} - 0.032 \quad ...(5.5)$$

$R = 0.872$, $R^2 = 0.761$, $S = 1.492$,
significant(α): sig $t_{Xp2} = 0.000$, sig $F = 0.000$

Table 5.9 Private Office Solid Waste Generation Rate Actual Values and Predicted Values

NO.	kg/store/day			Error	
	Actual	Predict			
		(1)	(2)	(1)	(2)
1	7.8	4.6	5.8	3.2	2.0
2	5.0	4.0	2.6	1.0	2.4
3	0.5	1.7	0.8	-1.2	-0.3
4	4.4	1.6	2.3	2.8	2.1
5	5.4	8.6	5.3	-3.3	0.1
6	5.0	3.5	5.8	1.5	-0.8
7	1.8	3.5	3.6	-1.6	-1.8
8	2.2	3.0	3.3	-0.8	-1.1
9	10.8	7.4	9.9	3.5	0.9
10	0.4	1.9	0.6	-1.5	-0.3
11	2.6	4.9	2.8	-2.3	-0.2
12	3.2	2.5	5.9	0.7	-2.7
13	4.1	3.1	3.5	1.0	0.6
14	0.6	2.2	1.5	-1.7	-0.9
15	0.7	2.1	1.0	-1.5	-0.3
Max.	10.8	8.6	9.9	3.5	2.4
Min.	0.4	1.6	0.6	-3.3	-2.7
Avg.	3.6	3.6	3.6	0.0	0.0
Std.	2.95	2.05	2.53	2.11	1.43

Note: (1):for Equation(5.4), (2):for Equation(5.5)

Equation(5.4),(5.5)andTable 5.9 indicate that the equation(5.5) is more fit than equation(5.4) but the area(X_{p1}) in equation(5.4) is recommended as the important variable in the first or rough estimation of store solid waste generation or in case of the workers(X_{p2}) data can not be obtained.

The average of office solid waste generation rate from the survey in the unit of affecting factor is 0.017kg/m^2/day and 0.16 kg/worker/day (see also Table E.8 in App.E).

5.1.2.4 Hotel

The variables input in the equation are defined as below :

Dependent variable :

Y_h = Solid waste generation rate , kg/hotel/day

Independent variable :

X_{h1} = Number of room

X_{h2} = Number of sold room per day, room

X_{h3} = Building area , m^2

X_{h4} = Number of employees, person

X_{h5} = Number of consumption electricity units per month, unit

X_{h6} = Price level

where X_{h6} = 3 if room price per day more than 1,000 bahts (1st class)

X_{h6} = 2 if room price per day between 500 to 1,000 bahts (medium class)

X_{h6} = 1 if room price per day less than 500 bahts (motels)

X_{h7} = Other services such as seminar, banquet,cafe,entertainment,...,etc.

where X_{h7} = 1 if having other services.

X_{h7} = 0 if not having other services.

Table 5.10 Regression Correlation Coefficient between Variables of Hotel, R^2

Independent variables	Y	X_{h1}	X_{h2}	X_{h3}	X_{h4}	X_{h5}	X_{h6}	X_{h7}
Y	1.0000 (N= 14)	.7050 (N= 14)	.6981 (N= 14)	.5846 (N= 14)	.9365 (N= 14)	.9736 (N= 14)	.5007 (N= 14)	.2114 (N= 14)
X_{h1}	.7050 (N= 14)	1.0000 (N= 14)	.9118 (N= 14)	.6266 (N= 14)	.6790 (N= 14)	.7600 (N= 14)	.2778 (N= 14)	.2179 (N= 14)
X_{h2}	.6891 (N= 14)	.9118 (N= 14)	1.0000 (N= 14)	.5275 (N= 14)	.6592 (N= 14)	.7651 (N= 14)	.3863 (N= 14)	.3435 (N= 14)
X_{h3}	.5846 (N= 14)	.6266 (N= 14)	.5275 (N= 14)	1.0000 (N= 14)	.7448 (N= 14)	.6613 (N= 14)	.1738 (N= 14)	.1172 (N= 14)
X_{h4}	.9365 (N= 14)	.6790 (N= 14)	.6592 (N= 14)	.7448 (N= 14)	1.0000 (N= 14)	.9428 (N= 14)	.4958 (N= 14)	.2087 (N= 14)
X_{h5}	.9736 (N= 14)	.7600 (N= 14)	.7651 (N= 14)	.6613 (N= 14)	.9428 (N= 14)	1.0000 (N= 14)	.5010 (N= 14)	.2539 (N= 14)
X_{h6}	.5007 (N= 14)	.2778 (N= 14)	.3863 (N= 14)	.1738 (N= 14)	.4958 (N= 14)	.5010 (N= 14)	1.0000 (N= 14)	.2700 (N= 14)
X_{h7}	.2114 (N= 14)	.2179 (N= 14)	.3435 (N= 14)	.1172 (N= 14)	.2087 (N= 14)	.2539 (N= 14)	.2700 (N= 14)	1.0000 (N= 14)

Note: N= number of cases
" . " is printed if a coefficient cannot be computed

Table 5.10 indicates that amongst independent variables, strong relationships existed amongst the number of rooms(X_{h1}),number of sold rooms and electricity consumption(X_{h5}), a strong relationship existed between building area(X_{h3}) and number of employees (X_{h4}) and existed between number of employees (X_{h4}) and electricity consumption(X_{h5}).

From multiple linear regression analysis (see App.G), solid waste generation is affected significantly by number of rooms and price level , number of sold rooms, number of employees or electricity consumption.

The best equation are obtained :

$$Y_{h1} = 1.866X_{h1} + 94.871X_{h6} - 242.679 \qquad ...(5.6)$$

$R = 0.896,\ R^2 = 0.802,\ S = 104.942$

significant(α): sig $t_{Xh1} = 0.001$, sig $t_{Xh6} = 0.032$, sig $F = 0.000$

$$Y_{h2} = 4.777X_{h2} - 167.345 \quad ...(5.7)$$

$R = 0.836$, $R^2 = 0.698$, $S = 124.578$

significant(α): sig $t_{Xh2} = 0.000$, sig $F = 0.000$

$$Y_{h3} = 1.557X_{h4} \quad ...(5.8)$$

$R = 0.968$, $R^2 = 0.936$, $S = 57.154$,

significant(α): sig $t_{Xh4} = 0.000$, sig $F = 0.000$

$$Y_{h4} = 1.864x10^{-3} X_{h5} \quad ...(5.9)$$

$R = 0.987$, $R^2 = 0.974$, $S = 36.854$,

significant(α): sig $t_{Xh5} = 0.000$, sig $F = 0.000$

Table 5.11 Hotel Solid Waste Generation Rate Actual Values and Predicted Values

No.	kg/store/day					Error			
	Actual	Predict							
		(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
1	653.2	639.05	620.9	638.4	724.43	14.1	32.3	14.8	-71.2
2	531.2	340.49	305.6	393.9	478.14	190.7	225.6	137.3	53.1
3	84.8	178.15	109.7	127.7	133.85	-93.4	-24.9	-42.9	-49.1
4	543.4	415.13	334.2	622.8	512.08	128.3	209.2	-79.4	31.3
5	210.5	291.98	291.2	116.8	196.91	-81.5	-80.7	93.7	13.6
6	172.3	309.07	310.4	161.9	161.1	-136.8	-138.1	10.4	11.2
7	42.4	16.105	-17.1	85.6	56.065	26.3	59.5	-43.2	-13.7
8	40.8	128.07	180.2	74.7	82.258	-87.3	-139.4	-33.9	-41.5
9	48.6	81.415	118.1	93.4	76.536	-32.8	-69.5	-44.8	-27.9
10	28.2	115	-24.0	20.2	34.063	-86.8	52.2	8.0	-5.9
11	71.4	-15.322	52.4	48.3	104.15	86.7	19.0	23.1	-32.7
12	20.6	-17.188	40.0	24.9	15.356	37.8	-19.4	-4.3	5.2
13	35.8	132.09	243.5	38.9	89.949	-96.3	-207.7	-3.1	-54.1
14	50.8	12.668	37.6	18.7	25.831	38.1	13.2	32.1	25.0
15	15.2	-76.9	-52.7	7.8	4.4475	92.1	67.9	7.4	10.8
Max.	653.2	639.1	620.9	638.4	724.4	190.7	225.6	137.3	53.1
Min.	15.2	-76.9	-52.7	7.8	4.4	-136.8	-207.7	-79.4	-71.2
Avg.	169.9	170.0	170.0	164.9	179.7	0.0	0.0	5.0	-9.7
Std.	218.49	195.72	182.32	211.39	215.61	97.16	119.85	55.08	35.51

Note: (1):for equation(5.6),(2):for equation(5.7),(3):for equation(5.8),(4):for equation(5.9)

Equation(5.6) to (5.9) and Table 5.11 indicate that the fit models are equation(5.8) and (5.9). Equation (5.6) and (5.7) gives some negative values for the medium and motel class. It may be mentioned that the data points were too small. For these constrains, equation (5.6) can be used to estimate solid waste generation for first class hotels and equation (5.7) is not suitable for the application.

The average of hotel solid waste generation rate from the survey in the different units are shown as the followings(see also Table E.9 in App.E) :

Price level	Generation Unit
3 (1st class)	2.16kg/room/day,3.63kg/sold room/day, 1.78kg/employee/day, 0.04kg/unit(electricity)/day
2 (medium class)	0.68kg/room/day,1.08kg/sold room/day, 1.25kg/employee/day, 0.04kg/unit(electricity)/day
1 (motels)	0.50kg/room/day,0.85kg/sold room/day, 2.46kg/employee/day, 0.0904kg/unit(electricity)/day
Over all samples	1.1kg/room/day,1.85 kg/sold room/day, 1.83kg/employee/day and 0.06 kg/unit (electricity)/day

5.1.2.5 Restaurant

The variables input in the equation are defined as below :

Dependent variable :

Y_u = Solid waste generation rate , kg/restaurant/day

Independent variable :

X_{u1} = Dining area , m^2

X_{u2} = Number of seats, seat

X_{u3} = Number of employees, person

X_{u4} = Number of clients, person

X_{u5} = Work hour per day, hour

Table 5.12 Regression Correlation Coefficient betweenVariables of Restaurant, R^2

Independent variables	Y	X_{u1}	X_{u2}	X_{u3}	X_{u4}	X_{u5}
Y	1.0000 (N= 14)	.9312 (N= 14)	.5044 (N= 14)	.9685 (N= 14)	.5448 (N= 14)	.1943 (N= 14)
X_{u1}	.9312 (N= 14)	1.0000 (N= 14)	.3283 (N= 14)	.9461 (N= 14)	.3992 (N= 14)	.2707 (N= 14)
X_{u2}	.5044 (N= 14)	.3283 (N= 14)	1.0000 (N= 14)	.4989 (N= 14)	.6663 (N= 14)	.0275 (N= 14)
X_{u3}	.9685 (N= 14)	.9461 (N= 14)	.4989 (N= 14)	1.0000 (N= 14)	.4523 (N= 14)	.2289 (N= 14)
X_{u4}	.5448 (N= 14)	.3992 (N= 14)	.6663 (N= 14)	.4523 (N= 14)	1.0000 (N= 14)	.0013 (N= 14)
X_{u5}	.1943 (N= 14)	.2707 (N= 14)	.0275 (N= 14)	.2289 (N= 14)	.0013 (N= 14)	1.0000 (N= 14)

Note: N= number of cases
" . " is printed if a coefficient cannot be computed

Table 5.12 indicates that amongst independent variables, a strong relationship existed between dining area(X_{u1}) and number of employees (X_{u3}).

From multiple linear regression analysis, solid waste generation is affected significantly by dining area and number of seats, number of clients and number of employees (see also in App.G).

The equations are obtained :

$$Y_{u1} = 0.094X_{u1} + 0.140X_{u2} + 2.953 \quad ..(5.10)$$

$R = 0.984$, $R^2 = 0.968$, $S = 14.410$,

significant(α): sig $t_{Xu1} = 0.000$, sig $t_{Xu2} = 0.005$, sig $F = 0.000$

$$Y_{u2} = 1.813X_{u3} + 0.140X_{u4} + 0.285 \quad ..(5.11)$$

$R = 0.990$, $R^2 = 0.979$, $S = 11.631$,

significant(α): sig $t_{Xu3} = 0.000$, sig $t_{Xu4} = 0.037$, sig $F = 0.000$

Table 5.13 indicates that the predicted values versus the actual values are reasonably close.

Table 5.13 Restaurant Solid Waste Generation Rate Actual Values and Predicted Values

NO.	kg/restuarant/day			Error	
	Actual	Predict			
		(1)	(2)	(1)	(2)
1	15.7	15.7	13.4	0.0	2.3
2	18.8	20.7	25.6	-1.9	-6.7
3	4.6	10.8	7.4	-6.3	-2.8
4	11.9	15.7	12.4	-3.8	-0.6
5	17.1	11.0	21.0	6.1	-3.8
6	29.3	55.7	50.6	-26.4	-21.3
7	29.3	14.7	24.1	14.5	5.2
8	14.1	26.9	22.1	-12.8	-7.9
9	17.6	23.6	13.8	-6.0	3.7
10	50.3	39.0	47.9	11.3	2.4
11	153.7	136.0	155.2	17.7	-1.5
12	10.7	19.4	10.6	-8.7	0.1
13	63.6	40.6	34.6	22.9	29.0
14	271.1	277.2	269.6	-6.0	1.6
Max.	271.1	277.2	269.6	22.9	29.0
Min.	4.6	10.8	7.4	-26.4	-21.3
Avg.	50.6	50.5	50.6	0.1	0.0
Std.	74.07	72.80	73.29	13.25	10.69

Note: (1): for equation(5.10),(2): for equation(5.11)

The average of restaurant solid waste generation rate from the survey in the different units of affecting factors are 0.24 kg/sq.m/day, 0.37 kg/seat/day,4.08 kg/employee/day, and 0.36 kg/client/day (see also Table E.10 in App.E).

5.1.2.6 Theater

In the survey period there were 7 theater in the municipality.The data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.14.

Table 5.14 Theater Solid Waste Generation Rate

NO.	Generation Unit		
	kg/theater/day	kg/sq.m/day	kg/seat/day
1	8.2	0.011	0.01
2	3.6	0.008	0.01
3	4.6	0.014	0.03
4	5.9	0.014	0.02
5	6.2	0.015	0.02
6	7.7	0.025	0.03
7	5.0	0.016	0.02
AVERAGE	5.9	0.015	0.02

The average of theater solid waste generation rate from the survey in the difference units are 5.9 kg/theater/day, 0.015 kg/sq.m/day and 0.02 kg/seat/day.

5.1.2.7 Market

The data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.15.

Table 5.15 Market Solid Waste Generations rate

NO.	NAME	Generation Unit		
		kg/market/day	kg/sq.m/day	kg/shop/day
1	THETSABAAL1	2382.9	1.17	10.32
2	THETSABAAL2	3364.3	0.54	12.74
3	THETSABAAL3	3078.6	1.45	16.64
4	BANGLUMPHU	4637.1	0.86	16.16
AVERAGE		3365.7	1.00	13.96

The average of market solid waste generation rate from the survey in the different units are 3365.7 kg/market/day, 1.00 kg/sq.m/day and 13.96 kg/shop/day.

5.1.2.8 Large Store

In the survey period there were four stores that can characterized in large store such as Sentosa, Raja Square, Sore-Setthakitj and Max Sell. The data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.16.

Table 5.16 Large Store Solid Waste Generations rate

NO.	Generation Unit			
	kg/store/day	kg/sq.m./day	kg/client/day	kg/employee/day
1	340.5	0.59	0.51	4.01
2	73.0	0.05	0.08	0.16
3	24.7	0.01	0.03	0.18
4	115.7	0.32	0.11	0.93
AVERAGE	138.5	0.24	0.18	1.32

The average of large store solid waste generation rate from the survey in different units are 138.5 kg/store/day, 0.24 kg/m^2/day, 0.18 kg/client/day and 1.32 kg/employee/day.

5.1.3 **Institutional**

5.1.3.1 School

a.) Kindergarten

The obtained data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.17.

Table 5.17 Kindergarten Solid Waste Generations Rate

No.	Generation Unit			
	kg/school/day	kg/sq.m (building)/day	kg/staff/day	kg/pupil/day
1	44.2	0.02	1.16	0.13
2	14.0	0.01	0.64	0.08
3	5.3	0.02	0.44	0.04
4	25.8	0.01	0.96	0.05
5	9.9	0.05	0.55	0.08
Average	19.9	0.02	0.75	0.08

The average of kindergarten solid waste generation rate from the survey in the different units are 19.9 kg/school/day, 0.02 kg/sq.m (building)/day, 0.75 kg/staff/day and 0.08 kg/pupil/day.

b.) Primary School

The variables input in the equation are defined as below :

Dependent variable :

Y_y = Solid waste generation rate , kg/school/day

Independent variable :

X_{y1} = Area , m^2

X_{y2} = Building area , m^2

X_{y3} = Number of staff, person

X_{y4} = Number of pupils, person

X_{y5} = Work hour per day, hour

X_{y6} = Owner

where X_{y6} = 1 if school is attached to government.

X_{p6} = 0 if school is attached to private.

Table 5.18 Regression Correlation Coefficient between Variables of Primary School, R^2

Independent variables	Y	X_{y1}	X_{y2}	X_{y3}	X_{y4}	X_{y5}	X_{y6}
Y	1.0000 (N=12)	.0214 (N=12)	.8073 (N=12)	.7683 (N=12)	.7227 (N=12)	. (N=12)	.0107 (N=12)
X_{y1}	.0214 (N=12)	1.0000 (N=12)	.0371 (N=12)	.0827 (N=12)	.0936 (N=12)	. (N=12)	.0265 (N=12)
X_{y2}	.8073 (N=12)	.0371 (N=12)	1.0000 (N=12)	.6732 (N=12)	.7205 (N=12)	. (N=12)	.0000 (N=12)
X_{y3}	.7683 (N=12)	.0827 (N=12)	.6732 (N=12)	1.0000 (N=12)	.8530 (N=12)	. (N=12)	.0813 (N=12)
X_{y4}	.7227 (N=12)	.0936 (N=12)	.7205 (N=12)	.8530 (N=12)	1.0000 (N=12)	. (N=12)	.1076 (N=12)
X_{y5}.	. (N=12)	. (N=12)	. (N=12)	. (N=12)	1.0000 (N=12)	. (N=12)	(N=12)
X_{y6}	.0107 (N=12)	.0265 (N=12)	.0000 (N=12)	.0813 (N=12)	.1076 (N=12)	. (N=12)	1.0000 (N=12)

Note: N= number of cases
" . " is printed if a coefficient cannot be computed

Table 5.18 indicates that a strong relationships existed between building area (X_{y2}) and number of pupils(X_{y4}) and number of staffs (X_{y3}) and number of pupils(X_{y4}).

From multiple linear regression analysis, solid waste generation is affected significantly by building area and number of staffs ,or only number of pupils (see App.G).

The equations are obtained :

$$Y_{y1} = 0.015X_{y2} + 0.434X_{y3} - 3.435 \quad ...(5.12)$$

R = 0.936, R^2 = 0.876, S = 13.950,

significant(α): sig t_{Xy2}= 0.032,sig t_{Xy3}= 0.053 sig F = 0.000

$$Y_{y2} = 0.035X_{y4} + 27.217 \quad ...(5.13)$$

R = 0.850, R^2 = 0.723, S = 19.763,

significant(α): sig t_{Xy4}= 0.001, sig F = 0.001

Table 5.19 indicates that the predicted values versus the actual values are reasonably close.

Table 5.19 Primary School Solid Waste Generation Rate Actual Values and Predicted Values

No.	kg/school/day			Error	
	Actual	Predict			
		(1)	(2)	(1)	(2)
1	96.2	118.9	116.0	-22.7	-19.8
2	92.2	93.3	109.2	-1.1	-17.0
3	90.4	89.4	71.1	1.0	19.3
4	60.4	71.0	53.4	-10.6	7.0
5	49.6	40.8	47.7	8.8	1.9
6	47.2	51.5	58.1	-4.3	-10.9
7	80.8	61.3	45.1	19.5	35.7
8	118.6	122.2	104.2	-3.6	14.4
9	29.6	33.4	45.4	-3.8	-15.8
10	36.0	34.8	46.2	1.2	-10.2
11	135.6	120.1	119.8	15.5	15.8
12	26.0	46.5	50.5	-20.5	-24.5
Max.	135.6	122.2	119.8	19.5	35.7
Min.	26.0	33.4	45.1	-22.7	-24.5
Avg.	71.9	73.6	72.2	-1.7	-0.3
Std.	35.79	34.10	30.65	12.63	18.85

Note: (1): for equation(5.12),(2): for equation(5.13)

The average of primary school solid waste generation rate from the survey in the different units of affecting factors are 71.9 kg/school/day, 0.02 kg/sq.m/day, 1.36 kg/staff/day and 0.07 kg/pupil/day.(see also Table E.15 in App.E).

c.) Secondary School and College

The obtained data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.20

Table 5.20 Secondary School & College Solid Waste Generation Rate

NO.	WASTE	Generation Unit		
	kg/school/day	kg/sq.m.(building)/day	kg/staff/day	kg/student/day
1	119.5	0.013	0.61	0.04
2	216.2	0.010	1.01	0.07
3	164.6	0.018	1.24	0.04
4	36.0	0.010	1.80	0.09
5	153.6	0.021	1.15	0.05
6	268.6	0.023	1.62	0.08
7	191.4	0.007	0.68	0.05
Average	164.3	0.015	1.16	0.06

The average of secondary school and college solid waste generation rate from the survey in the different units are 164.3 kg/school/day, 0.015 kg/sq.m(building)/day, 1.16 kg/staff/day and 0.06 kg/student/day.

5.1.3.2 Hospital

The obtained data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.21.

Table 5.21 Hospital Solid Waste Generations Rate

No.	NAME	Generation Unit			
		kg/hospital/day	kg/sq.m.(building)/day	kg/bed/day	kg/out patient/day
1	SREENAKARIN	3108.8	0.06	4.13	2.29
2	KHONKAEN	1615.2	0.05	2.53	1.57
3	MATHER&CHILD	84.4	0.02	0.56	0.32
4	HAN-A-SA	4.8	0.02	0.16	0.48
5	MOKUL	22.0	0.04	0.73	1.10
6	RATCHPREUG	181.2	0.05	1.81	3.62
	AVERAGE	836.1	0.04	1.66	1.56

The average of hospital solid waste generation rate from the survey in the different units are 836.1 kg/hospital/day, 0.04 kg/m^2(building)/day, 1.66 kg/bed/day , 1.56 kg/outpatient/day.

5.1.3.3 Government Office

The variables input in the equation are defined as below :

Dependent variable :

Y_g = Solid waste generation rate , kg/office/day

Independent variable :

X_{g1} = Building area , m^2

X_{g2} = Number of staff, person

X_{g3} = Number of visitor per day, person
X_{g4} = Work hour per week, hour

Table 5.22 Regression Correlation Coefficient between Variables of Government Office, R^2

Independent variables	Y	X_{g1}	X_{g2}	X_{g3}	X_{g4}
Y	1.0000 (N= 25)	.4546 (N= 25)	.5677 (N= 25)	.0857 (N= 25)	.0130 (N= 25)
X_{g1}	.4546 (N= 25)	1.0000 (N= 25)	.6841 (N= 25)	.1888 (N= 25)	.0157 (N= 25)
X_{g2}	.5677 (N= 25)	.6841 (N= 25)	1.0000 (N= 25)	.0248 (N= 25)	.0117 (N= 25)
X_{g3}	.0857 (N= 25)	.1888 (N= 25)	.0248 (N– 25)	1.0000 (N= 25)	.0039 (N= 25)
X_{g4}	.0130 (N= 25)	.0157 (N= 25)	.0117 (N= 25)	.0039 (N= 25)	1.0000 (N= 25)

Note: N= number of cases
" . " is printed if a coefficient cannot be computed

Table 5.22 indicates that high relationship existed between building area and number of staffs.

The following equations are obtained :

$$Y_{g1} = 2.608x10^{-3}X_{g1} + 1.262 \quad ...(5.14)$$

$R = 0.674$, $R^2 = 0.454$, $S = 2.189$,
significant(α): sig $t_{Xg1} = 0.002$, sig $F = 0.002$

$$Y_{g2} = 0.050X_{g2} + 0.961 \quad ...(5.15)$$

$R = 0.753$, $R^2 = 0.568$, $S = 1.949$,
significant(α): sig $t_{Xg2} = 0.000$, sig $F = 0.000$

Table 5.23 indicates that the predicted values versus the actual values are reasonably close.

Table 5.23 Government Office Solid Waste Generation Rate Actual Values and Predicted Values

NO.	kg/office/day			Error	
	Actual	Predict			
		(1)	(2)	(1)	(2)
1	3.5	3.3	4.1	0.2	-0.6
2	13.3	6.0	8.5	7.4	4.9
3	4.7	6.1	6.0	-1.5	-1.3
4	8.9	7.2	7.6	1.7	1.3
5	3.8	3.5	2.5	0.3	1.4
6	1.1	2.0	2.5	-1.0	-1.4
7	1.6	2.0	2.1	-0.4	-0.5
8	0.3	1.8	1.1	-1.4	-0.8
9	3.3	2.8	3.7	0.5	-0.4
10	5.0	8.2	4.2	-3.2	0.8
11	4.5	4.9	5.5	-0.4	-1.0
12	0.7	1.9	1.6	-1.2	-0.8
13	1.7	2.3	2.2	-0.6	-0.6
14	3.0	1.7	1.7	1.3	1.3
15	4.7	2.0	3.1	2.7	1.6
16	2.8	2.3	1.8	0.5	1.0
17	2.2	1.7	2.5	0.5	-0.4
18	0.6	1.4	1.9	-0.7	-1.2
19	4.4	3.5	2.6	0.9	1.8
20	1.0	1.3	1.2	-0.3	-0.2
21	4.2	1.8	1.8	2.4	2.3
22	0.6	1.8	1.5	-1.2	-0.9
23	1.9	5.4	7.9	-3.5	-5.9
24	0.8	2.4	1.5	-1.7	-0.7
25	1.1	2.4	1.5	-1.3	-0.4
Max.	13.3	8.2	8.5	7.4	4.9
Min.	0.3	1.3	1.1	-3.5	-5.9
Avg.	3.2	3.2	3.2	0.0	0.0
Std.	2.90	1.96	2.20	2.14	1.90

Note: (1): Equation(5.14)
(2): Equation(5.15)

The average of government office solid waste generation rate from the survey in the unit of the affecting factor is 0.10 kg/staff/day and 0.008 kg/m^2/day (see Table E.18 in App.E).

5.1.4 **Municipal Service**

5.1.4.1 Street

The obtained data points were too small to give reliable results by multiple linear regression analysis. From the results of investigations, values for solid waste generation unit were obtained as shown in Table 5.24.

Table 5.24 Street Solid Waste Generations Rate

NO.	Generation Unit	
	kg/1000sq.m/day	g./vehicle/day
1	2.22	10.13
2	2.94	11.72
3	1.69	9.80
4	0.98	10.66
5	1.85	6.78
6	0.22	3.28
7	0.93	11.10
AVERAGE	1.55	9.07

The average of street cleaning solid waste generation rate from the survey are 1.55 kg/1000 sq.m/day and 9.07 g/vehicle/day.

5.1.4.2 Park

In the survey period , there were two parks such as Beung Khannakorn and Suan Ratchada. They are too small data points to analysis by multiple linear regression.

Table 5.25 Park Solid Waste Generations Rate

NO.	NAME	Generation Unit		
		kg/park/day	kg/10,000sq.m/day	kg/visitors/day
1	BEUNG K.NAKORN	202.3	9.48	0.35
2	SUANRATCHADA	22.0	5.95	0.08
AVERAGE		112.2	7.71	0.21

From Table 5.25, the average of park solid waste generation rate in different units are 112.2 kg/park/day, 7.71 kg/10,000 m^2/day and 0.21 kg/visitor/day.

Table 5.26 shows the comaprision in generation rates with other municipalities.

Table 5.26 Comparision in Generation Rate with Other Municipalities

Source	Unit	Khon Kaen[a]	Chonburi[b]	Phuket[c]	Suratthanee[d]	Hadyai[e]	Bangkok[f]
Residential	kg/capita/day	0.34	0.26	0.337	0.406	0.16	0.315
Commercial							
Factory							
- Food processing	kg/employee/day	2.55	-	-	-	-	-
- Machinery	kg/employee/day	1.93	-	-	-	-	-
- Transportation equipment	kg/employee/day	1.76	-	-	-	-	-
- Textile & Apparel products	kg/employee/day	0.81	-	-	-	-	0.48
- Wood products	kg/employee/day	6.85	-	-	-	-	-
Store	kg/sq.m/day	0.013	0.017	-	-	0.009	-
	kg/employee/day	0.18	-	-	-	-	0.34
Private Office	kg/sq.m/day	0.017	-	-	-	0.013	-
	kg/officer/day	0.16	-	-	-	-	0.19
Hotel	kg/ unit(electricity)/day	0.06	-	-	-	-	-
	kg/ room/day	1.1	-	-	-	-	1.6
	kg/sold room/day	1.85	0.56	3.1	-	2.85	-
	kg/employee/day	1.83	-	-	-	-	-
Restaurant	kg/seat/day	0.37	0.607	-	-	0.48	-
	kg/employee/day	4.08	-	-	-	-	-
	kg/visitor/day	0.36	-	0.2	-	-	-
Theater	kg/sq.m/day	0.015	-	-	-	-	-
	kg/seat/day	0.02	-	-	-	-	-
Market	kg/sq.m/day	1.00	0.846	-	-	0.34	-
	kg/shop/day	13.96	-	-	-	-	3.74
Large Store	kg/sq.m/day	0.24	0.052	-	-	0.0084	0.045
Institutional							
School	kg/student/day	-	0.116	-	-	0.08	-
Kindergarten	kg/pupil/day	0.08	-	-	-	-	-
Primary School	kg/pupil/day	0.07	-	-	-	-	-
Secondary School & Collage	kg/student/day	0.06	-	-	-	-	-

Table 5.26 Comparision in Generation Rate with Other Municipalities (continue)

Source	Unit	Khon Kaen[a]	Chonburi[b]	Phuket[c]	Suratthanee[d]	Hadyai[e]	Bangkok[f]
Hospital	kg/hospital/day	836.1	-	-	861	-	660
	kg/bed/day	1.66	10.737	1.89	-	3.1	-
	kg/sq.m/day	0.04	-	-	-	-	-
	kg/outpatient/day	1.56	-	-	-	-	-
Government Office	kg/officer/day	0.1	-	-	-	-	-
	kg/sq.m/day	0.008	0.007	-	-	-	-
Municipal Service							
Street	kg/1,000sq.m/day	1.55	-	-	-	-	-
	kg/vehicle/day	9.07	-	-	-	-	-
Park	kg/sq.m/day	0.001	0.013	-	-	-	-
	kg/visitor/day	0.21	-	-	-	-	-

source: a) This Study
b) Pollution Solving Guideline in Regional City Chonburi,1987, NEB-PUB 1987-004 by Office of National Environmental Board
c) Pollution Solving Guideline Regional City Phuket,1987, NEB-PUB 1987-006 by Office of National Environmental Board
d) Pollution Solving Guideline in Regional City Suratthanee,1988, NEB 08-02-31 by Office of National Environmental Board
e) Pollution Solving Guideline in Regional City Hadyai,1989, NEB 08-01-32 by Office of National Environmental Board
f) The Bangkok Solid Waste Management Study,1982 by JICA

5.1.5 **Solid Waste Generation Rate in Municipality**

Table 5.27 shows the survey results for solid waste generation from various sources.

Table 5.27 Solid Waste Generation from Various Sources.

Source	Average Generation unit	No.of Sources	kg/day	%
1. Residential	0.34 kg/capita/day	146,805 (capita)	49,914	30.81
2. Commercial				
2.1 Factory	78.3 kg/factory/day	413	32,338	19.96
2.2 Store	0.7 kg/store/day	1,019	713	0.44
2.3 Office	3.6 kg/office/day	1,871	6,736	4.16
2.4 Hotel	169.9 kg/hotel/day	28	4,757	2.94
2.5 Restaurant	50.6 kg/ restaurant /day	629	31,827	19.65
2.6 Theater	(survey all of theater)	7	41	0.03
2.7 Fresh Market	(survey 4 markets)	4	13,462	8.31
2.8 Large Store	(survey all of large store)	3	553	0.34
3. Institutional				
3.1 Kindergarten	19.9 kg/ kindergarten /day	18	358	0.22
3.2 Primary School	71.9 kg/ school /day	21	1,510	0.93
3.3 Secondary School	164.3 kg/ school /day	10	1,643	1.01
3.4 Hospital	836.1 kg/hospital/day	12	10,033	6.19
3.5 Government Office	3.2 kg/office/day	105	336	0.21
3.6 University	(previous study)[a]	1	6,508	4.02
4. Municipal Service				
4.1 Street	1.54 kg/ 1000sq.m /day	678,018[b] (sq.m)	1,044	0.64
4.2 Park	(survey all of park)	2	224	0.14
	Total		161,998	100.00
	Whole Generation Rate (kg/capita/day)		1.10	

Note : a) Solid Waste Management in Khon Kaen University , 1995 by Pasawadee Churbundit
b) Asphalt and Concrete Street

Fig.5.1 shows the waste stream with waste amounts in wet weight from various generation sources. It is estimated that the residential, commercial, institutional and municipal service waste generated were 30.81%, 55.82%, 12.59% and 0.78% respectively.

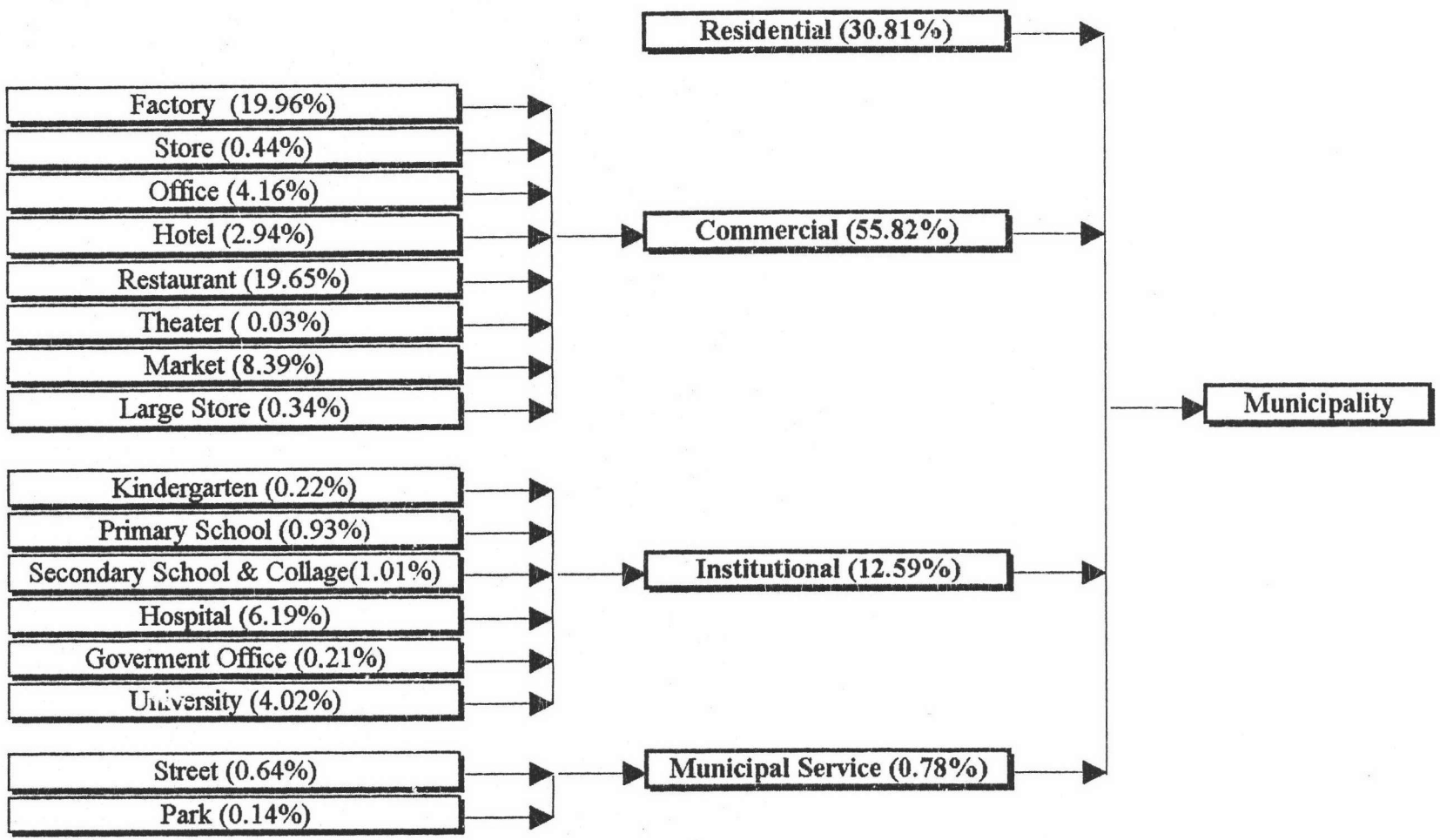

Figure 5.1 Schematic of Municipal Waste Stream (% in wet weight)

5.2 Composition

5.2.1 Residential

From Table 5.28 garbage was the highest composition (48.88 % to 59.84 %) as wet weight basis from all income lavels. The plastic and paper components were inferior in composition respectively. In dry weight basis, garbage was remaining the highest portion (26.37% to 34.87%). To be note that paper was highest as 11.36 % wet basis and 19.03 % dry basis in high income level, while plastic was highest as 16.75 % wet basis and 25.89 % wet basis in low come level in dry weight analysis.

Table 5.28 Average Physical Composition of Residential Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	HIGH INCOME		MEDIUM INCOME		LOW INCOME	
		WET	DRY	WET	DRY	WET	DRY
1	GARBAGE	59.84	34.87	48.88	26.37	57.85	29.52
2	PAPER	11.36	19.03	11.29	16.14	7.16	12.49
3	PLASTIC	13.73	18.13	16.08	21.55	16.75	25.89
4	RUBBER	0.12	0.29	0.00	0.00	0.05	0.11
5	LEATHER	0.03	0.07	0.00	0.00	0.00	0.00
6	WOOD	6.76	8.04	10.62	9.58	8.35	8.27
7	TEXTILE	1.97	4.09	3.23	5.55	1.18	2.33
8	GLASS	3.37	8.79	5.81	12.48	5.69	14.28
9	METAL	1.82	4.34	2.43	5.03	1.54	3.80
10	STONE	0.11	0.32	0.17	0.36	0.83	2.19
11	MISCELLANEOUS	0.90	2.03	1.49	2.94	0.60	1.13
	TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

5.2.2 Commercial

5.2.2.1 Factory

Table 5.29 show the waste characters of different operations of factories. The main components in food operations were garbage , wood and plastic. Machinery and transportation operations have shown a similar waste stream where the main components were metal and paper. The significant components in textile operations were plastic, garbage and textile . And the main component in wood furniture operations was wood (scrap wood and sawdust).

In dry weight analysis, because of the some components of waste in machinery, transportation and textile operations were attached by oil or grease that might cause a flame in hot air oven, so the portions in dry basis in these operations were not existed.

Table 5.29 Average Physical Composition of Factory Solid Waste (in Wet & Dry Weight , %)

NO.	COMPOSITION	FOOD		MACHINERY		TRANSPORTATION		TEXTILE		WOOD FURNITURE	
		WET	DRY	WET	DRY	WET	DRY	WET	DRY	WET	DRY
1	GARBAGE	33.45	14.53	3.82	-	2.73	-	18.54	-	0.00	0.00
2	PAPER	5.37	8.89	22.67	-	24.34	-	8.27	-	0.00	0.00
3	PLASTIC	16.35	23.51	7.95	-	6.88	-	42.99	-	0.00	0.00
4	RUBBER	0.00	0.00	0.00	-	1.48	-	0.59	-	0.00	0.00
5	LEATHER	0.00	0.00	0.00	-	0.00	-	0.28	-	0.00	0.00
6	WOOD	27.97	22.23	0.00	-	0.93	-	4.04	-	100.00	100.00
7	TEXTILE	0.00	0.00	0.00	-	0.38	-	16.47	-	0.00	0.00
8	GLASS	9.94	20.51	1.16	-	6.82	-	4.75	-	0.00	0.00
9	METAL	0.00	0.00	64.40	-	53.35	-	3.39	-	0.00	0.00
10	STONE	0.00	0.00	0.00	-	0.24	-	0.00	-	0.00	0.00
11	MISCELLANEOUS	6.92	10.32	0.00	-	2.86	-	0.69	-	0 00	0.00

Note : ' - ' = not available

5.2.2.2 Store

Table 5.30 show that the main components of store solid waste were paper and plastic .

Table 5.30 Average Physical Composition of Store Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	8.94	3.43
2	PAPER	43.37	45.31
3	PLASTIC	30.13	33.69
4	RUBBER	0.84	0.99
5	LEATHER	0.00	0.00
6	WOOD	2.55	0.76
7	TEXTILE	2.13	2.37
8	GLASS	3.22	3.60
9	METAL	5.92	6.71
10	STONE	0.24	0.26
11	MISCELLANEOUS	2.67	2.88
	TOTAL	100.00	100.00

5.2.2.3 Private Office

Table 5.31 show that the main components of private office solid waste were paper , garbage and plastic .

Table 5.31 Average Physical Composition of Private Office Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	24.36	9.90
2	PAPER	58.45	70.83
3	PLASTIC	8.34	9.62
4	RUBBER	0.15	0.21
5	LEATHER	0.00	0.00
6	WOOD	2.50	1.10
7	TEXTILE	0.33	0.36
8	GLASS	3.91	5.45
9	METAL	1.47	2.00
10	STONE	0.00	0.00
11	MISCELLANEOUS	0.48	0.52
	TOTAL	100.00	100.00

5.2.2.4 Hotel

Table 5.32 show that the main components of hotel solid waste were paper , garbage and plastic .

Table 5.32 Average Physical Composition of Hotel Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	53.50	23.31
2	PAPER	18.51	26.30
3	PLASTIC	8.59	15.84
4	RUBBER	0.39	1.02
5	LEATHER	0.10	0.19
6	WOOD	2.45	1.29
7	TEXTILE	2.96	3.52
8	GLASS	9.14	21.10
9	METAL	1.59	3.51
10	STONE	1.16	2.68
11	MISCELLANEOUS	1.18	1.24
	TOTAL	100.00	100.00

5.2.2.5 Restaurant

Table 5.33 show that the main components of restaurant solid waste were garbage ,plastic and glass.

Table 5.33 Average Physical Composition of Restaurant Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	66.95	40.54
2	PAPER	4.15	5.61
3	PLASTIC	10.44	11.25
4	RUBBER	0.00	0.00
5	LEATHER	0.00	0.00
6	WOOD	2.72	2.99
7	TEXTILE	0.31	0.32
8	GLASS	8.58	23.83
9	METAL	2.01	4.91
10	STONE	4.85	10.55
11	MISCELLANEOUS	0.00	0.00
	TOTAL	100.00	100.00

5.2.2.6 Theater

Table 5.34 show that the main components of theater solid waste were paper ,plastic, garbage and metal (soft drink can).

Table 5.34 Average Physical Composition of Theater Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	10.21	3.17
2	PAPER	11.85	10.95
3	PLASTIC	56.12	57.04
4	RUBBER	0.00	0.00
5	LEATHER	0.00	0.00
6	WOOD	0.64	0.72
7	TEXTILE	0.97	0.79
8	GLASS	6.12	9.52
9	METAL	8.68	12.39
10	STONE	0.16	0.23
11	MISCELLANEOUS	5.26	5.19
	TOTAL	100.00	100.00

5.2.2.7 Market

Table 5.35 show that the main components in the market solid waste were garbage , plastic and paper .

Table 5.35 Average Physical Composition of Market Solid Waste(in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	51.19	23.28
2	PAPER	13.22	18.33
3	PLASTIC	20.56	30.47
4	RUBBER	0.82	2.85
5	LEATHER	0.04	0.12
6	WOOD	8.75	7.56
7	TEXTILE	0.68	0.94
8	GLASS	2.32	8.18
9	METAL	2.30	7.90
10	STONE	0.11	0.37
11	MISCELLANEOUS	0.00	0.00
	TOTAL	100.00	100.00

5.2.2.8 Large Store

The main components in the large store were plastic,paper, glass and garbage as shown in Table 5.36

Table 5.36 Average Physical Composition of Large Store Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	46.98	13.74
2	PAPER	16.41	25.18
3	PLASTIC	17.18	29.09
4	RUBBER	0.25	0.47
5	LEATHER	0.00	0.00
6	WOOD	3.93	2.36
7	TEXTILE	1.48	2.57
8	GLASS	7.86	14.63
9	METAL	1.48	2.88
10	STONE	2.45	4.95
11	MISCELLANEOUS	1.96	4.13
	TOTAL	100.00	100.00

5.2.3 Institutional

5.2.3.1 School

From the Table 5.37, in wet basis, the main component of all school strata solid waste are garbage, paper and plastic, but to be note that kindergarten waste has a higher percentage of garbage, paper and plastic respectively, while primary school waste has a higher plastic, paper and garbage respectively, and secondary school (include collage) waste contains more garbage, plastic and paper respectively. In dry basis, kindergarten waste has a higher percentage of paper, garbage and plastic respectively, while primary school waste has a higher percentage of plastic, paper and wood respectively, and secondary school is contained more plastic, paper and garbage respectively.

Table 5.37 Average Physical Composition of School Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	KINDERGARTEN		PRIMARY SCHOOL		SECONDARY SCHOOL	
		WET	DRY	WET	DRY	WET	DRY
1	GARBAGE	48.54	24.78	21.77	7.51	39.89	19.95
2	PAPER	28.50	41.25	23.26	26.77	20.54	26.57
3	PLASTIC	13.34	19.77	27.89	34.76	23.82	32.42
4	RUBBER	0.18	0.38	0.61	0.97	0.18	0.30
5	LEATHER	0.00	0.00	0.73	1.31	0.00	0.00
6	WOOD	3.37	2.81	11.69	9.16	8.49	8.01
7	TEXTILE	1.04	1.07	2.84	3.36	1.65	2.49
8	GLASS	2.62	5.27	4.07	7.08	1.94	3.75
9	METAL	2.10	4.22	1.13	1.97	2.34	4.65
10	STONE	0.22	0.28	1.71	2.95	0.36	0.79
11	MISCELLANEOUS	0.10	0.18	4.31	4.16	0.79	1.08
TOTAL		100.00	100.00	100.00	100.00	100.00	100.00

5.2.3.2 Hospital

The main components in hospital were garbage, plastic and paper as shown in Table 5.38

Table 5.38 Average Physical Composition of Hospital Solid Waste(in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	42.42	24.02
2	PAPER	14.40	19.83
3	PLASTIC	25.12	29.80
4	RUBBER	2.01	3.48
5	LEATHER	0.00	0.00
6	WOOD	2.47	1.99
7	TEXTILE	4.59	3.81
8	GLASS	5.98	11.45
9	METAL	2.88	5.46
10	STONE	0.00	0.00
11	MISCELLANEOUS	0.11	0.16
	TOTAL	100.00	100.00

5.2.3.3 Government Office

The main components in government office were paper, plastic and garbage as shown in Table 5.39.

Table 5.39 Average Physical Composition of Government Office Solid Waste (in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	21.39	7.61
2	PAPER	53.66	65.69
3	PLASTIC	12.43	13.98
4	RUBBER	0.47	0.61
5	LEATHER	0.00	0.00
6	WOOD	3.23	1.27
7	TEXTILE	1.25	1.35
8	GLASS	4.89	6.42
9	METAL	1.20	1.52
10	STONE	0.20	0.26
11	MISCELLANEOUS	1.28	1.29
	TOTAL	100.00	100.00

5.2.4 Municipal Service

5.2.4.1 Street

The main components in street were stone (sand), plastic, paper and wood (leaf) as shown in Table 5.40

Table 5.40 Average Physical Composition of Street Solid Waste(in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	8.17	2.66
2	PAPER	13.38	13.20
3	PLASTIC	16.28	16.19
4	RUBBER	0.73	0.89
5	LEATHER	0.00	0.00
6	WOOD	12.79	11.43
7	TEXTILE	1.87	1.87
8	GLASS	6.40	8.05
9	METAL	2.81	3.43
10	STONE	33.18	38.15
11	MISCELLANEOUS	4.41	4.13
	TOTAL	100.00	100.00

5.2.4.2 Park

The main components in park were glass, plastic, garbage and paper as shown in Table 5.41.

Table 5.41 Average Physical Composition of Park Solid Waste(in Wet & Dry Weight, %)

NO.	COMPOSITION	WET	DRY
1	GARBAGE	16.42	5.29
2	PAPER	7.77	5.67
3	PLASTIC	27.36	25.80
4	RUBBER	2.47	3.30
5	LEATHER	0.00	0.00
6	WOOD	2.46	1.15
7	TEXTILE	0.44	0.28
8	GLASS	38.12	52.21
9	METAL	3.53	4.77
10	STONE	1.41	1.53
11	MISCELLANEOUS	0.00	0.00
	TOTAL	100.00	100.00

5.3 Moisture content and bulk density

5 3.1 Residential

From Table 5.42 ,the total moisture content and bulk density values are not much variations amongst different income levels. It can be said that residential solid waste has total moisture content in the range 54% to 61% and bulk density in the range 248 to 253 kg/m^3

Table 5.42 Average Bulk Density and Moisture Content (%) of Residential Solid Waste

NO.	COMPOSITION	HIGH INCOME	MEDIUM INCOME	LOW INCOME
1	GARBAGE	73.76	74.17	80.08
2	PAPER	24.87	34.99	32.06
3	PLASTIC	40.59	37.51	41.03
4	RUBBER	2.04	0.00	1.27
5	LEATHER	0.14	0.00	0.00
6	WOOD	61.25	58.77	60.07
7	TEXTILE	15.92	20.69	28.01
8	GLASS	0.39	0.96	0.66
9	METAL	5.62	2.98	2.35
10	STONE	0.07	0.20	0.07
11	MISCELLANEOUS	23.55	11.01	9.74
TOTAL (WHOLE SAMPLE)		57.28	53.86	60.81
BULK DENSITY, kg/cu.m		248.1	248.3	253.4

5.3.2 Commercial

Table 5.43 show the survey results for moisture content and bulk density of commercial solid waste. The high values of total moisture content are existed in solid waste from market, restaurant, hotel, food operation factory and large store (with fresh mart department),and the high values of bulk density are obtained in solid waste from market, restaurant, hotel, all the types of factory and large store. (with fresh mart department).

Table 5.43 Average Moisture Content (%) and Bulk Density of Commercial Solid Waste

NO.	COM/DATE	FOOD	MACHINERY	TRANSPORTATION	TEXTILE	WOOD FURNITURE
1	GARBAGE	79.96	37.34	68.35	86.90	0.00
2	PAPER	31.53	-	-	21.33	0.00
3	PLASTIC	30.65	-	-	8.53	0.00
4	RUBBER	0.00	0.00	-	0.00	0.00
5	LEATHER	0.00	0.00	0.00	1.79	0.00
6	WOOD	70.91	0.00	-	22.84	11.17
7	TEXTILE	0.00	-	-	3.86	0.00
8	GLASS	0.03	0.10	0.27	0.23	0.00
9	METAL	0.00	-	-	0.45	0.00
10	STONE	0.00	0.00	0.00	0.00	0.00
11	MISCELLANEOUS	11.58	0.00	-	6.20	0.00
TOTAL (WHOLE SAMPLE)		56.00	-	-	22.31	11.17
DENSITY, kg/cu.m		158.9	293.7	180.4	170.5	167.3

Table 5.43 Average Moisture Content (%) and Bulk Density of Commercial Solid Waste (continue)

NO.	COMPOSITION	STORE	OFFICE	HOTEL	RESTAURANT	THEATER	MARKET	LARGE STORE
1	GARBAGE	66.91	70.86	81.10	80.22	80.60	87.07	84.74
2	PAPER	10.16	13.33	39.20	53.69	40.74	63.68	18.83
3	PLASTIC	3.88	19.31	21.96	61.55	35.20	60.48	12.64
4	RUBBER	0.30	0.81	0.66	0.00	0.00	2.22	3.14
5	LEATHER	0.00	0.00	1.65	0.00	0.00	4.37	0.00
6	WOOD	59.62	69.26	76.70	59.21	19.16	78.13	64.59
7	TEXTILE	3.92	20.56	36.53	24.99	28.74	46.32	14.68
8	GLASS	0.46	0.26	0.29	1.89	0.13	0.60	0.22
9	METAL	1.94	4.82	6.98	8.98	8.70	3.89	4.02
10	STONE	0.42	0.00	4.29	10.04	0.02	0.05	1.78
11	MISCELLANEOUS	7.69	8.44	36.35	0.00	41.07	4.49	3.48
TOTAL (WHOLE SAMPLE)		13.81	28.67	56.86	66.45	34.73	73.16	48.33
BULK DENSITY, kg/cu.m		76.3	75.3	210.8	283.5	104.5	252.6	196.3

5.3.3 Institutional

From Table 5.44 , amongst the school strata, highest value of moisture content and bulk density are existed in the solid waste of kindergarten. It is due to higher garbage compositions in the sample. Amongst samples of institutional solid waste, the highest values of moisture content and bulk density are existed in hospital waste, while the lowests are existed in government office waste.

Table 5.44 Average Moisture Content (%) and Bulk Density of Institutional Solid Waste

NO.	COMPOSITION	KINDERGARTEN	PRIMARY SCHOOL	SECONDARY SCHOOL	HOSPITAL	GOVERNMENT OFFICE
1	GARBAGE	76.57	80.15	76.32	73.71	73.90
2	PAPER	30.56	34.66	38.03	41.40	7.98
3	PLASTIC	30.43	28.27	34.60	41.09	19.91
4	RUBBER	0.00	2.02	6.13	14.75	1.09
5	LEATHER	0.00	0.00	0.00	0.00	0.00
6	WOOD	58.23	55.64	50.91	48.86	68.88
7	TEXTILE	43.49	32.88	31.83	58.72	24.19
8	GLASS	0.37	0.42	0.45	0.84	0.53
9	METAL	4.33	1.34	3.15	6.68	5.14
10	STONE	5.33	0.75	0.45	0.00	1.54
11	MISCELLANEOUS	5.45	23.97	7.27	4.38	23.48
TOTAL (WHOLE SAMPLE)		52.06	42.78	51.87	53.16	25.44
BULK DENSITY, kg/cu.m		146.7	100.8	113.8	193.8	96.3

5.3.4 Municipal Service

Table 5.45 shows moisture content and bulk density of municipal service solid waste. It can be seen that the bulk density of street sweeping solid waste is highly, because of high sand content in the composition.

Table 5.45 Average Moisture Content (%) and Bulk Density of Municipal Service Solid Waste

NO.	COMPOSITION	STREET SWEEPING	PARK
1	GARBAGE	74.80	73.26
2	PAPER	20.31	45.92
3	PLASTIC	20.37	32.05
4	RUBBER	0.40	4.81
5	LEATHER	0.00	0.00
6	WOOD	29.44	41.74
7	TEXTILE	18.70	18.57
8	GLASS	0.09	0.47
9	METAL	1.97	2.18
10	STONE	7.65	5.75
11	MISCELLANEOUS	18.69	0.00
TOTAL (WHOLE SAMPLE)		19.55	28.15
BULK DENSITY, kg/cu.m		289.8	125.3

5.4 Solid Waste Quality in Municipality

The waste composition ,moisture content and bulk density for Khon Kaen Municipality in this study is estimated by the ratio of waste generation from each source as the equation 5.48.

$$W = \sum_{i=1}^{n} C_i P_i \qquad ...(5.48)$$

Where W = Particular component (moisture content, bulk density)

C_i = Average value of particular component from each source, %

P_i = Ratio of solid waste generation from each source

The value of each components are shown in Table 5.46

Table 5.46 The Municipality Solid Waste Quality

NO.	COMPOSITION	% BY WEIGHT
1	GARBAGE	45.28
2	PAPER	13.12
3	PLASTIC	15.11
4	RUBBER	0.34
5	LEATHER	0.03
6	WOOD	10.02
7	TEXTILE	1.92
8	GLASS	5.33
9	METAL	6.55
10	STONE	1.40
11	MISCELLANEOUS	0.90
MOISTURE(%)		52.87
DENSITY(kg/cu.m.)		233.04

From Table 5.39 indicate a high content of recyclable material i.e. the total amount of paper, plastic,metal and glass in wet weight basis are 40.11 %. This portion means about 65 tons of waste can be recycled daily. In other words,with the recycling scheme, about 40% of the municipal waste can be reduced in the disposal sites.

As for the garbage component, its portion is 45.28%. In other words, about 45 % of the municipal solid waste can be treated by composting method.