APPENDICES

1. Method for Estimation of Waste Quantity

1. Introduction

Waste quantity data is indispensable for planning solid waste management. It is also necessary to prepare a waste flow that shows waste generation quantity by sources, without which collection and disposal plan cannot be made. Preparation of a waste flow chart is a start point of the planning of the solid waste management. Fig 1-1 shows a example of waste flow prepared for Bucharest in 1994.

2. Categorization of Waste

In general, waste can be categorized as follows:

1. Household waste
2. Business waste
3. Street waste
4. Industrial waste
5. Demolition waste

Among these waste, household waste, street waste and a part of business waste is collected, treated and disposed by the public services in general,. In this guideline, "municipal waste" is defined as the waste which the municipality has responsibility to manage. If the municipality accepts industrial and demolition waste at its landfill sites, waste quantity and flow for such waste should be prepared.

3. Waste Quantity in Waste Flow

Generally, waste flow from generation to final disposal can be illustrated as follows:

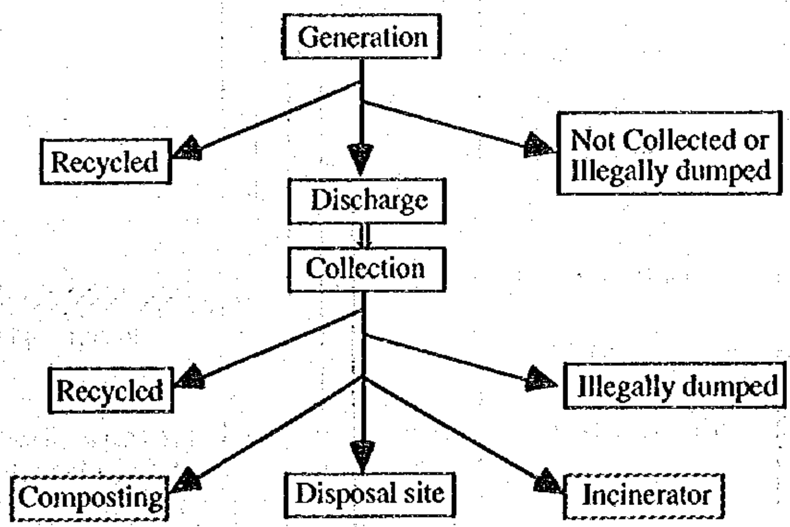
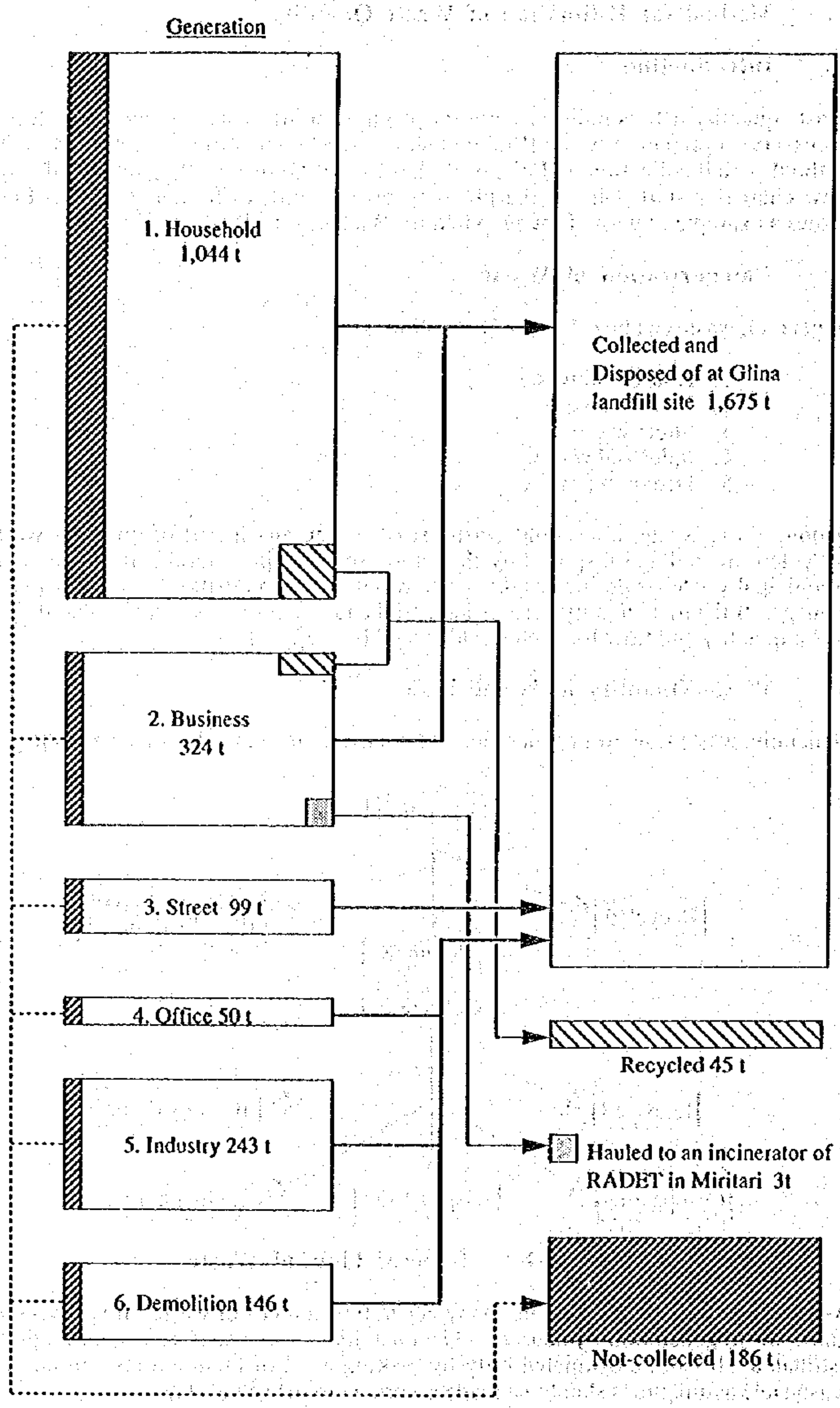


Fig. 3-1 General Flow of Waste

As shown in the figure, there are many generation sources of waste. It is advisable to know waste generation by sources. The quantity at some sources cannot be directly estimated. It can be estimated only by making a set of assumptions. In any case, reasonable assumptions should be made according to the actual state.

Fig. 1-1 Waste Flow of Bucharest [Example]



A. Municipal Waste (1+2+3): 1,467 tons/day
B. Non-municipal Waste(4+5+6) : 439 tons/day
Total : 1,906tons/day

Actual quantity data that can be obtained through surveys are quantity of generation, disposal, composting or incineration, while quantity of "Not collected" or "Illegal dumping" can not be estimated directly. Quantity of recycling can also be evaluated from data obtained from the department responsible for control of recycling.

4. Estimation of Generation Quantity

Waste generation or discharged quantity is estimated by waste category, i.e., household, business and street. Methods for estimation of generation quantity by waste type are described below.

1) Household Waste

a. Estimation Method

Theoretically, total generation quantity of house hold waste per day can be estimated by the following formula:

Total Generation Quantity (C) = $Q \times P$

where; Q: Daily average waste generation per capita

P: Total population in the studied area

Total population can be obtained from a statistics department, whereas daily waste generation per capita should be studied by actual survey. Actually, waste generation quantity per capita is dominated by number of resident in households. Generation quantity per capita tends to decrease as the number of persons in the household increases. To estimate more precisely, waste generation quantity per capita is surveyed by size of households. Therefore, the above formula can be modified as follows:

Total Generation Quantity (C) = $\Sigma\,(Qn \times Pn)$

where; Qn: Daily average waste generation per capita in households with n persons

Pn: Total number of persons living in households with n persons

b. Survey Method

Qn shown in the above formula should be obtained by a field survey in which waste samples are collected from households and weighed. For this survey, households to be studied are selected by their type and size. The selection should be made to reflect the population composition in the studied area according to the statistics of population distribution by the size of household. It is advisable to use plastic bags to collect waste samples. Waste samples should be immediately measured after collection. Generally, the survey is conducted for consecutive 8 days and the data of the second to last day are actually used for the estimation, while that of the first days is not used for its unreliability. Waste collected on the first day may contain waste generated on a few previous days. Daily waste generation per capita is estimated by the following method if the data is obtained for seven days:

$Qn = An \div 7 \div Bn$

where; An: Average waste generation quantity for seven days in households with n persons

Bn: number of residents living in the household studied

Results of the survey conducted for Bucharest city in 1994 is shown below as an example. According to these data, average daily waste generation per capita is 496.15 grams/day.

Table 4-1 Data used for Estimation of Household Waste Generation in Bucharest 1994

	Qn: Waste generation per Capita (kg)	Pn: Population by family size (persons)	C = Qn × Pn: Waste Quantity by family size (kg)
Households with 1 person	0.695	165,855	115,269
Households with 2 persons	0.599	390,520	233,921
Households with 3 persons	0.489	513,321	251,014
Households with 4 to 6 persons	0.424	965,964	409,569
Total		2,035,660	1,009,998

2) Business Waste

Concerning business waste, it is difficult to estimate per capita generation, because generation quantity greatly differs by type of business. For some business waste, generation quantity per unit of floor are (m^2) can be used as a unit generation index. However, this method can be applied to only the limited area where business category can be identified. Accurate data on floor area of business offices are not easily available.

If all business waste generated is collected, waste generation quantity is identical with collection quantity. In this case, it is preferable to measure the quantity by using a truck scale.

3) Street Waste

It is best to use a truck scale to estimate street waste collection quantity. Generation quantity should be estimated based on collection quantity by making appropriate assumptions.

5. Estimation of Recycled Quantity

Quantity of recyclable material accepted by recovering factories can be obtained from either the factories, or department responsible for material recycling. It should be noted that quantity of collected recyclable material and quantity of accepted may be different, because preliminary separation or selection may be conducted before the factories accept them. These data are presented by kind of material. It is useful to know rate of recycling relative to waste generation.

6. Quantity at Disposal Site

It is best to measure all the collection vehicles coming into these facilities by a truck scale. It is easy to measure by waste categories if each collection vehicle contains single category of waste. If a collection vehicle contains different types of waste, ratio by waste category should be checked.

If the truck scale does not have enough capacity to weigh all the incoming vehicles, an alternative method is as follows: some vehicles selected for each type is weighed as samples, and number of trips by type of vehicles is recorded. Total quantity hauled to disposal site can be estimated by the following formula:

Estimated Total Quantity = Σ ($Qv \times Nv$)

where; Qv: Average quantity of waste loaded by type of vehicles
Nv: number of trips to the site by type of vehicles

Method for Estimation of Waste Quality

1. Purpose

Waste quality is one of important basic data for planning of solid waste management. To know ratio of garbage or incombustibles in waste contributes to a better waste collection plan. By sorting waste by components, quantity of recyclable material contained in the waste can be known, which may be necessary for preparing a recycling plan. Calorific value is a determinant factor deciding on feasibility of waste incineration and designing incinerators.

Primarily, waste composition is expressed in terms of the following components, i.e., moisture, ash and combustible contents.

Secondly, it is physically classified into such components as paper, textile, plastic, glass, metal and so on.

Thirdly, it is chemically classified into such composition as carbon, hydrogen, nitrogen, oxygen, sulfur and chlorine.

Another important factor is low calorific value, which is measured by a calorimeter, or can be estimated by the composition.

In the following section, method and procedures for waste quality analysis are presented. Though there is no standardized method as recognized internatilnally, the following methods are standardized and adopted widely in Japan. However, for operation of calorimeter and chemical procedure for determination of elements standardized method depends on type of equipment. Establishment of Romanian standardized method is expected based on the methods described in this chapter.

2. Procedures of Waste Quality Analysis

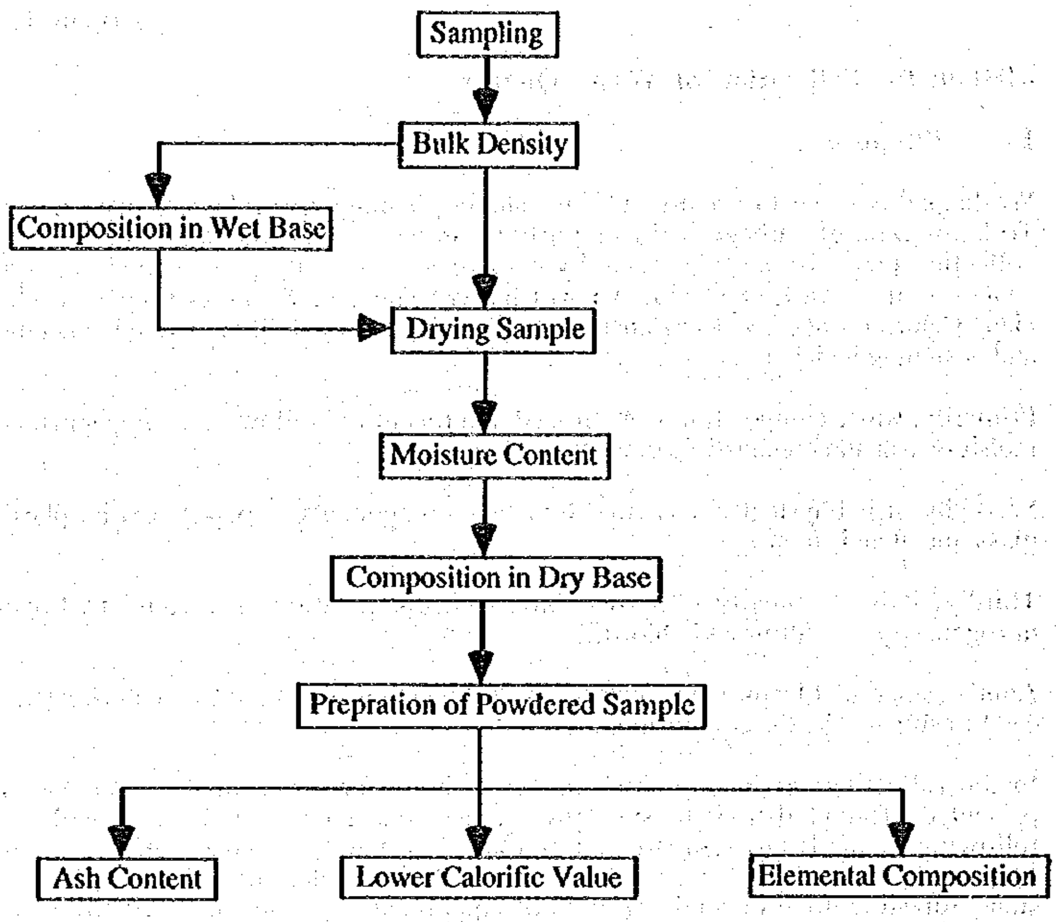
A series of procedures of waste quality analysis is shown as a flow chart in Fig. 2.2-1.

3. Sampling

Waste samples to be analyzed can be obtained from households, collection vehicles or waste pit of treatment facility. Random sampling from either source is necessary to obtain good representative samples. More than 200 kg of waste is desirable for the sample source. It is recommendable to take sample from as many vehicles as possible to lessen the characteristics of waste by area.

<u>**Sampling Procedures**</u>

(1) Mix waste well in containers of the vehicles if possible.
(2) Unload waste on floor. If large sized articles are contained, cut them into pieces smaller than 15 cm by 15 cm
(3) Mix them well again.
(4) Make the waste into cone-shaped mountain.
(5) Divide the waste into four sections.
(6) Choose two of four sections on opposite angle. and mix them well again.
(7) Repeat (4) to (6) three or four times, and then obtain about 10 kg of sample.



Fug. 2-1 Procedures of Waste Quality Analysis

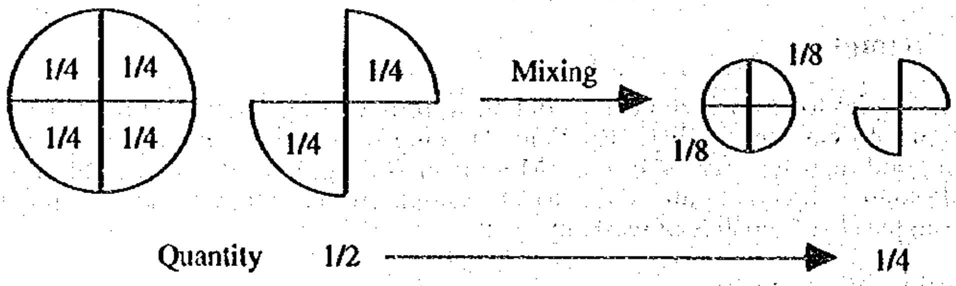


Fig. 3-1 Sample Division by Quartering

4. Bulk Density

Bulk density means weight per volume. This is an important factor to estimate weight of waste from its volume.

(1) Put the obtained sample into a container of which the capacity and the weight is known.
(2) Drop the container from 30 to 40 cm height three times.
(3) If the volume of waste reduces by this dropping, refill the waste supplementary and repeat the dropping.

(4) Repeat the refilling and dropping until the volume of waste does not reduce anymore.
(5) Measure weight of the sample and calculate the weight per volume by the following equation. The unit kg/litter is equal to $tons/m^3$.

Weight per Volume ($tons/m^3$) = weight of sample (tons) / capacity of container (m^3)

5. Composition in Wet Base

Waste composition by sorting components can be expressed in wet base or in dry base, but the composition in dry base is more preferable because composition in wet base does not necessarily indicate the original composition in weight. Moisture in waste mainly originates from kitchen garbage, and it moves to other components as time passes after discharged as waste. Thus, weight of paper in wet waste may be heavier than that in dried waste. This seems not reflect the original composition.

(1) Spread the sample over a plastic sheet or a platform and classify them into the following 10 categories of components by manual operation.
    a. Paper
    b. Textile
    c. Garbage
    d. Wood, bamboo and straw
    e. Plastics and synthetic resin
    f. Rubber and leather
    g. Metal
    h. Glass
    i. Ceramics and stone
    j. Other small particles smaller than 5 mm diameter. (This is obtained by using a sieve.)
(2) Weigh the each components and calculate percentages in weight.

5. Moisture Content

The sample is dried in a drier at constant temperature of 105 ± 5 °C for 3 to 5 days until the weight loses no more. Weigh the dried samples and calculate the moisture content by the following equation.

Moisture Content (%) =
(Wet Sample Weight (kg) - Dried Sample Weight (kg)) / Wet Sample Weight (kg)

6. Composition in Dry Base

Spread the dried sample over a plastic sheet or a platform and sort them according to the classification indicated in 2.4 Composition in Wet Base. Weigh each components and calculate percentages in weight.

7. Prepartion of Combustible Sample for Chemical Analysis

Powdered sample should be prepared for the following analysis as ash contents, calorific value and contents of elements. This sample is prepared from combustible components of the original sample. Thus, the direct result obtained is for this sample, and it should be converted into the value in the original waste by callculation. The composition of this powdered sample should be the same as that of the original composition with respect to the combustible components.

(1) Take a small portion of each combustible components.
(2) Grind each sampled components separately by mechanical grinder.

(3) Take each powdered components according to the composition shown by the composition in dry base, and mix them well as in the same composition of the original sample.

8. Ash Content

Ash contents indicate the ratio of incombustible matters in waste. Both incombustible components such as glass or metal, and ash contained in combustible matters should be taken into consideration.

(1) Put the powdered sample prepared in the section 2.7 into a porcelain crucible.
(2) Dry it at 105 ± 5 °C for 2 hours, and cool off for 30 minutes in a desicator.
(3) Weigh the crucible.
(4) Ignite the sample in the crucible at 800°C for 3 hours by an electric furnace.
(5) Weigh the crucible again.
(6) Calculate ash content in combustible components by the following equation.

Ash Content in the sample (%) =
Sample Weight after ignition/Sample Weight before ignition

(9) Calculate the ash contents in the combustible components of the original sample and add it to the incombustible contents, because incombustibles are regarded as all ash components. Total ash contents in the original sample is expressed by the following equation:

Total Ash Contents (%) =
Ash Contents in Combustibles (%) + Incombustible contents (%)

9. Content of Combustibles

Moisture, ash and combustibles are three major components. Moisture content is measured by the method shown in the section 2.5. Total ash contents in the original sample is obtained by the method and calculation shown in the section 2.9. The rest is considered to be combustible components. The content of combustibles is induced by the following equation.

Combustibles Content (%) = 100 - Moisture Content (%) - Ash Content (%)

10. Lower Calorific Value

Lower calorific value of sampled waste can be estimated by the following three methods; by a formula using combustible and moistures, by calorific value measured by a calorimeter, or by an estimation by elementary composition.

1) Estimation by Combustible and Moisture Contents

Lower calorific value can be estimated by combustible and moisture contents according to the following formula:

Lower calorific value (kcal/kg) = $4500 \times V/100 - 600 \times W/100$
where; V: Combustible content
W: Moisture content

This result tends to be lower than the result obtained by calorimeter of estimation from elemental composition.

2) Calorific Value Measured by a Calorimeter

Take the small portion of the powdered sample and measure the calorific value by calorimeter. Detail of operation of the calorimeter should be referred to a manual of each calorimeter. As a calorific value (Hc) obtained by a calorimeter means a higher calorific value of sole combustible components, lower calorific value should be calculated by the following two equations.

Higher Calorific Value of Original Sample (Hh) (kcal/ kg) =

$$Hc \times (100 - u)/100 \times (100 - W)/100$$

where; Hc: Calorific value indicated on the calorimeter
u: Contents of incombustibles in the original sample (%)
W: Moisture content

Lower Calorific Value of Original Sample (Hl) (kcal/ kg) = Hh - 6 (9H + W)

where; Hh: Higher calorific value obtained by the equation above
H: Hydrogen content obtained by elemental analysis, which is mentioned in the next section.
W: Moisture content

3) Estimation by Elemental Composition

Lower calorific value can also be estimated by elemental composition. Several formula are proposed as follows:

a. Dulong's formula
Lower calorific value (kcal/kg) = 81C + 342.5 (H - O/8) + 22.5S - 6 (9H + W)
where; C: Carbon content
H: Hydrogen content
O: Oxygen content
S: Sulfur content
W: Moisture content
Note; This formula fits well to fuel which contains much Carbon like coal.

b. Steuer's formula
Hl (kcal/kg) = 81(C - 3O/8) + 57 × 3 × O/8 + 345 (H - O/16) + 25S - 6 (9H + W)
Note; In this formula, it is assumed that half of oxygen contained is H_2O, and the rest is CO

c. Scheurer - Kestner's formula
Hl (kcal/kg) = 81(C - 3O/4) + 342.5H + 22.5S + 57 × 3 × O/4 - 6 (9H + W)
Note; It is assumed that all oxygen is CO.

11. Elemental Composition

For elemental analysis of waste, initially the sample of combustible components is analyzed, then each contents ratio to the original sample including incombustibles and moisture are calculated. The elements to be detected are carbon, hydrogen, nitrogen, oxygen, sulfur and chlorine. Elemental composition data is useful for estimation of the following value concerning incineration or land-fill.

a. Theoretical air volume required for complete combustion of waste in a incinerator.
b. Lower calorific value as a reference of heat durability of a incinerator. This is already referred in the previous section

c. C/N ratio indicating a suitability for composting and land-fill.
d. Generation of air pollution after incineration. N, S and Cl indicates the possible generation of sulfur oxide, nitrogen oxide and hydrogen chloride gas.

1) Carbon and Hydrogen

Theoretically, analysis method is detection of gassified elements generated by ignition of the sample at 800°C by an electric furnace. Carbon and hydrogen are detected as CO_2 and H_2O respectively. Fig. 2.10-1 shows an apparatus for detection Dried pure oxygen is used as carrier gas. Detectors used and estimation formula are as follows:

<u>Determination of Carbon</u>

Detector for carbon: a carbon dioxide absorber containing sodium carbon oxide

Carbon content (%) = 27.29 × Weight increase of detector (g) / sample weight (g)

<u>Determination of Hydrogen</u>

Detector for hydrogen: a moisture absorber for H_2O containing calcium chloride or magnesium perchlorate.

Hydrogen content (%) = 11.19 × Weight increase of detector (g) / sample weight (g)

2) Nitrogen

Nitrogen content is determined by Kjeldahl method, in which nitrogen as ammonium form is determined by titration. Ammonium is derived from decomposition of organic matter in sample by heated sulfuric acid. Details of the method is as follows:

(1) Take small portion of the sample between 5 to 10 g, weigh it and put it into a Kjeldahl flask with the capacity of 300 to 500 ml
(2) Add 80 ml of concentrated sulfuric acid to the flask and heat it. Add 0.5 to 1 g of decomposition accelerator (mixture of potassium sulfate:copper sulfate = 9:1). continue to heat until the contents becomes transparent.
(3) Add distilled waster up to 500 ml. Take 100 ml of the contents to a distilling flask and adjust pH of the contents to 7 by adding 4 % sodium hydroxide. Add the distilled water to the flask up to 350 ml.
(4) Put 50 ml of N/20 sulfuric acid solution into a receiver flask of the distilling apparatus. Start distillation until 250 ml of the distillate is obtained.
(5) titrate the distillate with N/20 sodium hydroxide by adding mixed indicator of methyl red and bromcresol green.
(6) Nitrogen content is determined by the following formula.

Nitrogen Content (%) = $(50 \times f_1 - af_2) \times 5 \times (1/\text{sample weight (g)}) \times 0.7/100 \times 100$

where; f_1 : Actual factor of N/20 sulfuric acid used (titrated respectively)
a : Quantity (ml) of N/20 sodium hydroxide needed for the titration
f_2 : Actual factor of N/20 sodium hydroxide used

3) Chlorine and Sulfur

Chlorine and sulfur are determined by titration of gassified elements generated by ignition of samples at 800°C by an electric furnace. Apparatus for gassification is similar to that for carbon shown in Fig. 2.10-1, but the detector is different. Detectors used and estimation formula are as follows:

Determinatin of Chlorine

Detector for chlorine : N/10 Sodium hydroxide

(1) Absorb the gassified chlorine by two detectors each of which contains 50 ml of sodium hydroxide.
(2) Collect the absorbents and make it 250 ml in total by adding distilled water.
(3) Take 25 ml of the diluted absorbent and add 5 ml of nitric acid, 5 ml of N/20 silver nitrate, 3 ml of Nitrobenzene and 1 ml of ferric sulfate ($Fe_2(SO_4)_3$)in ammonium solution.
(4) Titrate by N/20 ammonium thiosianate.
(5) Conduct blank test for unabsorbed detector by the same procedure.
(6) Chlorine content is determined by the following formula:

$$\text{Chlorine content (\%)} = (b-a) \times f \times 250/25 \times (1/\text{sample weight (g)}) \times 1.773/1000 \times 100$$

where; f : Actual factor of N/20 ammonium thiosianate used
a : Quantity (ml) of N/20 ammonium thiosianate needed for the titration
b : Quantity (ml) of N/20 ammonium thiosianate needed for the blank test

Determination of Sulfur

Detector for sulfur : 3% Hydrogen peroxide solution

(1) Absorb the gassified sulfur by two detectors each of which contains 50 ml of hydrogen peroxide solution.
(2) Collect the absorbent and make it 200 ml in total by adding distilled water.
(3) Take 10 ml of the diluted absorbent and add 40 ml of isopropyl alcohol, 1 ml of acetic acid and 3 or 4 drops of arsenazo III solution as an indicator.
(4) Titrate by N/100 barium acetate.
(5) Conduct blank test for unabsorbed detector by the same procedure.
(6) Chlorine content is determined by the following formula:

$$\text{Chlorine content (\%)} = (a-b) \times f \times 200/10 \times (1/\text{sample weight (g)}) \times 0.163/1000 \times 100$$

where; f : Actual factor of N/100 barium acetate used
a : Quantity (ml) of N/100 barium acetate needed for the titration
b : Quantity (ml) of N/100 barium acetate needed for the blank test

4) Oxygen

Oxygen content can be obtained by subtracting carbon, hydrogen, nitrogen, chlorine and sulfur content from total combustible content, that is, this is expressed as the following formula:

Oxygen content (%) =
Combustible content - (Carbon + Hydrogen + Nitrogen + Chlorine + Sulfur)

Time and Motion Study (TMS)

1. General

Time and Motion Study (TMS) is an important method to obtain basic data on actual conditions of collection and haulage service. TMS measures the following:

1. Time spent for each activity including waste loading, haulage, dumping, etc.
2. Weight of waste collected and hauled (a truck scale should be used.)
   (in the case of street sweeping: Net street length swept and waste amount collected)
3. Consumption of fuel and its cost.
4. Number of containers or bins from which waste is collected.

Based on data obtained loading efficiency, hauling velocity and efficiency can be measured. Further more, by combining cost data, cost efficiency also can be estimated. Such indicators are indispensable for evaluating existing collection and hauling systems, also applicable to street sweeping.

2. Method of TMS

1) TMS Team Formation

TMS team consists of the following members:

1. One team leader
2. One for time measurement and record
3. One for coordination

2) Necessary Equipment

1. One car for study team
2. Two chronometer
3. Record papers
4. Camera or video recorder
5. Truck scale

3) Time schedule

A time and motion study should cover a collection and haulage activities of a truck for a whole day. A typical flow of the activities are shown in the diagram hereto attached.

4) Record Sheet

A sample sheet used for recording time and other information is hereto attached.

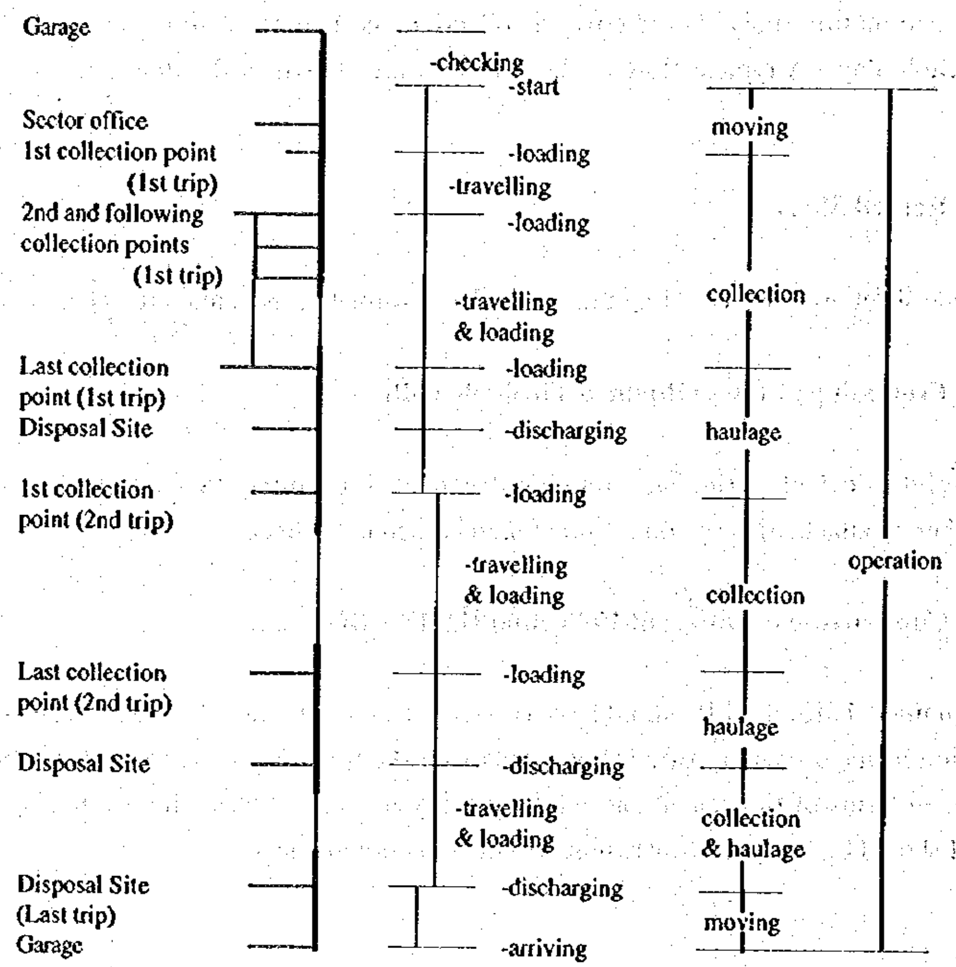
5) Processing of Data Obtained Through TMS

It is useful to calculate time and running distance for each trip (See a sample trip record hereto attached) based on information recorded on a sheet.

6) Comparison of Different Collection/Haulage Systems

As explained before, TMS should be conducted at least once for each type of collection/haulage system. Efficiency comparison should be made between different systems in terms of time spent and waste quantity hauled. Information on haulage amount should be used to estimate unit cost of collection/haulage.

Typical Activities Flow of Collection and Haulage



TMS Record Sheet (Example)

Record of Activities

TMS

No. ____________

Date Nov. , 1994

Car No.	Type	Capacity	Crew	Trip	Collection area	Mileage (km)	Fuel consumption	Collected container
			Driver:	1st				
		m^3	Worker A:	2nd				
		ton	Worker B:	3rd				

Start	Kind of Activities				
: ' "	Collection	Nos. of container	Traveling	Hauling	Other
1)	' "		' "	' "	( ) ' "
2)	' "		' "	' "	( ) ' "
3)	' "		' "	' "	( ) ' "
4)	' "		' "	' "	( ) ' "
5)	' "		' "	' "	( ) ' "
6)	' "		' "	' "	( ) ' "
7)	' "		' "	' "	( ) ' "
8)	' "		' "	' "	( ) ' "
9)	' "		' "	' "	( ) ' "
10)	' "		' "	' "	( ) ' "
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14)	' "		' "	' "	( ) ' "
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18)	' "		' "	' "	( ) ' "
19)	' "		' "	' "	( ) ' "
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Trip Record (Example)

System: Compactor (MEDIAS) + 110 ℓ steel bins

Registered number: 32B4157, Capacity: 10 m^3, Crew: 3,
Collection area: Sector 1
Date of Study: November 8, 1994 (Start work 6:34, Finish work 15:59,
Work hours: 9:25)

Item	1st trip	2nd trip	3rd trip	Total
1) Loading time	1:54'	2:13'	–	4:07'
2) Traveling time and distance	18' 5.9 km	3' 1.6 km	– –	21' 7.5 km
3) Haulage time (to disposal site) and distance	47' 20.9 km	47' 19.7 km	– –	1:34' 40.6 km
4) Haulage time (to next trip) and distance	44' 16.7 km	– –	– –	44' 16.7 km
5) Collected waste	5.5 ton	5.5 ton	–	11.0 ton
6) Collection time efficiency { 1) + 2) } / 5) [min./ton]	24.0	24.7	–	24.4
7) Haulage velocity [km/h]	24.8	25.1	–	25.0
8) Moving time (to 1st trip) and distance	21' 11.7 km			
9) Moving time (to garage) and distance	32' 18.2 km			
10) Total operation distance	94.7 km			
11) Fuel Consumption	45 ℓ			
12) Fuel efficiency 10) / 11)	2.1 km/ℓ			

Efficiency Comparison of Different System (Sample)

Item / Collected Area / No. of trip	MEDIAS (110 ℓ) Sec. 1 2	PELIC. (110 ℓ) Sec. 3 2	LIAZ (110 ℓ) Sec. 2 2	RGR-16 (240 ℓ) Sec. 6 3	SRDAC (4 m^3) Sec. 6 3	PELI-CON (4 m^3) Sec. 5 2
1) Loading time	4:07'	4:04'	4:10'	2:03'	44'	4:33'
2) Traveling time and distance [km]	21' 7.5	40' 5.4	24' 8.8	19' 5.4	11' 4.5	50' 14.2
3) Haulage time (to disposal site) and distance [km]	1:34' 40.6	1:44' 32.9	51' 20.7	2:11' 59.3	3:32' 64.0	1:52' 33.4
4) Haulage time (to next trip) and distance	44' 16.7	34' 17.1	22' 11.5	1:05' 38.1	1:35' 36.4	23' 13.9
5) Collected waste ( ): theoretical figure	6.6 (11.0)	8.8 (11.6)	8.1 (9.7)	12.3 (17.2)	3.5 (3.9)	8.9 (16.7)
6) Collection time efficiency { 1) + 2) } / 5) [min./ton] ( ): theoretical figure	40.6 (24.4)	32.3 (24.5)	33.8 (28.2)	11.5 (8.3)	15.7 (14.5)	36.3 (19.3)
7) Haulage velocity [km/h]	25.0	21.7	26.5	29.8	19.6	21.0
8) Moving time (to 1st trip) and distance [km]	21' 11.7	31' 11.6	15' 5.1	18' 8.4	15' 5.6	24' 8.8
9) Moving time (to garage) and distance [km]	32' 18.2	23' 12.3	29' 15.0	31' 19.0	46' 18.9	27 13.5
10) Total operation distance [km]	94.7	79.3	61.0	156.7	129.4	83.8
11) Fuel Consumption [ℓ]	45	62	40	85	38	73
12) Fuel efficiency 10) / 11) [km/ℓ]	2.1	1.3	1.5	1.8	3.4	1.1

Technical Guidelines for Selection of Landfill Site

1) Landfill Site Selection

In selecting a sanitary landfill site, it is necessary to ensure that the site has a sufficient capacity to accept the planned landfill volume. In addition, the following aspects should also be jointly considered:

a. Efficiency of collection and transport
b. Surrounding conditions
c. Topography and geological conditions
d. Safety against disaster
e. Ultimate landuse plan
f. Layout of related facilities
g. Availability of cover soil
h. Landfill area is of sufficient size

In the construction of a landfill system it is necessary to plan with sufficient consideration each of the following factors. It is also important to carry out a preliminary assessment of the site.

a. Efficiency of Collection and Transport

Collection and transport costs form a large portion of the solid waste management cost. This amount varies with the collection method, the area of coverage, the location of the treatment plant and road traffic conditions. Generally, the larger the city, the lager the share of collection and haulage cost becomes. Therefore, in selecting a site, it is important to examine each of these items carefully so that collection and transport can be provided efficiently.

b. Surrounding conditions

The disposal site and traffic generated by collection and hauling vehicles can potentially cause environmental problems. Therefore, in order that the landfill system does not become a source of pollution in the surrounding area, it is desirable to carefully consider the following points and at the same time ensure that the system also contributes to regional improvement.

(a) Appropriate adjustment to all relevant urban planning regulations.
(b) Effluent discharge point.
(c) Haulage route, approach road and access road.
(d) If a housing area is located nearby, the conditions of the buffer zone (green belt) should be assessed for: noise, vibration and offensive odor.
(e) Check the location of the housing area and public facilities such as schools and hospitals.
(f) Availability of utilities such as electric power, telephone and water.

c. Topography and Geology

It is preferable to choose a site with good geological conditions to reduce construction and maintenance costs. As far as possible the landfill system should be built on nonpermeable ground, but not on soft ground or places where subsidence may occur. However, if such a situation is unavoidable it will be necessary to take countermeasures to prevent land subsidence.

Moreover, a site should not be chosen in an area with high rainfall or a watercatchment area, and where there is a water intake point located immediately downstream of the landfill site. As for underground water, it is important to study the conditions of the aquifer, the water level and water usage.

d. Safety Against Disaster

It is necessary to make a preliminary study to ensure that the landfill site is from, for example the risk of landslides, flooding subsidence or avalanches in the site.

e. Ultimate Landuse Plan

It is desirable that the landfill system should not only be seen to support environmental conservation, but should also contribute towards improving the well-being of people in the region.

In recent years, public consent has become a very important in the construction of landfill sites and their facilites. The effective use of the completed landfill has also become an important factor in obtaining public consent. A landfill system implemented in this way should therefore select an ultimate landuse plan which promises effective regional improvement, and which is based on the present situation of the surrounding area and the future plan for urban development.

f. Location of Related Facilities

In principle, solid waste treatment consists of the process of collection/hauling and treatment/disposal of wastes which must be done quickly without causing environmental problems and at the same time economically. Therefore, the related facilities should be located in a functional manner.

The location of a landfill system should preferably be:

(a) near the cleansing office and activity base of intermediate treatment facilities.
(b) near the pit where cover material is kept.

g. Availability of Cover Soil

In identifying the suitability of a landfill site, it is important to consider the availability of cover material in the vicinity, to facilitete the soil covering. Ideally speaking, one fourth of the total volume of the landfill site should be assigned for cover soil. Therefore, a large volume of cover material is needed and the cost of transporting the material for some distance will be quite significant.

h. Landfill Area is of Sufficient Size

It is also necessary to ensure that the area proposed for the landfill should be utilized for a number of years. This is because the construction costs of landfill facilities, which include approach and access roads, leachate collection and treatment facilities, drainage system, guard house, etc. will be approximately the sameexpense of the area of its landfill site. If the landfill has a short life because the area is small, this will mean that capital investment cost to build new landfill will increase.

Technical Guidelines for Design of Landfill Site

1) Landfill Disposal Concept

The aim of solid waste disposal is to immediately remove solid waste from urban community and reduce its volume, making it stable and hygienic. In choosing the process of proper treatment and disposal, not only the geographical area should be considered but also the financial situation and the level of technology within the organization responsible for solid waste management. This management process can usually be divided into three processes such as collection/transport, intermediate treatment and final disposal. Basically landfill disposal is the only final disposal process which finally restores solid wastes to the nature.

The purpose of landfill disposal is to stabilize the solid waste and to make it hygienic through proper dumping of waste and use of natural metabolic function. Therefore, it is important to have a practical method of disposal which can be decided upon by regional conditions and organizational situation. In making this decision, it is important to take into account the type, form, composition of wastes, location of landfill site, regional, hydrological and climatic condition.

In planning the final disposal, it is necessary to determine the types and volume of waste for landfill and to formulate an effective masterplan for solid waste management based on the actual needs of the region. The final disposal plan should also be formulated in such a manner as to be organic with the collection or hauling plan and intermediate treatment plan.

2) General Requirements for Landfill

a. Definition of Landfill

"Landfill" means a waste disposal site used for the controlled deposit of the waste onto or into the land, and the landfill system has been prepared many facilities and equipments to protect the surround secondary pollutions from the site.

"Landfill" consists of eleven basic contents as follows:

1. Considered location;
2. Planned access road from service areas;
3. Fencing sufficiently to prevent free access to the site;
4. Considered landscaping;
5. Identification and information boards must be provided;
6. Control of access and information;
7. Water control and leachate management;
8. Protection of soil and ground water;
9. Gas control;
10. Monitoring system;
11. Control of stability.

b. Basic Contents

1. Considered location

The location of a landfill must take into consideration requirements that is shown as "Technical Guidelines Regarding Location Landfill Site".

2. Roads and service area

(1) Access to a landfill shall be planned in such a way that it creates minimal hindrance to existing public road.
(2) The landfill shall be equipped so that dirt originating from the site is not dispersed onto public roads and surrounding land.
(3) All the roads are service areas within the boundary of the landfill must be built and maintained to comply with the water control and soil and ground water protection measures required for the site itself.

3. Fencing

The landfill shall be surrounded by fencing sufficient to prevent free access to the site. The gates shall be locked outside operating hours.

4. Landscaping

Measures shall be taken in order to reduce the visual impact of a landfill, in particular when easily visible from residential areas, recreation area and roads.

5. Site identification and information

(1) At the entrance of a landfill an identification and information board must be provided displaying the following information:

- name and class of the site;
- name of the owner and or operator;
- licensing identification;
- operating times;
- contact and emergency telephone numbers;
- authority responsible for the operating permit and control of the site;

(2) The additional information must always be available to be public on request:

- type of wastes for which the site has received an operating permit;

6. Control of access and operation

(1) An appropriate system for control of access must always be provided at the entrance of the site.

(2) All waste delivered shall always be controlled on its

- origin
- type of characteristics
- quantity weight or volume
- the appropriate identification

(3) The system of control and access to each facility should contain a programme of measures to detect and discourage illegal dumping.

(4) During operation hours, a suitability qualified person in charge of the landfill operations must always be present.

7. Water control and leachate management

a. Appropiate measures shall be taken in order to control surface and or ground water entering into the landfiled waste.
b. All water or leachate emanating from the landfill shall be collected by means of an efficient drainage system, so as to ensure that no water accumulates at the bottom of the site, unless, though an environmental impact assessment, it is determined that collection is not required.
c. Contamined water and leachate collected from the landfill shall be treated to the appropriate standard required for its discharge.

8. Protection of soil and groundwater

(1) A landfill must meet the necessary conditions, naturally or artificially achieved to prevent pollution of the soil or groundwater

(2) The non-saturated geological formations constituing the substratum of the landfill base and sides shall satisfy the following permeability and thickness requirements. Maximum values of the permeability coefficient, k (m/s), for a substratum thickness of three meters measured under conditions of water saturation:

- Landfill for hazardous waste: $k = 1.0 \times 10^{-9}$ m/s
- Landfill for municipal and nonhazardous wastes and for other compatible wastes: $k = 1.0 \times 10^{-9}$ m/s
- Landfill for inert waste: k = no limit value

9. Gus control

(1) Appropiate measures shall be taken in order to control the accumulation and migration of landfill gas.

(2) Landfill gas shall be collected and properly treated and preferably used in such a way as to minimise damage to or deterioration of the environment unless by an environmental impact assessment it is determined that collection is not required.

10. Nuisances

Measure shall be taken to prevent arising from the landfill through:

- emission of odours and dust
- wind blown materials
- noise and traffic
- birds, and vermin and insects
- formation of aerosols

11. Control of stability

To provide for stability of the mass of waste and associated structures, particularly in respect of avoidance of slippages, the emplacement of waste on the site shall take place under suitable system of quality assurance.

Japanese Experience in Acquiring Local Residents' Consents to Landfill Projects

1. Land Acquisition

Land acquisition shall legitimately and smoothly be carried out by the relevant authorities starting with the Bucharest Municipality as soon as possible or at least in time to meet the proposed schedule of the waste final disposal site development. Land acquisition is carried out through the necessary steps and legal procedures based on the existing laws concerned such as the Constitution of Romania/1991, and particularly articles of Local Administration (Section 2), Land Law No. 18/19 February 1991, Law No. 33/1994 concerning Expropriation for a cause of Public Use, etc.

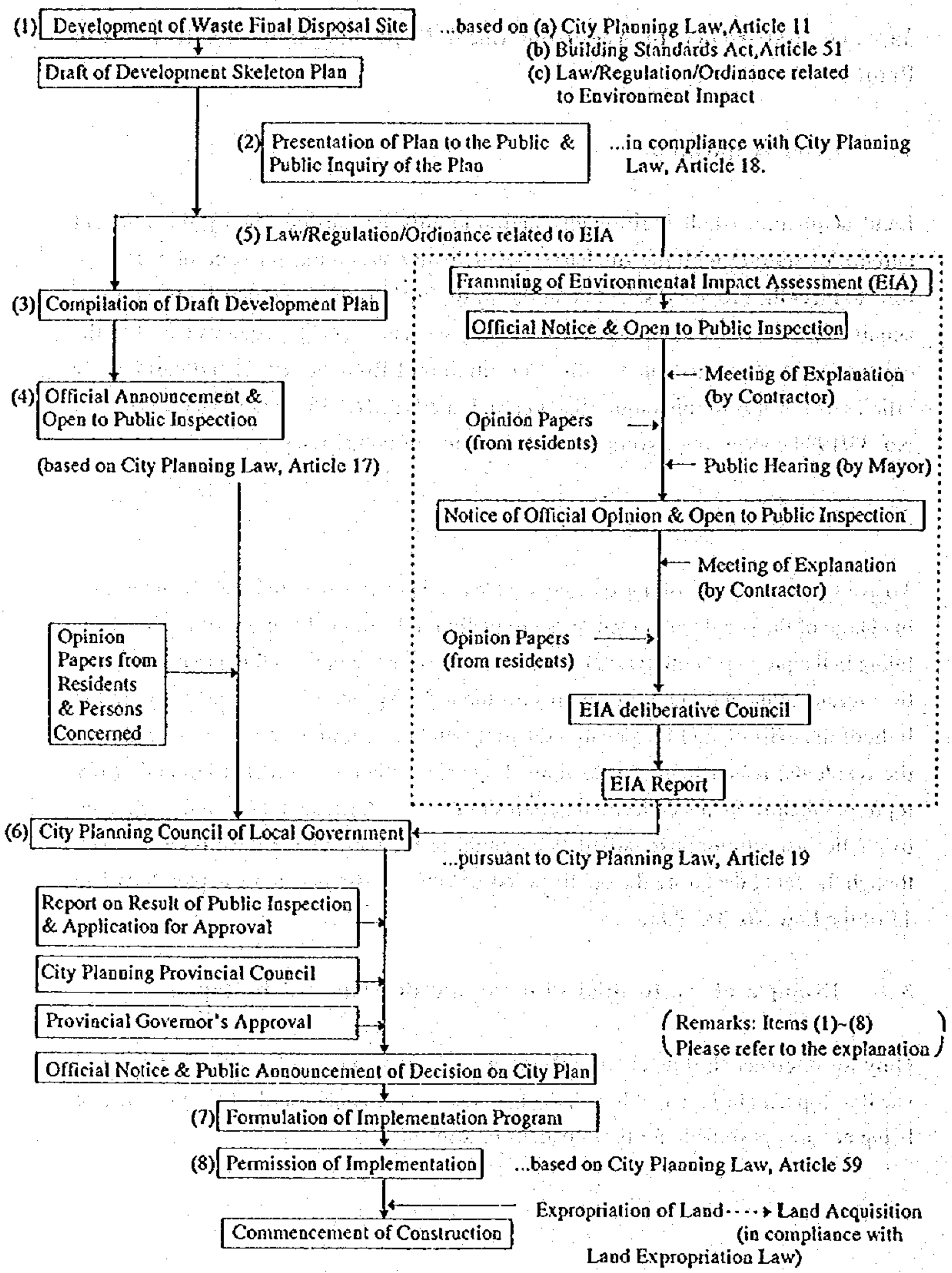
2. Resident's Consent

To avert the occurrence of unexpected troubles on land, it is required that the authorities in charge of the site development peacefully obtain the mutual consent of the residents living in the proposed county/village for the site development in addition to carrying out the aforementioned de jure procedures for the land expropriation of public use. In the light of the existing and foreseeable situations and/or conditions on land in relation to the residents, it had better be examined again whether the relevant councils fully represent their residents concerned in terms of the case. Official notices and/or opening to public inspection are regarded as essential in the case of the development, even though the act of declaring the public purpose is clearly stipulated in Chapter 2. Article 11 of the Law No. 33/1994.

3. Example of waste final disposal site development in Japan

Only for reference, a flow chart is shown as follows as a case of waste final disposal site development in Japan, although the laws and acts are not described here because of being not always suitable for the situations in Romania.

A Case of Waste Final Disposal Site Development in Japan



Explanation

(1) Waste treatment facilities are regulated as follows by City Planning Law and Building Standards Act.
The facilities are stipulated as "Urban Facilities" by Article 11 in City Planning Law while as "Locations of particular buildings utilized for wholesellers markets etc.", by Article 51 in Building Standards Act.
In principle, decision on the city plan shall be made by local government.

(2) Meetings are held for presentation of the city plan to the public and comments on it from the people, as one of procedures toward decision in compliance with City Planning Law, Article 16, in order to reflect the opinions of the residents and the persons concerned (land owners etc.) in the draft of urban development plan during the process of its compilation.

(3) A draft of the city plan shall be mapped out considering the opinions of the residents and the persons interested made at the public meetings.

(4) Decision shall entail the public inspection on the city plan made by local government according to City Planning Law, Article 17. Opinion papers on the plan shall be submitted to the local government by the residents and/or the persons concerned should they have any opinions.

(5) Implementation of the environmental impact assessment (EIA) shall be required to determine the city plan as stipulated in the ordinance dated 6th June, 1985 of the General Director, City Directorate of the Ministry of Construction. The process of EIA implementation is shown in the flowchart.

(6) The city plan shall be decided at the approval of the provincial governor after the City Planning Council deliberates the residents' opinion papers and the EIA report(s), according to City Planning Law, Article 19.
In the case that the city plan is related to urban facilities to be installed in an area of another city, adjustments shall sufficiently be required for the plan between the relevant local governments, since the installation is liable to influence the other cities.

(7) An official notice and public announcement shall be issued on the decision of the city plan immediately after the decision is made and the contractor shall formulate an implementation programme.

(8) Based on City Planning Law, Article 59, the implementation of the city planning programme shall start with such execution as land acquisition etc., upon the provincial governor's approval of the programme applied by the local government.

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