IV. Collection Improvement

IV COLLECTION IMPROVEMENT

This Chapter is written to facilitate the productivity improvement of solid waste collection process which is the most expensive process of SWM.

4.1 INTRODUCTION

In many of the cities in developing countries, heaps of garbage are left uncollected due to the inefficiency and ineffectiveness of existing solid waste collection services, thus causing serious damage to urban health and the quality of life. Generally speaking, the collection process is the most labour intensive and expensive process in the whole municipal SWM system which consists of the processes of storage, collection, street sweeping, transfer, transportation, treatment and final disposal. The expenditure for solid waste collection service is already very high in many local governments of developing countries, but more financial resources will be required for this service as the service demand will increase especially in poor area because of the rapid urbanization process.

However, with the prevailing unfavourable economic situation the resources available for this service such as financial and human resources as well as equipment are limited. Therefore, the productivity improvement (in other words, do more with less) in municipal solid waste collection is an urgent task to satisfy the ever increasing service demand with limited available resources. The aim of this Chapter is to give a practical orientation about how to improve refuse collection productivity to the people who are responsible for SWM in local governments.

4.2 WORK MEASUREMENT SYSTEM*

Solid waste collection is a very labour intensive work. At the same time, collection vehicle cost is relatively high in developing countries compared with labour cost. Therefore, the following two things become necessary to improve the collection efficiency:

(1) Maximum use of legal working hours
(2) Maximum use of vehicle capacity

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* Examples shown in this part have been developed based on the work included in Klang Valley Environmental Improvement Project prepared in April 1987 by Engineering Science Inc. and SEATEC International in conjunction with Department of Environment of Malaysia.

For these maximization, it is necessary to know first of all their present level. This can be done by the application of work measurement systems.

4.2.1 Section Foreman's Evaluation

In this Chapter, the words route, district, section and zone are used. The word route means the path each collection crew follows in the collection area per shift. A route may be covered by one trip, two trips or more. The word district means the portion of collection area covered by one route. If a daily collection system (six times or seven times per week) is used, a crew will be responsible for one district. If twice a week collection is carried out, then a crew will be responsible for two districts which are covered by the Monday-Wednesday-Friday route and Tuesday-Thursday-Saturday route. Therefore, three districts will be covered by one crew if three times per week collection system is used. The words section and zone mean the portions of collection area to which a foreman and a supervisor are responsible respectively. Generally a foreman is assigned to a section with five to six collection crews, and a supervisor is assigned to a zone with five to six foremen.

The collection activity is a repetable cycle with crew assignment in the form of route maps instead of work orders. Therefore, work measurement can be done by recording crew assignment and work statistics for each route. This recording can be done, for example, by asking drivers to fill in the Daily Collection Route Information Form shown in Figure 4-1. If it is troublesome to get the drivers to do it, then the foremen can fill in the Daily Lineup Sheet shown in TABLE 4-1. In this Chapter, the discussions will be made on how to establish work measurement systems based on the Daily Lineup Sheet, because the Daily Collection Route Information Form gives enough informations to fill in the Daily Lineup Sheet.

The Daily Lineup Sheet can be prepared by the foreman with intended crew, route and vehicle assignments filled in and necessary modifications made at the beginning of the day. Entries would be made at the end of the day by him for each crew giving such information as quantity of waste collected, time, distance, disposal site, exceptions such as delays or breakdowns and similar data of value in assessing performance. This form also functions as the source of information for payroll time.

Evaluation of the performance of each crew would be made by the foreman at the end of day filling the Foreman's Evaluation Form shown in TABLE 4-2 and interpreting the figures through their comparison with the averages. Typical foreman's evaluation is shown in the following:

(1) Crew No.1 is performing well. Their work is being completed in less than a standard working day resulting in undertime, but their paid man hours per ton are low and the vehicle capacity utilization is high (87%).

Figure 4-1 Daily Collection Route Information Form

DAILY COLLECTION ROUTE INFORMATION

ROUTE ____________ DATE ______________ DAY ______________ CREW SIZE ______________

VEHICLE NO. ______________ FUEL (GAL) ________ ENG. OIL (QT) ____________

NO. HOMES SERVED ____________	TIME	MILES	WEIGHT	DISCHARGE POINT
LEAVE MOTOR POOL				
START COLLECTION				
LEAVE ROUTE				
AT DISCHARGE POINT				
ARRIVE BACK ON ROUTE				
LEAVE ROUTE				
AT DISCHARGE POINT				
ARRIVE BACK ON ROUTE				
LEAVE ROUTE				
AT DISCHARGE POINT				
ARRIVE BACK ON ROUTE				
LEAVE ROUTE				
AT DISCHARGE POINT				
ARRIVE BACK ON ROUTE				
LEAVE ROUTE				
AT DISCHARGE POINT				
ARRIVE AT MOTOR POOL				

LUNCH – START – FINISH			BREAK DOWN – PROBLEM
BREAKDOWN – START – FINISH			1 Brakes, wheels, tires 2 Cooling or exhaust sys 3 Electrical sys 4 Fuel sys 5 Packer 6 Power or steering sys 7. Other
VEHICLE REPLACED			

ENTER NUMBER
1. INCENERATOR
2. LANDFILL
3. TRANSFER STATION

REMARKS:

DATA VERIFIED BY: ______________

Source: American Public Works Association. Solid Waste Collection Practice (Fourth Edition). p.392.

TABLE 4-1 A Typical Example of Filled-In Daily Lineup Sheet

DAILY LINEUP SHEET

Section : A
Date : Saturday 3 February 1990

Crew No.	Names	Route No.	Equip. No.	Start Time	End Time	Ton	Trips	Disp. Site	Km	Exc. Code*
1	Name 1 Name 2 Name 3 Name 4	A6	23	0600	1330	7.8	2	S1	45	
2	Name 5 Name 6 Name 7 Name 8 Name 9	A4	15	0600	1400	10.2	3	S2	57	
3	Name 10 Name 11 Name 12 Name 13	A1	8	0830	1630	8.3	2	S2	40	D
4	Name 14 Name 15 Name 16	A5	17	0600	1330	2.8	1	S2	22	B
5	Name 17 Name 18 Name 19 Name 20	A3	5	0600	1315	5.7	2	S1	42	

* Exception Codes :

D = delay at start
B = breakdown

TABLE 4-2 A Typical Example of Filled-In Foreman's Evaluation Form

FOREMAN'S EVALUATION FORM

Section : A
Date : Saturday 3 February 1990

Crew No.	Crew Size	Route No.	Ton	Trips	Ton/ Trip	Ton/ Cap.	Time Hrs.	Man Hrs			PMH	PMH/ Ton	Exc. Code
								ACT	OT	UT			
1	4	A6	7.8	2	3.9	0.87	7.0	28.0	0	2.0	30.0	3.85	
2	5	A4	10.2	3	3.4	0.76	7.5	37.5	0	0	37.5	3.68	
3	4	A1	8.3	2	4.15	0.92	10.0	40.0	10.0	0	40.0	4.82	D
4	3	A5	2.8	1	2.8	0.62	7.0	21.0	0	1.5	22.5	8.04	B
5	4	A3	5.7	2	2.85	0.63	6.75	27.0	0	3.0	30.0	5.26	
Totals			34.8	10				153.5	10.0	6.5	160.0		
Averages					3.48	0.76						4.60	

Exception Codes:
D = delay at start
B = breakdown

ACT = actual man hours worked
PMH = paid man hours
OT = overtime
UT = undertime

Payment Basis Used in This Example:

Standard paid workday is 7.5 hours (a 0.5 hour meal time is not paid). A modified task system is used. If crews complete their assignment in less than 7.5 hours, they are released and paid 7.5 hours. Time paid but not worked is undertime. If they need more than 7.5 hours to complete their assignment, overtime is paid at straight time.

Capacity of vehicle : 4.5 ton/trip

(2) Crew No.2 is in good balance. Paid man hours per ton are the lowest and the vehicle capacity utilization is acceptable (76%). High efficiency of this crew may be the result of the high concentration of the wastes in the assigned route.

(3) The overtime for crew No.3 resulted from unavailability of equipment at the start of the shift. Performance was otherwise satisfactory (If the delay effect were subtracted, paid man hours per ton would be the lowest. And there would be neither overtime nor undertime). The

vehicle capacity utilization is the most efficient (92%).

(4) The poor performance of Crew No.4 was due to a breakdown on the route.

(5) Crew No.5 appears to have too small a route. Undertime exists, vehicle capacity utilization is low (63%), and paid man hours per ton are higher than the average.

It should be noted that all of the above evaluations are based on the single day's performance of the crews. The foreman should verify these tentative evaluations with data from previous records. Continuous work measurement will give informations on long term performance and help the foreman to identify the crew with poorest performance. This problematic crew (or problematic route or district) has the highest necessity and possibility of collection productivity improvement.

However, it is also very important to note that the comparison with the averages has only limited validity because each collection district has its own conditions such as topography, road condition, waste generation density, collection frequency, collection point (curbside vs. backyard), type of refuse bins (bags, palstic containers, concrete bins, etc.), type of collection vehicle (animal traction vehicle, flat bed truck, tipper truck, compactor vehicle, etc.) and so on. Therefore, the work statistics should be interpreted properly by foremen based on their knowledges on the special features of each collection district. If two crews show a big difference in their performance although their assigned districts have more or less similar conditions and the used collection systems are similar except one factor, then that factor is quite worthy of a detailed study because it may show the way to improve productivity.

4.2.2 Zone Supervisor's Evaluation

As already mentioned, a supervisor is assigned to a collection zone with five to six foremen. The results of work measurement by these foremen will be reported to their supervisor. Therefore, an evaluation should be made at the zone level by the zone supervisor based on the reports submitted by foremen. This evaluation can be done on monthly basis using the Zone Supervisor's Evaluation Form shown in TABLE 4-3.

Typical supervisor's evaluation based on TABLE 4-3 is shown in the following:

(1) Section A is performing satisfactorily. Overtime and undertime are reasonable, each less than 5 per cent of PMH. Paid man hours per ton are slightly above the average. Vehicle capacity utilization is better than the average for the zone.

TABLE 4-3 An Example of Filled-In Zone Supervisor's Evaluation Form

ZONE SUPERVISOR'S EVALUATION FORM

Zone : C
Period : 1 - 28 February 1990

Section	Ton	Man Hours			PMH	PMH/	Ton/
		ACT	OT	UT		ton	Capacity
A	832	3680	150	170	3850	4.63	0.75
B	1080	4805	300	85	4890	4.53	0.72
C	875	4265	65	310	4575	5.23	0.84
D	735	3575	425	360	3935	5.35	0.71
E	1210	4420	600	15	4435	3.67	0.73
F	970	2970	130	510	3480	3.59	0.68
Total	5702	23715	1670	1450	25165		
Average						4.41	0.73

(2) Section B is performing well. Although overtime is higher than Section A, it is not excessive and the paid man hours per ton and the vehicle capacity utilization are about average for the zone.

(3) Section C has a high paid man hours per ton, undertime is high and overtime is low. The vehicle capacity utilization is the highest. This indicates that the section has too many workers for the amount of waste being collected. The zone supervisor should discuss this with the Section C foreman and decide whether this is a long term trend. If so, personnel should be transfered to other sections. Expansion of the routes is not recommended because the vehicle capacity is already highly used.

(4) Section D is performing poorly, having the highest man hours per ton of the zone. Both overtime and undertime are high, in the order of 10 per cent of the PMH. This is an indication that the work load is not balanced among the crews, some have too much and some have too little. The zone supervisor should review the daily work summaries with the Section D foreman and assist him in making adjustments, i.e., increasing some crew routes and decreasing others.

(5) Section E is the opposite case of Section C. The productivity expressed in ton/PMH is very high. Undertime is very low (less than 1 per cent) and overtime is the highest in the zone at 14 per cent. This indicates that the section's workforce is too small for the amount of waste being collected. The zone supervisor should discuss this with the Section E foreman and decide whether this is a long term trend. If so, personnel for this section should be increased to reduce the overtime.

(6) Section F has the highest productivity expressed in ton/PMH. However, the undertime is the highest and the vehicle capacity utilization is the lowest in the zone. This may show the possibility of one or some of the following:

   (a) Performance of Section F is really excellent.
   (b) High productivity is the simple result of rushed service with problematic service quality (spill, missed pick-up, etc.).
   (c) High productivity is the result of the high concentration of the wastes in the section (i.e. commercial area).
   (d) Assigned routes are not enough for the workforce and equipment. Therefore, Section F should be expanded to have more work assignment.

The supervisor should inspect the work in the field to see which the case is. After the identification of the real cause, necessary measures should be taken. If the performance of Section F is really excellent, any innovative measures in Section F should be studied for their possible application in other section.

4.2.3 A Weighbridge as a Basic Equipment for Productivity Improvement

The essence of work measurement is to measure the time consumed for the collection work and the amount of solid waste being collected. Therefore, the installation of weighbridges at the entrance of strategic facilities such as transfer stations, composting plants, incineration plants and final disposal sites is indispensable for the establishment of the work measurement system.

However, the decision makers of many local governments are usually not so favourable for the installation of weighbridges believing that weighbridges do not collect solid waste. Although weighbridges do not collect solid waste directly, they help the existing collection vehicles to collect more solid waste through the identification of the underutilized collection vehicles.

TABLE 4-4 shows the results of time and waste amount measurement made by the author and his group for a SWM service in an Asian city. Waste amount measurement was made using a private weighbridge because the city had no weighbridge in spite of its relatively large population (half million). This TABLE shows that both the working hour utilization efficiency and the loading capacity utilization efficiency were astonishingly low. However, the most important thing is the fact that this city had been delivering its SWM service without noticing its low efficiency. Even in the case of a modern electronic weighbridge fitted with a personal computer (See Figure 2-4), its price including the cost of installation is about one half of a compactor type collection vehicle (16~20 cubic yard). As such, the installation of a weighbridge definitely pays if a city has a population more than two hundred thousands because the weighbridge will easily identify the underutilized loading capacity equivalent to one compactor vehicle.

TABLE 4-4 Example of Resource Underutilization

Area No.	Area/System Type	Collection Frequency	Number of Trips	Total Working Hours	Working Hour Utilization Efficiency (%)	Amount of Waste Collected (ton)	Loading Capacity Utilization Efficiency (%)
1	Commercial	Daily	2	4h40min	66.7	2.62	26.2
2	Residential/ Flat	3 times/w	1	4h12min	60.0	3.90	39.0
3	Side Loader	Daily	1	4h20min	61.9	1.30	52.0
4	Commercial	Daily	1	4h57min	70.7	2.20	22.0
5	Residential	3 times/w	1	4h04min	58.1	3.68	36.8
6	Residential	3 times/w	1	4h01min	57.4	3.64	36.4
7	Residential	3 times/w	1	4h55min	70.2	2.78	27.8
8	Roll-on Roll-off	Daily	4	6h12min	88.6	6.56	54.7
9	Mechanical Bin	Daily	1	5h14min	74.8	3.36	33.6

Notes: (1) Legal working hours = 7 hrs = 420 min.
(2) Loading capacity of a compactor vehicle (13 yd^3)
13 yd^3 X 0.76 m^3/yd^3 X 0.5 ton/m^3 X 2 trips/day = 10 ton/day
(3) Loading capacity of a side loader (8 yd^3)
8 yd^3 X 0.76 m^3/yd^3 X 0.2 ton/m^3 X 2 trips/day = 2.5 ton/day
(4) Loading capacity of a big bin for Roll-on Roll-off vehicle (20 yd^3)
20 yd^3 X 0.76 m^3/yd^3 X 0.2 ton/m^3 X 4 trips/day = 12 ton/day

The use of a weighbridge has one more advantage. It will be very helpful to check overloading which is fatal for vehicles coupled with bad accesses to dumping sites. Solid waste in developing countries has higher specific weight compared with that of industrialized countries. As such, collection vehicles imported from industrialized countries can be easily overloaded causing premature breakdown. If a collection crew is assigned to an area where a work load is a little bit more than one trip, it is very natural for them to try to collect all the waste in one trip so as to go back early to their homes. Therefore, the solid waste collection service without weight check system will suffer from overloading in the first trips and underloading in the second trips which will result in both poor productivity and premature breakdown of equipment.

4.3 TIME AND MOTION STUDY

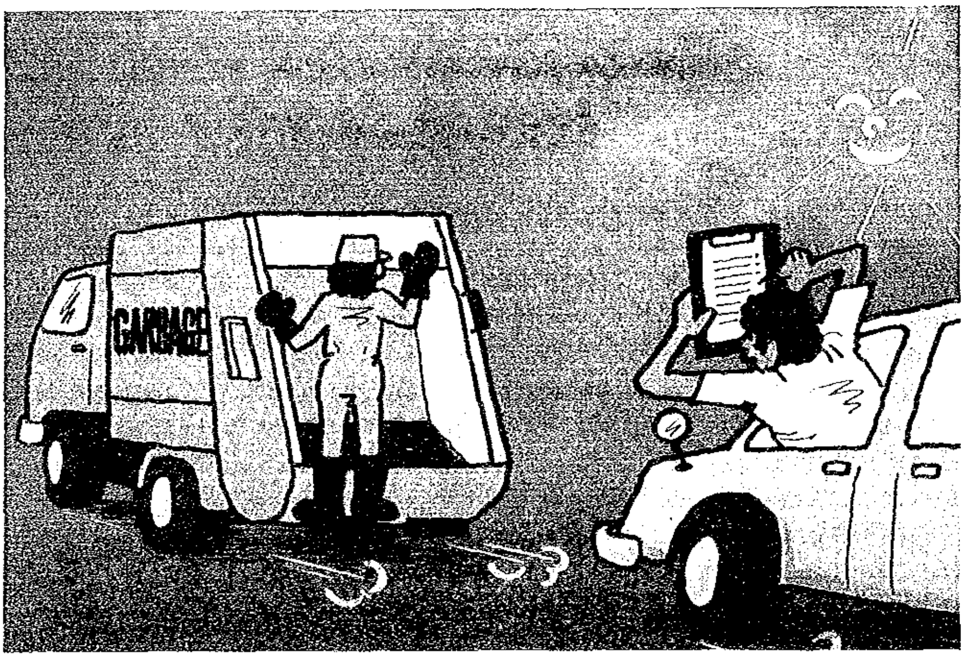
Work measurement system described in 4.2 shows the collection districts (routes), sections and zones with poor performance. Once identified by the work measurement system, these problematic districts, sections and zones should be analyzed more in detail to determine the causes of poor performance and work out remedial measures. Recommended methodology for the detailed analysis is the time and motion study of the collection process.

The time and motion study is a procedure to carry out the collection of relevant data in the field and the analysis of those data in the office in a systematic manner, and, if properly used, will be very useful for decision makers of SWM services in developing countries in their task to identify actual requirements and viable options for the improvement of their solid waste collection systems.

4.3.1 Objectives of the Time and Motion Study

The general objective of the time and motion study is to diagnose the present collection system and to obtain basic data to plan for its improvement. To achieve this objective, data will be collected in the field by the study team as it follows the collection vehicle (See Figure 4-2). The collected data will be analyzed later in the office to identify possible improvements in the collection systems.

Figure 4-2 A Collection Vehicle Followed by a Study Team



Source : JICA, May 1986. Slide Programme : A Time and Motion Study of Municipal Solid Waste Collection Systems

To improve the collection system, the decisions shown in TABLE 4-5 should be made by top and middle management. A time and motion study will give managers useful information to make these decisions.

TABLE 4-5 Necessary Decisions for Collection System Design

1. Areas to be attended by service (Service coverage)
2. Wastes to be collected
   - Household wastes
   - Commercial wastes
   - Hospital wastes
   - Market wastes
   - Industrial solid wastes
3. Type, size and material of containers
4. Point of collection
   - Door to door (backyard)
   - Door to door (curb)
   - Fixed station
5. Use of communal containers
6. Agencies of collection operation
   - Municipality
   - Municipal enterprise
   - Private contractors
   - Scavengers
7. Frequency of collection
8. Collection in holidays
9. Use of shifts
10. Collection timetable
11. Type and size of collection equipment
    - Human powered equipment
    - Animal powered equipment
    - Motorized vehicles
      - with or without compaction
      - with or without tipping facility
      - with or without cover
12. Fixed working hours vs. task system
13. Crew size
14. Use of transfer stations
15. Sorted collection with source separation vs. mixed collection

Specific objectives of the time and motion study are as follows:

(1) To know how efficiently the collection equipment is used;
(2) To know how collection workers spend their time;
(3) To check whether the collection route is appropriate or not;
(4) To check whether the collection time schedule is appropriate or not;
(5) To check the characteristics of dustbins;
(6) To know the crew's behaviour; and
(7) To know the level of user cooperation with collection work.

<u>The first objective</u> is to know how efficiently the collection equipment is used. In this connection, the following two questions should be answered:

(1) Are the collection vehicles loaded to capacity ? (Loading capacity utilization efficiency)
(2) Are the working hours being used efficiently ? (Working hour utilization efficiency)

In developing countries where vehicle costs are high and labour costs are low, and available foreign exchange for vehicle purchasing is limited, it is reasonable to assign several collection workers to each collection vehicle with the aim of maximum utilization of equipment (labour intensive system). On the other hand, in industrialized countries labour costs are so high that labour saving measures such as the use of one-man vehicles necessitate investing more in equipment (capital intensive system). With economic and social advances, labour costs are likely to increase more rapidly than equipment costs, so the gradual mechanization of solid waste collection services would become necessary in every country.

<u>The second objective</u> is to know how efficiently the collection workers spend their time. Working efficiency of collection workers can be expressed as follows:

(a) Gross Man-Minutes*/Ton of solid waste collected.
    * This includes all time elapsed between departure from and return to the garage.
(b) Net Man-Minutes**/Ton of solid waste collected.
    ** This includes only the time used in collection area.
(c) Ton of solid waste collected/Man-Day

It is not expedient to compare the efficiencies (both equipment utilization efficiency and collectors' working efficiency) of different cities and areas because local conditions are different. However, it is very useful to compare the efficiency after system modification with that prior to modification within the same city and area. By doing so, it becomes possible to evaluate the improvement achieved by system modification.

<u>The third objective</u> is to check whether the collection route is appropriate or not. The typical collection route is selected by the driver and is fragmented. A fragmented route reduces the collection efficiency.

As factors contributing to inappropriate collection routes, the following may be pointed out:

(a) Duplication and/or fragmentation.
(b) Too many right turns and U-turns (in the case of countries where drivers keep to the <u>left</u>).
(c) Uphill collection.
(d) The first dustbin is located far from the garage and the last far from the dump site, even though it is possible to begin with dustbins located near the garage and finish with those located near

the dump site.

(e) Infractions of traffic regulations.

A fragmented route should be transformed into a compact route using the "heuristic routing" method shown in 4.5.

The fourth objective is to check whether the collection time schedule is appropriate or not. An example of an inappropriate time schedule would be the collection work being done in commercial areas during rush hours. It is more practical to carry out the collection work in these areas in off peak hours. In city center areas, early morning collections or midnight collections are utilized very often in order to avoid inefficient collection during rush hours. There are also many cities where the first trip is assigned to early morning collection in the city center areas and the second to residential area collection.

The fifth objective is to check the characteristics of dustbins. Inappropriate dustbins will threaten not only health and aesthetic conditions but also collection efficiency. Therefore, the size and the material of containers, their condition, and whether their lids fit well or not should be checked. If there are any regulations on dustbins, then it will be necessary to check the degree of compliance and identify areas that require improvement and viable options to bring about improvement. If such regulations do not exist, then the dustbin study will give basic data for the preparation of such regulations.

The sixth objective is to know the crew's behaviour. The points to be checked in a crew behaviour study are as follows:

(a) Collaboration among crew members;
(b) Relations with the users (citizens);
(c) Unsafe movement;
(d) Material recovery (pick-up); and
(e) Tipping.

It is especially important to identify the unsafe behaviour of collection workers to be able to reduce the risks of accidents. In the magazine "Waste Age" (December 1975), there was a very interesting article about the results of a study on safety in SWM services. The study sponsored by the U.S.Environmental Protection Agency showed that the accident frequency rate of solid waste collection enterprises was, at least seven times higher than the mean accident frequency of all industries in the United States. This observation justifies the establishment and implementation of work safety programmes in SWM services not only for increasing of the workers' welfare but also for the reduction of total service costs.

The Municipal Company of Public Cleansing of Rio de Janeiro (COMLURB) trains its collection workers using the following eight safety rules and has reduced dramatically its accident frequency:

(a) When riding on the steps of a collection vehicle, GRAB HANDLES FIRMLY and DON'T ENGAGE IN HORSEPLAY with colleagues.

(b) Never travel sitting in the hopper of a compactor vehicle. The compaction mechanism CAN START TO WORK unexpectedly and you may be INJURED.

(c) When you collect refuse in plastic bags, try always to pick up without holding them in your arms. There may be broken GLASS inside which can INJURE you.

(d) Be very careful of the compaction mechanism at the time of refuse loading. NEVER TRY TO PICK ANY MATERIAL OUT OF THE HOPPER when this mechanism is working since there is danger of injury to your hands.

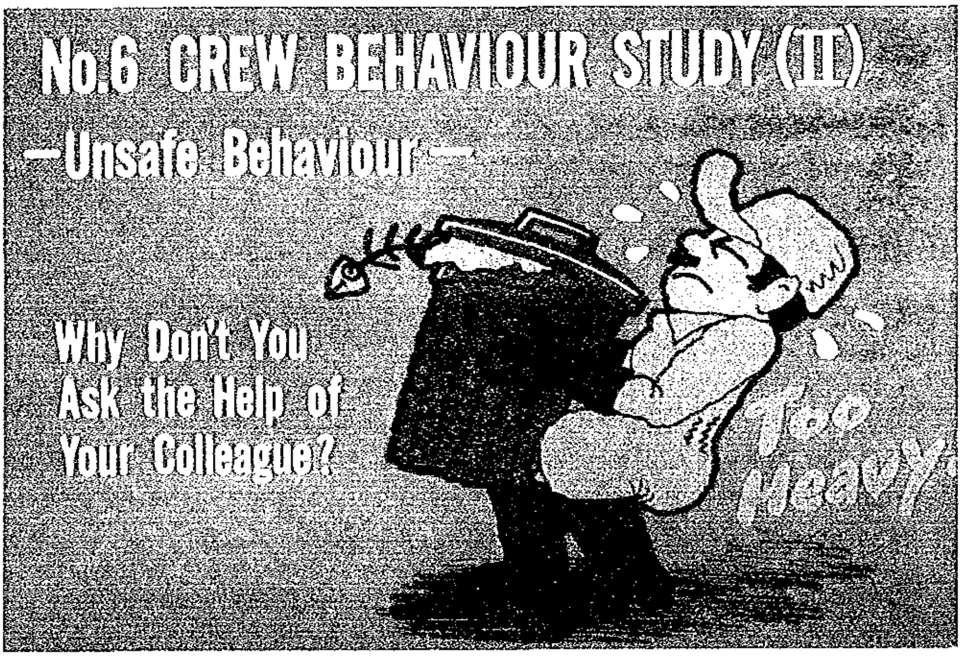
(e) If a DUSTBIN is TOO HEAVY, call your colleague for help. Don't strain yourself transporting excessive weight. The result could be a VERY SERIOUS back injury. (See Figure 4-3)

(f) Always work wearing a FULL and CLEAN UNIFORM. It is for your SAFETY.

(g) If you suffer any accident during your work, try to inform your boss of it IMMEDIATELY.

(h) Avoid ACCIDENTS. Always follow the SAFETY RULES.

Figure 4-3 Back Injury as the Typical Health Problem of Collection Workers



Source : JICA, May 1986. Slide Programme : <u>A Time and Motion Study of Municipal Solid Waste Collection Systems</u>

The seventh objective is to know the level of user cooperation with collection work. The lack of user cooperation will lead to reduced collection efficiency. The following points should be checked regarding user cooperation:

(a) Use of standardized dustbins;
(b) Setting out of dustbins in pre-established setting out points;
(c) Setting out of dustbins at pre-established times; and
(d) Correct source separation (in the case of separate collection).

4.3.2 Preparation of the Time and Motion Study

Careful preparation of information and documents, equipment and tools, personnel, coordination, and data collection format, is the key to the success of the time and motion study.

4.3.2.1 Necessary information and documents

The following information and documents are necessary for the time and motion study:

(a) Map of the collection district (preferable scale 1:5,000);
(b) Population in the collection district;
(c) Number of households in the collection district;
(d) Day and time of collection;
(e) Crew composition;
(f) Characteristics of collection vehicles; and
(g) Others.

4.3.2.2 Necessary equipment and tools

The following equipment and tools are necessary for the time and motion study:

(a) Watch (A digital watch is preferable);
(b) Measure (with length of 2 m);
(c) Counter (very often used in traffic volume surveys);
(d) Weighbridge (with a capacity of 30 tons or more); and
(e) Passenger car or pick-up.

In the case of a motorized vehicle collection system, a passenger car or a pick-up will be necessary if the time and motion study is to be carried out by a group of persons. If the study is carried out as a one-man study, then the surveyor can ride in the cabin of the collection vehicle. In the case of a hand cart collection system, it will be required to follow the hand cart on foot.

If the SWM service has no weighbridge, then it has to study the possibility to use the one installed by other department or a private company.

It is relatively easy to know the location and owners of weighbridges through the local weighbridge dealers.

4.3.2.3 Duty assignment to study team members

If the time and motion study is carried out by a group, data collection work in the field should be specifically assigned to each member of the group in the preparation stage. The following is an example of work assignment in the case of a three-man-study.

(a) Group Leader---Mapping of the route and dustbin set-out points, road condition study and crew behaviour study
(b) Member A-------Time, distance and weight measurement
(c) Member C--------Dustbin study

4.3.2.4 Coordination prior to the time and motion study

For the successful implementation of the time and motion study, it is absolutely necessary to get the understanding of collection workers. Therefore, the collection crew should be informed of the objectives and general procedures of the time and motion study so that unnecessary conflict will be avoided. If it is required to deal with labour union(s), it is very important to have a preliminary talk with union leaders convincing them that the aim of the study is not the intensification of labour but the improvement of working conditions and work efficiency. If the improvement of work efficiency causes intensification of labour, a reduction in working hours and/or a wage increase may be proposed to the union(s) as compensation.

If the SWM service has no weighbridge, then it is necessary to arrange the lease of a weighbridge which is conveniently located for the study. The most important selection criteria is the detour time (the least is the best).

4.3.2.5 Necessary format

Other preparatory work includes the design of a format for data collection. An example of data collection format is attached as Annex 8. However, it must be modified and adapted to local conditions before use. Test use is strongly recommended to facilitate the proper adaptation.

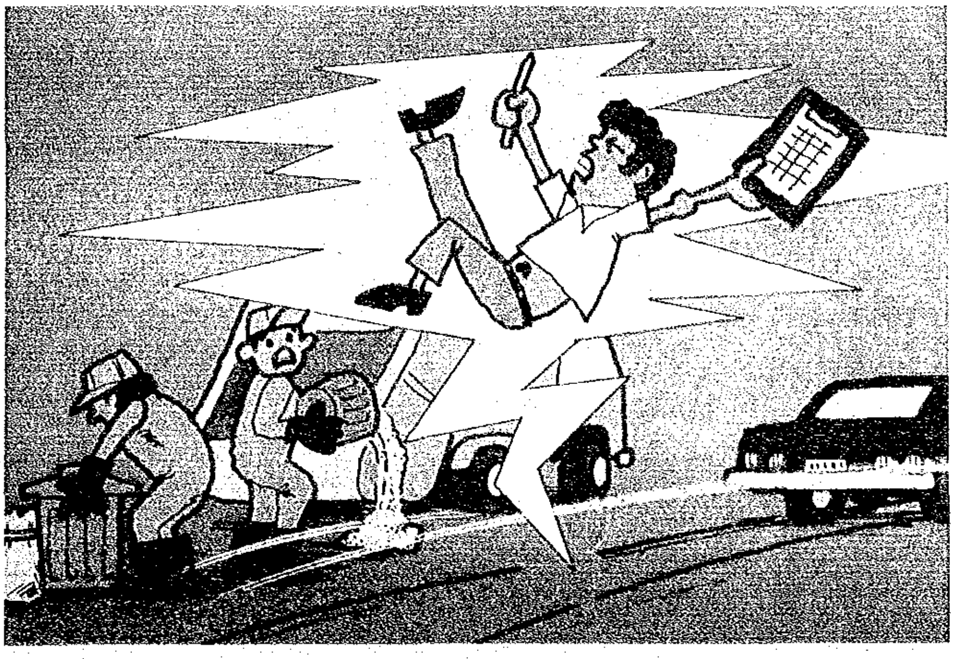
4.3.3 Execution of the Time and Motion Study

The following advices may be useful for the smooth conduct of the time and motion study:

4.3.3.1 Traffic accidents

The most important thing is to carry out the study in a safe manner avoiding traffic accidents (See Figure 4-4). Also, it is very important not to disturb the collection work.

Figure 4-4 Safe Conduct of the Study is Requested



Source : JICA, May 1986. Slide Programme : A Time and Motion Study of Municipal Solid Waste Collection Systems

For the safety, it is necessary to pay special attention to the movement of collection vehicles (backing, compaction, etc.) and the movement of other vehicles. Luminescent vests may be useful for safe conduct of the study. It is also advisable not to carry out the study on rainy days. If the study team is involved in an accident, they should stop the study immediately and inform the superior of the problem.

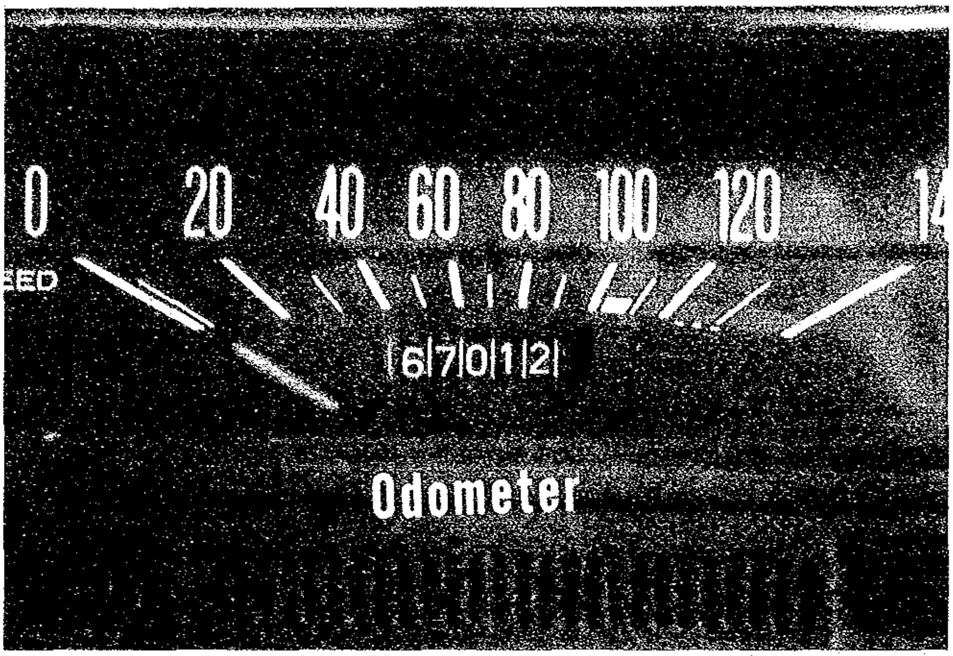
4.3.3.2.Time recording

The recording of time should be done in the field with a watch upon arrival at, and departure from each point of a collection route. For the recording of time in the field, digital watches are more convenient than analogue watches because of the reduced possibility of misreading. Time should be read and recorded in units of seconds. The time consumption in each step can be calculated later in the office.

4.3.3.3 Odometer

The measurement of mileage should be done in the field by reading the odometer (See Figure 4-5) of the passenger car in which the study team follows the collection vehicle. The distance travelled between two points can be caluculated later in the office based on the measured mileage at each point. Should the vehicle's odometer be out of order, distances can be measured on a map.

Figure 4-5 Distance is Measured by Reading Odometer



Source : JICA, May 1986. Slide Programme : A Time and Motion Study of Municipal Solid Waste Collection Systems

4.3.3.4 Size of dustbin

Dustbins should be counted and classified according to their size and types. The size of the dustbins should be measured now and then so that they can be classified correctly into large, medium and small dustbins. Size ranges of large, medium and small dustbins should be pre-established in each city taking into account the size of locally prevalent dustbins.

4.3.3.5 Weighbridge

If the SWM service has no weighbridge, it is necessary to lease one from other department or from a private company. The use of a leased weighbridge will cause detours from the normal collection route, as such it is requested to subtract the detour time and distance from the field survey result to obtain the real travel time and distance.

4.3.3.6 Mapping

The member responsible for mapping is requested to mark clearly in the map the collection route, collection points and garage location. Road conditions such as pavement condition, one-way streets, parking problem, slopes and obstacles (trees, etc.) may also be recorded in the map. Serial numbers should be assigned to the collection points so that references can be readily made in the dustbin study.

4.3.3.7 Motion of a collection vehicle in one complete working shift

In some cities, collection vehicles make several trips from the collection routes to disposal sites during one working shift. The time and motion study should be carried out covering all processes of one complete working shift. In other words, it should cover the period from the departure from the garage to the arrival at the garage.

The total time (Y) in one working shift can be broken down into component parts as shown in the following equation:

$$Y = a + b + n(c_1 + c_2 + d) - c_2 + e + f + g$$

Where a = time from garage to route
b = total collection time on route
n = number of trips
c_1 = time from route to disposal site
c_2 = time from disposal site to route
d = time at disposal site
e = time from disposal site to garage
f = time for official break
g = slack time : lost time due to breakdowns and other delays, incentive time, lunch time

4.3.3.8 Treatment of collection workers

The collection crew members are likely to work more rapidly than usual because they are conscious of being observed. As such it is very important to advise them not to hurry. They can be told something like "If you hurry, this can lead to accidents."

Even with the instructions not to hurry, it is very probable that the crew members will work more rapidly than usual. Therefore, the hurry-up effect on the work crew should be taken into account at the time of data analysis. The best way to know the working efficiency of collection workers without the "hurry-up effect" is to establish a work measurement system (See 4.2). In this system, a daily collection route information form is filled in by drivers of collection vehicles or section foremen and checked by their supervisors and weighbridge masters. By processing the data collected through this system, it becomes possible to determine the working efficiency with less bias.

After the field survey, it may be convenient for the study team to give the crew members something as a token of appreciation.

4.3.4 Analysis of the Field Survey Results

Once the data are collected in the field, then it comes to the stage of their analysis in the office. Analysis should be carried out in such a manner that the problems which require improvement actions would be identified. The study team may identify, among others, the following problems:

4.3.4.1 Working hours utilization study

The analysis of how working hours are spent may show, among others, the following problems:

(a) Start-up delay at the beginning of each shift due to the insufficient number of operating vehicles, badly coordinated work assignment or limited capacity of fueling stations;
(b) Time consuming loading (e.g. loading of loose garbage) and unloading (e.g. intentionally slowed down mechanical unloading to facilitate the activities of scavengers) operations;
(c) Time loss caused by collection during rush hours; and
(d) Too early completion of assigned work (i.e. more work should be assigned).

If a definite area is assigned to a crew with three times a week collection (i.e. This area is divided into two collection districts.), the amount of refuse to be collected on Mondays and Tuesdays is greater than that of the other days of the week. Consequently an assigned work load on these days which slightly exceeds the regular working hours is advisable. The payment of overtime allowances on Mondays and Tuesdays will be more than recovered through effective working hours' utilization on the other days. This is especially true in countries where equipment costs are very high compared with labour costs.

4.3.4.2 Loading capacity utilization study

The analysis of how the vehicles are loaded with waste may show that the vehicle is overloaded on the first trip and underloaded on the second trip because crew members generally want to collect all the garbage in an assigned district in one trip.

Garbage collection vehicles imported from industrialized countries are designed generally for the refuse of the countries of origin (i.e. industrialized countries). Therefore if they are filled with the refuse of developing countries whose density (200~400 kg/m^3) is much higher than that of industrialized countries (100~150 kg/m^3), the resultant overloading can be a cause of premature equipment breakdown. One way to avoid this is, at the time of specification preparation, to select the best combination of chassis and body based on the local conditions. Another is to control overloading by daily use of weighbridges. Identified inappropriate utilization of loading capacity can and should be corrected through re-design of collection routes, modification of collection districts, adjustment of collection vehicle assignment, intensification of supervision, etc.

Vehicle breakdown is very frequent in the SWM services of developing countries for the following reasons:

(a) Overloading due to high density of refuse;
(b) Poor road conditions on access roads to landfill sites;
(c) Incorrect driving due to the lack of driver training; and
(d) Poor preventive maintenance systems.

4.3.4.3 Dustbin study

The third point to be covered in the analysis is the appropriateness of dustbins used by service users. The study team may feel that dustbin types should be standardized. However, the income-level of the community will affect the degree to which standardized containers can be bought. Therefore, the use of standardized dustbins should be introduced first in well off areas.

In choosing the best storage containers for a collection system, the effects on the users (in terms of economy and convenience), public health, and collection efficiency have to be considered. Proper containers can save collectors' energy, increase collection speed, and improve the health conditions of communities. Once selected, the types of containers that residents may use should be defined either by ordinance or regulation, and citizens should be informed of what is expected of them and why. Proper information about collection days, collection time, setting-out points, etc. should also be supplied through appropriate channels together with the information about container types.

The following are the six main categories of containers, and each of them has its own advantages and disadvantages:

(a)* Stationary storage bins are permanent, immovable structures used either to enclose another type of container or for direct storage of solid waste.
(b)* Fifty-five-gallon (200 ℓ) drums are large, heavy, cylindrical containers, usually having no lids. They are commonly discarded oil or chemical drums.
(c)* Containers designed for mechanized collection are used with specialized collection vehicles. They come in a great variety of shapes and sizes.
(d)* Standard, lightweight, 20 to 32 gallon metal or plastic cans are readily moved rigid containers which normally come equipped with lids.
(e)* Paper and plastic bags are used as liners for rigid containers, being removed from rigid containers and set-out on collection days. They are used only once and then discarded.

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*Source : U.S.EPA, 1976. Decision-Makers Guide in Solid Waste Management (Second Edition). p.30.

(f) Improvised containers such as cartons, kerosene tin cans, wood boxes, bamboo baskets, newspaper wrapping, etc. are frequently used in developing countries.

4.3.4.4 Route study

The fourth point to be analyzed is the collection route. The criteria for the identification of route problems are as follows:

(a) Are there unnecessary duplications of trips in the route?
(b) Is the route smooth or fragmented?

(c) Does the route respect traffic regulations?
(d) How many right turns, left turns and U-turns are there in the route?
(e) Are the first and last collection points on the way from the garage to the disposal site?

It will be possible to find ways to save time by using the above-mentioned criteria. Right turns and U-turns are dangerous and time consuming in countries with the policy of driving on the left. If the drivers in the county in question drive on the right side, then it is necessary to reduce left turns and U-turns.

4.3.4.5 Road condition study

The fifth thing to be done is the road condition study. The road conditions such as pavements, traffic regulations, congestion, parking, slopes, blind alleys, narrow lanes and obstacles should be summarized. These road conditions should be taken into account in routing, developoment of proper collection procedure, and negotiations with other relevant authorities responsible for such things as pavement, traffic regulations, parking and so on.

4.3.4.6 Crew behaviour study

The sixth analysis is to be done on the crew behaviour. Crew behaviour should be evaluated in such areas as cooperation between crew members, their relations with the users, unsafe movement, material recovery, and tipping. This evaluation will facilitate the identification of a safer, more comfortable and more efficient way of garbage collection.

Collection workers have direct contact with service users (citizens) on a daily basis, so the impression they give to citizens is crucial for any SWM service to enjoy the positive cooperation of citizens. However, generally they are not trained in how to communicate effectively with others such as citizens and their supervisors. Therefore it is very important to establish a permanent training programme for the improvement of their communication skills as well as for work safety.

4.3.4.7 User cooperation study

The seventh thing to be done is the user cooperation study. User cooperation should be studied in areas such as the use of standardized dustbins, the setting out of dustbins in pre-established collection points according to pre-arranged time schedules, and the grade of material separation, if a separate collection system is used. If lack of user cooperation is identified, it becomes necessary to analyze its causes and take relevant measures to rectify it. The following are typical causes of lack of user cooperation:

(a) Collection service is delivered with doubtful reliability (e.g. lack of punctual service delivery according to a pre-established timetable).
(b) Service users are not informed properly of collection days, collection times, type of standard dustbins, their setting-out points and so on.
(c) Human relations between users and collection workers are not good.

4.3.4.8 Study of the areas of difficult access

The eighth thing to be done is to study areas of difficult access. In many cities of developing countries, there are areas of difficult access for collection vehicles. If the route includes such areas, the present collection methods used in such areas should be analyzed to find wasys to improve them.

For refuse collection from areas with difficult access, non-conventional appropriate systems based on communal participation have to be developed with a great deal of imagination and creativity. Conventional system means, in this case, door-to-door collection by normal size motorized vehicles. Non-conventional collection system is discussed in detail in Chapter V.

4.3.5 <u>Application of the Study Findings for the Collection System Improvement</u>

In 4.3.4, areas where improvements should be made in the collection system have been identified. Next step is to apply the findings of the time and motion study to improve the existing collection system.

Improvement plan should be elaborated based on the study findings. For example, if the necessity of collection route improvment is identified, the route improvment plan should be worked out. This can be done in a simple, noncomputerized "heuristic" or common sense manner based on some rules of thumb (See 4.5).

The improved system should be applied at first on a pilot scale. Pilot scale application followed by evaluation and further modification is very useful in streamlining the improved system. This will reduce the probability of conflicts being caused by the large scale application of an improved system and increase the probability of successful implementation of the new system.

After the necessary modification, the improved system is ready for full application. The cycle from identification of problems and viable options for improvement to full application of the improved system should be carried out continuously because conditions affecting a SWM service are changing day to day necessitating continuous adaptation of the service to its environment. To carry out this cycle continuously, there should be a continuous planning activity within the SWM service.

4.4 POLICY MIX FOR COLLECTION PRODUCTIVITY IMPROVEMENT

Generally, many problems can be identified in the existing collection system as the causes of poor collection productivity. Therefore, more often than not, various improvment measures are required to be taken simultaneously as a policy mix for collection productivity improvement.

To facilitate the elaboration of improvement plan, typical measures for collection productivity are listed up in the following. Although the list is not exhaustive, it will be useful as the source of ideas for collection productivity improvement.

(a) Promotion of communal recycling activities of paper, cardboard, glass, etc. These activities will reduce the waste quantity to be collected.
(b) Standardization of containers. This will make the collection operation more fast and increase the waste quantity to be collected by each vehicle each day.
(c) Use of curbside collection system of fixed station system (in both cases, set-out and set-back of household containers will be done by users). Door-to-door backyard collection is too expensive and time consuming.
(d) Rationalization of collection frequency. In residential areas, 2 ~ 3 times per week collection will be sufficient. Daily collection has lower efficiency and needs more vehicles and personnel.
(e) Use of communal containers in convenient areas in order to accelerate the loading speed.
(f) Design of collection routes:

<u>Macro-routing</u>:

Assign each collection route to a particular disposal site or processing facility so that the total pattern of assignments will result in optimal use of facilities and will minimize total costs.

<u>Route balancing and districting</u>:

Determine a fair day's work and divide the collection areas into equal workloads so that each district will have an appropriate workload for each collection vehicle.

Micro-routing:

Determine the path each collection vehicle will follow so that the non-collection distance (repeat distance and streets with no services) and delay times (such as U-turns, heavily trafficked streets, and right turns*) will be minimized.

* In countries where drivers keep to the left.

(g) Selection of technically, economically and socially appropriate equipment. For example, such equipment that would have a greater availability of spare parts and better guaranty sercvices.

(h) Assignment of sufficient number of workers to each collection equipment in order to accelerate its travel speed and to increase number of trips per shift.

(i) Use of 2 or 3 shifts in order to increase the productive hours per vehicle per day. However, it should be taken into account that the use of 2 ~ 3 shifts would reduce the equipment life.

(j) Establishment of preventive maintenance service system for motorized vehicles in order to reduce the number of equipment out of service. In many cities of developing countries, more than 50 per cent of vehicles are out of service due to the lack of small parts, etc.

(k) Installation of transfer stations, when it is economically justifiable, in order to reduce the non-productive time of collection vehicles.

(l) Location of final disposal sites in the vicinity of the city through the use of sanitary landfill method. The "time" to and from the site is more important than the "distance" because the aim is to reduce the non-productive time of collection vehicles.

(m) Incorporation of incentives and disincentives to aid the crew behaviour improvement (better working conditions, promotion, task system, assignment of better workers to wealthier neighbourhood with higher "picking" opportunities, etc.).

(n) Establishment of operation control system (use of sufficient number of supervisors, installation of weighbridges in landfill sites, establishment of a work measurement system, etc.).

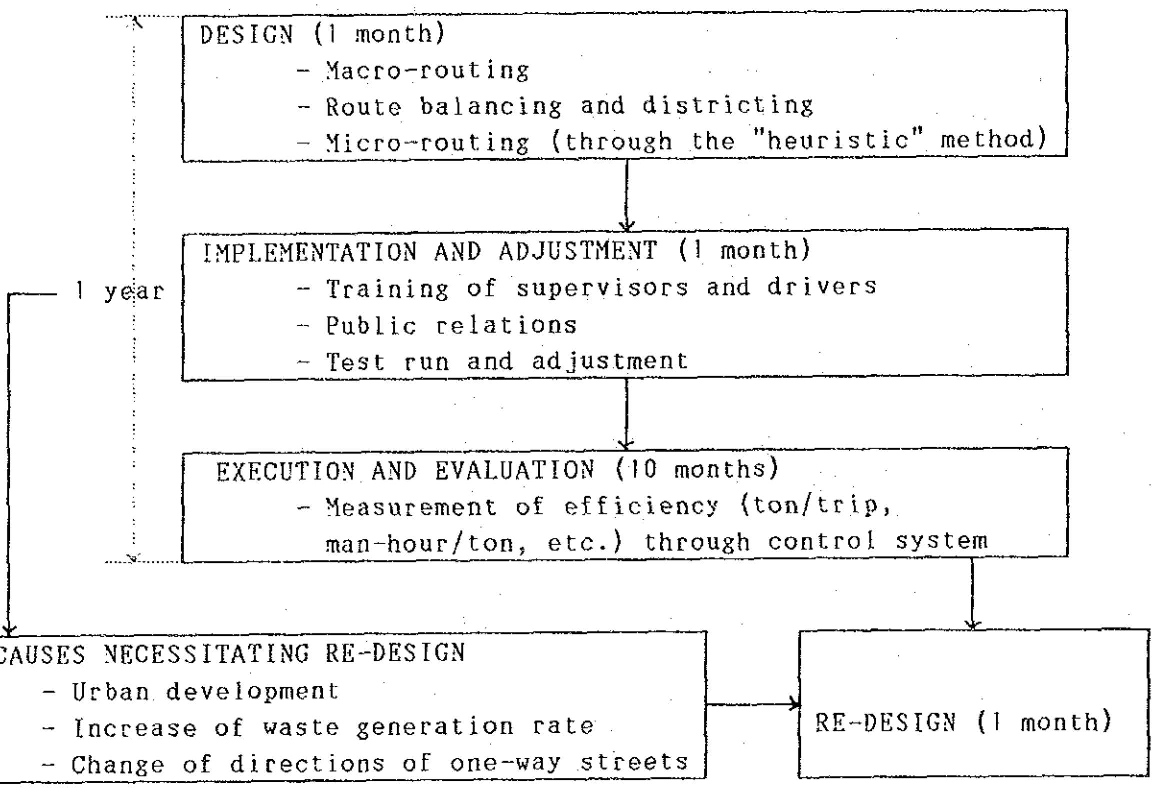
(o) Use of pilot projects, which test neighbourhood collection systems of various types, in order to identify the locally most appropriate and efficient system.

4.5 MACRO-ROUTING, ROUTE BALANCING AND DISTRICTING, AND MICRO-ROUTING

In many developing countires, the development of collection route is left to the judgement of collection vehicle drivers. Generally this results in poorly conceived routes because the drivers receive no technical orientation for route design. Collection routes should be developed by the people with proper training.

Route design should be carried out in three steps, namely, macro-routing, route balancing and districting, and micro-routing. The outline of each step has already be shown in 4.4 (f). Route design should be followed by the processes of implementation and adjustment, execution and evaluation, and re-design, as shown in Figure 4-6.

Figure 4-6 Flow Diagramme of Collection Vehicle Routing



4.5.1 Macro-Routing

Macro-routing becomes necessary when a city has several destinations for collection vehicles. Processing plants (such as composting plants and incineration plants), transfer stations, and disposal sites are considered as destinations for collection vehicles. The idea of macro-routing is to assign each collection route to a particular destination in such a manner that the total transportation cost would be minimized.

As an example, a city with (m) routes and (n) destinations is considered. To simplify the explanation, daily collection (seven times per week) is supposed all over the city. Route R_i ($i = 1,\ldots,m$) generates Q_i ton/day of solid waste. The city as a whole generates Q ton/day ($\Sigma Q_i = Q$). Destination D_j ($j = 1,\ldots\ldots,n$) can receive V_j ton/day ($\Sigma V_j \geqq Q$). Unit transportation cost from route R_i to destination D_j is c_{ij} \$/ton. The waste amount to be sent from R_i to D_j is expressed as $a_{ij} \cdot Q_i$ (a_{ij} = 0 or 1, $a_{i1} + a_{i2} + \cdots\cdots + a_{in} = 1$).

In this case, total transportation cost (TTC) can be expressed as follows:

$$TTC = \sum \sum a_{ij} \cdot c_{ij} \cdot Q_i$$

$$\text{Where } (a_{1j} \cdot Q_1 + a_{2j} \cdot Q_2 + \cdots\cdots + a_{mj} \cdot Q_m) \leqq V_j$$

As long as c_{ij}, Q_i, V_j are determined based on relevant studies, the cost minimum transportation system can be identified by finding the minimum TTC case using linear programming (LP) method. LP computer software is available in the market.

Above mentioned approach can be applied without any modification if all the destinations are final disposal sites. However, if some processing facilities and/or transfer stations are included in the destinations, then some modifications will be required so that the waste flow from these facilities to final disposal sites would be duly considered.

4.5.2 Route Balancing and Districting

The idea of route balancing and districting is to determine a fair day's work and divide the collection areas into equal workloads so that each district will have an appropriate workload for each collection vehicle. This task can be achieved as follows:

First Step : To calculate the number (N) of inhabitants to be served by each vehicle per shift by the following equation:

$$N = \frac{\text{Min } \{L_e, L_c\}}{\frac{7}{F} \times \frac{G}{1{,}000}}$$

Where:

N = Number of inhabitants to be served by each vehicle per shift

Min { } = The smallest figure included in { }

L_e = Maximum workload (ton/shift) defined by the collection efficiency (E) = C X H ÷ E

L_c = Maximum workload (ton/shift) defined by the collection vehicle capacity (V X D) = V X D X T

C = Crew size (workers*/crew)

H = Working hours (minutes**/shift)

E = Collection efficiency adopted in the design (man*-minutes**/ton)

* Collection vehicle driver should be counted as a member of collection crew. In other words, C and E should be determined including the driver.

** H and E should use the same time measurement system. If H is gross working hours, then E should be decided based on gross working hours. If net working hours are used for H, then E should be expressed in net working hours.

F = Frequency of collection (1/week)
G = Solid waste generation rate (kg/person/day)
V = Volume of vehicle body (m^3)
D = Solid waste density in the vehicle body (ton/m^3)
T = Number of trips per shift (1/shift)

Second Step: To calculate the average number of blocks (B) to be served by each vehicle per shift by the following equation:

$$B = \frac{N}{I}$$

Where:

B = Average number of blocks to be served by each vehicle per shift
N = Number of inhabitants to be served by each vehicle per shift
I = Average number of inhabitants per block

Third Step : To divide the collection area into districts with "B" blocks each, utilizing where possible for district boundaries the natural and artificial boundaries such as rivers, lakes, streams, mountains, valleys, railroads, highways, major roads, parks, cemeteries, hospitals, and other areas without services.

In the case of a large city, it is preferable to divide it at first into several typical areas and to establish design factors (number of inhabitants per block, type of equipment, collection frequency, collection efficiency, etc.) for each area. The usefulness of "block" approach depends on the physical characteristics of the city in question. If the blocks are not so clear or the size of blocks is very irregular, then the average district size (A) in hectare to be served by each vehicle per shift can be used instead of the average number of blocks (B). Factor (I) means, in that case, the average population density.

4.5.3 Micro-routing through the "heuristic" method

The idea of micro-routing is to determine the path each collection vehicle will follow so that the non-collection distance and delay times will be minimized. This task can be achieved by "heuristic" method.

4.5.3.1 Necessary data for micro-routing

The following data are necessary to carry out micro-routing:

(a) Location of garage;
(b) Location of transfer stations, processing plants and final disposal sites;
(c) Direction of one-way streets;

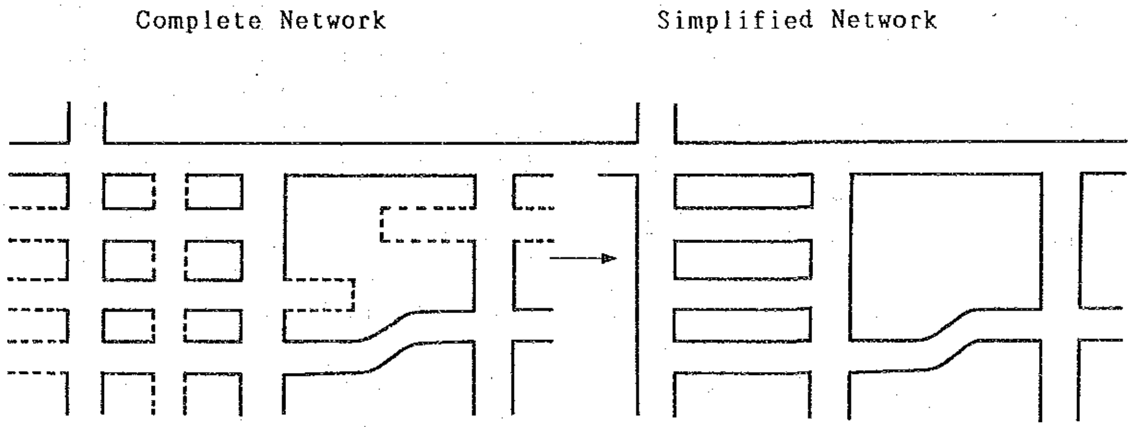
(d) Traffic jam and rush hour;
(e) Topography; and
(f) Passable roads and non-passable roads.

4.5.3.2 Procedure of micro-routing

Micro-routing can be carried out based on the following procedure:

(a) To prepare a map of the city (preferable scale 1:5,000).
(b) To prepare the working map for each district utilizing tracing papers and the road network simplification technique shown in Figure 4-7.

Figure 4-7 Road Network Simplification



Note: The collection vehicle will not travel along the roads shown by the dotted lines.

(c) To develop the most appropriate routes on try and error basis, utilizing tracing papers put on the working map and the rules of "heuristic" routing. It is necessary to do two or more tries in order to get the more opportune routes.

4.5.3.3 Rules of "heuristic" routing*

The "heuristic" routing is a simple, noncomputerized and common sense approach to micro-routing based on the following rules of thumb:

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* Source: Shuster, K.A. A Five-Stage Improvement Process for Solid Waste Collection Systems. Environmental Protection Publication SW-131. Washington, U.S.Government Printing Ofice, 1974.

(a) Routes should not be fragmented or overlapping. Each route should be compact, consisting of street segments clustered in the same geographical area.
(b) The collection route should be started as close to the garage or motor pool as possible.
(c) Heavily traveled streets should not be collected during rush hours.
(d) Services on dead-end streets can be considered as services on the street segment that they intersect, since they can be collected only by passing down that street segment. To keep right* turns at a minimum, however, the dead-end streets should be collected when they are to the left* of the collection vehicle. They must be collected by walking down, backing down, or making a U-turn.
(e) When practical, steep hills should be collected on both sides of the street while the vehicle is moving downhill, for safety, ease, speed of collection, reduced wear on vehicle, and conservation of gas and oil.
(f) Higher elevations should be at the start of the route.
(g) Backing up should be avoided as much as possible. Streets where there is no garbage to be collected should also be avoided.
(h) The collection route should be ended as close to the waste final destination (transfer station, processing facility or landfill site) as possible.
(i) For collection from one side of the street at a time, it is generally best to route with many counterclockwise* turns around blocks and to collect solid waste when it is to the left* of the vehicle.
(j) For collection from both sides of the street at the same time, it is generally best to route with long straight paths across the grid before looping counterclockwise*.
(k) Streets should be traveled only twice if only one side of a street is picked up at a time (See (i)). If both sides are collected at the same time (See (j)), streets should be traveled onlu once.
(l) For certain block configurations within the route, and in the case of the collection form one side of the street at a time, the specific routing patterns shown in Figure 4-8 should be applied.

4.5.3.4 Exercises of "heuristic" routing

In order to facilitate the understanding of the above-mentioned methodology of "heuristic" routing, two exercises are shown in Figure 4-9 and Figure 4-10. Figure 4-9 deals with the collection system from both sides of the street at the same time while Figure 4-10 is the case of collection system from one side of the street. Model solutions of these exercises are shown in Annex 9.

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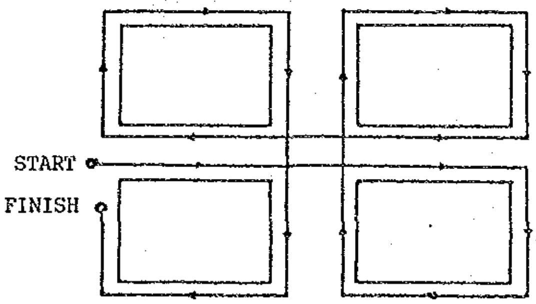
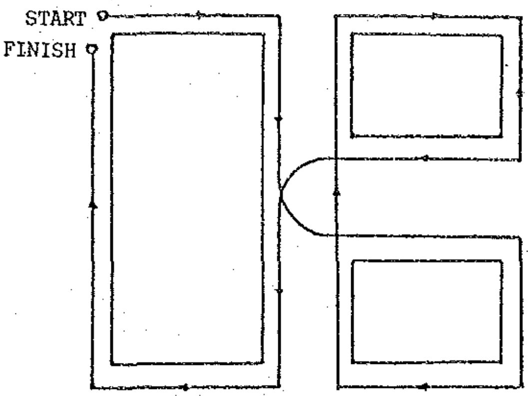
* These rules are for the countries with keep the left driving rules. In the case of the countires with keep the right driving rules, left and right and clockwise and counterclockwise should be exchanged.

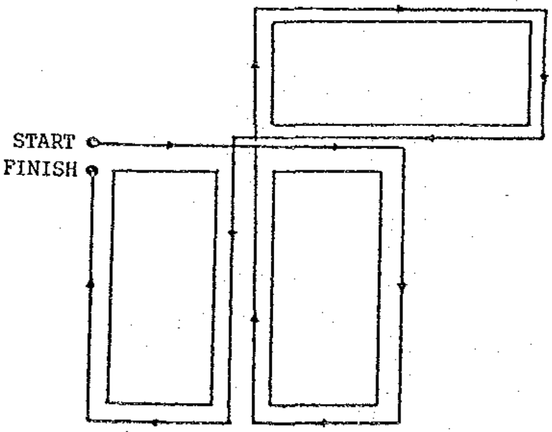
Figure 4-8(1) Routing Patterns (1)



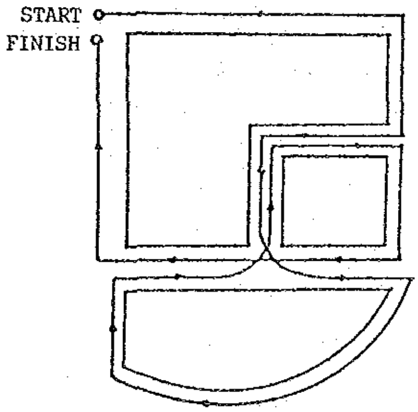
ROUTING CONFIGURATION APPLICABLE WHEREVER FOUR BLOCKS ARE POSITIONED AS SHOWN



THREE-BLOCK CONFIGURATION



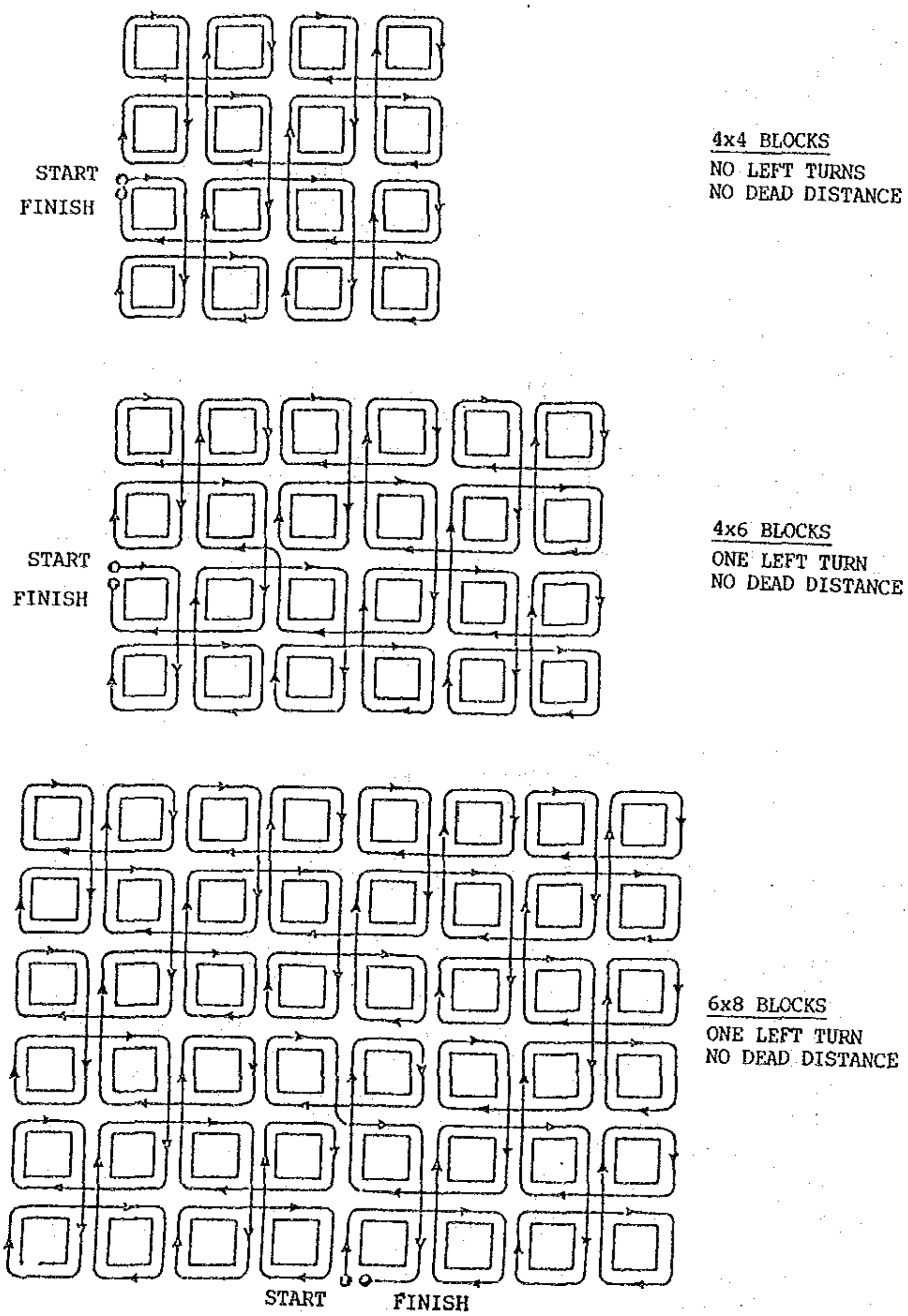
VARIATION OF THREE-BLOCK CONFIGURATION



VARIATION OF THREE-BLOCK CONFIGURATION

Source: Shuster, K.A. A Five-Stage Improvement Process for Solid Waste Collection Systems. Environmental Protection Publication SW-131.

Figure 4-8(2) Routing Patterns (2)

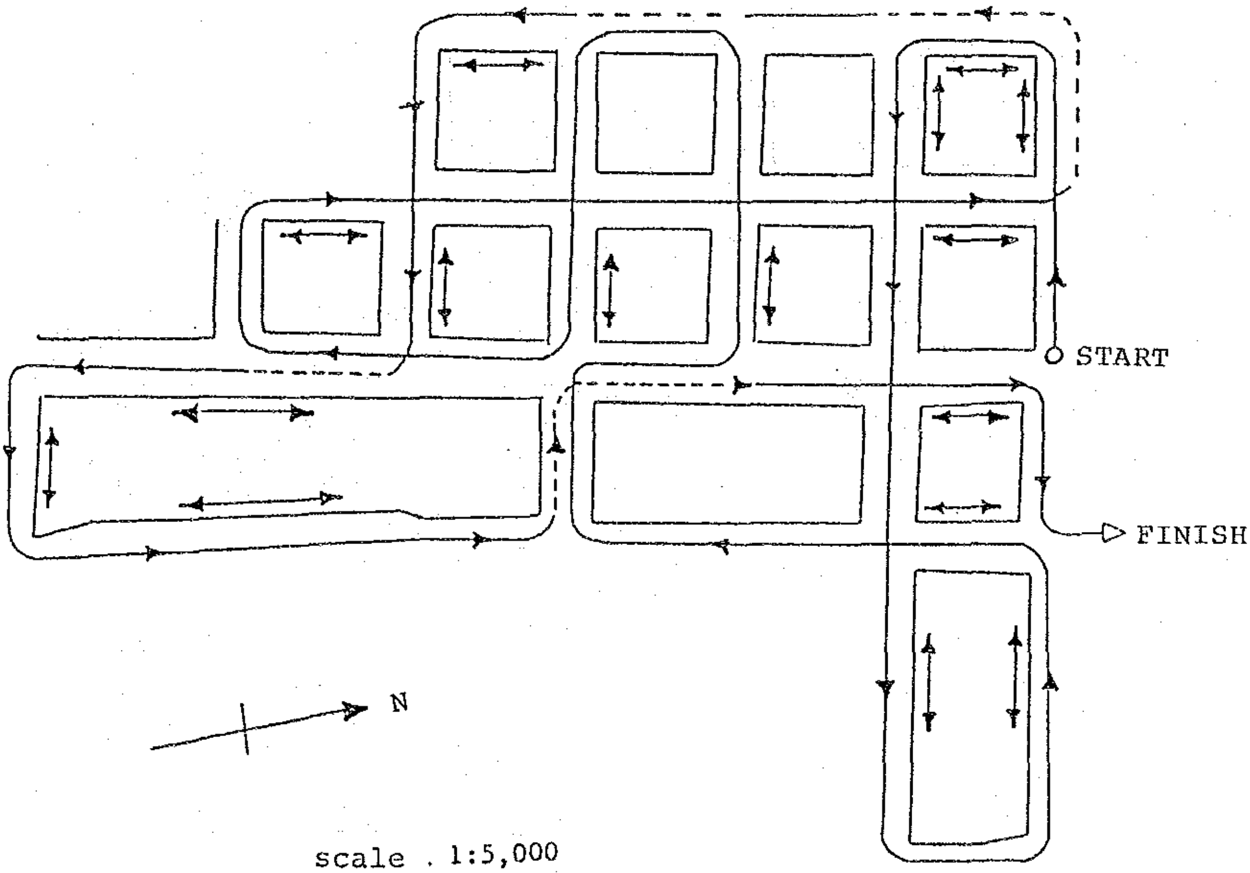


Source: Shuster, K.A. A Five-Stage Improvement Process for Solid Waste Collection Systems. Environmental Protection Publication SW-131.

Figure 4-9 Exercise-1

Heuristic Routing for the Collection from Both Sides of the Street at the Same Time

Task : To improve the following route for the collection from both sides of the street at the same time. The topography is flat and the garage and the sanitary landfill are located in the north direction of this area. There are no one-way streets.



scale . 1:5,000

Right turns------------------ 8

Left turns-------------------15

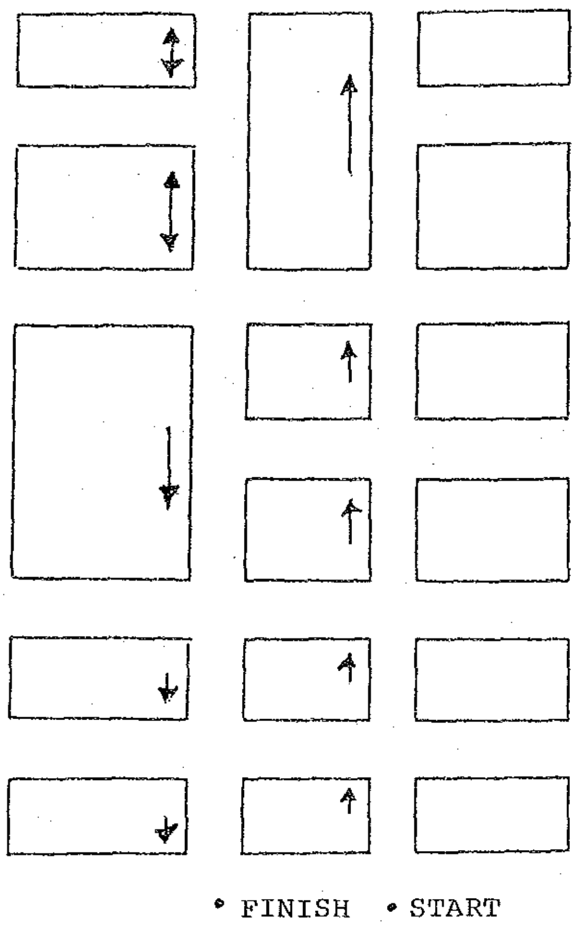
Nonproductive distances----- 6 blocks

Note: A model solution is shown in Annex 9.

Figure 4-10 Exercise-2

Heuristic Routing for the Collection from One Side of the Street at a Time

Task : To develop the most appropriate route for the collection from one side of the street at a time.



Right turns-----------------____

Left turns------------------____

U-turns---------------------____

Nonproductive distances----____ blocks

Note: A model solution is shown in Annex 9.

4.5.4 Implementation and Adjustment

Once the route design is ready, it comes to the stage of implementation as shown in Figure 4-6. For the successful implementation of new routes, training of supervisors and drivers as well as proper public relations are indispensable.

In addition, it is necessary to make a test run and adustment of new routes before their finalization. Districting mentioned in 4.5.2 is carried out based on the average design factors. However, the physical and socio-economic conditions of each district have some bias from the average and the testing will clearly show the effect of that bias. If the results of the test run require it, adjustment should be made as shown in Figure 4-11. The duration of the test will be for one or two weeks.

Figure 4-11 shows the idea of adjustment where the workload in Distict A is more than the required level while in the neighbouring District B the workload is less than that level. Adjustment can be done by changing the boundary of Districts A and B in such a manner that the workloads of two districts would be equalized.

Figure 4-11 Adjustment of Workloads Between Two Districts

District A (High population density area)	District B (Low population density area)
Working hours : 8.5 hours	Working hours : 7.5 hours
1st. trip : 5.5 ton	1st. trip : 5.5 ton
2nd. trip : 5.4 ton	2nd. trip : 2.7 ton

Adjustment

District A'	District B'
Working hours : 8.0 hours	Working hours : 8.0 hours
1st. trip : 5.0 ton	1st. trip : 5.0 ton
2nd. trip : 5.0 ton	2nd. trip : 4.1 ton

Note : In this example, the following conditions are used:
(a) Official working hours : 8 hours/shift; and
(b) Vehicle capacity : 5 ton/trip.

Once implemented, new routes should be monitored in terms of their efficiency as shown in Figure 4-6. As physical and socio-economic conditions are changing very rapidly in the cities of developing countries, the routes should be re-designed periodically with the frequency of, at least, once a year.

V. Collection in Urban Fringe Areas

V COLLECTION IN URBAN FRINGE AREAS

This Chapter is written to provide the people interested in the improvement of living conditions of urban fringe areas with practical guidelines for the expansion of refuse collection service towards such areas.

5.1 INTRODUCTION

The radical expansion of urban fringe areas in developing countries caused by rapid population growth and accelerated urbanization is aggravating the health conditions of these areas including basic sanitation such as wastewater and excreta disposal, and solid waste management (SWM). For this reason, the urban fringe areas will become one of the strategic target areas in achieving the worldwide goal of "Health for All in 2000" set by WHO member countries. Improvement of SWM in these areas is increasing its importance day by day in the urban administration of developing countries*.

For the improvement of SWM in these areas, R&D of non-conventional SWM systems will be indispensable because in most cases the conventional door-to-door collection system is not applicable to these areas for technical, economic and sociocultural reasons.

Through his five years' work as the PAHO/WHO regional Advisor in Solid Wastes (April 1979 - April 1984), the author coordinated several R&D projects on this theme in Latin American countries (Tegucigalpa-Honduras, Lima-Peru, Rio de Janeiro-Brazil, etc.) and organized an international meeting on this topic, 12-16 March 1984, in Lima-Peru. The author also promoted applied researches on the same topic in Malaysia when he was assigned to the Malaysian Government as a JICA expert from October 1986 to November 1988. These activities have made it possible for him to clarify and prepare the basic concepts and procedures for the improvement of SWM in urban fringe areas, which may be of use for other large cities in developing countries as a starting point for their own improvement projects.

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* Kitakyushu Declaration cited in Chapter II states on this point as follows:

The (expert) group, recognizing

(c) the need for commitment to enhance the SWM sector in providing efficient, effective and equitable services;

declares that:

(b) SWM is an essential service and should be extended to low income, marginal setlements regardless of affordability and legal status of land tenure;

5.2 BACKGROUND OF PROBLEM

As the background of problem, it is necessary to understand the dimension of the population growth and urbanization in developing countries. Naigzy Gebremedhin summarizes on this point as follows*:

> The world population has doubled over the past four decades to reach five billion. According to recent United Nations forecasts, it will rise by a quarter to over six billion people by the Year 2000, and reach eight billion by 2025. An increasing population will live in towns and cities. In 1900 less than 14 percent of the world's population lived in urban areas, by 1985, the proportion was over 40 percent. By the year 2010, for the first time in history, more people will live in urban areas than in rural areas, 3.62 billion out of 6.99 billion.
>
> The population of large cities is growing more rapidly than that of the urban population as a whole, especially in the developing countries. If present trends continue, close to half the urban population of the developing countires will be living in cities with more than one million people by 2025. One in four of them will be living in cities with more than four million inhabitants. In 1950, only seven cities on earth had more than five million inhabitants. By 1980, the picture had changed dramatically, there were 51 cities of over four million inhabitants of which 34 exceded five million and most were in developing countries. Moreover, many of the largest cities in the developing countries are projected to double in size in the next 15 years.
>
> These trends indicate the magnitude of the global problem posed by human settlements. At a time of financial stringency, developing countries have the task of providing shelter, services, and work in cities for an additional 140,000 people every day. They must seek to do this when more than 300 million are already without productive employment, 700 million people live in absolute or relative poverty, and development prospects for many of them appear more constrained than ever before.
>
> Most of the new urban population crowd into urban fringe areas such as old slums or new shanty towns springing up around the outskirts of most Third World cities. Because urban land is scarce and expensive, millions of poor households inhabit unauthorized squatter settlements on marginal sites subject to natural disasters or industrial accidents. They are found on precarious hillsides in Caracas and Rio-de-Janeiro, where landslides brought on by torrential rains have often led to death or injury, and in flood-prone depressions around many tropical cities. Shanty towns built alongside industrial zones and chemical plants have met disaster from industrial accidents in India and Mexico.

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* N. Gebremedhin, "Urbanization and Sustainable Development" (Paper presented at the International Symposium '89 on Environmental Pollution Control in Urban Areas of the Developing Countries, Kitakyushu, 3-6 October 1989).

As a typical case of radical urban fringe areas' expansion in developing countries, TABLE 5-1 shows the population change of Lima Metropolitan Area, Peru, and of its urban fringe areas denominated Pueblos Jovenes. In 28 years from 1956 to 1984, the total population of Lima Metropolitan Area has increased from 1.4 to 5.2 millions at the annual growth rate of 4.8 percent. This growth rate was almost double of the national population growth rate. In the same period the population of Pueblos Jovenes has increased from 0.12 to 2.08 millions showing an extremely high growth rate of 10.7 percent. As a result, the percentage of people who live in Pueblos Jovenes has also increased dramatically from 8.6 percent in 1956 to 40 percent in 1984.

TABLE 5-1 : POPULATION EXPLOSION IN LIMA METROPOLITAN AREA, PERU

(in millions)

	1956	1959	1961	1970	1972	1981	1984	2000*
Total Population (A)	1.4	1.7	1.8	3.0	3.3	4.6	5.2	9.0
Pop. in Urban Fringe Areas (B)	0.12	0.24	0.32	0.76	0.81	1.69	2.08	4.50
B/A x 100 %	8.6	14.3	17.2	25.6	24.4	36.7	40.0	50.0

* Estimation

Population explosion in urban fringe areas shown in TABLE 5-1 has been caused by the rural-urban migration and the static population growth within these areas. The excess population who lack their own land occupy national barren land illegally in a group, construct their shanties on it, and try to legalize land tenure over a period of time. In Lima, Peru, where there is no rain, two or three hours are sufficient to carry out illegal occupation and construction of shanties made of bamboo-mat. Residents of these shanties work as day laborers, street vendors, maids, etc. in the city, saving little money, and rebuild their houses little by little using "noble" materials such as bricks.

In urban fringe areas having 10 or 20 years' history after their creation, living environment has been gradually improved according to the residents' affordability including housing, transport, electricity, drinking water, health centers, community halls, meal service centers for malnourished children, etc. On the other hand, in the case of newly formed urban fringe areas, the residents are forced to live without basic public services such as piped drinking water, sewerage, garbage collection and in some cases electricity. Drinking water of doubtful quality due to the lack of inspection and of prohibitive price for abundant use is bought from cistern vehicles. Sullage is drained directly to public roads in extreme cases, and the lack of garbage collection service is creating many open dump sites of garbage in various places of the area and these sites tend to be used as open-air public conveniences. Due to the economic limitations, the nutritional condition is poor especially in infants, and the coverage of vaccination and other preventive health services is low. In addition to this, the lack of public health knowledge is more prevalent in the fringe areas because of the relatively low education level.

Morbidity and infant mortality in the area are extremely high due to the above-mentioned complex of unfavorable conditions. This is the reason why the urban fringe areas are one of the target areas in achieving the worldwide goal of "Health for All in 2000" to which WHO member countries are committed.

5.3 BASIC CONCEPTS

As a result of R&D projects in Latin American and Asian countries, the following eight are identified as the basic concepts for the development of SWM systems in urban fringe areas:

5.3.1 Comprehensive Development of Living Environment

Generally speaking, the priority given to the garbage collection service by the residents of urban fringe areas is not so high. They have a lot of needs with higher priority such as legalization of land tenure, housing improvement, transport, employment, drinking water, sewerage, electricity, education, health care, etc. The approach which tries to satisfy these needs one by one will be inefficient and hardly reach the improvement of the garbage collection service. Therefore it is advisable to prepare the project of garbage collection combining it with other high priority ones, forming an attractive package of projects and aiming at the comprehensive development of the living environment.

The following are examples of such packages :

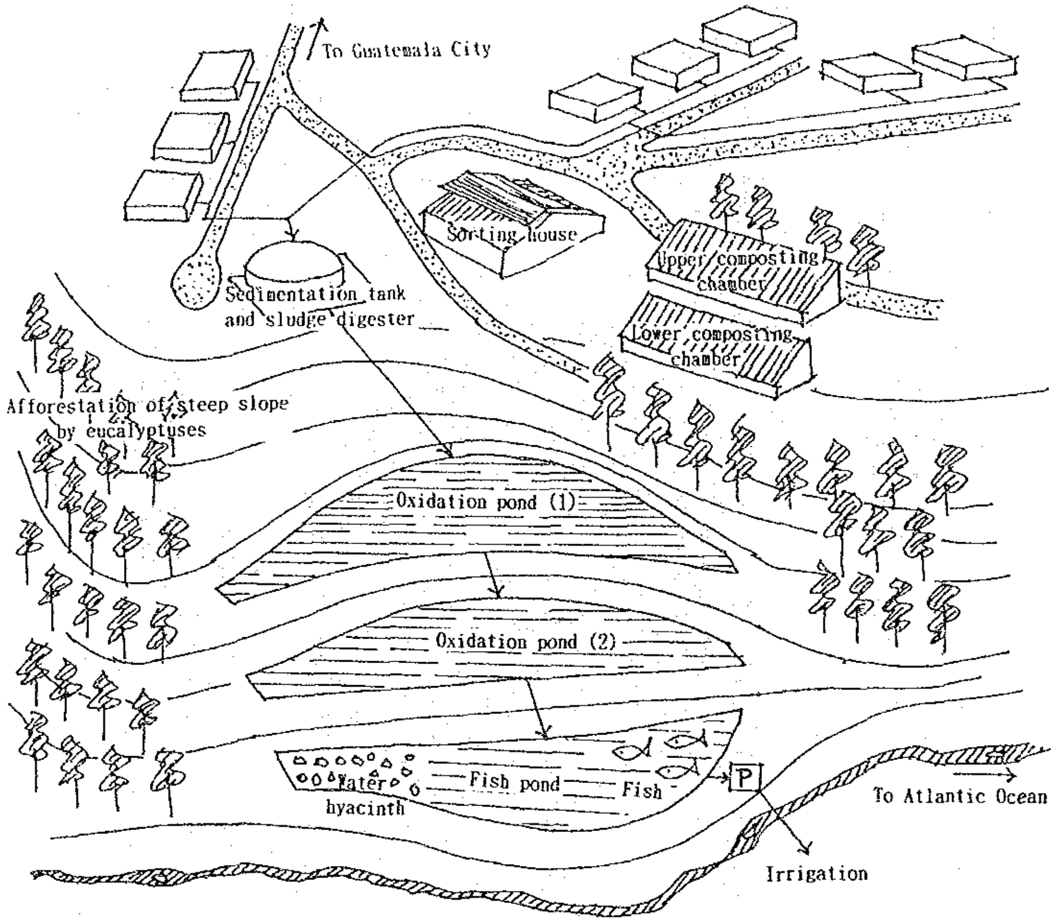
(a) In the case of relatively flat land with unplanned housing development, the combination of urban renewal, road construction and garbage collection service improvement will solve the problem because the main obstacle is the lack of access roads to the area to be served. Kampong Improvement Programme (KIP) in Indonesia is such an good example. This World Bank assisted programme has improved pavement, water supply and drainage in urban kampongs in Indonesia. Garbage collection based on the use of pushcarts has become easiser as the result of pavement improvement (See Figure 5-1).

(b) If there is no alternative but to bring down the garbage manually to the communal containers placed at the foot of hills, it is advisable to employ the youth of the area as much as possible for this work in order to create employment opportunities. As for the wages, they shall be covered by the contribution of beneficiaries and local government subsidies. This approach is used in Rio de Janeiro.

Figure 5-1 Road Improved by Kampong Improvement Programme (KIP) in Jakarta

(c) *In areas with deforestation and soil erosion problems such as* shanty towns in Guatemala, the combination of tree-planting campaigns and garbage collection improvement may be useful. In a marginal settlement called Alameda Norte in Guatemala City, a pilot plant for the integral treatment of solid wastes and wastewater was constructed in 1983 according to the design shown in Figure 5-2. The plant has been operated by the local people creating employment opportunities. Domestic solid wastes are source-separated into garbage and non-garbage, the former being converted into compost using the natural slope to turn over the wastes (See Figure 5-3), while the reusable items of the latter such as carton paper, plastics, cans, glass bottles are salvaged, and the rest being collected by municipal cleansing services. Produced compost is mainly used in the afforestation projects of nearby slopes. In the urban fringe area called Ollantay, Lima, Peru, the housewives are producing compost on their own initiatives, not collectively but individually, utilizing it for the production of vegetables in home gardens and improving the nutritional balance of their diet.

Figure 5-2 Design Concept of Alameda Norte Pilot Plant in Guatemala City
(Integral Treatment of Refuse and Wastewater by Local Cooperative)



FLOWCHART OF ALAMEDA NORTE PILOT PLANT

Household Solid Wastes (Source Separated)
- → Non-organic Wastes
  - → Sorting of paper, plastic, glass, etc. → Sale
  - → Rejects → Collection by Guatemala City
- → Organic Wastes → Upper composting chamber → Lower composting chamber → Compost
  - → Afforestation of slope
  - → Family garden
  - → Compost sale

Household Wastewater → Sedimentation tank and sludge digester
- → Sludge (to upper and lower composting chambers)
- → Supernatant → Oxidation pond (1) → Oxidation pond (2) → Fish pond
  - → Sludge (to composting chambers)
  - → Effluent → Irrigation
  - → Fish
- → Methane gas → Fuel for kitchen

Notes: (1) 3000 people (600 families) are served by this pilot project operated by the local cooperative.

(2) Although the construction of the Plant was begun in 1983, oxidation ponds and a fish pond are not constructed yet as of November 1989.

Figure 5-3 Composting Facility at Alameda Norte Pilot Plant

(Organic wastes are turned over manually from the upper chamber to the lower chamber using the natural slope. The lady seen in this photo is the leader of the local cooperative.)

5.3.2 Communal Participation

The disparity in wealth is great in developing countries, and the garbage collection in the area where the upper and middle income classes live is generally of high service level (daily collection, without source separation and sometimes backyard collection) because of the high economic capacity of the beneficiaries. On the other hand, the collection system in the urban fringe areas should be of such service level as to be sustainable economically by the residents depending heavily on communal participation to compensate for the low service level. For example, if the communal containers are placed at the foot of steep hills, the residents are expected to bring down their garbage every morning when they go to schools or working places. In the case of a communal composting plant, communal participation such as source separation and labor contribution will be indispensable.

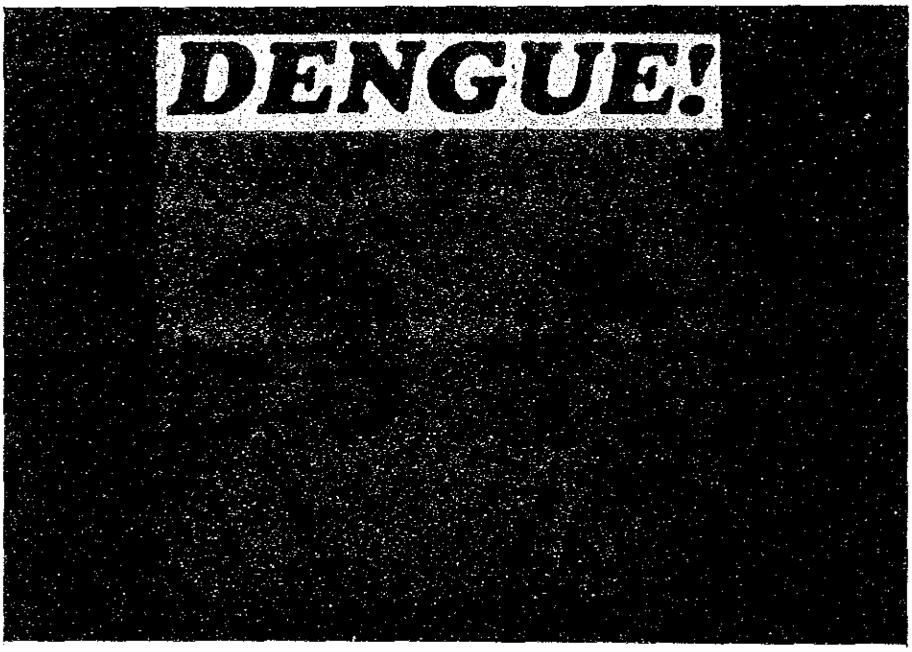
There are two types of communal participation, namely, (A) participation in the operation and maintenance of the SWM system, and (B) participation in the selection process of the most appropriate system for the community. The above-mentioned examples belong to type A participation, but they should be preceded by type B participation. The system selected by the professionals as the most appropriate is not necessarily accepted by the community. The system should be such that brings benefits which the residents consider important, falls in the cost range which they consider bearable, and is selected by them. Whenever this condition is fulfilled, the type A participation in the operation and maintenance of the selected system will not be passive participation forced by local governments but positive one carried out on their own initiatives.

To promote communal participation, it is very important to combine the SWM improvement projects with other high priority projects as mentioned above, but the more important is that municipal cleansing departments perform their services as scheduled because communal participation will be discouraged if containers are seen with overflowing garbage due to the lack of punctual collection services.

5.3.3 Public Health Education

The other incentive to promote communal participation will be public health education. The improvement of SWM at source, namely in households, such as source separation and storage will be possible only through public health education.

Figure 5-4 Dengue Fever As The Major Health Problem Caused By Bad SWM



Note: In South-East Asian countries such as Malaysia, dengue fever is considered to be one of the most important health problems to be caused by bad SWM. This figure which is taken from Malaysia's ABC Auto-slide Programme (See Figure 2-5) tries to get the people to be more conscious of the importance of better SWM.

The diffusion of public health knowledge should be done systematically through proper communication media so that everyone knows about how improper SWM will bring vector animals' proliferation and spreading of typhoid, dysentery, hepatitis, dengue fever (See Figure 5-4), etc. affecting the health of people, sometimes causing death and at the same time damaging the people economically in the form of medical expenses and loss of employment. Knowledge should also be diffused about what the most appropriate SWM system is for the community in question.

Generally speaking, adults are reluctant to change their habits. Therefore the efficient way of public health education will be to focus the efforts on young generations. In this sense, it is indispensable to include public health education in the curriculum of compulsory education (See Figure 5-5). Also it is recommendable to utilize actively, in public health education, audio visual aids which have made remarkable advances in recent years. Especially the use of video-programmes will be of great help because there are many illiterates within the people who have migrated from rural areas. In Lima, Peru, the author organized a team of six members (two social workers, two teachers specializing in video-programmes and two specialists of SWM including two female professionals) which produced a video-programme about SWM in the urban fringe areas of the City of Lima and repeatedly showed it in Lima. The reaction of the community has been very favorable.

Figure 5-5 A Booklet Used in SWM Education in A Japanese City

武蔵野市環境整備部

In Japan, SWM education is included in the curriculum of compulsory education. In order to facilitate that education, many Japanese cities have prepared booklets explaining their own SWM systems like the one shown in this figure ("People's Lives and Refuse" by Musashino City).

5.3.4 Women's Acceptance

The members who manage garbage in households, pay for collection service and take care of families' health are generally housewives. Therefore, the SWM system to be established in an urban fringe area should be in conformity with the living pattern of housewives of the area and should be such that will be accepted by them.

For this reason, it is very important to get the participation of female specialists in the diagnosis of the problem, opinion susrveys of housewives and design of the management system. In societies where men are predominant over women such as Latin American countries, it is fairy difficult for male investigators to have interviews with housewives when their husbands are out. If these interviews are carried out by a team of female social workers and male sanitary engineers, the friction will be far smaller.

5.3.5 Persuasion of Local Authorities

For the construction, operation and maintenance of the SWM system in urban fringe areas, we need not only the communal participation but also the active participation of the municipal cleansing service clarifying the responsibility of each party and the form of coordination between them. However, the local authorities of developing countries have many other high priority needs for which they have not achieved satisfactory results yet. Therefore their interest in the garbage problem is generally low, especially in that of urban fringe areas because people there have relatively little influence on politics. As such it is of vital importance to convince the local authorities with the necessity, possibility and convenience of garbage collection improvement in urban fringe areas.

As for the necessity of proper garbage collection, it will not be sufficiently persuasive only to point out its necessity for the health and economy of the residents of urban fringe areas. It should be pointed out that the whole city will suffer from a deficient garbage collection service in urban fringe areas because the residents will have many contacts with other citizens every day as street vendors, waiters in restaurants, salespeople of groceries, housemaids, etc. and because they form a great market for local industries holding sometimes more than half of the total population. Therefore the local authorities should be duly informed of the fact that if the residents of urban fringe areas suffer physically and economically the rest of the city will also be affected.

As for the possibility of improved garbage collection, it is extremely important to point out scenarios for improvement based on the existing physical, human and financial resources. Due to the huge external debt and the low international price of primary commodities, many developing countries are forced to adopt a policy of austerity, and the allocation of extra human and financial resources for the municipal cleansing services is very difficult. Even if they get necessary equipment through grant aid programmes from industrialized countries, it will not alleviate the problem so much because more than 80 percent of the total cost of SWM is the operation and maintenance cost. Therefore, there will be no other possibility but to rationalize the existing service and utilize the available resources efficiently so as to create extra capacity inside the municipal cleansing services allocating it for the improvement of garbage collection service in urban fringe areas*. A careful diagnosis of the present services by experienced specialists of SWM will identify a series of rationalization possibilities because in many developing countries SWM has been carried out in an intuitive manner.

As for the convenience of garbage collection improvement, it will be sufficient to point out the fact that the local authorities will be able to show their administrative ability very visually if they clean the city. Undoubtedly this will improve their political image.

5.3.6 Appropriate Technology

Generally speaking, the urban fringe areas have irregular topography (steep hills, swampy lands, on water, etc.), lack urban planning, and their residents have very limited economic capacity. Therefore, the conventional door-to-door collection method utilized in residential areas is not applicable to these areas from a technical, economic and social point of view. This is the reason why we need to develop and apply appropriate technologies.

The physical, economic, social and cultural conditions differ from city to city. Even in the same city, each fringe area has its own peculiarities (topography, residents' birthplace and/or race, religion, habits, age of community, coverage of other public services, etc.). As such there cannot be a universally appropriate technology which is applicable to urban fringe areas in general.

The following are some examples of appropriate technology search carried out in some large cities of developing countries taking into account their own peculiarities:

(1) Residents bring down their refuse to the communal containers placed at the foot of hills (Tijuana, Mexico);
(2) Garbage is composted in the backyard and utilized afterwards in family gardens, reusable items are salvaged and bartered for fruits, and the rests are collected once a week by private haulers contracted directly by beneficiareis (Ollantay, Lima-Peru);
(3) Garbage is composted communally and utilized afterwards for the afforestation of nearby steep slopes (Alameda Norte, Guatemala-Guatemala) (See Figures 5-2 and 5-3);

* Chapter Ⅴ explains about how to rationalize refuse collection process, which is the most expensive process of SWM, based mainly on the use of existing resources.

(4) On steep hill sides, the refuse is carried down on the colletors' backs in big cloth wrappers (Valparaiso, Chile);
(5) Refuse is brought down steep hills through open ducts placed on the slope (Rio de Janeiro, Brazil);
(6) Garbage and domestic wastewater without synthetic detergents are introduced to anaerobic digesters producing methane gas for kitchens, and the remaining refuse is brought down the steep hill by an aerial cableway (Rio de Janeiro, Brazil);
(7) Refuse is collected by small agricultural tractors (35 HP) with 1.6 cubic meter open-top bodies which can penetrate into the steep urban fringe areas without pavements (Rio de Janeiro, Brazil);
(8) Pushcart collection of refuse has become possible because of the pavement of narrow lanes (Jakarta, Indonesia) (See Figure 5-1).

Many of these searches have the nature of pilot projects, and it will be opportune to point out here the importance of pilot projects to verify the technical, economic and socio-cultural feasibility of any technical system before its use on a big scale.

5.3.7 Cost Bearing

Even after the efforts to make the systems less expensive, the systems for the management of solid wastes in urban fringe areas still need some capital investment and have operation and maintenance costs. Therefore it is indispensable to determine beforehand who will bear the cost, how and to what extent. Although cross subsidy should be actively used as a measure of social structural adjustment to overcome widely observed disparity of wealth in developing countries, costs should be borne mainly by the area's residents themselves for long-term and reliable functions of SWM in urban fringe areas. A system which depends too much on the subsidies from other sectors will not last long. Generally speaking, the item which may have outside help is capital investement such as communal containers and agricultural tractors (subsidy from local governments or donation from local industries). Therefore the steps to be taken will be the following:

(1) To know the capacity of the residents to bear the cost;
(2) To search for a solution within this cost bearing capacity (source separation and reduction of refuse to be collected by public cleansing service is a good example);
(3) To activate communal participation (e.g. source separation, reduction, carrying out, etc.) in order to reduce the system cost; and
(4) To cause a revolution of consciousness so that each resident will be prepared to pay one more cent for the public cleansing service.

The last step is very important because in many cases the head of a family can afford to drink beer every day but he tends to think that he cannot afford to allocate money worth one or two bottles of beer per month to the public cleansing service. Therefore it is of extreme necessity to change the sense of values about SWM both in local authorities and in local residents. The main driving force for this change will be public health education.

5.3.8 Technical Cooperation among Developing Countries

International technical cooperations used to be vertical ones between North and South which focus mainly on the technology transfer from industrialized countries to developing countries through the dispatch of experts and the supply of equipment. In quite a few cooperations, industrialized countries are forcing, consciously or unconsciously, the developing countries to use the technologies of industrialized countries without regard for the difference of socio-economic conditions and refuse characteristics.

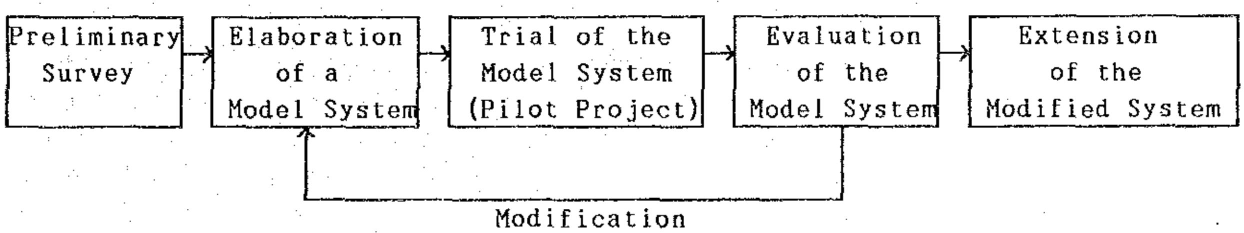
Since many developing countries share similar socio-cultural conditions with neighbouring countries, horizontal technical cooperations between them (TCDC = Technical Cooperation among Developing Countries) will be of great use looking for the appropriate technologies by themselves. The industrialized countries will be requested to increase their financial assitance to the TCDC activities initiated and implemented by the professionals of developing countries.

The International Meeting on Garbage Collection in Urban Fringe Areas, Lima-Peru, 12-16 March 1984 was organized by the author just to promote the TCDC in Latin American countries on this issue. Two International Expert Group Seminars organized by United Nations Centre for Regional Development (UNCRD) in Beijing-China (5-9 September 1988) and Kitakyushu-Japan (16-21 October 1989) activated the exchange of experiences on this issue among Asian metropolises.

5.4 BASIC PROCEDURES

The R&D of the non-conventional system, which is indispensable for the improvement of SWM in urban fringe areas, needs to be carried out through five steps indicated in the following figure:

Figure 5-6 Five Steps for the R&D of Non-conventional SWM Systems



These steps should be desisgned and implemented by a team of sanitary engineers, sociologists, social workers (as mentioned in 5.3.4, women are preferable) and environmental health supervisors. The selection of team members should be done very carefully so as to win public confidence. The main points of each step are as follows:

5.4.1 Preliminary Survey

The objective of this step is to collect the necessary information for the second step (elaboration of a model system) such as:

(1) Residents' interest in knowledge about the garbage problem;
(2) Current storage, collection and disposal method;
(3) Residents' socio-economic conditions such as family make-up, education, job, income, etc.;
(4) Experiences of communal participation; and
(5) Existing communal organizations including schools and churches and cummunication media.

This preliminary survey includes the following components:

(a) Collection and analysis of existing information;
(b) Categorization of urban fringe areas based on topography, age, land tenure, residents' birthplace and race, existence of self-governing systems, coverage of other public services, population densisty, etc. and preliminary selection of two to three communities for each category;
(c) Consultation with the leaders and housewives of pre-selected communities to know their concerns about garbage problems and the possibility of their voluntary cooperation;
(d) Selection of one community for each category which seems to have the highest probability of success as a model community in the pilot project;
(e) Design, experimental use and modification of three questionnaires (consciousness, socio-economic conditions and SWM practices at each household level; existing organizations and experiences of communal participation at each community level; observations of interviewers about the SWM practices in each community such as open dumping), explanation of survey aims in the general assemblies of the selected communities to acquire acknowledgement, and survey implementation; and
(f) Determination of waste generation rate (gr/capita/day) and analysis of waste characteristics.

Careful selection of model communities in the components (c) and (d) is of vital importance and it should be avoided to extort interests in and cooperations for the development of SWM systems because fabricated interests do not last long and tend to cause failures of pilot projects. Before the execution of the component (f), determination of waste generation rate and analysis of waste characteristics, it is indispensable to get rid of all the accumulated waste in the community through a special collection campaign. Otherwise it is impossible to take representative samples. The sampling should cover at least eight consecutive days discarding the first day's sample and utilizing the remaining seven days' samples as representative waste of one week. The minimum sample size is 30 households for each model community.

5.4.2 Elaboration of a Model System

Based on the information collected in the Preliminary Survey, a model system of SWM for the model community will be elaborated including the following three subsystems:

(1) Management system at household level (selection of storage containers, source separation, material recovery, etc.);
(2) Management system at community level (collection in the community, storage, communal material recovery, style and motivation of communal participation, administrative plan of oiperation and maintenance, necessary training and execution, cost estimation and financial plan); and
(3) Management system at public cleansing service level (secondary collection, transport and final disposal, collection frequency, collection vehicle, administrative plan of operation and maintenance, coordination with local industries and voluntary groups for the posssible donation of equipment and tools, public relations, cost estimation and financial plan).

In the elaboration of the model system, a great deal of ingenuity should be exercised adapting in some cases the experiences of other developing countries to the local conditions of the urban fringe area in question through TCDC. Participation of community members in this design process is crucial as mentioned in 5.3.2. As such their participation should be promoted as much as possible although it may seem cumbersome for the manager of the public cleansing service in question.

5.4.3 Trial of the Model System (Pilot Project)

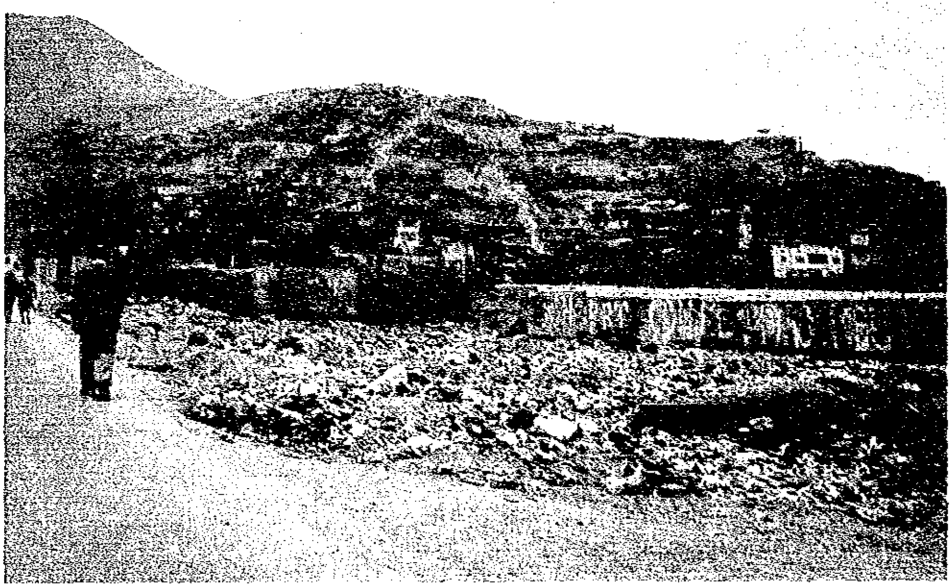
In order to verify the effectiveness and feasibility of the model system, it will be implemented on a trial basis in the model community. The implementation will be carried out as follows:

(1) To inform the community leaders of the model system asking for their cooperation and persuasion of residents for the system introduction;
(2) To make public the model system through various information channels;
(3) To determine the location of communal containers (in many cases, existing open dumping spots in the community are appropriate for the location) (See Figure 5-7); and
(4) To put into operation the model system assuring the coordinated

participation of the public cleansing service.

Figure 5-7 Best Place for the Location of Communal Containers

(Existing open dumping spots are appropriate for the location of communal containers. Photo taken in an urban fringe area of the City of Lima, Peru)



5.4.4 Evaluation of the Model System

After the trial of the model system in the model community, the system evaluation should be carried out to clarify:

(1) How the SWM at household level and community level is improved;
(2) What opinions the residents have about the system;
(3) What problems the system has and what countermeasures are available; and
(4) How much the system costs for each family and how much the residents are paying.

System modification should be done based on the evaluation results so that it will be more effective and acceptable for the residents. After that modification, an agreement should be exchanged between the self-governing organization of the model community and the public cleansing service about the implementation of the modified system on a regular basis.

5.4.5 Extension of the Modified System

The modified system which is proved to be effective and feasible in the model community should be extended to other urban fringe areas of the same category taking into account the technical and financial capacity of the public cleansing service.

5.5 CONCLUSION

The procedures for the development of a SWM system in urban fringe areas which suffer a rapid expansion in large cities of developing countries have been discussed in this Chapter.

Adding to the quantitative growth of urban fringe areas mentioned here, the life and consciousness of the residents are under qualitative transition including dramatic changes of surrounding socio-economic conditions.

Therefore the procedures presented here should be evaluated periodically reflecting the dynamic evolution of urban fringe areas. For example, some of the "appropriate technologies" presented in this Chapter may be "appropriate" for the first generation who migrated from rural areas but may not be "appropriate" for the second and third generations who have got accustomed to urban life. In this sense, it will be more practical to consider them to be "transitionally appropriate".

As such further active discussions on this theme based on practice are strongly requested to improve the environmental sanitaion of urban fringe areas.